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HW 17381 - DEL REV

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DEVELOPMENT DIVISION

HEALTH INSTRUMENT DIVISIONS

DISSOLVING OF TWENTY DAY METAL AT HANFORD

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May 1, 1950

REPOSITORY PNL

COLLECTION I-131 Atmosphere

BOX No. N/A

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HANFORD WORKS

RICHLAND, WASHINGTON

HW-17381 -DEL REVI

DISSOLVING OF TWENTY DAY METAL AT HANFORD

by

D. E. Jenne
and
J. W. Healy

May 1, 1950

HANFORD WORKS
RICHLAND, WASHINGTON

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I. SUMMARY

One ton of irradiated uranium with fifteen days cooling was dissolved from a two ton batch loaded into a clean dissolver on December 2, 1949. Calculated amounts of activity evolved were 4000 curies of I-131 and 7900 curies of Xe-133; measured values were higher than this by a factor of 2 to 3. Preliminary calculations of the hazard were made by the method of O. G. Sutton and attempts made to check these values by readings on fixed and mobile instruments.

The meteorological conditions during the actual hours of dissolving were unstable with the wind veering from a southerly direction at the start to a northerly direction about half-way through the run. Rawinsonde readings at Richland during the run indicated a shallow surface inversion with an unstable condition aloft. It is postulated that much of the dilution occurred above the inversion.

Readings as high as 2×10^{-4} uc/l of I-131 and 2000 to 3000 c/m on portable Geiger counters were obtained within a radius of 4 to 5 miles from the stack. Significant readings appeared in the Richland - Pasco - Benton City area about noon of December 3. Estimated maximum concentrations were on the order of 10^{-7} to 10^{-6} uc/l of I-131. Questionable positive readings were obtained on filters at Spokane on December 3 and December 5, 1949.

Aircraft measurements made in the direction of Spokane on December 3, 1949, indicated peak activities in the morning at Ritzville and between Richland and Connell. It is postulated that the peak closest to the project was due to I-131 while the one at Ritzville was due to Xe-133.

Considerable deposition occurred particularly close to the stacks. Positive vegetation readings, above the permanent tolerance value of 9 muc/kg occurred over a region extending from The Dalles, Oregon, to Spokane, and from Yakima to the Blue Mountains. The rate of deposition in water was estimated at 2×10^4 uc/meter^3/hr/uc/l; and on vegetation as 4×10^5 uc/meter^3/hr/uc/l. The I-131 on vegetation decayed to background with an eight day half-life.

Exposures of clean potted plants in the area gave results comparable to those found in other plants. Animals collected from the region indicated that specimens from within the project boundary received thyroid irradiation varying from tolerance to 80 times tolerance daily.

meter^2

DISSOLVING OF TWENTY DAY METAL AT HANFORD

INTRODUCTION:

The Health Instrument Divisions were interested primarily in obtaining monitoring results to see that no one was overexposed to the active fumes, and secondarily in the travel of the activity and deposition on the vegetation.

Since it is almost impossible to write such a report without designating areas, buildings, terrain features, etc. by their local names, Figure 1, included in the introduction to the report, is a map showing the location of the more prominent features.

II. Planning

Upon receiving this information, each group participating started more detailed work directed towards obtaining as much information as possible from the operation and seeing that the fumes were liberated safely. An outline of this planning is given below since much of the work done at this time aided considerably in interpreting results.

A. Weather Required.

With this amount of activity being released, good dilution of the fumes before they came to the ground in the areas were required to avoid gross contamination of the buildings and possible exposure of personnel. Criteria decided upon for weather conditions were:-

(1). An inverted vertical temperature gradient extending from the ground to several hundred feet above. This stipulation necessitated scheduling the run during night-time, as it is only then that inversion conditions at Hanford Works are frequent.

(2). No rain, fog, low cloudiness, or other factor which might prevent the plane from flying.

(3). Light to moderate wind speeds 15 mph at the 200 ft. level was decided upon as the upper limit of permissible wind speed.

(4). Wind from a westerly or southwesterly direction so that the plane would not be forced to fly in the vicinity of such rugged topographic features as 3600 feet high Rattlesnake Mountain to the south of the area.

(5). Conditions whereby the bulk of the stack effluent would stay aloft. A dilution factor of 1500:1 was decided upon as the lowest permissible factor.

A review of data from the past several years at the HW Meteorology Station showed that during night hours at this season of the year the "aloft" condition prevailed 76% of the time, and that the sky coverage averaged 6.7 on a scale of 10. Hourly wind speeds between 0300 and 1200 averaged from 4-6 mph at the 7 feet level to 10-11 mph at the 400 foot level. The prevailing direction was northwest. A moderate inversion usually overlies the area at night, forming near sunset and terminating about one-half hour after sunrise. Normally, precipitation is infrequent and the probability of its occurence during any particular 24 hour period is always small.

The above statistics indicate that the chance of finding favorable meteorological conditions for the dissolution on any particular date might be good. However, the month of November, 1949, was plagued with inclement weather which included two periods of recurrent storms with attendant wind and rain, interspersed by a 10-day stagnant period during which ceilings were continually low and fog was present on an average of nearly 10 hours each day. This inclement weather necessitated postponement of the run for one week.

On the morning of December 1, the United States Weather Bureau in a special forecast to this plant, predicted that the end of the current series of frequent storms was in sight, and that conditions favorable for the operation could be expected by Saturday night, December 3. The dissolver was then loaded so that operations could begin Friday night, December 2, if conditions were favorable.

B. Operations

The "S" Division, in charge of the actual dissolving, elected to use the spare dissolver in the "T" plant (200 West Area) so that the "heel" resulting from the dissolution of only a portion of the metal charged, could be stored in the dissolver for an additional cooling period. Two tons of metal pushed on November 17, were loaded into a clean dissolver on December 1, 1949, and the jackets dissolved on the 12-8 shift on December 2, 1949. The actual length of the dissolving time could not be predicted accurately since normal operating procedure calls for three tons of metal per charge on top of a one ton heel. An estimate of 12-16 hours for the dissolution of one ton was made.

The amounts of I-131 and Xe-133 in the metal after 16 days cooling were estimated at 6150 and 6070 curies per ton respectively. Assuming that 50% of the iodine(2) remains in the dissolver and that there is a 30% increase over the average in the amounts of fission products in the outer portion of the slug, the dissolution of one ton would liberate 4000 curies of I-131 and 7900 curies of Xe-133. Since the off-gas scrubbers were not operated, all of this activity would be discharged from the stack.

The rate of discharge was estimated from three evolution curves measured in 1947 by the H. I. Divisions. These curves indicated that with an eight hour dissolving period the Xe-133 reaches a maximum in 1-1/2 hours and the I-131 reaches a maximum in 3-4 hours. Extrapolation of these curves to a 16 hour dissolving (Fig.2) indicated a xenon peak at about three hours and an iodine peak at about seven hours after the start. The maximum rate of emission was estimated at 0.41 curies/sec for Xe-133 and 0.14 curies/sec for I-131. These values would amount to about 28 uc/l of Xe-133 and 10 uc/l of I-131 in the stack on the basis of an air flow of 25,000 cfm up the stack.

The start was planned for 2000 on December 2 as a compromise between the Air Force's desire to start at 0100-0300 on December 3 so that the maximum would occur about daybreak, and the operation's need to start as soon after sundown as possible so that the bulk of the activity would be liberated before the inversion broke the next morning. With the start at 2000, the maximum Xe-133 activity would occur about midnight and the maximum I-131 activity would occur about 0300, with a total of 12 hours before sunup to eliminate most of the activity.

C. Air Forces

Extra weather forecasting and observation stations were set up by the Air Weather service to augment existing stations in order to obtain sufficient data for forecasting the movement of the cloud and to correlate the existing conditions with the activity pattern found.

Reports of forecasting and observation stations over the Northwest were utilized to get a clear picture of the weather for weeks before the test. In addition, a mobile Rawinsonde station and two pibal units were moved into the vicinity of the Hanford Project for a more detailed analysis. The Rawinsonde unit was placed at the Richland Airport and one each of the pibal stations at Washtucna and Moses Lake. These facilities were part of the 2060th Mobile Weather Squadron at Tinker Air Force Base, Oklahoma. An additional forecaster was added to the staff of the Spokane AFB Weather Station especially to forecast for this test.

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Background values were established for the aerial instruments prior to the run. Flights were made at different altitudes over the area and the instrument values were plotted against altitude changes. A set of curves for the principal instruments appears in the section on equipment and procedures.

D. Site Survey

The H. I. Site Survey Crew was interested in checking upon the hazards encountered in the run plus any information that could be obtained upon the spread or deposition of activity. A series of calculations based on the work of O. G. Sutton and others on the dilution of gases in the lower atmosphere were performed (3, 4, 5, 6). The basic equation for these calculations is:

$$\chi_{(x,y,z)} = \frac{Q\, e^{-\frac{y^2}{C_y C_z U x^{2-n}}}}{C_y C_z U x^{2-n}} \left[e^{-\frac{(z-h)^2}{C_z^2 x^{2-n}}} + e^{-\frac{(z+h)^2}{C_z x^{2-n}}} \right]$$

where:

$\chi_{(x,y,z)}$ - concentration in gms or curies/meter^3 at a point given by the coordinates x, y, z on a system where the origin is at the source and the x direction is down wind.

Q - rate of emission in gms/sec or curies/sec.

Cy, Cz - are virtual diffusion coefficients for the Oy and Oz directions, respectively.

U - Mean wind velocity in meters/sec

n - a pure number lying between 0 and 1. The precise value is reported as a measure of the stability of the atmosphere.

h - the height of the stack in meters.

Values of the coefficients Cy, Cz and n were abstracted from papers of Sutton's as he used them for tests in Porton, England. This is one of the weak points in such a calculation since the conditions at Hanford are undoubtedly different with regard to gustiness, etc. However, it was felt that estimations by this method would be valuable in foreseeing hazards and in interpreting results. The coefficients used in the calculations for a 200' stack are given in Table 1.

Table 1
Coefficients for Sutton's Equations on Diffusion in the Lower Atmosphere

Atmospheric Condition	n	U Meters/sec	Cz = Cy
Large lapse	1/5	7	0.165
Zero or small temperature gradient	1/4	5	0.095
Moderate Inversion	1/3	3	0.060
Large Inversion	1/2	2	0.0475

In Figure 3 appear the calculated concentrations from a continuous point source 200' above the ground at distances up to 200 miles. These concentrations are the maximum expected along the axis of the cloud if it is assumed that uniform meteorological conditions and flat terrain are encountered throughout the entire path of the cloud. Two values are given for each distance: (1) the coefficient of the equation $\chi = k \frac{Q}{U}$ where Q is the rate of emission in microcuries/sec, U is the wind speed in meters/sec, and χ is concentration in uc/l; and (2) the actual concentration for an emission rate of 0.05 curies/sec (close to the average expected for I-131) and a wind speed of 11 mph.

Figure 4 presents an estimate of the width of the cloud at various distances if it is assumed that the wind is steady in one direction. In this case the cloud width is defined as the distance between the two points on the extremities that have a concentration one-tenth of the peak concentration.

The maximum activity expected at the ground is presented in Figure 5 under the same conditions as for the air concentrations. The ground pattern expected for a steady moderate inversion condition with a wind speed of 11 mph is given in Figure 6.

Fixed instruments were located at strategic spots where power was available on the reservation. The location of monitoring instruments during the run is given in Figure 7. All of the counting rate meters and most of the air scrubbers were put out specially for the operation and later removed.

Field crews to carry out the following jobs were planned:

(1). Two men in four wheel drive equipment were to attempt to locate the point of maximum air concentration and make traverses across the cloud taking readings on portable GM counters and small scrubbers designed to pull one cubic foot of air through a caustic solution.

(2). Three men were to operate a radio transmitting GM counter, built by the Health Instrument Development Group. This unit was intended to be sent up in a balloon to several hundred feet so that traverses of the cloud at the axis could be made.

(3). One man was to travel from the intersection of routes 4S and 2S to several miles above Hanford reading detachable chambers every mile and taking small scrubber and portable GM readings.

(4). Two men were to travel from Pasco to Connell with a recording GM counter and a 1-1/2 CFM air scrubber operated from a mobile generator.

(5). One man was to check all instruments during the run and to take small scrubber samples on the reservation.

E. Coordination

In order to keep current with activities in the field during the time of evolution, the H. I. Emergency Plotting Room at Patrol Headquarters was used. This allowed the use of three telephones and was conveniently located to WGMB, the patrol radio station. Thus it was possible to obtain reports from the field cars by radio, from various survey groups by telephone, and meteorological data from the special units set up by the Air Forces by telephone. This also allowed the use of the plotting room facilities in conditions approximating those of an actual emergency and was very valuable in gaining information on techniques.

The plotting room was manned by Health Instrument Personnel from 1900 on 12/2 to 1000 on 12/3 and by an Air Forces representative from 0100 on 12/3 to 1000 on 12/3.

III. Equipment and Procedures

In general, a brief discussion of the equipment and procedures used for a particular reading or series of readings is included in the section presenting the data. This section of the report is intended to describe those items which were used generally throughout the run and procedures which were used in the analysis of samples, etc.

A. Air Forces

1. Atmospheric Conductivity Apparatus

The Atmospheric Conductivity Apparatus is essentially the same unit that was used on previous tests.(1) The only change is in the method of signal amplification and recording. A vibrating-condenser monitron and an Esterline-Angus Recorder replace the vacuum-tube electrometer circuit and Brown recorder.

The vibrating condenser converts the D. C. potential developed across the capacitor by a collected charge from the collection tube, into an A. C. voltage which is then amplified, rectified, and measured in a vacuum-tube voltmeter circuit. This monitron is built around a modified vibrating condenser which was used in the APN-1 radar altimeter (Part Y-101, Stock No. P255062-501). Modification of the condenser included the addition of a material of high insulating properties between the plates and electroplating the vibrating diaphram with 24-karat gold. A two-stage AC amplifier, a rectifier, a vacuum-tube voltmeter stage, and an oscillator for the vibrating condenser comprise the vacuum-tube unit in addition to the conventional power supply.

The ionization rate is recorded on a 0-1 milliammeter in the form of the Esterline-Angus recorder. There is an additional indicator on the pilot's instrument panel.

Two ranges are available on this extremely stable monitron. A switch on the front panel allows the operator to choose the most suitable range for the job. These ranges differ by approximately a factor of ten, with Victoreen Hi-meg precision resistors being ...

A schematic diagram of the monitron appears in Figure 8 and a photograph of a complete monitoring set up in Figure 9. However, it will be noted that the collecting tube shown here is considerably shorter than that used in the aircraft. (The setup shown is for ground monitoring at a low velocity air flow.)

2. N.R.L. Dual-Channel Airborne Unit

This unit was described in reference 1 and more fully by the designers(7). However, because the "C" channel went out just prior to the run, the set was used as a straight counting rate meter with no coincidence cancellation.

The tube bank was different from those originally used. Instead of the metal counters, glass counter tubes were inserted into 1" brass sleeves by the instrument division to give approximately the same density as the metal counter.

3. AMC Filter Box

A standard AMC filter box is mounted on the aircraft in the position shown in Figure 10. It accommodates two 8" x 18" filters and passes about 450 cubic feet of air per minute through each filter at 150 miles per hour indicated airspeed.

4. External Counter Tube

For the first time on the project, an external beta counter was used. The assembly consisted of a Tracerlab stainless steel counter tube mounted atop the filter box on two aluminum brackets. A deflector cap shielded the tube from the direct blast of the slip-stream and also covered the co-axial connection. The co-axial cable passed through the front mount and terminated at a pre-amplifier just inside the cabin of the aircraft. Pulses from this cathode-follower stage were fed into a scaler for counting.

When the tube was subjected to near freezing temperatures it practically ceased counting. However, under warmer conditions the performance was very good. A sketch and photographs of the assembly follow in Figures 11, 12, and 13.

5. Scrubber Installation

The Health Instruments Division installed in the aircraft a system designed to "scrub" the iodine from the air passing through it. It consisted principally of a tank containing about two gallons of scrubber solution (50% 0.5N NaOH and 50% 0.1N Na_2CO_3), and two glass wool filters (Figure 14). Slipstream air flowed through the liquid from the bottom and splattered the caustic solution on the filter. Both the solution and the filters were analyzed for iodine content.

Difficulty was encountered when the system was in operation. It was found that by taking the air for the scrubber from the exhaust end of the conductivity tube, the head of solution reduced the airflow through the conductivity tube to such a low value that much of the conductivity sensitivity was lost, and the scrubber had to be disconnected during the flight in order that the readings taken from the conductivity meter would be reliable.

6. Halogen Detector

A standard General Electric Leak Detector was put aboard and equipped with a recorder. The probe was taped to a window with the tip extending through the window into the slipstream.

B. Site Survey

Portable Geiger Counters used for field measurements were mostly the Victorsen Model #363A as listed on page SCM-2B of the AEC Radiation Instrument Catalog #1. A few readings were made with the El-Tronics Portable Counter Model #SM3 as listed on SCM-18A of the same document.

The counter used for the balloon ascensions was a modified mark 11, Model 21 Unit put out by the Radiation Counter Laboratories, Inc. This instrument uses a low voltage thin wall counter and is known locally as the "atomic blinker". The case and all surplus parts were removed and the circuit rearranged on an aluminum rod framework with the tube protruding underneath so that all possible weight would be removed. The high voltage was supplied from ten minimax batteries. Each impulse was transmitted on a frequency of 19.7 megacycles by means of an 11 meter antenna which formed part of the cable holding the balloons to a mobile pulley on the ground. The counter pulse modulated a national HRO receiver which detected the carrier; the detected pulses were recorded on a Hallicrafters Model 5A Higenbothem Scaler.

The counting rate meters spotted around the area were General Radio Units feeding into Esterline-Angus Recorders

They operated a glass GM counter with a 30 mg/cm^2 wall and a cathode 3/4" in diameter by 3" long. The counters were fastened to the outer walls of buildings at minimum heights of 5' above the ground. In every case, these counters were surrounded by a heavy wire screen to protect from damage.

The constant air monitors were GM tubes, of the same type as was used for the counting rate meters, surrounded by an annular CWS type 6 filter paper through which air was pulled by a Motcaire pump at a rate of 1.5 - 2.0 CFM. These tubes record readings on a Leeds and Northrup Recorder through a counting rate meter. The filterable activity is then evaluated by noting the increase in counting rate over a given period of time. These readings are subject to fluctuation in the natural radioactive materials in the air and care is needed to insure that only increases in counting rates due to the materials with longer half-lives are read.

Fixed scrubbers containing a 0.5N NaOH and 0.1N Na_2CO_3 were improvised from four liter filter flasks. About one liter of the scrubber solution was placed in the flask and a piece of saran tubing inserted through a rubber stopper so that it lay coiled in the solution. Air volumes of 1.5 to 2 cfm were pulled through the saran tubing and out the suction nozzle on the flask by a Motcaire pump. This gives a satisfactory unit for temporary use with an efficiency of about 50%.

Small scrubbers to be used with a hand pump for spot samples of one cubic foot consisted of a test tube 20 cm long and 2 cm in diameter with a two hole rubber stopper. One hole in the stopper held a straight piece of glass tubing leading to the bottom while the other had a right angle piece terminating just under the stopper. A wad of glass wool about 2 cm long was placed half-way up the test tube.

These were operated by placing 20 ml of a 0.05N NaOH-0.1N Na_2CO_3 solution in the tube, and pulling 30 liters of air slowly through the solution. The glass wool broke up entrainment and allowed intimate contact between the air and the solution. An estimate of 50% efficiency was made by calibrations during the run.

C. Laboratory

A large number of scrubber and vegetation samples were analyzed after the run.

Scrubber solutions were analyzed by neutralization of the caustic with nitric acid followed by a precipitation with silver iodide and filtration through a 1-1/2" ashless filter paper. The filter paper was counted on the first shelf of a mica window counter (23% geometry) and corrections applied for backscatter, absorption in the counter window, and sample size.[8] Spiked samples accompanying the analyses averaged 50% yield.

Vegetation samples were analyzed only for I-131 according to the procedure developed by Leboeuf.[9] In every case five gram samples were used. The results were calculated to uc/kg of vegetation by use of the overall yield values obtained by running spiked samples.

Considerable difficulty was encountered with these analyses due to the presence of large quantities of I-131 in the laboratory following the run. Scrubber samples were taken in the laboratory at various times with the results presented in Table 2.

Table 2

SCRUBBERS FROM LABORATORY			
Date	Time	Air Conc. uc/l x 10^9	Remarks
12/5	1530	79	
	1630	36.	Air cooler off
	2130	57	Air cooler off
	2230	78	Air cooler off
12/6	0900	7	Air cooler off
	1400	38	Screens cleaned-Air cooler on
12/7	morning	46	Air cooler on
12/8	1400	24	Air cooler on
12/9	0930	30	Air cooler on
	1330	5	Water in air cooler cleaned
	2330	19	

It is believed that most of this contamination originated in the air supply system which passes the air through wet pads with the water recirculated. A sample f the water from this unit on 12/5 gave 0.38 uc/l.

As a result of this contamination, the blank vegetation samples gave positive results for several weeks following the run. The activity found in such blank samples is given in Figure 15 which is a plot of the average of all samples run on a shift versus the time run.

IV. Meteorology

A. General Conditions

On December 2, a cold front oriented in a northwest-southeast direction passed the HW Meteorology Station at 0500. Although there was considerable cloudiness with shower activity prior to this time, skies cleared immediately afterward. Southwest winds at moderate to strong speeds began sometime prior to the frontal passage and continued afterward. The weather outlook on the morning of the 2nd, however, was for substantially reduced wind speeds after sunset. The current fair weather was expected to continue, and it was anticipated that an inversion would form early that evening. Thus it was decided to go ahead with plans (Section II) to begin the run that evening.

At Hanford Works and at all neighboring stations from which reports are received via CAA weather broadcasts over the radio, weather conditions were ideal during the entire period of the run. Skies were clear for the most part, and no stations reported any precipitation or fog. Only at Spokane was there any appreciable amount of cloudiness. Here the sky was broken to overcast most of the period, with a ceiling of about 5000 feet. All other nearby reporting stations had either clear skies or high thin scattered clouds and unlimited ceilings and visibilities. Spokane was also the only nearby reporting station with any appreciable wind speed during the time of the run. Here the wind averaged about 15 mph from the SW until 0200, after which time the speed declined to less than 10 mph. Walla Walla reported SSE 13 mph at 2030, but all subsequent reports were of winds of less than 10 mph. Ellensburg had the lightest wind of any reporting station during the time of the run, and this station also had the lowest temperature, 21 degrees being reported both at 0630 and 0730. The average of Ellensburg's 14 hourly wind reports from 1930 to 0830 incl. was only 3.3 mph. No reported speed exceeded 7 mph and calm was reported on five different occasions.

The weather maps for the period show a cold front passing through Helena and north of San Francisco at 1030 on the 2nd, (Figure 16) This is the same front which passed Hanford Works at 0500. A steep pressure gradient on the 1030 map accounts for the strong winds at HW at the time. The 2230 map of the 2nd (Figure 17) shows a further advance southeastward of the cold front. The steep pressure gradient which was affecting Hanford at 1030 had by now passed eastward resulting in light winds.

The map of the 3rd (Figure 18) shows the entire Inland Empire to be under the influence of a high pressure cell, although a new storm front off the coast has brought rain to the western and northern portions of Washington by 2230. Because of the flat pressure gradient on the 3rd, winds in the Pacific Northwest had quite a variable pattern. Hanford, Yakima, Ephrata, and Pendleton had mostly west to northwest flow. Walla Walla and The Dalles, on the other hand, had mostly east to southeast flow.

The maps of the 4th (Figures 19 and 20) show the new storm front advancing eastward with a warm-front type occlusion shown passing east of Vancouver, B.C. and west of Lakeview, Oregon. Winds on the 4th were NW all day at the HW Meteorology Station, and were mostly W to NW again at Ephrata, Yakima, and Pendleton. Lewiston, Walla Walla, Meacham, La Grande, and The Dalles all had mostly E to SE winds on the 4th, while Spokane had NE winds on this day.

The 700 millibar constant pressure chart at 0700 on the 3rd (Figure 21) shows that the cold front, which passed HW 26 hours earlier, was now linked with a warm front approaching HW from the SW. The resultant warm air advection brought increasing high cloudiness to HW during the day. The chart at 0700 on the 4th (Figure 22) shows warm air advection over all of Washington, Oregon, and Idaho. This brought light rain to large portions of Washington and Oregon before 2230. Hanford lay just outside of the precipitation belt at 2400 on the 4th, but light rain began falling at the Meteorology Station at 0150 on the 5th and continued until 0510, leaving 0.05 inch of precipitation.

In the 24 hour period ending at 2230 on the 2nd, the precipitation area

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covered all of Washington and a large section of Oregon. Amounts, however, were light. This precipitation was all associated with the cold front which passed the HW Meteorology Station at 0500. Precipitation amounted to only a trace at this station.

During the 24 hours ending at 2230 PST on the 3rd, precipitation in the Pacific Northwest was confined to the western and northern positions of Washington. Amounts, however, were negligible, as skies were mostly clear after the frontal passage on the previous day.

During the 24 hours ending at 2230 PST on the 4th, the new front advancing from the Pacific brought precipitation to nearly all of Washington and to more than half of Oregon. Amounts were mostly light, although Tatoosh Island reported 0.54 inch. The HW Meteorology Station had no precipitation up to 2230, but received 0.05 inch of rain during the early morning hours of the 5th as the storm spread eastward.

B. Temperatures

The air temperatures 3' from the ground as measured with an electrical resistance thermometer at the 622 Building are given for the period of the run in Figure 23. After a high of 54°F at 1250 on 12/2, the temperature started a downward trend until a low of 24°F was reached at 0750 on 12/3. This was the lowest temperature recorded at the station since October 20. Figure 24 shows the observed instantaneous temperature differences between the three foot level and three of the tower levels from noon on 12/2 until noon 12/3. This graph shows that an inversion formed promptly near the time of sunset on the 2nd, and lasted until more than an hour after sunrise the next morning.

Table 3

Dilution Factors

Time	Dilution Factor
2030-2100	1400
2100-2130	1600
2130-2200	1700
2200-2230	1700
2230-2300	1600
2300-end	aloft

The term "dilution factor" was used by Dr. P. E. Church to describe the minimum dilution of gases that would occur before they strike the ground under the existing meteorological conditions.(10) An "aloft" condition indicates that the gases will not reach the ground within a radius of 5-10 miles. These factors were measured by Dr. Church with a smoke generator and light absorption apparatus and correlated empirically with the meteorological conditions.

The surface temperatures and instantaneous differences between the surface and tower temperatures are given in Figures 25 and 26 for December 3 and 4. All measurements were made at the 622 Building.

C. Winds

The surface winds from 14 stations in the Pacific Northwest are summarized in Figures 27-31 inclusive. These charts illustrate the generally low wind speeds prevalent during the 3rd with gradual increases during the 4th. The winds early on the 3rd were characterized throughout the region by their inconsistency as to direction. This would be expected with the low speeds encountered.

Also given in Figure 32 are the wind velocities recorded at the Meteorology Tower for the 100' level, 200' level and 400' level. Resultant winds at HW and at nearby stations from which data are available for the period covered by the run, are given in Table 4. At HW, the figures are based on data taken with regard to the continuous traces on the wind recorder tapes from 2000 until 0800. At other stations the figures are based on the instantaneous velocities reported at hourly intervals from 1930 to 0830 incl.

Table 4

RESULTANT SURFACE WINDS			
Station	Azimith of Resultant Wind	Resultant # Miles Gone By	Ave. Speed of Resultant Wind (mph)
HW - 7' Level	285°	15	1.2
HW - 50' Level	279°	32	2.7
HW - 200' Level	278°	61	5.1
HW - 400' Level	277°	81	6.8
Yakima	254°	18	1.5
Spokane	253°	116	9.7
Walla Walla	148°	84	7.0
Pendleton	133°	47	3.9
The Dalles	141°	13	1.1
Ellensburg	330°	16	1.3

A series of pilot balloon readings made by the U.S. Weather Bureau were obtained for the country for the period from 12/2 to 12/4 1949. The data abstracted from the maps submitted for stations in the Northwest are presented in Table 5. The speeds are recorded in knots as is customary in such maps. To convert to miles per hour multiply by 1.15; to convert to kilometers per hour multiply by 1.85.

Table 5
WEATHER BUREAU - WINDS ALOFT
knots

Time	2000' Above Surface	2000' Above M.S.L.	4000' Above M.S.L.	6000' Above M.S.L.	8000' Above M.S.L.	10,000' Above M.S.L
Spokane						
1400-12/2	SW-38	SW-38	WSW-38	W-42	W-36	-
2000	W-30	-	W-30	WNW-28	NW-20	WNW--
0200-12/3	W-20	NE-6	W-20	W-17	NW-7	-
0800	E-3	-	E-3	SE--	NW-3	N-9
1400	SE-9	-	SE-9	SSW-7	SSE-9	S-17
2000	ENE-16	-	E-6	N-14	SW-18	SW-21
0200-12/4	ESE-72	-	ESE-12	N-13	SW-20	WSW-24
0800	ESE-19	-	ESE-17	N-14	WSW-20	WSW-29
Pendleton						
1400-12/2	W-29	W-26	W-31	NSW-26	NSW-23	W-25
2000	W-24	W-17	W-22	WSW-18	W-14	WNW-20
0200-12/3	SW-10	SW-6	W-13	W-17	W-12	W-19
0800	S-5	S-5	clm.	SSW-7	SW-7	N-8
1400	ESE-4	ESE-6	SSE-6	SSW-10	SSW-14	WSW-18
2000	SSE-14	S-9	S-12	SSW-17	SW-22	W-25
0200-12/4	-	-	S-10	SSW-17	SW-22	WSW-28
0800	SE-7	S-5	S-9	SSW-20	SSW-17	SSW-18
Lewiston						
1400-12/2	SW-21	WNW-18	W-23	W-24	W-30	W-29
2000	-	-	-	-	-	-
0200-12/3	W-19	-	WSW-11	-	-	-
0800	SE-4	NE-4	SSE-5	SSW-3	W-4	SW-8
1400	E-15	ENE-13	E-14	SE-11	S-8	SSW-13
2000	-	-	-	-	-	-
0200-12/4	NE-2	ENE-2	-	-	-	SW-24
0800-12/4	SSE-17	SE-14	S-19	SSE-22	SW-22	WSW-21
Portland						
1400-12/2	W-14	W-14	W-14	-	WNW-11	-
2000	NNW-18	NW-18	WSW-17	-	-	-
0200-12/3	-	-	-	-	-	-
0800-	Fog	-	-	-	-	-
1400	ESE-22	SE-22	SSE-18	S-21	SW-25	WSW-27
2000	SE-12	SE-12	SSW-19	SSW-27	SW-18	-
0200-12/4	SE-16	SE-16	SSW-23	SSW-23	SW-38	SW-40
0800	E-27	E-27	S-21	SSW-27	SSW-30	SW-33
Ellensburg						
1400-12/2	WNW-20	WNW-20	W-20	WNW-28	WNW-33	WNW-40
2000	WNW-8	NNW-8	W-4	WNW-72	WNW-29	W-32
0200-12/3	SE-4	NNE-5	WNW-16	WNW-14	NNW-19	NW-22
0800	E-2	NW-4	E-5	SE-10	ESE-12	E-15
1400	ESE-6	SE-8	ESE-8	SE-14	SSE-18	S-22
2000	NNE-11	SE-4	E-12	SSE-15	SW-18	WSW-34
0200-12/4	NW-2	NW-2	E-9	SSE-16	SW-25	SW-27
0800	clm	clm	E + 10	SSE-16	S-24	SW-23

Special pilot balloon runs were also made by the Air Force at Moses Lake, Washtucna, and Richland and by the HW Meteorology Group at the 622 Building. The wind velocities as measured by these groups are given in Table 6. The direction in this table is given in degrees of azimuth followed by the wind speed in knots.

Table 6

METEOROLOGICAL GROUP MEASUREMENTS OF WINDS ALOFT

units (degrees of azimuth - knots

Time	Height Above MSL							
	1000	2000	3000	4000	5000	6000	8000	10,000
622 Building								
1900-12/2	220-5	250-17	250-17	250-17	210-18	250-13	-	-
2300	290-11	260-21	260-21	280-13	280-11	280-13	-	-
0100-12/3	250-3	290-10	290-9	300-12	330-6	30-4	-	-
0400	40-2	310-6	320-7	20-10	30-11	40-10	-	-
0700	90-2	340-3	100-5	110-5	130-6	150-7	-	-
1100	310-1	60-5	70-7	120-8	120-10	110-10	160-10	-
1300	340-5	360-4	50-6	120-5	140-10	140-11	170-13	190-16
1900	340-16	310-10	360-10	70-9	-	-	-	-
0100-12/4	340-14	330-6	330-7	90-6	190-12	180-11	-	-
0700-12/4	340-14	340-10	340-10	50-6	140-14	160-15	200-23	220-23
1300-12/4	360-4	340-5	330-9	80-10	150-15	180-21	200-34	210-42
1900-12/4	310-16	350-7	330-8	60-11	-	-	-	-
Moses Lake								
1900-12/2	270-11	270-19	270-17	270-17	270-16	270-15	270-19	270-21
0100-12/3	230-4	280-11	290-12	310-14	330-15	330-15	330-14	310-16
0400	clm	10-10	20-9	20-8	20-7	360-7	330-6	350-13
0700	clm	30-7	40-7	60-6	90-3	190-3	60-3	70-17
1300	90-8	120-5	140-7	150-9	150-11	150-13	170-19	170-19
1900	360-7	90-14	100-12	130-9	160-8	190-11	250-25	270-6
0700-12/4	360-11	90-8	130-8	160-11	180-15	200-18	220-23	220-27
1300	40-12	70-10	110-10	160-13	180-16	180-20	190-34	200-39
1900	360-12	90-13	120-15	150-19	170-21	180-21	220-27	220-23
Washtucna								
1900-12/2	260-23	250-20	260-20	260-21	270-20	290-15	290-20	300-12
0100-12/3	260-20	230-19	240-13	290-17	300-27	280-29	260-22	260-34
0700	clm	220-5	-	-	-	-	-	-
1300	90-11	100-6	130-13	90-12	120-15	120-15	140-12	180-21
1900	100-20	110-25	110-22	130-15	130-17	120-19	-	-
1300-12/3	90-6	80-6	90-4	120-20	200-30	210-24	220-34	200-41
1900	90-7	100-10	90-14	140-19	-	-	-	-
Richland								
2000-12/2	250-14	260-15	260-10	260-8				
0100-12/3	250-5	350-3	310-4	300-3				
1300	10-7	40-8	70-7	110-9				
1900	360-12	60-3	160-7					
0100-12/4	80-7	30-6	100-4	180-7				
1300	340-7	20-6	70-8	130-10				
1900	50-9	30-10	150-4	160-13				

A summary of the wind data from several locations is given in the wind maps of Figures 33 and 34. A series of four arrows is given for each location with the top arrow representing the wind at the surface and the three arrows below, the wind at 2000', 4000' and 6000' respectively above mean sea level. These readings are ones taken in the period indicated and may or may not be representative of the entire period.

These maps indicate the westerly and southerly winds encountered at the start of the period. Between 2200 on 12/3 and 0200 on 12/3 there is a slight shift at some locations, particularly in the higher altitudes, to a northerly component. This component is quite evident in the readings from 0200-0600. After 0600 on 12/3 the winds shifted to a definite easterly direction with a strong northerly component near Richland.

D. <u>Stability</u>

The atmospheric stability during, and immediately following, the time of the run is shown graphically in Figures 35 and 36. Here, temperature in degrees Fahrenheit is plotted against height in feet above mean sea level. The data are taken from special radiosonde observations made at Richland on December 2-4, incl.

Figures 35 and 36 are from data taken during the actual course of the run. During this time it is readily seen that the air was conditionally unstable above the normal shallow surface inversion occurring at night.

V. Evolution Measurements

A. Sampling

The sampling line from the 50 foot level of the stack to the 292-T Building was used to obtain samples of the stack gases. A Motoaire pump pulled a stream of about 0.5 cfm of gases into the building, past a sampling port, and waste gases was expelled through a scrubber containing a solution of sodium hydroxide to the small disposal stack on the roof of the 292-T Building. Samples of the gas were taken approximately every 15 minutes in evacuated, one liter boiling flasks that contained 10 ml of a 0.5N NaOH - 0.5N Na_2CO_3 solution. While sampling, the stop-cock leading to the stack gas line was barely cracked so that the gas flowed in over a period of 30-60 seconds. The estimated holdup time in the line from the stack to the sampling port was 5-10 minutes.

This sampling line had been used in the past to obtain 24 hour samples of the stack gases employing a small scrubber and filter to obtain I-131 and particulate activities separately. The results were consistent with calculated amounts expelled assuming 90% efficiency of the scrubber on the dissolver.

B. Xe^{133}

The one liter samples of gas were shaken well and allowed to stand for several days to remove the I-131 from the air. The flask was connected to an evacuated one liter ionization chamber[11] and the gas allowed to divide between the two units. The ionization chamber was then bled carefully to atmospheric pressure with air and the ionization current measured with a vibrating reed electrometer. The readings were expressed as curies by the following correction factor:

Assumptions:

(1). Average specific ionization of beta particles is 120 ip/cm.

(2). Average path length in the chamber is six centimeters.

(3). Ionization from gamma radiation is negligible.

$$\frac{120 \times 6 \times 3.7 \times 10^4}{6.281 \times 10^{18}} = 4.25 \times 10^{-12} \text{ amperes/uc}$$

The results of this sampling are given in Figure 37 which is a plot of the concentration in uc/liter versus time. An integration of this curve over the entire sampling period assuming an air flow up the stack of 25,000 cfm gives a value of approximately 20,000 curies which is higher than the calculated estimate by a factor of about three. This discrepancy may be due to uncertainties in the calculation given above, in the air flow up the stack, and possibly in the assumption of 30% increase in the amount of fission products in the outer layers of the slug. The shape of the curve and the consistency of the points indicate adequate sampling and measuring techniques.

Decay curves were run on two of these samples by reading the chambers at intervals on the vibrating reed electrometer. These curves are given in Figure 38. The early part of the decay checks the 5.4 day half-life of Xe^{133} very closely. The tailing off after a factor of 100 decay is believed to be due to the presence of Kr^{85}.

C. I-131

The $NaOH-Na_2CO_3$ solution left in the sampling flask after the removal of the Xe-133 was sampled and analyzed for the I-131 content. Original expectations indicated that about 10 λ of this solution would suffice to give about 1000 c/m on the first shelf of a mica window counter. Analysis of this quantity by precipitation of silver iodide, however, indicated that the concentrations were lower than expected by a factor of 100. Analysis of the entire sample in each case gave the results presented in Figure 39. The inconsistencies in the points after 0300 started in the samples on which it was necessary to use sampling flasks with rubber stoppers due to the failure of a shipment of glassware promised for two weeks earlier to arrive. Attempts were made to analyze the stoppers so that this value could be added, with some slight gain in consistency.

Two things were puzzling about this curve; the total activity up the stack upon integration yielded only 58.8 curies, a value only 1% of that expected; and the high concentration remaining at 0800 on the morning of 12/3, presumably the tail of the dissolving. An investigation of the sampling system yielded 2700 ml of condensate from the sampling line. An analysis of this material corrected for the volume of air up the stack during the run gave a value of 7780 curies which is high by a factor of two over that expected, but still closer to the proper order of magnitude than that obtained in the scrubbers.

Because of the amazing efficiency of this scrubber action, a chemical analysis of the condensate was made with the results given in Table 7.

Table 7

ANALYSIS OF CONDENSATE	
H+	0.39 N
Ag group	Not detectable
Cu, As group	Not detectable
Fe, Zinc group	19 mg Fe/25 ml condensate No Al or An group
Alkaline Earths	Not detectable
Na	None (Flame Test)

D. Miscellaneous

A test of a proposed monitoring system for xenon was made by pulling one liter of air through 30 ml of olive oil, and later sweeping the gases into a one liter ionization chamber with argon for measurement on the vibrating reed electrometer. Two such units indicated that about 17% of the xenon was dissolved which, assuming saturation of the olive oil by the one liter of air, would give a solubility of 5.7 uc/l of xenon per uc/l of air. This would indicate that using one liter of olive oil with a detectable current above background of 10^{-15} amperes, it should be possible to detect about 4×10^{-3} uc/l of xenon in the air. The combination of the olive oil with an internal proportional counter should give possibilities of measuring even lower concentrations.

Attempts to measure the oxidation state of the I-131 in the gases failed because of the low activity obtained. An analysis of the condensate from the sampling line gave approx. 48% of the iodine as I_2, 50% as I^- and 10% as IO_3^- or higher oxidation states. This spectrum was undoubtedly distorted since most of the gaseous nitrogen oxides are good reducing agents.

The small scrubbers used in the field for I-131 measurement were tested by pulling one liter of air through three of them and analyzing the sodium carbonate solution. A value of about 46% efficiency was obtained.

, Surface Atmospheric Readings

A. Field Crews Near Stack

Two groups were operating near the stack with four-wheel drive equipment and assignments to make measurements in the most likely locality. One group was to use the transmitting Geiger Counter supported above the ground by meteorological balloons to obtain traverses of the cloud at approximately the axis. The receiver was operated from a mobile generator. This unit was in the field in line with the gases from the stack at 2030 on 12-2-49. The wind velocity during this period was about 15 mph which caused considerable drag on the balloons, and although there was nearly 400 yards of nylon cord attached to the balloon, the maximum height reached by the balloon was 75-100 feet. Only three readings were made with this unit, when the cord apparently frayed at the point that it crossed the guide from the winch and broke at approximately 2230. The unit was later found near Pleasant View, Washington a point about 55 miles away and 5° south of east from the T plant stack.

Three readings taken on the equipment are given in Table 8.

Table 8

Balloon Readings

Location	Time	c/m
Background	-	60
1000' N - 200 W Gate House	2140	1410
175' N - 200 W Gate House	2200	2350
100' N - 200 W Gate House	2215	3340

After loss of the balloon, this group joined in making readings with the second crew.

The second field crew was assigned to locating the point of maximum deposition and making measurements and traverses. Immediate readings were made with portable GM counters held in the air; one cubic foot samples were also taken with small scrubbers designed to obtain the I-131 content. Considerable difficulty was encountered after about 2300 on 12/2 with shifting winds which made the location of any single spot to run the traverses extremely difficult. Again the point at which the maximum activity occurred appeared to considerably closer to the base of the stack than was expected. Inadequate testing of the equipment used for sampling was indicated when certain of the hand pumps used for pulling the samples failed.

The readings obtained by this group in the field are given in Table 9.

Table 9
FIELD READINGS

Time	Location	Readings VGM c/m	Readings Scrubber uc/l	Remarks
2110	1000 yds. N 200 W Gate	750-1000	-	
2135	1000 yds. N 200 W Gate	3000	-	Very narrow band of activity - approx. 20 paces
2135	Route 3 mi. 1 & 2	500	-	
2140	1000 yds. N 200 W Gate	-	1.8×10^{-4}	
2150	Route 3 mi. 1	-	1.9×10^{-5}	At estimated edge cloud
2206	Route 3 mi. 3	3000	-	
2220	Route 4S mi. 1	1000	-	
2224	3000 yds N. 200 W Gate	1200	-	
2230	1/4 mi. W of Met. Twr.	3000	2.3×10^{-5}	
2235	Route 4S mi. 1	1000	4.9×10^{-6}	
2300	Route 4S mi. 3	1000	4.8×10^{-6}	
2307	200 W Gate	1500	-	
2310	1/4 mi. SW of Met. Twr.	-	1.3×10^{-5}	
2321	100-F Area	125	-	
2334	Route 4S mi. 5	1000	-	Inst. Contaminated
2335	Route 3 mi. 3	2500	-	
2338	Route 4S mi. 7	1500	-	Inst. Contaminated
2340	Route 4S mi. 3	2500	-	Inst. Contaminated
2342	Route 4S mi. 9	800	-	Inst. Contaminated
2345	Route 4S mi. 9	1000	-	Inst. Contaminated
2350	Route 4S mi. 3	700	-	Inst. Contaminated
2354	Route 4S mi. 15	800	-	Inst. Contaminated
12-3-49				
0022	Route 4S mi. 5	160	-	
0029	Route 4S mi. 7	60	-	
0035	Route 4S mi. 9	80	-	
0040	Route 4S mi. 11	60	-	
0045	Route 10 mi. 1	40	-	
0050	Route 10 mi. 3	20	-	
0054	Route 10 mi. 4	20	-	
0055	Route 10 mi. 5	20	-	
0108	Route 3 mi. 1	500	-	
0115	Route 3 mi. 0	2000	-	
0155	200 W Gate	7400	-	Instrument later shown to have background of 2000 c/m
0155	Route 11A mi. 10	300		
0202	Route 11A mi. 13	300		
0217	200 East Area	1500-2000		General Readings in area
0255	200 W Gate	2000	2.3×10^{-5}	
0300	1/2 mi. S. Met. Twr.	3000	1.2×10^{-4}	
0305	Administration Bldg, 200 West Area	1500	6.1×10^{-5}	-

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Table 9 (Continued)

Time	Location	Readings VGM c/m	Scrubber uc/l	Remarks
0310	Near Power House Bldg. in 200 West Area	1500	7.7×10^{-5}	
0315	100 yd. N. 200 W Gate	2200	1.5×10^{-4}	
0400	200 yd. N. 200 W Gate	3000	1.1×10^{-4}	
0405	300 yd. N. 200 W Gate	-	8.6×10^{-5}	
0405	400 yd. N. 200 W Gate	-	1.6×10^{-4}	
0512	Route 11A mi. 3	-	6.0×10^{-6}	
0520	Route 11A mi. 1	-	4.8×10^{-6}	
0535	Route 3 mi. 1	500		
0545	1/2 mi. S. Route 11A, Mile 9	600	3.4×10^{-5}	
0620	Met. Twr.	600	1.7×10^{-5}	
0620	S. Corner 200 W	-	5.6×10^{-6}	
0626	200 y S Met. Twr.	600	1.3×10^{-5}	
0634	Route 4S mi. 22	60	-	
0640	200 yd. W. Twr. #4	-	5.9×10^{-6}	
0640	SW corner 200 W	200	2.3×10^{-5}	
0641	500 yds. S. Met. Twr.	600	-	
0643	50 y E. Stack	3700	-	Eltronics GM
		4000	-	Victoreen GM
0650	1-1/2 mi. S 200 W	1100	2.1×10^{-5}	
0655	Route 3 mi. 3	400	5.0×10^{-5}	
0700	1-1/2 mi. SE 200 W	700	1.8×10^{-5}	
0710	2 mi. S Route 3 mi. 3	1000	8.8×10^{-6}	
0715	200 yd. E 231	-	6.2×10^{-6}	
0715	Route 3 mi. 3	400	3.7×10^{-5}	
0725	Route 3 mi. 3	500	6.9×10^{-6}	
0735	200 yd. SE stack	-	4.4×10^{-6}	
0740	100 yd SE stack	-	4.6×10^{-6}	
0745	200 yd SW stack	-	4.6×10^{-6}	
0745	1 mi. SE 200 W Gate	650	1.4×10^{-5}	
0745	1/2 mi. S.W. Gate	1000	1.6×10^{-5}	

As is apparent from the data above, considerable difficulty was encountered with contaminated instruments after about midnight.

Immediately one man was sent down Route 4S to Richland. He reported readings of 1000-1500 c/m on a portable Geiger Counter all the way in, but a later check indicated about that much contamination on his instrument. Follow-up surveys between 0000 and 0600 gave background readings in this region.

The sensitivity of the analysis of these scrubbers is estimated at 3 to The laboratory.

4 x 10^{-6} uc/l due to the contaminated conditions of the laboratory.

A series of readings were taken by the Survey Group of the Operational Division A series of readings were taken by the Survey Group of the Operational Division in a lead pig.

by the use of filter papers later counted on a 30 mg/cm^2 GM tube in a lead pig. These data corrected, for an estimated 10% retention on the filter paper, are given in Table 10.

Table 10

FIELD FILTER SAMPLES

Time Sample Removed	Location	Estimated Conc. uc/l
2400	Roof 271B	2.4×10^{-5}
2400	In operating Gallery - 271B	2.6×10^{-6}
0035	In 221 B	2.8×10^{-6}
0045	In canyon - 271B	2.3×10^{-6}
0050	In 222B	4.5×10^{-6}
0055	In 224	3.3×10^{-6}
0305	Operating Gallery - 271B	3.8×10^{-6}
0315	271B Roof	8.3×10^{-5}
0315	224B Operating Gallery	3.1×10^{-6}
0315	222B Hall	2.4×10^{-6}
0320	Roof 2243	5.5×10^{-5}
0500	221 B Bldg.	3.2×10^{-6}
0505	224 B Bldg.	3.6×10^{-6}
0505	222-B Bldg.	3.6×10^{-6}

A series of thyroid counts on 12/5 on the men operating close to the stack gave no values greater than 7 c/m above background. This value is not significantly greater than the background. Several measurements on thyroids with portable counters at the time of the run were positive, but were later shown to be due to contamination on the clothing.

B. Detachable Chamber Measurements

A series of twelve detachable ionization chambers, designated as XB - 22's were located at mile intervals along routes 2S and 2N to a point several miles above Hanford. These chambers consists of a bakelite case 7" in diameter and 9" long with 7-1/16" long central electrode 1/4" in diameter. The electrode is insulated with polystyrene from the case which is made conducting by a coat of rubalt on the inner surfaces. About 50% of the area of the case has been removed by drilling one inch diameter holes and covering with 0.001" aluminum foil. The chambers are charged with a battery operated minometer and placed at the desired location for the period of time of interest, after which the loss of charge is read with a minometer. Tests have indicated that the 0.001" aluminum will absorb about 50% of the beta radiation from an I-131 source close to the chamber.

Readings were started on these chambers about 0700 on 12/2 and continued until 1000 on 12/3 with one long break between 0500 and 0900 due to difficulties with the automobile used. Some readings were also taken with portable GM counters and samples with the small caustic scrubbers used for estimation of I-131 in the air. These readings are presented in Table 11 as the average of neighboring locations.

Table 11
SPECIAL DETACHABLE CHAMBER READINGS

Time Read	2S Mi. 6&7 Chamber mrep*/hr.	2S Mi. 6&7 Scrubber uuc/1	2S Mi. 4 & 5 GM c/m	2S Mi. 4 & 5 Chamber mrep*/hr.	2S Mi. 4 & 5 Scrubber uuc/1	2S Mi. 2 & 3 GM c/m	2S Mi. 2 & 3 Chamber mrep*/hr.	2S Mi. 2 & 3 Scrubber uuc/1	2S Mi. 0 & 1 GM c/m	2S Mi. 0 & 1 Chamber mrep*/hr.	2S Mi. 0 & 1 Scrubber uuc/1	2S Mi. 1 & 2 GM c/m	2S Mi. 1 & 2 Chamber mrep*/hr.	2S Mi. 1 & 2 Scrubber uuc/1	2N Mi. 3 & 4 GM c/m	2N Mi. 3 & 4 Chamber mrep*/hr.	2N Mi. 3 & 4 Scrubber uuc/1	2N Mi. 3 & 4 GM c/m
1730-1800	-	-	60	0.019	-	-	0.022	-	-	0.010	-	-	-	-	-	-	-	-
1830-1900	0.023	-	-	0.012	-	-	0.035	-	-	0.014	-	45	0.006	-	-	0.008	-	-
1930-2000	0.010	-	45	0.010	-	-	0.020	-	-	0.003	-	-	0.009	-	-	0.015	-	-
2030-2100	0.022	-	-	0.017	-	-	0.019	-	-	0.005	-	-	0.005	-	-	0.005	-	-
2115-2145	0.032	3.33	-	0.017	-	-	0.016	-	-	0.007	-	60	0.007	-	-	-	-	-
2230-2300	0.023	-	170	0.022	-	125	0.023	-	-	0.013	-	45	0.017	-	-	0.052	-	45
2330-2400	0.038	-	-	-	-	-	0.035	-	150	0.018		175	0.014	-	150	0.026	-	-
0045-0145	-	-	-	-	-	-	0.017	3.15	160	0.013	6.68	110	0.008	3.10	110	0.013	2,63	110
0200-0300	0.014	2.74	85	0.022	2.40	100	0.018	-	120	-	-	-	-	-	130	0.017	2.35	140
0300-0500	-	5.99	85	0.026	-	85	0.027	2.46	-	0.027	2.98	130	0.020	-	160	0.019	-	140
0900-1000	0.016	-	-	0.030	-	-	0.028	-	-	0.026	-	-	0.024	-	-	0.029	-	-

*Readings were converted to mrep/hour by calibrating the chambers with radium gamma rays and considering the ionization in air for one rep to be equivalent to one roentgen.

The chamber readings fluctuate around the background expected. These chambers when leak tested for a 24-hour period averaged 0.026 mrep/hour with a standard deviation of 0.006. The large fluctuations noted in the table are due to reading a background drift rate over a short period with a consequent small total amount of discharge. It is of interest to note that the last values, those read at 0900-1000 on 12/3, were for a longer period and check the average for the leak tests very well.

The small scrubber samples for I-131 were all apparently positive, but most of this activity has been attributed to contamination in the laboratory which was close to the 200 W stack. An apparent limit of sensitivity for the analysis under the conditions was about 2-3 uuc/liter. On this basis only the sample from route 2S mile 0, 1 at 0100 and from route 2S, mile 6,7 at 0400 on 12/3 would be positive.

Readings made on the smaller detachable chambers used for routine monitoring of radiation levels at locations where no power is available indicated no response to the activities liberated since readings continued at about the same levels after the run as before. This would be expected for a short exposure of relatively low intensity on these units designed to integrate readings over a period of days or weeks.

A weapons carrier with a two KVA generator operated between Pasco and Connell, Washington from 0000 on 12/3 to 1200 on 12/3. Monitoring equipment included a Motoaire pump pulling 1.5 cfm of air through a caustic scrubber to monitor for I-131, a GM tube recording every 64th pulse through a scaler on a micromax recorder and portable Geiger Counters carried by the driver. The solution in the scrubber was changed at approximately one-half hour intervals while the unit traveled at an average speed of 20-30 mph.

Some difficulty was encountered with the pen not inking on the recorder, but the GM counter was allowed to run throughout the periods described below as the sampling times and the average counting rate noted. The results of the measure-

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ments by this group are given in Table 12.

Table 12
PASCO - CONNELL MEASUREMENTS

Sampling Time	Location	Scrubber Total uc	Scrubber Conc. uc/l	GM Probe c/m
0000-0100	22 mi. N Pasco	5.7×10^{-5}	2.4×10^{-8}	97
0100-0140	Connell	4.8×10^{-5}	3.9×10^{-8}	138
0140-0215	8 mi. S. Connell	3.2×10^{-5}	2.2×10^{-8}	149
0215-0310	21 mi S. Connell	2.9×10^{-5}	1.3×10^{-8}	156
0310-0340	Pasco	$- \times 10^{-5}$	$- \times 10^{-8}$	186
0340-0530	17 mi. N Pasco	4.2×10^{-5}	2.8×10^{-8}	139
0530-0615	1 mi. S. Connell	5.8×10^{-5}	3.2×10^{-8}	175
0615-0700	21 mi. S. Connell	2.6×10^{-5}	1.0×10^{-8}	132
0700-0730	21 mi. S. Connoll	2.4×10^{-5}	1.9×10^{-8}	174
0730-0800	Pasco	2.0×10^{-5}	1.6×10^{-8}	-
0845-0915	3 mi. N. Connell	6.9×10^{-5}	5.4×10^{-8}	124
0915-1000	Eltopia	4.5×10^{-5}	2.0×10^{-8}	126
1000-1030	32 mi. N. Pasco	3.4×10^{-5}	2.6×10^{-8}	-
1030-1100	7 mi. S. Connell	1.4×10^{-5}	1.1×10^{-8}	-
1100-1130	16 mi S. Connell	6.5×10^{-5}	4.2×10^{-8}	162
1130-1200	Pasco	2.0×10^{-5}	1.6×10^{-8}	156
1200-1400	Richland-North limits	39×10^{-5}	15.7×10^{-8}	168
1400-1430	4S mi. 13	53×10^{-5}	34.6×10^{-8}	218
1430-1500	200 E	21×10^{-5}	14.3×10^{-8}	227
1500-1520	200 E	21×10^{-5}	24.0×10^{-8}	135

The background of these scrubber analyses were high due to contamination of the laboratory. The limits of detection were probably on the order of 3×10^{-5} microcuries in the sample. Thus, most values up to noon were of dubious significance. The values obtained between noon and 1430 around Richland and the 300 Area are definitely quite positive. The scrubber results are also confirmed by the counter.

The counter results are difficult to explain since backgrounds at the 200 East Area on 12/2 were on the order of 32-46 c/m. The increase over this background noted from the first measurement at midnight may be due to faulty operation of the equipment with the vehicle in motion or could be due to the presence of Xe^{133} without I-131.

D. I-131 Scrubbers

A total of 28 of the larger air scrubbers were installed at key locations, usually where an air pump was already present. It was hoped that the activity would be blown away from the region at a fairly consistent rate and the integrated amount of iodine could be obtained by estimating a 10-20 hour deposition period. Most of these units were started with fresh solution between 1000 and 1500 on 12/2 and removed between 0400 and 1300 on 12/3 in an attempt to fractionate the pickup. The results from these units are given in Table 13.

Table 13
I-131 CONCENTRATIONS FROM SCRUBBERS

Location	Air Flow	Time Started on 12/2	Time Off on 12/3	Activity in Scrubber	Average Conc.	Time Off	Activity	Average Conc.
	cfm			uc	uc/l		uc	uc/l
222T	1.5	1445	1410	788 x 10^{-3}	1704 x 10^{-9}	12/7-1450	28 x 10^{-3}	150 x 10^{-9}
200 W Gate	1.5		0550	8.4 x 10^{-3}*	350 x 10^{-9}*	-	-	-
200 W Twr. 4	1.5	1430	0640	38 x 10^{-3}	900 x 10^{-9}	-	-	-
200 W Twr. 15	1.5	1425	0610	22 x 10^{-3}	840 x 10^{-9}	12/8-1400	30 x 10^{-3}	15 x 10^{-9}
231	4	1435	1420	95 x 10^{-3}	770 x 10^{-9}	-	-	-
U Plant	4	1400	1430	27 x 10^{-3}**	266 x 10^{-9}**	12/8-1045	16 x 10^{-3}	81 x 10^{-9}
2701 E	1.5	1300	0440	53 x 10^{-3}	2390 x 10^{-9}	12/8-1045	62 x 10^{-3}	110 x 10^{-9}
2704 E	4	1330	0420	171 x 10^{-3}*	3032 x 10^{-9}*	-	-	-
200 ESE	1.5	1200	0430	10 x 10^{-3}	450 x 10^{-9}	-	-	-
200 E Twr. 16	1.5	1310	1430	45 x 10^{-3}**	940 x 10^{-9}**	-	-	-
200 E Biology	1.5	1500	0945	5 x 10^{-3}**	34 x 10^{-9}**	12/8-1100	5.1 x 10^{-3}	9.7 x 10^{-9}
11A mile 2	4	1320	1330	2.3 x 10^{-3}	20 x 10^{-9}	12/7-1000	1.6 x 10^{-3}	26 x 10^{-9}
Gable Mtn.	1.5	1000	1020	3.6 x 10^{-3}**	925 x 10^{-9}**	-	-	-
Hanford	1.5	1010	0500	0.85 x 10^{-3}	37 x 10^{-9}	-	-	-
100 F	4	1030	1100	2.1 x 10^{-3}	20 x 10^{-9}	-	-	-
White Bluffs	1.5	1055	1115	0.3 x 10^{-3}**	7.8 x 10^{-9}**	12/7-1415	1.7 x 10^{-3}	9.2 x 10^{-9}
100 H	1.5	1100	1105	2.5 x 10^{-3}	65 x 10^{-9}	-	-	-
100 D	4	1115	1130	7.0 x 10^{-3}	66 x 10^{-9}	-	-	-
100 B	4	1130	1240	0.4 x 10^{-3}**	0.04 x 10^{-9}**	-	-	-
Riverland	1.5	-	1255	0.02 x 10^{-3}	0.56 x 10^{-9}	12/7-1235	1.5 x 10^{-3}	8.2 x 10^{-9}
300 Area	1.5	-	0945	0.05 x 10^{-3}	1.35 x 10^{-9}	-	-	-
N. Richland	1.5	0930	0925	0.01 x 10^{-3}*	0.35 x 10^{-9}	12/7-1310	6.2 x 10^{-3}	34 x 10^{-9}
Benton City	1.5	11/29-0930	0840	0.10 x 10^{-3}*	3.40 x 10^{-9}*	12/7-1110	0.69 x 10^{-3}	3.8 x 10^{-9}
Richland	1.5	11/29-1010	0910	0.03 x 10^{-3}	0.97 x 10^{-9}	12/7-1200	0.07 x 10^{-3}	0.25 x 10^{-9}
Pasco	-	-	-	-	-	12/7-1500	0.07 x 10^{-3}	0.25 x 10^{-9}
Spokane	-	-	-	-	-	12/7-1200	0.07 x 10^{-3}	0.25 x 10^{-9}
Boise	-	-	-	-	-	12/7-1700	0.01 x 10^{-3}	0.03 x 10^{-9}
Klamath Falls	-	-	-	-	-			

*Indicates that scrubber was dry when picked up and reading listed is consequently low.
**Motor was off when scrubber was picked indicating a collection over only part of the time.

The results were calculated to microcuries per liter assuming that the start of activity pickup was at 2000 on 12/2. An extreme amount of trouble occurred with the scrubber solution drying out and with pumps stopping during the time of the run. It has been impossible to duplicate the drying on either test runs or later actual operation.

The limit of sensitivity on the analysis of these solution was 0.43×10^{-3} uc for the first nine samples listed in the table and Hanford picked up on 12/3. The limit for the others was 0.08×10^{-3} uc. The results indicate that the major portion of the cloud passed over the 300 Area - Richland area after 0900 on 12/3 since the activity in the later scrubbers was considerably greater than the ones obtained during the run. The extremely high result at 222-T is completely unexpected since this location is only 300' from the base of the stack in a southerly direction.

Several of these scrubbers were preceded by CWS type 6 filter papers, routinely used to monitor for the aerosol type of activity usually composed of the longer-lived fission elements. These filters were collected on 12/7 and measured by counting on a mica window counter. The data from these filters, along with an estimate of the fraction of the total activity as measured by the sum of the scrubber and filter activity is given in Table 14. It would appear reasonable to assume that the bulk of the activity on the filter paper is I-131 since its concentration in the air was so high. The lack of proper operation with the motors and the mysterious drying of the scrubber solutions combined to make these estimates very unreliable and probably on the high side.

Table 14
FILTER ACTIVITIES

Location	Total Activity on filter uc	Total Activity in Scrubber uc x 10^{-3}	% Retained by filter
200 W Gate	4.6×10^{-3}*	36.4×10^{-3}*	11
200 W Twr. 4	7.1×10^{-3}*	38×10^{-3}*	+16
200 W Twr. 15	8.9×10^{-3}*	22×10^{-3}*	+29
200 ESE	0.04* x 10^{-3}*	10×10^{-3}*	-
Gable Mountain	0.32×10^{-3}*	5.2×10^{-3}*	6
300 Area	1.0×10^{-3}*	1.55×10^{-3}*	39
Benton City	2.4×10^{-3}*	6.3×10^{-3}*	+28
Pasco	0.04** x 10^{-3}*	0.07×10^{-3}*	+28

*Unit was later shown to have a leaky hose from the air pump.
**Motor was known not to be running on 12/2 and 12/3.
+Indicates that at least one of the two scrubbers was dry when picked up making this a maximum estimate.

Decay curves on these filter papers indicated that better than 90% of the activity deposited was I-131. These values are fairly consistent with previous estimates for type 6 paper of 10-20% retention when the errors in the collections are considered.

E. Fixed Instruments

(1). Constant Air Monitors

The four units in service were located at the 200 West Area Gate, in the middle of the south fence of the 200 W Area, in the northwest corner of the 200 West Area, and in Richland. In addition, a special unit using two mica window counters with 2" diameter filter papers arranged so that air was pulled alternately through each paper for three hours while the other unit recorded the decay of its paper was in operation in the 300 Area.

It was expected that these units would show some indication of the activity although the results would be by no means quantitative for I-131 since past experience indicates that only 10-20% of the iodine in the stack gases will deposit on the filter paper. The overall geometry of the four units has been measured in the past as 1.2%. The data from these instruments are given in Figure 40.

The three instruments in the 200 W area indicate a definite increase in readings shortly after midnight on the second. The instrument at Richland indicates a questionable increase at about 6:00 AM with a definite increase shortly after noon on the third. It is possible to estimate the activity causing these increases by noting the time required for the counting increase and assuming a 10% collection efficiency of the filter. This information plus the activity obtained by counting the filter paper on a mica window counter is given in Table 15.

Table 15

MAXIMUM AND AVERAGE CONCENTRATIONS FROM CONSTANT AIR MONITORS

Location	Activity from M. W. Counter	*Average Conc.	Time of Max. Increase-c/m	Activity Collected	Maximum Conc.
	uc	uc/l		uc	uc/l
Richland	7.4×10^{-4}	2.0×10^{-9}	0500-1100 12/3	5×10^{-4}	2×10^{-8}
200 W Gate	4.6×10^{-3}	2.1×10^{-8}	0000-0100 12/3	1×10^{-3}	4×10^{-7}
Twr. 15	8.9×10^{-3}	1.8×10^{-8}	1250-0130 12/3	$>5 \times 10^{-3}$	charts off scale
Twr. 4	7.2×10^{-3}	1.3×10^{-8}	0100-0115 12/3	$>4 \times 10^{-3}$	

*From noon 12/2 to 12/7/49.

The small increase at the 200 W Gate in comparison with the other locations is rather surprising since this is normally the "hottest spot" on the reservation. Decay curves on the filter papers after removal from the instrument indicated that the activity collected was all I-131. These decay curves were followed over a period of five half-lives.

A sample curve from the unit in 300 Area on which air was pulled through a filter paper for three hours and allowed to decay for three hours is given in Figure 41. The collection and decay of radon daughters is quite apparent. If the small activity due to ThB is ignored, the result after the three hour decay should be an indication of the amount of long-lived activity collected. Since this is an experimental unit, no accurate geometry values are available. Table 16 is a summation of the results from this counter after the three hour decay period. Counting rates were corrected to microcuries assuming 10% collection efficiency of the filter and 15% geometry.

Table 16
300 AREA CONSTANT AIR MONITOR

Collection Period	Unit	Counting Rate After 3 hour decay c/m	Activity Collected in Period c/m	Air Concentration uc/l
1800-2100, 12/2	1	30	-	-
2100-0000	2	40	-	-
0000-0300, 12/3	1	45	15	4.5×10^{-8}
0300-0600	2	60	20	6.0×10^{-8}
0600-0900	1	110	65	1.9×10^{-7}
0900-1200	2	260	200	6.0×10^{-7}
1200-1500	1	525	415	1.2×10^{-6}
1500-1800	2	370	110	3.3×10^{-7}
1800-2100	1	575	50	1.5×10^{-7}
2100-0000	2	410	40	1.2×10^{-7}
0000-0300 12/4	1	625	50	1.5×10^{-7}
0300-0600	2	470	60	1.8×10^{-7}
0600-0900	1	630	5	1.5×10^{-8}
0900-1200	2	440	-	-
1200-1500	1	690	60	1.8×10^{-7}
1500-1800	2	430	-	-
1800-2100	1	690	0	0
2100-0000	2	430	0	0
0000-0300 12/5	1	680	-	-
0300-0600	2	410	-	-

Decay curves on the filters followed the half-life of I-131 over one and one-half half-lives.

These data would indicate that the major portion of the cloud at the 300 Area passed between 0900 and 1800 on December 3. This confirms the reading from the Richland Constant Air Monitor.

(2). Counting Rate Meters

General Radio counting rate meters operating a small 30 mg/cm^2 GM tube mounted on the outside of the building were located at the 100-H Area, Riverland, 200 W Gate, Site Survey headquarters in the 200 E Area, Benton City, and Pasco. In general the operation of these units was poor with obvious failures in two of the units and possible zero shift in the others. The instruments were placed in operation on 12/2 because of difficulties in overhauling the circuits. The counting rates on these units as read at two hour intervals are given in Figure 42.

No significant increase is noted at 100-H, Riverland, or Pasco. Failure of the instrument at the 200 W Area about midnight on 12/2 makes this data very questionable. A definite increase in counting rate about 2030 on 12/2 coincides very well with the time of dissolving and the first detectable reading on the portable Geiger counters in the 200 W Area. Since this unit was located almost due east of the stack and the wind was from the west at this period, it is quite probable that the increase is real. An increase occurred at about 1000-1200 on 12/3 at Benton City. The time agrees very well with the results of the constant air monitors at 300 Area and Richland which indicates a strong probability that the reading may be real.

Normally one would expect a decrease in the reading from such a unit after the cloud had passed. The difficulties encountered with contamination of the portable GM's and the known tendency of I-131 to deposit strongly on surfaces, leads to the belief that the readings on these counters may be due as much to the I-131 absorbed on the counter and immediate environs as to the presence of an atmosphere of active materials. In this case the reading would be expected to remain at a high level and the calibrations made for a uniform I-131 atmosphere would not apply. Unfortunately it was necessary to remove these units on 12/5 and decay data were not obtained.

(3).

Samples were taken over six hour periods starting at 0200 on 12/2/49. Decay curves were measured on a glass gamma tube 2" in diameter and 20" long, by wrapping the paper around the tube and measuring a counting rate and background for five minutes each every hour.

Most of these samples decayed to background with the 10.6 hour half-life of Th1. Two samples, however, showed positive residual activity after decay of the Th1. These curves were analyzed by drawing an eight day half-life line through the longer-lived components and subtracting from the total curve. Since the residual activity decayed with a half-life of 11-12 hours, this was considered as confirmation that the longer component was I-131.

These results occurred in samples collected between 1400 and 2000 on 12/3/49 and 1400-2000 on 12/5/49. The sample preceding the positive one on 12/3 decayed with no sign of a longer half-life. The one following showed very slight signs deviating at the end but the activity was too low to measure accurately. Samples preceding and following the positive value on 12/5 showed very slight deviations from a straight decay towards the end. The two positive decay curves are given in Figures 43 and 44.

VII. AIRCRAFT MEASUREMENTS

A. Flight Plan

A briefing was held at 0615 3 December as to the latest weather and the forecast position of the maximum concentration of the radioactive cloud. The air-crew then proceeded to the Richland airport. After takeoff, the first check point, Richland airport, was crossed at 0654 3 December at an altitude of 1000 ft MSL.

The map in Figure 45 shows the track of the morning flight. Where repetition of certain legs occured, they were omitted on this map, but a complete log of this first, or morning survey, as well as the rest of the two-day operation is included in Table 17 at the end of this section.

Evidence of high concentrations of the radioactive cloud was found in the Davenport area and thorough investigation of the region was made with cross-section flights at different altitudes.

Finally, at 1645 3 December, the aircraft arrived over the Richland airport to conclude the first day's operation. No attempt was made to analyze data from this flight after landing although a brief critique was held. Plans were discussed for another attempt to intercept the cloud the next day.

Because of difficulty with the external counter, take-off on the 4th of December was considerably delayed. At 1139 hours, however, the aircraft was over Kiona, 10 miles west of Richland, and turned on a course to Yakima and the Ellensburg area, where the cloud was forecast to move under the influence of winds which had shifted from westerly to northeasterly.

The highest reading of the day was found on the Kiona-Yakima leg, with secondary peaks on the Yakima-Ellensburg, Ellensburg-Beverly, and Quincy-Mansfield logs. The flight worked on into Spokane before returning to Richland to conclude the operation.

B. Instruments

Figure 47 is a combined record of the data obtained from the conductivity apparatus, the NRL unit and the filter analyses for 3 December while Figure 48 gives the data from the same instruments for 4 December. The most practical purpose that these charts serve is to give correlation between activity levels, altitude, and time. Figures 49 and 50 present the data obtained from the instruments in terms of constant activity contours.

All readings shown have been corrected for background change with altitude by the values given in Figure 51. While the indicated flight altitude varied as shown in the log, essentially the picture obtained is for an average elevation of 1000 to 1500 ft. above the ground.

The best vertical cross-section could be obtained either with two aircraft working two altitudes simultaneously or by correlation of flight data from one altitude with that taken by ground survey teams. Since only one aircraft was used, the second method is the basis for the discussion which follows on flight data.

Several secondary peaks were recorded on the conductivity throughout the remainder of the flight as far as Odessa. By comparing the I-131 contamination overlay (Fig. 59) over Fig. 49, it will be noted that the red flight path very nearly encompasses the outer edge of the iodine deposition pattern and cuts the highest ground value from halfway from Richland to Kiona to a short distance northwest of Kiona, more or less in the same place that the conductivity and NRL gave their best response. While this leg is best explained, none of the other indications of activity with the exception of Beverly-Vantage, seem to fit the ground pattern. The most interesting thing about this flight is the fact that the cloud was detected south of the project, rather than to the north on the second day and agrees with the deposition pattern as it was actually recorded by ground measurements. Had this condition been realized at the time of the flight, the iodine may have been tracked to a fair distance in a southwesterly direction.

C. Airborne Filters

In a search to find a chemical agent which would improve the collection of iodine for the WS #5 filter paper, twenty-nine of the filters exposed were impregnated with either $AgNO_3$, $NaHSO_3$, or NaOH prior to exposure. Only two of the entire group exposed during the two-day operation showed activity with a half-life of greater than that of Thorium B. The half-life of the activity on both of these filters was approximately that of I-131. A decay curve on each of these papers is given in Figure 52. The activity on these filters was picked up on the second and third legs of the first day's operation, the same legs on which the NRL unit indicated the presence of gamma radiation. The NRL was the only instrument in the aircraft which would discriminately record only that type of radiation.

One of these two filters was treated with $NaHSO_3$ while the other was plain. The count recorded on the treated filter was greater than that on the plain paper (216 cpm to 170 cpm) but the exposure time was longer for the treated paper (15 min. to 9 min.). It appears, therefore, that the treated paper offered no advantage but a definite conclusion cannot be drawn from only two specimens.

Filters which were left in for the entire flight on each day showed nothing more than natural activity.

By extrapolation of the decay curves in Figure 52, values of 170 cpm and 216 cpm at 1200 3 December were found for Filters 3-4 and 5-6, respectively. An excerpt of the flight log below shows the exposure time for each filter.

Point No.	Position	Time	Altitude	
3	Connell	0709:55	1500	
4	Lind	0718:47	1800	9 minutes
5	Lind	0721:40	2500	
6	Riparia	0736:53	2500	15 minutes

For a flow of 450 cu ft/min through each filter, we have - :

For Filter 3-4 — Counter Geometry: 5%

$$\frac{170 \text{ cpm}}{450 \times 9} = 0.0414 \text{ c/m/cu ft}$$

$$0.0414 \times 20 = 0.818 \text{ d/m/cu ft}$$

or $\underline{1.33 \times 10^{-8}}$ uc/liter

And for Filter 5-6 — Counter Geometry: 5%

$$\frac{216 \text{ cpm}}{450 \times 15} = 0.032 \text{ cpm/cu ft}$$

$$0.032 \times 20 = 0.640 \text{ d/m/cu ft}$$

or $\underline{1.03 \times 10^{-8}}$ uc/liter

D. Scrubber Analysis

The airborne scrubber was in the line from take-off at Richland until arrival over Garfield at 0914 on 3 December or for a total of 140 minutes and scrubbed 11,200 cubic feet of air during that time. It was removed from the line because of the adverse effect it was having on the performance of the conductivity apparatus. The pressure drop across the caustic solution caused the airflow through the collecting tube of the conductivity unit to fall below design tolerance making interpolation necessary when analyzing the results.

Back in the laboratory, the scrubber solution was divided into two parts, the liquid evaporated, and the residue counted.

Results of the counting were:

		Part I	Part II
Counts per minute (Corrected to 1200 hrs 3 December)	-	162.9	220.2
Counter Geometry	-	9.75%	23.0%

For one-half the air-flow, the first half of the solution gives:

$$\frac{162 \text{ cpm} \times 10.25}{5600 \text{ cu ft}} = 0.296 \text{ d/m/cu ft}$$

or 4.76×10^{-9} uc/liter

The second half gives:

$$\frac{220.2 \times 4.35}{5600} = 0.171 \text{ d/m/cu ft}$$

or 2.73×10^{-9} uc/liter

Table 17

Flight Log for 3 December 1949

Point No.	Position	Time PST	Altitude MSL	Temp. °C
1	Richland	0654:30	1000	
2	Connell	0707:35	1000	
3	Connell	0709:55	1500	3.7
4	Lind	0718:47	1800	
5	Lind	0721:40	2500	3.5
6	Riparia	0736:53	2500	
7	Riparia	0740:23	3000	2.7
8	Lind	0754:05	3000	
9	Lind	0802:37	3000	2.7
10	Odessa	0812:03	3000	
11	Odessa	0815:02	3500	1.6
12	Ritzville	0823:16	3500	
13	Ritzville	0832:25	2500	3.5
14	Winona	0844:00	2500	
15	Winona	0847:40	3000	
16	Pullman	0900:25	3000	
17	Pullman	0904:40	3500	
18	Palouse	0909:02	3500	
19	Palouse	0911:26	4000	
20	Garfield	0914:33	4000	
21	Garfield	0917:15	4500	
22	Oaksdale	0920:45	4500	
23	Oaksdale	0924:25	5000	
24	Malden	0928:55	5000	
25	Malden	0935:17	4500	-1.6
26	Cheney	0941:25	4500	
27	Cheney	0944:20	4000	
28	Harrington	0956:25	4000	
29	Harrington	1004:56	4000	1.0
30	Roundhouse	1019:20	4000	

Flight Log for 3 December (cont.)

Point No.	Position	Time PST	Altitude MSL	Temp. °C
31	Roundhouse	1023:20	4000	
32	Spangle	1030:45	4000	
33	Spangle	1033:10	3500	
34	Rosalia	1039:30	3500	
35	Rosalia	1042:20	3500	
36	Cheney	1048:30	3500	
	Landed at Spokane AFB at 1102			
37	Spokane AFB	1236:50	3500	
38	Davenport	1246:55	3500	
39	Davenport	1247:25	3000	
40	Harrington	1251:40	3000	
41	Harrington	1253:25	3000	
42	Rodna	1303:05	3000	
43	Rodna	1305:43	3000	
44	Malden	1312:10	3000	
45	Malden	1315:25	3000	
46	Tekoa		3000	
47	Tekoa	1324:40	3500	
48	Cheney	1337:55	3500	
49	Cheney	1341:45	3500	
50	Davenport	1352:55	3500	
51	Davenport	1355:20	3500	
52	Wilbur	1404:25	3500	
53	Wilbur	1407:45	3500	
54	Dams	1426:00	3500	
55	Dams	1430:15	3500	
56	River Bend	1440:20	3500	
57	River Bend	1441:45	3500	
58	Dam Z-26	1458:10	3500	
59	Dam Z-26	1500:10	3500	
60	Davenport	1513:00	3500	
61	Rocklyn	1515:35	2500	
62	Reardan	1523:00	2500	

Flight Log for 3 December (cont.)

Point No.	Position	Time PST	Altitude MSL	Temp. °C
63	Reardan	1526:05	3000	
64	Rocklyn	1533:00	3000	
65	Rocklyn	1536:25	4000	
66	Reardan	1543:45	4000	
67	Reardan	1549:50	5000-3500	
68	19-W	1558:00	3500	
	To			
69	Harrington	1558:00	3500	
	To			
70	Odessa	1609:50	3500	
71	Odessa	1610:20	3500	
72	Ritzville	1618:50	3500	
73	Ritzville	1620:15	3000	
74+75	4 north Connell	1633:20	2000	
	to			
76	Richland Airport	1645:00	2000	

Flight Log for 4 December 1949

Point No.	Position	Time PST	Altitude MSL	Temp. °C
1	Kiona	1139:35	2000	+ 3.0
2	Yakima Airport	1203:32	2000	
3	Yakima Airport	1208:19	3000	+ 1.2
4	Ellensburg	1221:02	3000	
5	Ellensburg	1224:00	4000	+ 2.2
6	Yakima Airport	1236:14	4000	
7	Yakima Airport	1240:23	5000	+ 0.5
8	Ellensburg	1251:14	5000	
9	Ellensburg	1258:16	3000	
10	Beverly	1311:07	3000	
11	Beverly	1315:45	2500	
12	Vantage	1319:13	2500	
13	Vantage	1323:38	2000	
14	Beverly	1326:40	2000	
15	Beverly	1328:16	3000	
16	Quincy	1340:40	3000	
17	Quincy	1342:15	3000	
18	Mansfield	1358:48	3000	
19	Mansfield	1400:07	3000	
20	Coulee Dam	1413:50	3000	
21	Coulee Dam	1417:37	3000	
22	Odessa	1435:35	3000	
23	Odessa	1438:15	3000	
24	Davenport	1453:03		

VIII. Deposition

A. On Area

Calls were received at the coordination center as early as 5:00 am on 12/3 indicating that any person who had walked outside of a building returned with shoes that counted above the warning level on the foot counters. This was the first indication of the very strong deposition that had occurred in the areas. Surveys with portable Geiger counters were made on 12/3 around the areas and a few vegetation samples were obtained at this time. During the following week, the area was blocked off in one mile grids and GM readings and vegetation samples taken at the intersection of each grid.

On 12/3 portable GM surveys were made in the 200E and 200W areas and between the areas. In the 200E Area, a traverse was made across the area 500 yds east of the west perimeter fence with a total of eighteen readings on ground and vegetation with a portable GM. Three readings were also taken along the west fence. In the 200 W Area a traverse was made 0.1 mile north of the gate which ran from the east perimeter fence to a point just south of the stack. A second traverse was then made 0.1 mile north of the first one. Six readings on ground and vegetation were made for each traverse. The background in the 200 W area was determined as 300-500 c/m by holding the probe over the head. The results of these surveys are given in Table 18, not corrected for background of the instrument.

Table 18
PORTABLE INSTRUMENT SURVEY - 12/3
200E 500 YDS. FROM WEST PERIMETER FENCE

Location	VGM Readings		Location	VGM Readings	
	Ground c/m	Vegetation c/m		Ground c/m	Vegetation c/m
At south fence	180	400	5040' N. south fence	250	600
560' N. south fence	180	500	5600' N. south fence	300	600
1120' N. south fence	200	500	6160' N. south fence	250	600
1680' N. south fence	350	650	6720' N. south fence	300	500
2240' N. south fence	350	650	7280' N. south fence	150	350
2800' N. south fence	200	400	7840' N. south fence	500	800
3360' N. south fence	200	400	8500' N. south fence	300	600
3920' N. south fence	300	650	9150' N. south fence	350	600
4480' N. south fence	350	650	At. N. fence	150	500

200E - EAST PERIMETER FENCE

Location	VGM Readings	
	Ground c/m	Vegetation c/m
NE corner	200	400
Middle	200	300
SE corner	180	300

200W AREA

Location	0.1 Mile North of Gate VGM Readings		0.2 Mile North of Gate VGM Readings	
	Ground c/m	Vegetation c/m	Ground c/m	Vegetation c/m
ast fence	400	1000	450	900
00' West, East fence	400	900	300	900
00' West, East fence	400	1000	500	1000
200' West, East fence	400	1200	450	900
800' West, East fence	450	1600	400	1000
outh of stack	500	1700	400	1200

BETWEEN AREAS

Location	VGM Readings	
	Ground c/m	Vegetation c/m
Route 4S Mi. 3	400	750
Route 4S Mi. 2	400	1000
Route 3 Mi. 3	500	1000
Route 3 Mi. 2	500	1000
Route 3 Mi. 1	240	800
Route 3 Mi. 0	240	500

Normal readings on the vegetation in the most active parts of this region are < 150 c/m. The 200E Area appeared to be reasonably uniformly contaminated although readings were apparently slightly lower at the east end of the area.

On 12/5 a survey was made in the 200W area to determine deposition on various surfaces. During this survey samples of soil and vegetation were taken for analysis. The results of these samples are given in Table 19.

Table 19
SAMPLES FROM 200 WEST AREA - 12/5

Location	Soil muc/kg	Vegetation muc/kg
NE corner 200 West Area	72	6690
NE corner 200 West Area	18	-
1000 yds. N 200 West Gate	18	28,400
200W Gate	92	-
500' south 200 W Gate	28	14,200
1000' south 200 W Gate	148	7,020
SE corner 200 West area	42	3,330
Near 292 Bldg. - 100's stack	120 - 290	-

It was impossible to make good GM surveys in the region of the stack because of the high backgrounds from the fans. A survey of the guard tower in the NE corner of the T plant indicated a general reading on all wood surfaces about 1000 c/m above background. In general it was found that readings on wooden power poles were above background by 100-1000 c/m and that the activity seemed to collect in corners and rough spots as would be expected from dust particles. A metal screen on the guard tower at the NE corner of the "T" plant gave readings about 2000 c/m above background while the wood was only about 1000 c/m above background. This was confirmed on the metal screens on the windows in the Site Survey headquarters in the 200E Area where a reading of 1000 c/m above background was obtained on 12/6. A chemical analysis of a strand of this wire showed that it was an iron wire with a trace of zinc indicating a possible zinc-coated wire.

During the week of 12/5 - 12/9 several crews surveyed the region surrounding the two areas by marking the region into one mile square grids and obtaining portable GM readings and vegetation samples at each grid intersection. The results of the VGM survey were immediately available for study while the samples were analyzed the following week. A rough map showing the vegetation readings obtained is given in Figure 53.

Additional samples were taken during the following month from all portions of the reservation and the results extrapolated by the eight day half-life of iodine to 12/3. The results of this survey are given in Figure 54 which is an isoactivity map showing the extent of I-131 activity on the reservation. This map is a summation of about 600 individual results.

This figure indicates a very strong deposition pattern at the 200W Gate and along route 3 between the areas. The distance from the stack to the center of this maximum area is about 2-3 miles which agrees well with Sutton's estimate for a moderate inversion condition. The maximum activity in an individual sample was 28 uc/kg from a sample collected near the perimeter fence directly east of the stack.

The major part of the activity leaving the immediate vicinity of the 200 Areas trails off south in a very narrow band widening toward the lower end of the reservation. The two spots of 500-1000 muc/kg on the Wahluke plateau north of the reservation are characteristic of the deposition patterns in this area. When activity is found on Wahluke it is usually in these two approximate locations. The direct southerly deposition is slightly irregular since the normal patter is slightly wider and shifted to the east. For comparison, the readings obtained on samples in November are listed in Table 19. This will give a good indication of the tremendous increase in readings occasioned by this run.

Table 19
READINGS FOR NOVEMBER

Location	I-131 Conc, muc/kg
Richland	<2
Hanford	<2
Benton City	<2
200W Gate	13.2
Near 100 Areas	<2
Security of 300 Area	<2

Figure 55 presents the results of the analysis of the vegetation collected in a survey up Rattlesnake Mountain which is one side of the Benton gap at the southwest corner of the reservation. From Figure 54 this direction was the main exit of the gases from the area. The figure is a profile of Rattlesnake Mountain with the base at the Yakima River two miles NE of Benton City and the survey in a line NW of the starting point. The activity found in samples at various altitudes is designated by the height of the crosshatched portion with 1/2" equal to 1000 muc/kg. It appears from this chart that the activity is highest on the plateau at about 2000 feet possibly due to turbulence of the air passing over this region.

Figure 56 presents a similar picture for a survey up the Horse Heaven Hills immediately south of Benton City.

B. Off-Area

Immediate off-area surveys were conducted during the week of 12/5 - 12/9 in a northerly direction towards Spokane since this was the direction estimated for the bulk of the cloud. As the data began to arrive from these surveys and the area surveys it was apparent that a considerable concentration occurred to the south of the reservation. As a result, the later surveys were directed mainly toward The Dalles, Goldendale, Walla Walla, etc.

Figure 57 is a map of the roads covered in the three week period following the green run. Samples were obtained every five or ten miles depending upon the activity expected in the region. This figure is a base map on which the following maps may be overlaid to orient them.

Figure 58 is an overlay indicating the individual readings obtained at each off-area sampling location. The results are in terms of muc/kg with all values corrected to 12/3 by means of the eight day half-life of I-131. The usual estimate of the sensitivity of this analysis is 3 muc/kg. For this work, however, the contamination in the laboratory ventilation system was such that values up to 10-15 muc/kg were obtained on blank samples at the beginning of the week of 12/5. During the period that these samples were analyzed the average blank sample gave about 5-6 muc/kg. For this reason the overall limit of sensitivity for consideration of these results was estimated at 10-20 muc/kg.

For use in analysis of the data the average blank for the analyses performed for several of the trips is listed in Table 20.

Table 20
BLANK VEGETATION ANALYSES

Location	Blank Samples	
	Maximum muc/kg	Average muc/kg
Wallula-Pendleton-Walla Walla	29	11
Yakima Barricade Wenatchee-Ritzville	23	9
Walla Walla-Spokane-Kettle Falls	23	10
Toppenish-Maryhills-Umatilla	5	4
Biggs-Klamath Falls-Pendleton	5	4
Arlington	-	3
The Dalles to Hood River	-	3

Figure 59 is an isoactivity chart prepared from the values in Figure 58. This map presents the contamination found in an area bounded by Ellensburg, Kettle Falls, and Baker. The very pronounced southerly trend is again noted in this map. Concentrations as high as 500-1000 muc/kg extend well below Benton City into the Horse Heaven Hills. Concentrations as high as 500 muc/kg extend NNE above Odessa (about 80 miles) and southwest to The Dalles, Oregon (about 110 miles). A pronounced deviation from the general Northeast-Southwest pattern of this contour occurs in the narrow strip which protrudes to include Walla Walla. The 20-30 muc/kg area is doubtful because of the peculiar geography of the roads and the high contamination occuring in the analysis. The limits of the area surveyed are marked by the dot-dash line.

Unfortunately the lack of roads and the snow encountered at the end of December did not allow an examination of the areas east of Walla-Walla in the Blue Mountains and west of Goldendale in the Cascade Mountains. Such roads as are available in this region were impassible at the time.

Figure 60 is a map of the same area covered by Figures 5-7 showing prominent feature of the terrain which could affect the travel of the cloud.

C. Miscellaneous

Five shallow pans 20" x 20" containing about one liter of water were placed at five locations near the 200 Areas on December 2 and collected for analysis on December 5. The object was to obtain information on the rate of fall out of I-131 in a body of water. The activity collected by these pans and the average air concentration at each location as measured by the scrubber is given in Table 21.

Table 21
ACTIVITY IN WATER PANS

Location	Total Activity in Water muc	Average Conc. in Air uc/l x 10^9	Deposition Rate uc/hr/meter^2/uc/l
200 West, Tower 15	86.6	840	3.3×10^4
200 West, Tower 4	98.2	1400	2.3×10^4
200 East, Tower 16	45.6	1460	1.0×10^4
200 East, SE	22.8	450	1.6×10^4
Hanford	12.3	37	1.1×10^4

The deposition rates in the above table were calculated assuming that all of the activity in both the water and air was obtained over a 12 hour period. This is a close approximation for the scrubber since at each of these locations the scrubber value was available only through 12/3. The ratios are remarkably consistent considering the nature of the experiment. They are undoubtedly maximum figures since the air concentrations were measured for a much shorter period of time than the water pans were exposed.

A series of ten vegetation samples were picked up from the immediate vicinity of the same scrubber and analyzed for I-131. The results of this test are given in Table 22.

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Table 22
ACTIVITY ON VEGETATION

Location	Vegetation Activity		Average Conc. in Air	Deposition Rate
	Maximum muc/kg	Average muc/kg	uc/l x 10^9	uc/hr/meter^2/uc/l
200 West, Tower 15	10,908	6584	840	1.3×10^6
200 West, Tower 4	4,897	3378	1400	4.0×10^5
200 East, Tower 16	4,644	3314	1460	3.8×10^5
200 East, SE	5,266	3899	450	1.4×10^6
Hanford	1,022	445	37	2.0×10^6

The deposition rates were calculated assuming a 12 hour exposure and a 2 kg/meter^2 vegetation cover. These results are higher than the water presumably due to the greater area of exposure on the vegetation.

Both of these values are within a factor of 10 of the value of 10^5 uc/meter^2/hr per uc/l calculated by Parker[12] from data on atmospheric pollution, emission of discrete active particles, and former I-131 deposition data. Apparently the values for vegetation are slightly higher and the value for water slightly lower than his assumption.

The decay of the I-131 on the vegetation is available from a number of measurements made in January, 1950. In reviewing this data, it should be borne in mind that results from individual analyses may vary by a factor of 3-4 due to uncertainties in sampling of the various portions and therefore differences in dry weight and surface area.

In Figures 61 and 62 are given decay curves of the I-131 as measured at widespread locations. In every case the general trend of the activity follows the known decay of the iodine within the experimental error of the measurements.

IX. Biological Monitoring

A. Botany

Potted plants of wheat and winter peas were placed at five different stations throughout the area on the afternoon of December 2, 1949. These plants were left exposed until 1:00 p.m. on December 3.

The stations selected were in the 614 Buildings throughout the Hanford Area to allow protection to the plants in case of freezing weather during the period of exposure to the gases.

At Station #1, which was the 614 Building located at the center of the north fence in 200 West Area, one of each type of plant was placed inside of the building and one of each type of plant was placed outside of the building. The same procedure was followed for Station #2, 200 East Area west center, Station #3, 100-B Area southeast, Station #4, 100-F Area southwest, and Station #5, North Richland north.

The plants were as they had been growing in the greenhouse at the Botany Laboratory at 100-F Area except for the wheat plants, which were placed at Stations #1 and #2. The soil of these plants was covered with a layer of paraffin to separate the soil from the atmosphere.

After the plants had been exposed to the radioactive gases, they were brought back to the Botany Laboratory. Samples were immediately taken from the plants and one gram portions counted directly on the first shelf of a mica window counter.

Plants which were placed outside of the building at Station #1 and #2 accumulated the most activity. The average activity in microcuries per kilogram for the aerial portions of these plants were as follows:

Station #1		Station #2	
Winter peas	1.0	Winter peas	2.1
Wheat	1.7	Wheat	2.2

The samples of those plants which were placed inside the buildings at Station #1 and #2 had average activity of less than 0.1 microcuries per kilogram for the aerial portions of the plants.

Samples from the plants placed both inside and outside at Stations #3, #4 and #5 had average activities of less than 0.01 microcuries per kilogram.

The counting results of the roots of the wheat plants placed outside the building at Station #1 showed the average activity to be 0.02 microcuries per kilogram. For the roots of wheat plants outside at Station #2, the average activity was 0.05 microcuries per kilogram.

A comparison of the amount of activity in the roots of the wheat plants and the activity of the plants at Station #3, #4, and #5 would tend to indicate that here may be a small amount of activity translocated from the tops to the roots.

B. Zoology

As a followup on the special dissolving of December 2, considerable emphasis was placed upon the collection of birds (principally fowl) and mammals from arbitrary locations on and near the reservation. A total of 68 animals were assayed for iodine^{131} in the thyroids. Levels detected in birds and mammals are given in Table 22:

Table 22
SUMMARY OF ACTIVITY IN BIRDS AND MAMMALS

Location	BIRDS Number	BIRDS Maximum uc/kg	BIRDS Average uc/kg	MAMMALS Number	MAMMALS Maximum uc/kg	MAMMALS Average uc/kg
100-B to 100-D	5	110	47	0	-	-
100-H to 100-F	5	9	5	2	44	30
Hanford	7	33	15	3	30	24
300 Area	2	1.4	1.3	0	-	-
N. Slope of Rattlesnake*	10	270	87	12	300	160
200 N	1	9	9	0	-	-
Benton City to Prosser	4	26	12	0	-	-

*Includes specimens from Benson and Snively Ranches and from Rattlesnake Springs.

Seven mallard ducks from Lacrosse and one from Kennewick were also assayed. [illegible] then less than 0.5 uc/kg in all cases.

The highest levels detected were from specimens collected about three weeks following the dissolving. Since 4 uc/kg approximates the tolerance for I^{131} in tissue, it may be concluded that nearly every specimen of wildlife within the project boundary will have received in December and January thyroid irradiation varying from tolerance to 80 times tolerance daily.

[redacted]

I. Discussion

The weather conditions at the time chosen for this run were rather poor in that the atmosphere was unstable and winds shifted direction badly. Probably the most significant information in evaluating the results is the radio sonde measurements made at Richland [redacted] From these plots, it may be seen that in spite of the inversions occuring close to the ground, the upper atmosphere was very unstable with a lapse rate approaching the dry adiabatic rate during the period of evolution. Under these conditions, it is difficult to compare the actual results with the theoretical values of Sutton's since the gases were emitted into an inversion close to the ground with some or all of the fumes escaping into the stable upper atmosphere. For purposes of comparison, we have chosen to consider the dilution as occuring according to the coefficients quoted for the large lapse condition. [redacted]

Establishment of theoretical values of the concentration at any given location at a given time is made difficult by the shifting wind directions and speeds and the failure of the sampling technique to give a good I-131 evolution curve. An examination of the wind data indicates that the early portion of the fumes would travel east and north. Sometime between 0100 and 0400 on 12/3 the wind shifted so that the fumes would tend in a more southerly direction toward Richland. The evolution curves indicate that the xenon peaked at about 2200 - 2300 while the iodine did not appear in significant quantities until after this time and peaked at 0200-0400. Thus it appears that the bulk of the xenon with only a small fraction of the iodine went in a north-easterly direction before 0200-0300 on 12/3 while the bulk of the iodine traveled in a southerly direction after 0300-0400 on 12/3. The speeds varied widely from 10-20 mph at the start to 1-5 mph at 12/3. Since the data is inadequate to estimate the travel on an hour to hour basis, an average speed of 6-7 mph was chosen.

The scrubber, constant air monitor, and counting rate meter data indicate that the I-131 passed over the 300 Area, Richland, Benton City area on 12/3 with the maximum about noon. Wind speeds near the ground at this time near Richland were 5-7 mph with speeds as low as 1-2 mph at the 622 Building. This activity, then, could have been that from the end of the dissolving between about 0400 and 0800 on 12/3.

The best concentration data obtained in this region were from the scrubber taken from 1200-1400 on 12/3 and the constant air monitor at 300 Area. These instruments indicated concentrations of $1.6 - 3.5 \times 10^{-7}$ uc/l on the scrubber and a maximum three hour concentration of 10^{-6} uc/l at 300 Area. The factor of three difference in these readings is probably due to the differences in calibrations of the two instruments. The values are a factor of 2-5 lower than would be estimated from the Sutton equations for an evolution rate of 0.05 curies/sec and a wind velocity of 5 mph with unstable air conditions. This would appear to be an adequate check considering the lack of information on the location of the axis of the cloud and the unknown form of dilution.

The plot of the conductivity from the aerial survey on the morning of 12/3 shows two peaks, one close to the project between Richland and Connell and the other at Ritzville. Two suppositions may be advanced concerning these peaks.

(1) The "highs" represent the two peak output concentrations of gases from the dissolving operation. The one farthest from the reservation could well be the Xe-133 while the I-131 is just leaving the project.

(2) Assuming that the above is true, the gentle shift of winds from the northwest and west to southerly and northeasterly caused the iodine to veer to the north during the morning and afternoon of 3 December, depositing contamination found on the vegetation near Odessa.

These theories are substantiated by the following facts;

(1) The peak farthest from Hanford during the morning is approximately 70 miles from the dissolving stack. These readings were made from 0815 to 0840 hours

or at a mean time of 0827. A mean wind of 6.5 from the WSW would place this peak at the stack at approximately 2148 hours on the 2nd which is reasonably close to the true value. The iodine peak was estimated to be at 0200 on the 3rd. For a rough estimate, the same wind speed can be used to place the iodine maximum at 33 miles from the stack at measuring time (0700 3 December). This checks with the position of the second "high" on the morning flight.

(2) No I-131 was found on the filters east of the flight between Lind and Riparia. This could be the boundary between the two highly concentrated clouds.

(3) Movement of both of these "highs" northward simultaneously would place the xenon at Davenport and deposit the iodine near Odessa. Therefore, if no iodine was present to any extent east of Lind, the scrubber had to collect what it did on the Richland, Lind, Riparia, Lind, Odessa survey. In this case the amount of air-flow through the scrubber could be reduced by a factor of 2-2.5 and the iodine concentration raised by the same factor and falls in line with the figures obtained from the filters. If we can rely on the agreement of the two methods of sampling, (filters and scrubber) then an approximate calibration for the conductivity apparatus can be made. On page 48, the flight legs between Connell-Lind-Riparia, where the iodine was detected, show a mean value of 12 divisions above background for the conductivity. Assuming that 1/3 of the reading (or 4 divisions) was caused by the radioactive iodine, we have:

$$\frac{1.4 \times 10^{-8}}{4} = 0.35 \times 10^{-8} \text{ uc/liter/div.}$$

$$\text{or } 3.5 \times 10^{-9} \text{ uc/liter/div}$$

From this value, the highest concentration encountered on the two-day operation was 1 x 10^{-7} uc/liter at Davenport (100 miles).

According to Sutton's estimates of this concentration with an estimated evolution rate at the peak of 0.6-1.5 curies/second and a large lapse condition, the concentration should be on the order of 1-2 x 10^{-6} uc/l, a value 10-20 times the one obtained.

Considering the number of assumptions involved in the calculation and the calibration of the equipment, this could be considered within the error of the measurement. The above calibration is correct to the order of magnitude only but serves to show the increase in sensitivity of the vibrating condenser monitron over the electrometer tube circuit for which F. J. Davis gives a sensitivity of between 10^{-3} and 10^{-7} uc/liter/division.

The large deposition on vegetation to the south of the stack, then, undoubtedly occurred from the gases leaving the stack after 0200-0400 on 12/3. An interesting comparison with the theoretical values may be made by comparing the Sutton values to the air concentrations from the deposition rates estimated in section VIII. If we assume that the average exposure time in the 100-500 muc/kg region between Kiona and The Dalles was 20 hours, then the concentration must have been 1-5 x 10^{-8} uc/l. Sutton's values for a large lapse condition would indicate 5 x 10^{-3} to 3 x 10^{-7} uc/l, assuming a wind speed of 5.5 mph and an evolution rate of 0.05 curies/sec.

Although no conclusive statements as to the validity of Sutton's treatment when applied to these distances may be made because of the uncertainties in the meteorological constants involved, it does appear that the coefficients as used give reasonable values if the primary assumption that the gases diluted in the unstable upper atmosphere is correct.

From experience gained from this test, two facts are evident concerning use of the aircraft for tracking such activity:

(1). If at all possible, a running plot should be kept in flight to determine regions of highest activity while in flight. Knowledge of the existence of areas of concentrated activity is of little use when the information is brought to light days after the data is taken. Values plotted every thirty or forty minutes (or at lesser time intervals if required) with background subtracted will enable the operator to sketch in lines of equal intensity and furnish the pilot with a flight path which would either remain in the concentration for a longer sampling period or find even higher values.

(2). The services of two or more aircraft could greatly increase the amount of monitoring coverage for a given period of time. Working as a team at the same or different altitudes, the progress of a cloud could be traced both laterally and vertically.

During this run the aircraft surveyed an area in one day which took two weeks to cover by surface vehicles. The degree of accuracy was very close. Under the worst possible meteorological conditions for such a test, the airborne instruments detected the radioactive gases at a distance better than 100 miles from the stack. Under favorable conditions, it was estimated that with the same concentrations this distance could have been increased by up to a factor of ten.

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(1)

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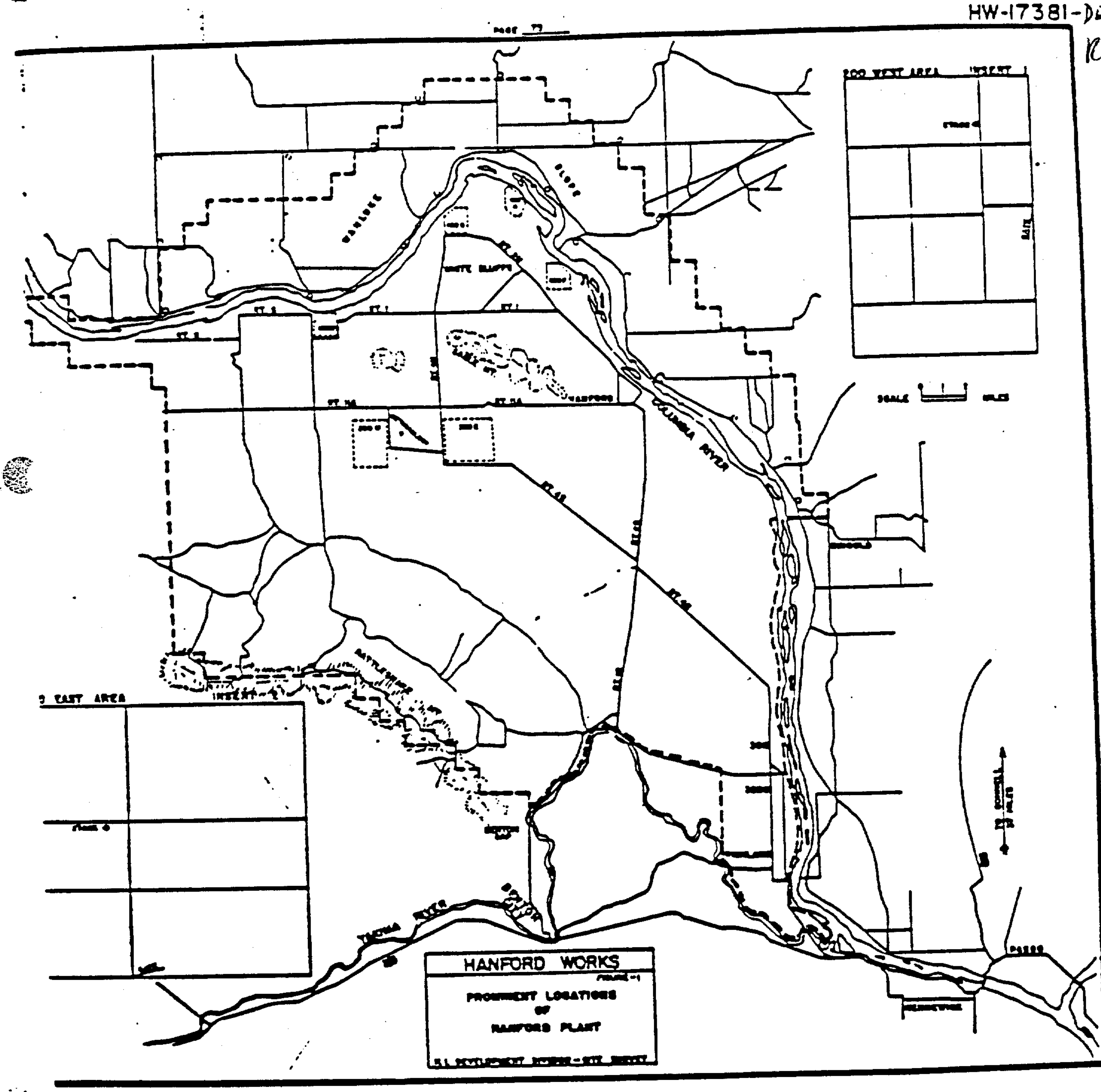
9. M. B. LeBouef, HW-15743, January 27, 1950.

10. P. E. Church & C. A. Goslin, Jr.; HW-7-4806, Undated.

11. R. C. Thorburn, HW-17257, March 20, 1950.

12. H. M. Parker, HW-14058, August 2, 1949.

HW-17381-DEL REV 1



1082600

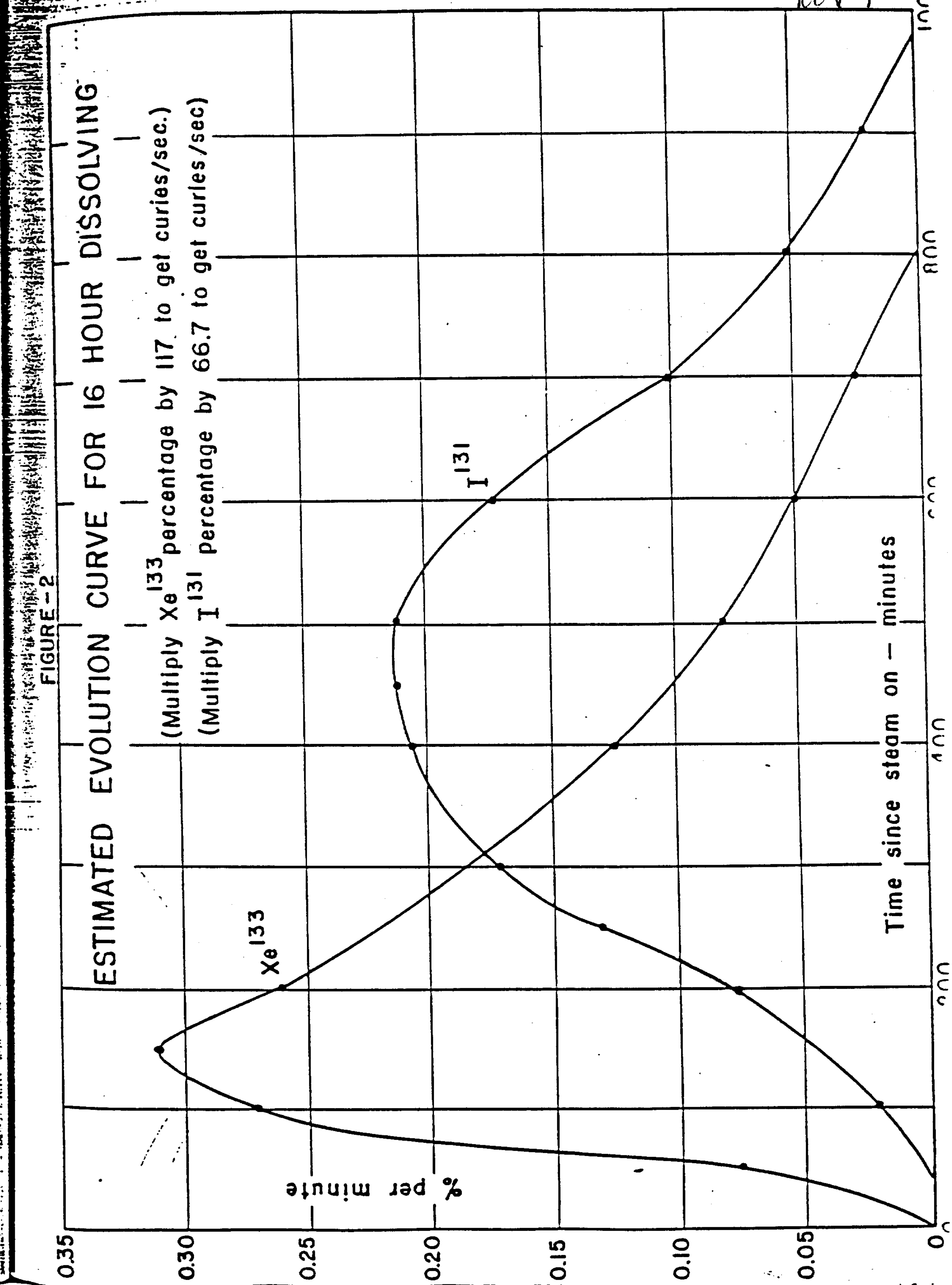


FIGURE - 2
ESTIMATED EVOLUTION CURVE FOR 16 HOUR DISSOLVING

FIGURE-3

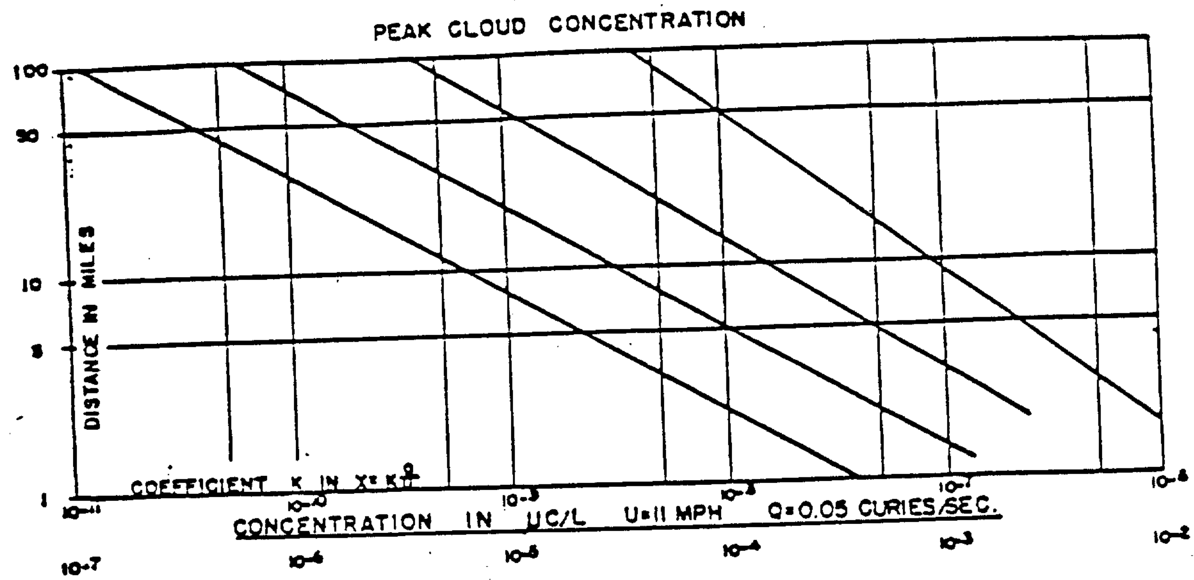
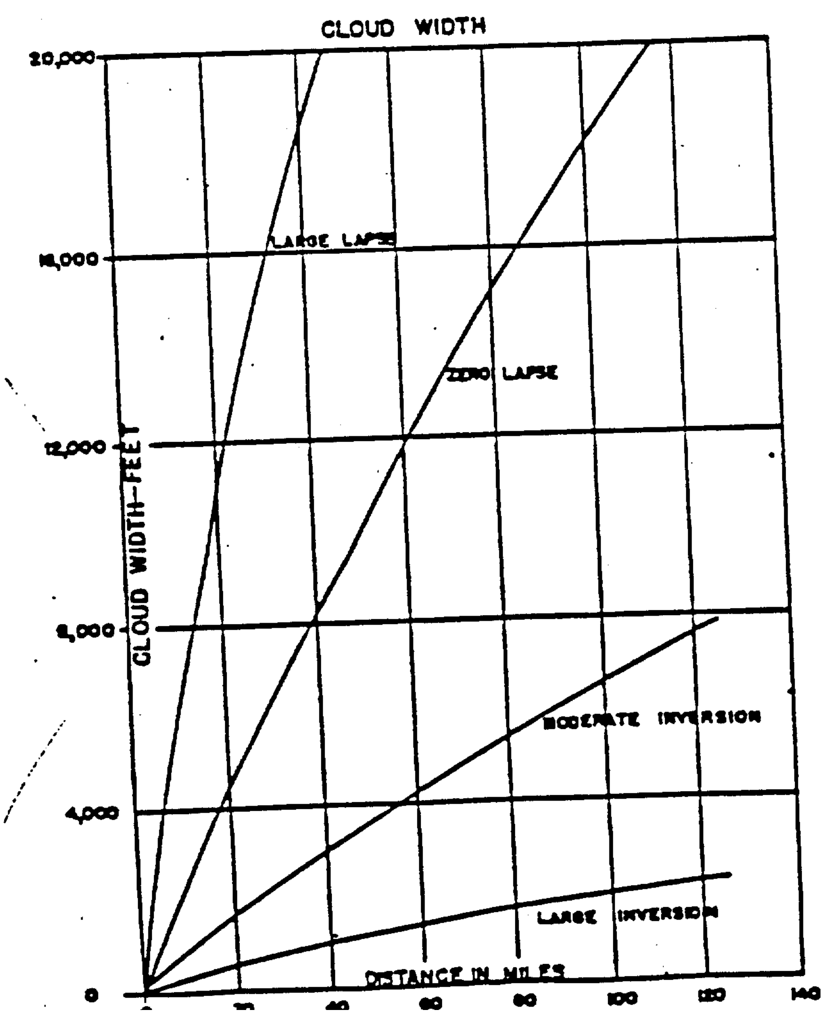
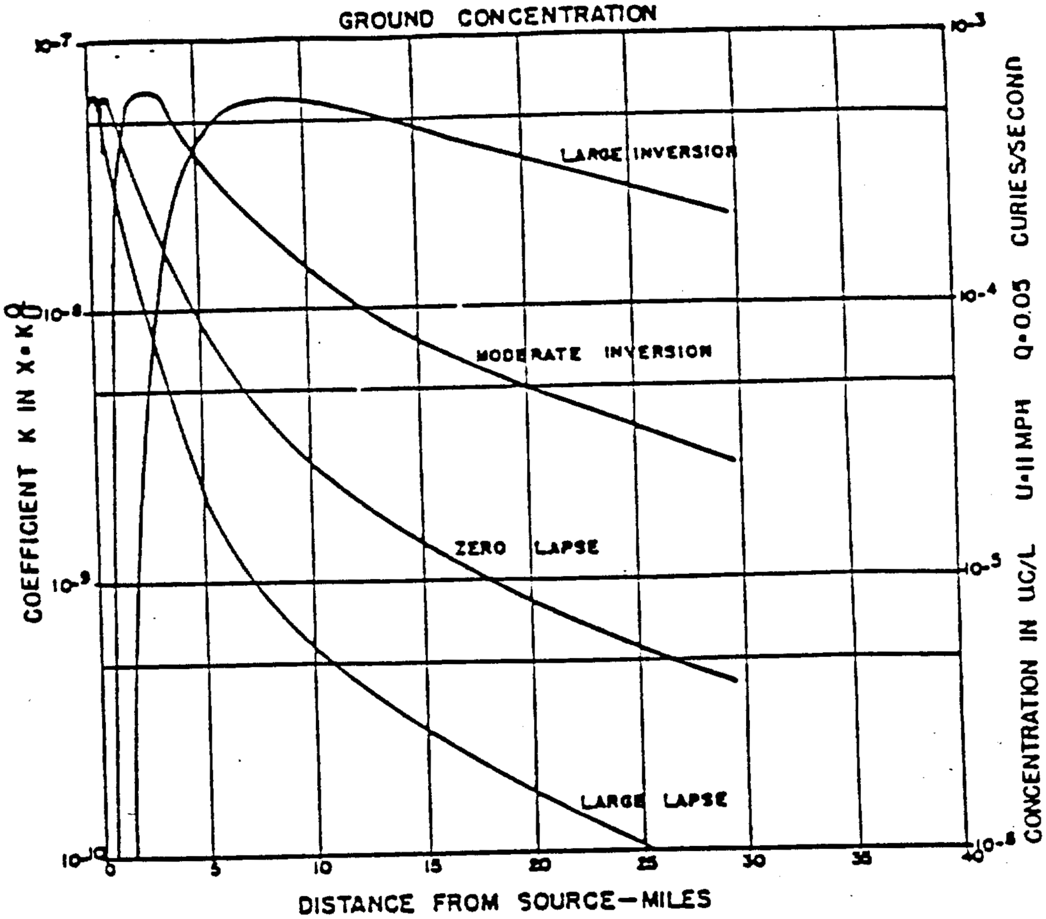


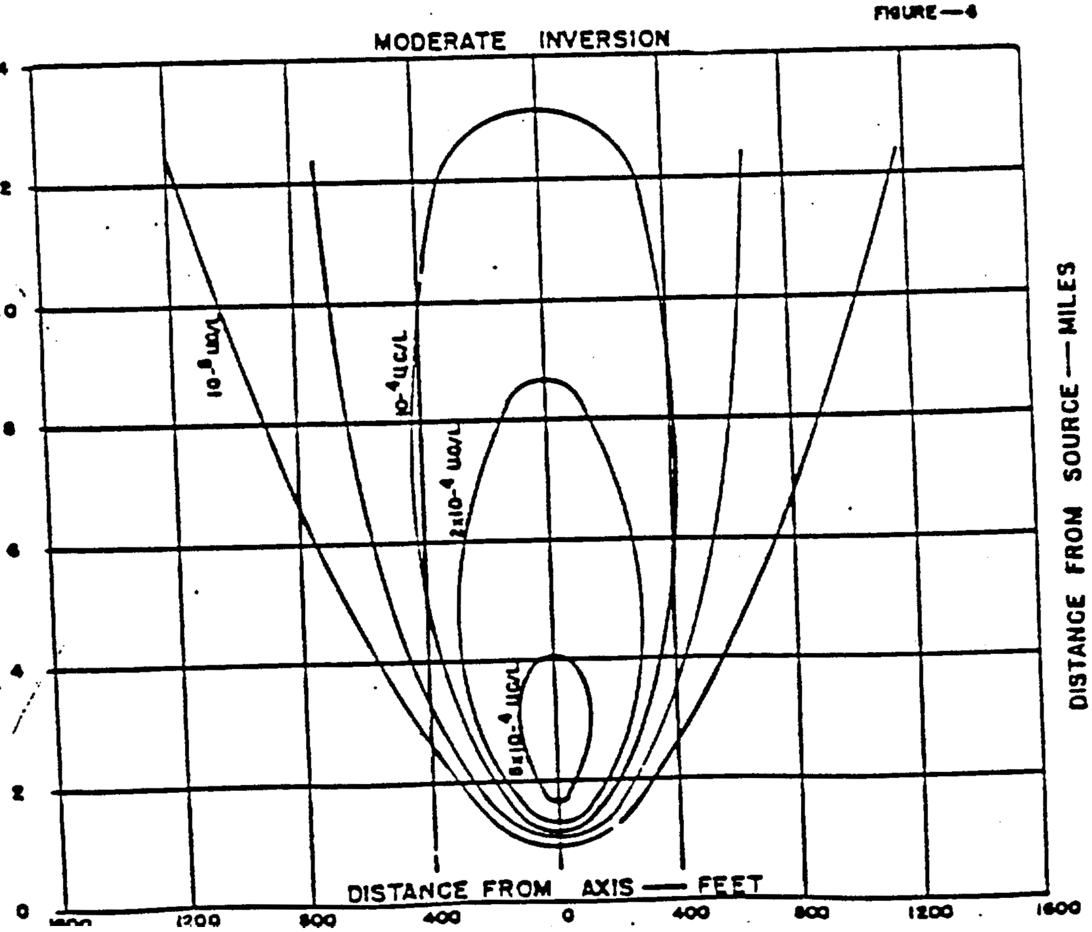
FIGURE-4



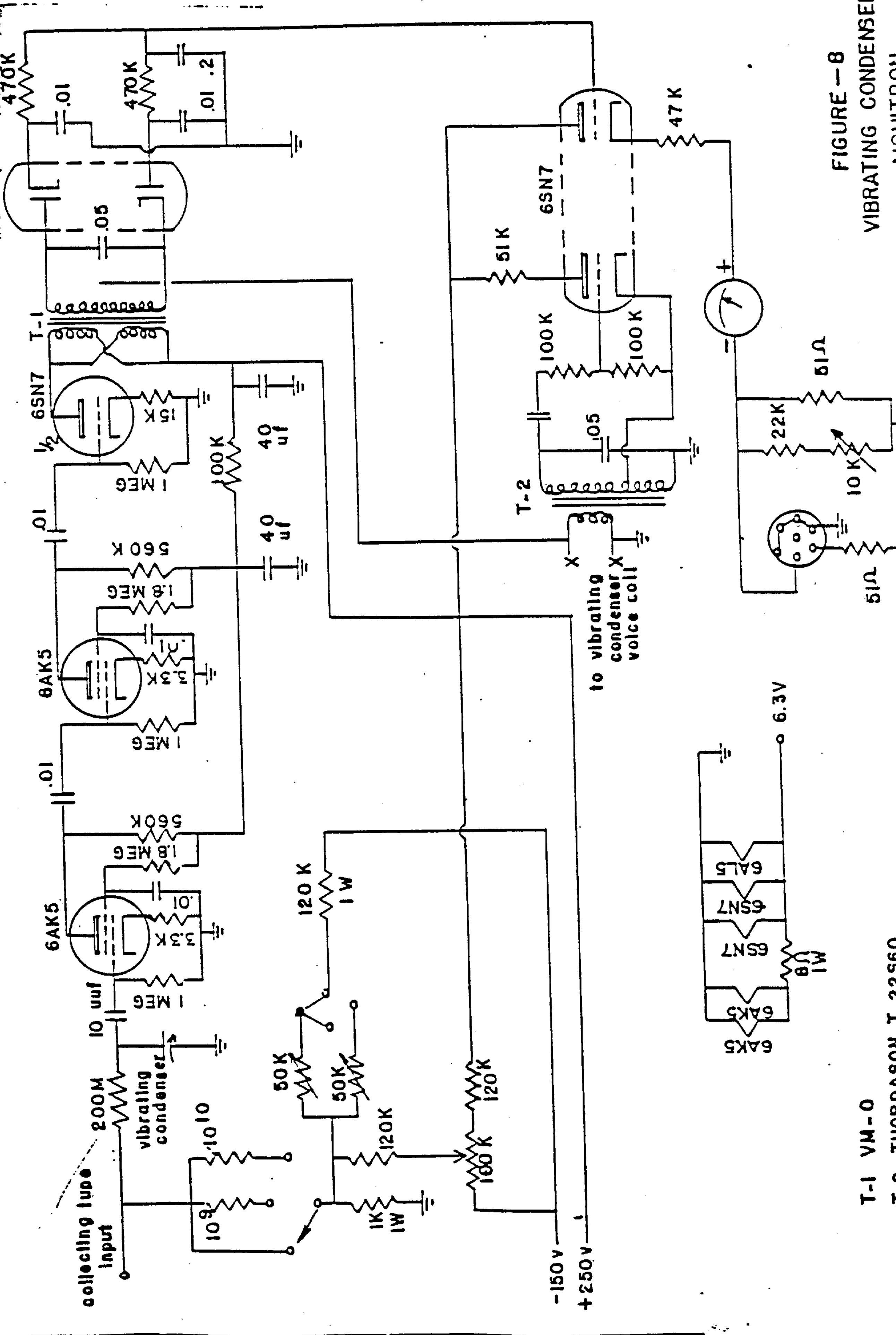
FIGURE—5



FIGURE—4



1082603



FIGURE—8
VIBRATING CONDENSER MONITRON

T-1 VM-0
T-2 THORDASON T-22S60

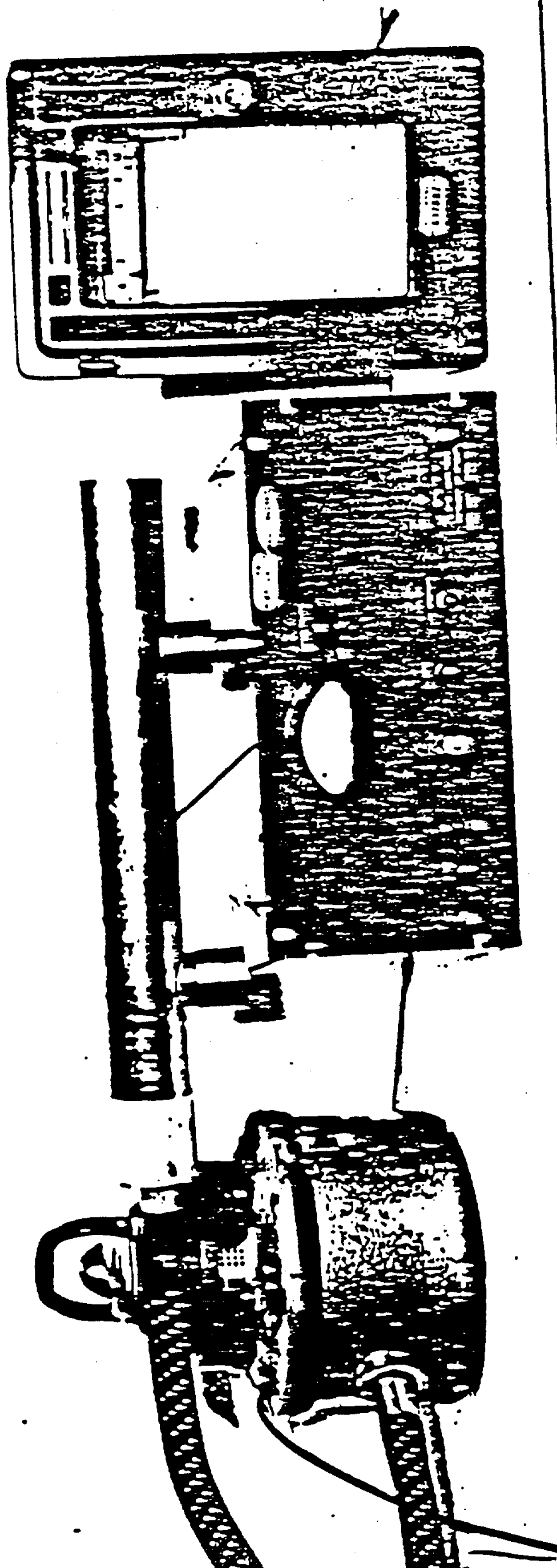


FIGURE-9
ATMOSPHERIC CONDUCTIVITY APPARATUS

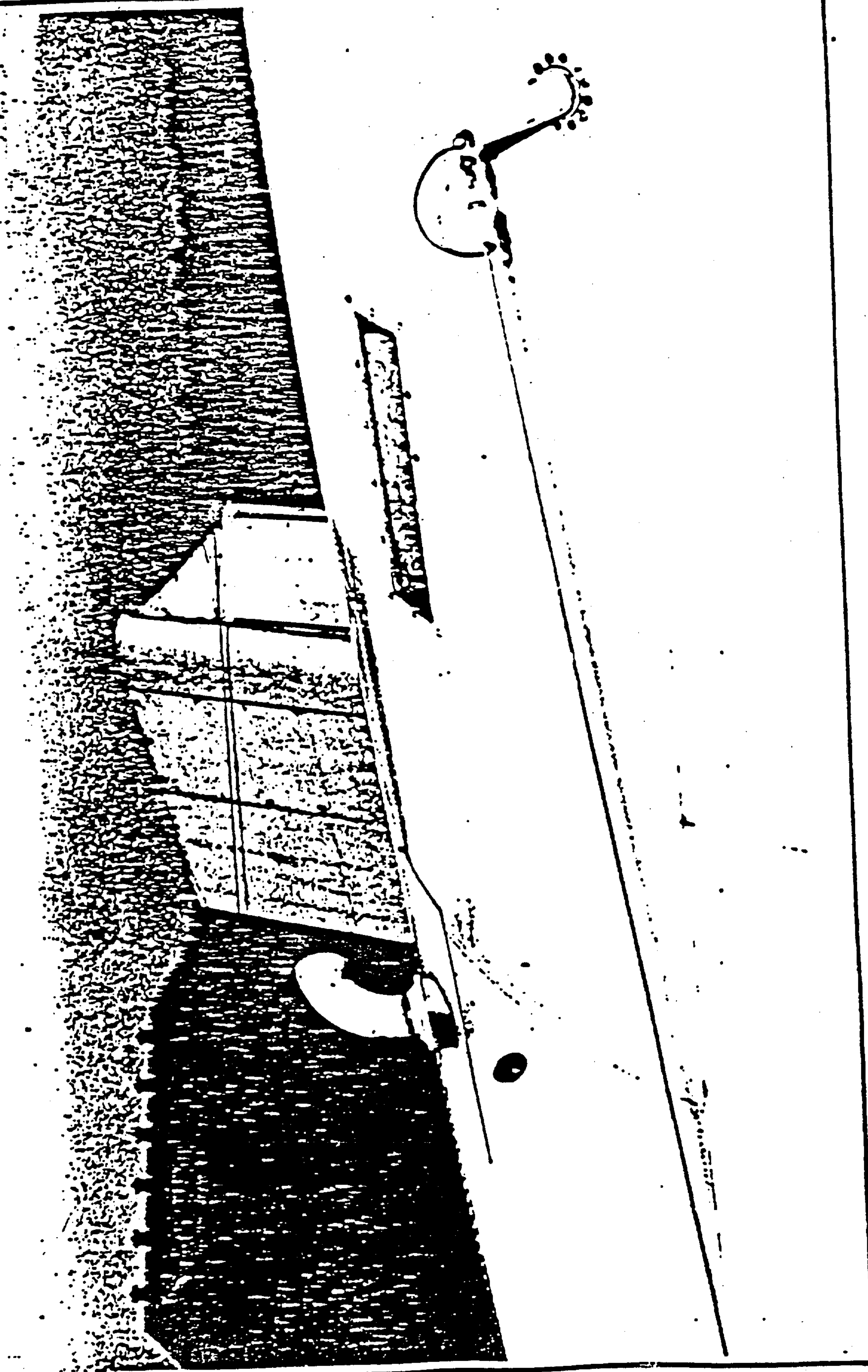
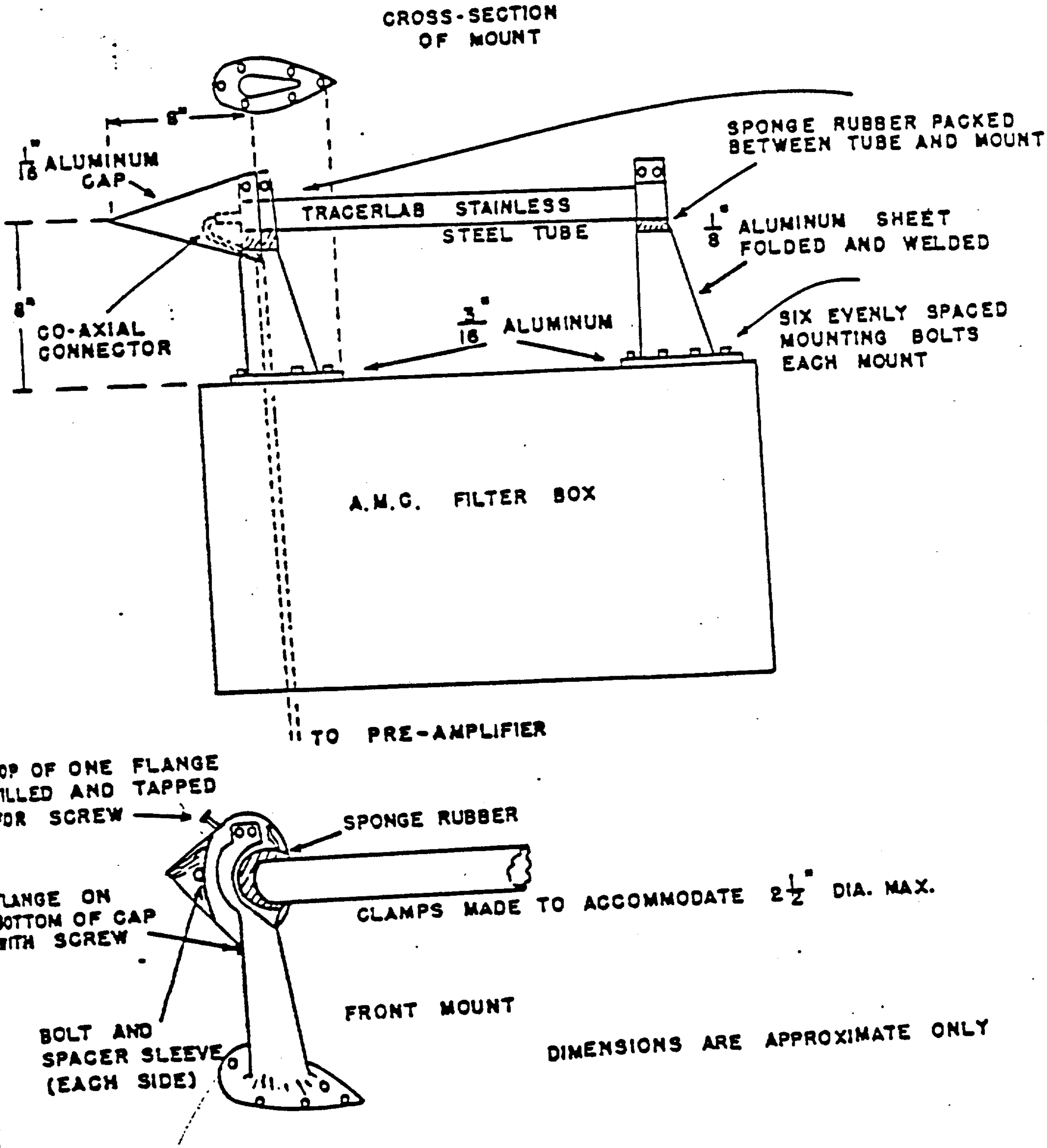


FIGURE-10
MOUNTED AMC-FILTER BOX



1082607

FIGURE—11

MOUNTING FOR EXTERNAL COUNTER

EXTERNAL COUNTER TUBE

FIGURE-12

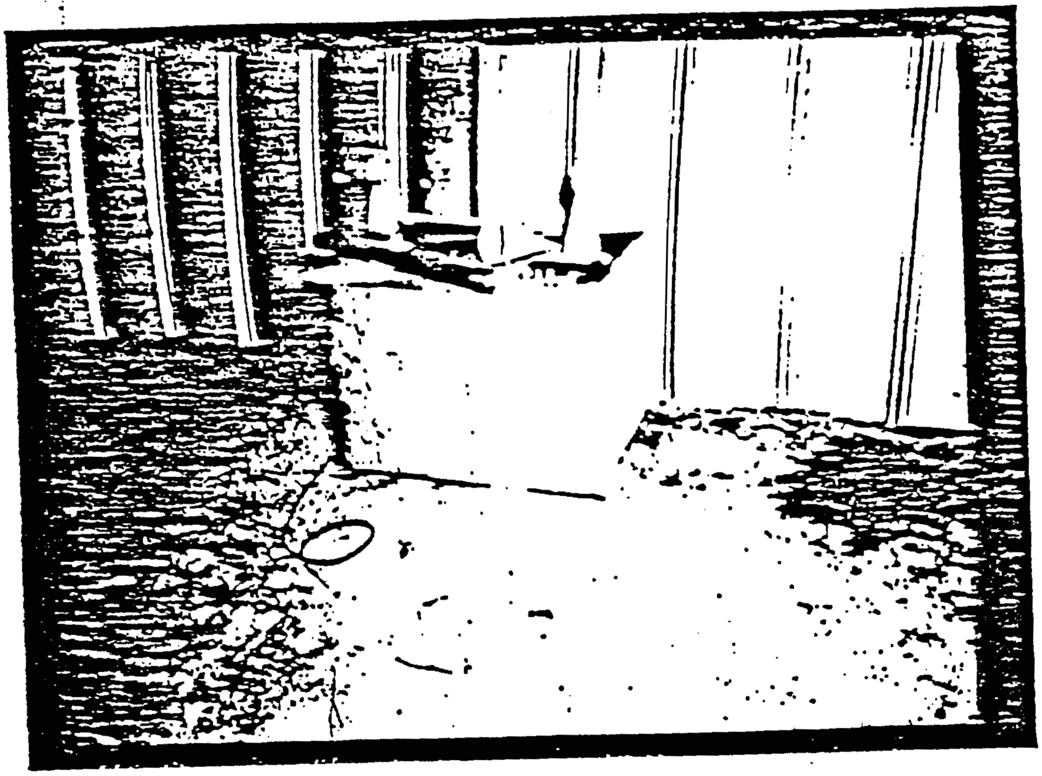


FIGURE-13

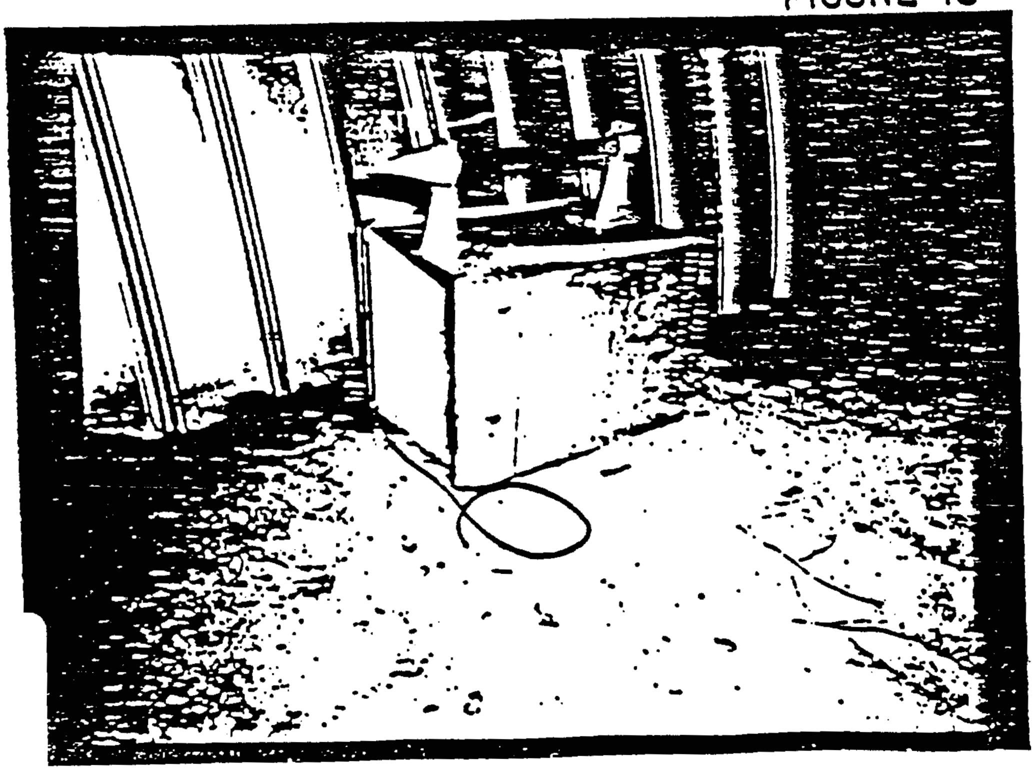
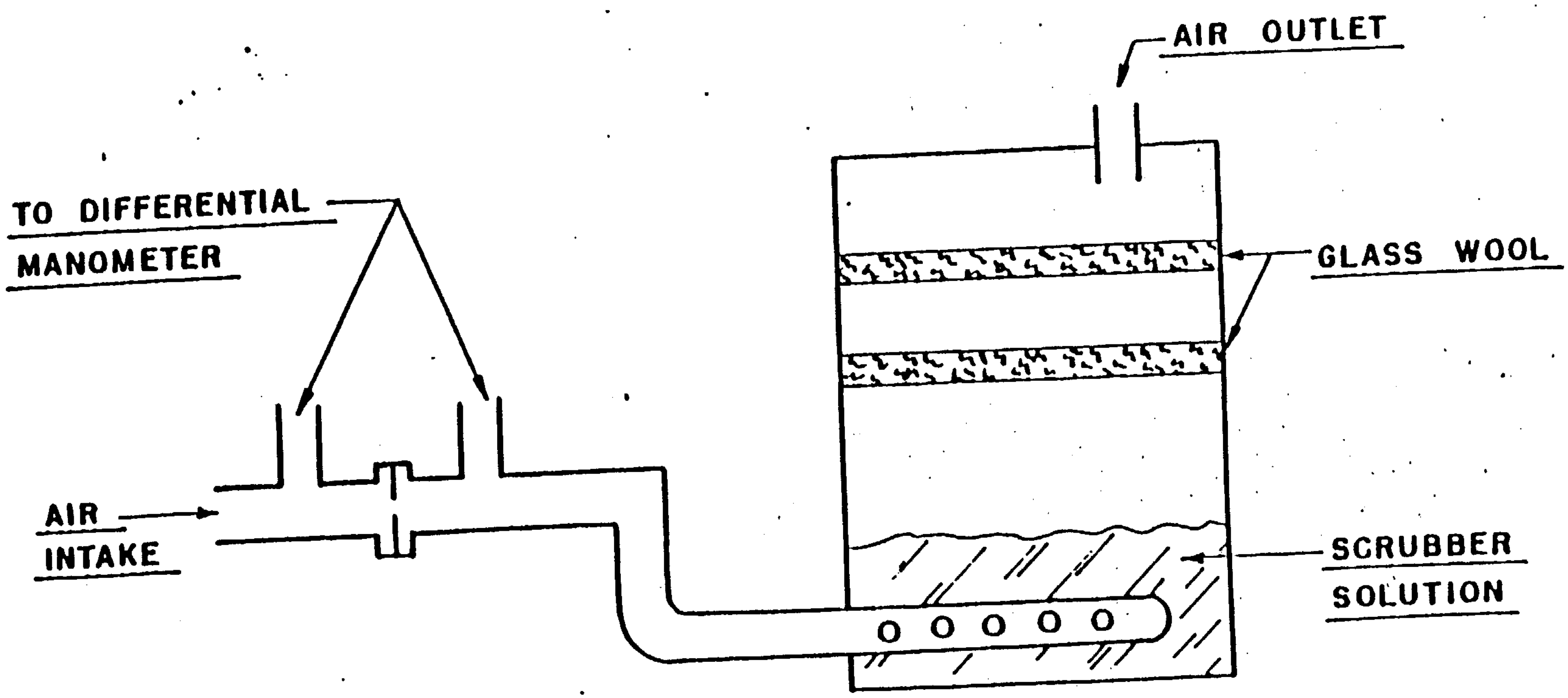


FIGURE 14

HIGH CAPACITY SCRUBBER



1082609

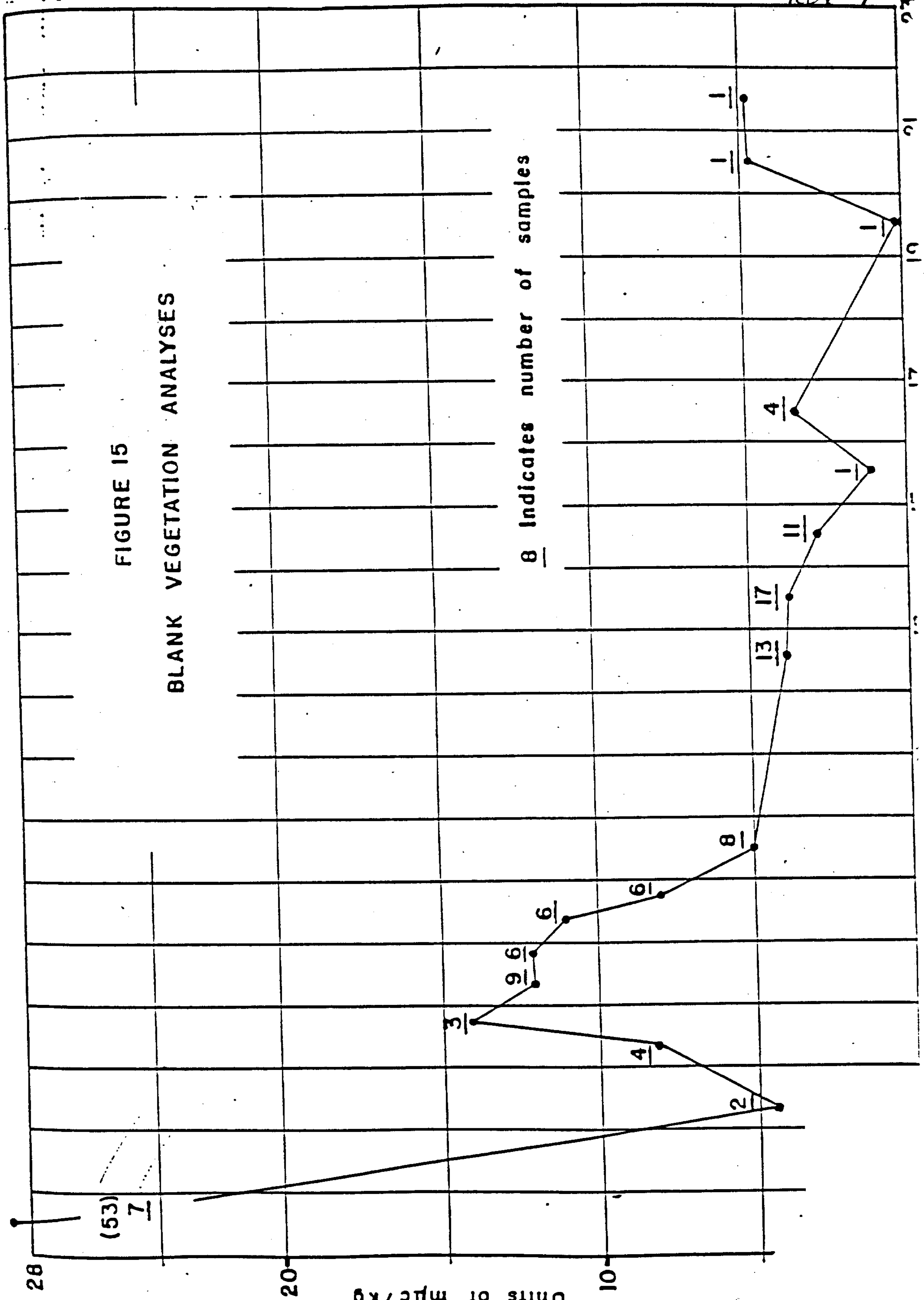


FIGURE 15

BLANK VEGETATION ANALYSES

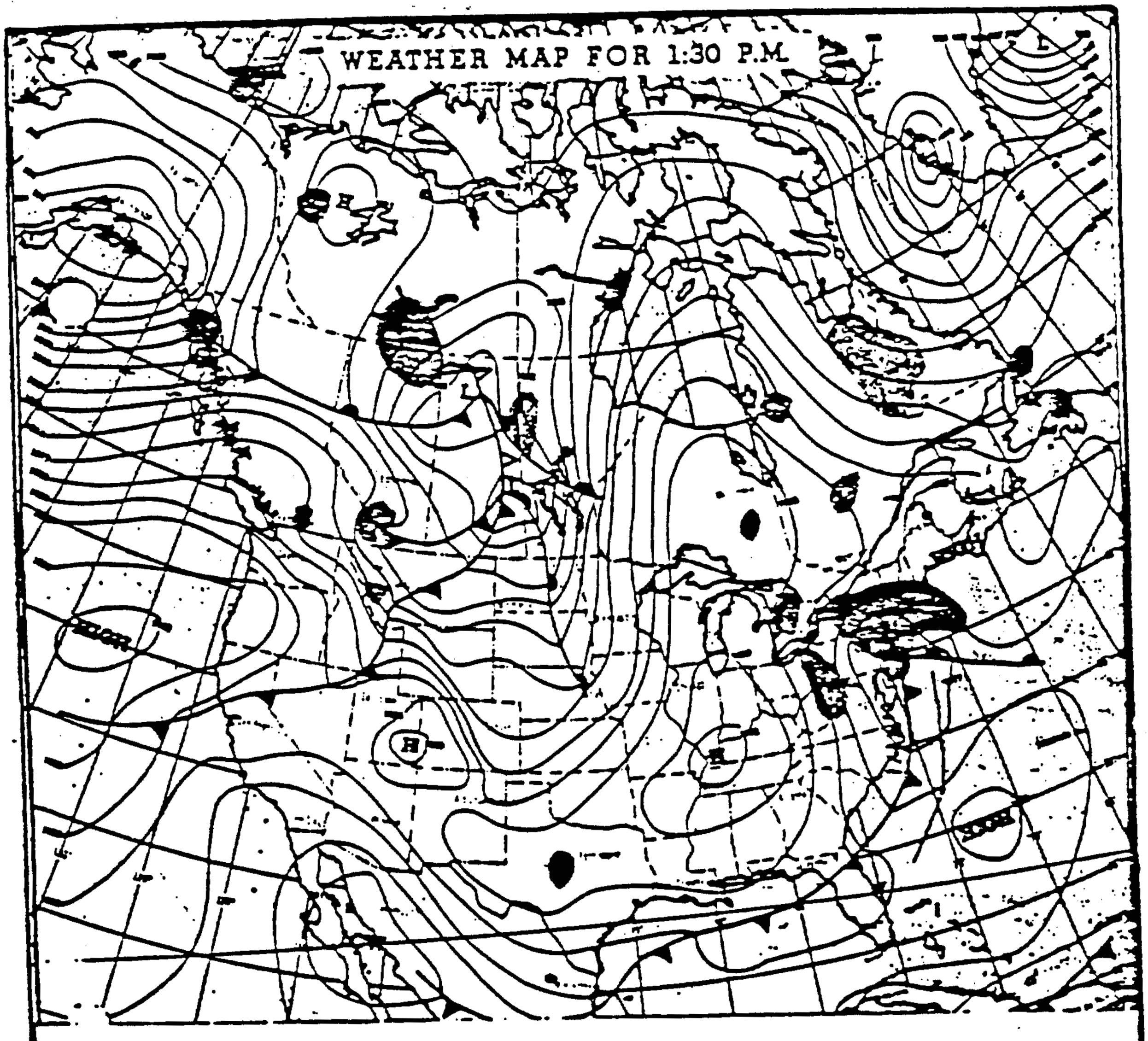


FIGURE — 16

1030 PST ON 12—2—49

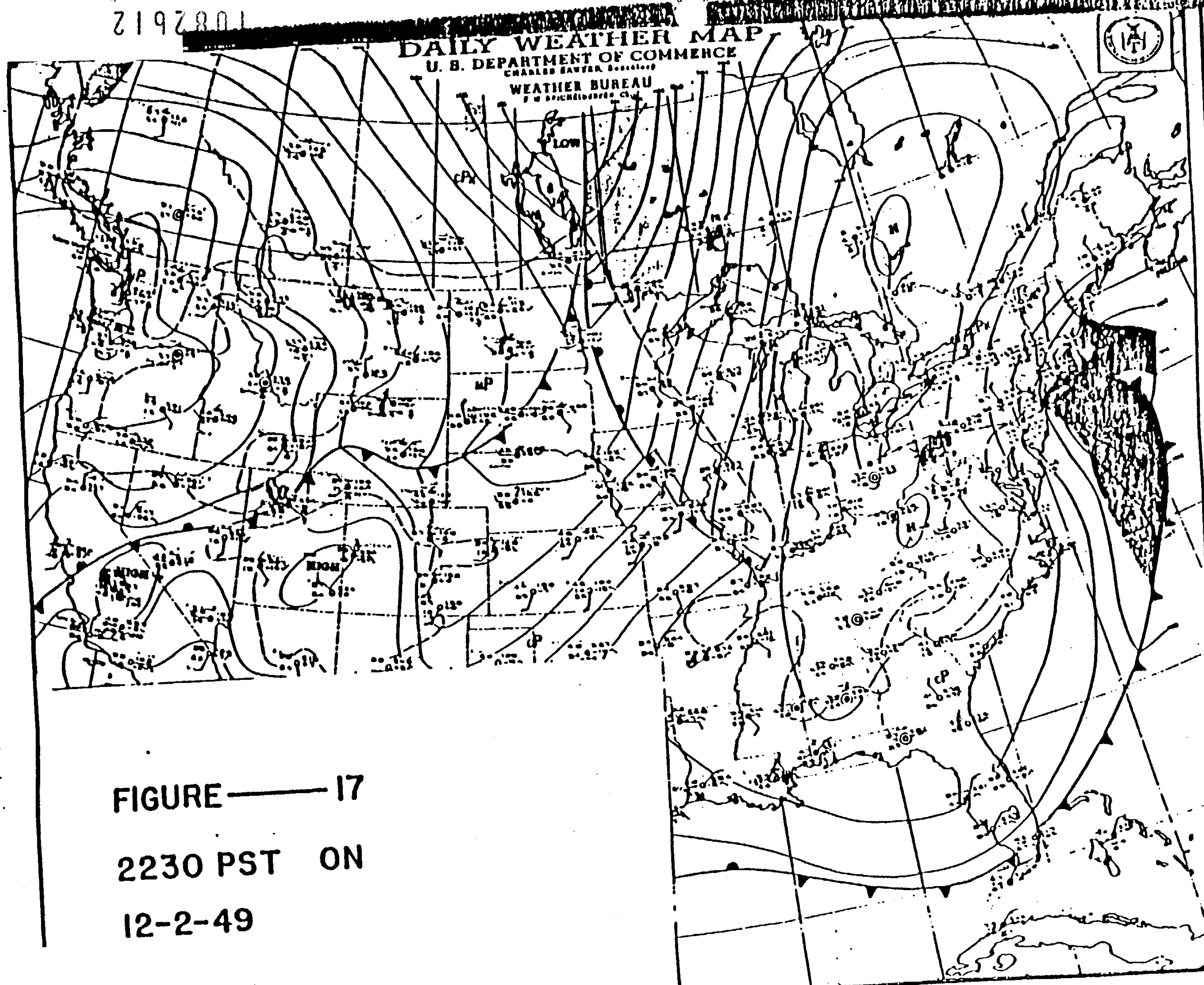


FIGURE —— 17

2230 PST ON

12-2-49

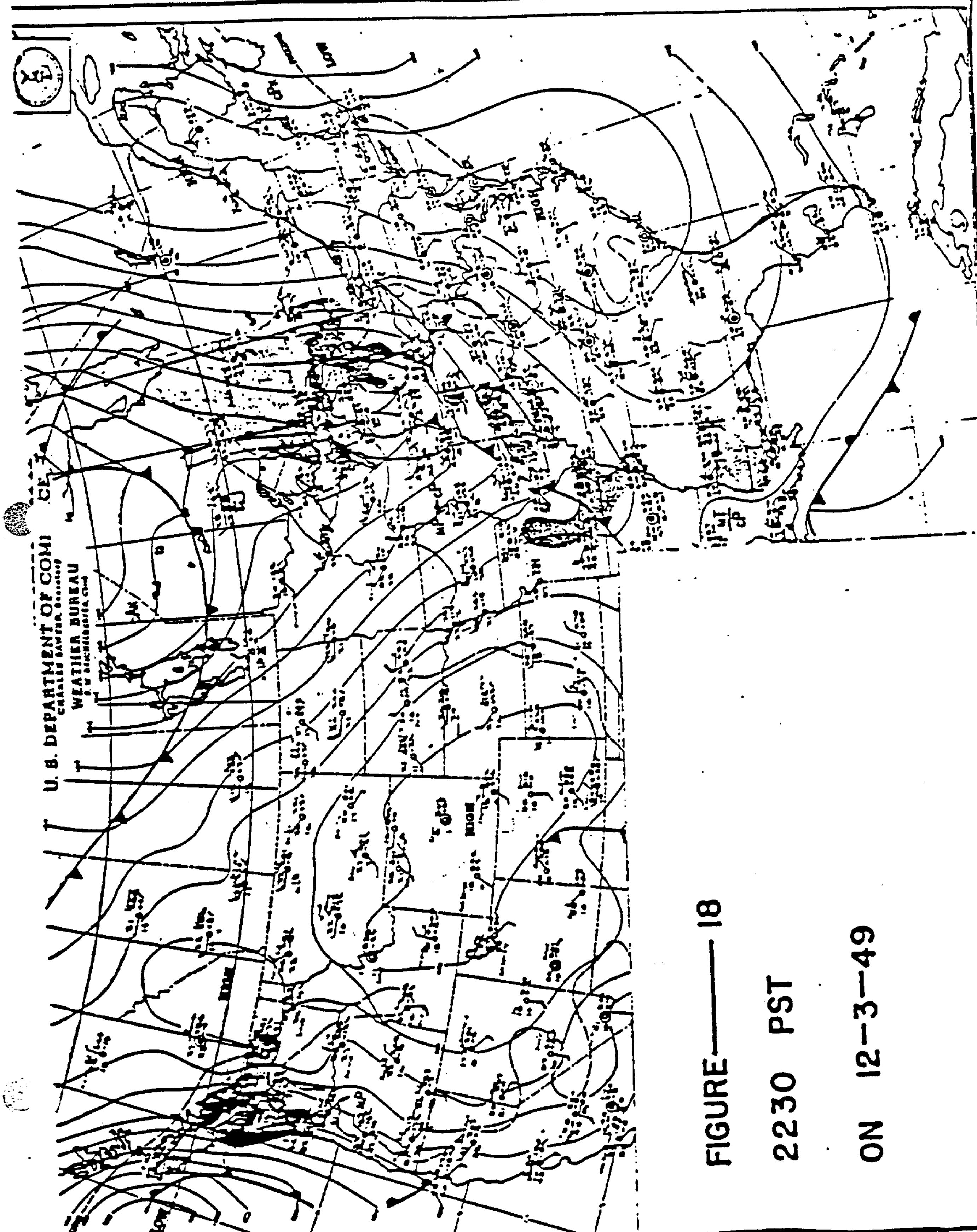


FIGURE — 18
2230 PST
ON 12-3-49

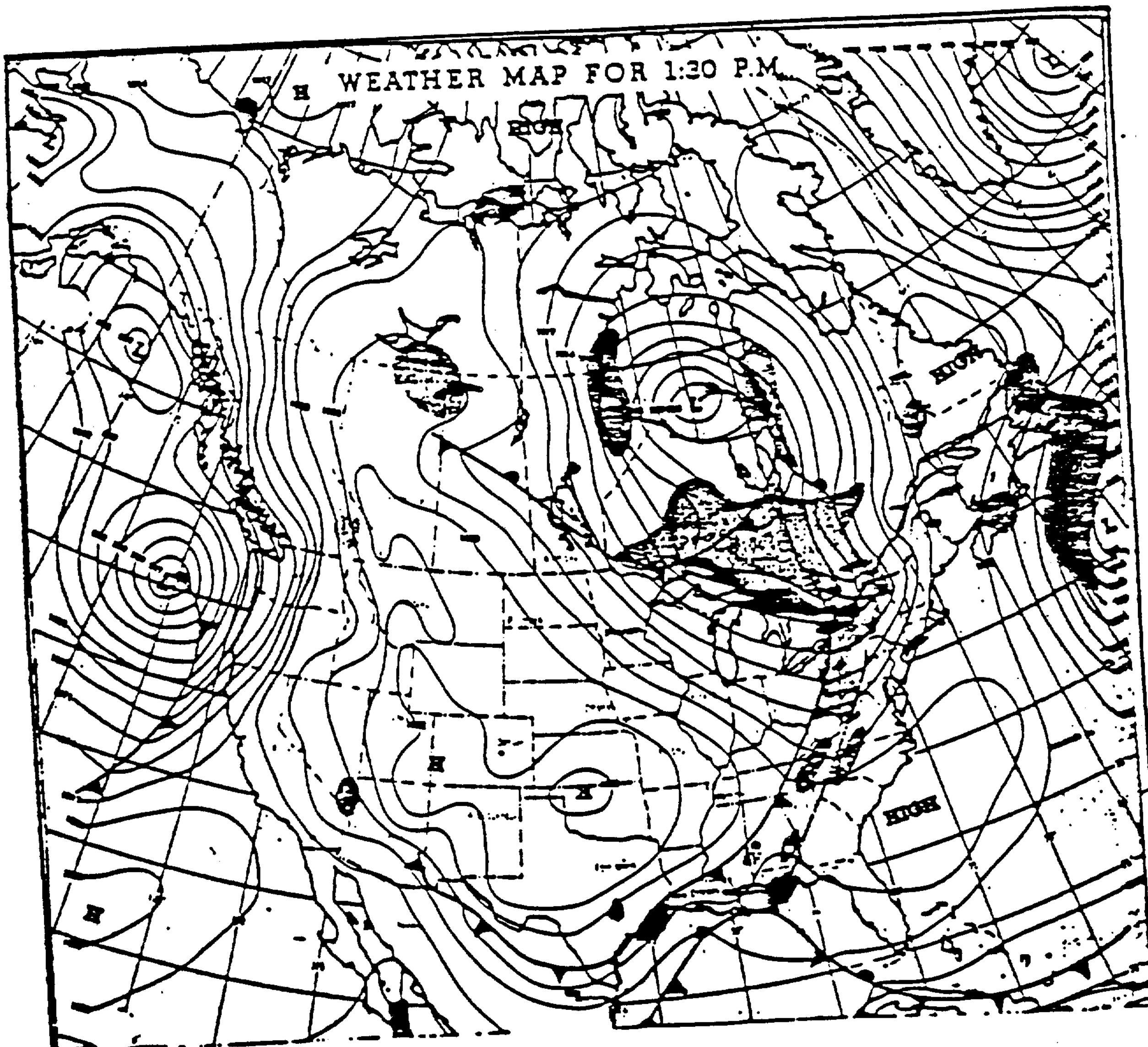


FIGURE — 19

1030 PST ON 12—4—49

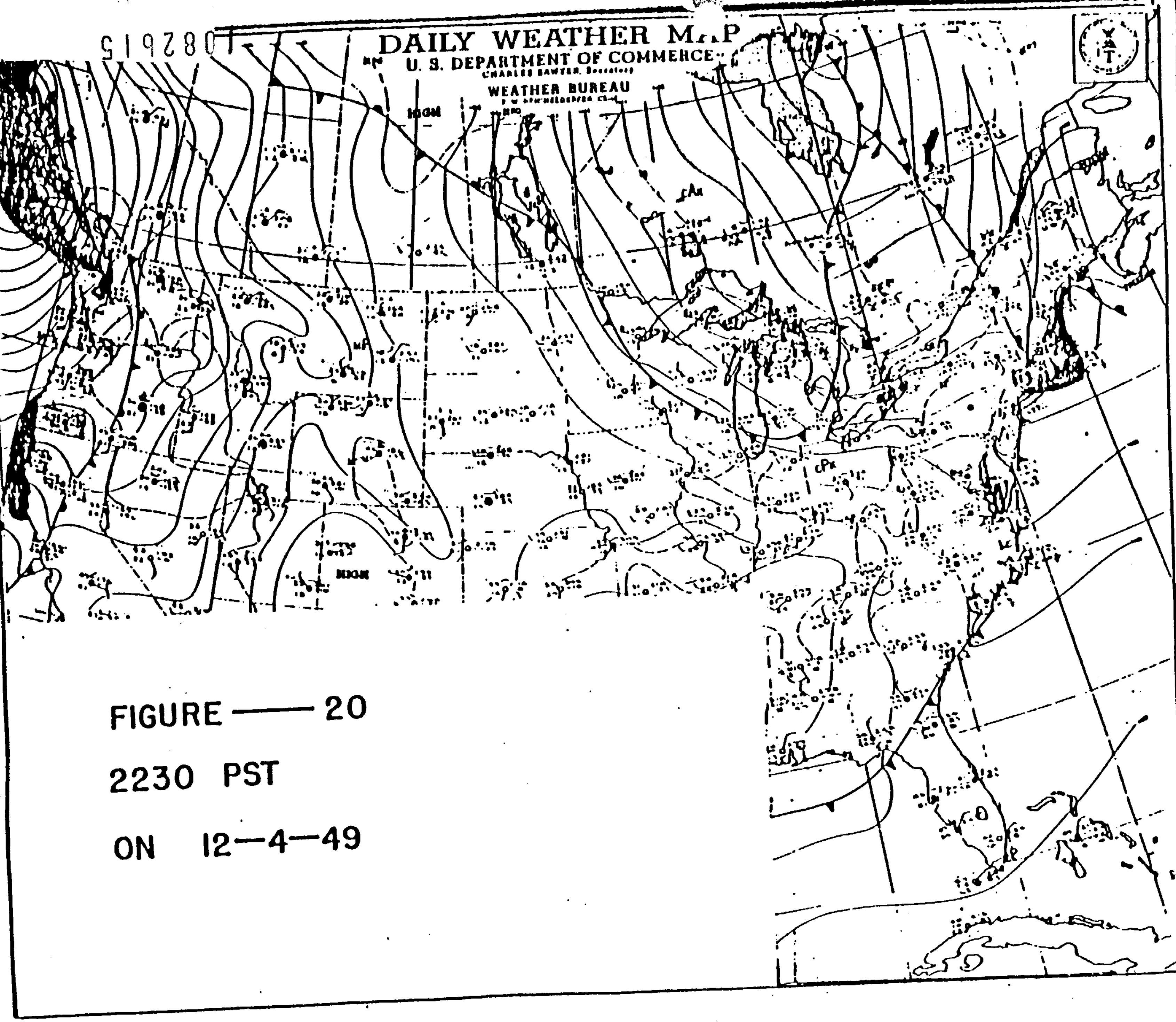


FIGURE —— 20
2230 PST
ON 12—4—49

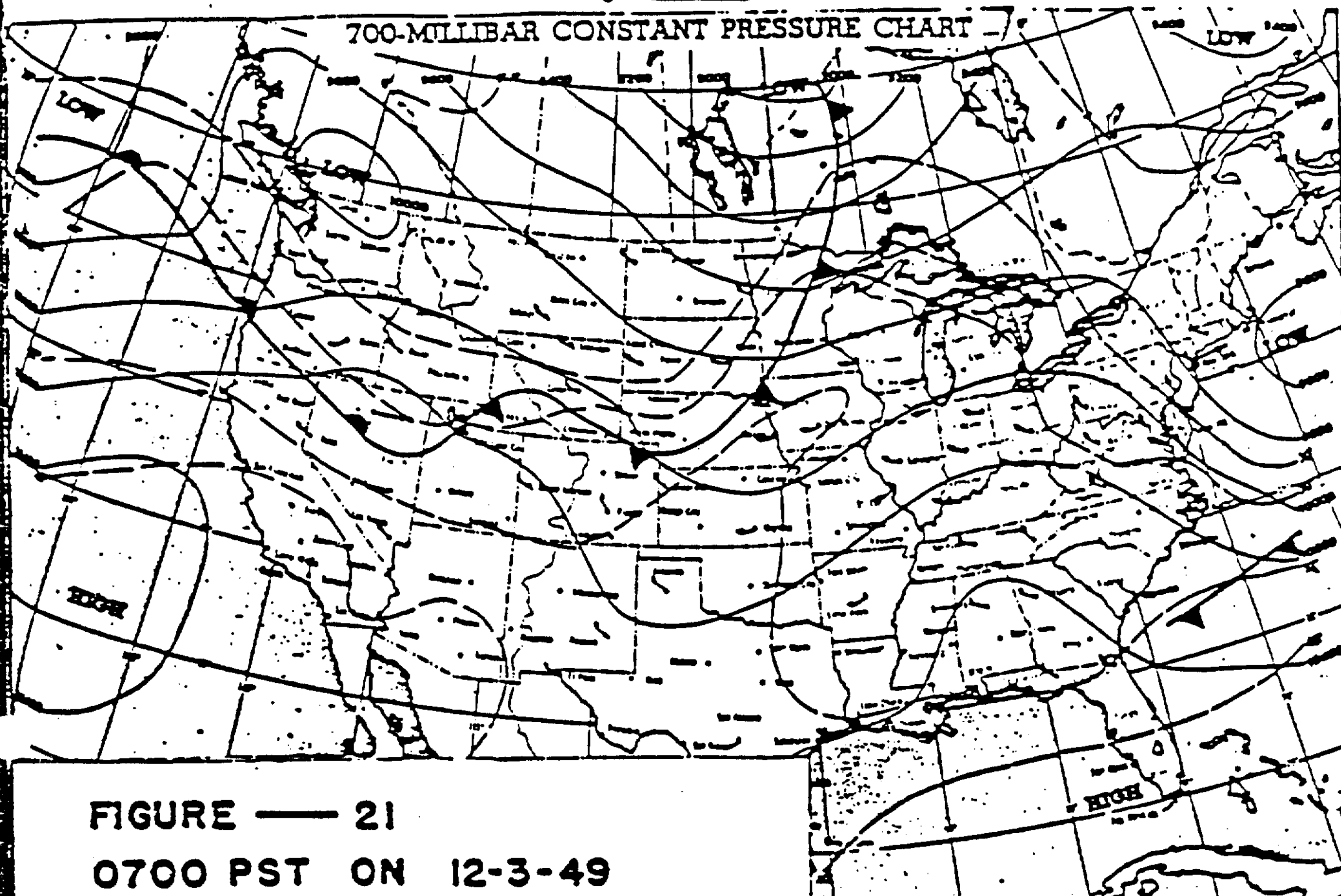


FIGURE — 21
0700 PST ON 12-3-49

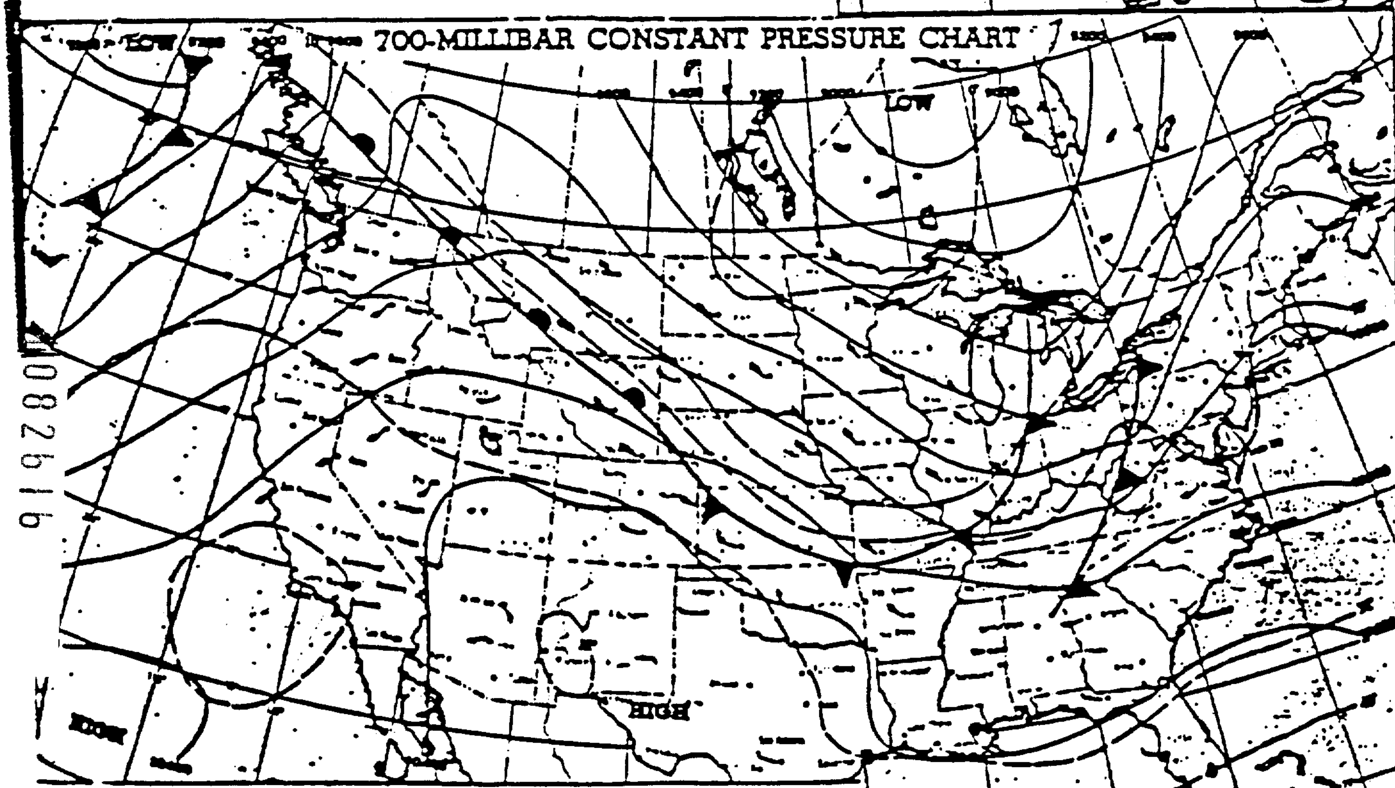


FIGURE — 22

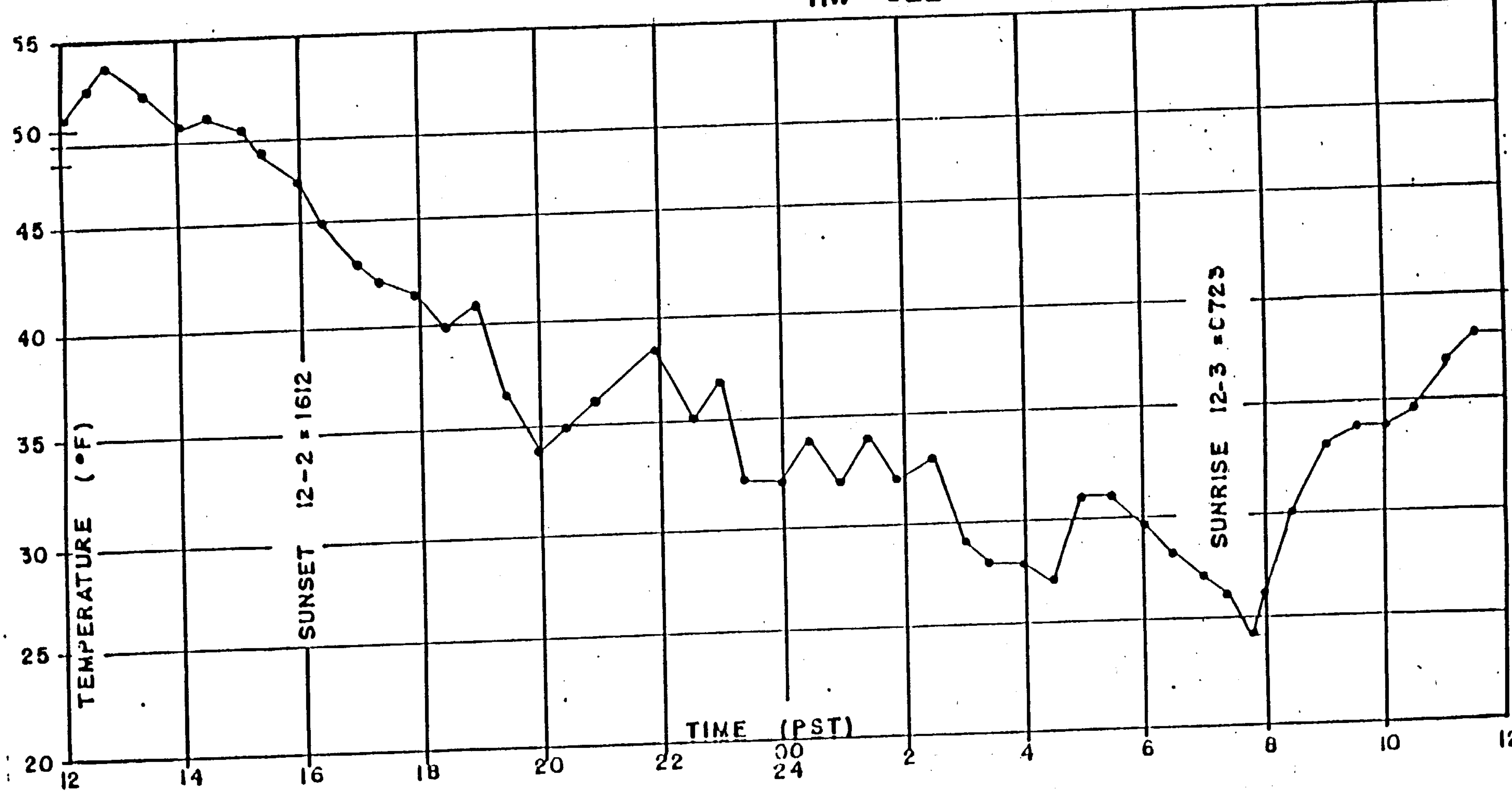
0082616

1082617

OBSERVED 3' LEVEL TEMPERATURES

AT

HW-622 BLDG. DEC. 2-3, 1949



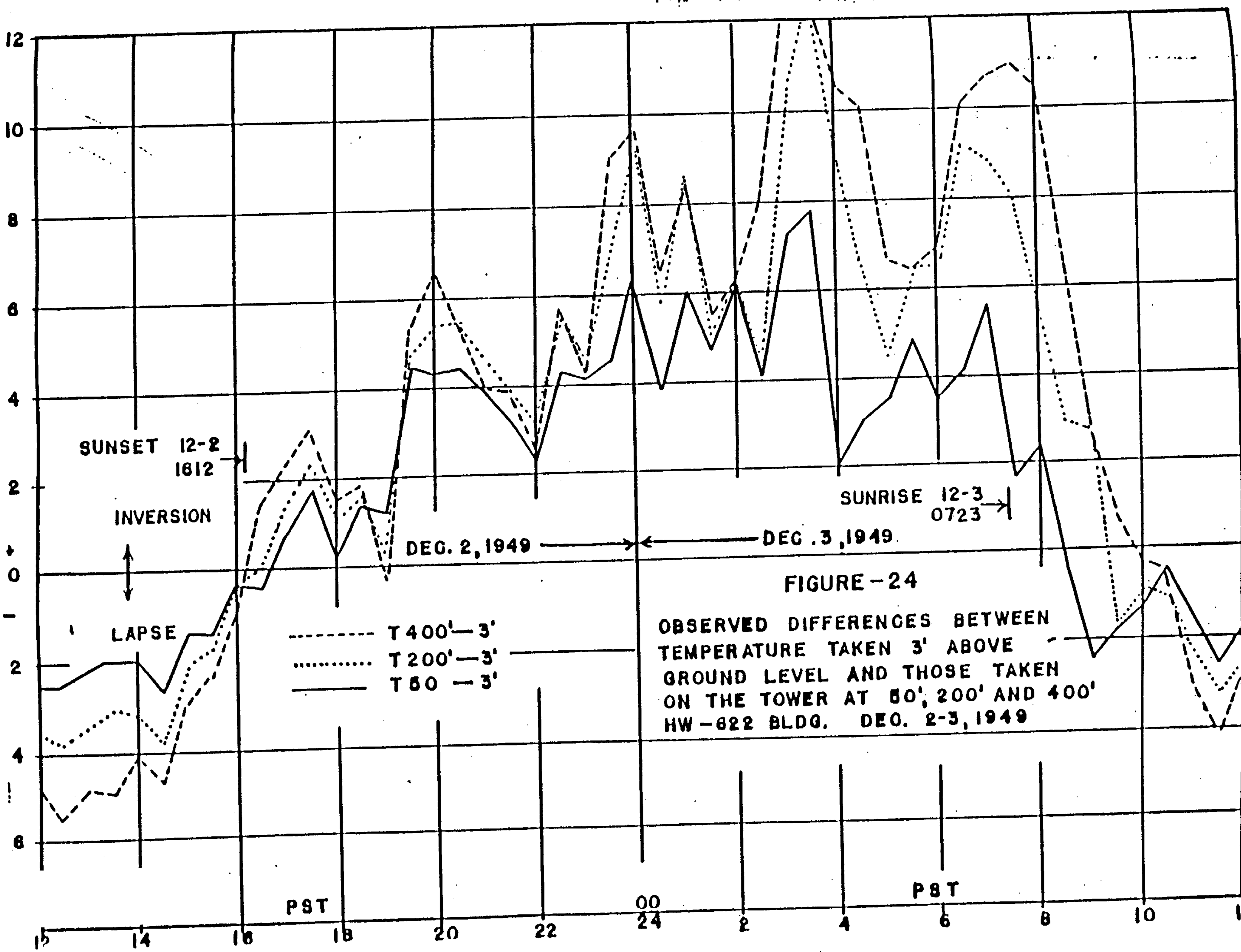
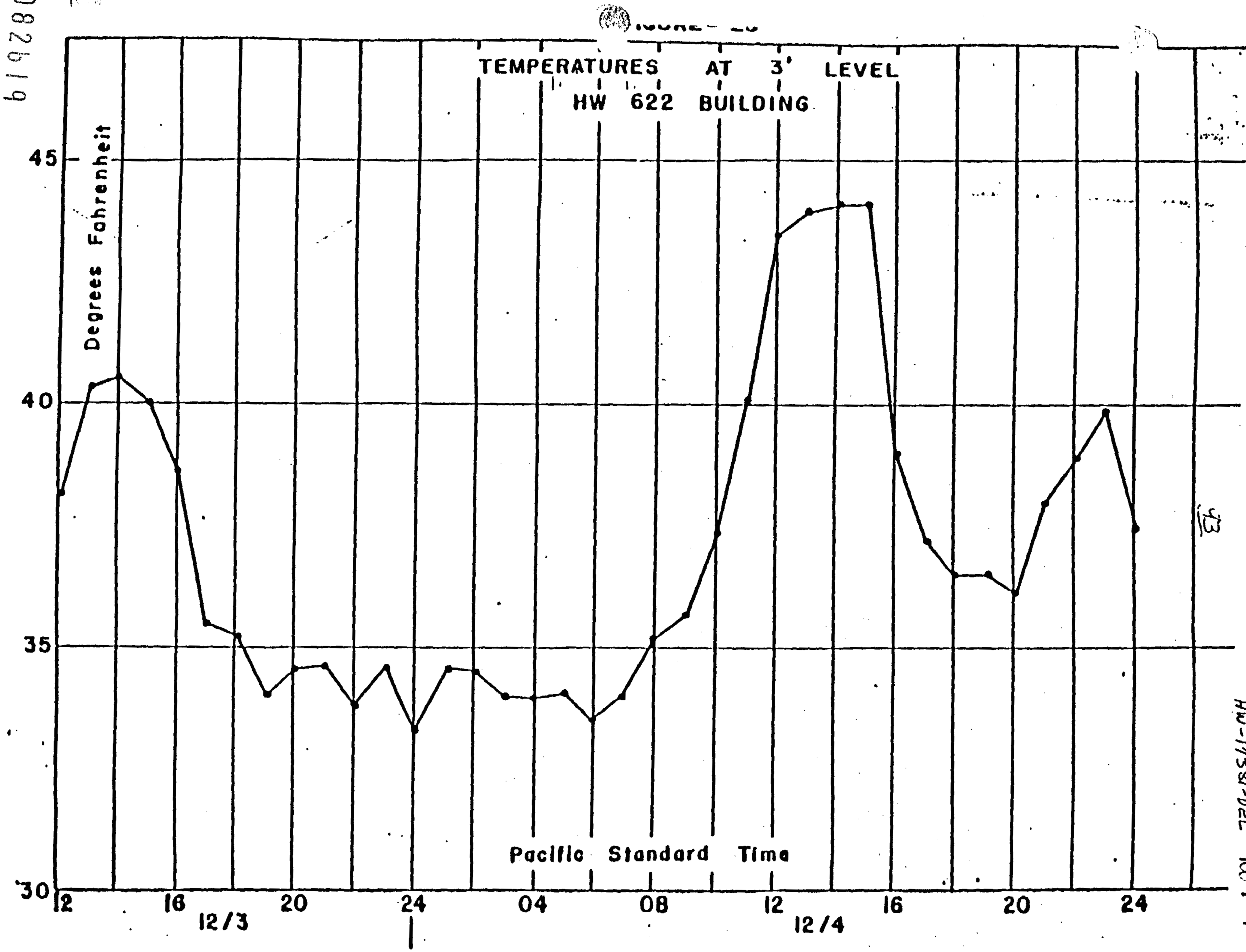


FIGURE - 24

OBSERVED DIFFERENCES BETWEEN TEMPERATURE TAKEN 3' ABOVE GROUND LEVEL AND THOSE TAKEN ON THE TOWER AT 50', 200' AND 400' HW-622 BLDG. DEC. 2-3, 1949



HW-17381-DEL KEY 1

93

1082619

FIGURE-26

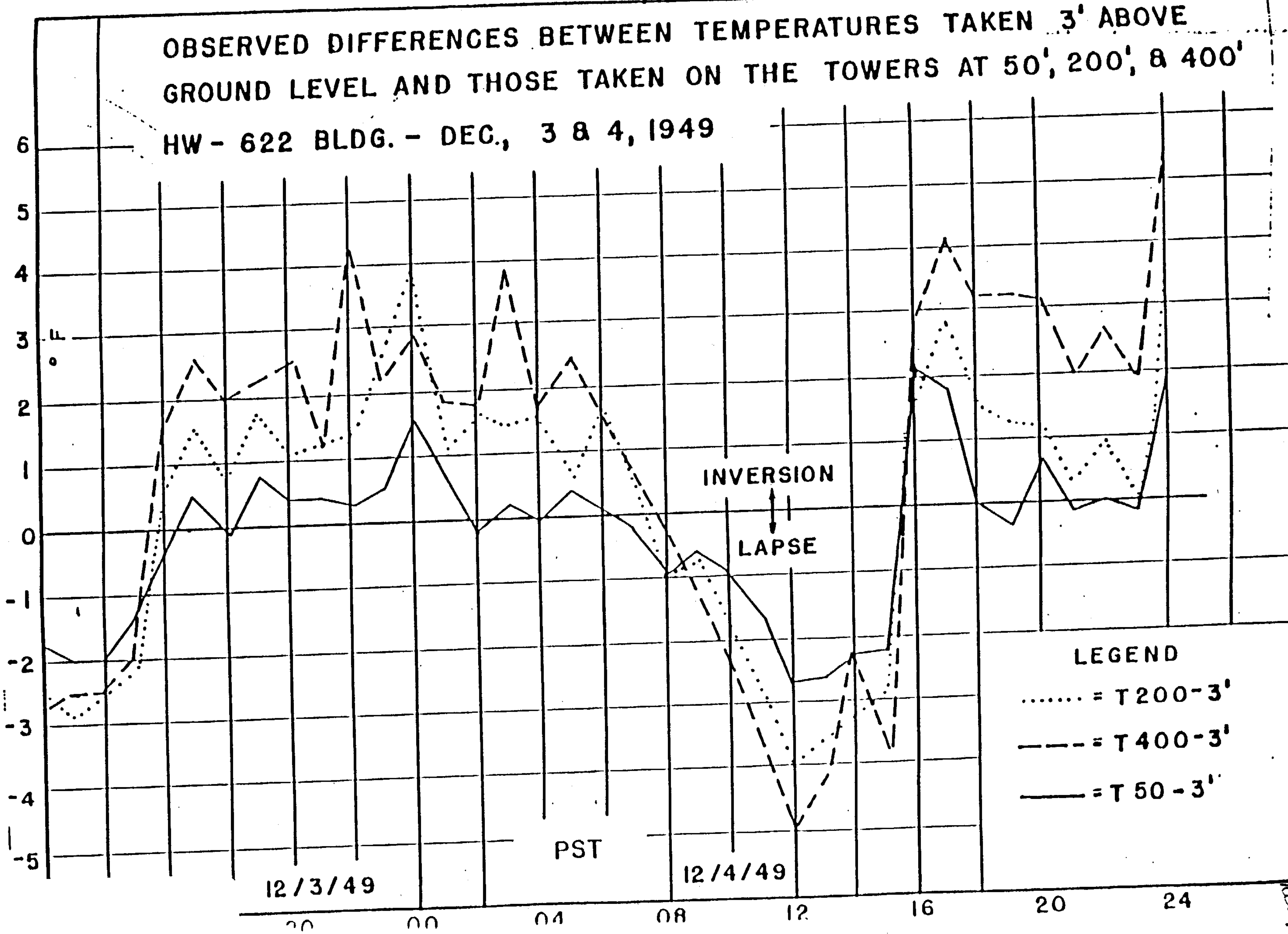
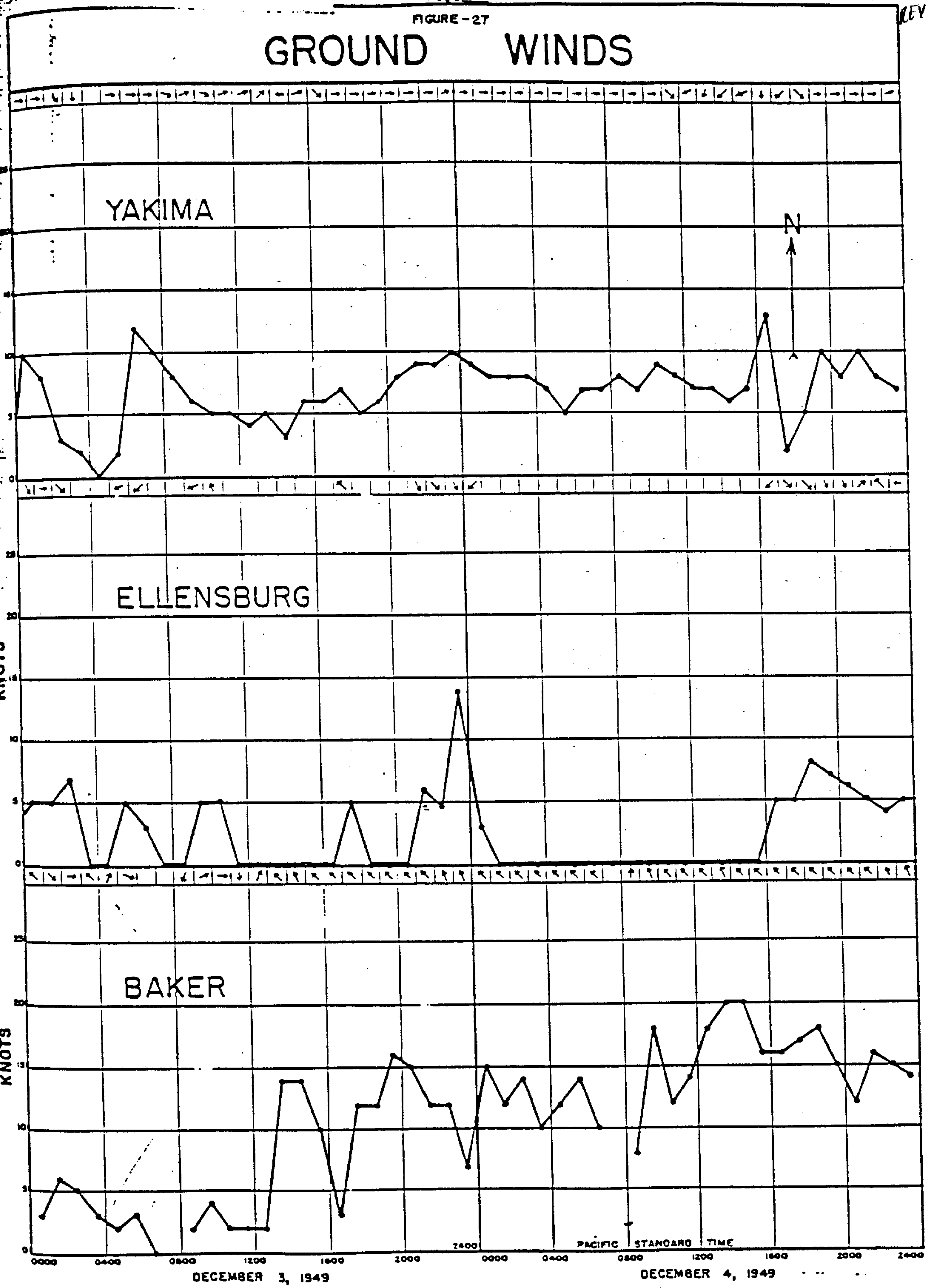

OBSERVED DIFFERENCES BETWEEN TEMPERATURES TAKEN 3' ABOVE GROUND LEVEL AND THOSE TAKEN ON THE TOWERS AT 50', 200', & 400'
HW - 622 BLDG. - DEC., 3 & 4, 1949
6
5
4
3
2
1
0
-1
-2
-3
-4
-5
°F
INVERSION
LAPSE
LEGEND
= T200-3'
= T400-3'
= T50-3'
PST
12/3/49
12/4/49
20
00
04
08
12
16
20
24

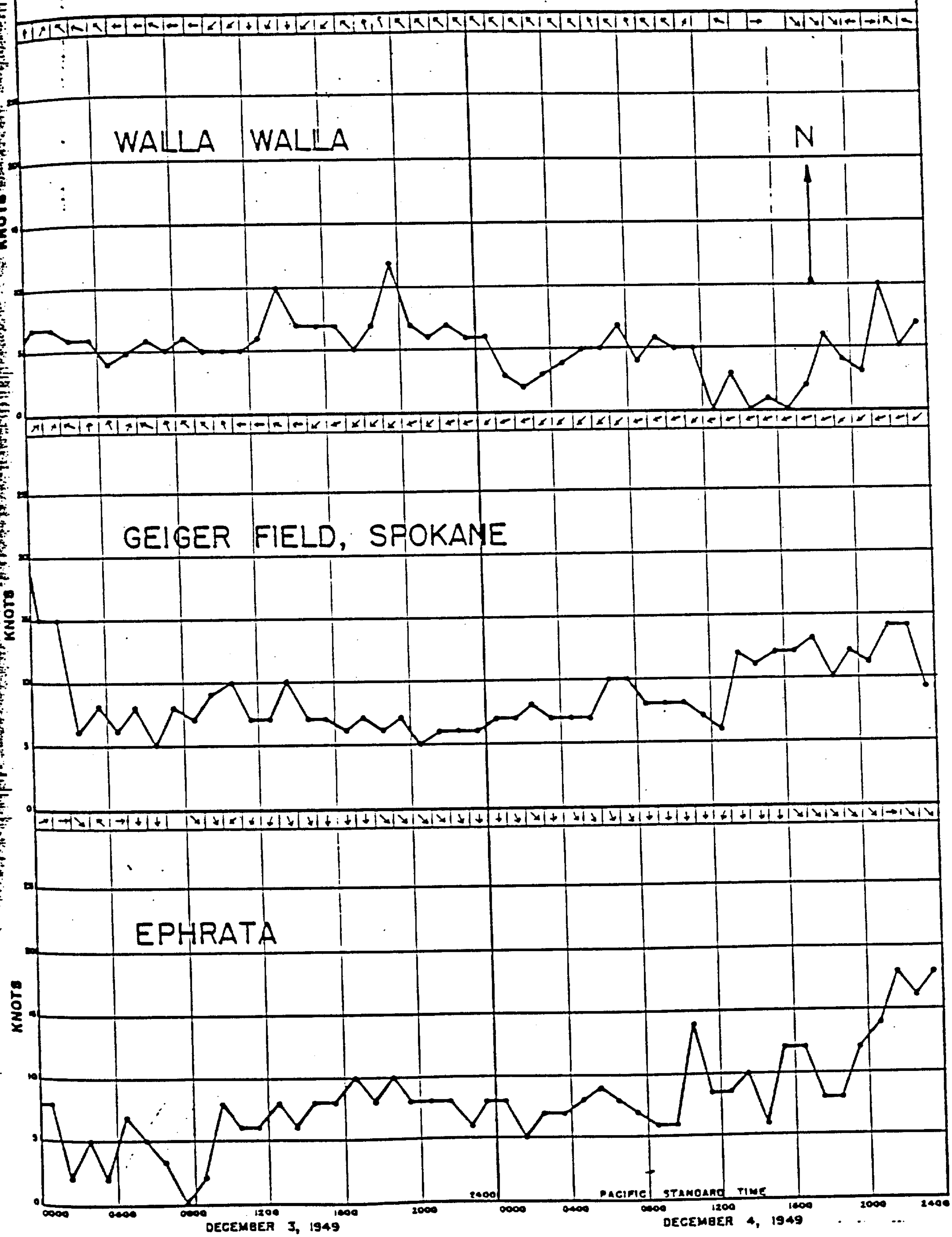
FIGURE - 27



1082621

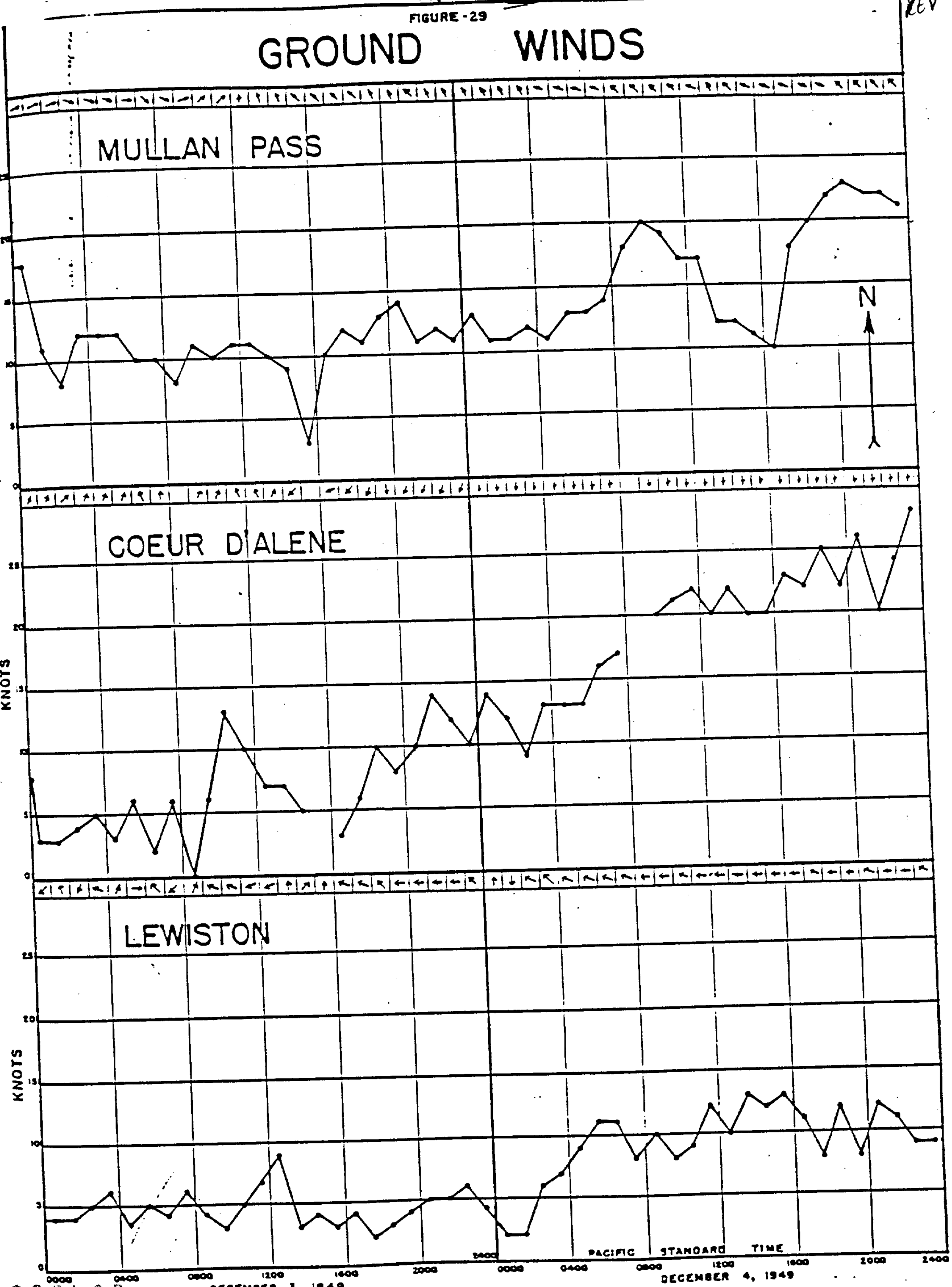
FIGURE - 28

GROUND WINDS



1297801

HW-17381-DEL
REV 1



1082623

FIGURE-30

GROUND WINDS

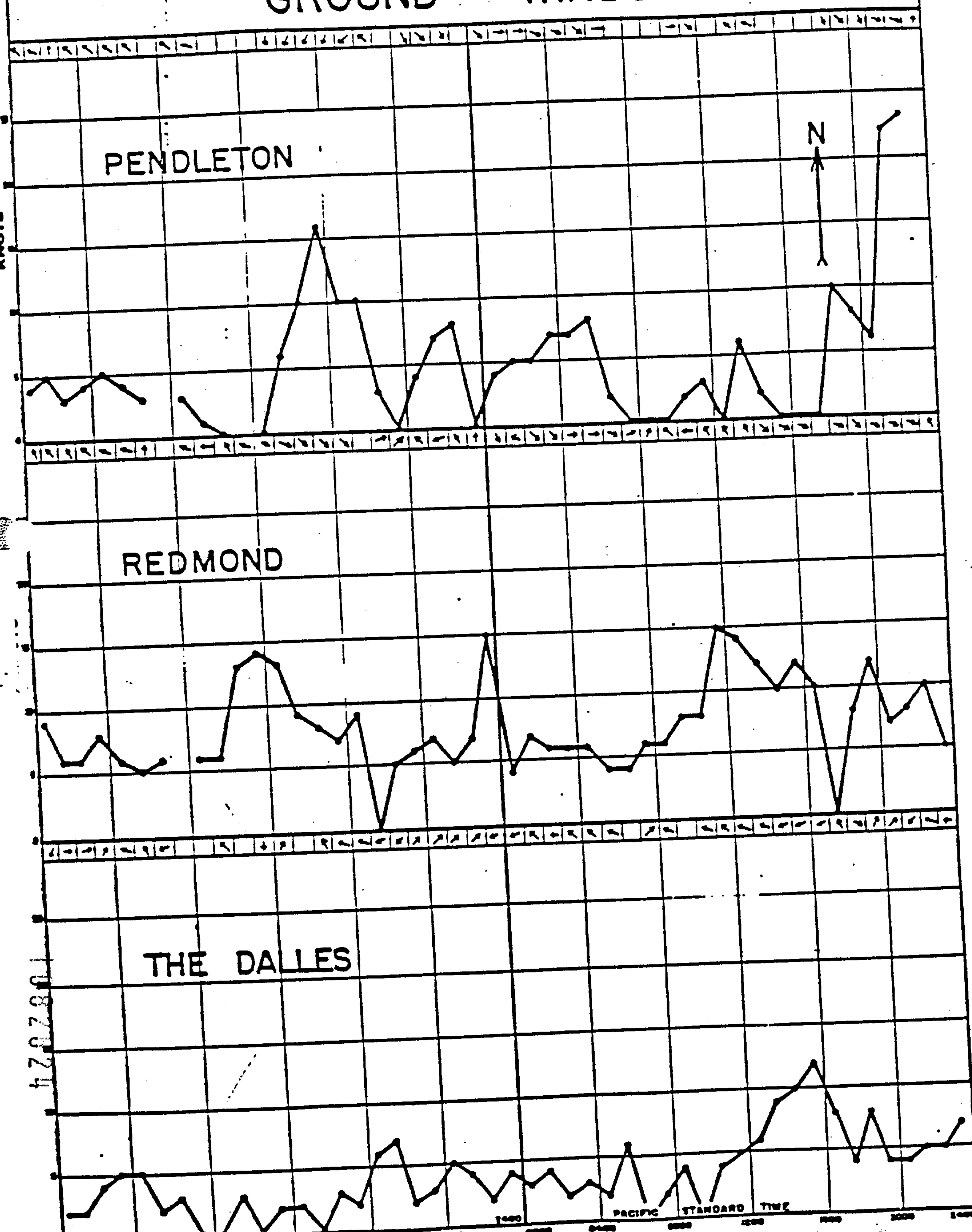


FIGURE - 31

GROUND WINDS

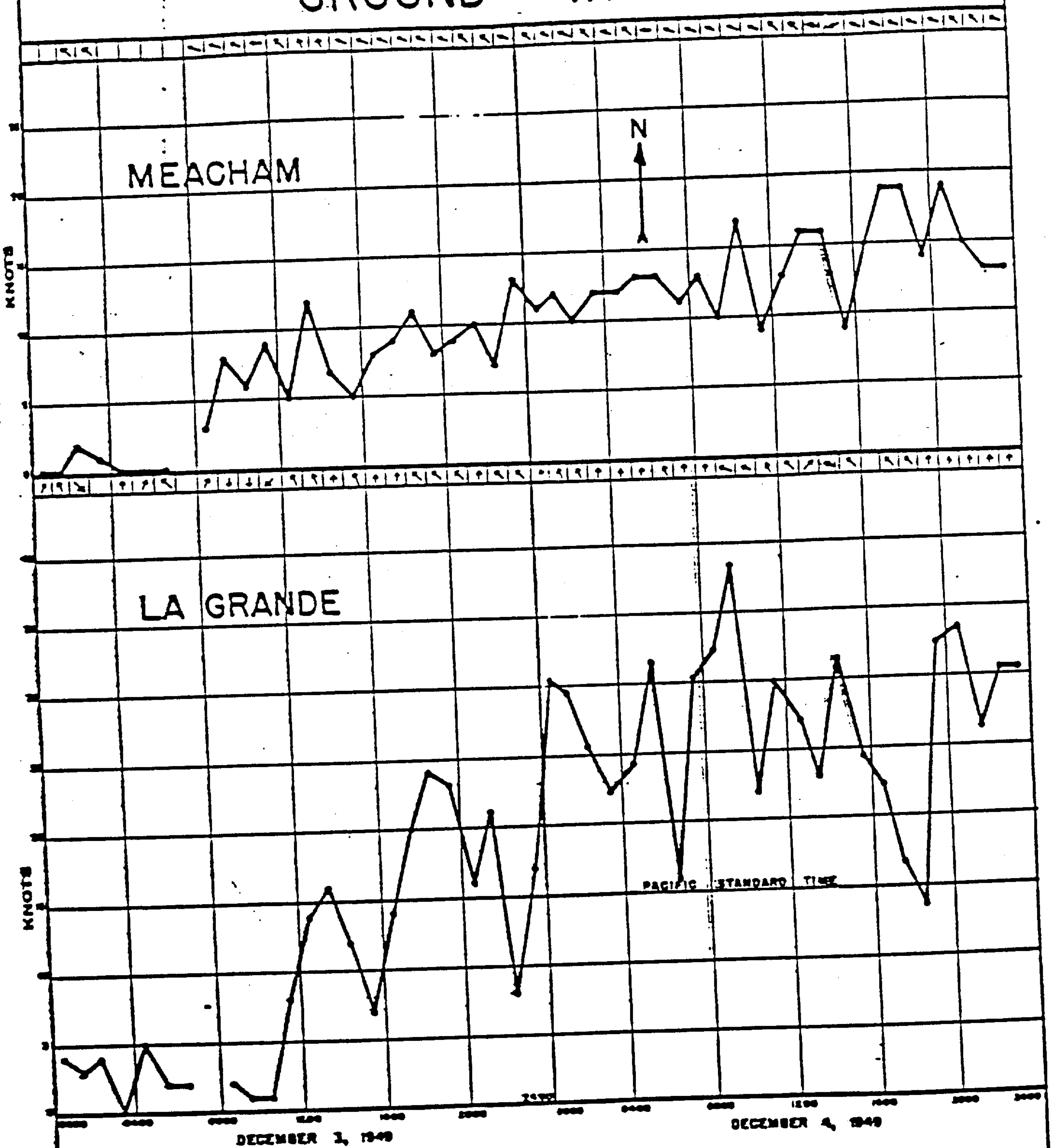
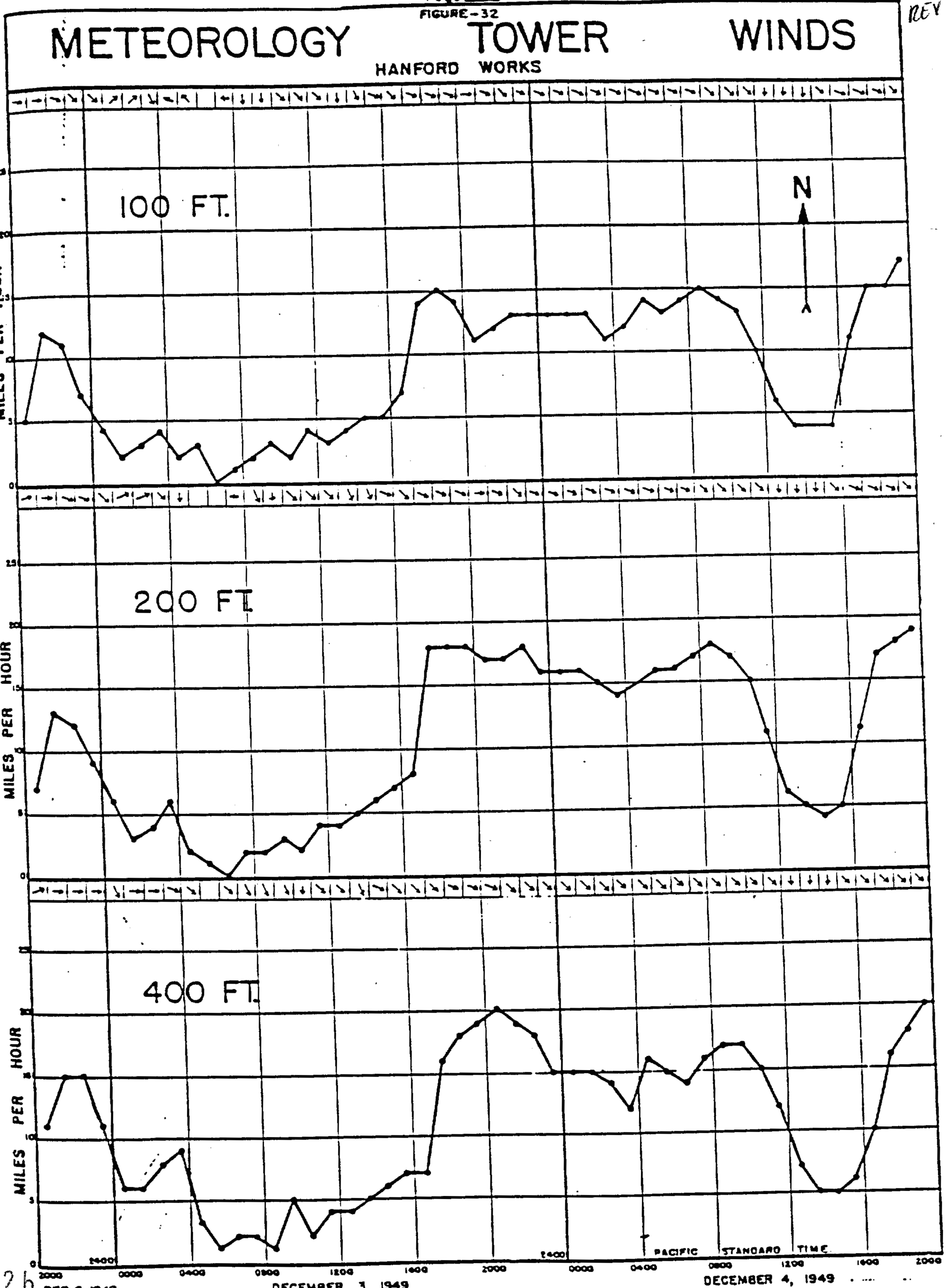


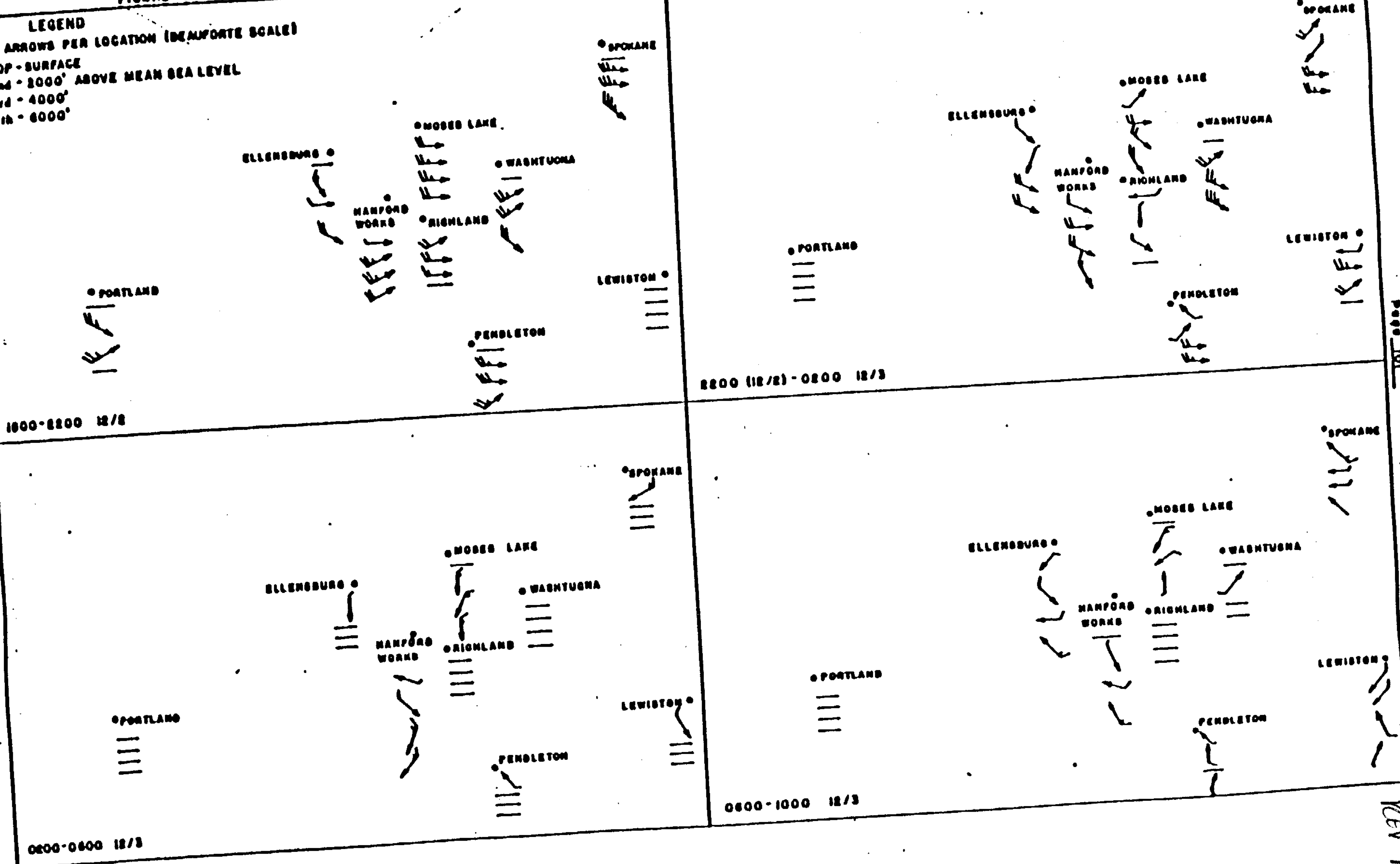
FIGURE-32


METEOROLOGY TOWER WINDS
HANFORD WORKS
100 FT.
200 FT.
400 FT.
N
MILES PER HOUR
PACIFIC STANDARD TIME
DEC. 2, 1949
DECEMBER 3, 1949
DECEMBER 4, 1949

1082627

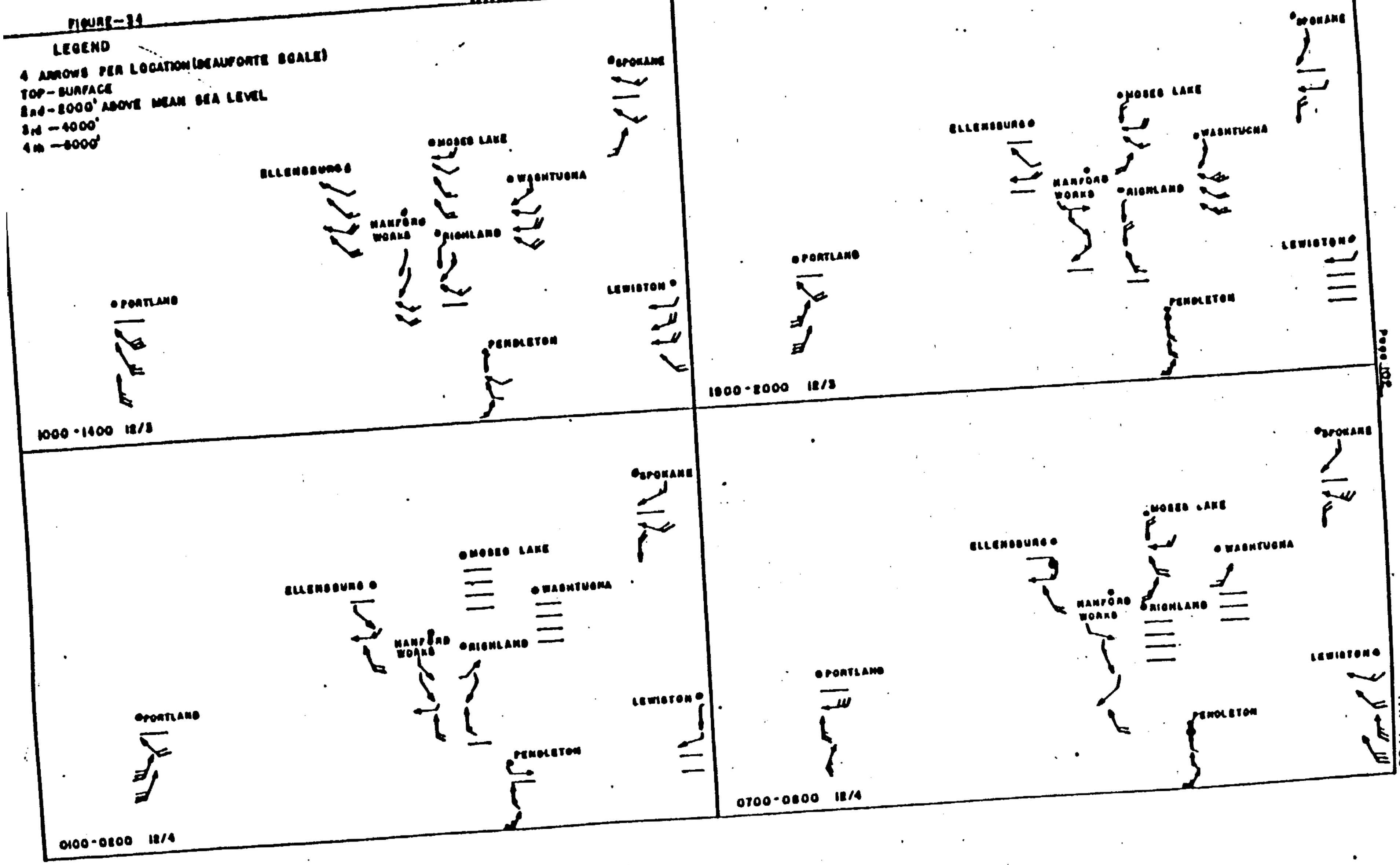
WINDS ALOFT — PACIFIC NORTHWEST

FIGURE-33



WINDS ALOFT — PACIFIC NORTHWEST

FIGURE-34



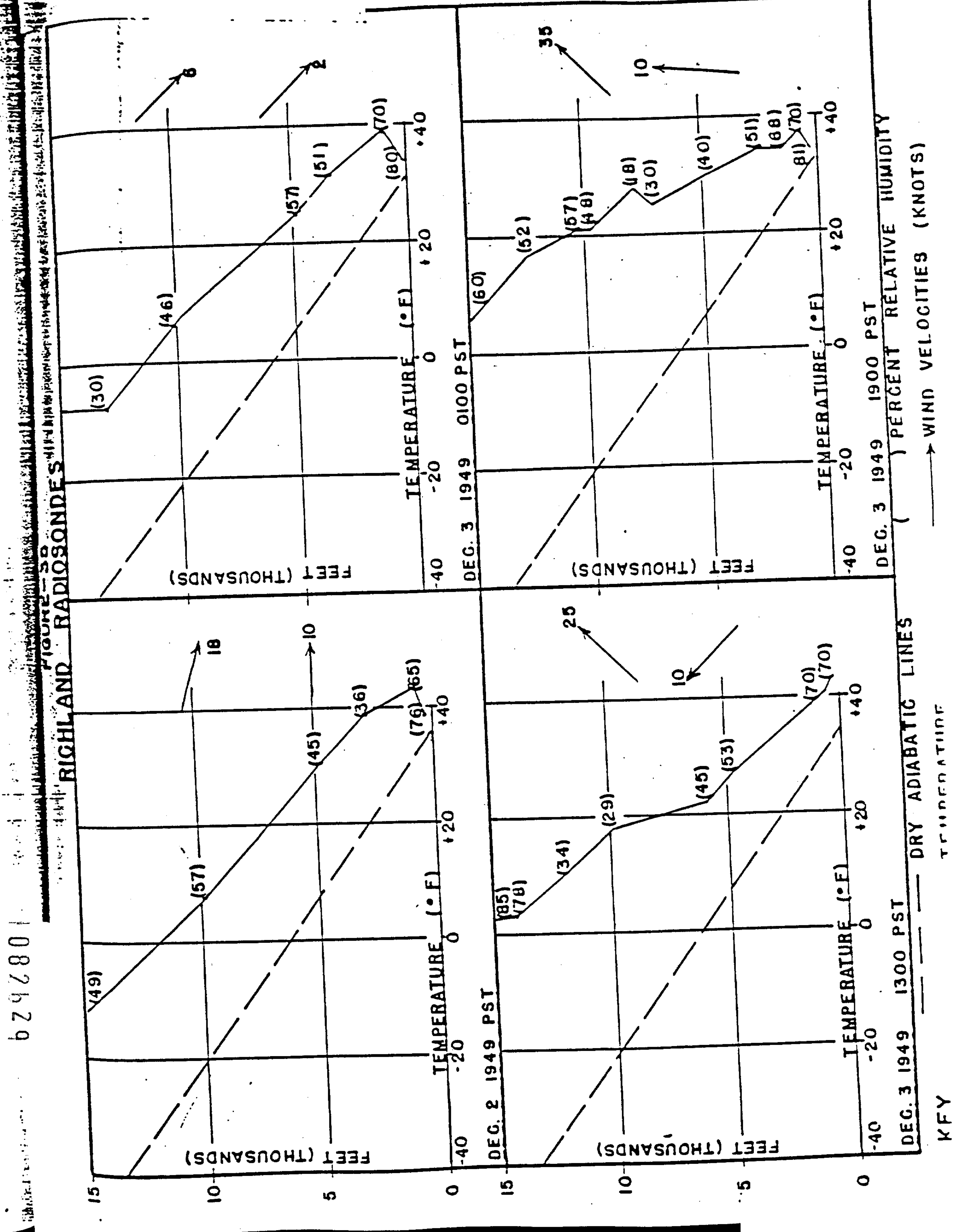


FIGURE 58
RICHLAND RADIOSONDES
DEC. 2 1949 PST
DEC. 3 1949 0100 PST
DEC. 3 1949 1300 PST
DEC. 3 1949 1900 PST
TEMPERATURE (°F)
FEET (THOUSANDS)
-40 -20 0 +20 +40
0 5 10 15
KEY
( ) PERCENT RELATIVE HUMIDITY
→ WIND VELOCITIES (KNOTS)
— — — DRY ADIABATIC LINES
TEMPERATURE

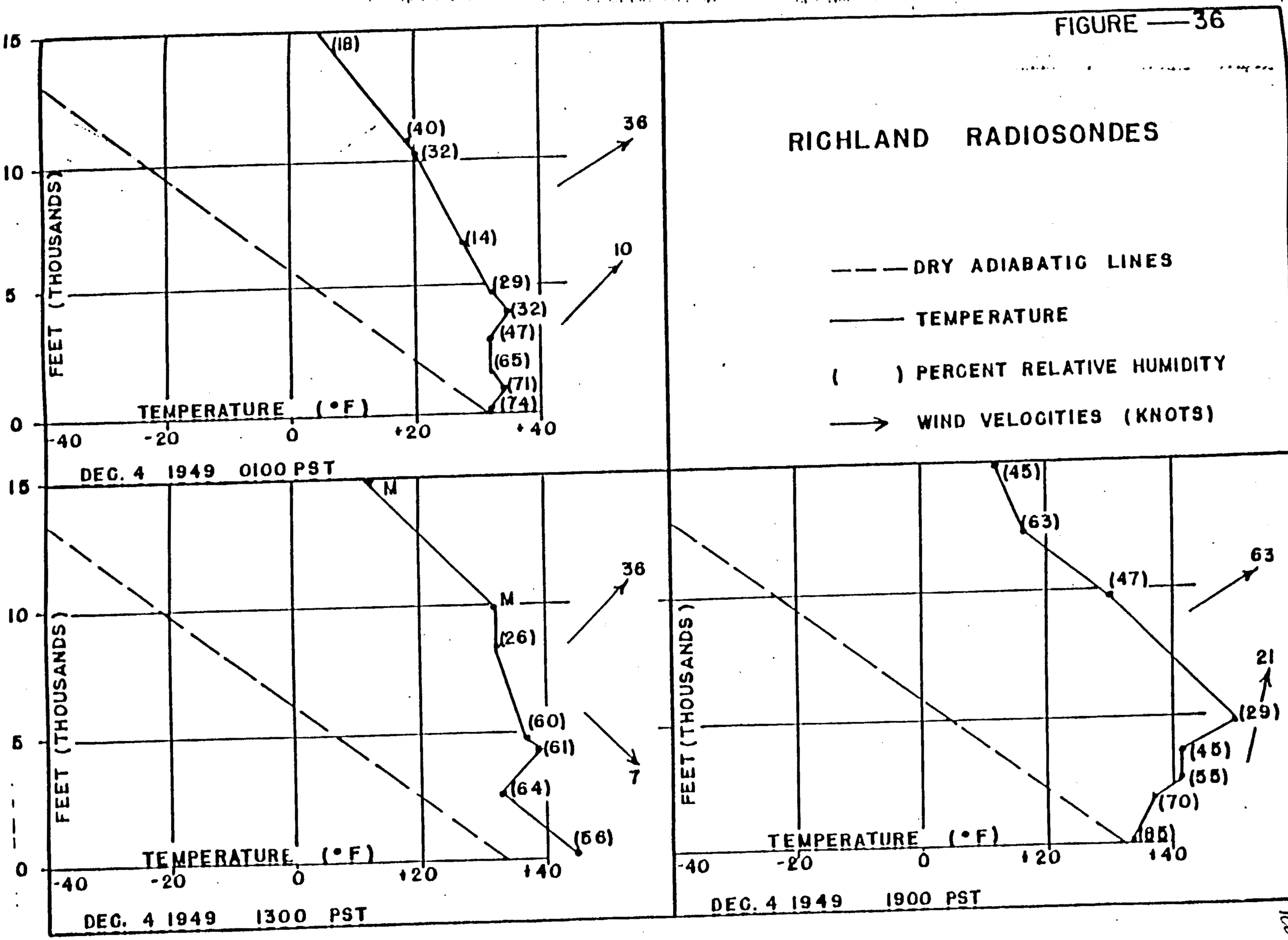


FIGURE — 36
RICHLAND RADIOSONDES
- - - DRY ADIABATIC LINES
—— TEMPERATURE
( ) PERCENT RELATIVE HUMIDITY
→ WIND VELOCITIES (KNOTS)
FEET (THOUSANDS)
TEMPERATURE (°F)
-40 -20 0 +20 +40
0 5 10 15
(18) (40) (32) (14) (29) (32) (47) (65) (71) (74)
36
10
DEC. 4 1949 0100 PST
M M (26) (60) (61) (64) (56)
36
7
DEC. 4 1949 1300 PST
(45) (63) (47) (29) (45) (55) (70) (85)
63
21
DEC. 4 1949 1900 PST

FIGURE - 37

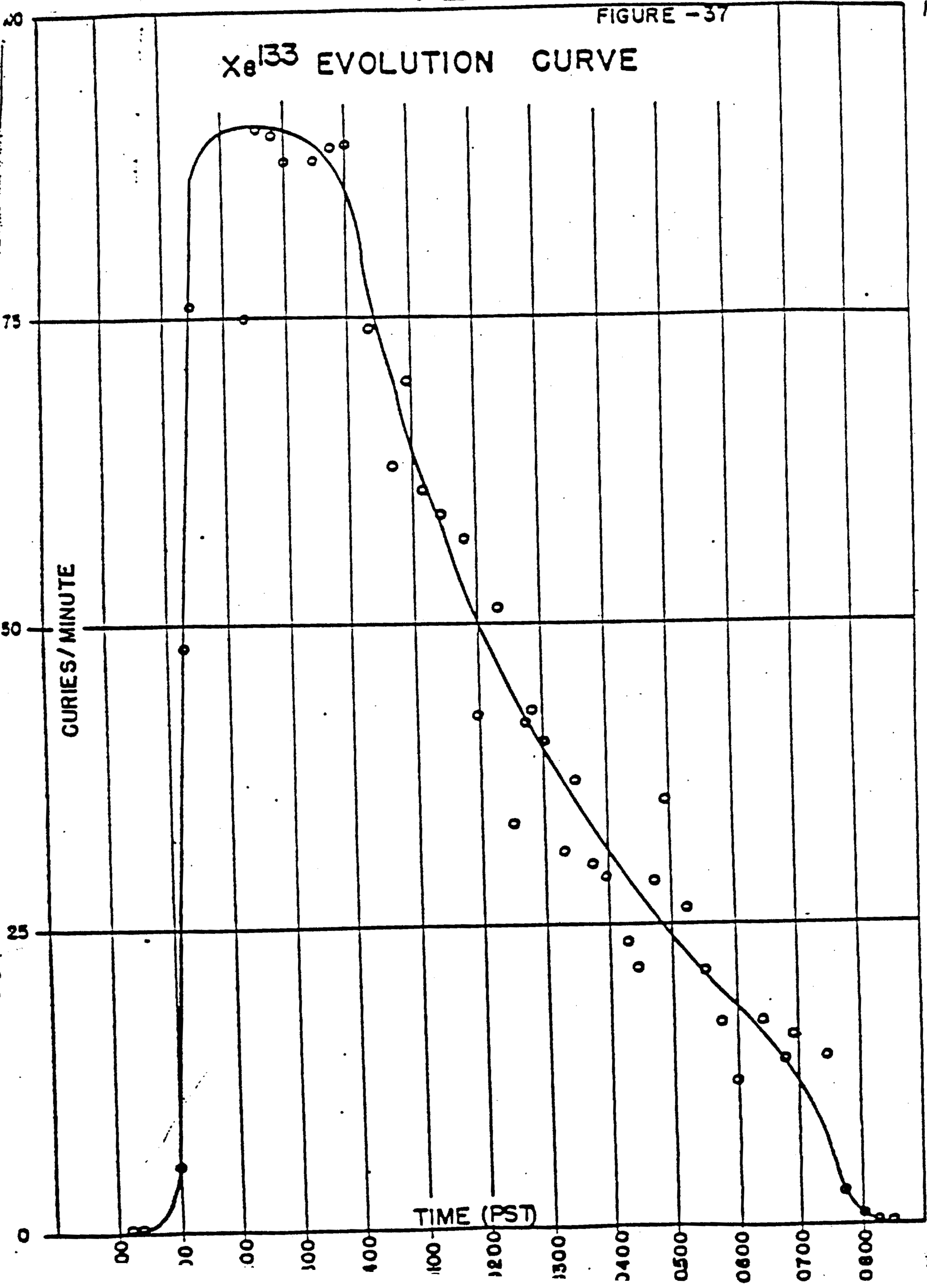
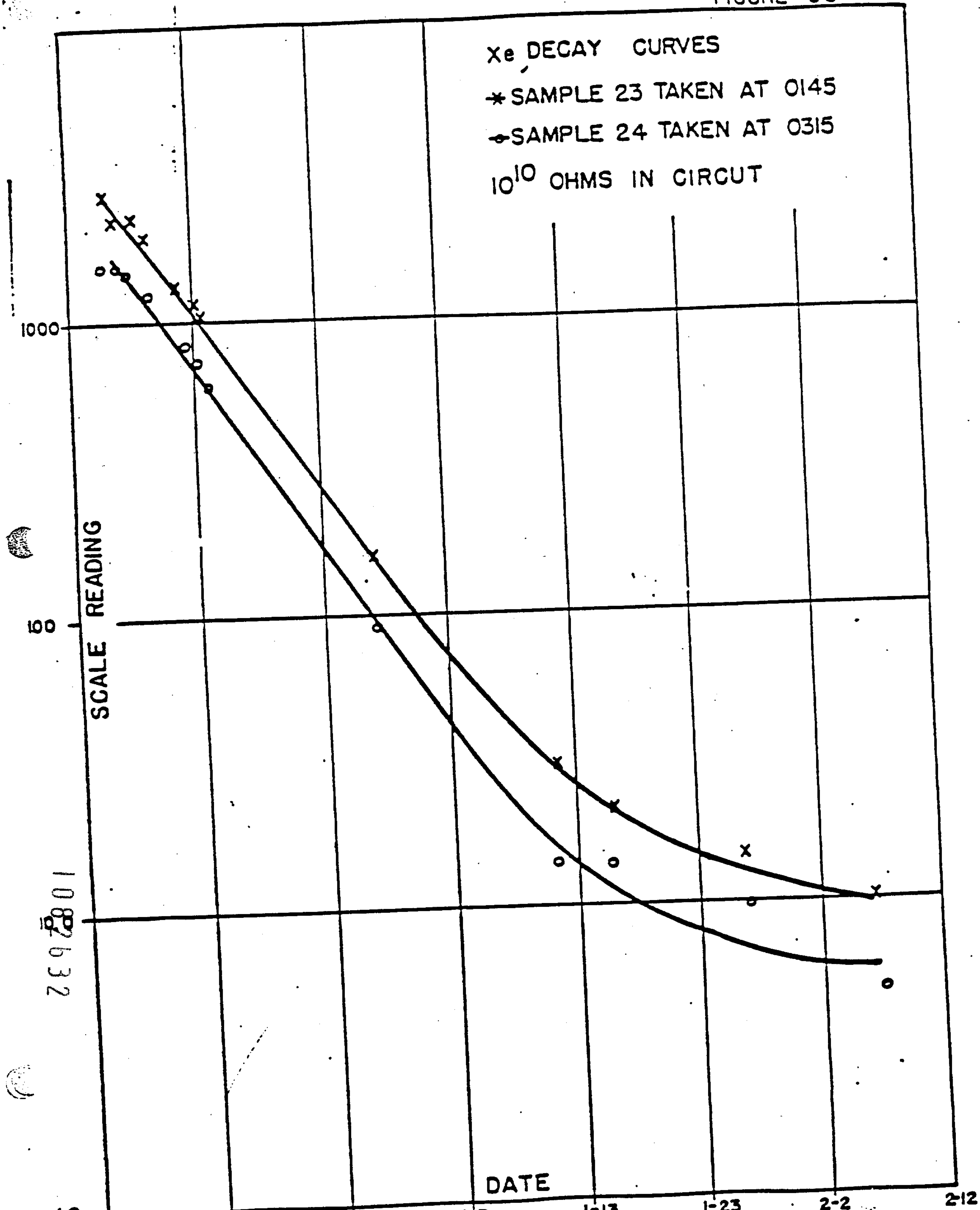

Xe133 EVOLUTION CURVE
CURIES/MINUTE
75
50
25
0
TIME (PST)
1200
1300
0400
0500
0600
0700
0800

FIGURE-38


Xe DECAY CURVES
SAMPLE 23 TAKEN AT 0145
SAMPLE 24 TAKEN AT 0315
10^10 OHMS IN CIRCUT
1000
100
10
SCALE READING
DATE
1-13
1-23
2-2
2-12

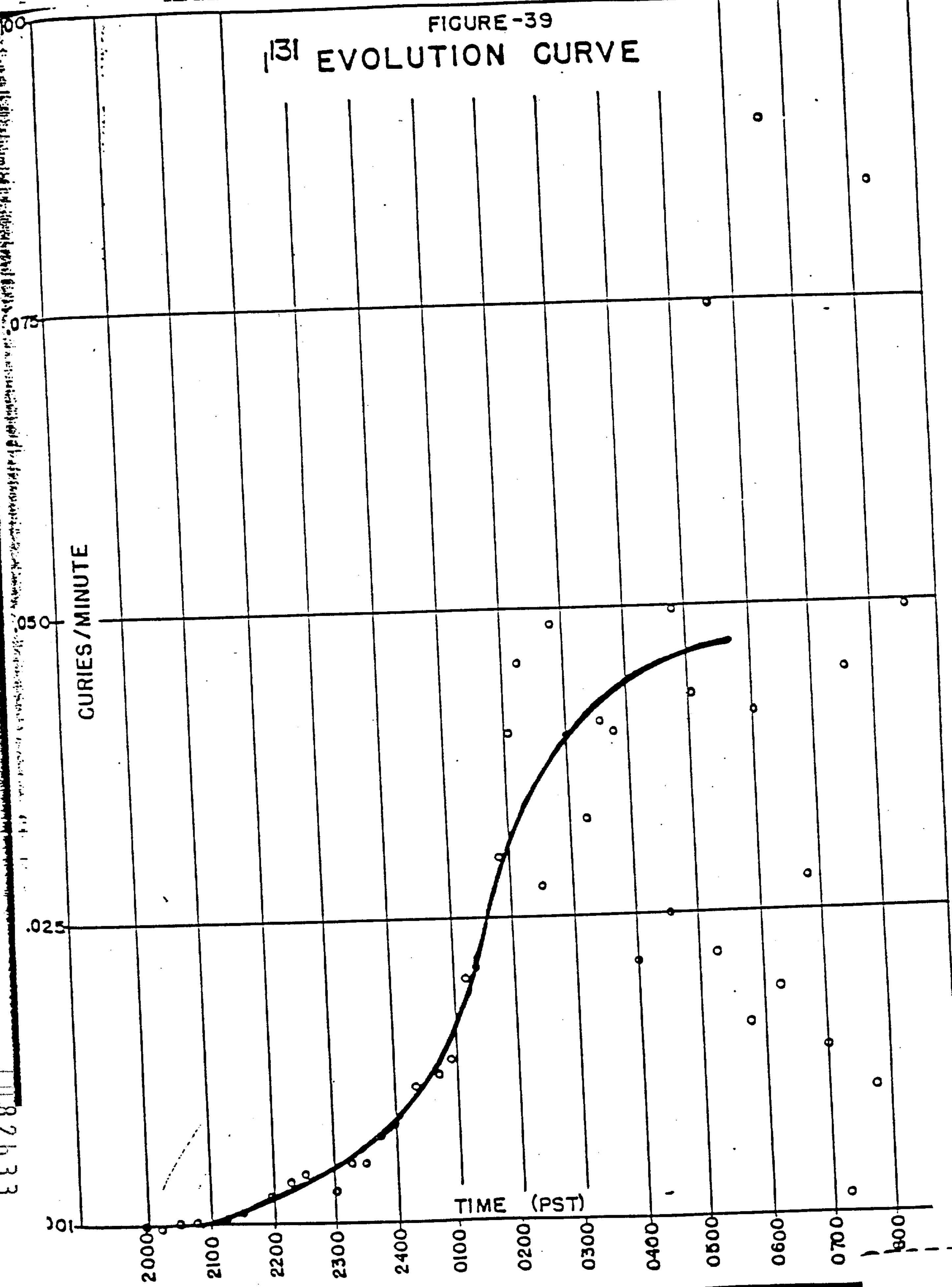


FIGURE-39
I^{131} EVOLUTION CURVE
CURIES/MINUTE
.100
.075
.050
.025
.001
TIME (PST)
2000
2100
2200
2300
2400
0100
0200
0300
0400
0500
0600
0700
0800

FIGURE—40

CONSTANT AIR MONITOR READINGS

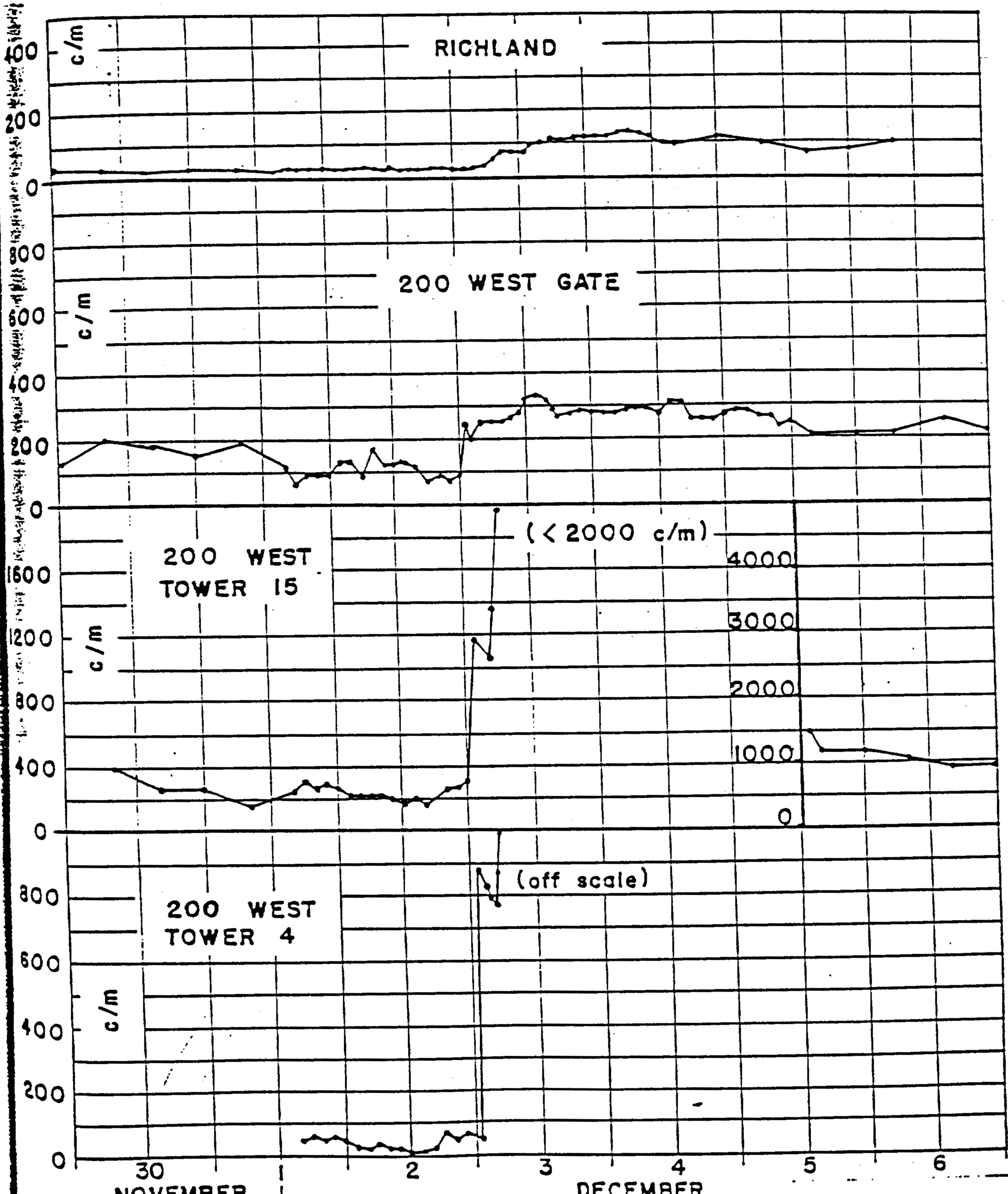
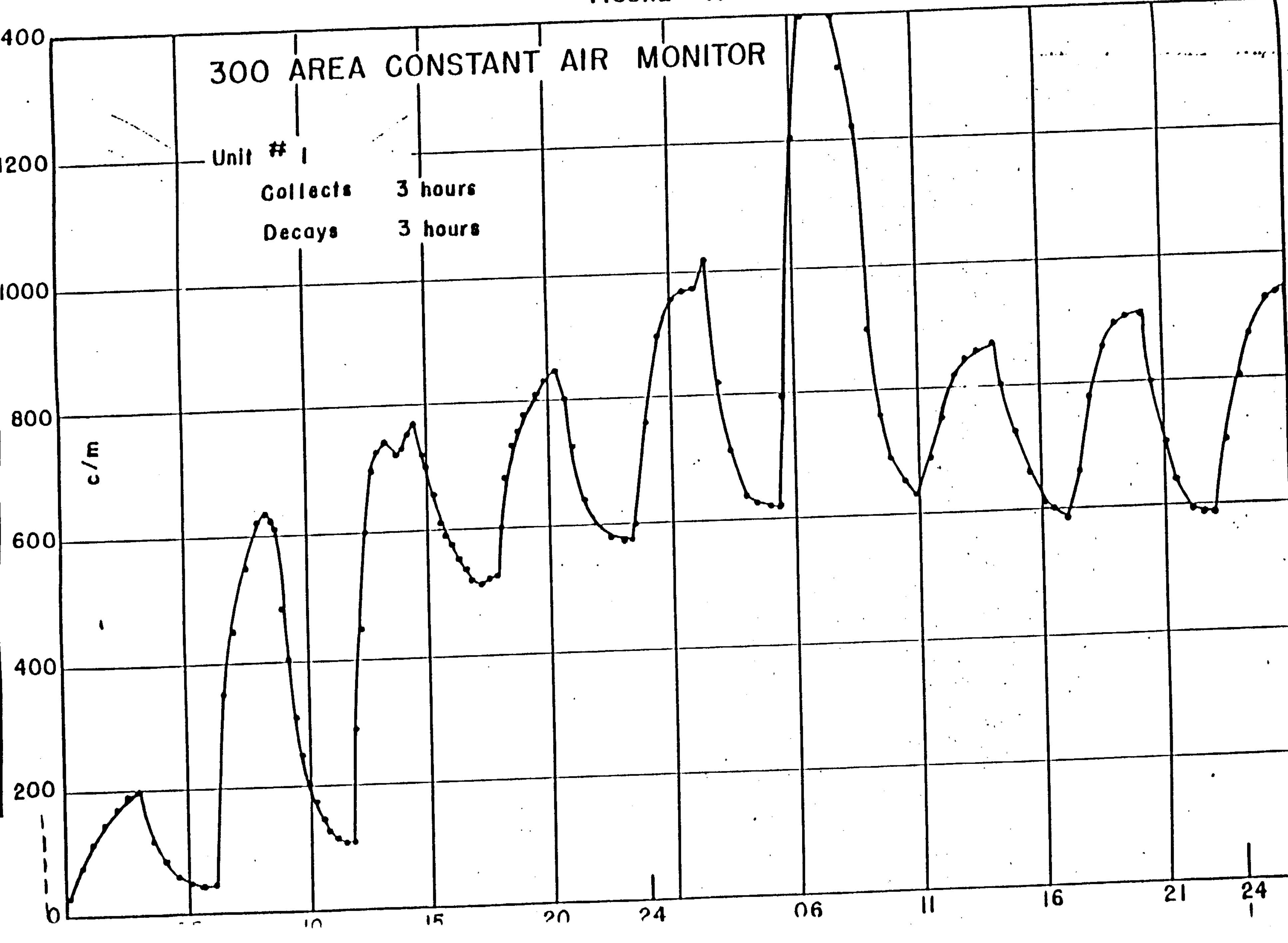
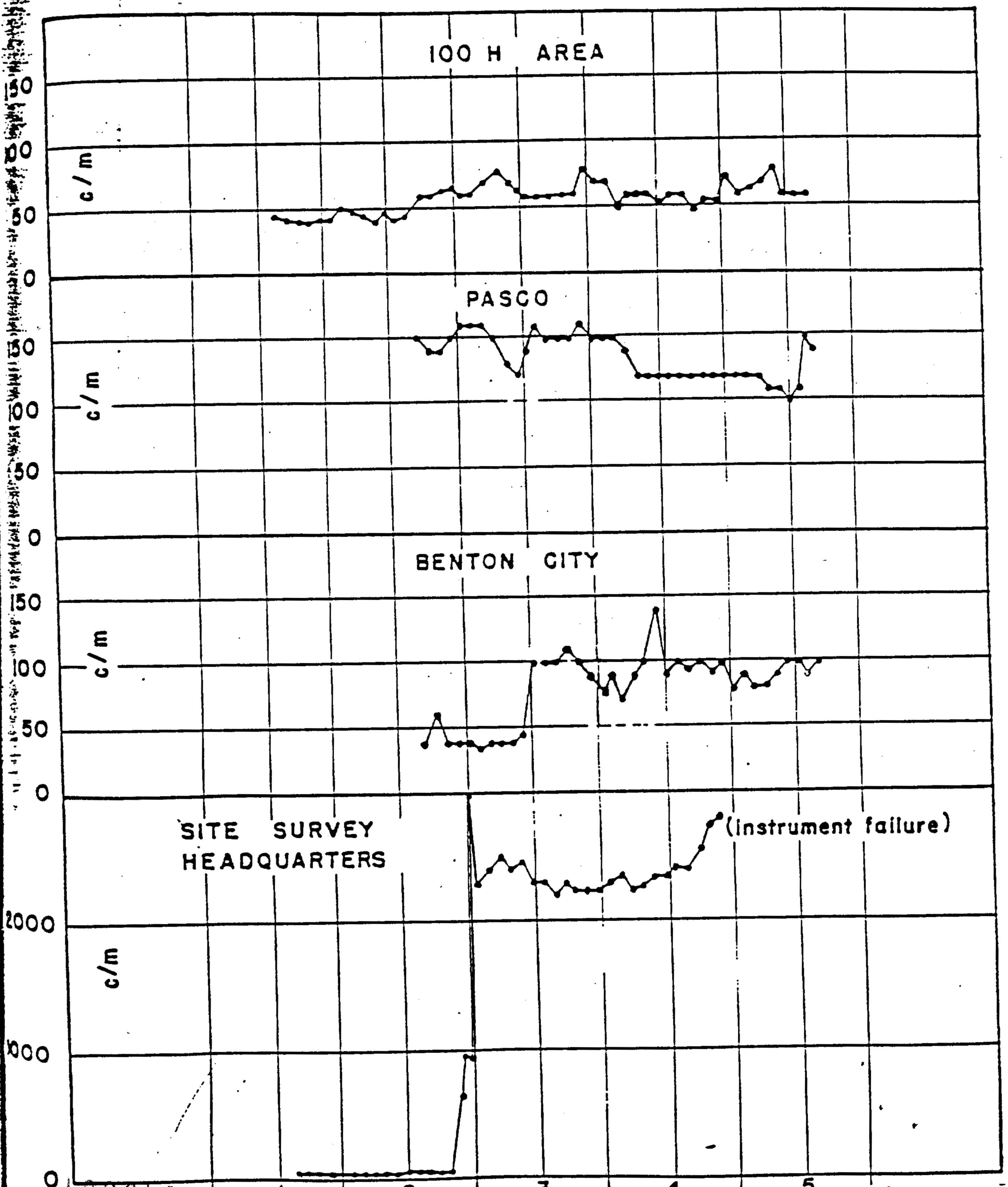


FIGURE – 41


300 AREA CONSTANT AIR MONITOR
Unit # 1
Collects 3 hours
Decays 3 hours
c/m
0
200
400
600
800
1000
1200
1400
10
15
20
24
06
11
16
21
24

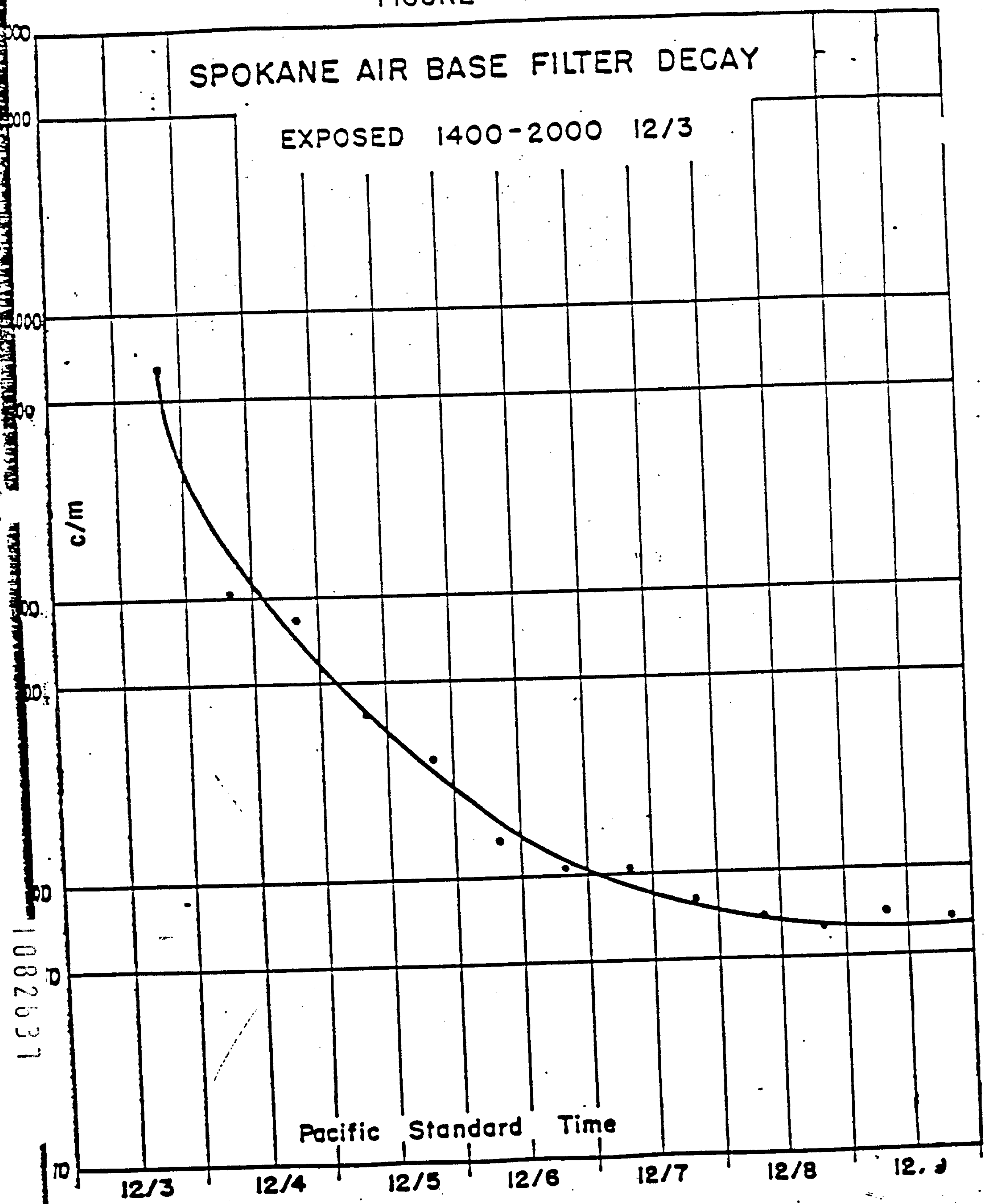
COUNTING RATES ON GENERAL RADIO CRMS

HW-17381-DEL-
REV 1



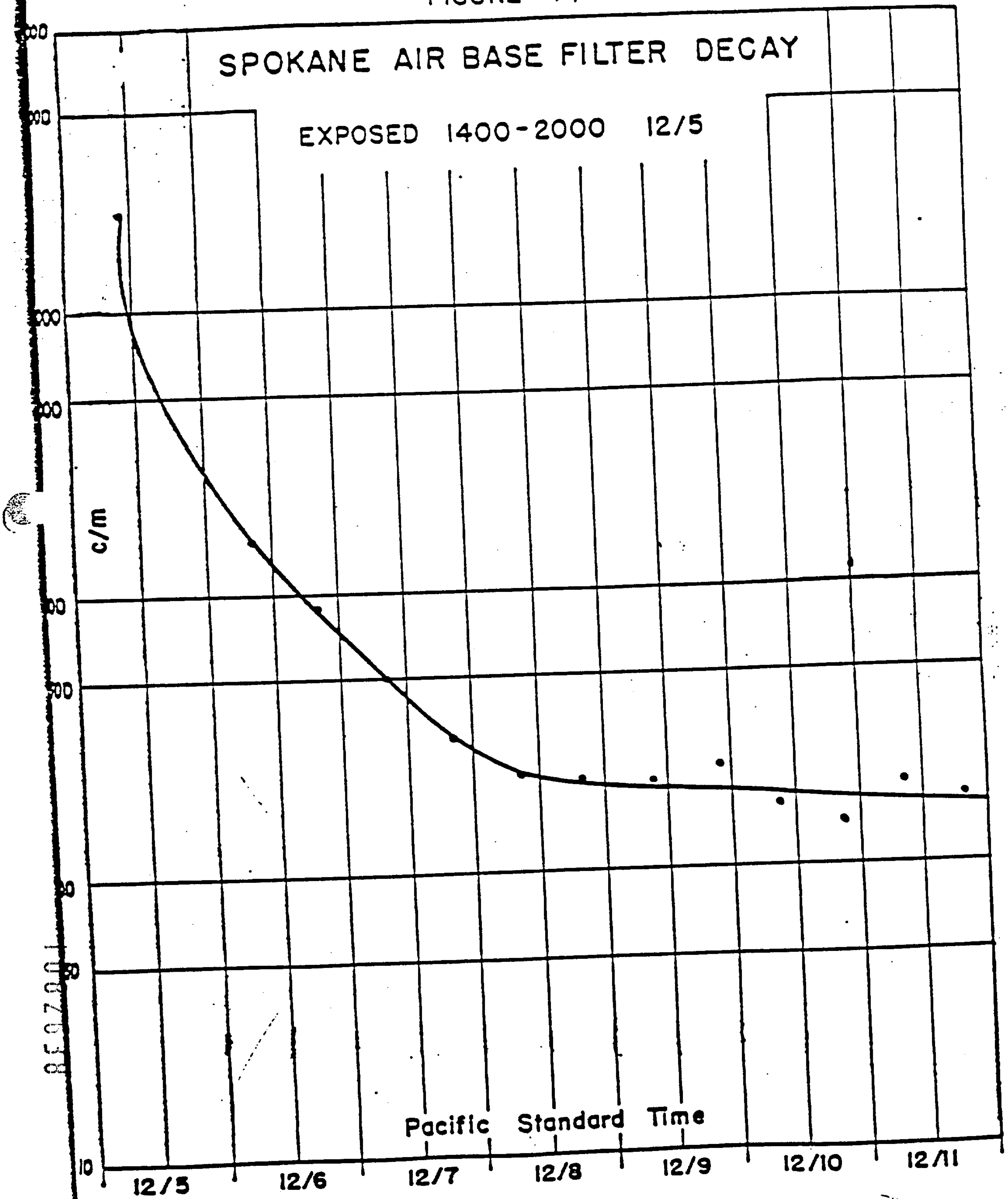
1082636

FIGURE-43



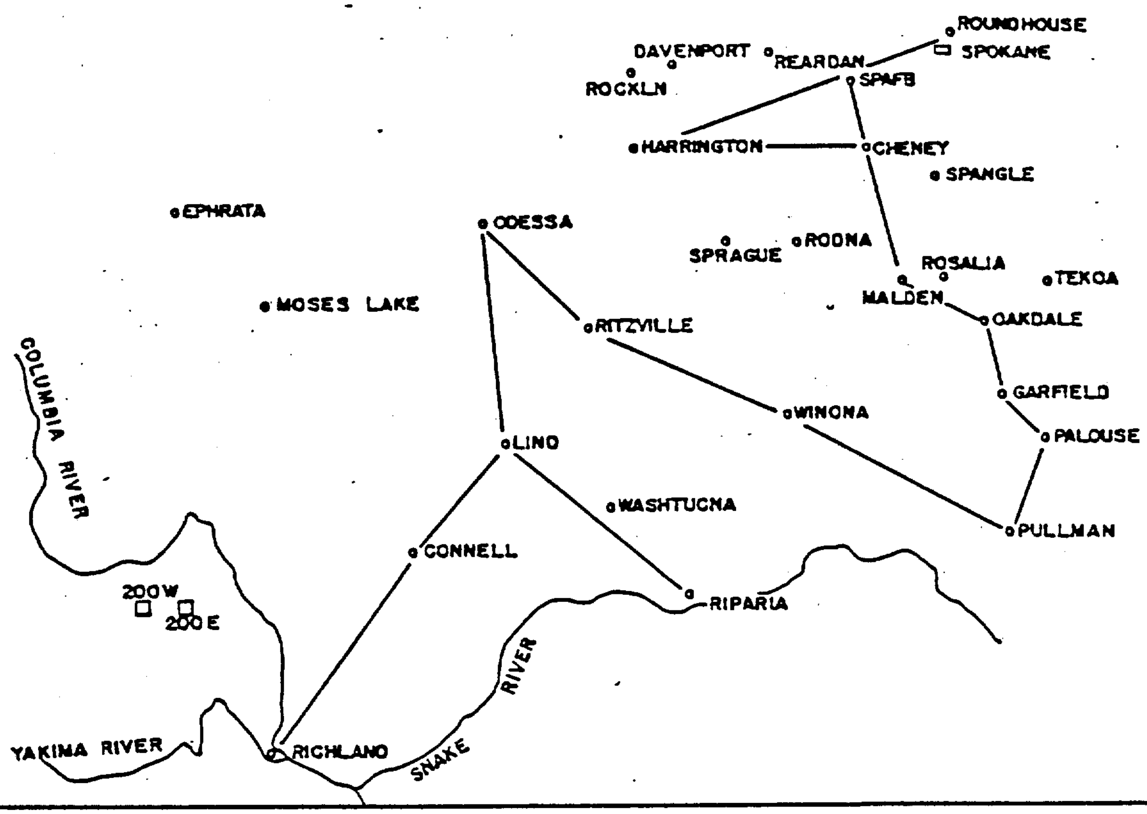
1082637

FIGURE-44


SPOKANE AIR BASE FILTER DECAY
EXPOSED 1400-2000 12/5
c/m
Pacific Standard Time
10
12/5
12/6
12/7
12/8
12/9
12/10
12/11

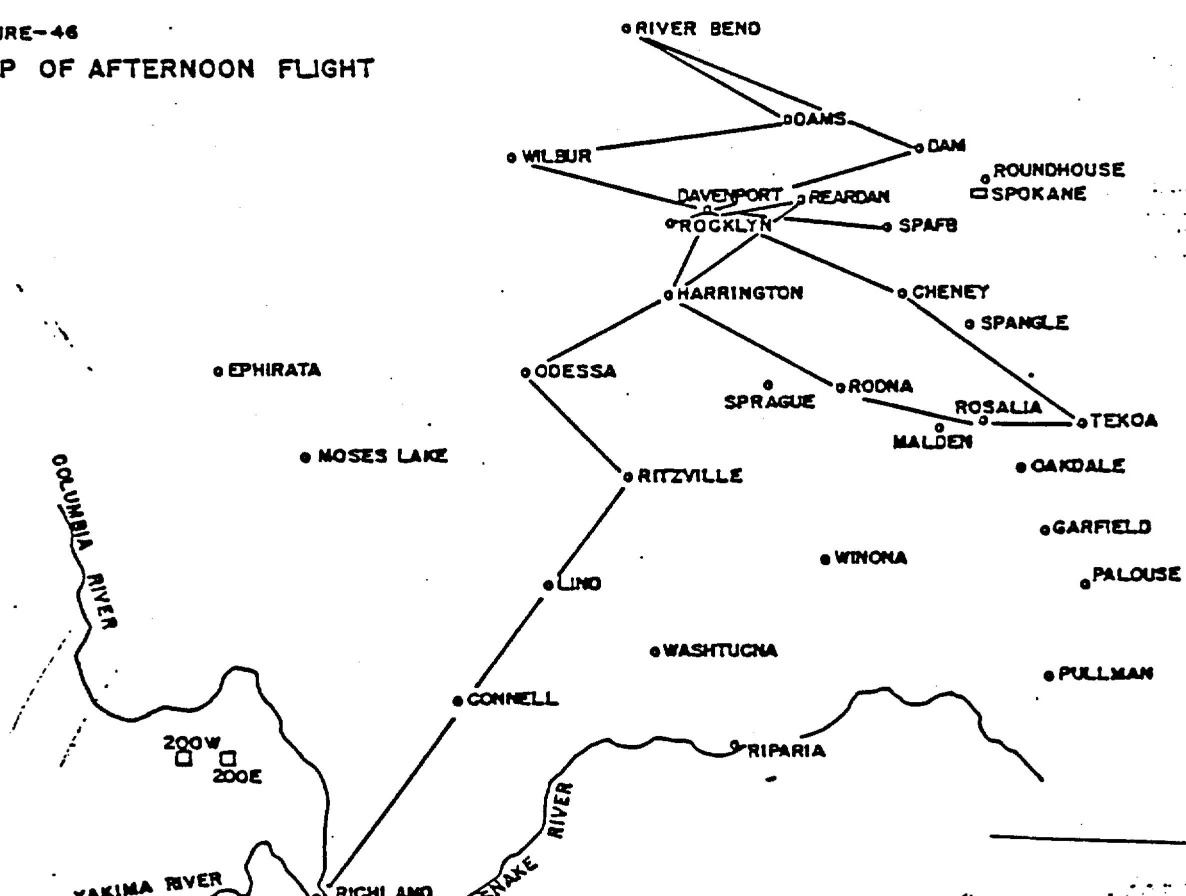
FIGURE—45

MAP OF MORNING FLIGHT



FIGURE—46

MAP OF AFTERNOON FLIGHT



1082639

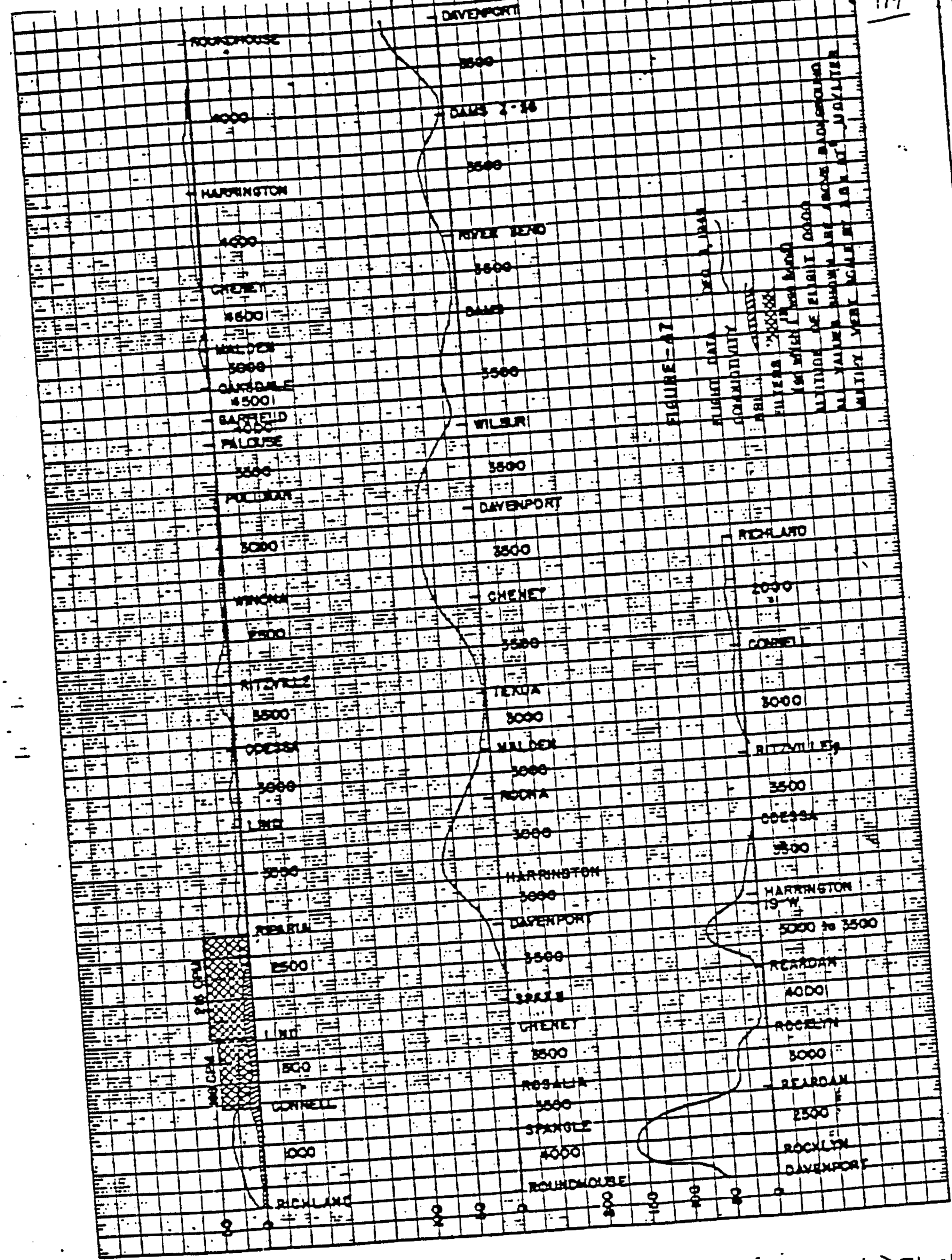
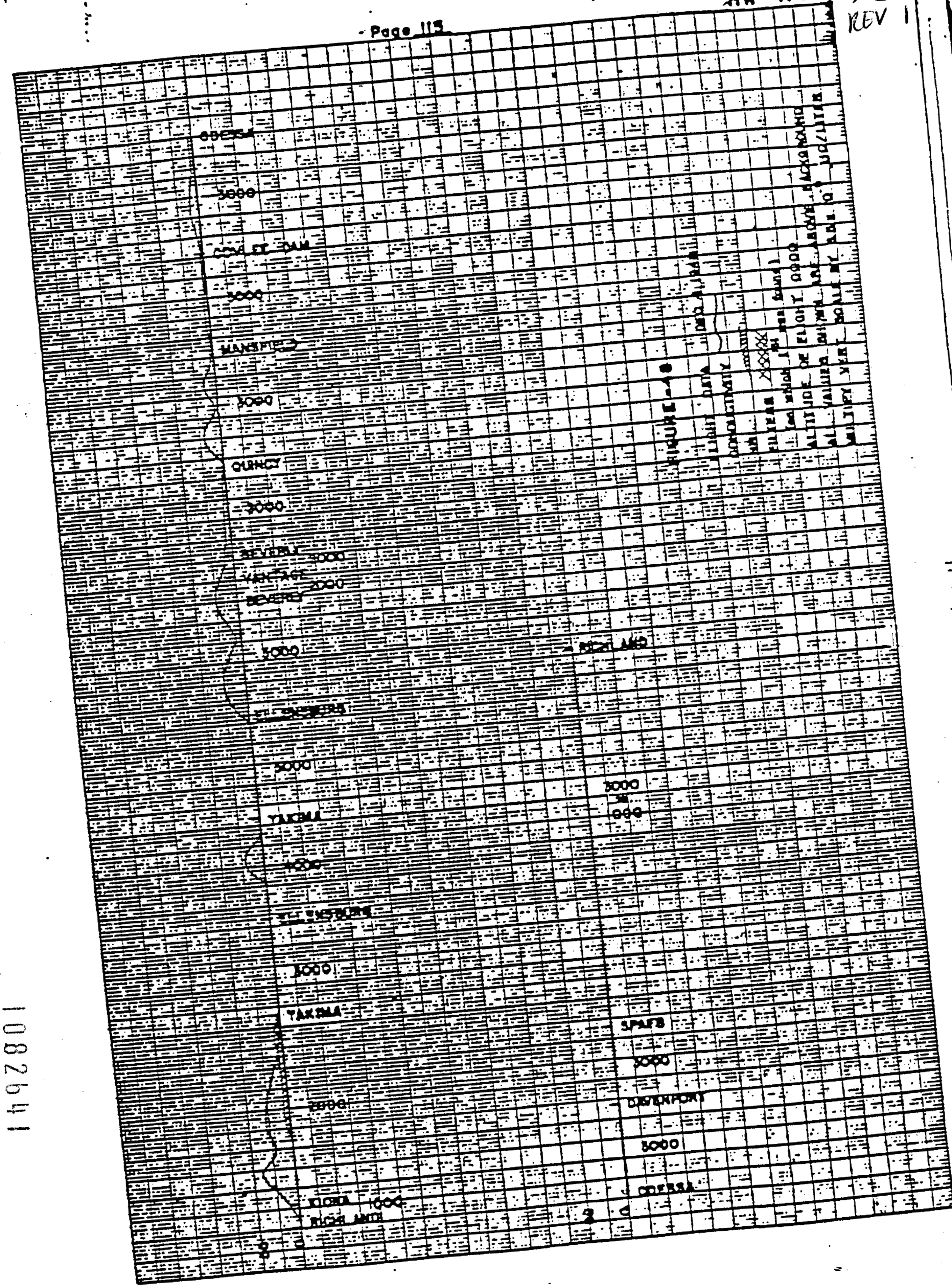


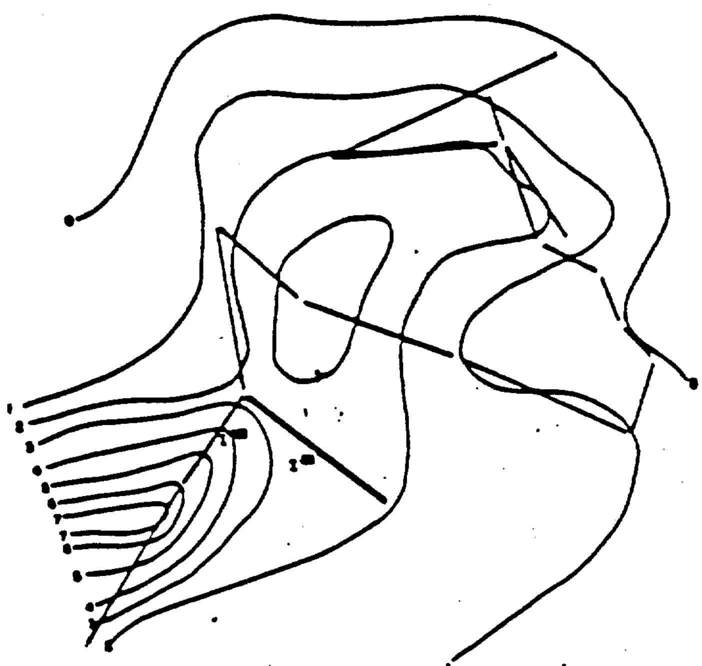
FIGURE-47

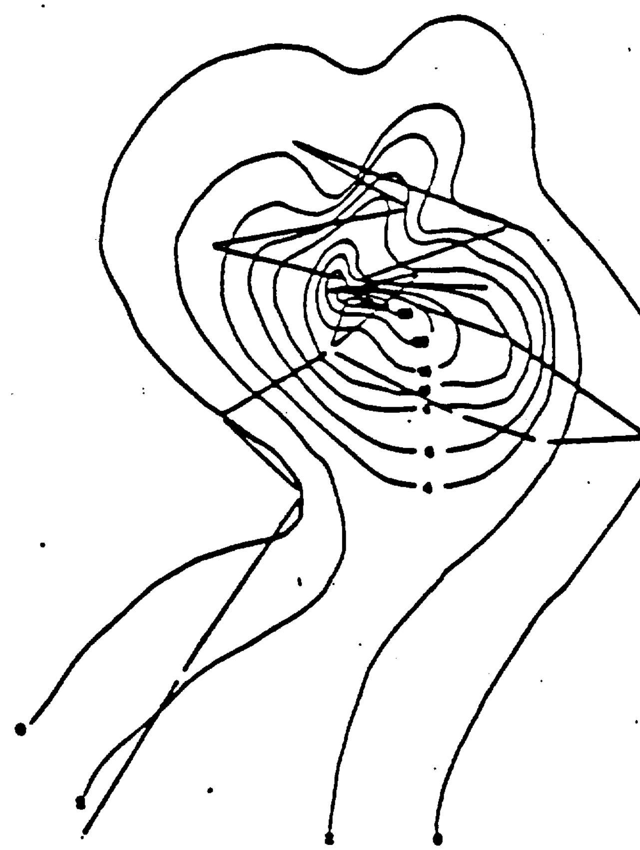
HW-17381-DEL REV 1

1082640

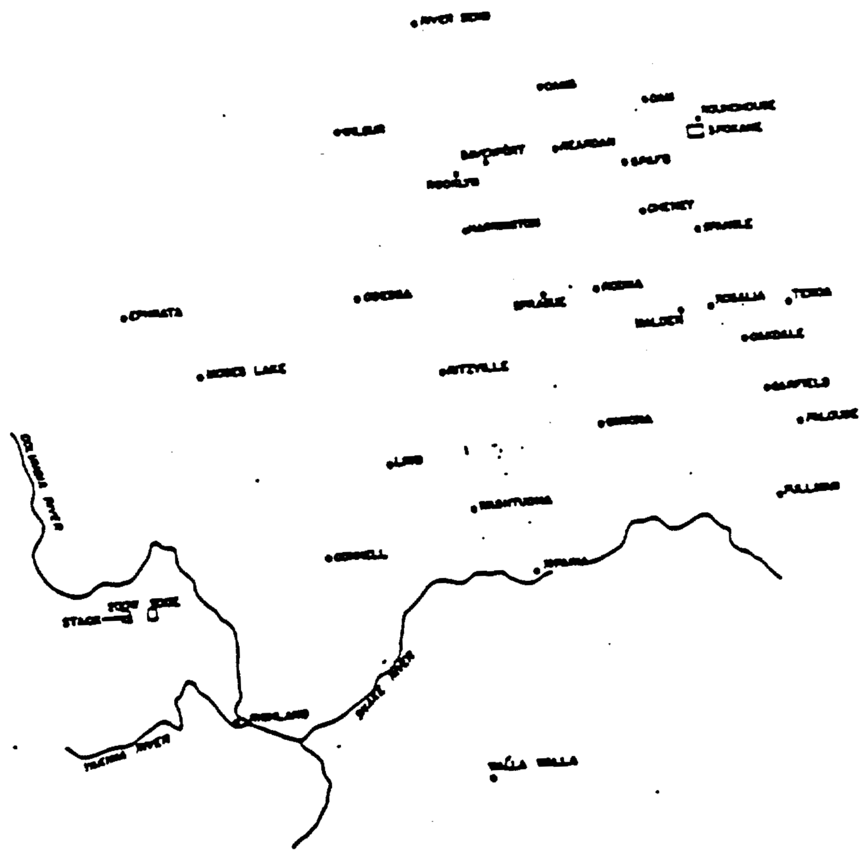

ODESSA
3000
COULEE DAM
3000
MANSFIELD
3000
QUINCY
3000
VANTAGE
BEVERLY
3000
RICHLAND
3000
YAKIMA
1000
3000
YAKIMA
3000
SPAFB
3000
DAVENPORT
3000
ODESSA
RICHLAND
FIGURE

1082641





HW-17381-DEL-REV 1
FIGURE 50-A
PAGE 118



1082644

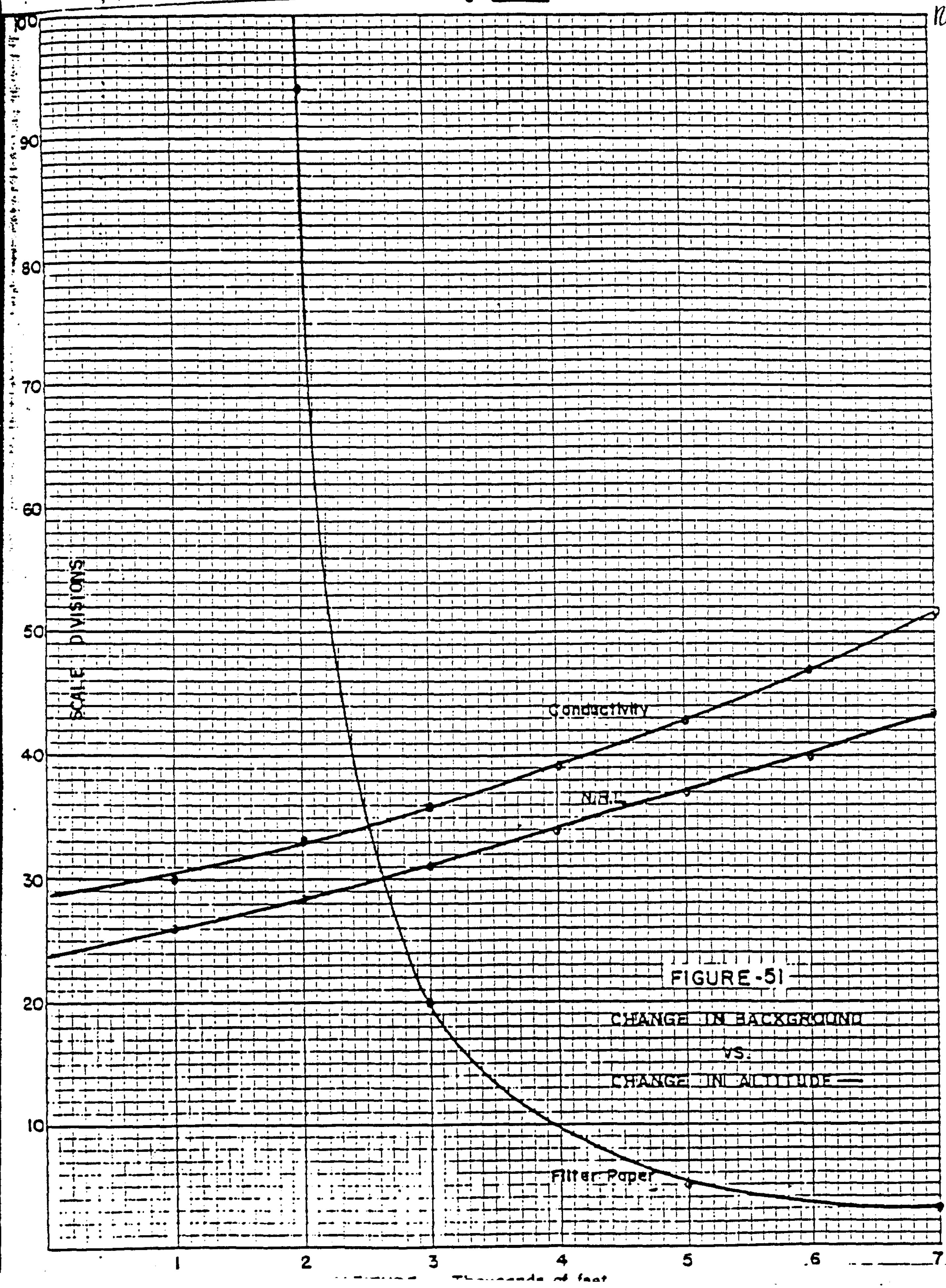
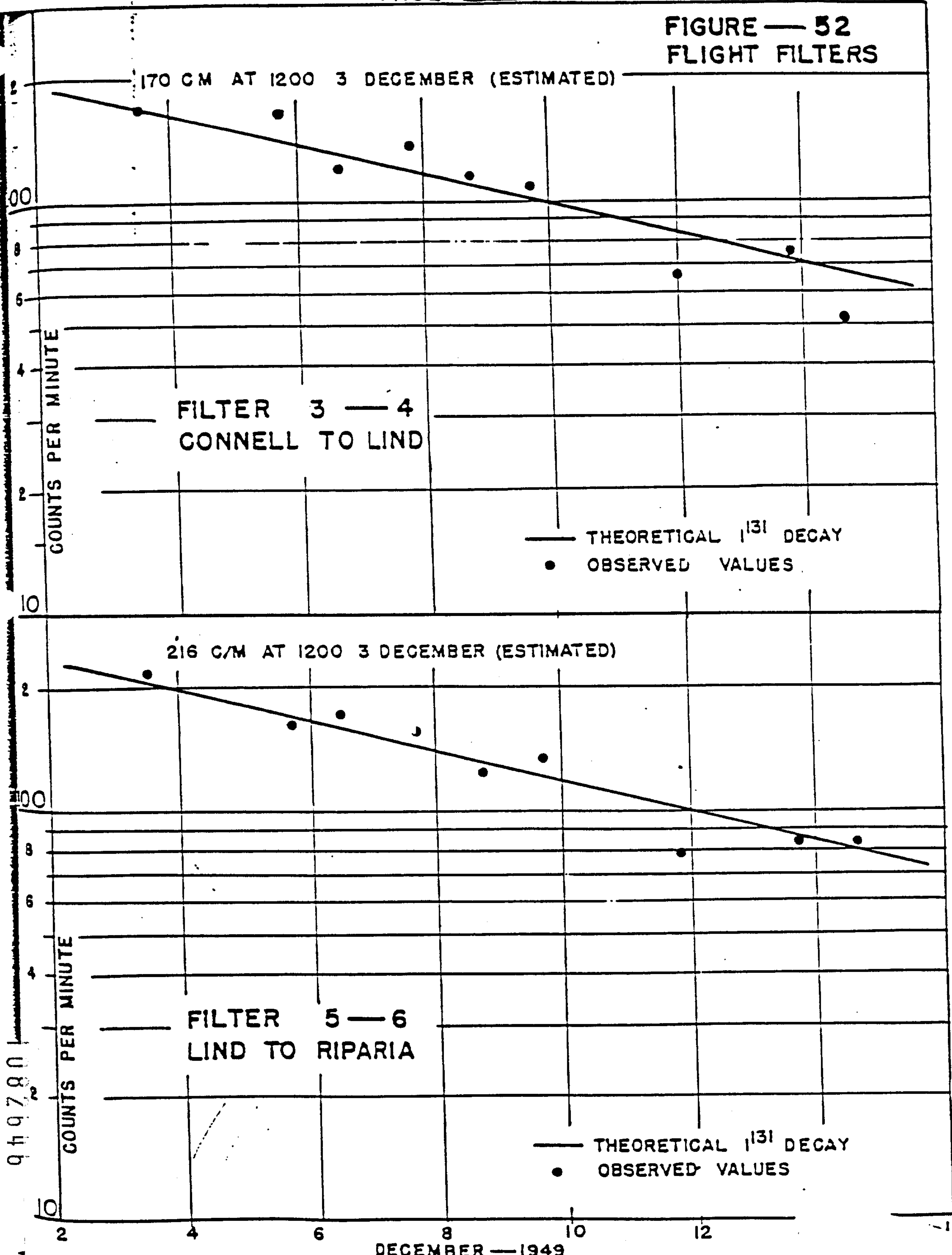


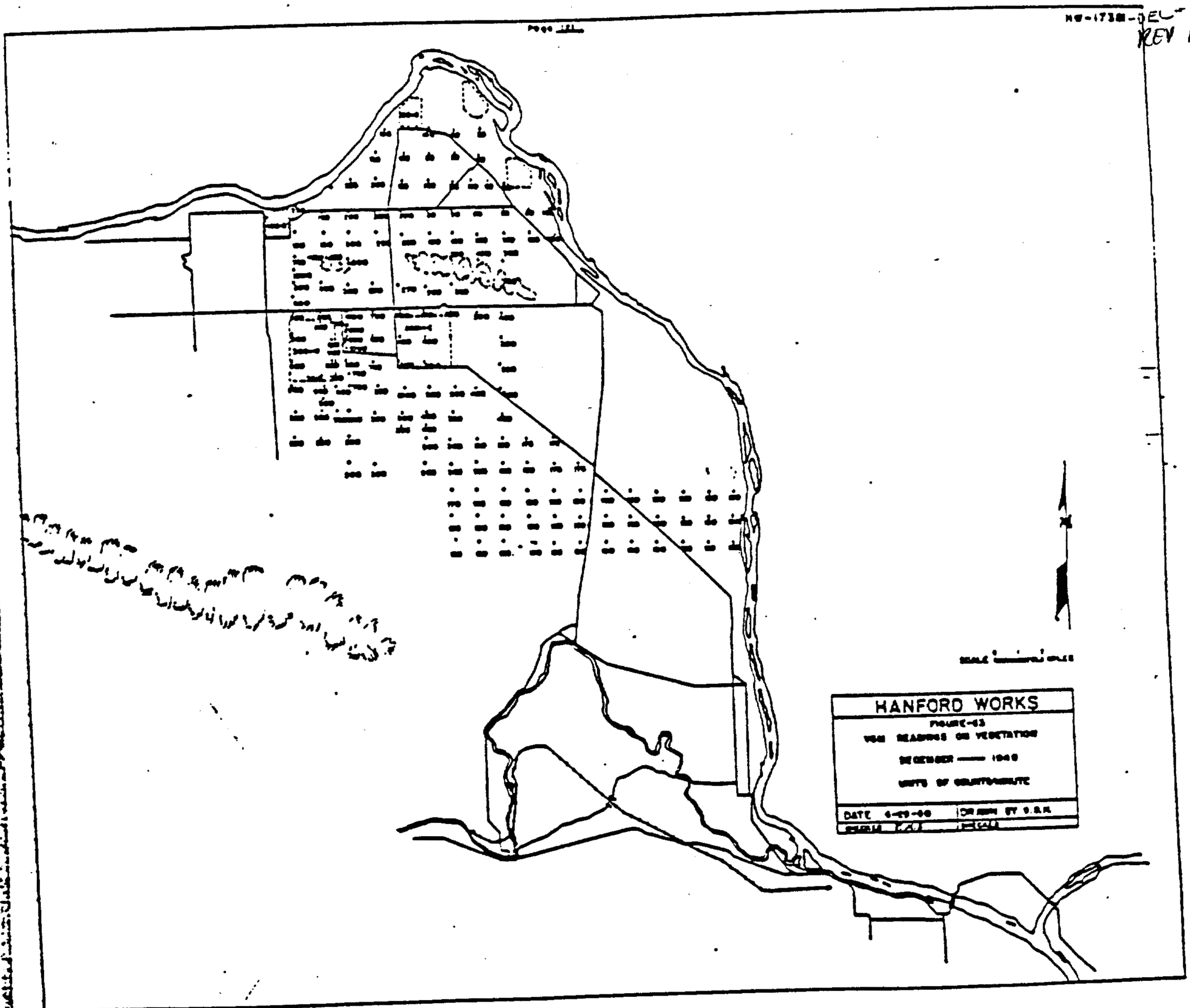
FIGURE-51
CHANGE IN BACKGROUND
VS.
CHANGE IN ALTITUDE

1008645

FIGURE — 52
FLIGHT FILTERS

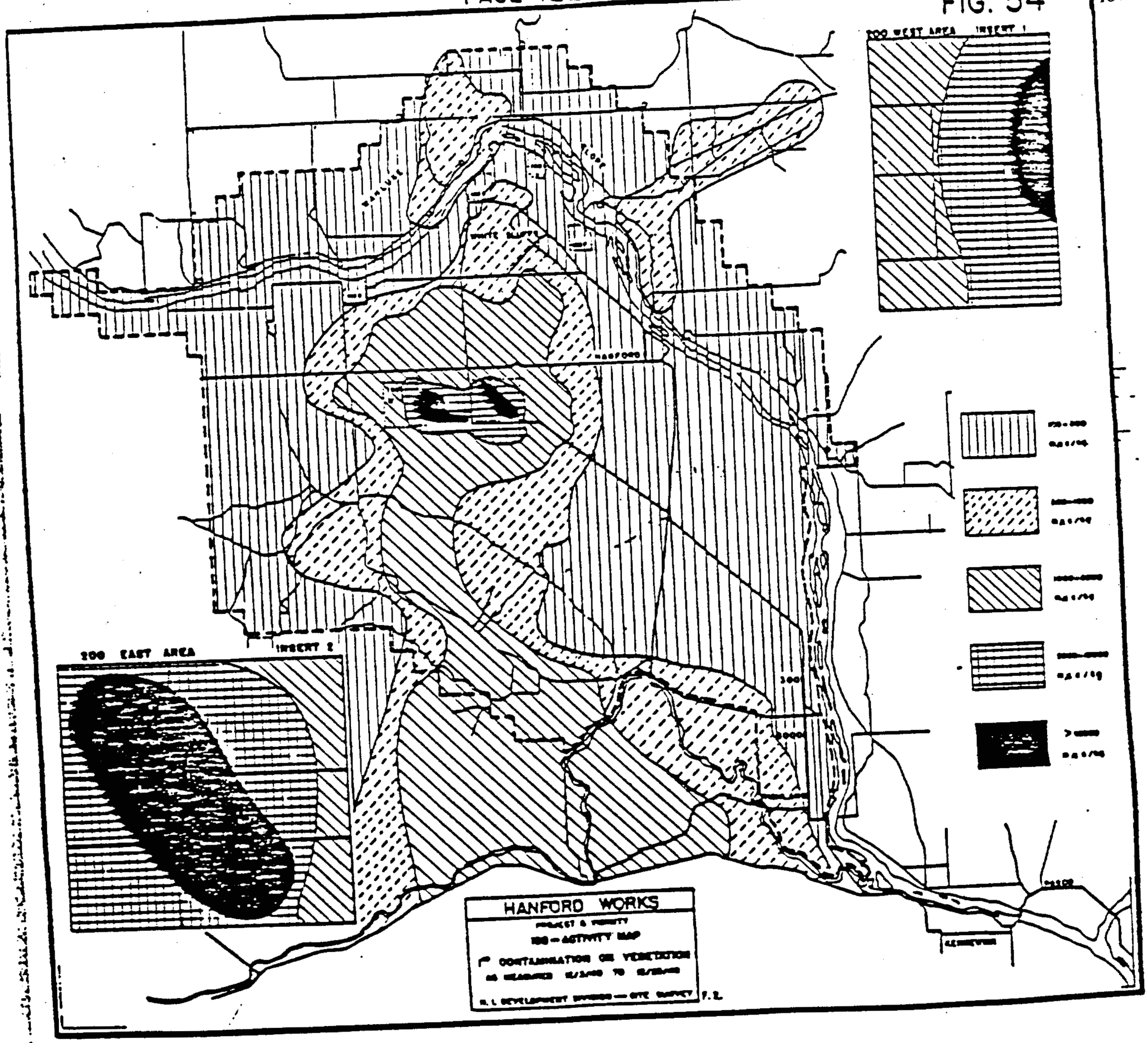


949780


HANFORD WORKS
READINGS ON VEGETATION
DECEMBER
DATE

HW-17381-DEL-REV 1

FIG. 54



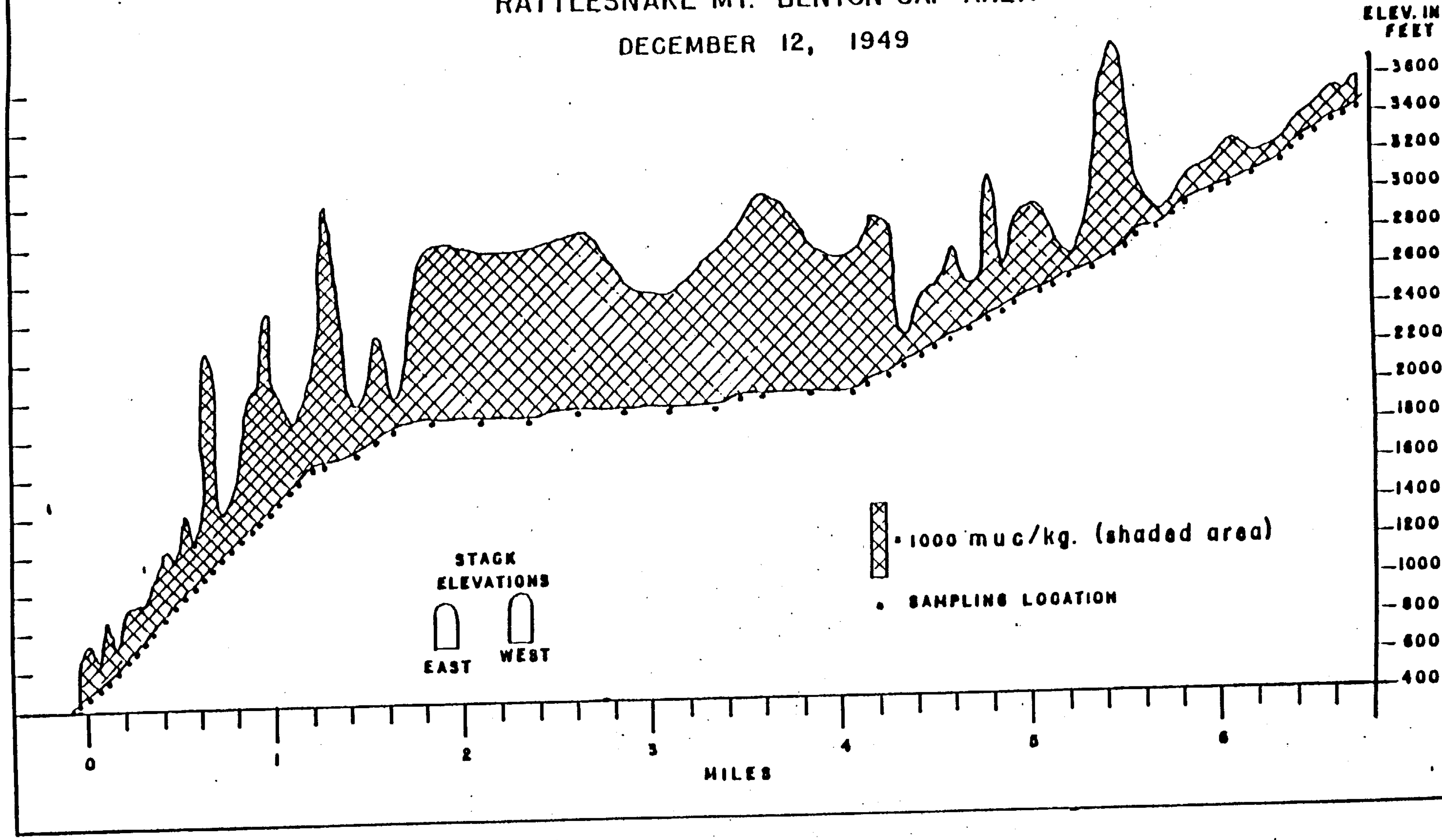
1082648

FIGURE-55

I^{131} CONTAMINATION ON VEGETATION

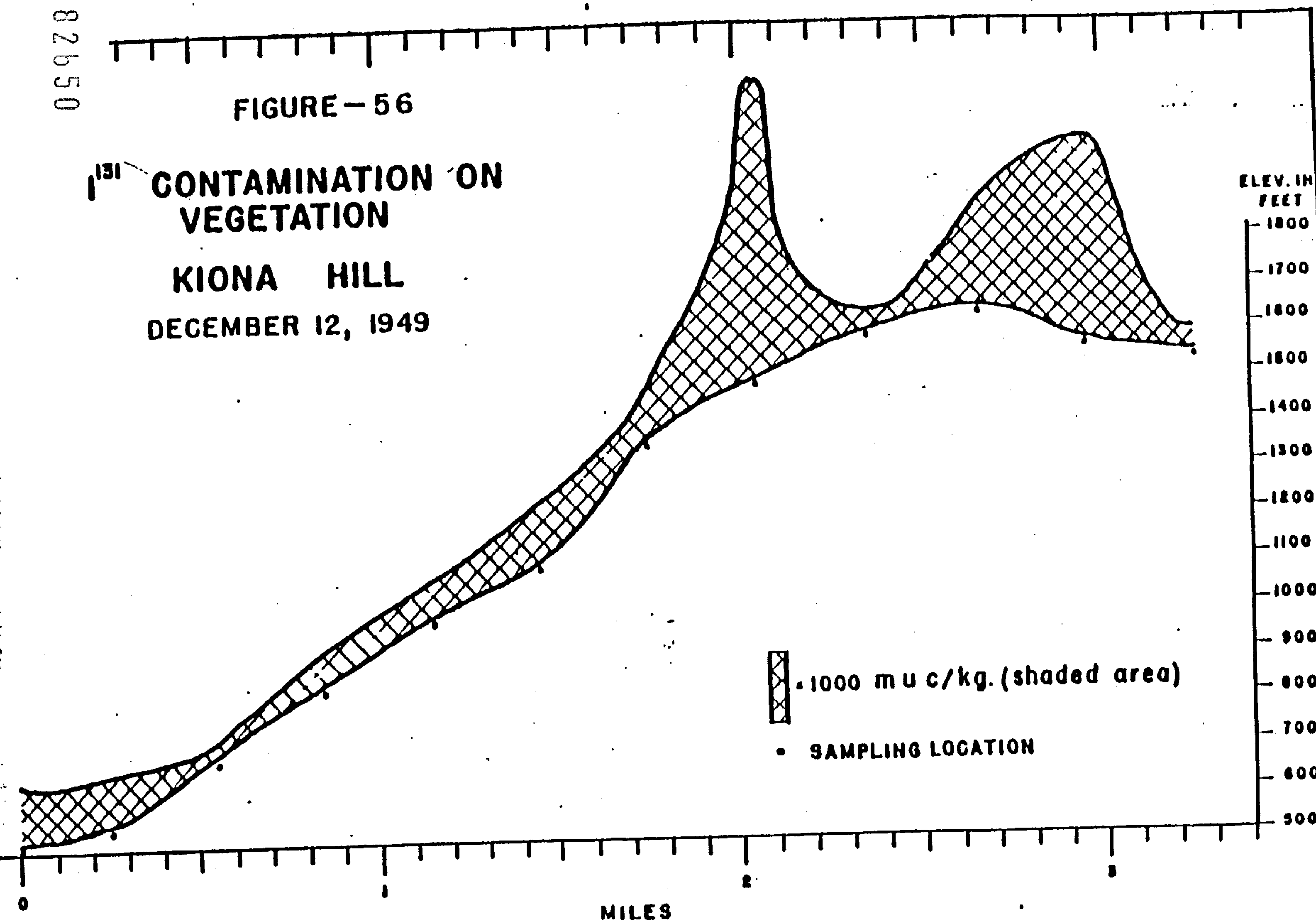
RATTLESNAKE MT.-BENTON GAP AREA

DECEMBER 12, 1949



1082649

HW-17381-DEL-REV 1



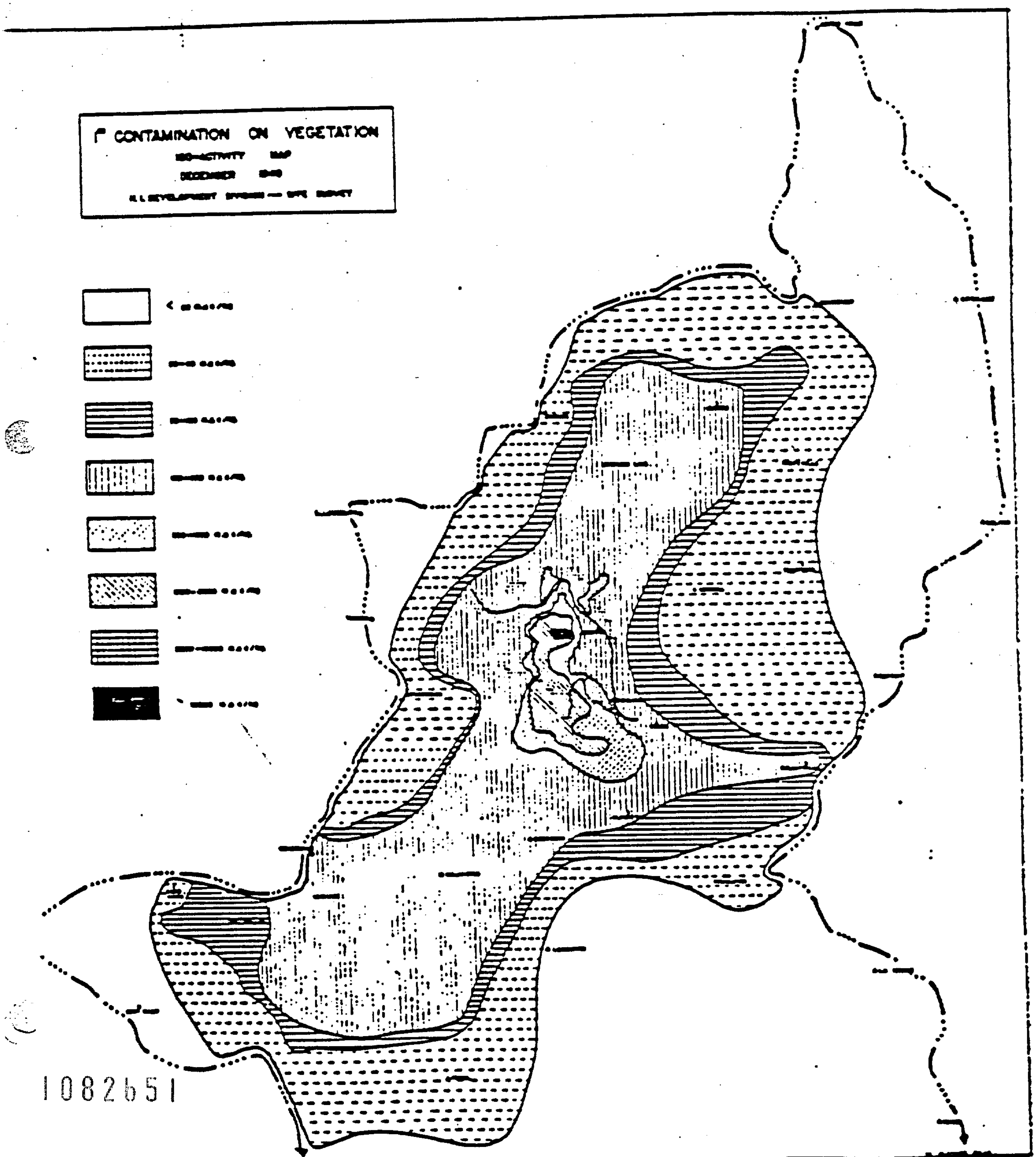
FIGURE—56

I^{131} CONTAMINATION ON VEGETATION

KIONA HILL

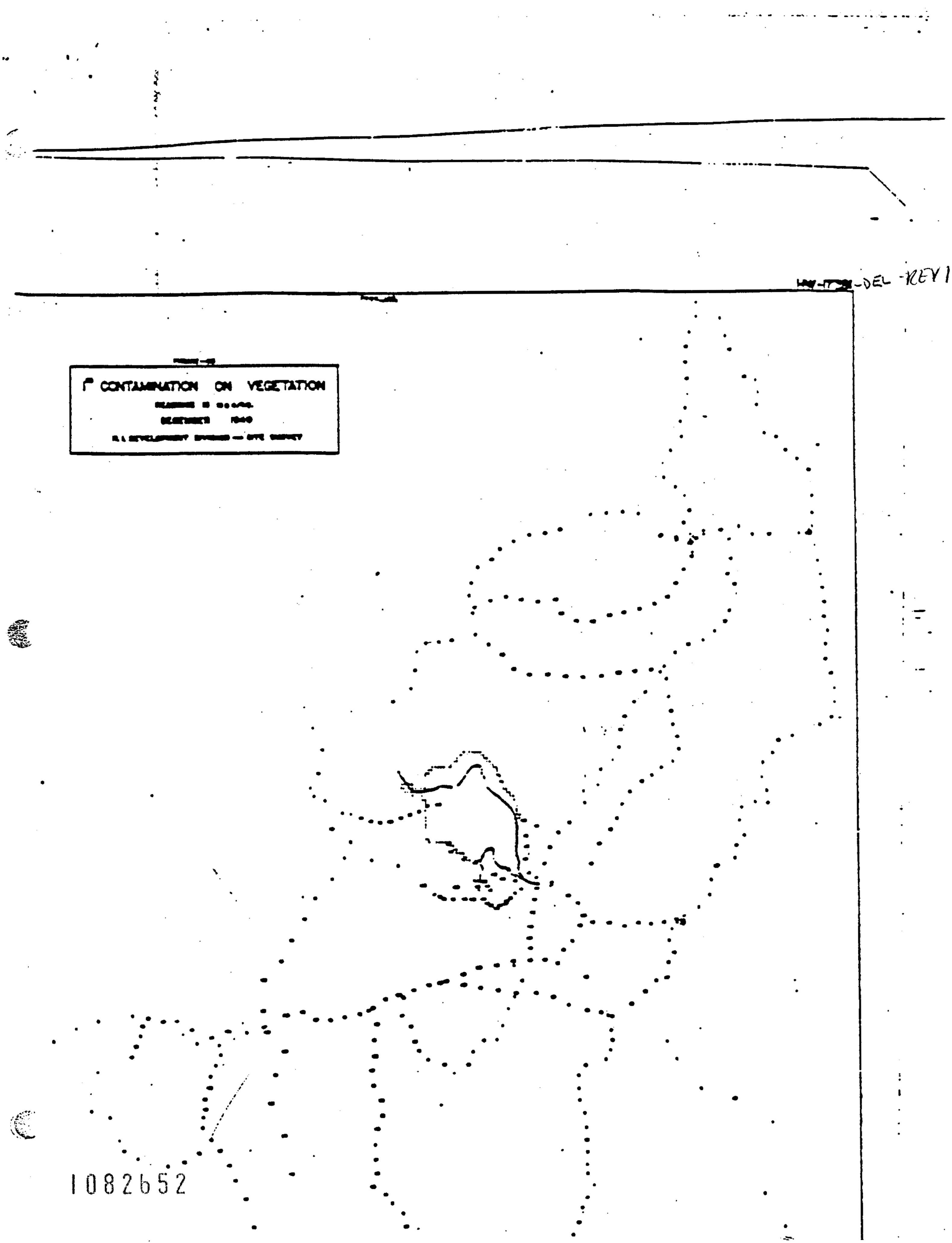
DECEMBER 12, 1949

1082650



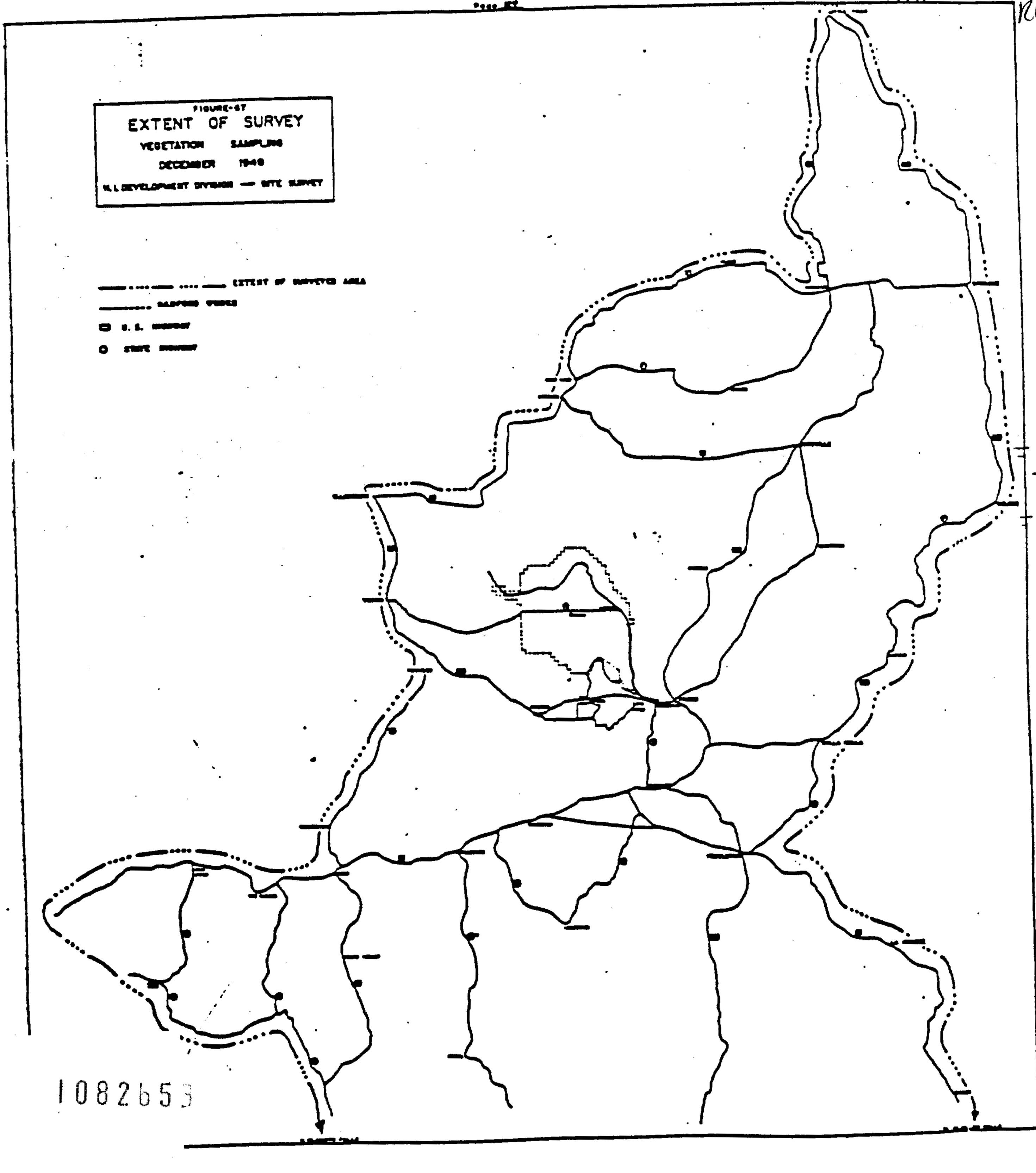
1082651

HW-[illegible]-DEL-REV1



1082652

HW-17381 DEL
REV 1



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PROMINENT TERRAIN OF EXTENDED SURVEY

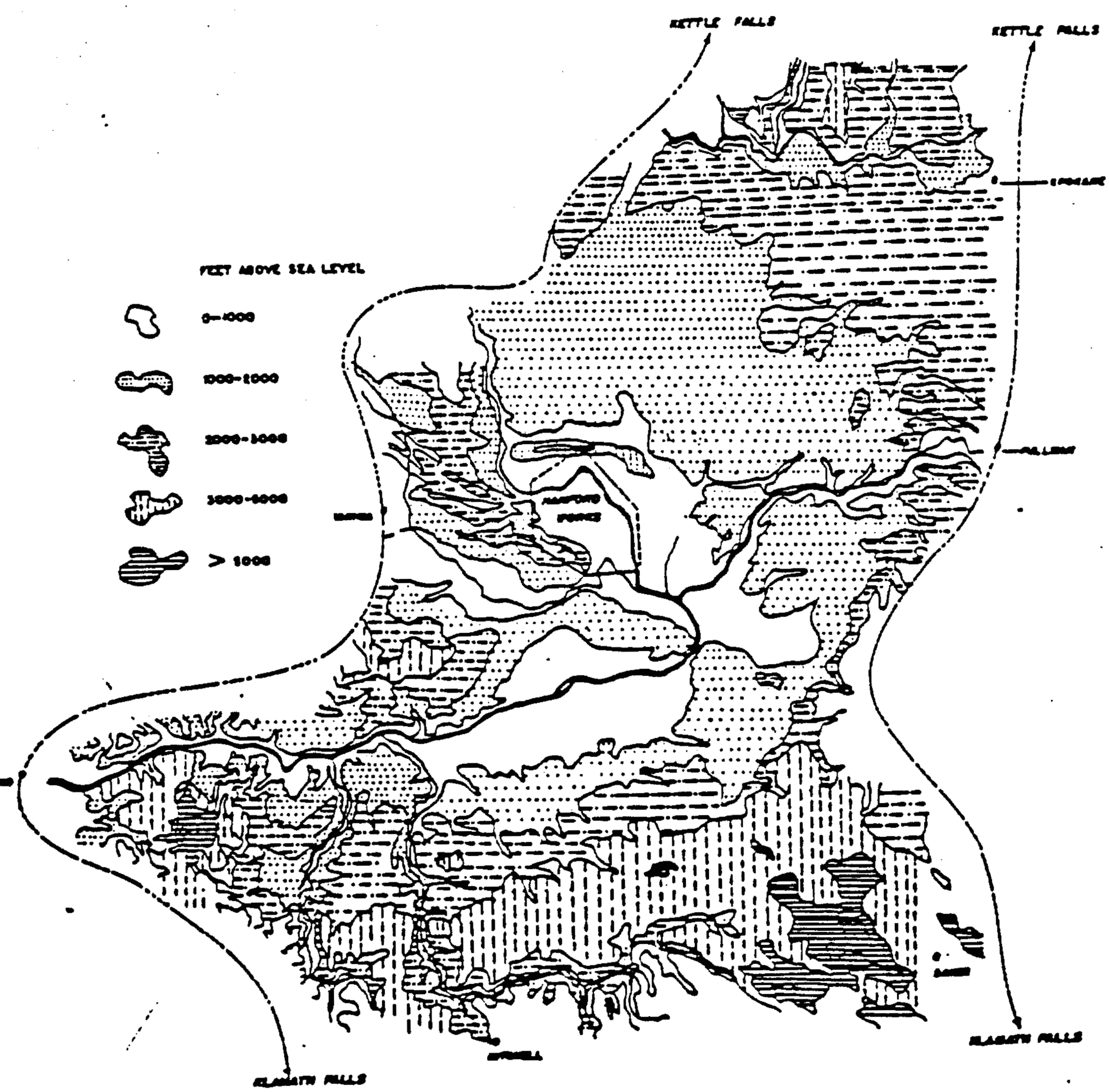

FIGURE - 61

DECAY OF ACTIVITY DEPOSITED ON VEGETATION