AD-A174 260 CLIMATIC ATLAS OF ICING POTENTIAL OVER NORTH AMERICA (U) AIR FORCE ENVIRONMENTAL TECHNICAL APPLICATIONS CENTER SCOTT AFB IL JAN 86 USAFETAC/DS-86/001 1/2

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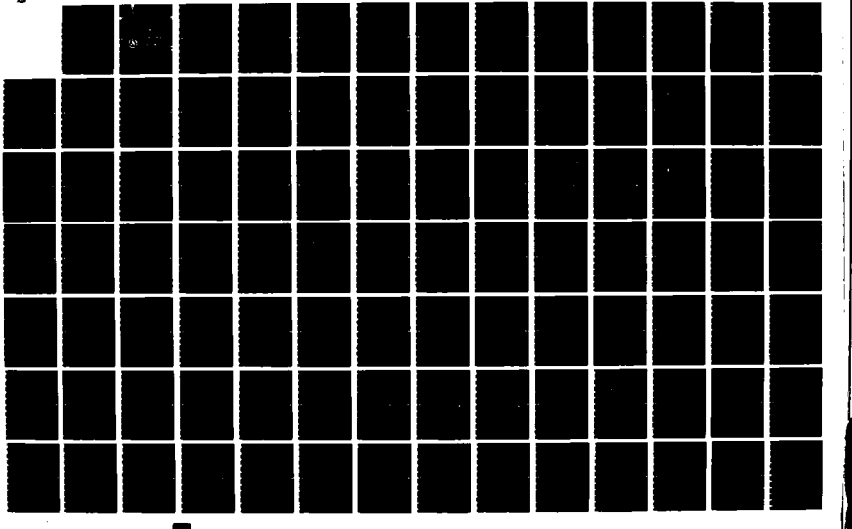

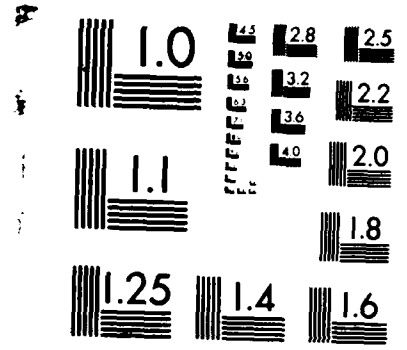

USAFETAC/DS-86/001

CLIMATIC ATLAS OF ICING POTENTIAL OVER NORTH AMERICA

JANUARY 1986

UNITED STATES AIR FORCE
AIR WEATHER SERVICE (MAC)
USAF
ENVIRONMENTAL
TECHNICAL APPLICATIONS
CENTER
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19. Abstract: A climatic atlas of charts that show percent frequency of occurrence of potential icing conditions over North America. Since icing reports are sparse, an accurate icing climatology is difficult to obtain. A climatology of elements for potential icing conditions, however (such as liquid water content and temperature), can be derived. The Smith-Feddes Liquid Water Content (LWC) computer model uses combined data from the Air Force Global Weather Central ~~(AFGWC)~~; Three-Dimensional Nephanalysis Data Base (3DNEPH) and the upper air Analysis Data Set ~~(ADS)~~ for input. Output consists of percent frequency of occurrence of a liquid water content threshold concentration in a defined layer and temperature range. Output was generated for three concentrations, three layers and for temperatures at or below freezing. This data was then manually converted into 117 monthly and annual maps showing percent frequency of occurrence for potential icing conditions.

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22b. Telephone: 618 256-2642

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PREFACE

This document was completed for USAFETAC Project 3702, initiated to satisfy a 5th Weather Wing request for icing climatology. SMSgt Charles Travers, USAFETAC/ECO, started the project in April 1985 and was the project manager until his transfer to another branch in August 1985. He was succeeded as project manager by 1st Lt Paul Thorson, who saw the project through to its completion. All manual chart contouring was by SSgt Charles Carrier. Capt James Millard was the technical consultant. TSgt Ronald Coleman wrote computer software that simplified data extraction from the liquid water content database. The USAFETAC Data Automation Branch also deserves recognition for dealing with the considerable computer time requirements for the Smith-Feddes liquid water content model.

CONTENTS

PURPOSE AND BACKGROUND

The Requirement. This atlas is based on a 5th Weather Wing request for North American aircraft icing climatology to use in close air support and other low-level operations. Unfortunately, the science of forecasting icing is far from exact and reports of aircraft icing were scarce. In addition, aircraft icing is a function of airframe geometry, airspeed, flight profile, and degree of exposure--none of which can be quantified or averaged to produce a meaningful icing climatology. For all these reasons, production of an accurate icing climatology was a challenge. Nonetheless, the requirement was genuine; there was a definite need for a simple and universally applicable climatology related to aircraft icing.

The Solution. USAFETAC/ECC chose to fulfill the requirement with preparation of this atlas, which provides graphic presentation of aircraft icing potential, given certain specified conditions. The four elements that determine potential icing conditions are (1) liquid water content, (2) cloud drop-size distribution, (3) cloud temperature, and (4) ambient temperature. Of these, liquid water content and ambient temperature can be derived and quantified. The tool used to produce the charts in this atlas was the Smith-Feddes Liquid Water Content (LWC) model, which uses the Air Force Global Weather Central (AFGWC) Three-Dimensional Nephanalysis Data Base (3DNEPH) and the upper air Analysis Data Set (ADS) for input. The combined data sets, using satellite meteorological data, surface observations, and rawinsonde observations, were transformed into percent frequency occurrence of a threshold or higher concentration of liquid water content by layer and temperature. That output was then gridded on maps, upon which percent frequency isopleths were drawn. Through the use of accurate liquid water content and temperature climatology, then, a useful tool for predicting the potential for aircraft icing was produced.

THE SMITH-FEDDES LWC MODEL

LWC Model Description. The Smith-Feddes liquid water content model was developed in the mid-1970's at USAFETAC. It determines liquid water content at a given point in the atmosphere with an empirical model. There are two inputs to the Smith-Feddes model. The first is the 3DNEPH data base, a fifteen-layer vertical cloud distribution data base with a 25 nautical mile (NM) resolution. The 3DNEPH is based on an AFGWC analysis model whose data points contain information on cloud types, bases, tops, percent cloud cover of layers, total cloud cover, present weather, and terrain height. The second input is the Analysis Data Set (ADS), from which ambient temperatures are obtained. This data set has fifteen pressure levels and a coarser 200 NM resolution.

How the LWC Model Works. The Smith-Feddes model extracts moisture data from the first source (3DNEPH) and temperature data from the second source (ADS), creating a liquid water content data base, by layer and temperature, with 200 NM resolution. Liquid water content varies from zero (no cloud) to a maximum of 6 g/m^3 (cumulonimbus cloud). Terrain height is taken into account (from 3DNEPH) so that values of each layer are given in meters above ground level (AGL).

PERIOD OF RECORD

Data used for input to the Smith-Feddes model covered a 4-year period of record (1977 to 1980). Because of computer time limitations and the tremendous amount of information contained in the liquid water content data base, it was impractical to work with more than 4 years of data. Each data point contained about 240 observations for any 1 month (4 years times 30 days a month times two observations a day) and over 2,800 observations for its annual summary. Therefore, even though only a 4-year period of record was used, the results are statistically representative because of the high observation count.

CHART PREPARATION METHOD

It was necessary to obtain liquid water content data for North America before relating it to a potential icing climatology. The data extracted from the computer runs included point percent frequencies of liquid water content with a 200 NM resolution. These percent frequencies were then plotted on a 1:9,000,000 polar stereographic projection. The data were manually contoured with percent frequency isopleths. Contour intervals were chosen to maintain a similar gradient and consistency in spacing between groups of charts. Manual plotting and contouring allowed elimination of some spurious data points and also allowed smoothing for easier interpretation.

To [illegible] output charts were plotted by month, with annual [illegible]. These layers were [illegible] surface to 1,524 meters (0-5,000 feet), 1,525 [illegible] meters, [illegible] meters (5,001-10,000 feet). All values are [illegible].

Three concentrations of liquid water content were selected as threshold values to simulate three environments for potential icing. If the concentration of liquid water was at or above the threshold value, that observation was counted toward the percent frequency of occurrence. The concentrations used are: .10 grams per cubic meter (g/m^3) (trace to light icing), .50 g/m^3 (moderate icing), and 1.00 g/m^3 (severe icing). In the liquid water content data base, only cumulus and cumulonimbus clouds have concentrations greater than or equal to 1.00 g/m^3. Therefore, only in these types of clouds would the potential for severe icing be indicated by the liquid water content model. Since most in-cloud severe icing reports occur in cumulus and cumulonimbus clouds, this is desirable.

USING THE CHARTS

The liquid water content charts that follow are climatological data summaries that indicate the potential for aircraft icing. They are intended for use as planning and forecasting aids, not as substitutes for operational icing forecasts, procedures for which are given in AWS/TR-80/001, "Forecasters Guide on Aircraft Icing."

The charts give "percent frequency of occurrence" isopleths at or above a given threshold concentration. Charts are categorized by month, layer, and concentration. The temperature range of all charts is 233 to 273 degrees Kelvin. All layers are above ground level (AGL).

EXAMPLE CHART INTERPRETATION

In Chart 1, the layer shown is surface to 1,524 meters above ground level. The concentration of liquid water content at or below freezing is .10 grams per cubic meter. Since the month is January, winter's colder temperatures and cloudy skies are reflected in the rather high percent frequencies of liquid water content. To interpret the chart, read the isopleths in the same way as a topographic map. New York City is near the 60 percent isopleth. Therefore, New York City's January cloud cover will have a liquid water concentration of .10 grams per cubic meter (or more) about 60 percent of the time. The concentration of .10 grams per cubic meter is not very high and has a high occurrence, but the frequency drops quickly in a moderate (.50 g/m^3) or severe (1.00 g/m^3) icing environment.

The frequencies of liquid water content will be higher than the actual corresponding environments of icing. Even if adequate liquid water content is present at a temperature below freezing, other factors in icing formation (like airspeed or cloud droplet size distribution) may not be conducive to formation of ice on the aircraft.

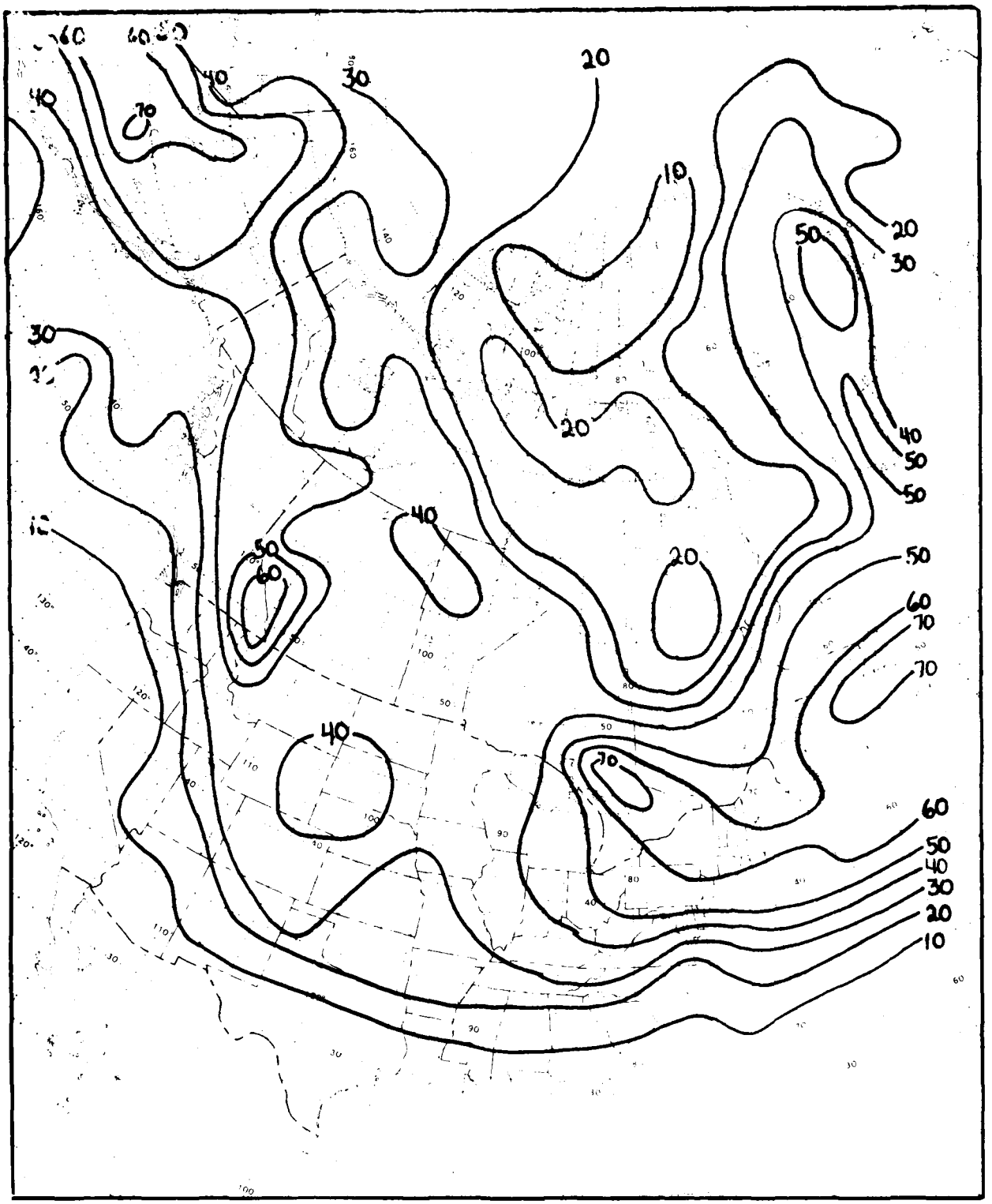
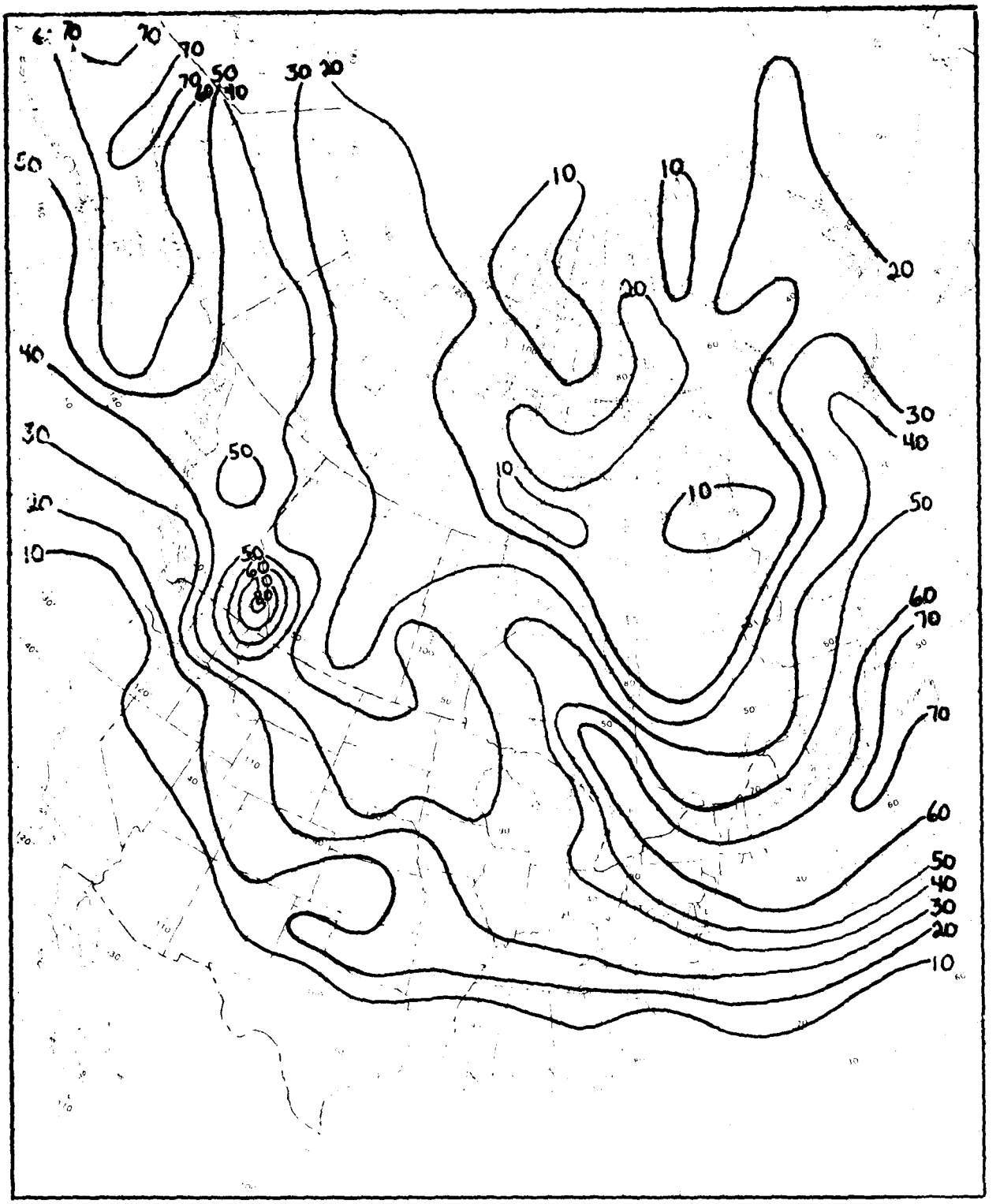


CHART 1 JANUARY SURFACE TO 1,524 METERS, CONCENTRATION .10 G/M^3



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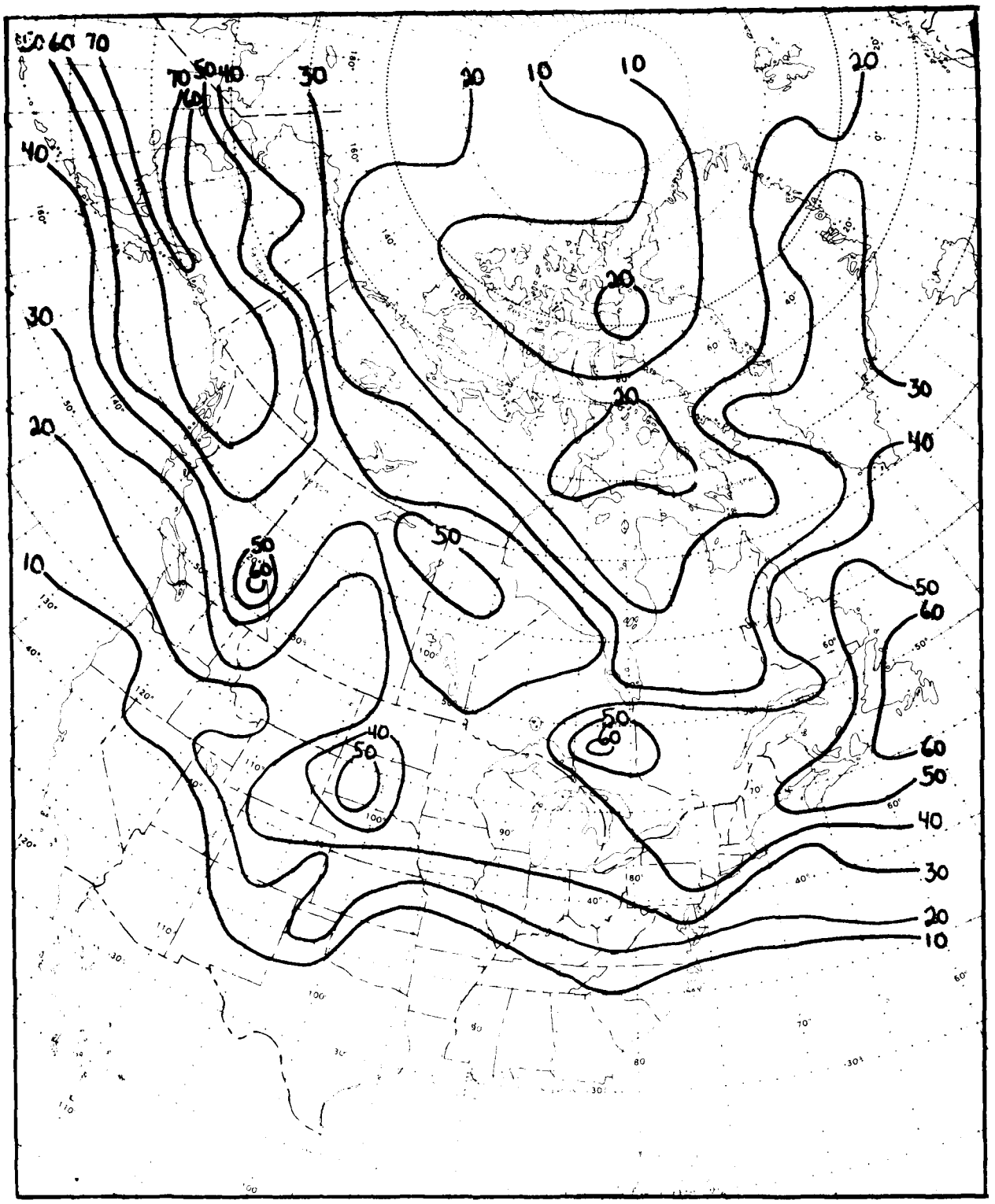

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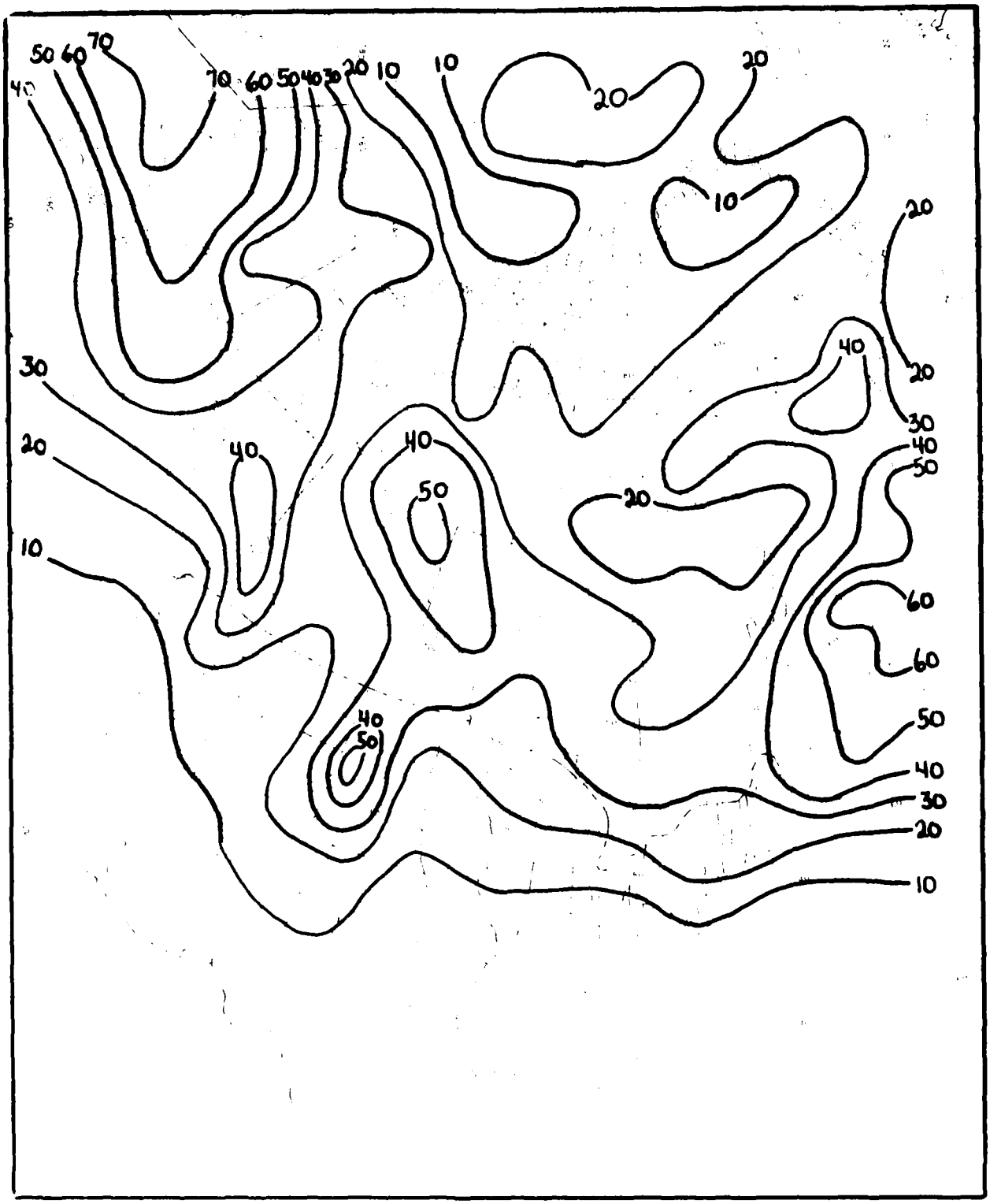

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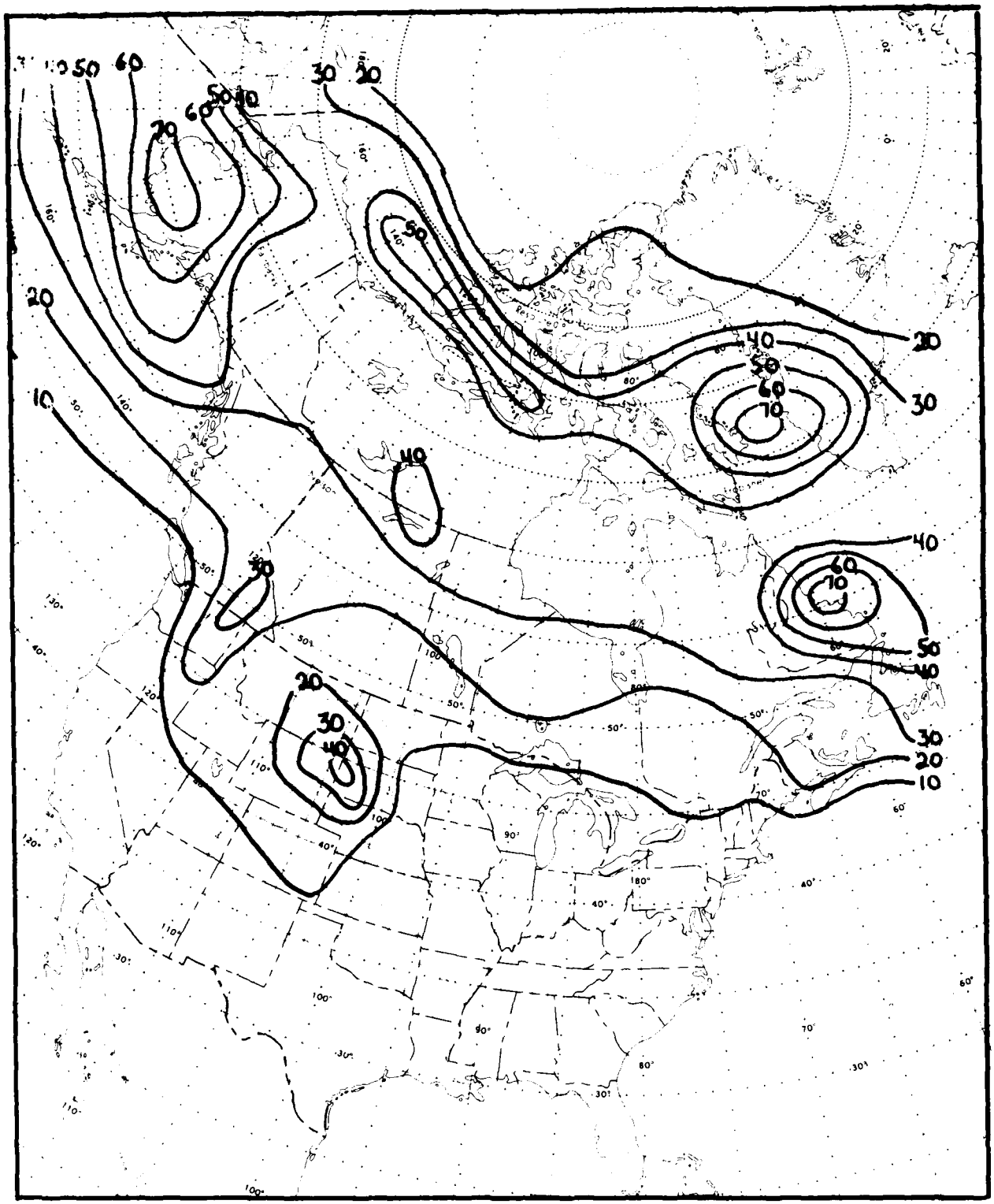

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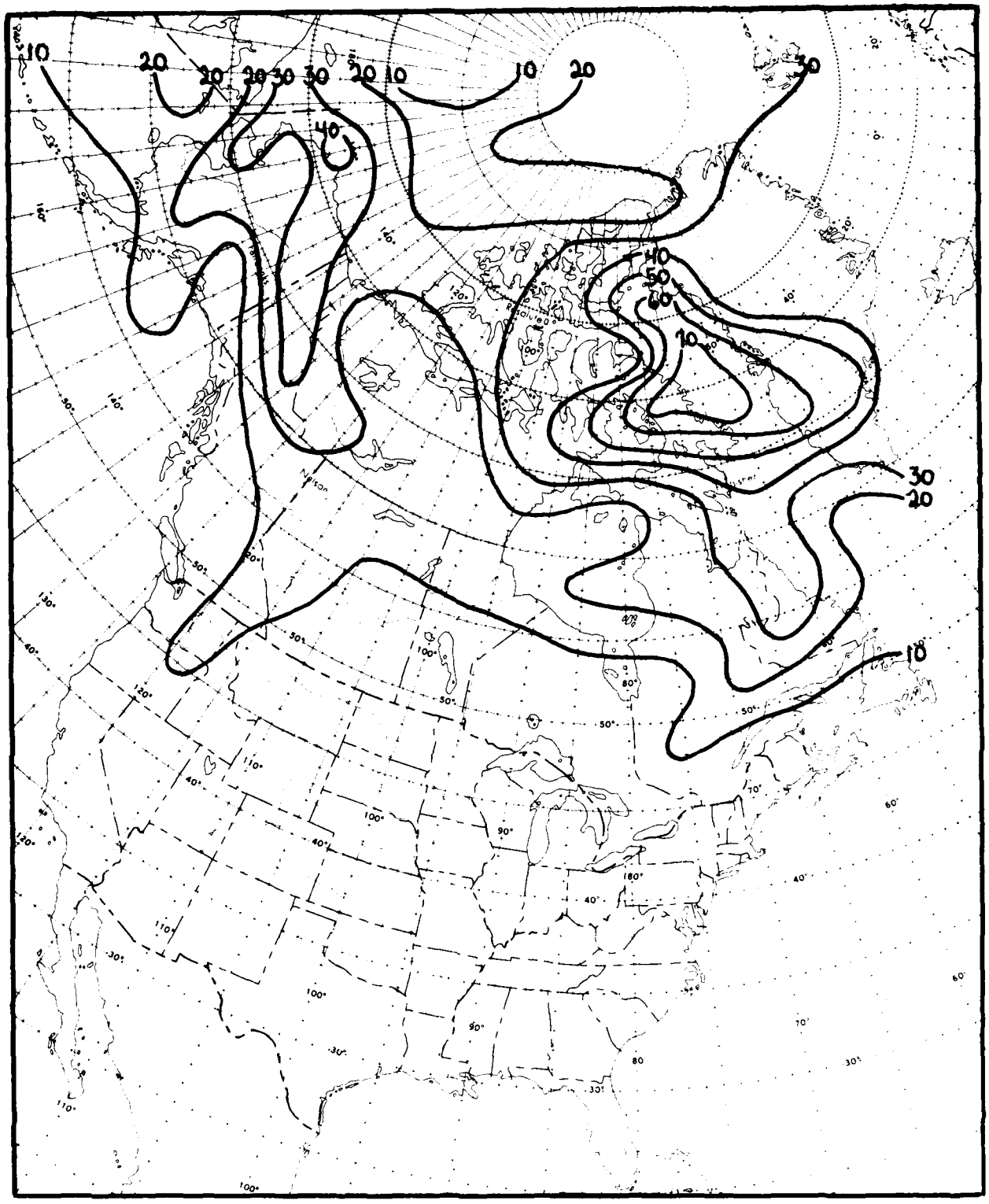

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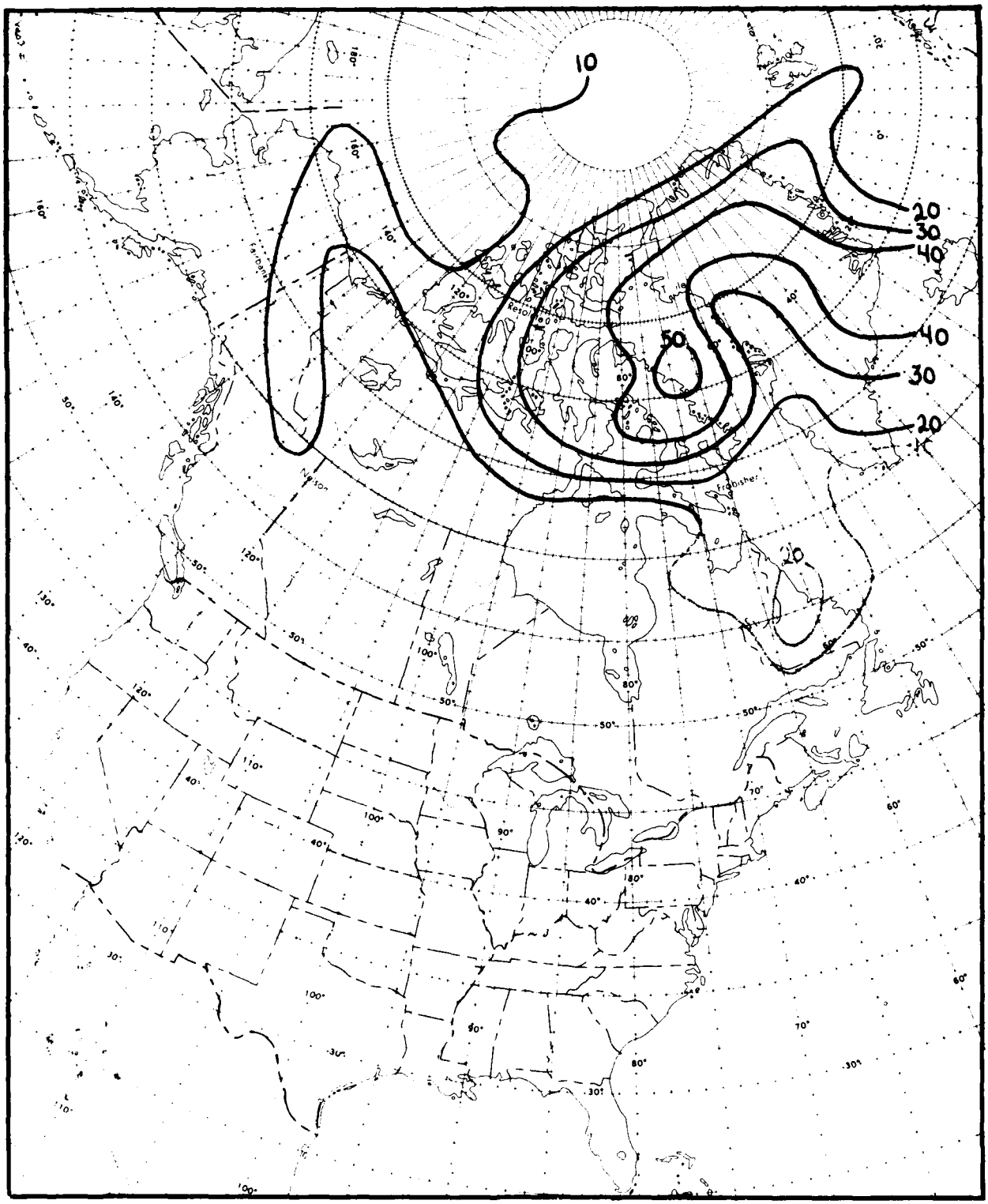

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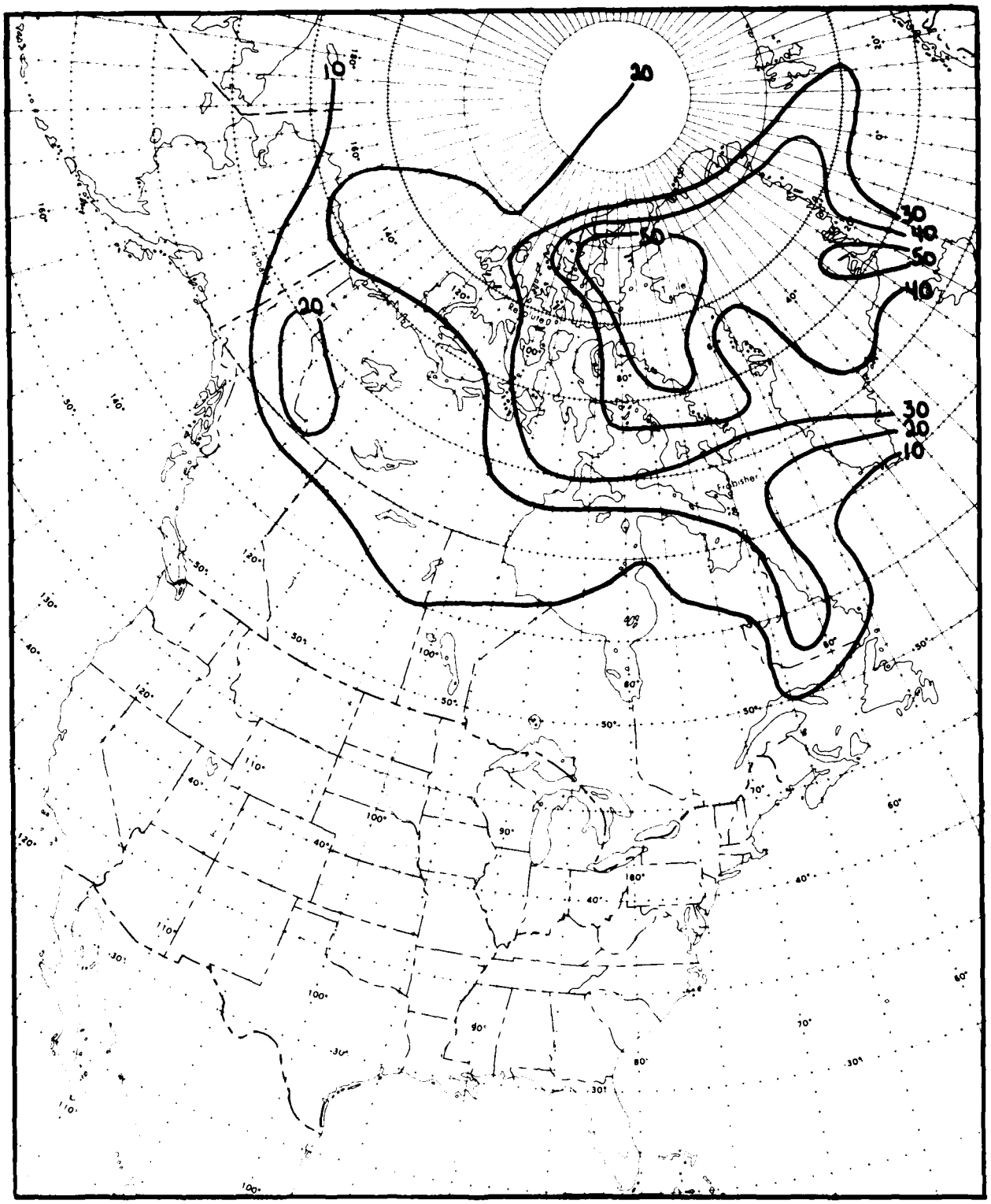

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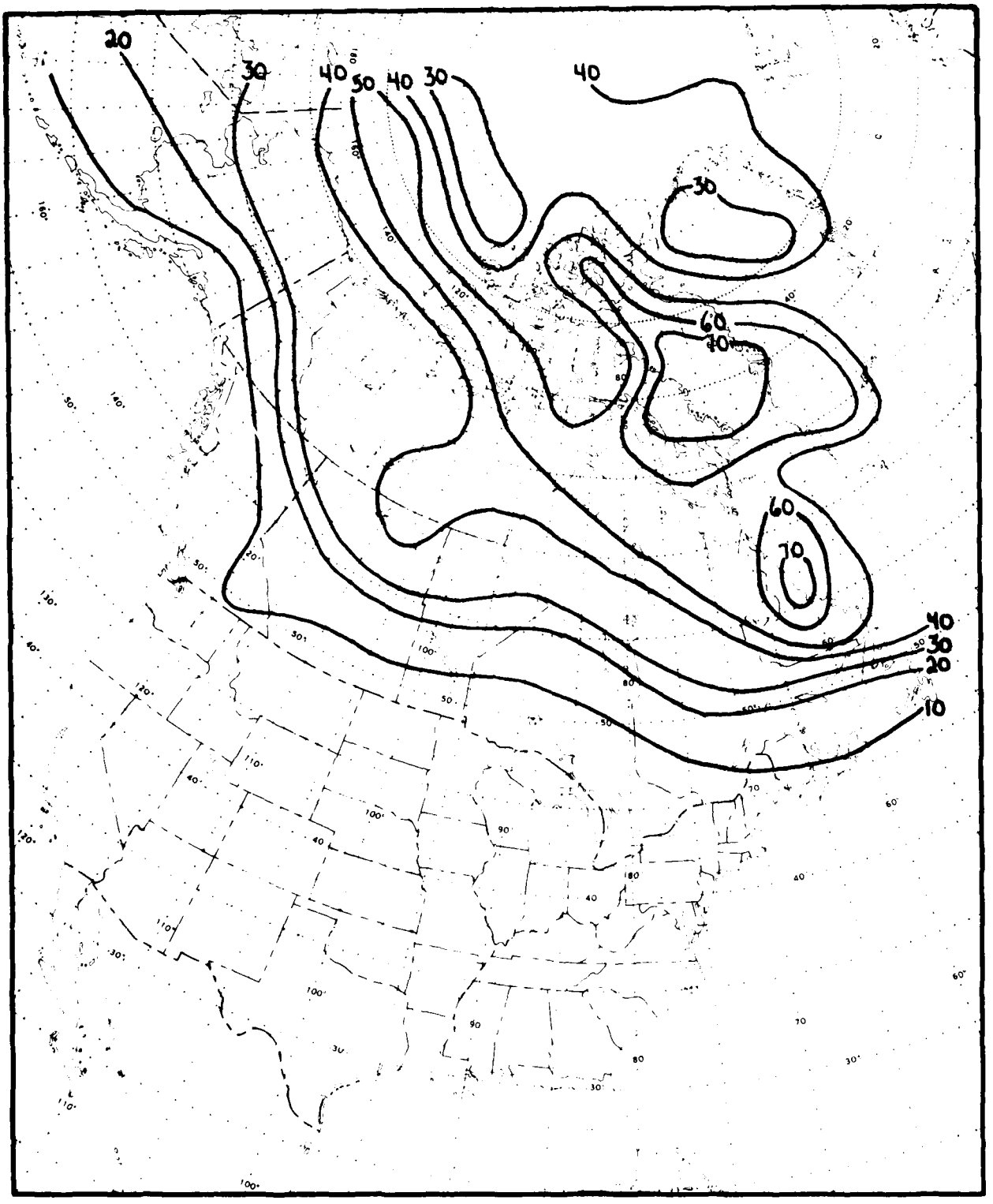

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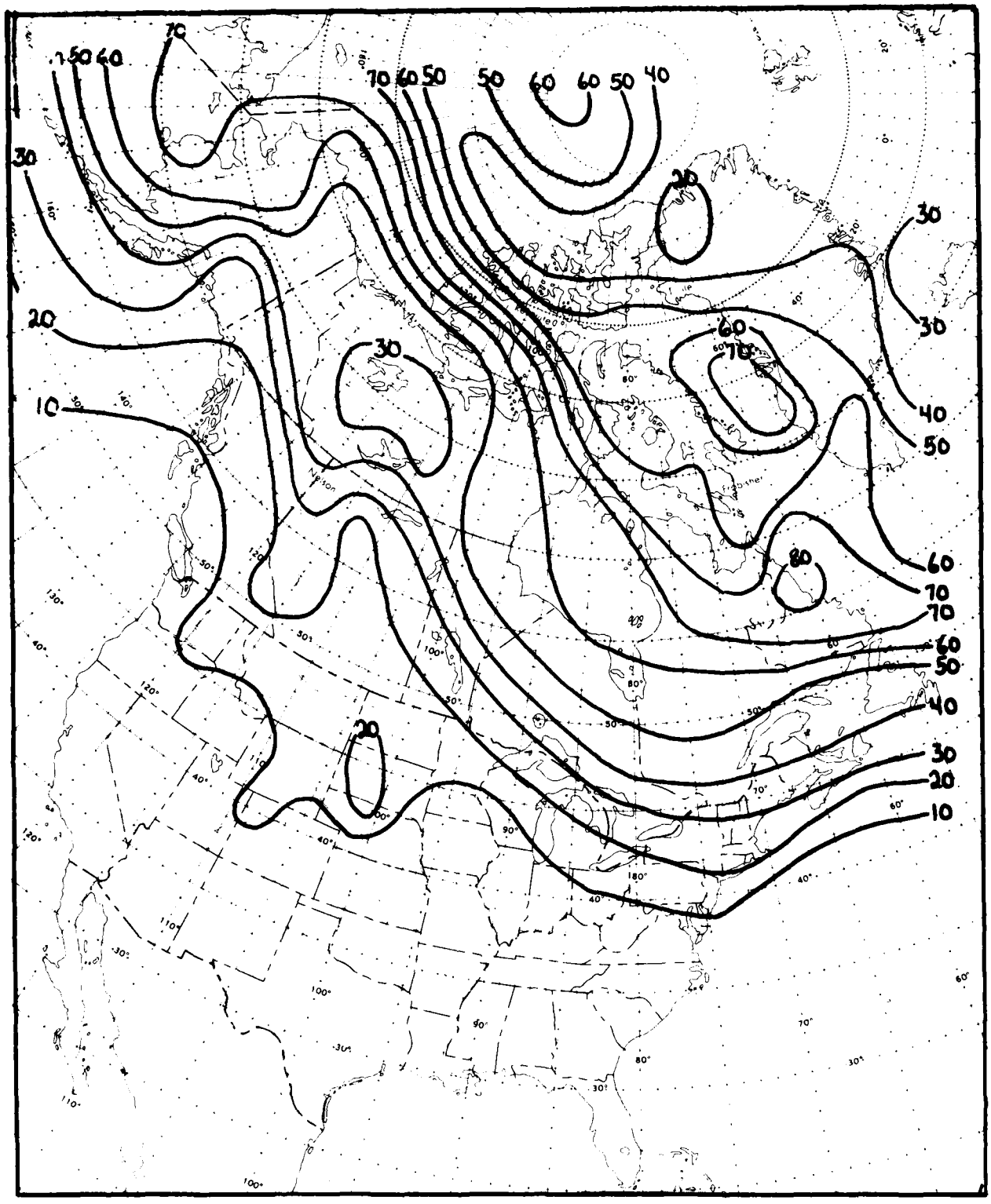

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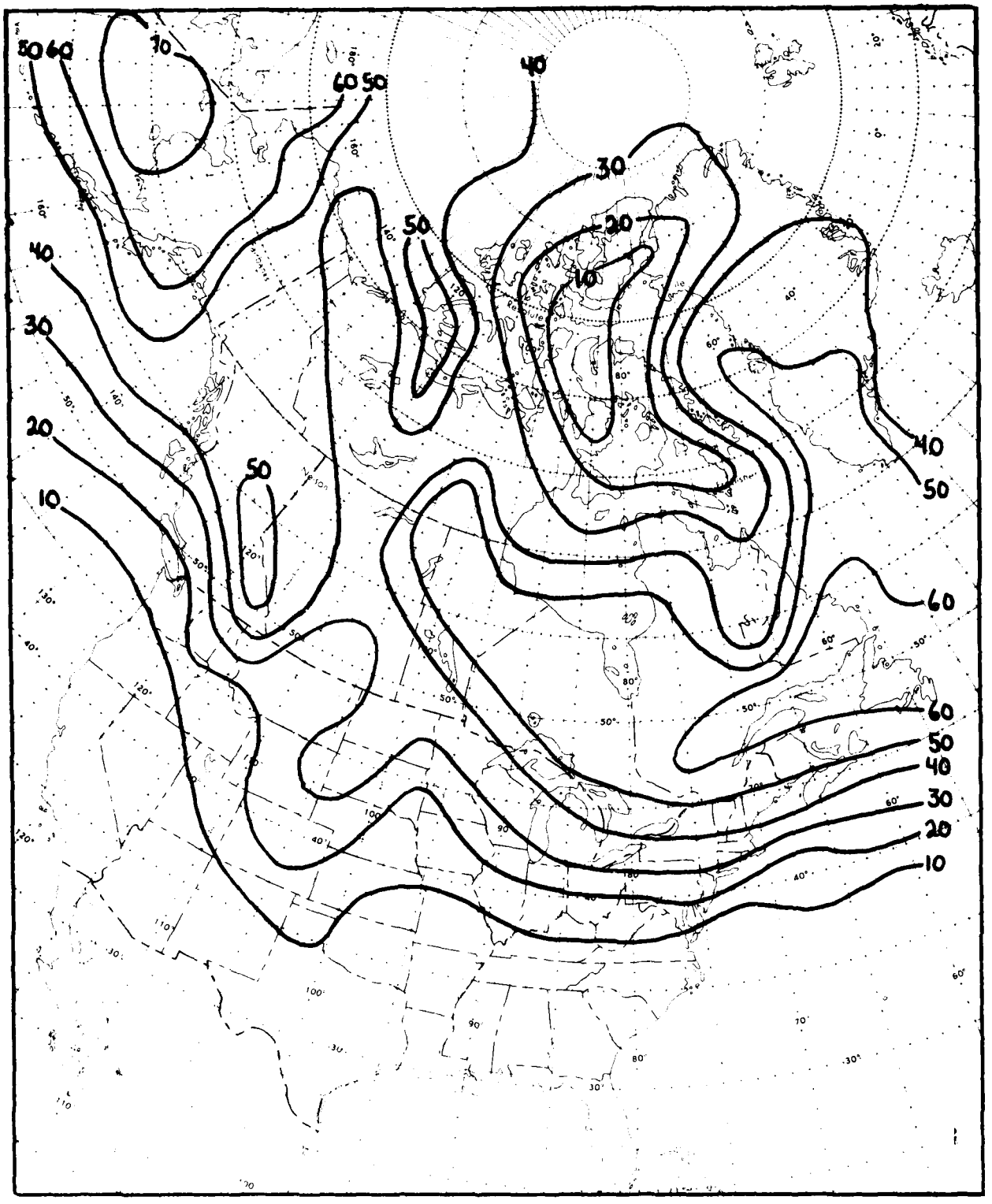

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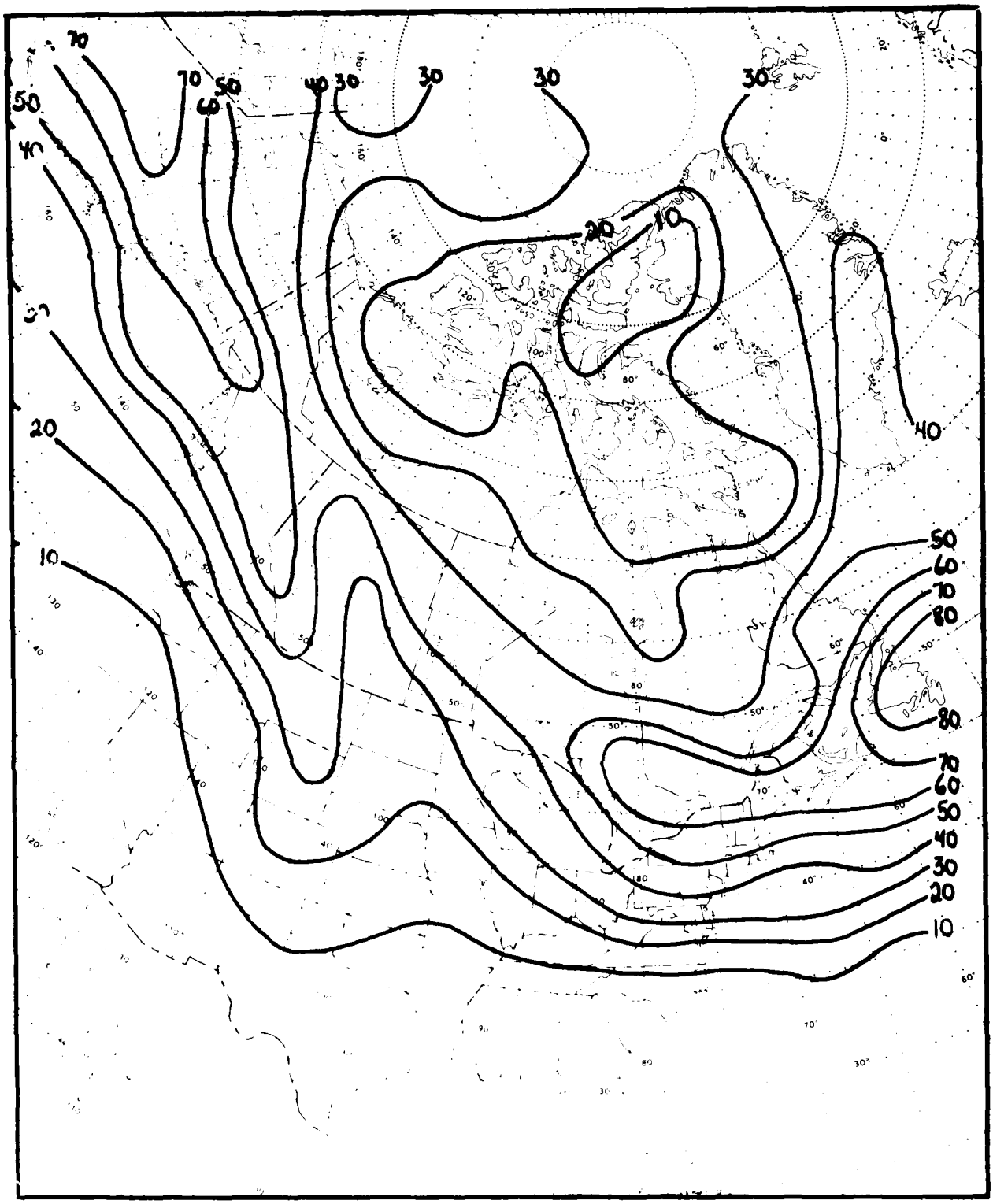

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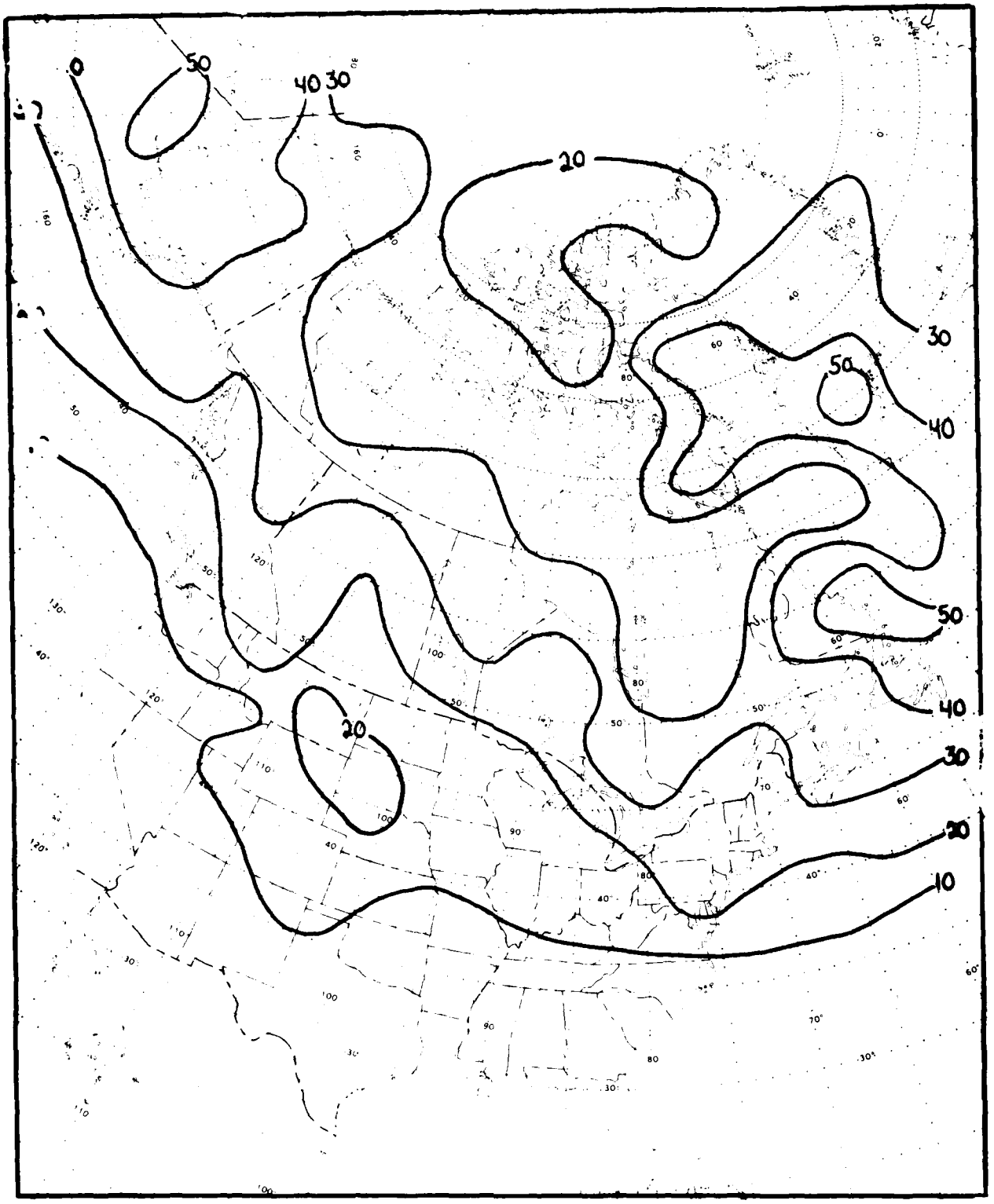

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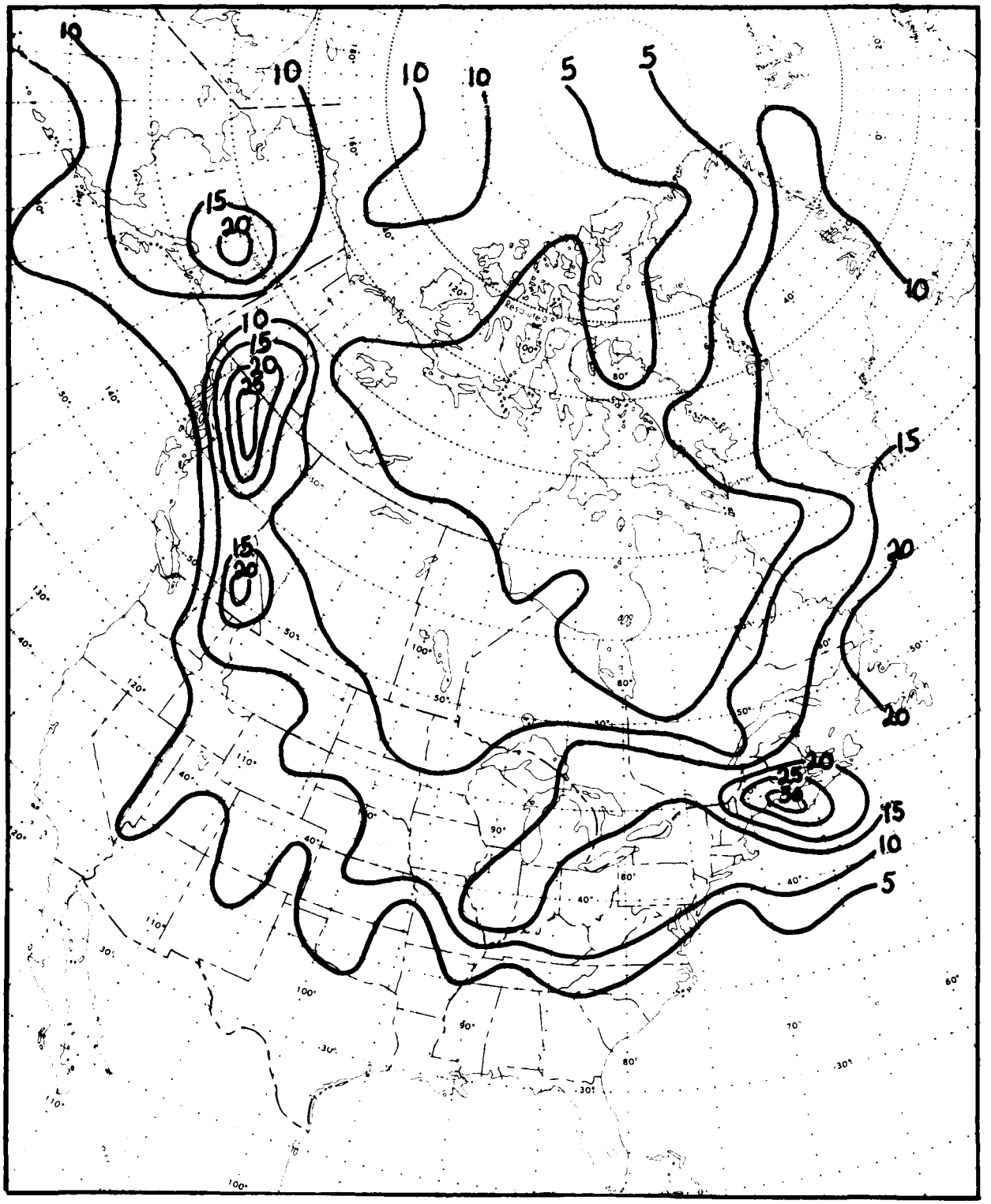

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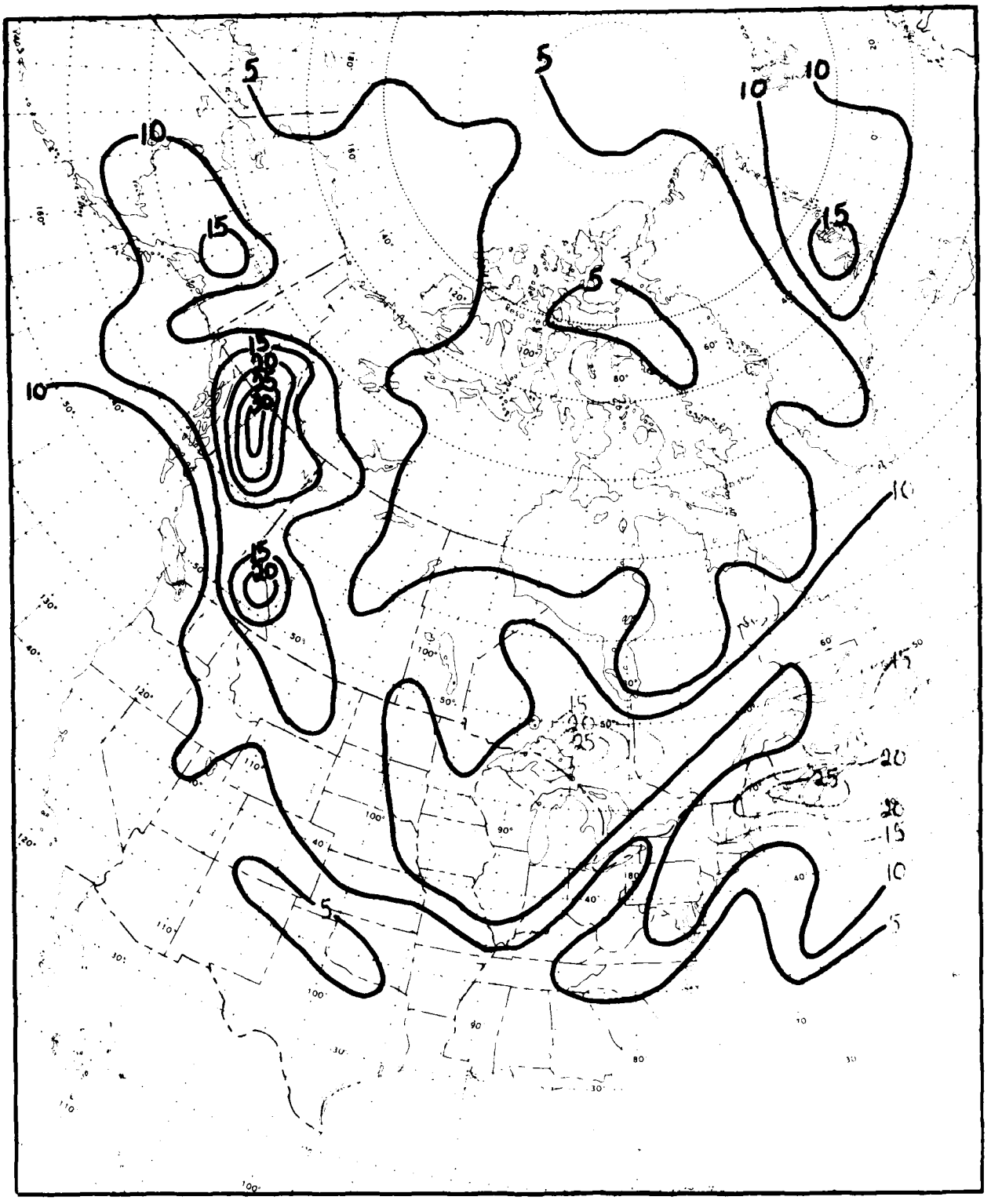

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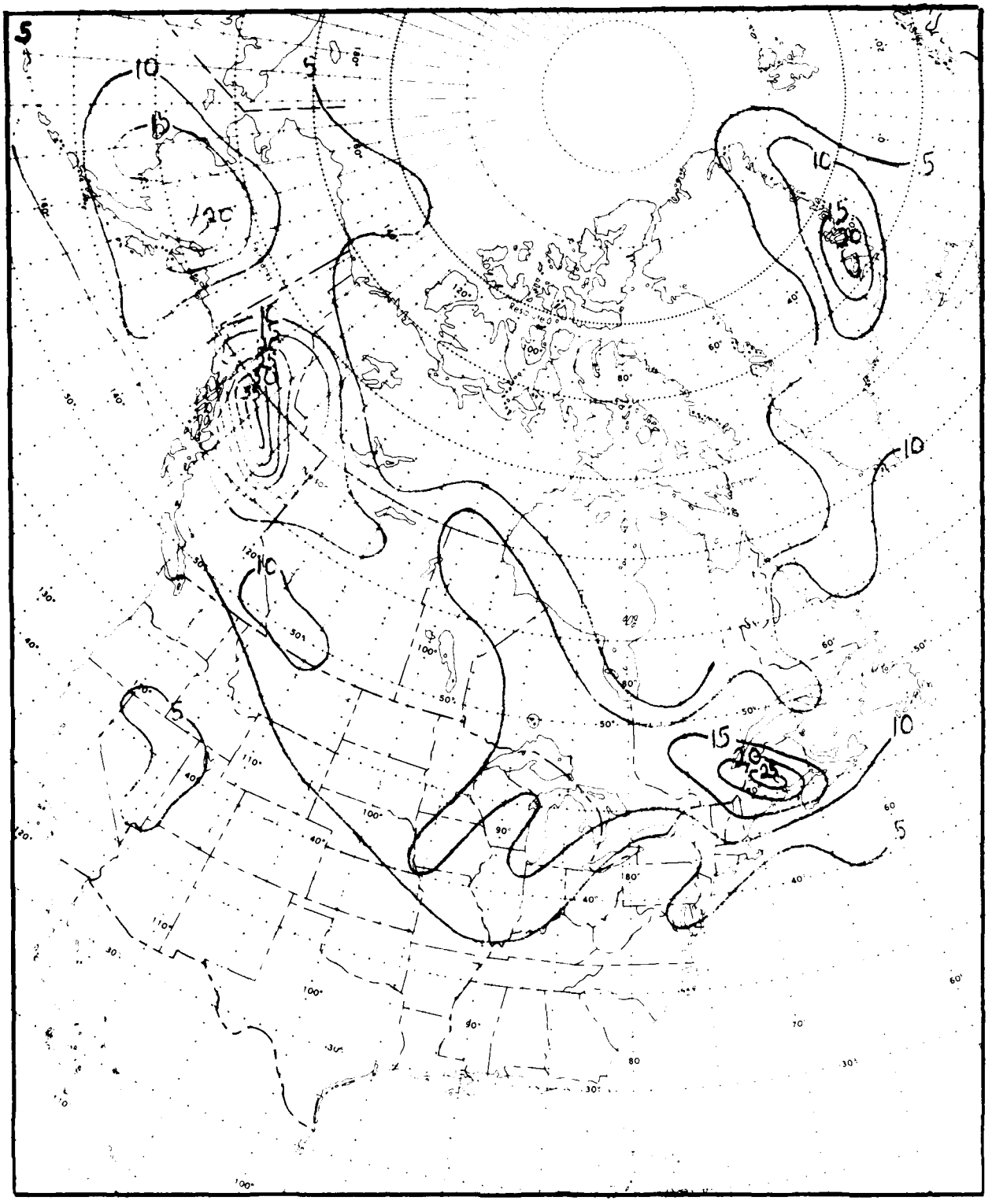

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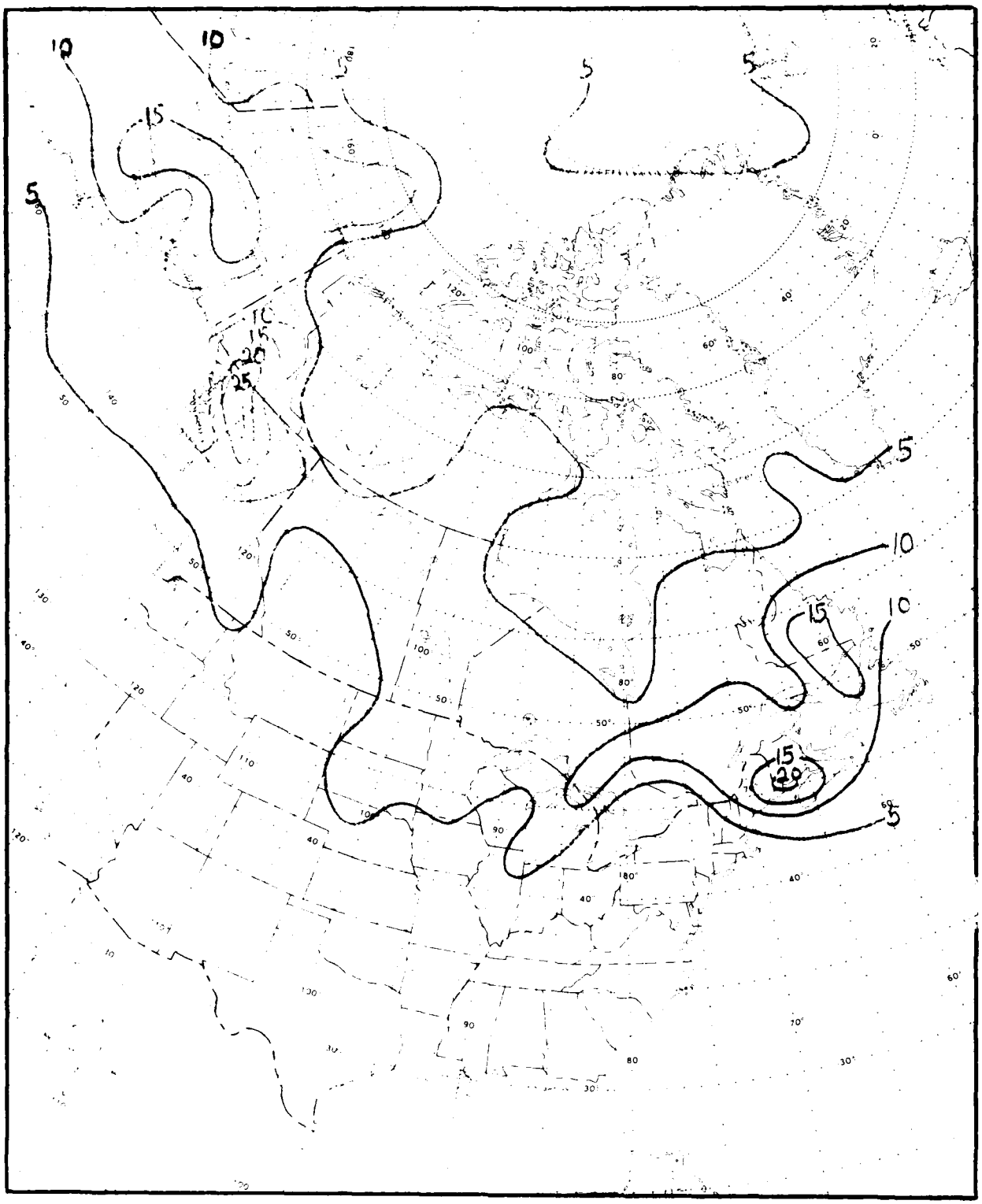

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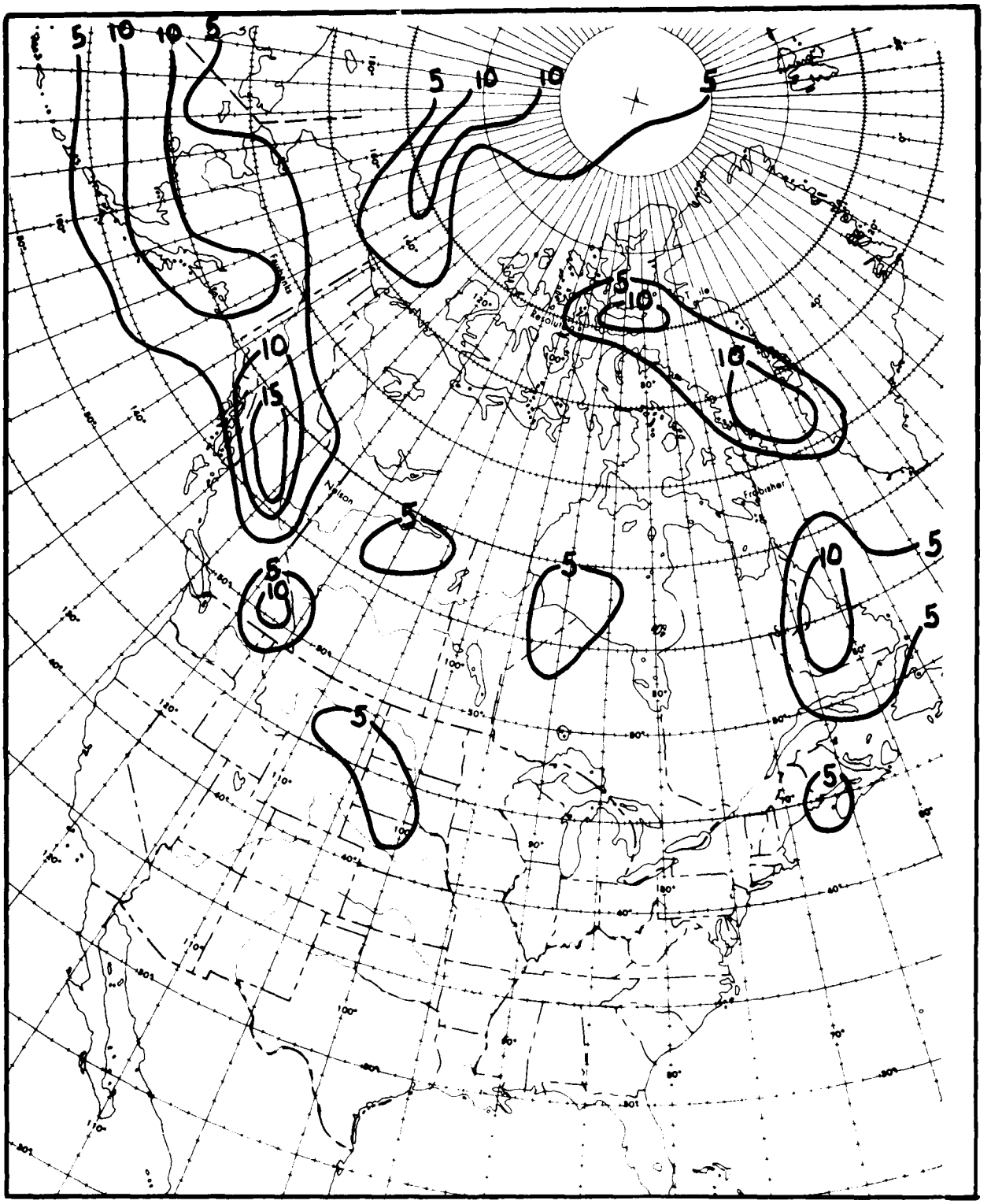

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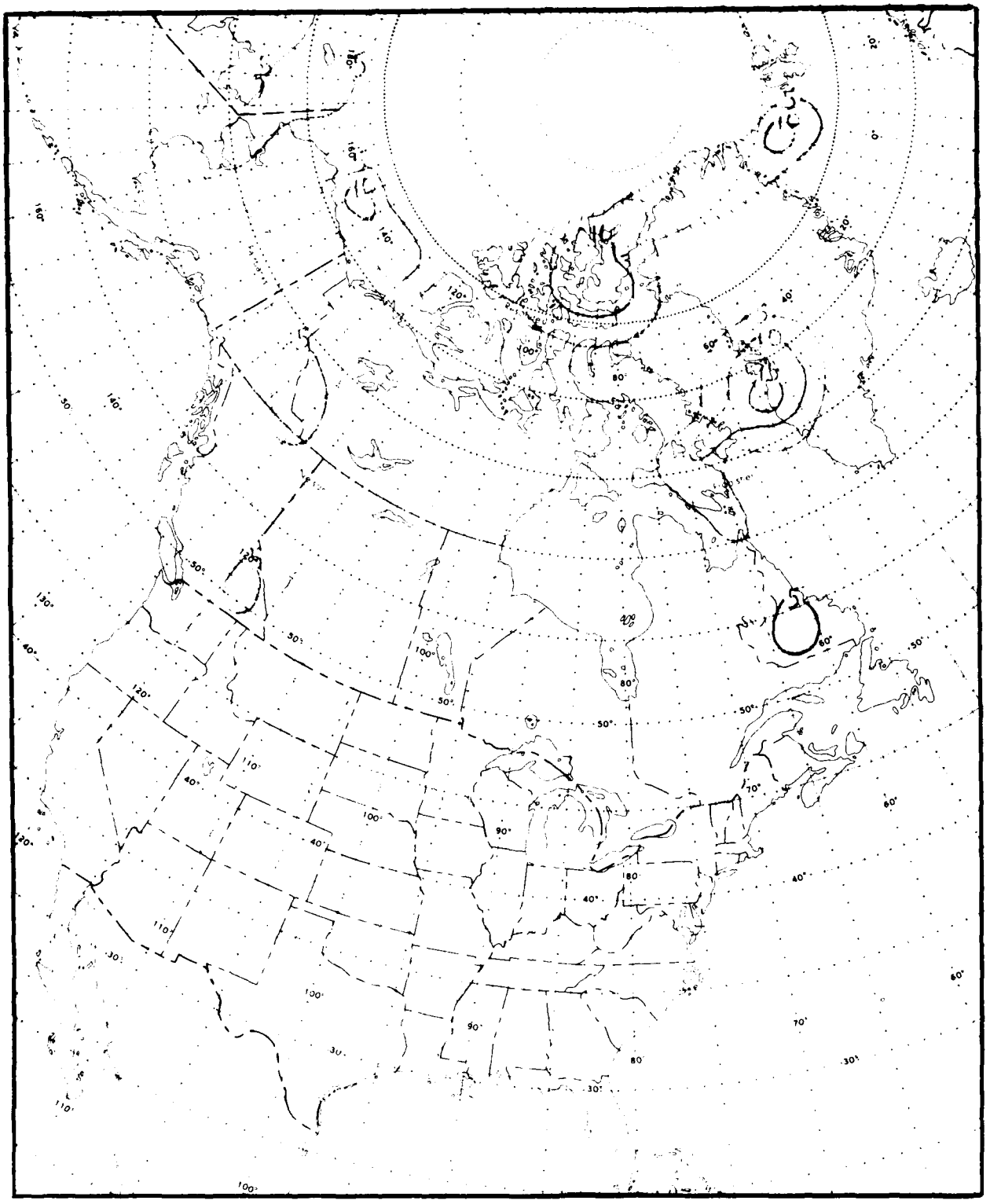

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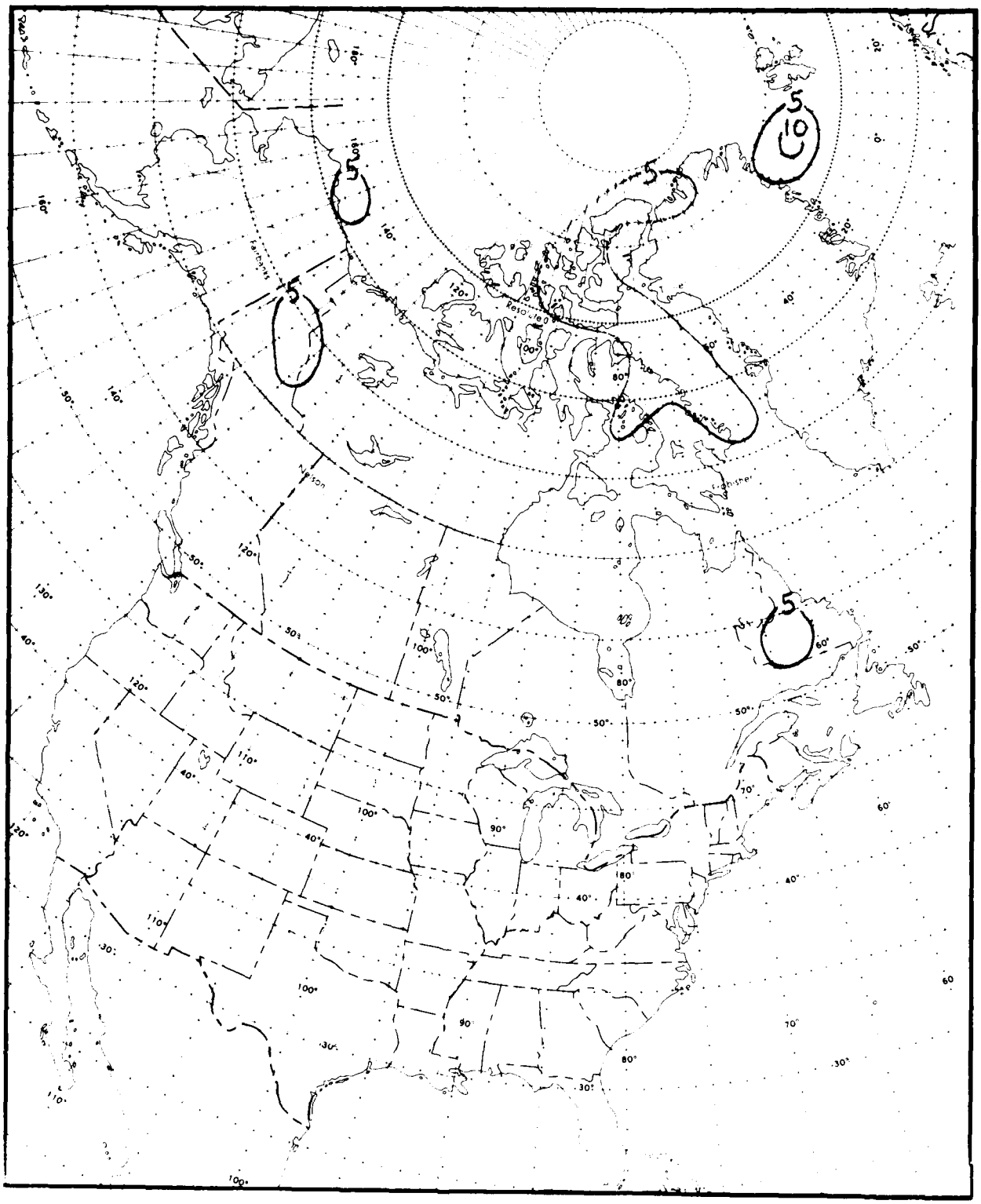

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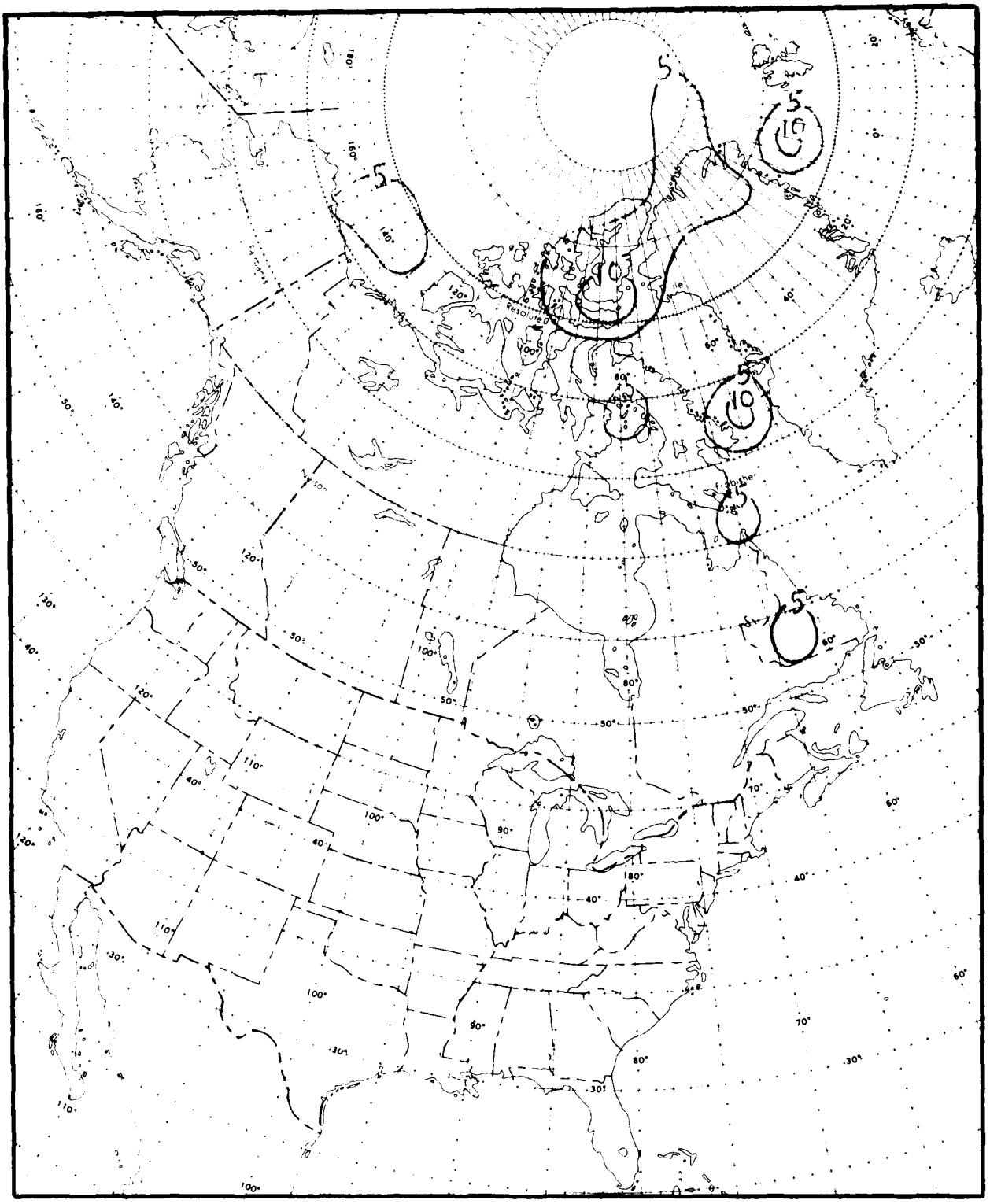

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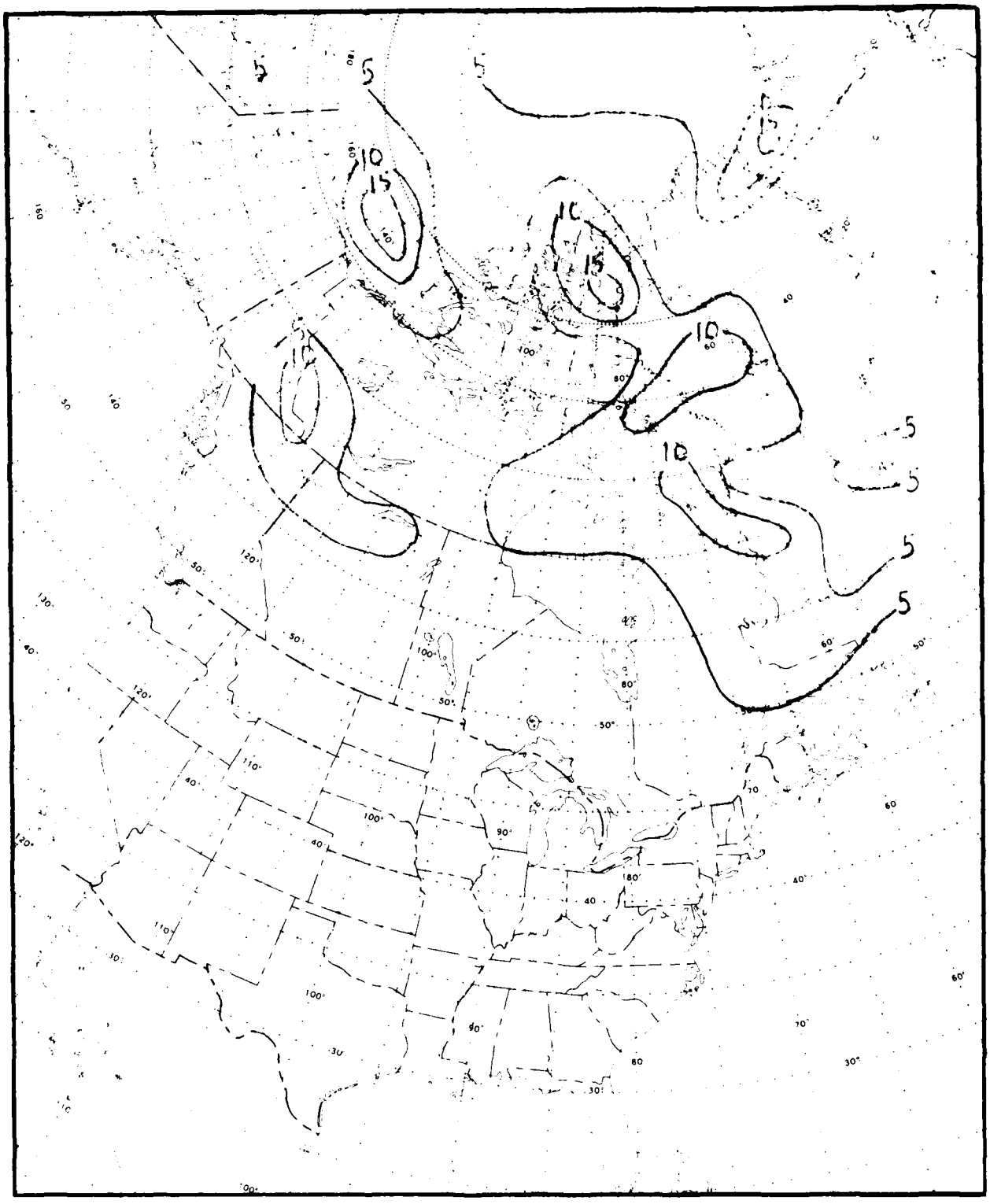

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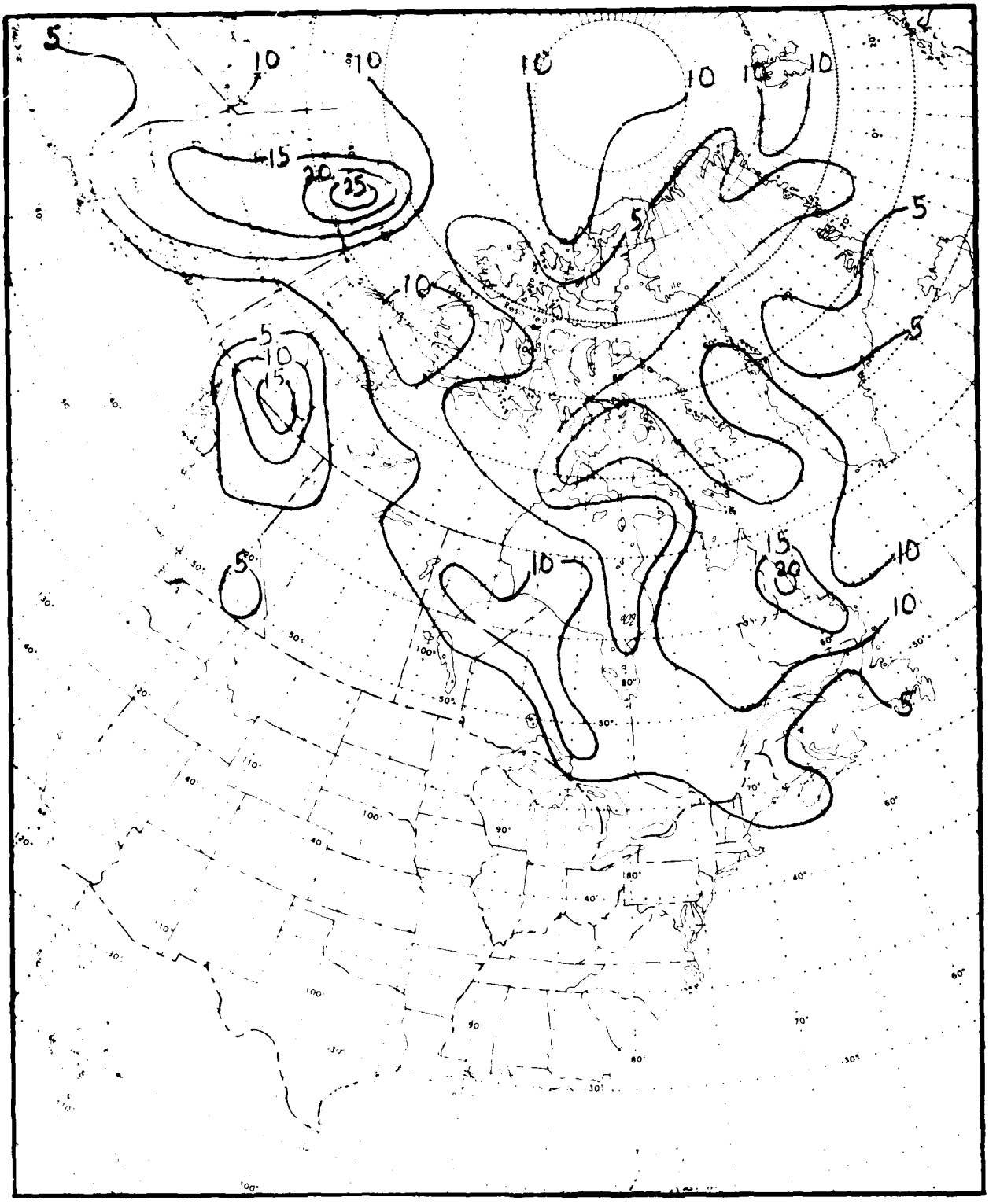

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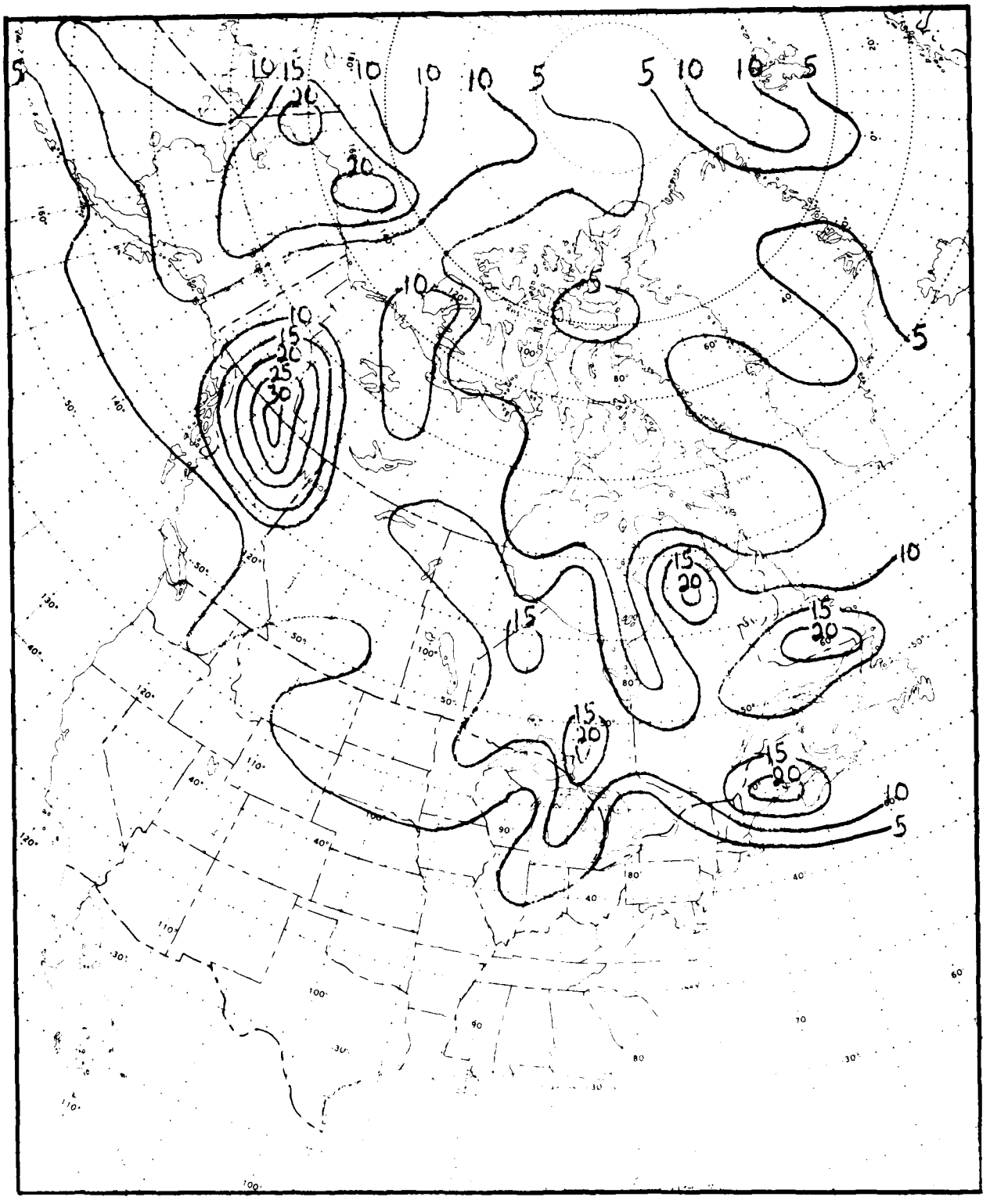

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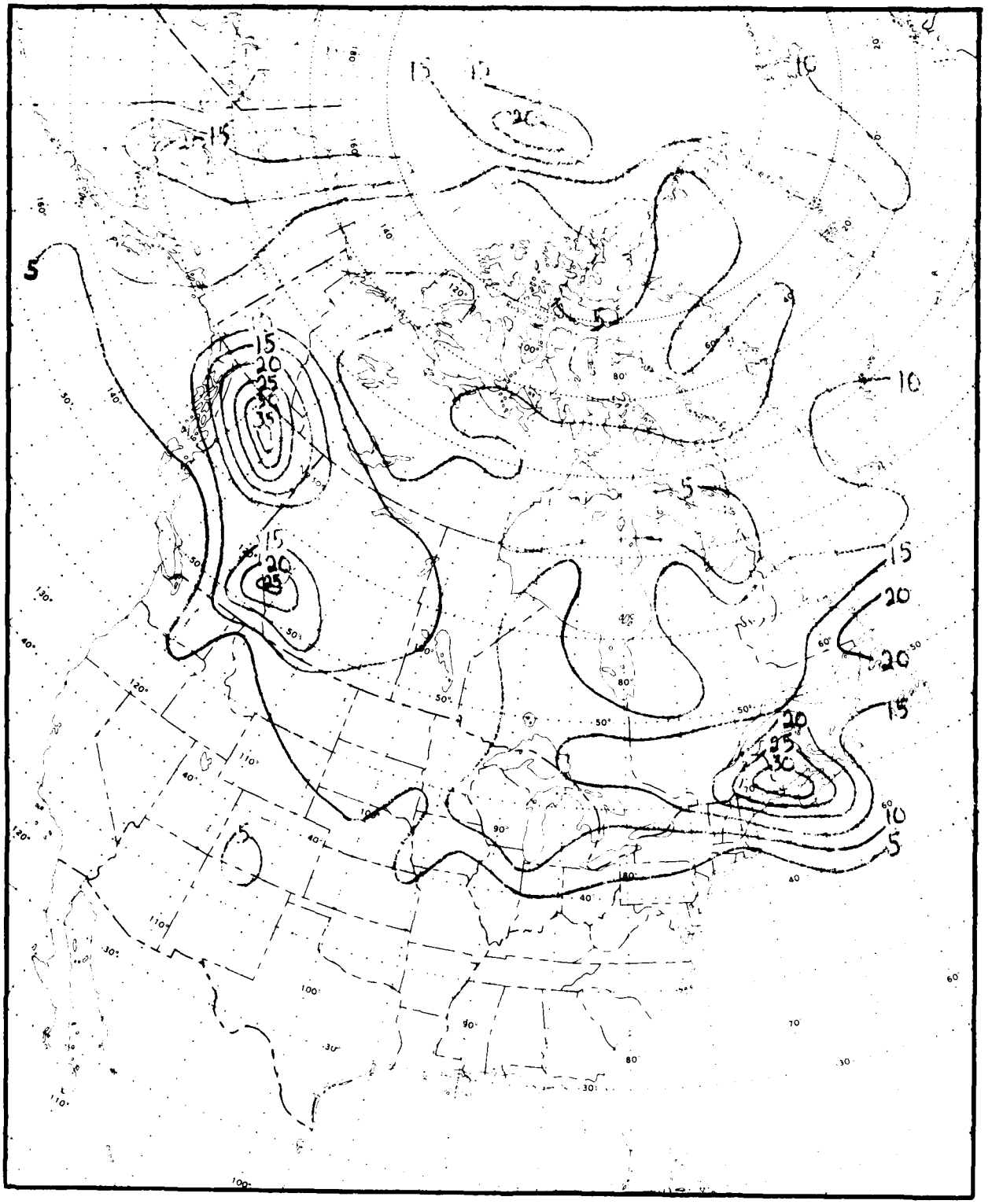

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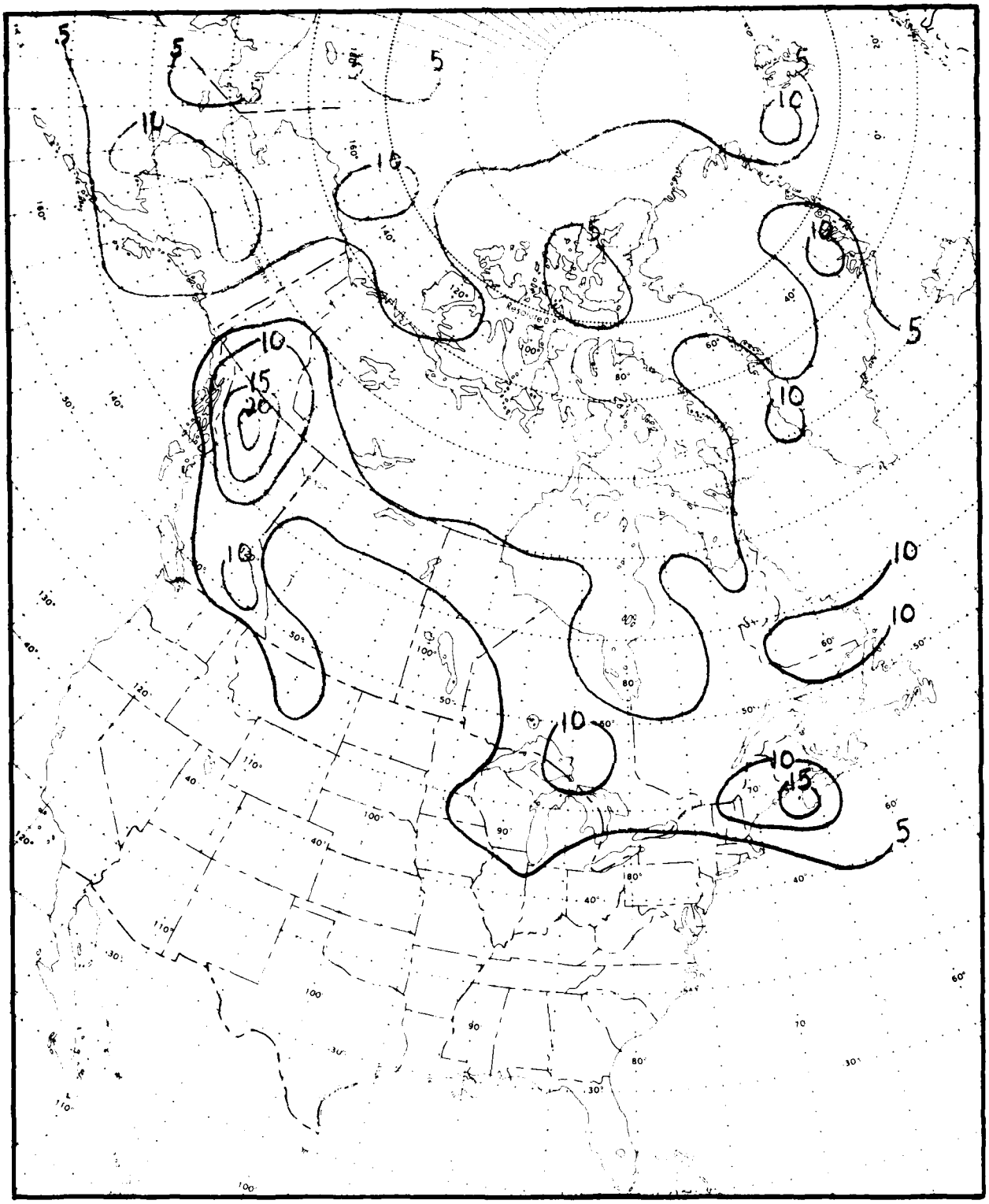

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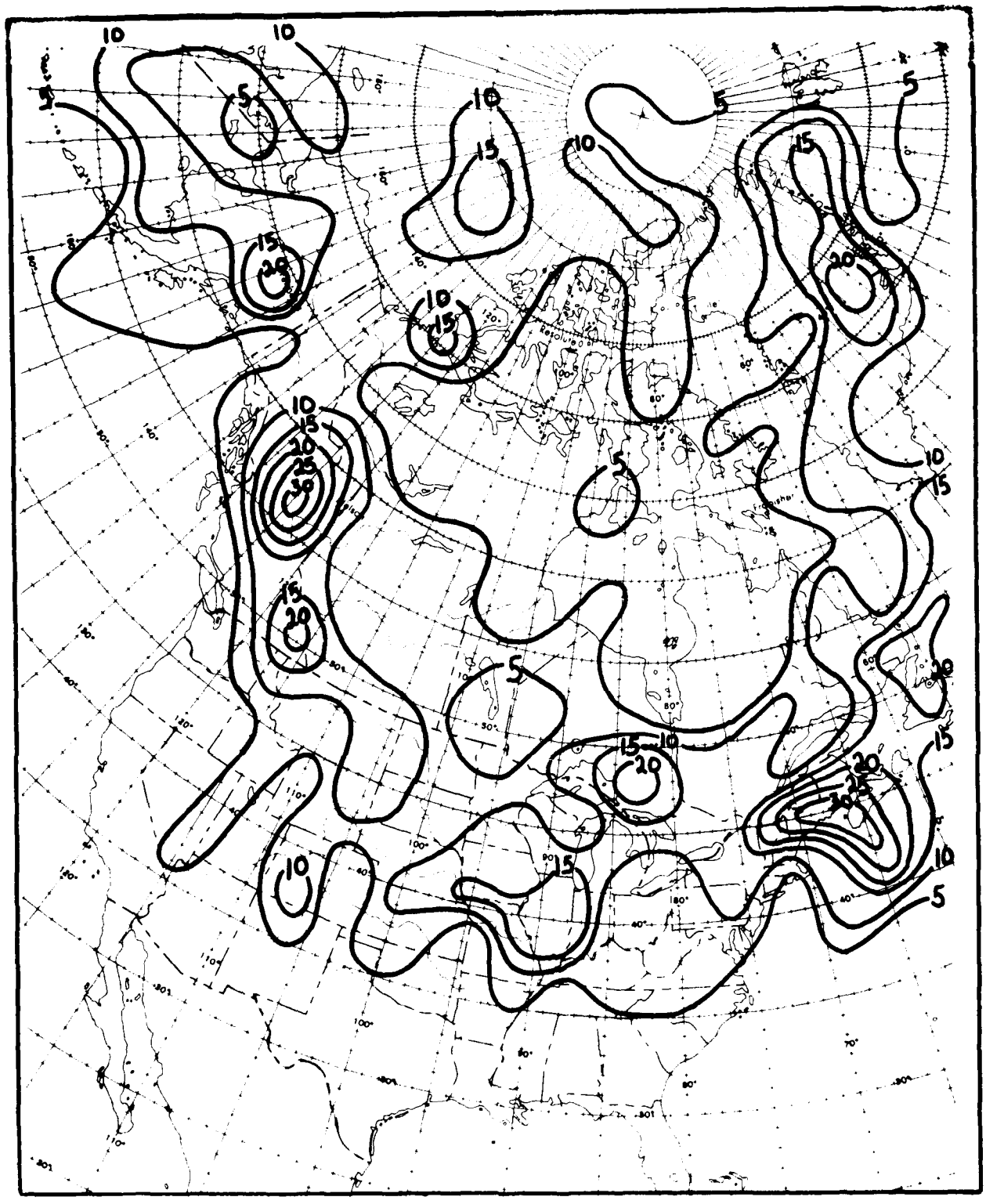

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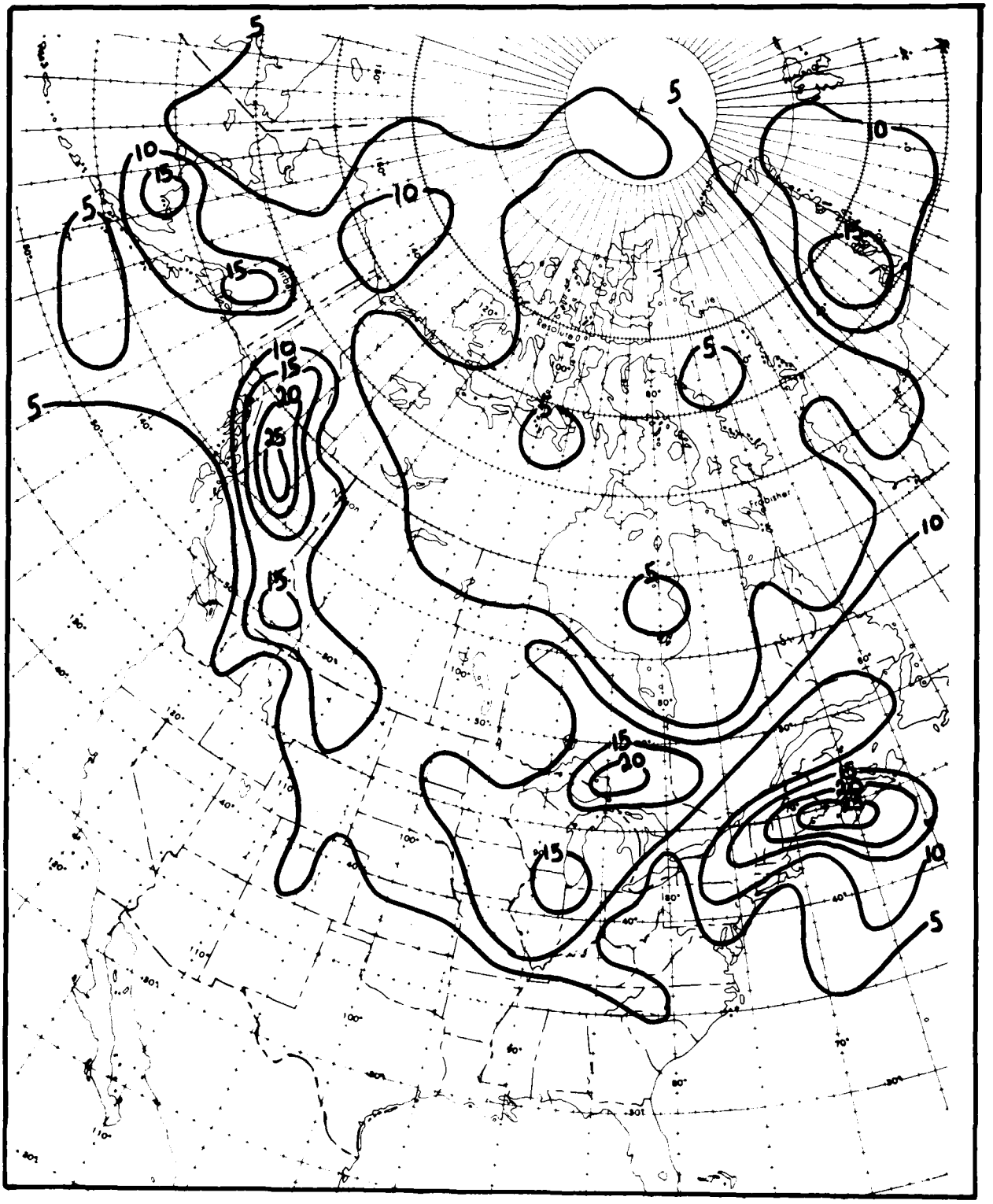

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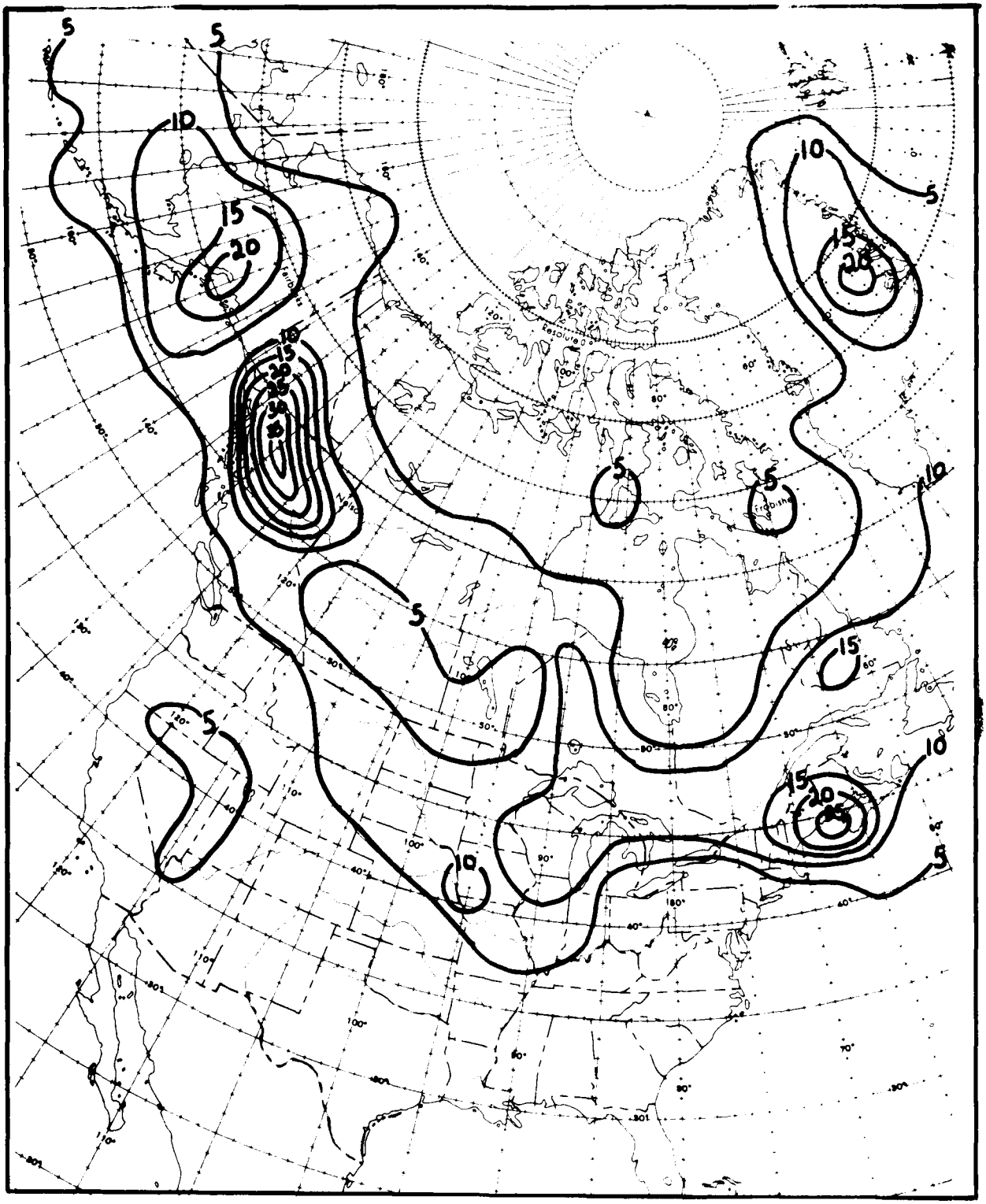

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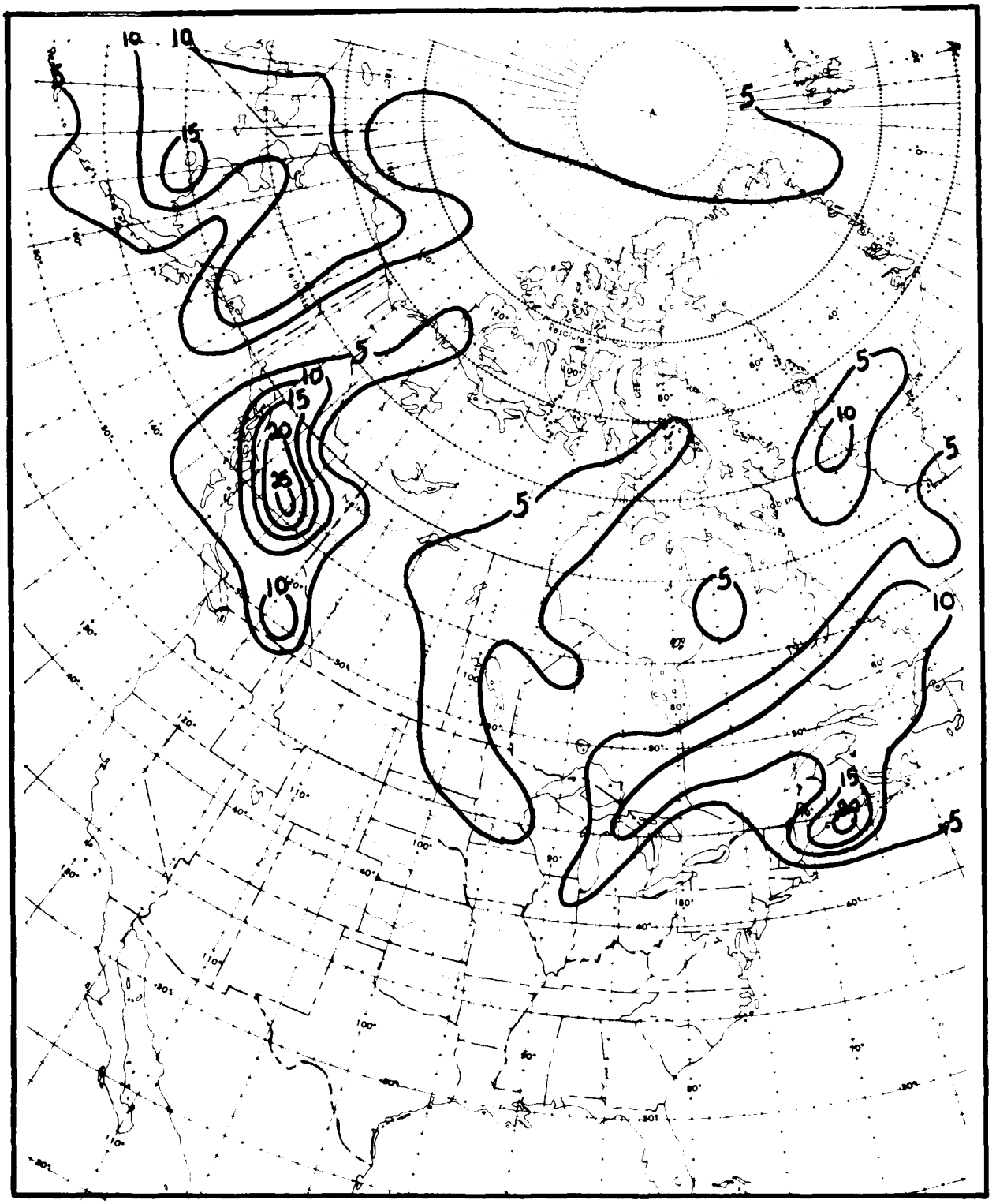

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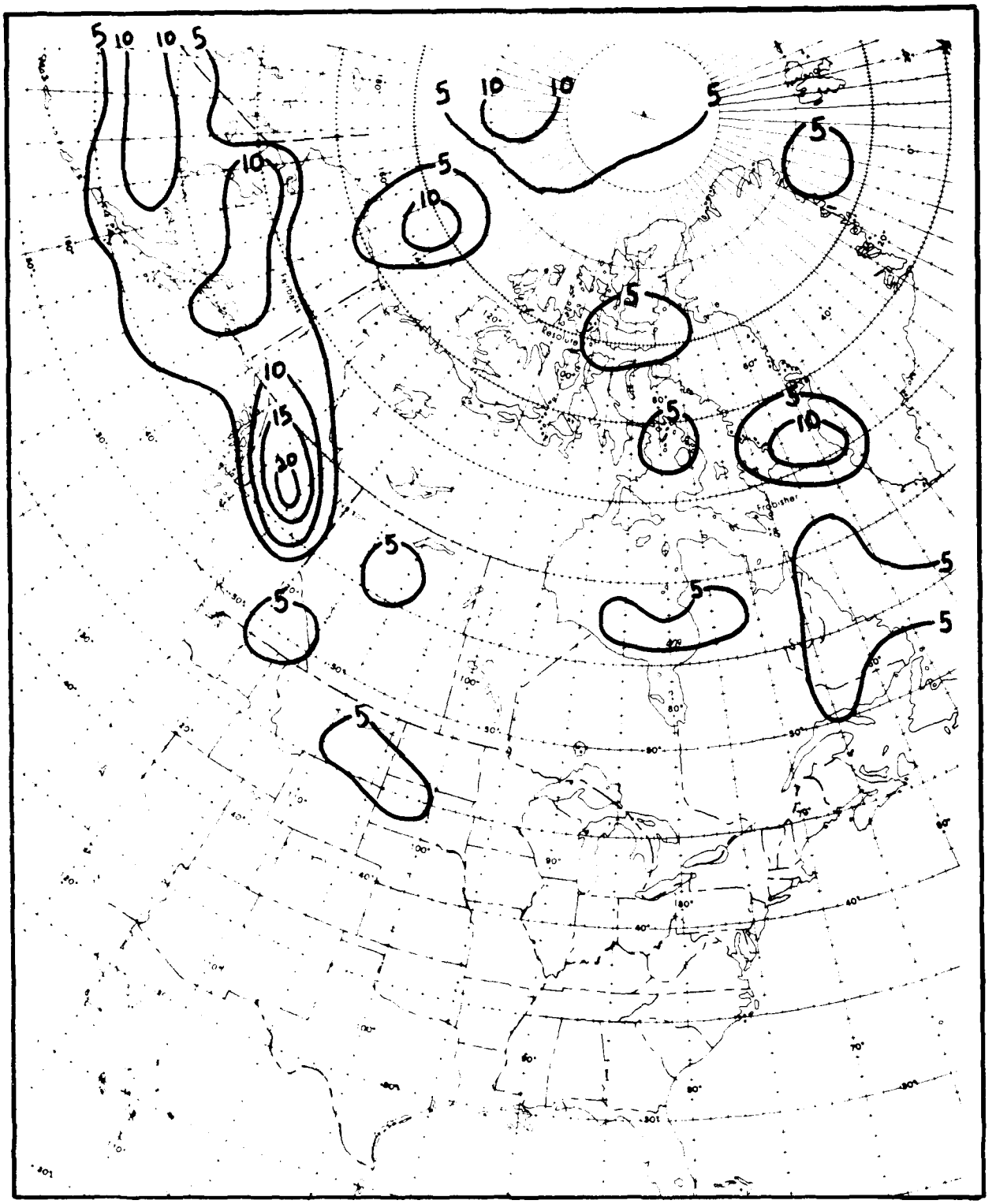

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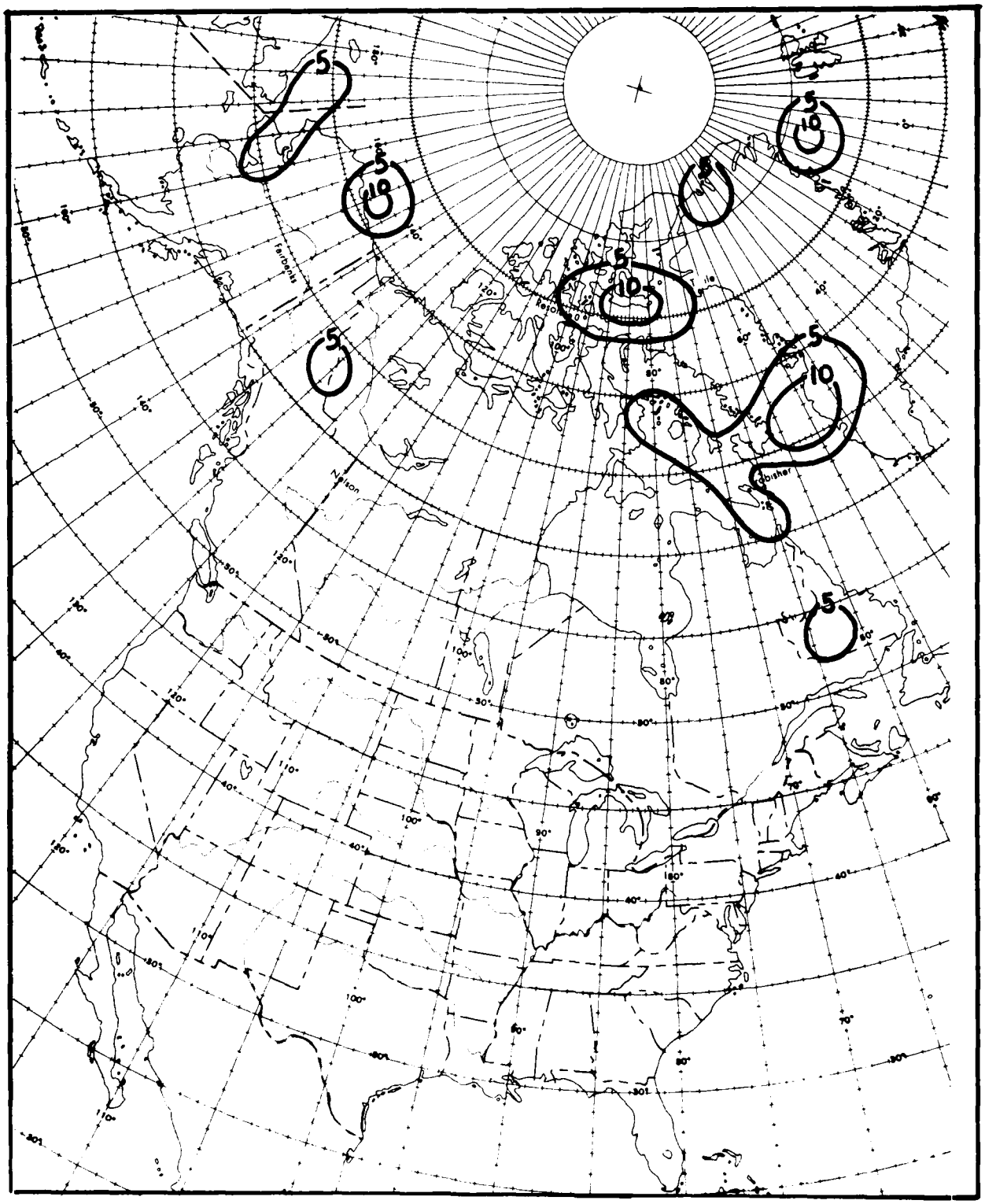

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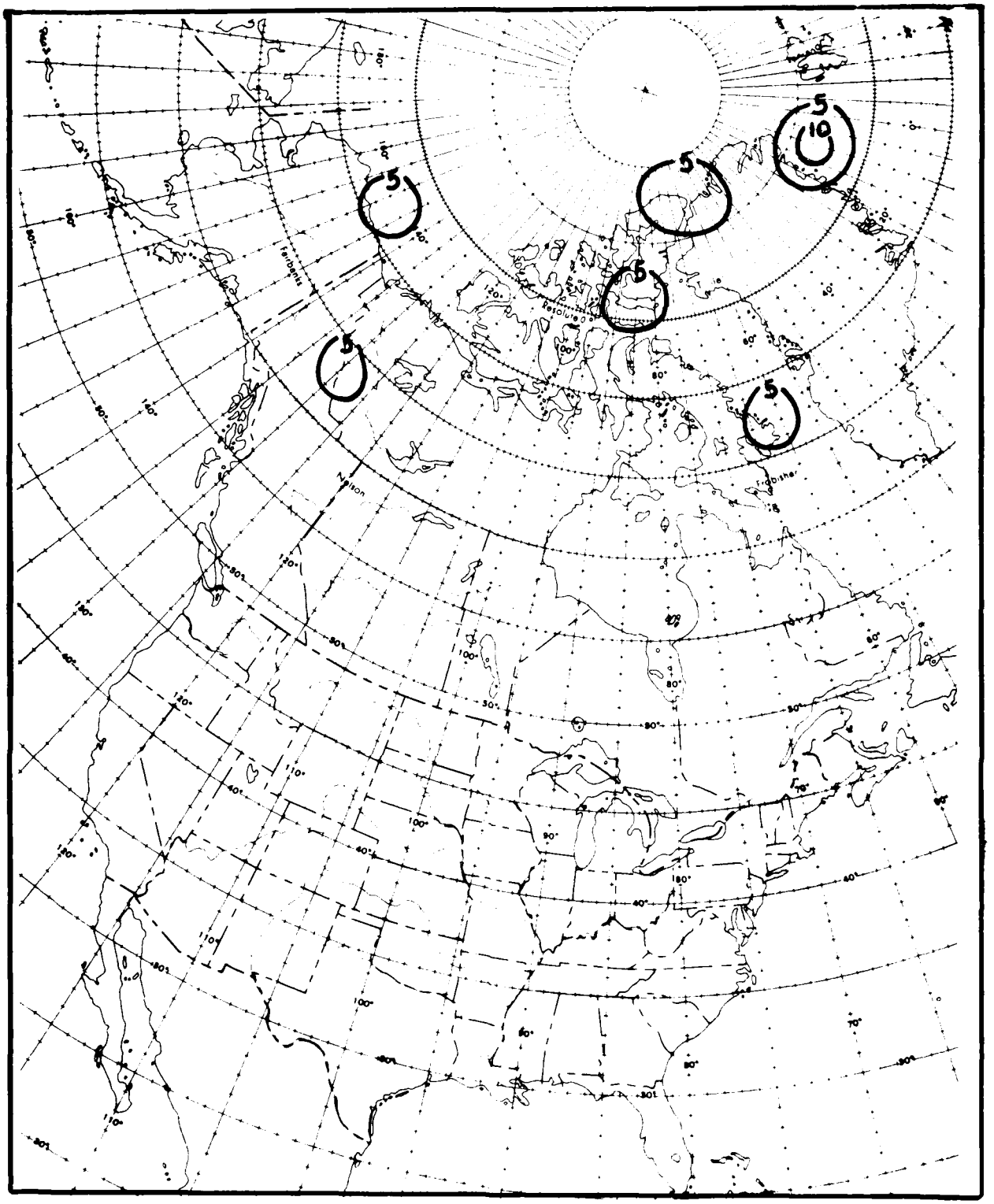

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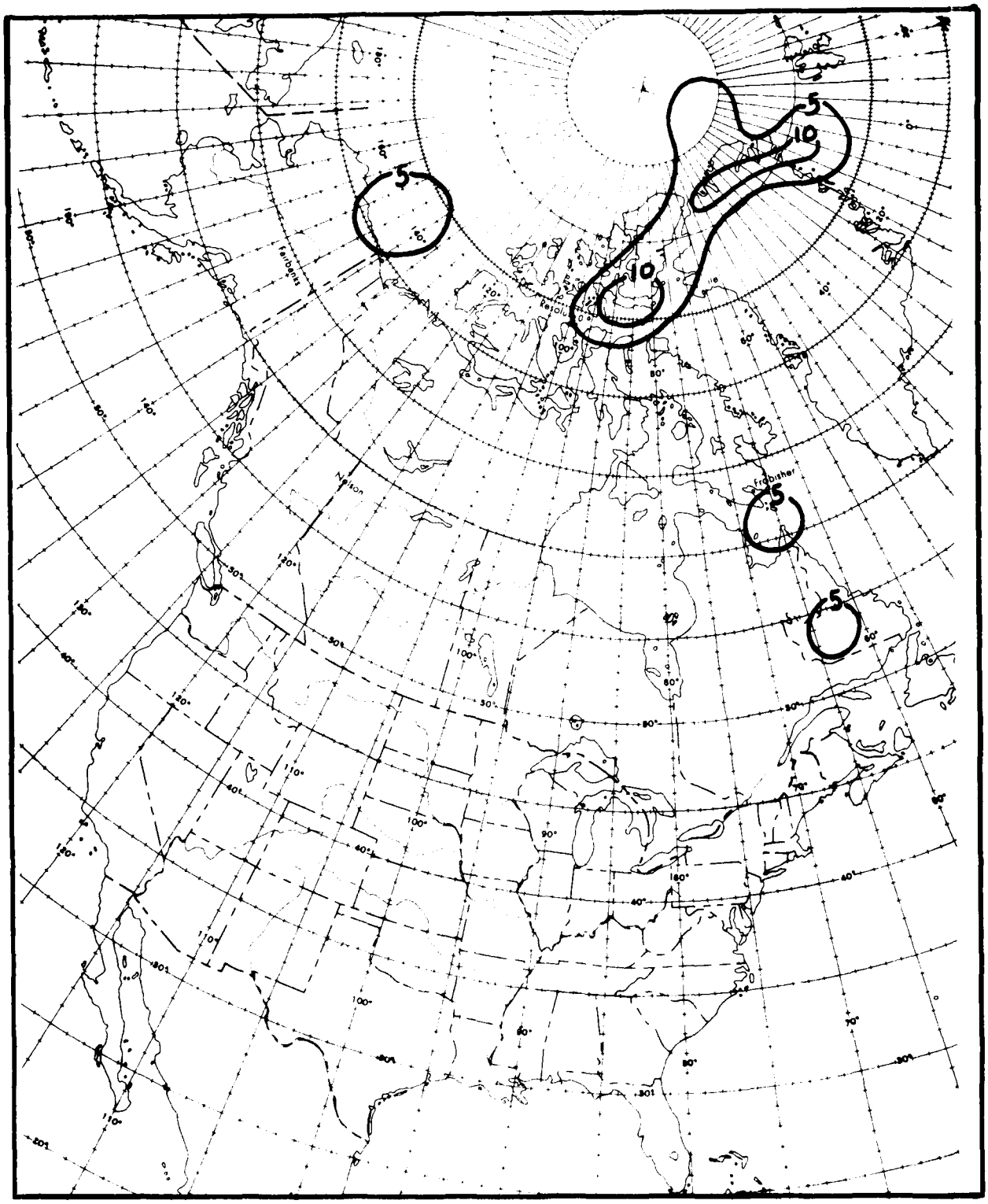


CHART 34 AUGUST SURFACE TO 1,524 METERS, CONCENTRATION 1.00 G/M^3

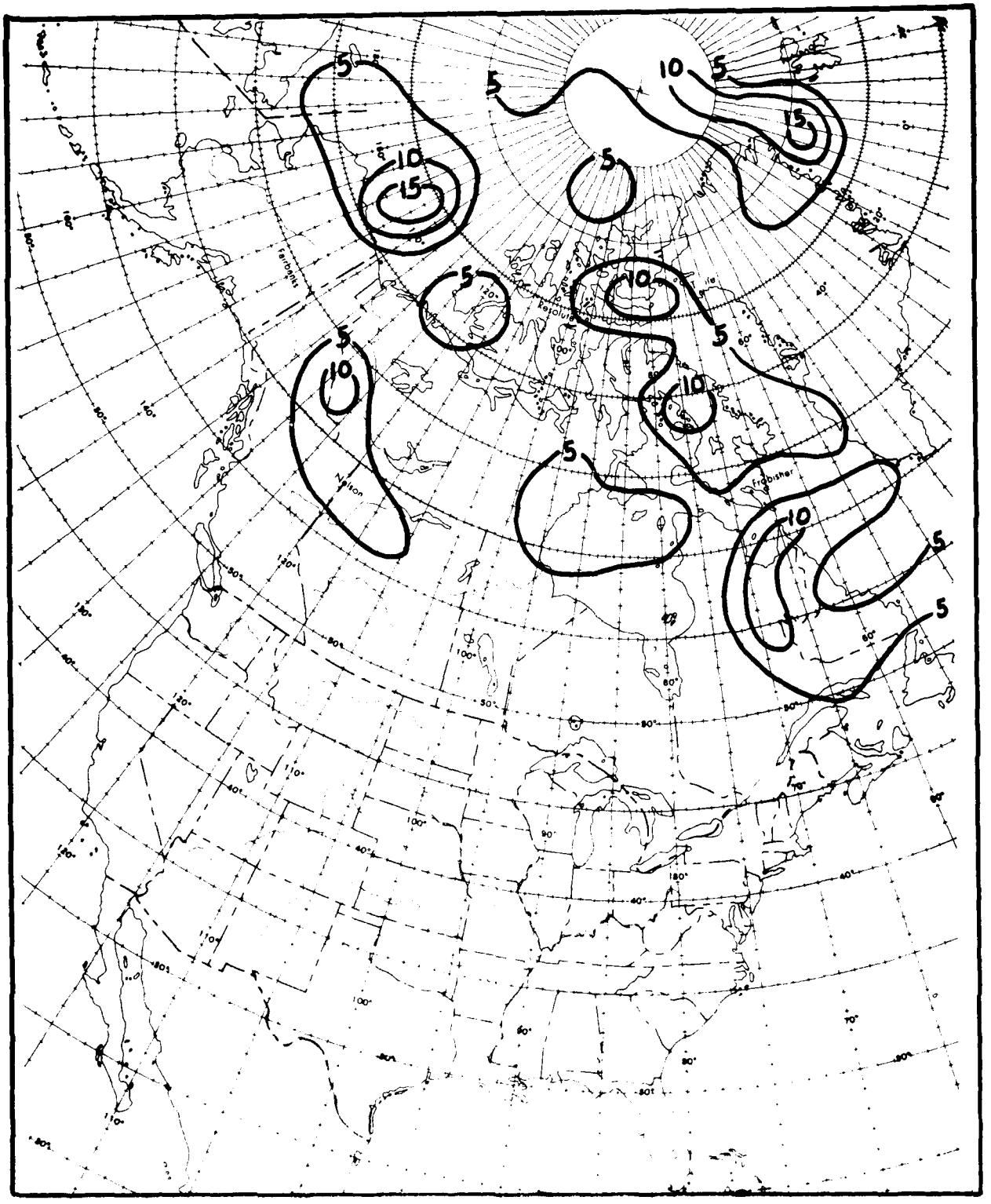


CHART 35 SEPTEMBER SURFACE TO 1,524 METERS, CONCENTRATION 1.00 G/M^3

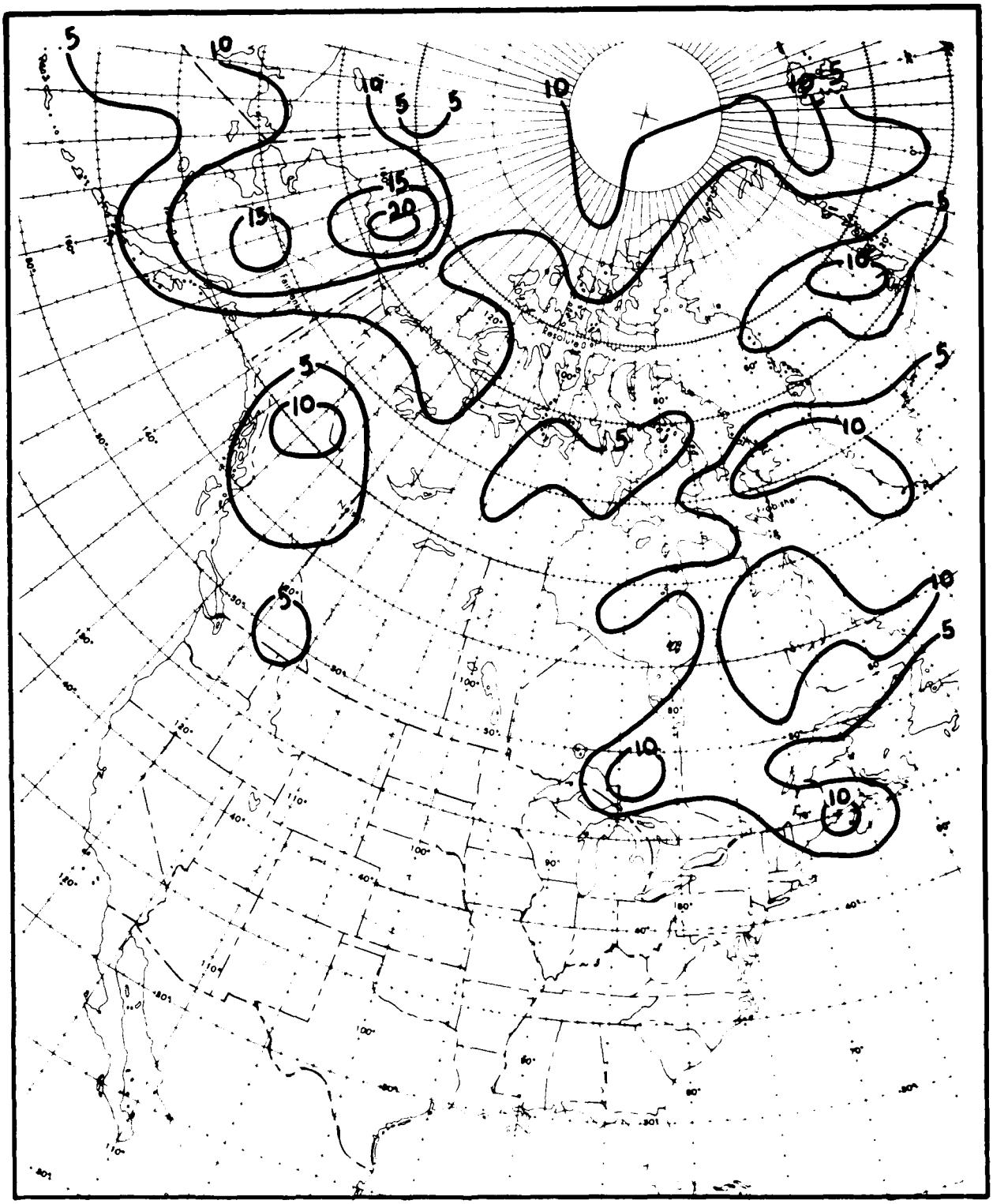


CHART 36 OCTOBER SURFACE TO 1,524 METERS, CONCENTRATION 1.00 G/M^3

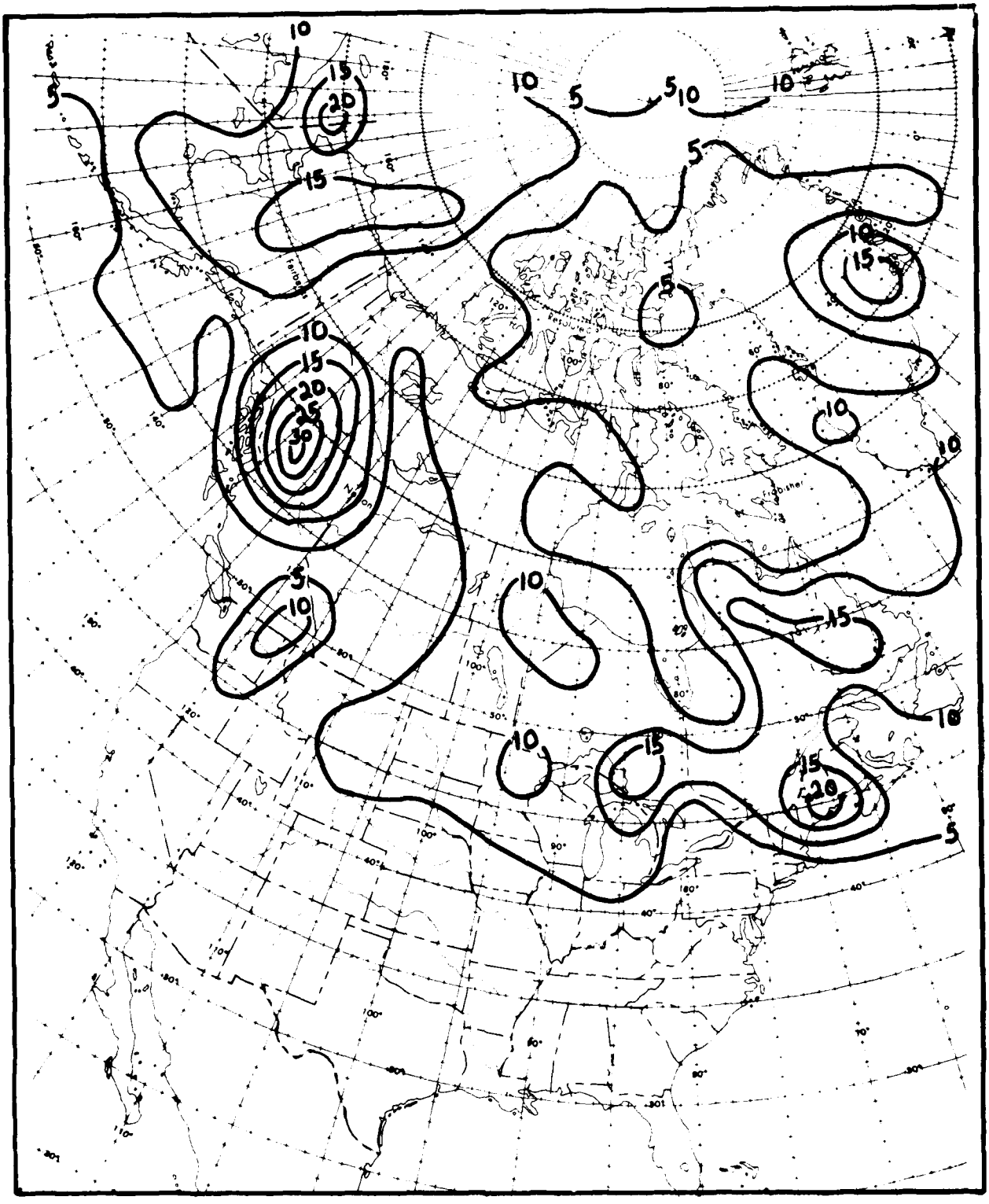


CHART 37 NOVEMBER SURFACE TO 1,524 METERS, CONCENTRATION 1.00 G/M^3

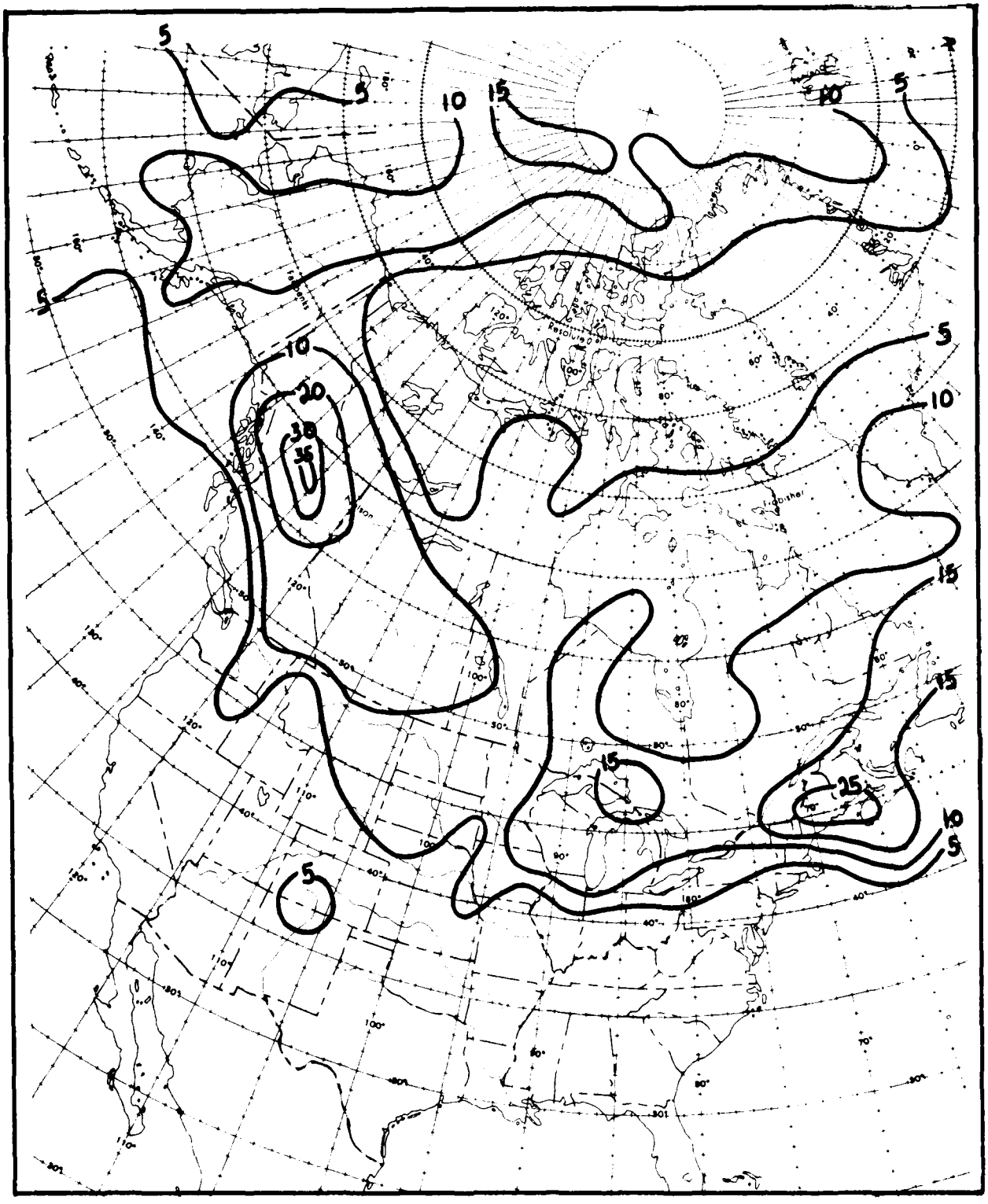


CHART 38 DECEMBER SURFACE TO 1,524 METERS, CONCENTRATION 1.00 G/M^3

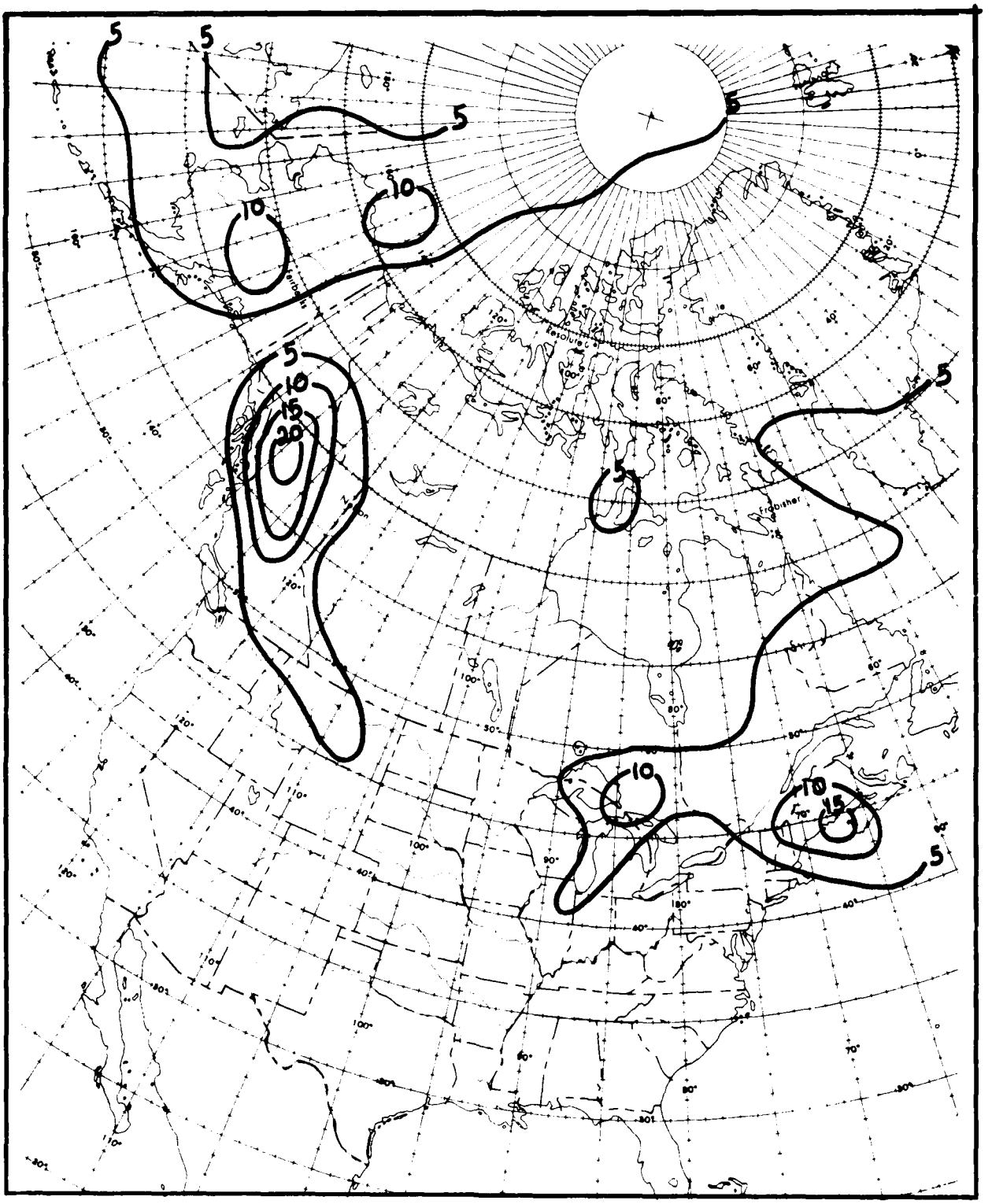


CHART 39 ANNUAL SURFACE TO 1,524 METERS, CONCENTRATION 1.00 G/M^3

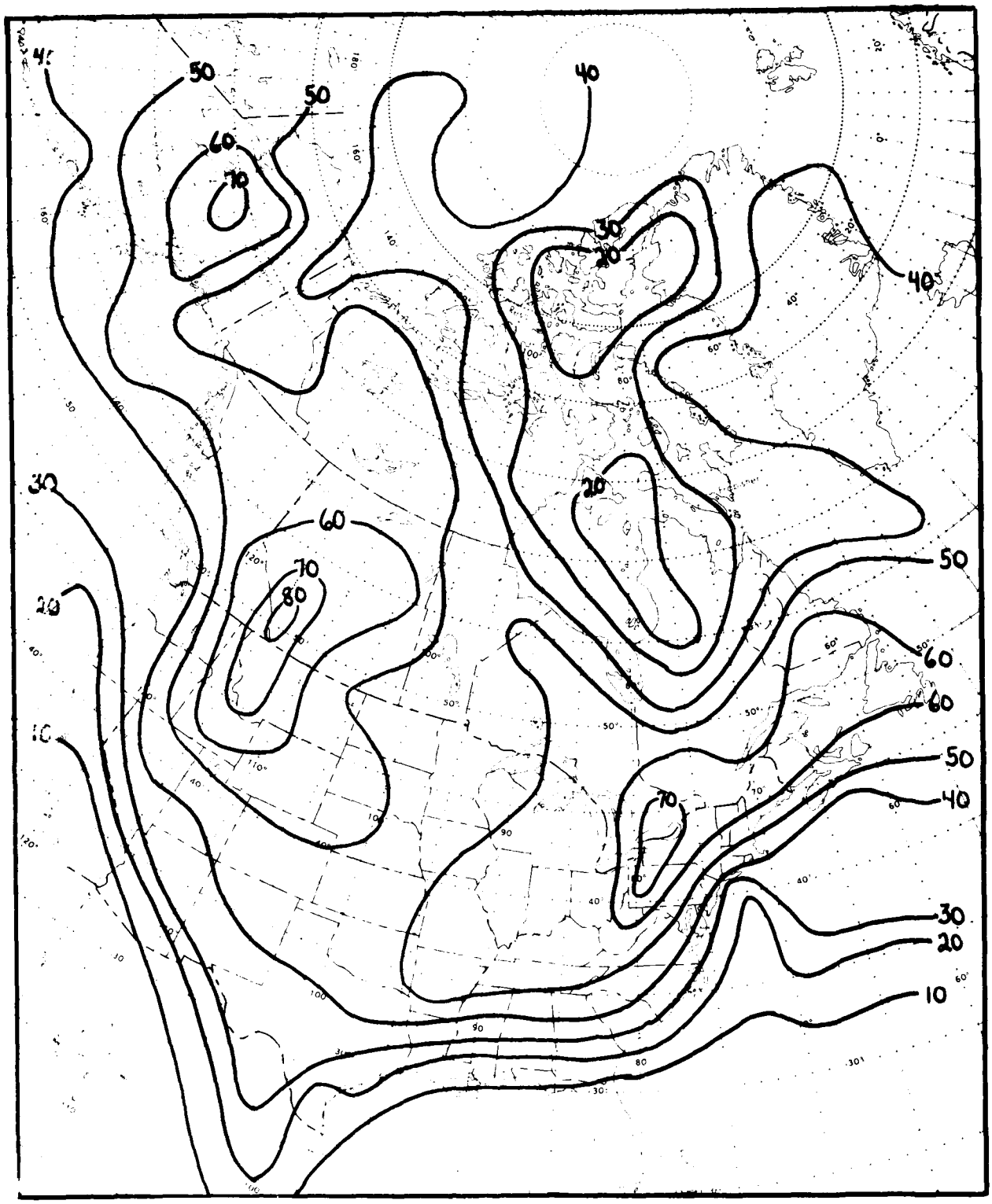


CHART 40 JANUARY 1,525 TO 3,048 METERS, CONCENTRATION .10 G/M^3

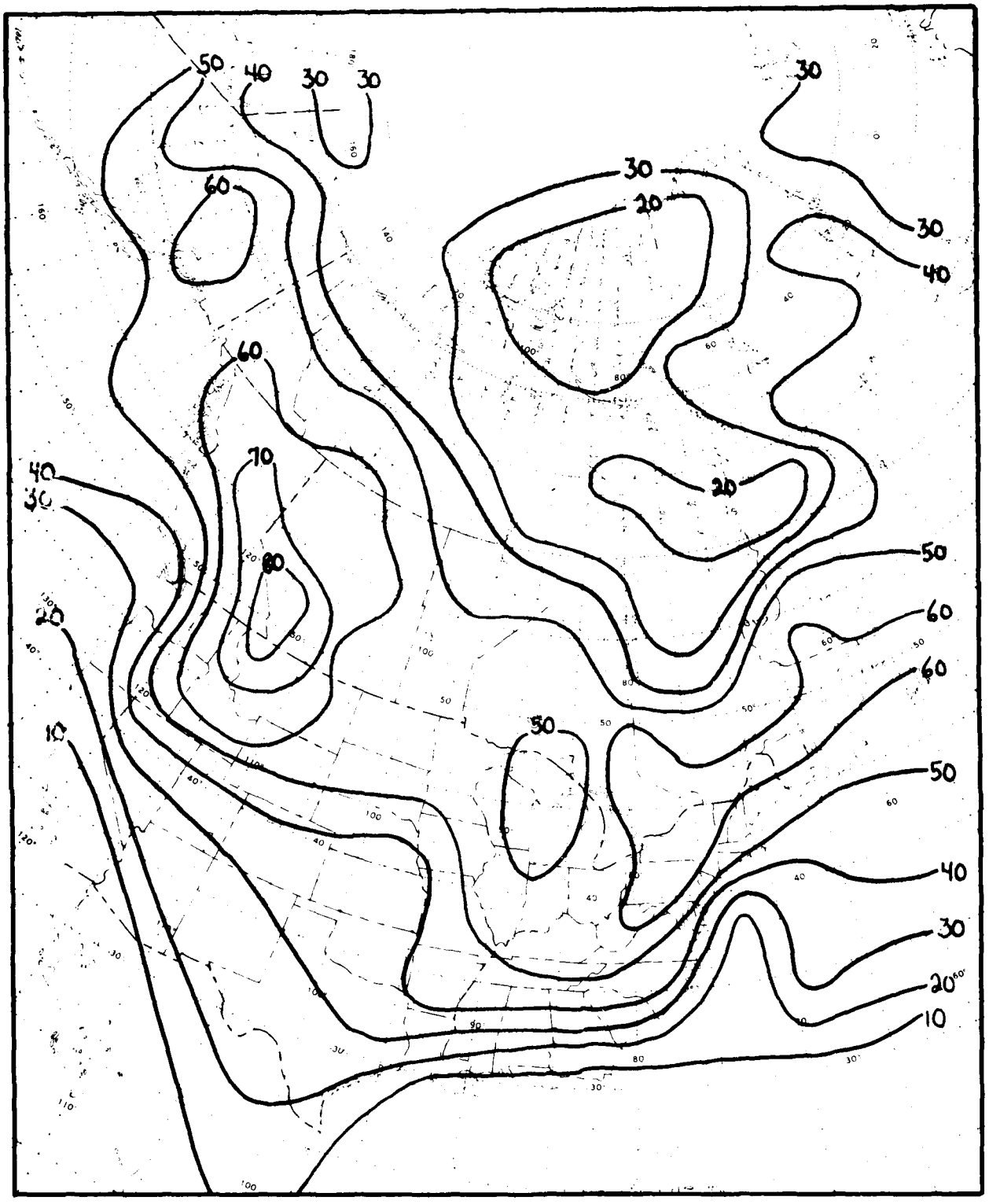


CHART 41 FEBRUARY 1,525 TO 3,048 METERS, CONCENTRATION .10 G/M^3

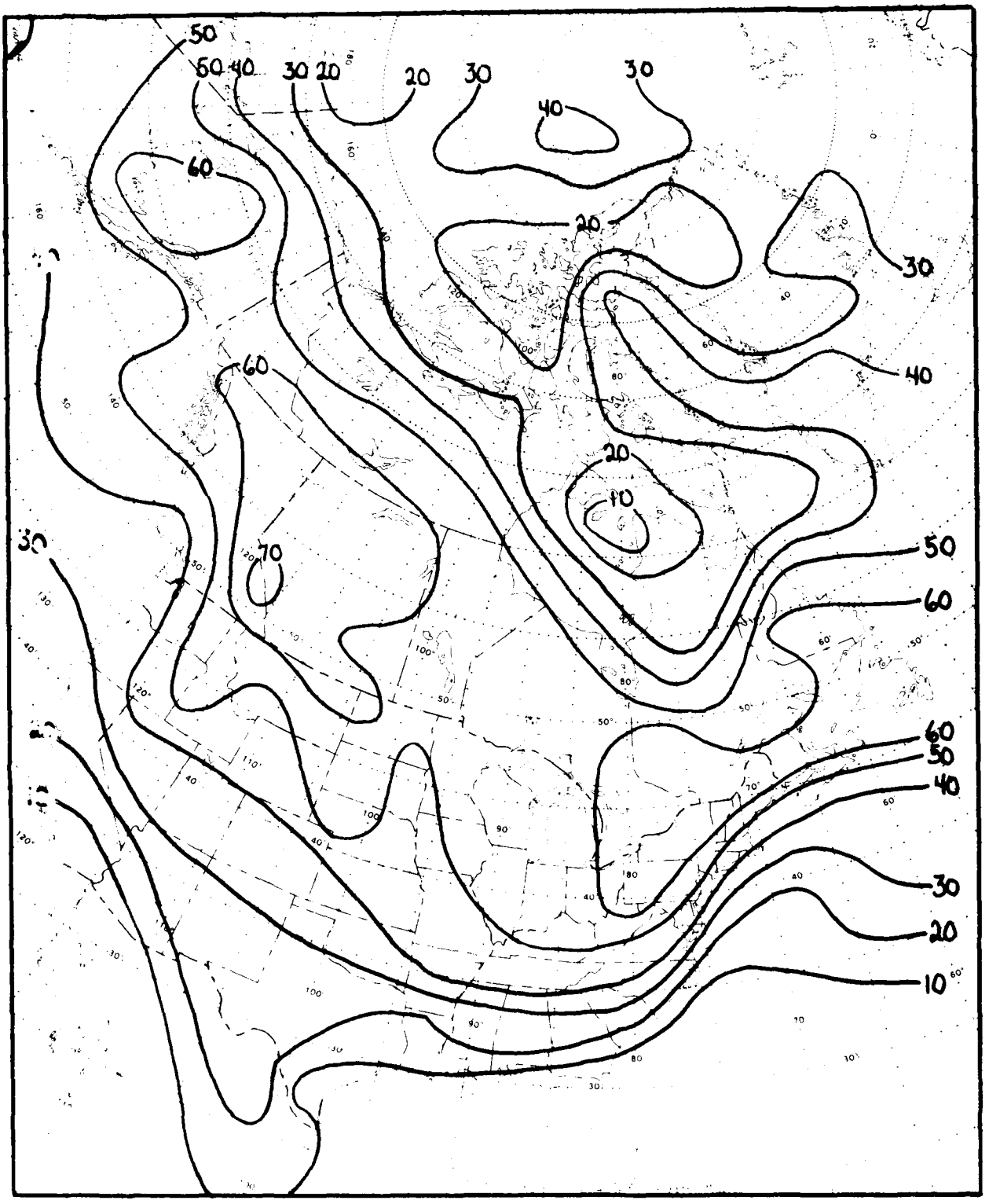


CHART 42 MARCH 1,525 TO 3,048 METERS, CONCENTRATION .10 G/M^3

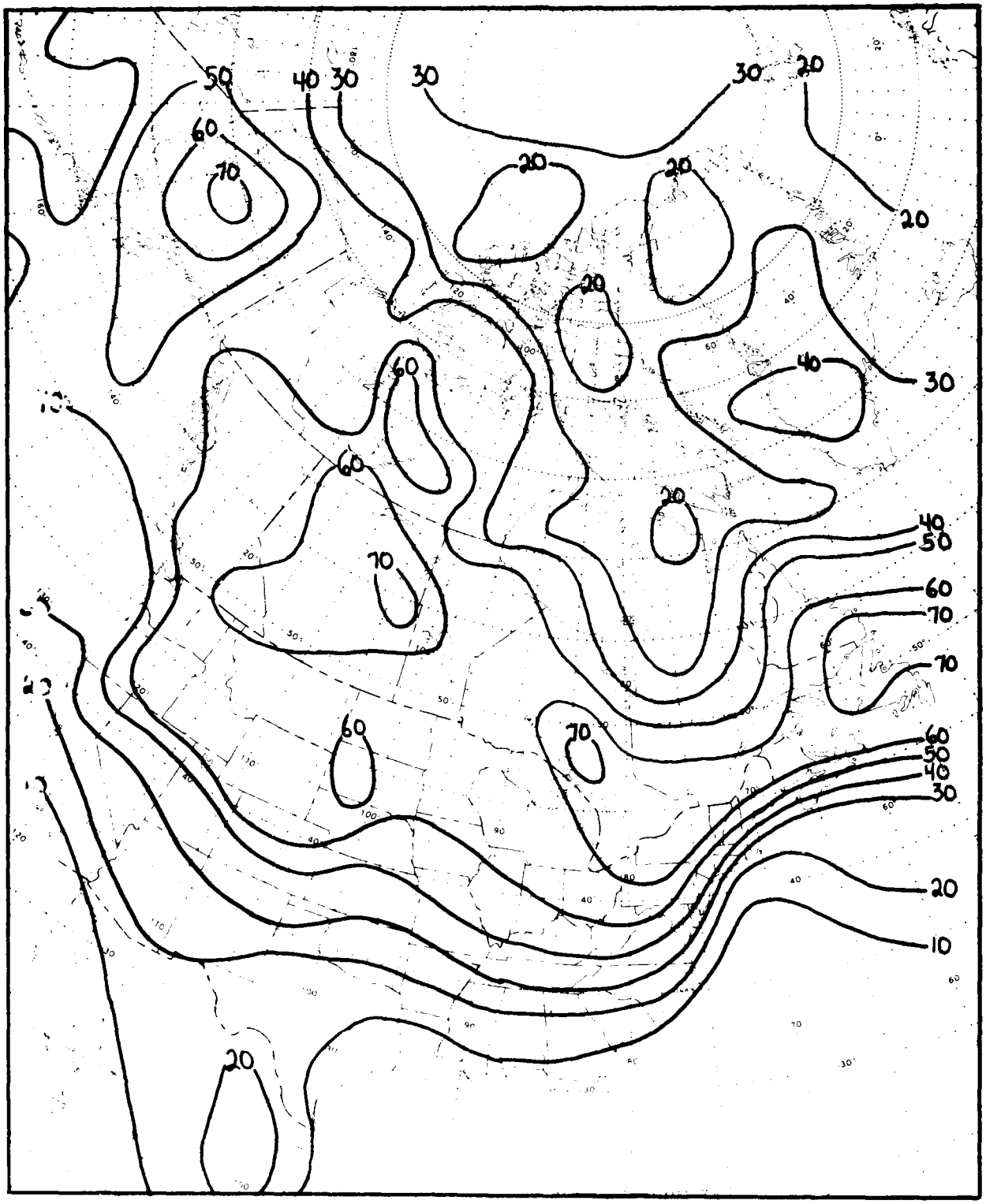


CHART 43 APRIL 1,525 TO 3,048 METERS, CONCENTRATION .10 G/M^3

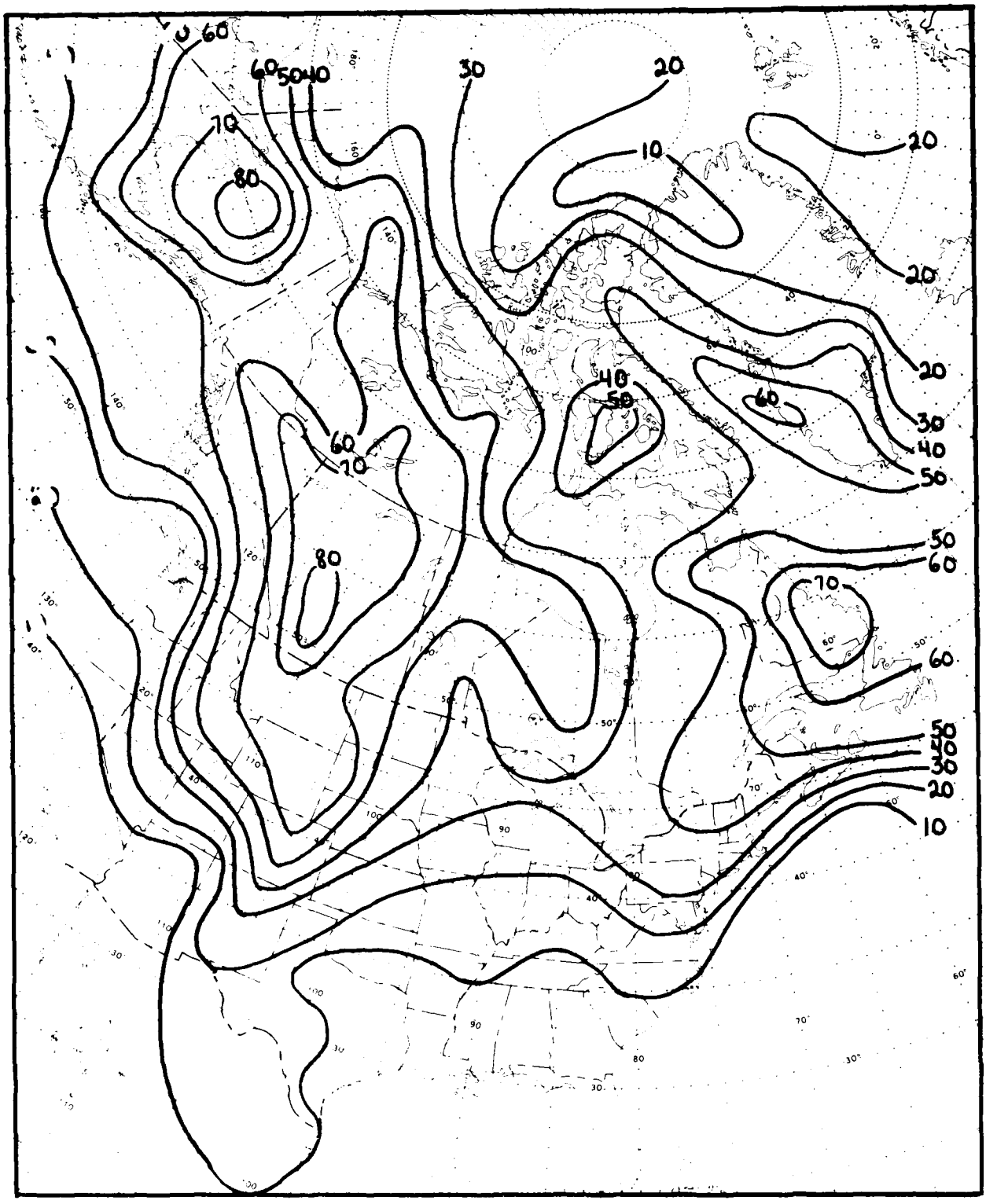


CHART 44 MAY 1,525 TO 3,048 METERS, CONCENTRATION .10 G/M^3

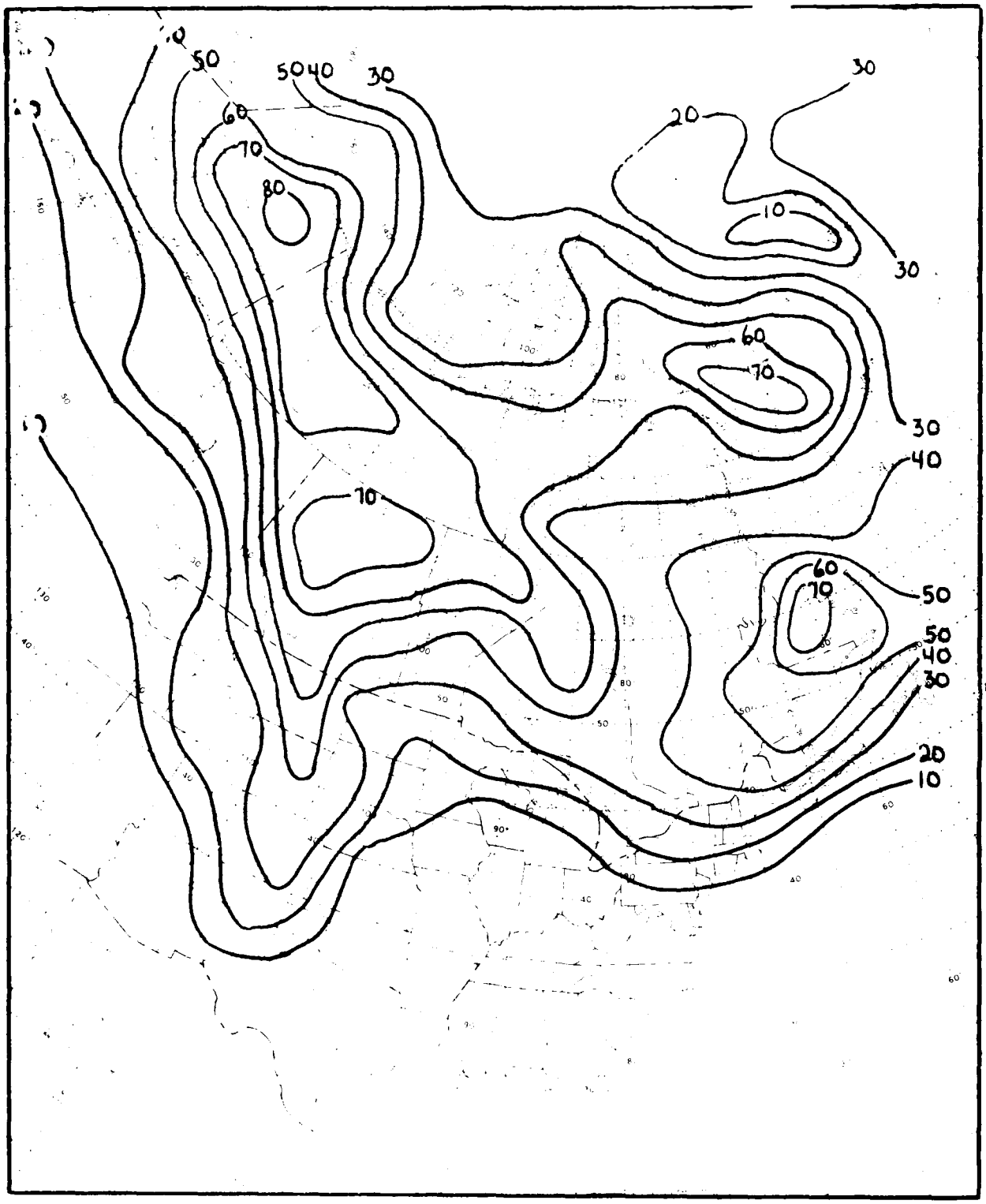


CHART 45 JUNE 1,525 TO 3,048 METERS, CONCENTRATION .10 G/M^3

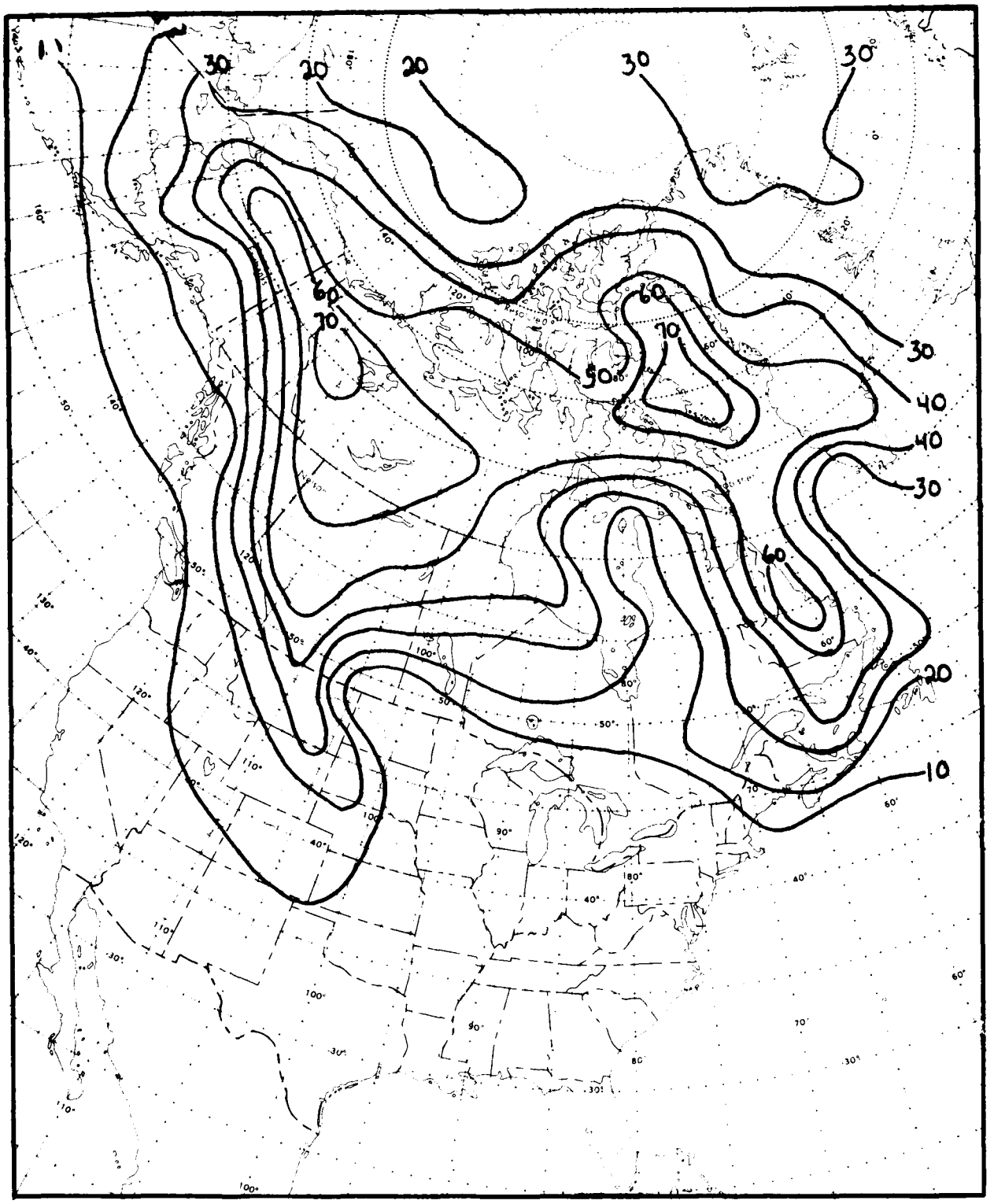


CHART 46 JULY 1,525 TO 3,048 METERS, CONCENTRATION .10 G/M^3

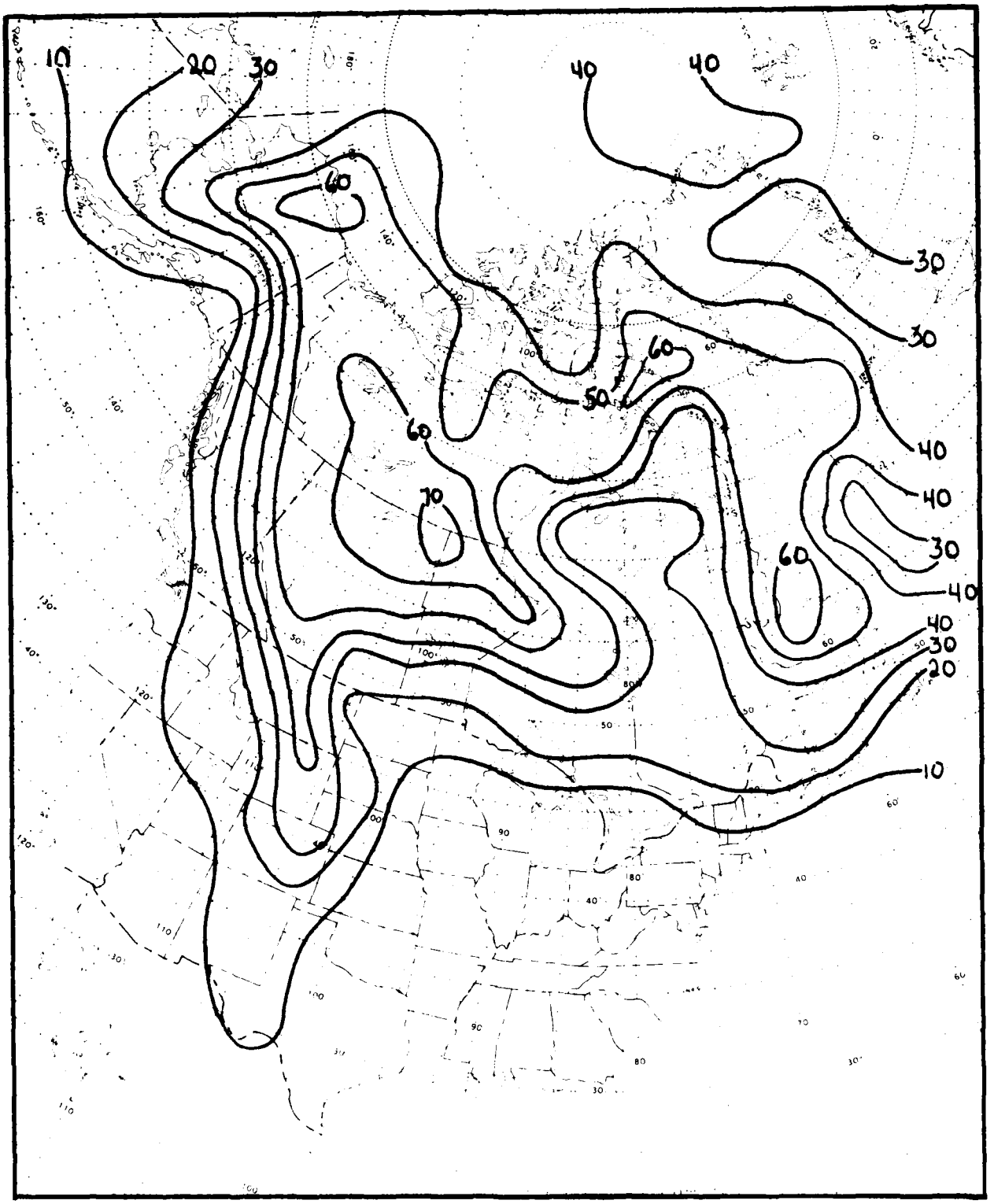


CHART 47 AUGUST 1,525 TO 3,048 METERS, CONCENTRATION .10 G/M^3

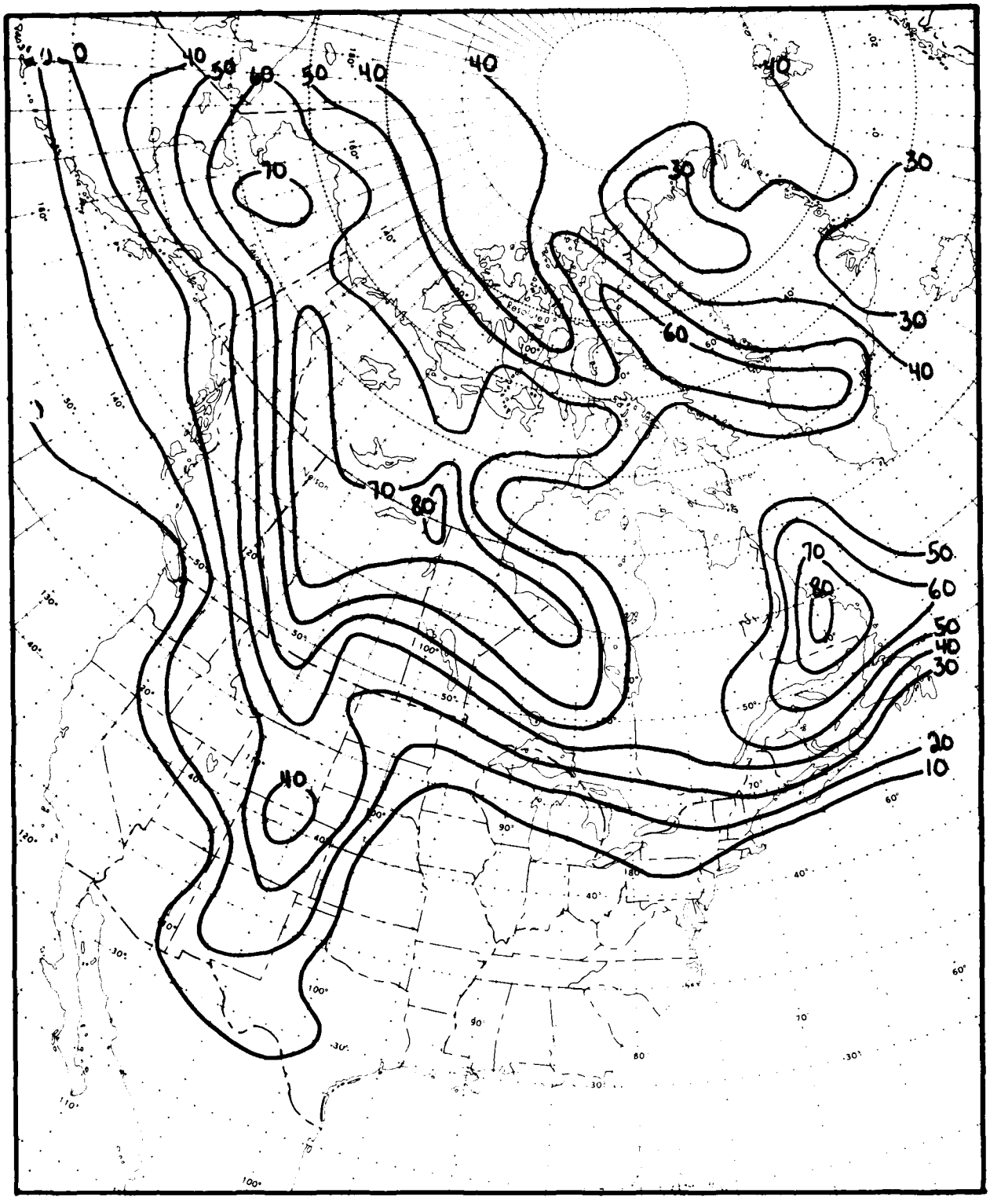


CHART 48 SEPTEMBER 1,525 TO 3,048 METERS, CONCENTRATION .10 G/M^3

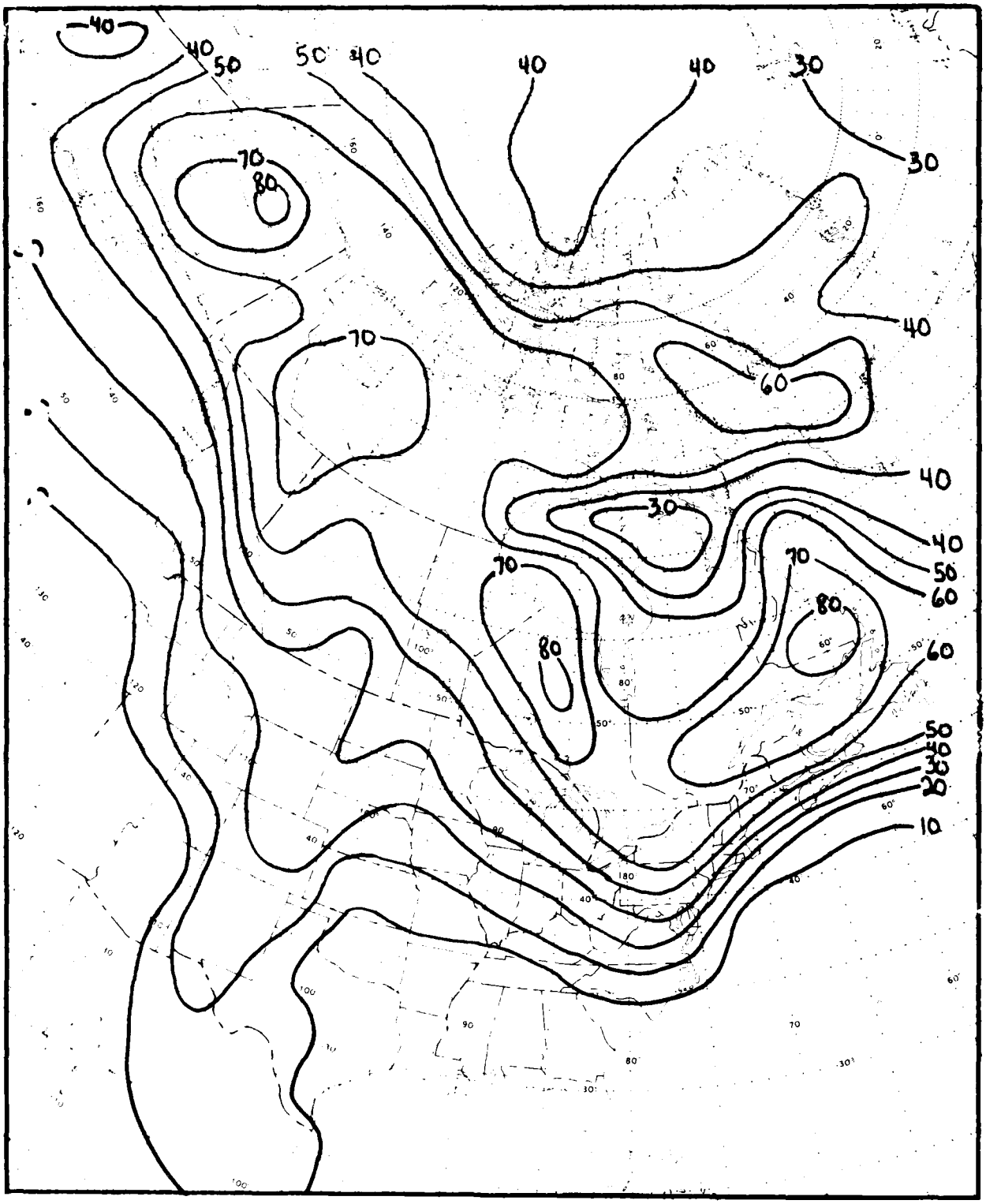


CHART 49 OCTOBER 1,525 TO 3,048 METERS, CONCENTRATION .10 G/M^3

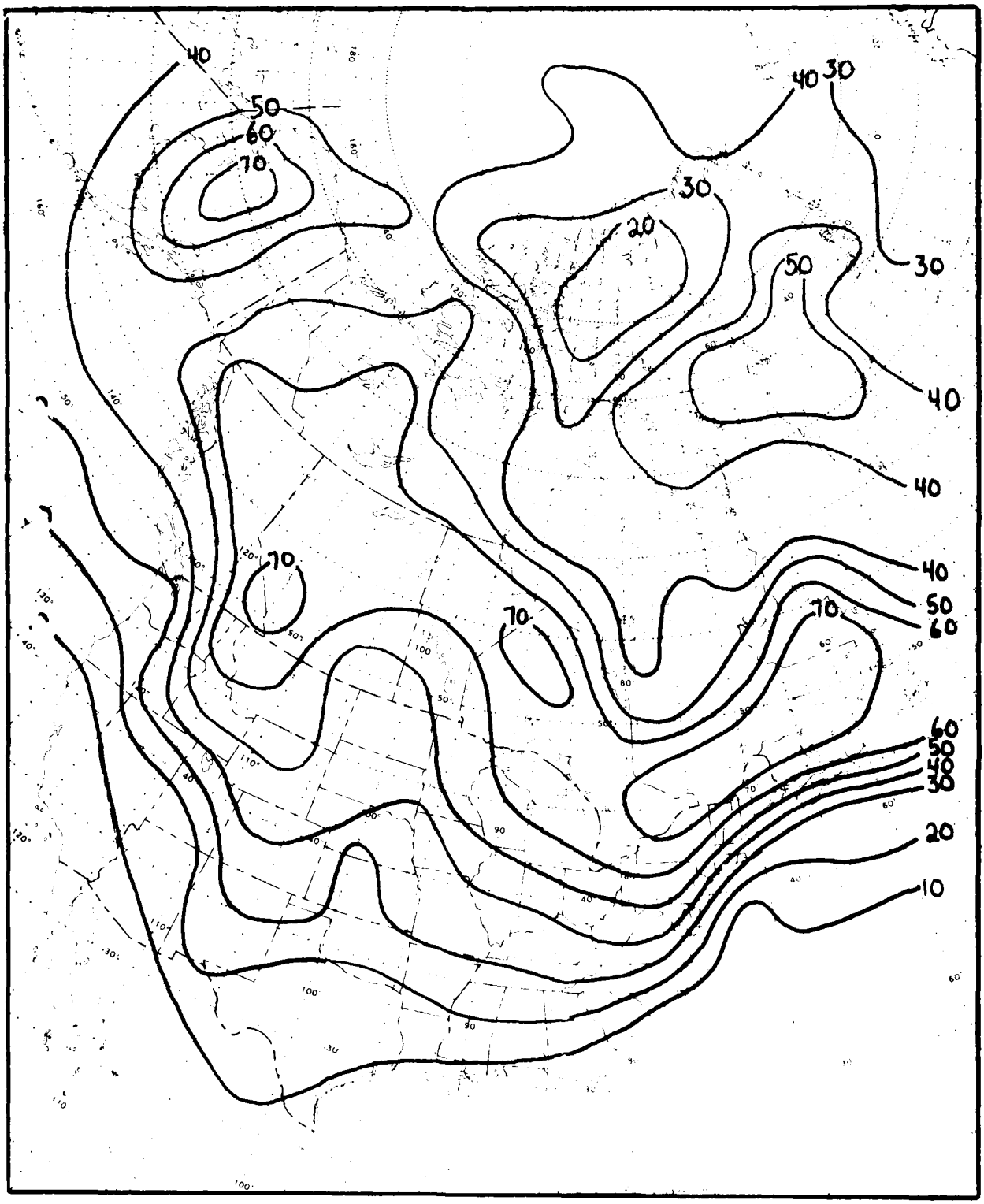


CHART 50 NOVEMBER 1,525 TO 3,048 METERS, CONCENTRATION .10 G/M^3

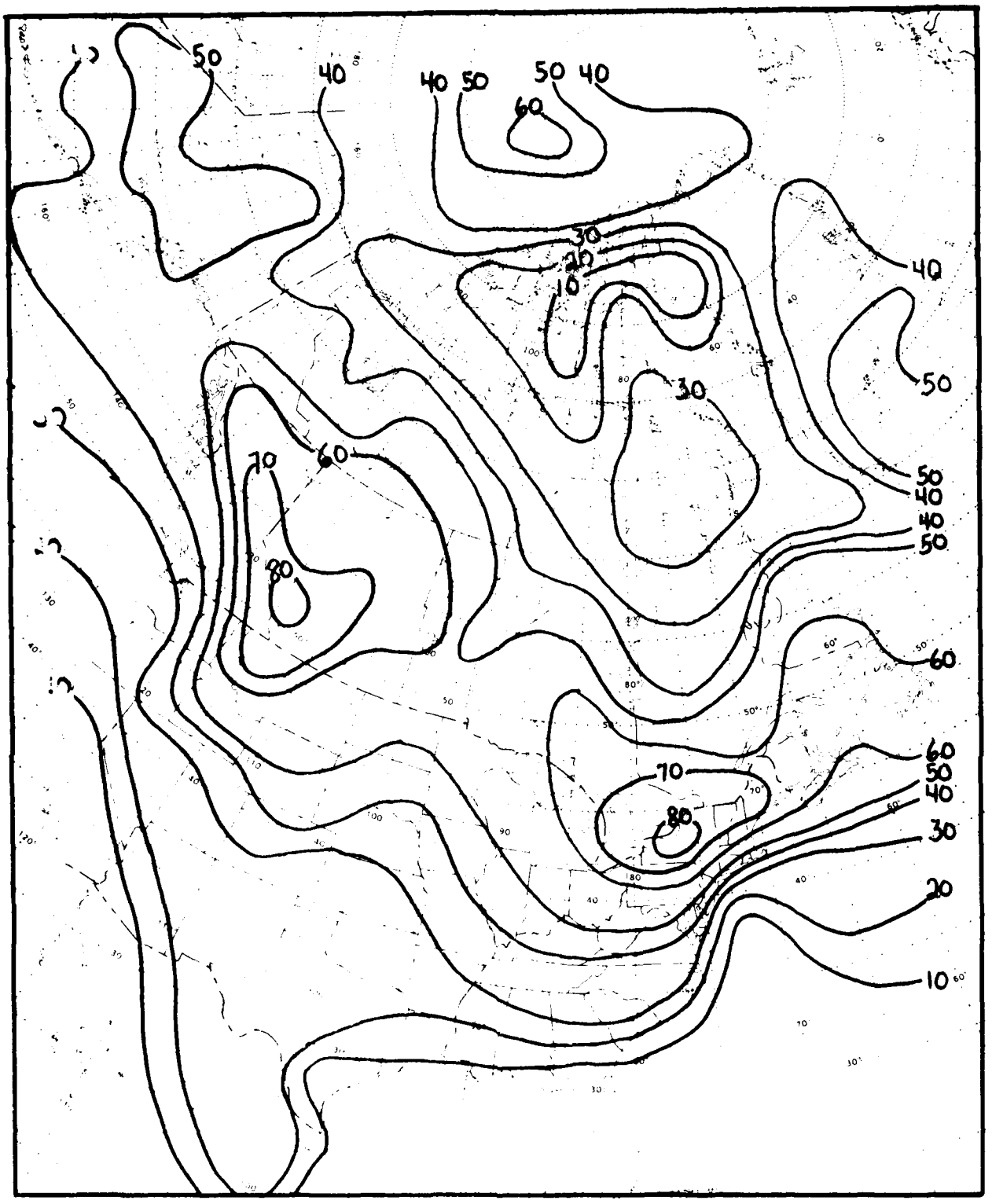


CHART 51 DECEMBER 1,525 TO 3,048 METERS, CONCENTRATION .10 G/M^3

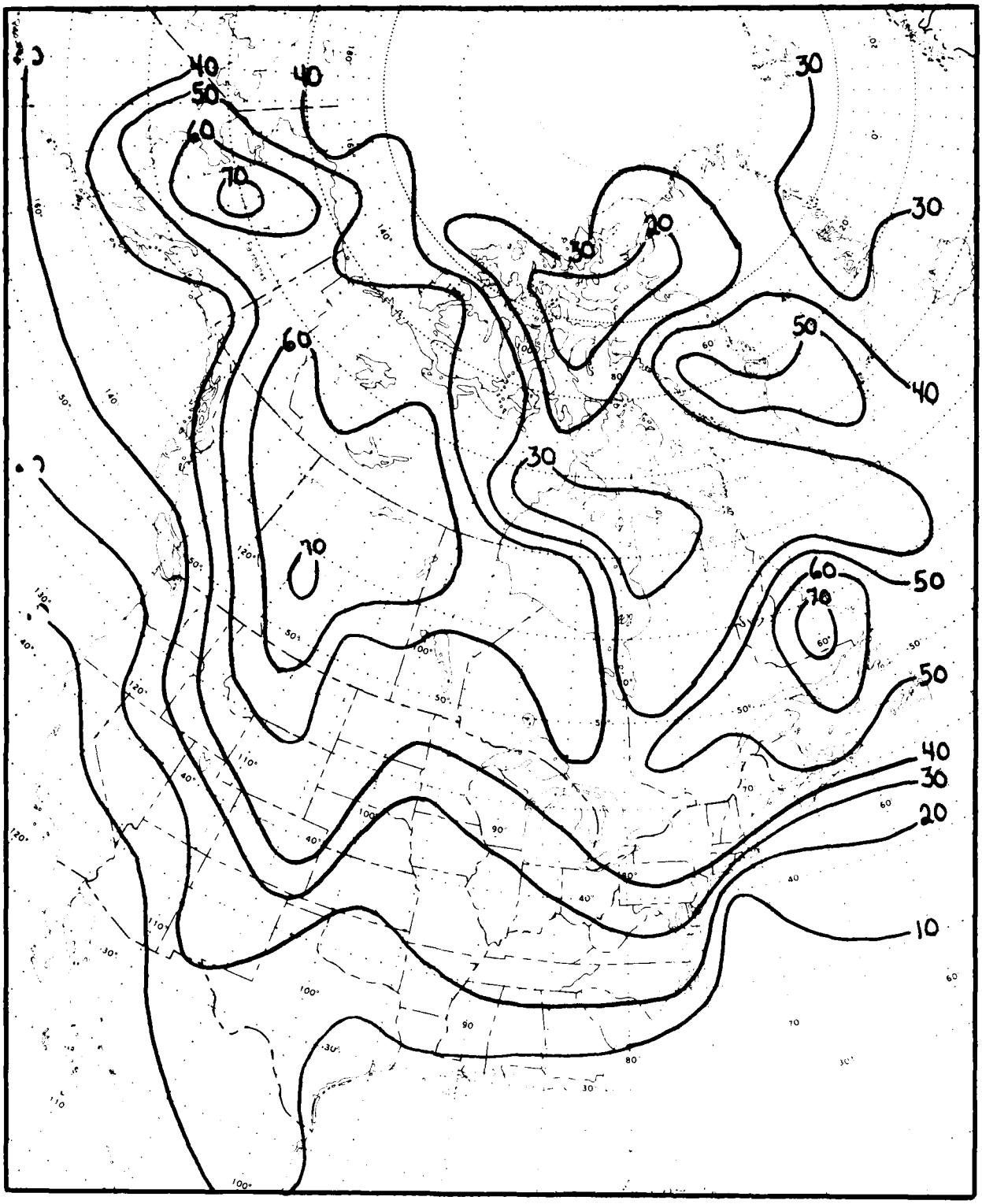


CHART 52 ANNUAL 1,525 TO 3,048 METERS, CONCENTRATION .10 G/M^3

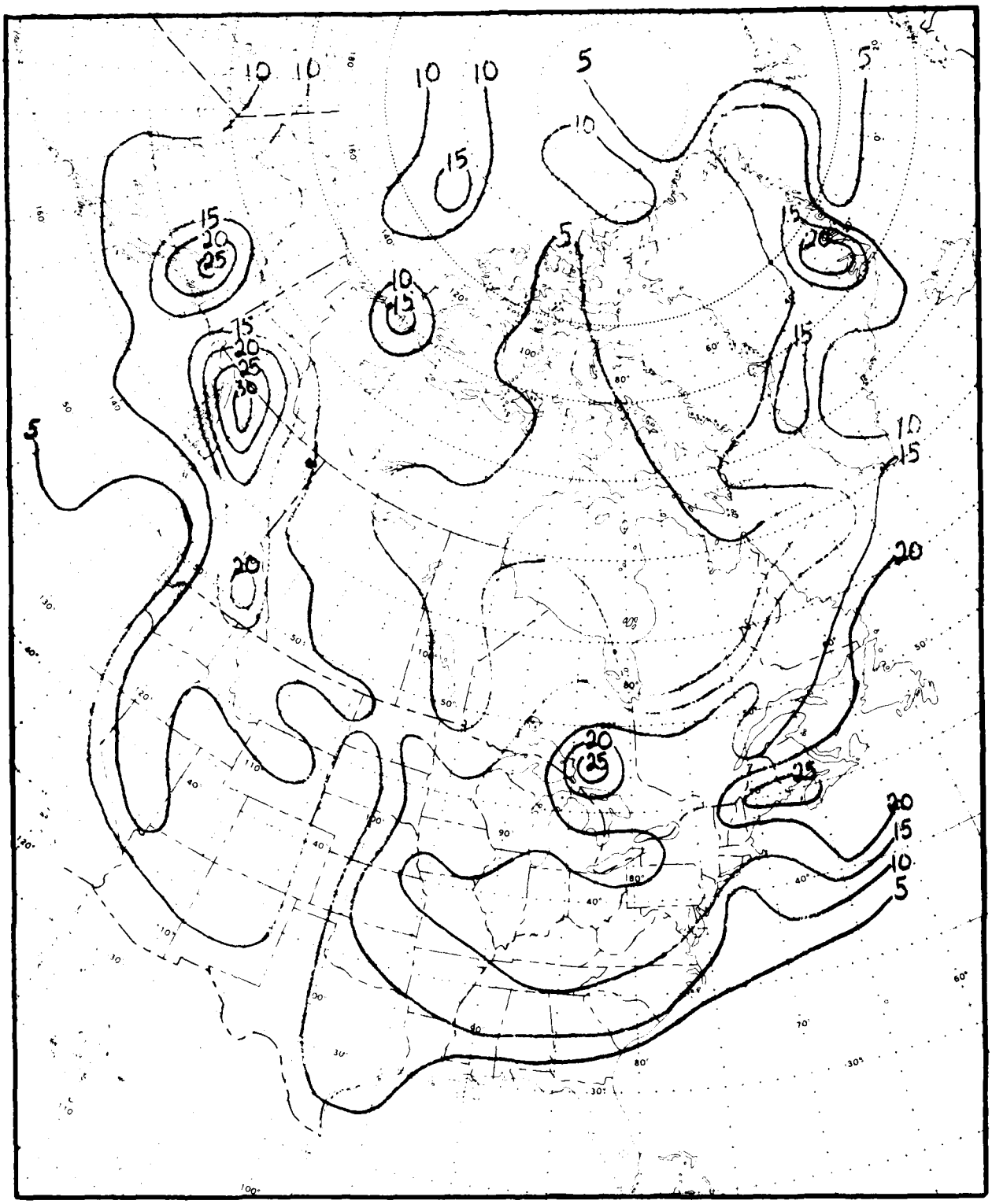


CHART 53 JANUARY 1,525 TO 3,048 METERS, CONCENTRATION .50 G/M^3

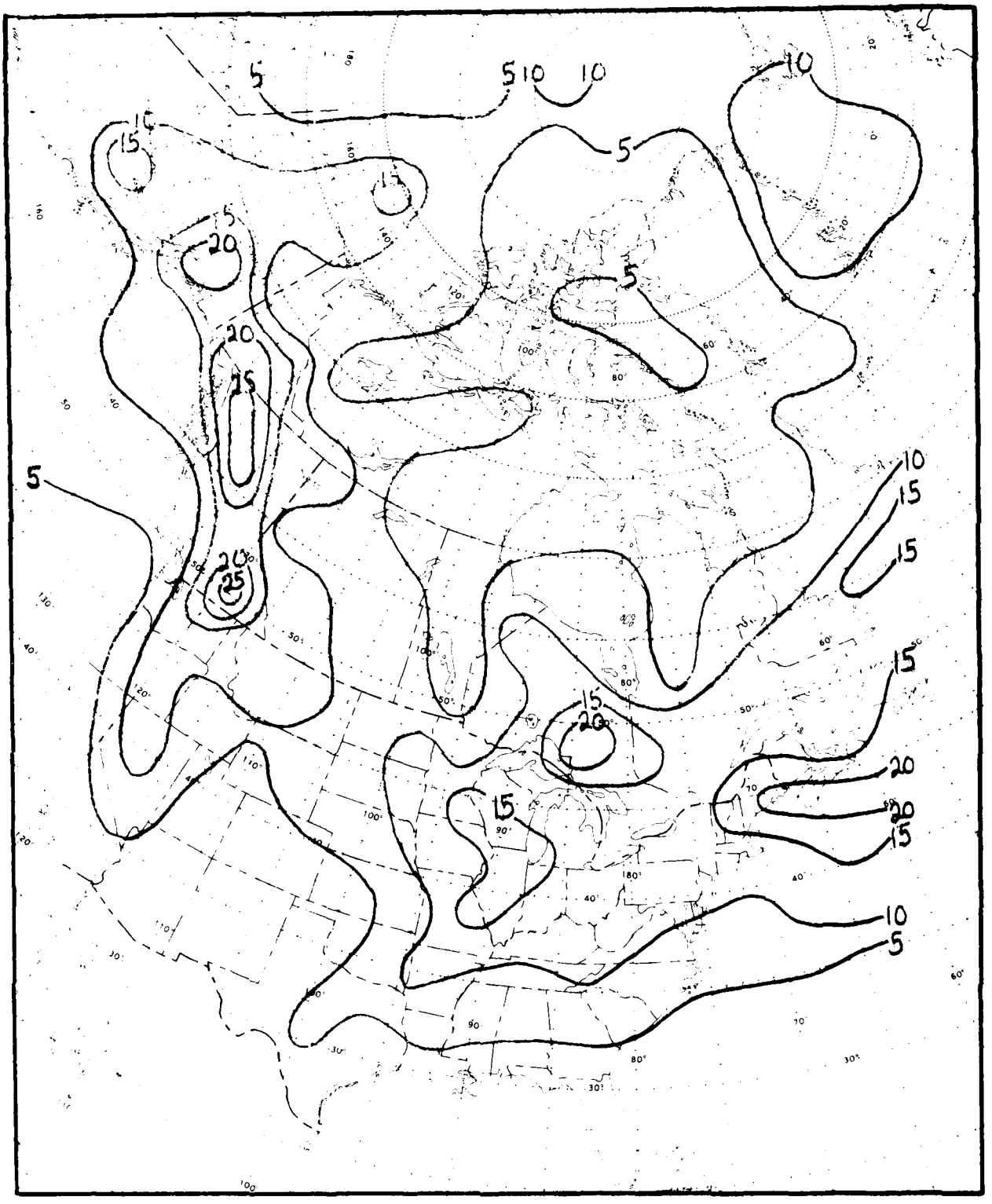


CHART 54 FEBRUARY 1,525 TO 3,048 METERS, CONCENTRATION .50 G/M^3

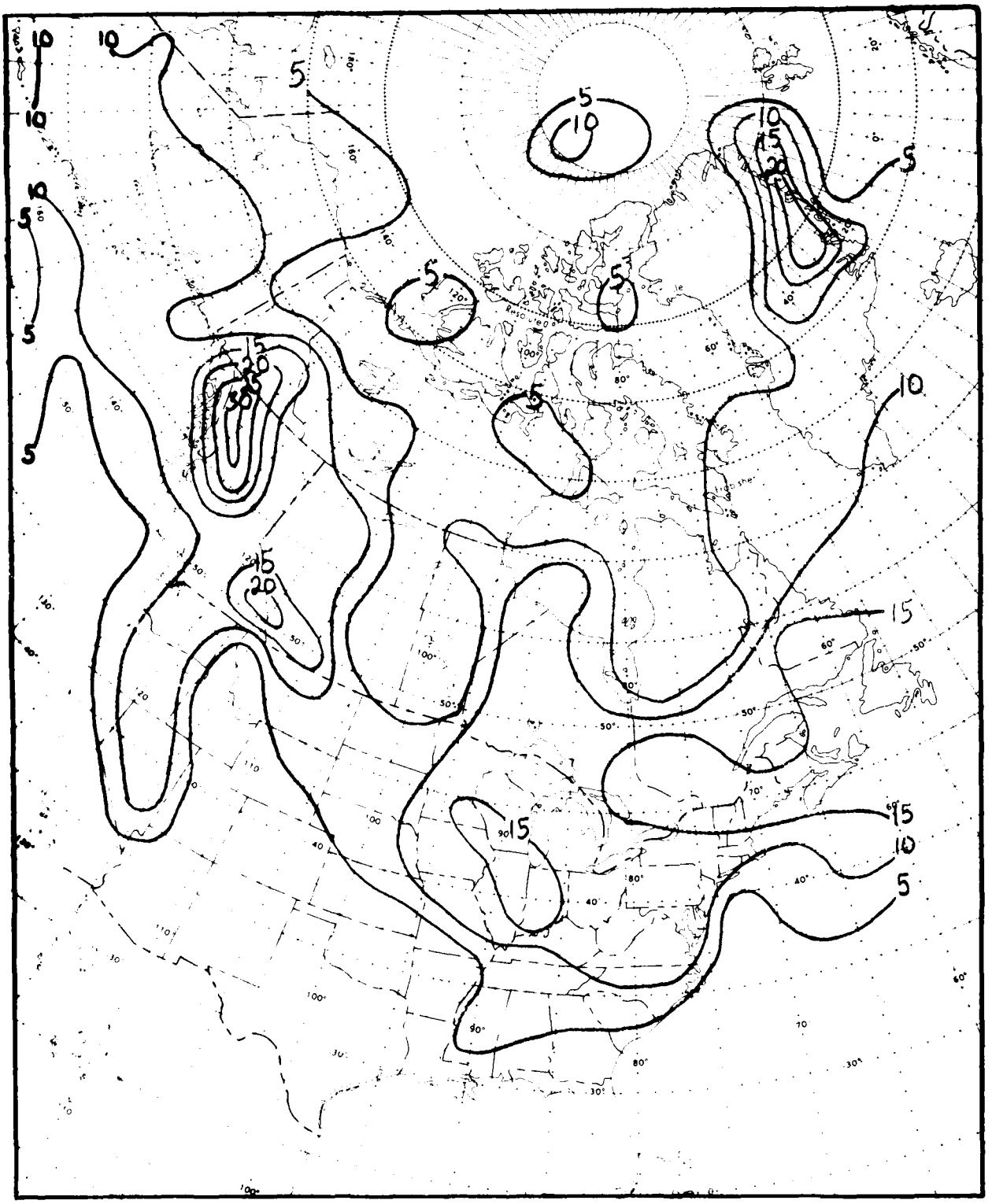


CHART 55 MARCH 1,525 TO 3,048 METERS, CONCENTRATION .50 G/M^3

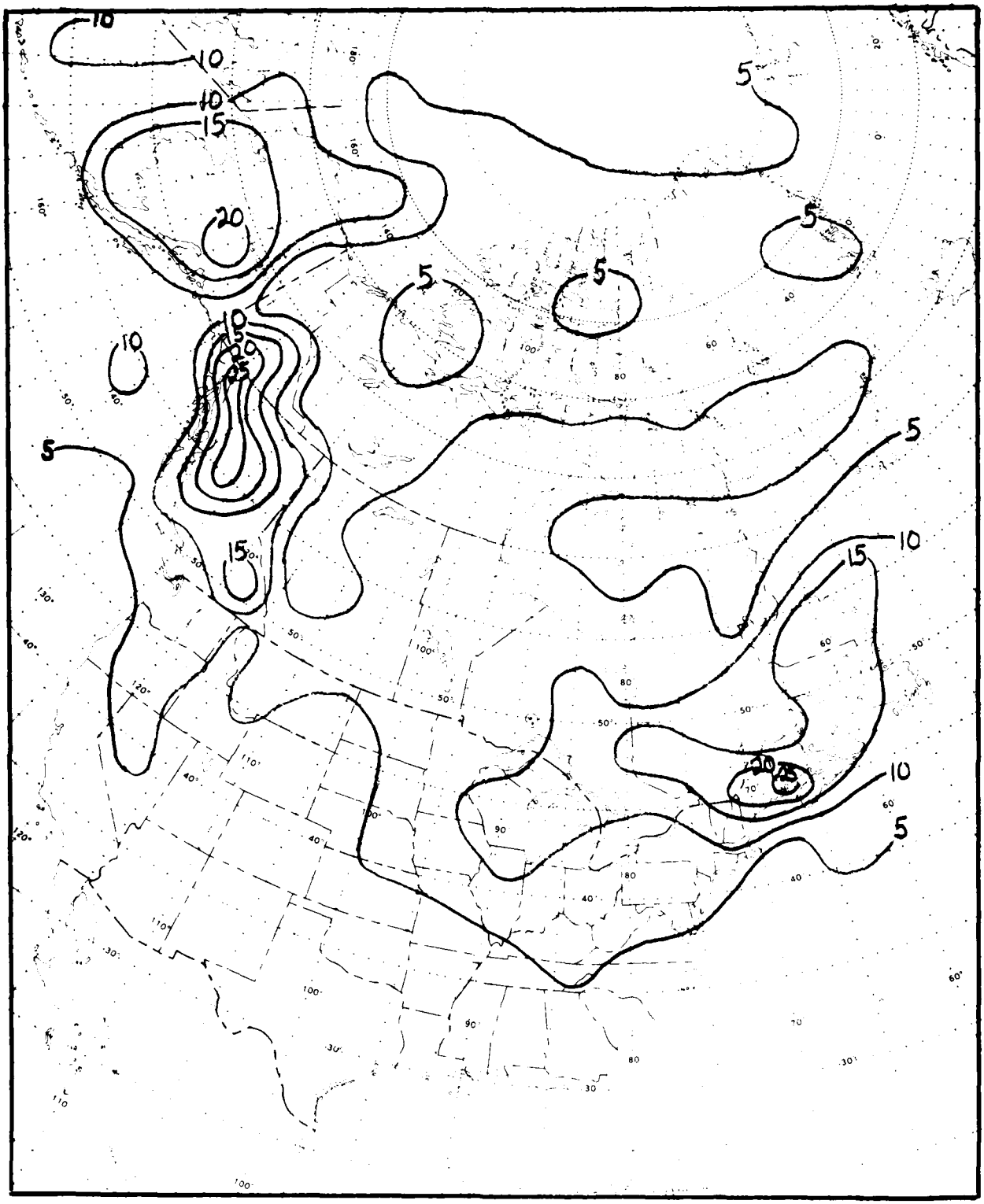


CHART 56 APRIL 1,525 TO 3,048 METERS, CONCENTRATION .50 G/M^3

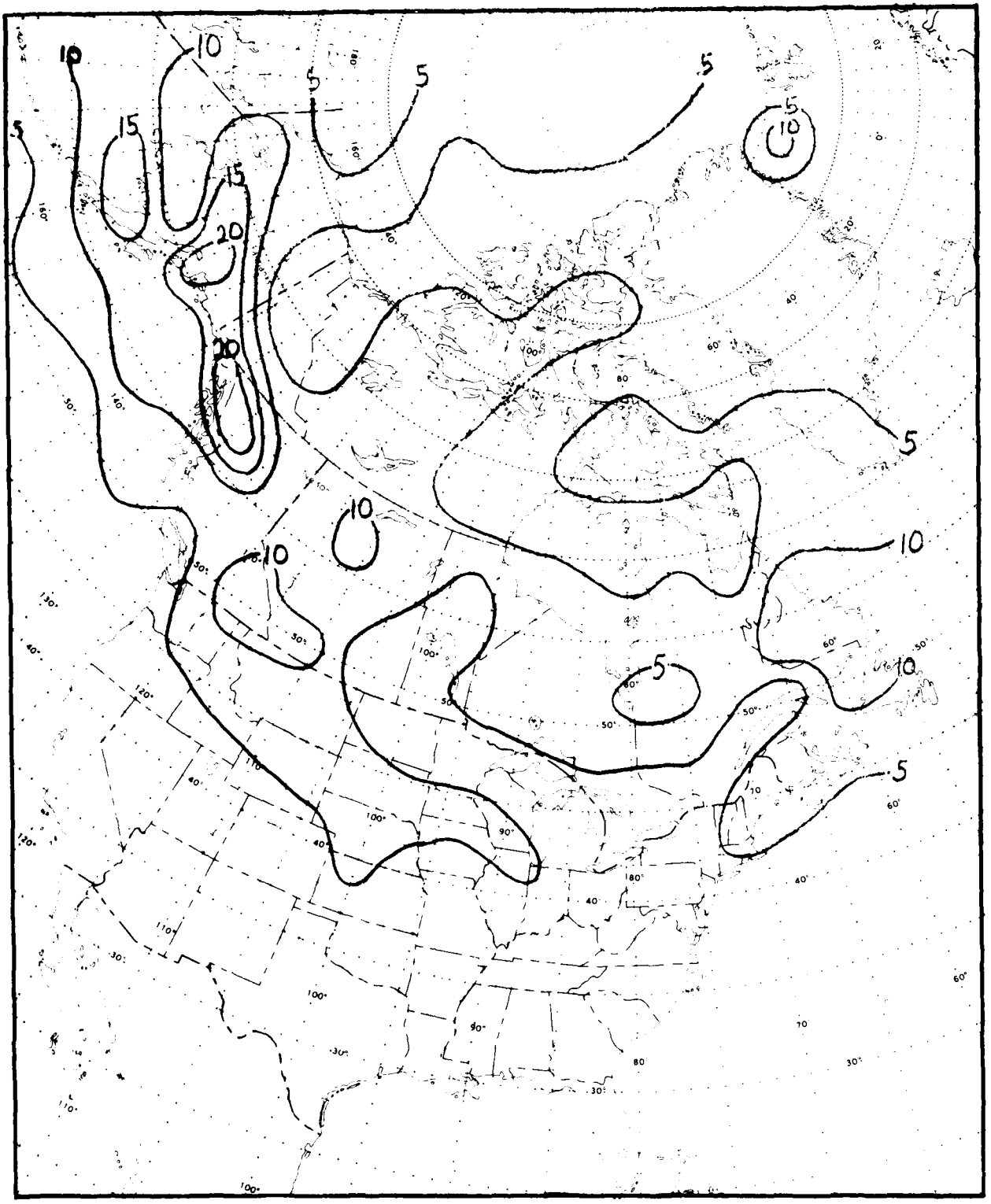


CHART 57 MAY 1,525 TO 3,048 METERS, CONCENTRATION .50 G/M^3

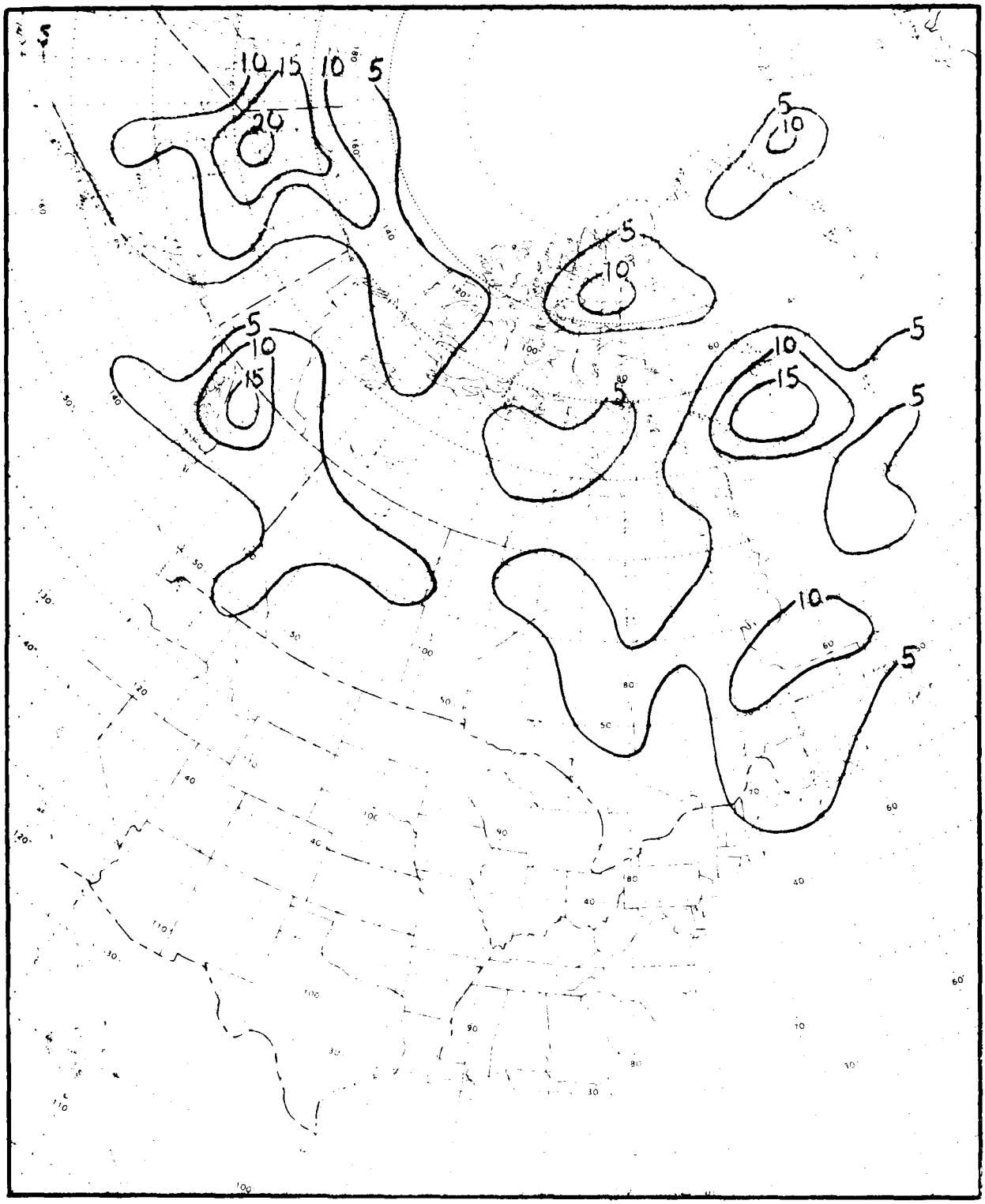


CHART 58 JUNE 1,525 TO 3,048 METERS, CONCENTRATION .50 G/M^3

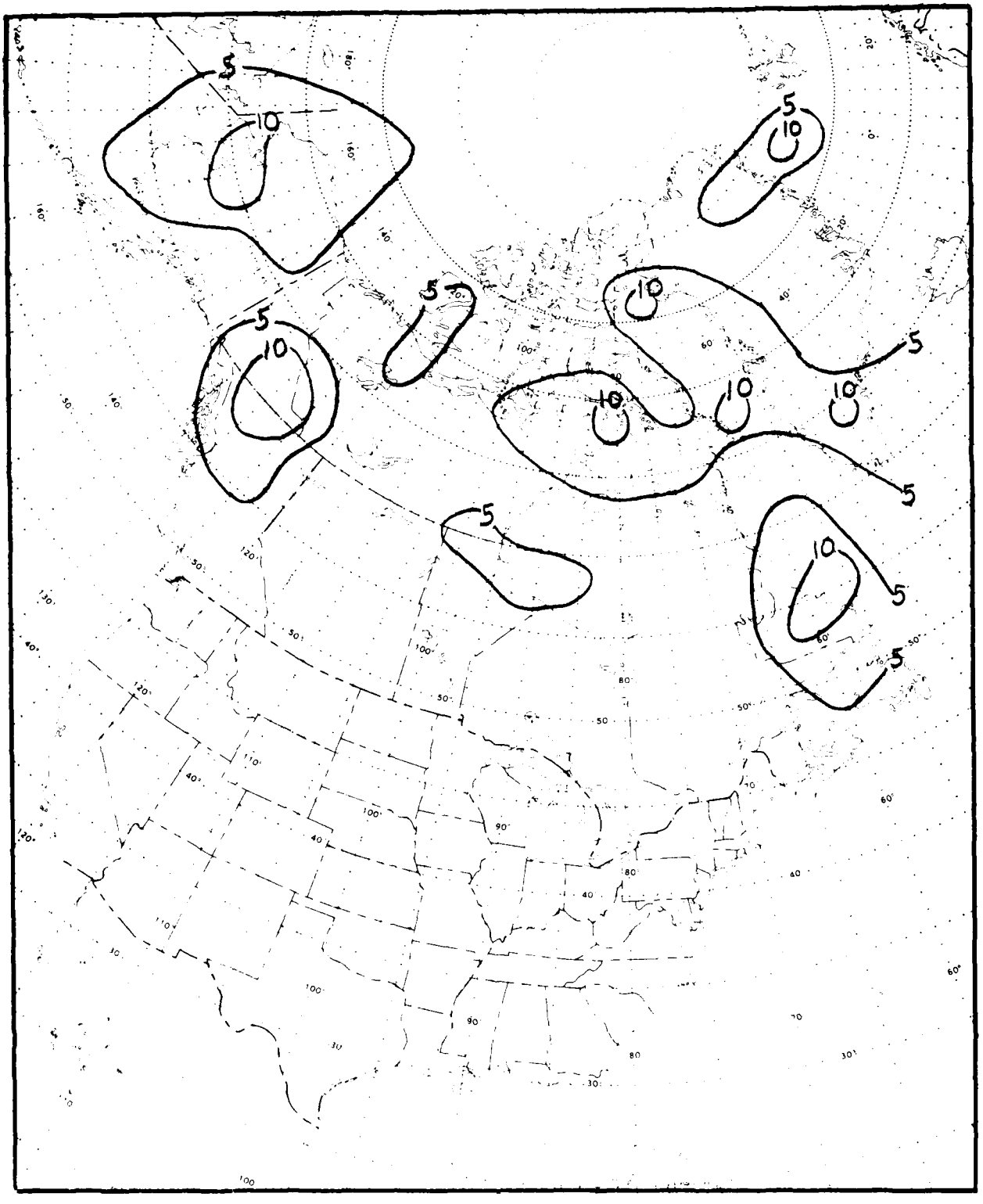


CHART 59 JULY 1,525 TO 3,048 METERS, CONCENTRATION .50 G/M^3

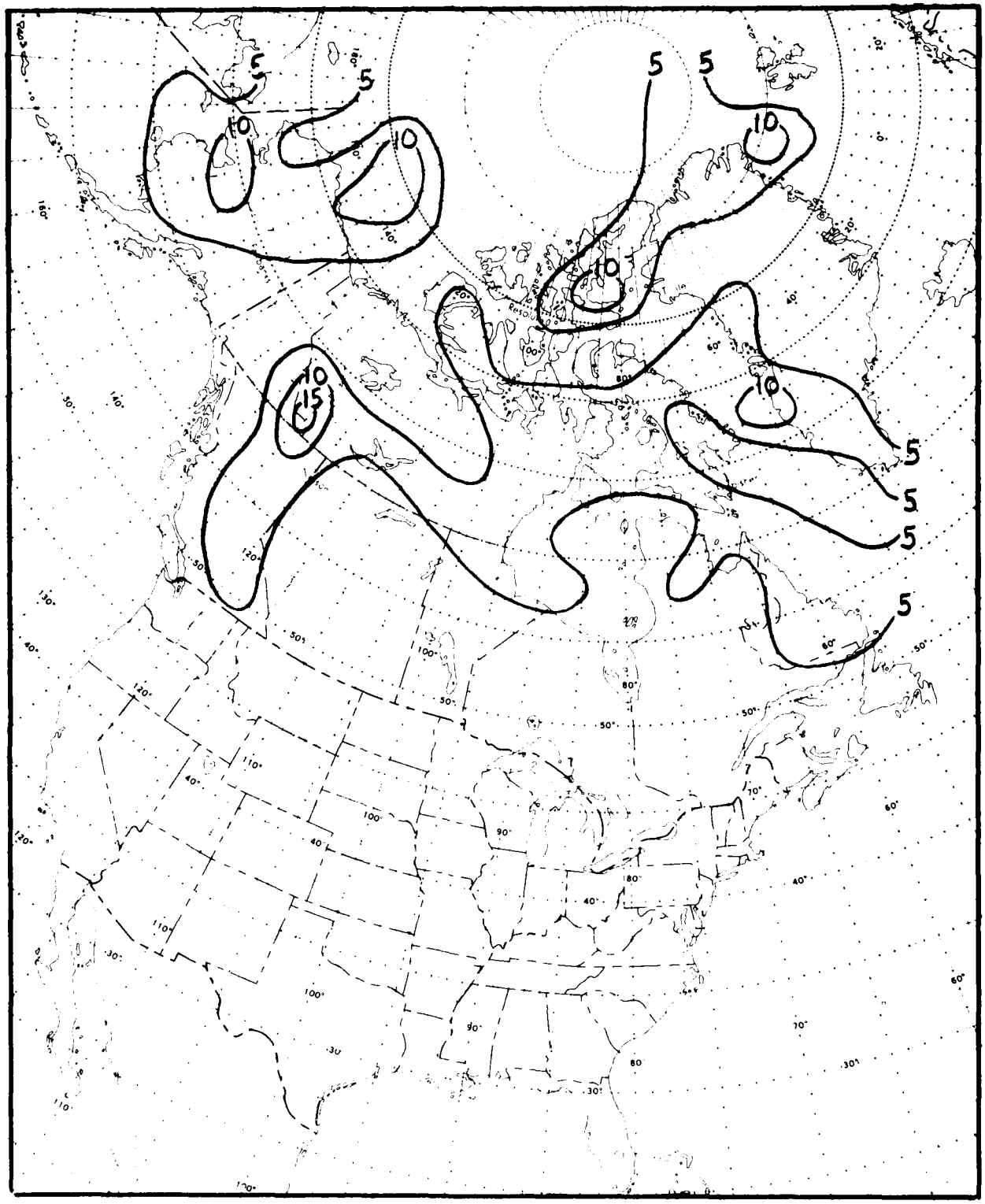


CHART 60 AUGUST 1,525 TO 3,048 METERS, CONCENTRATION .50 G/M^3

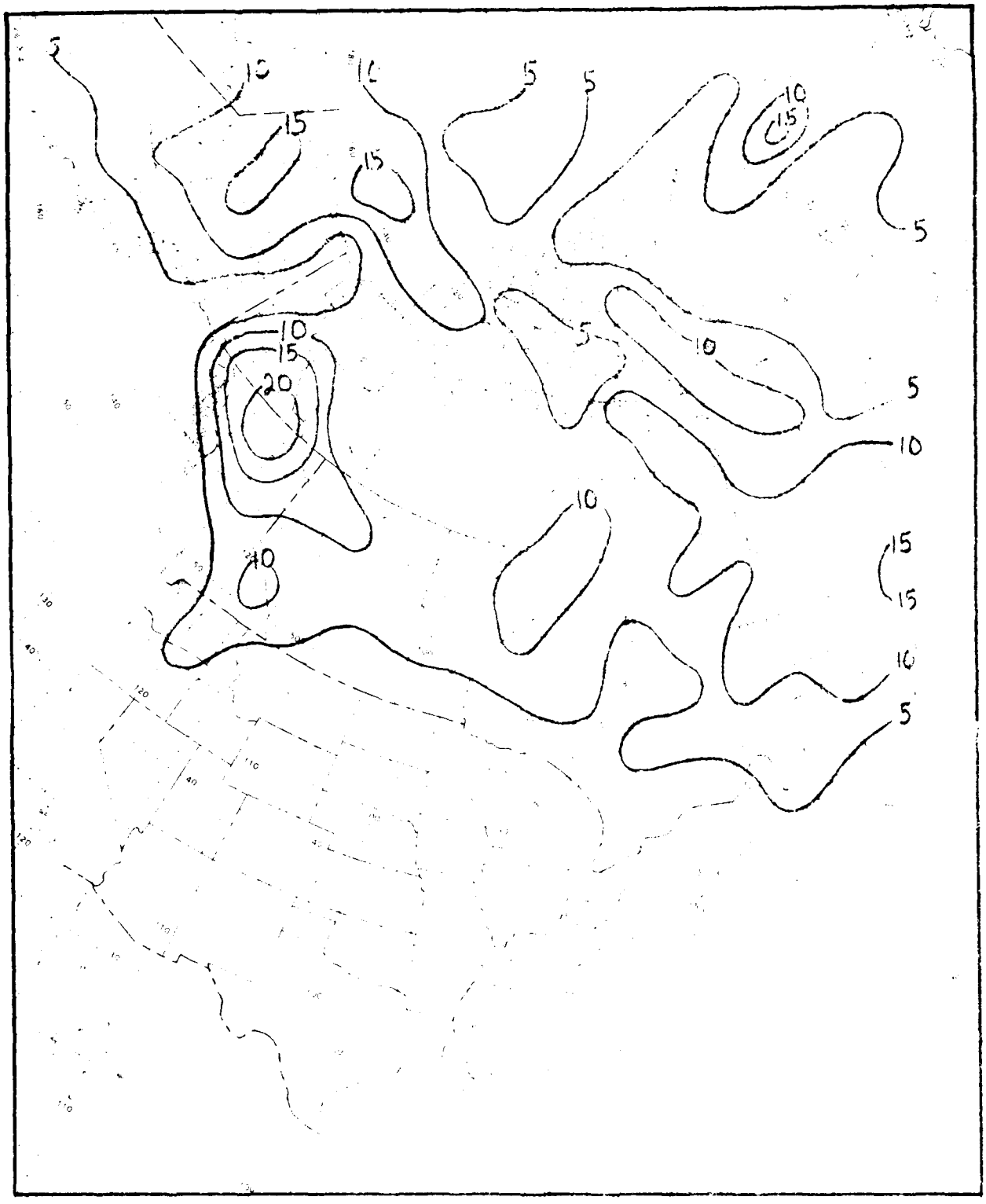


CHART 61 SEPTEMBER 1,525 TO 3,048 METERS, CONCENTRATION .50 G/M³

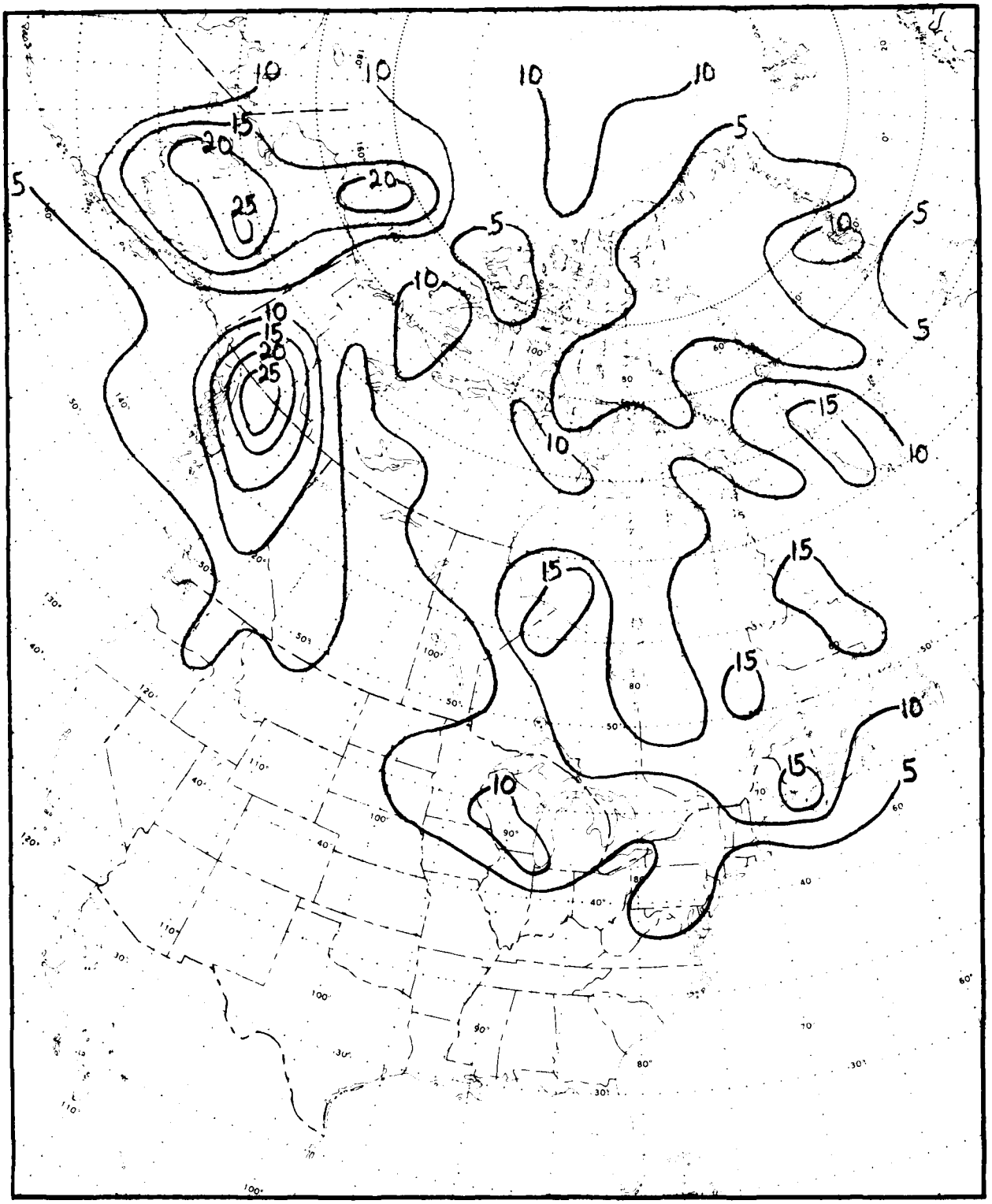


CHART 62 OCTOBER 1,525 TO 3,048 METERS, CONCENTRATION .50 G/M^3

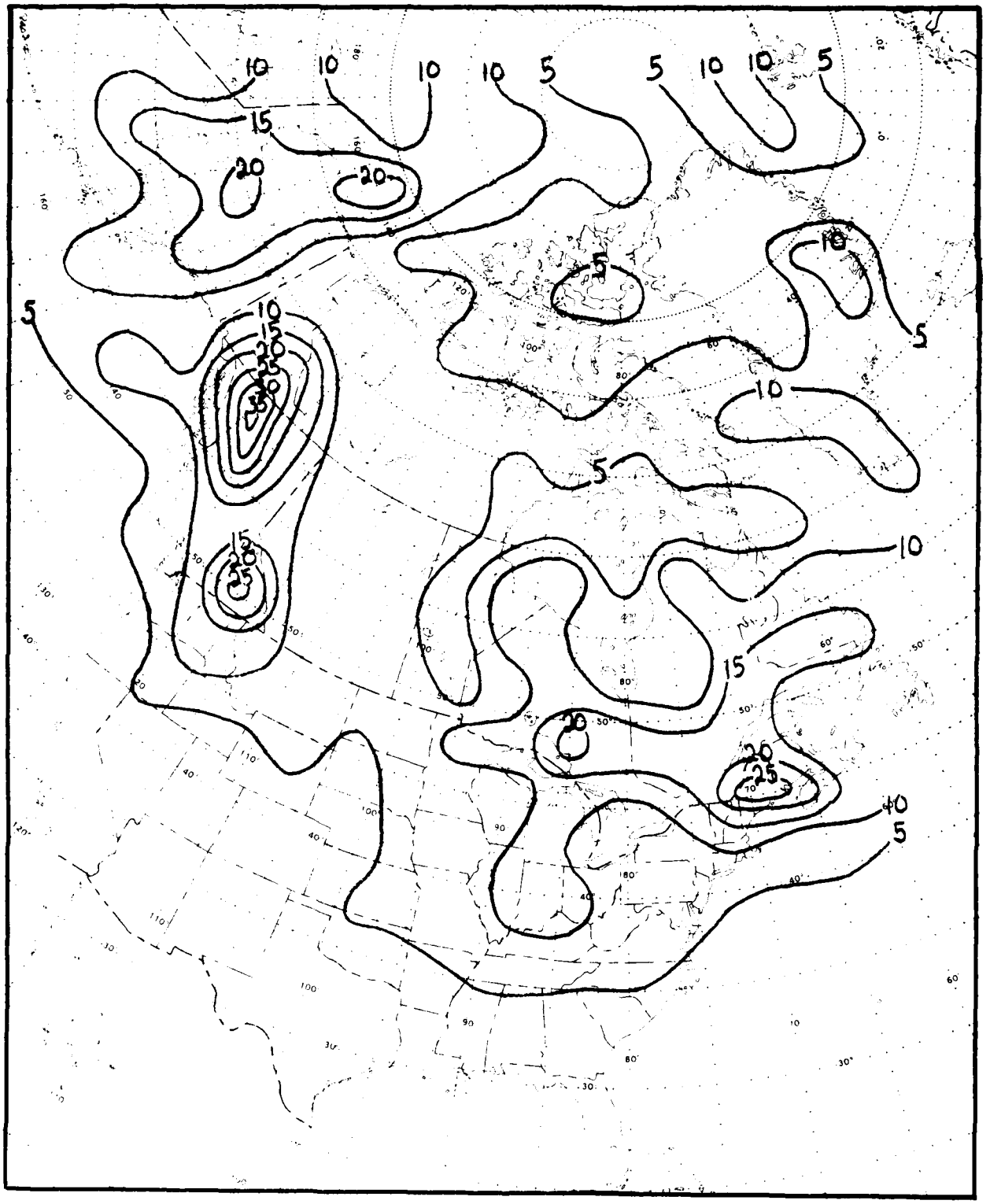
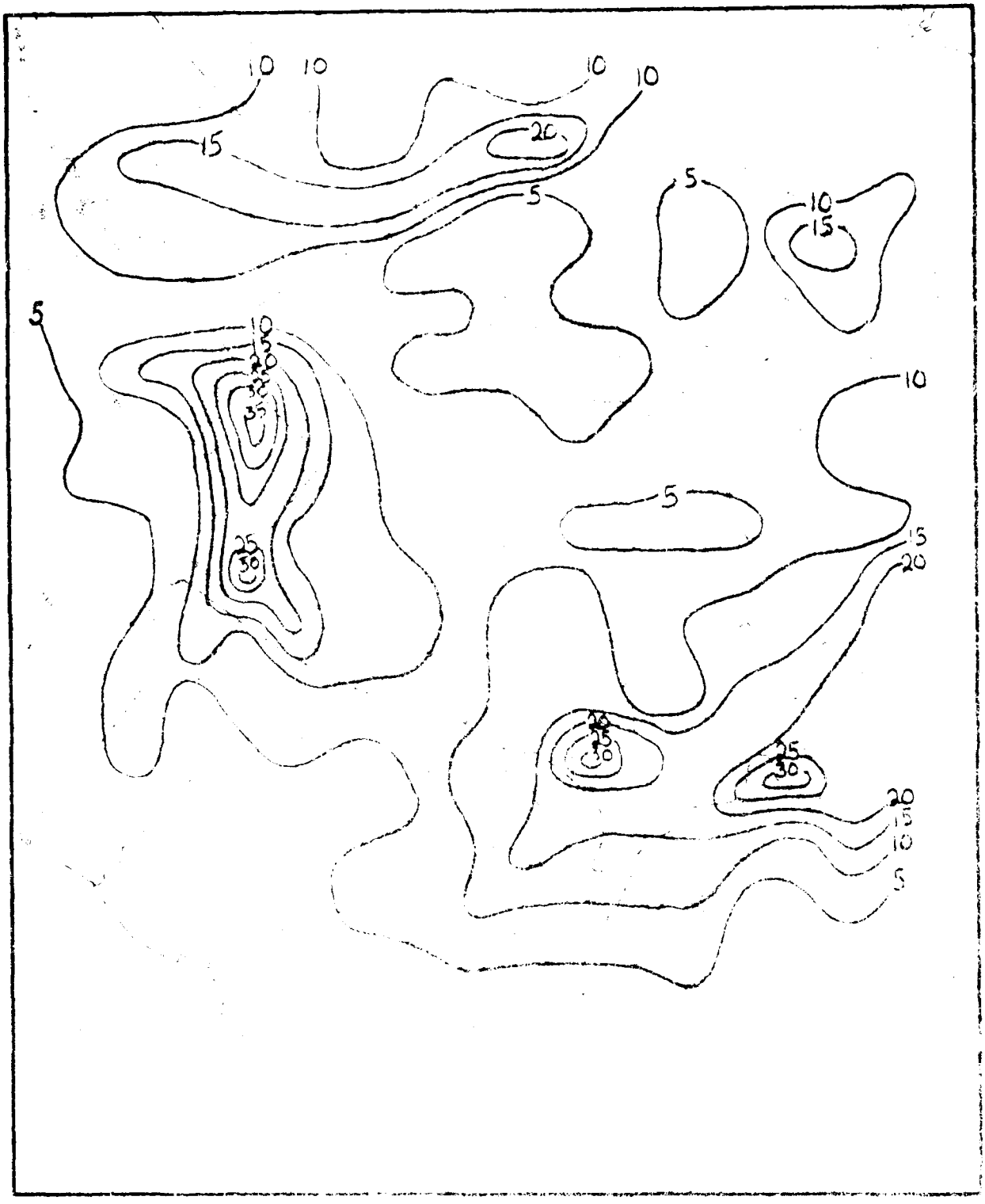


CHART 63 NOVEMBER 1,525 TO 3,048 METERS, CONCENTRATION .50 G/M^3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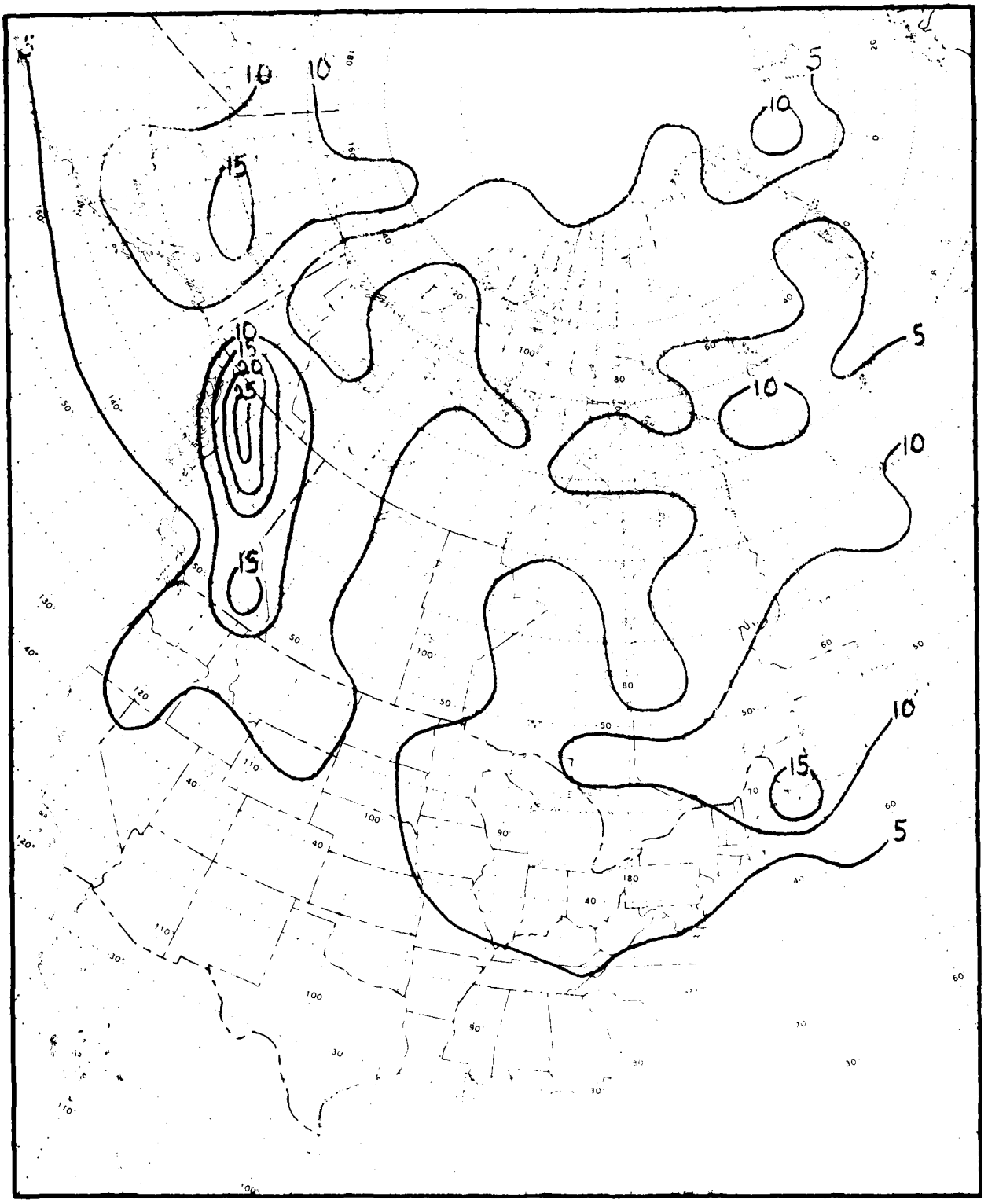


CHART 65 ANNUAL 1,525 TO 3,048 METERS, CONCENTRATION .50 G/M^3

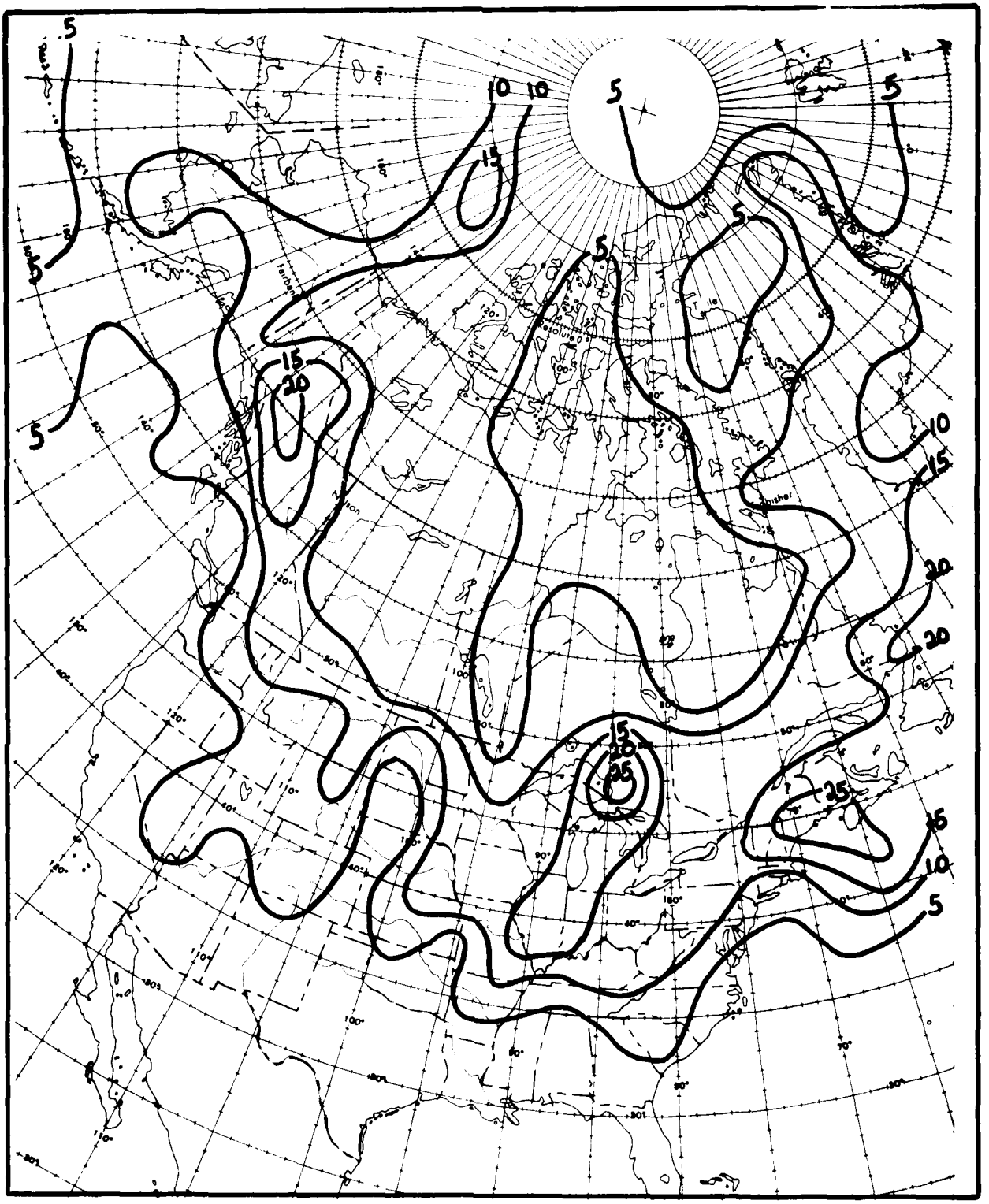


CHART 66 JANUARY 1,525 TO 3,048 METERS, CONCENTRATION 1.00 G/M^3

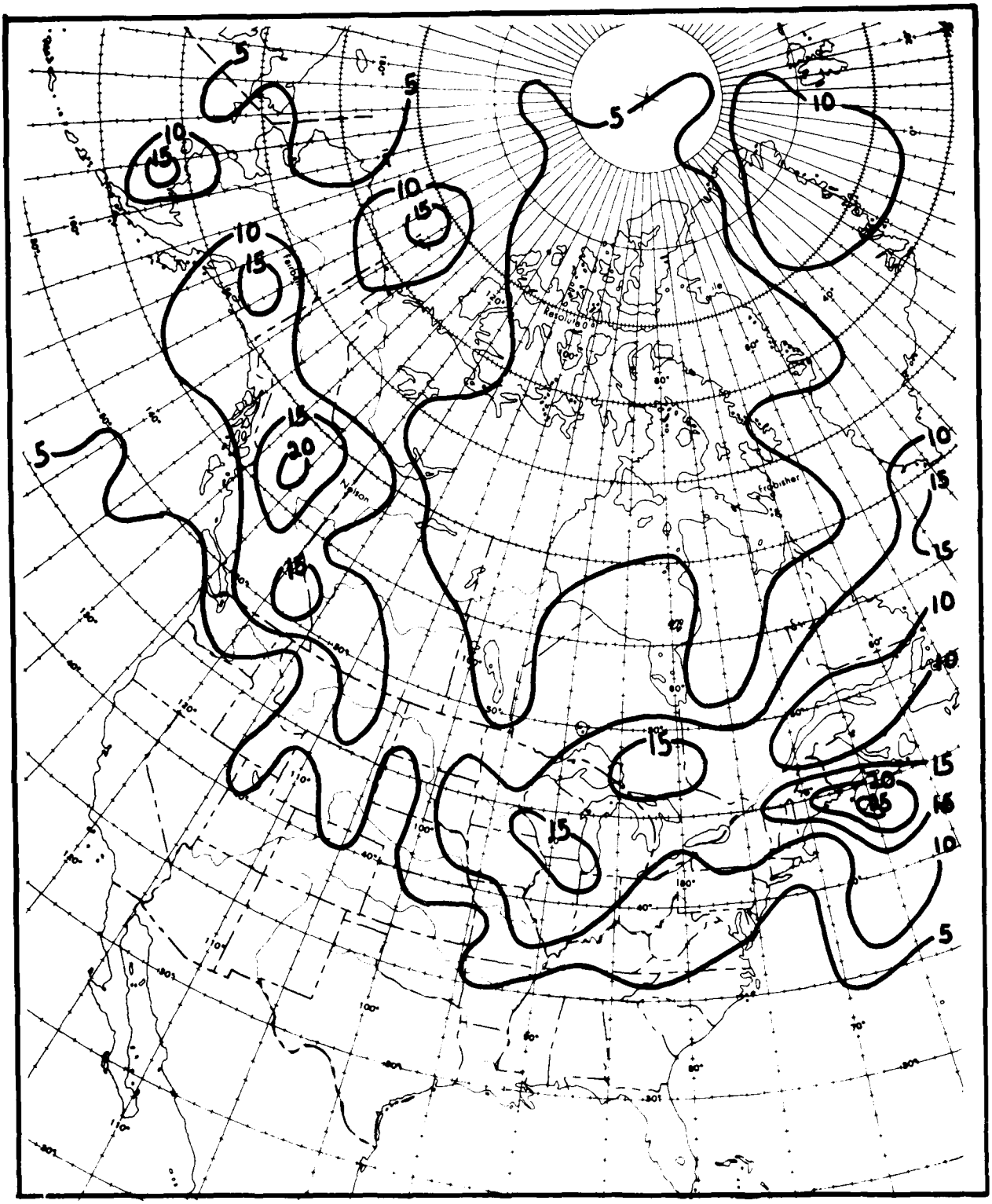


CHART 67 FEBRUARY 1,525 TO 3,048 METERS, CONCENTRATION 1.00 G/M^3

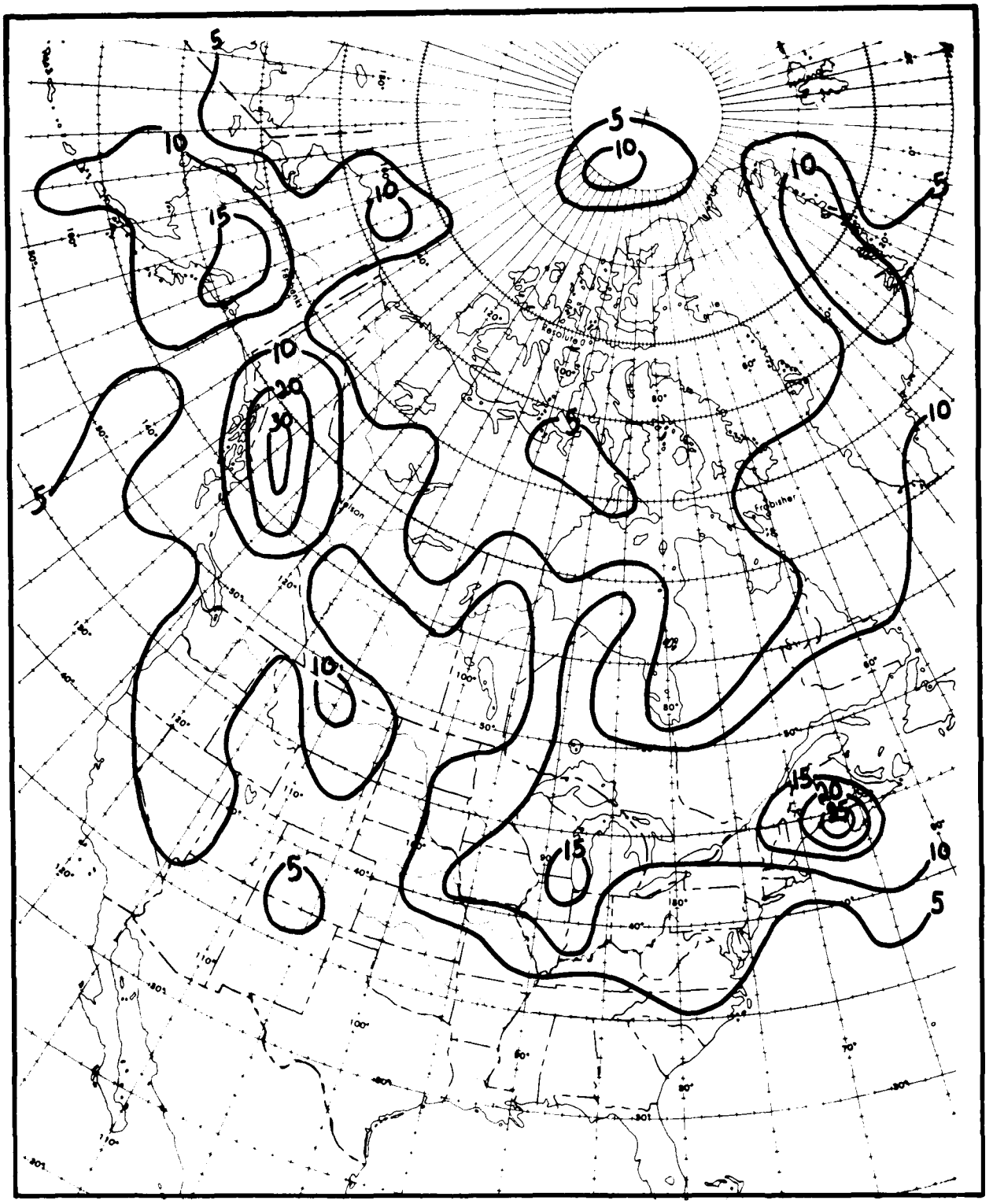
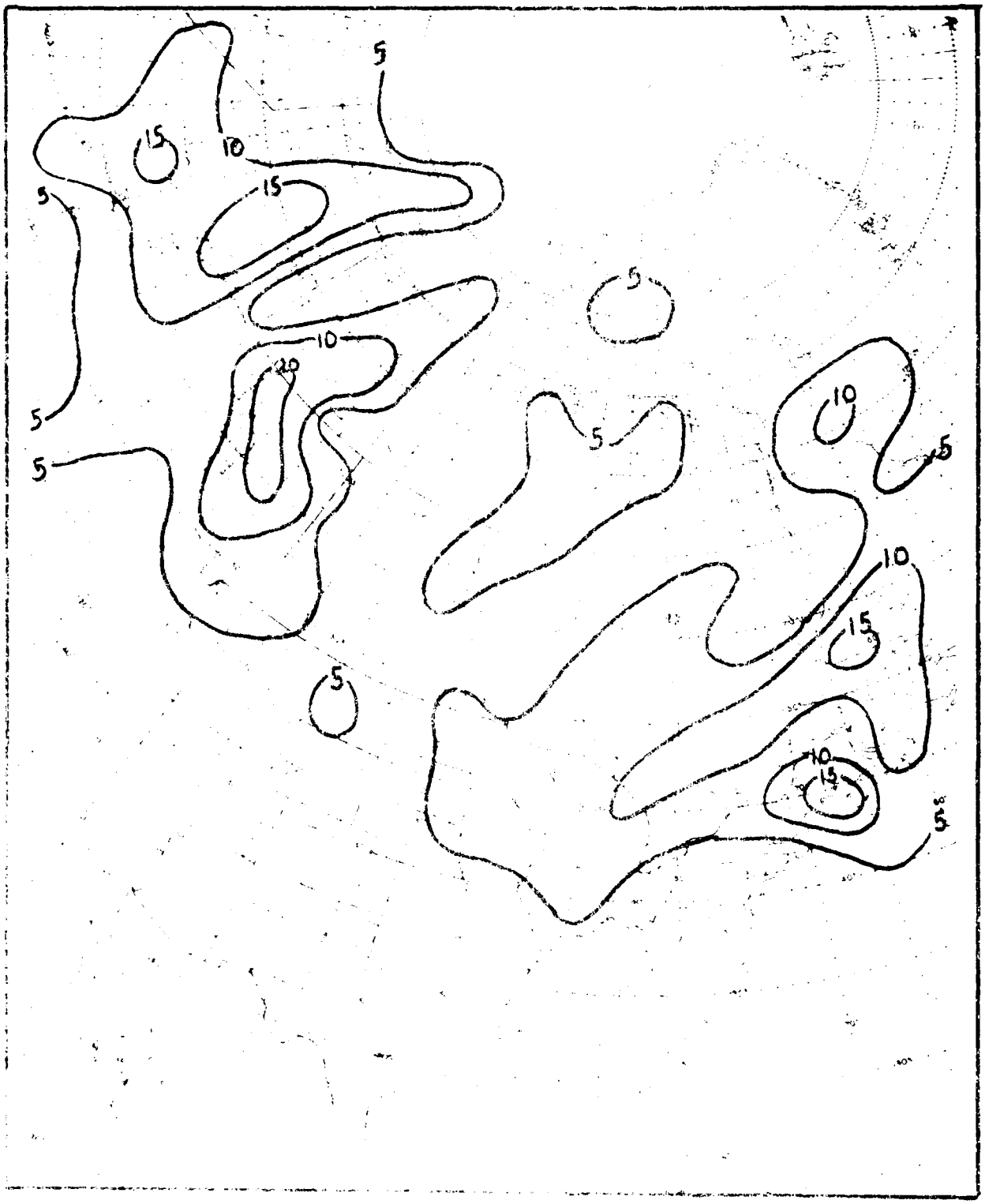


CHART 68 MARCH 1,525 TO 3,048 METERS, CONCENTRATION 1.00 G/M^3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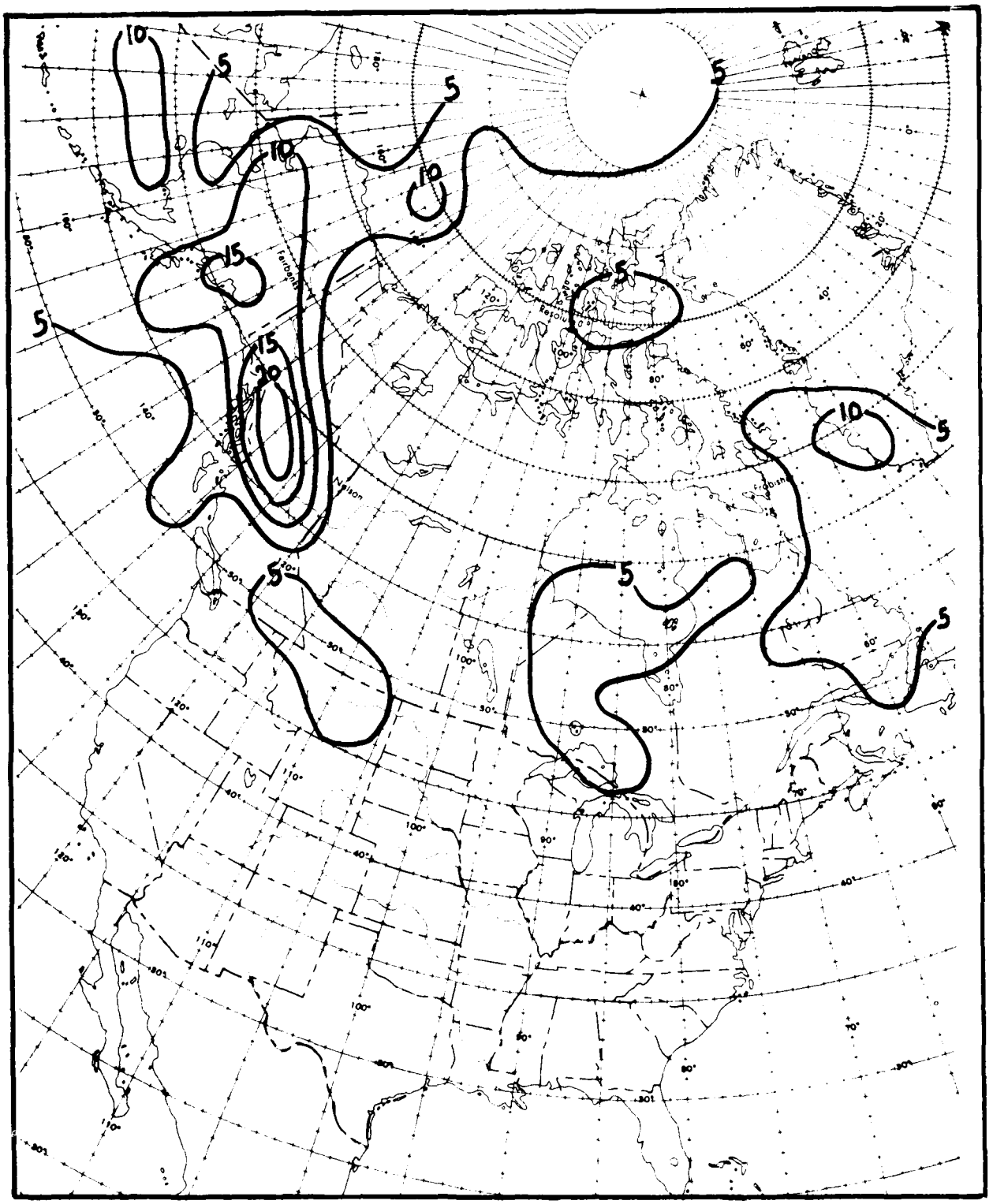

CHART 70 MAY 1,525 TO 3,048 METERS, CONCENTRATION 1.00 G/M^3

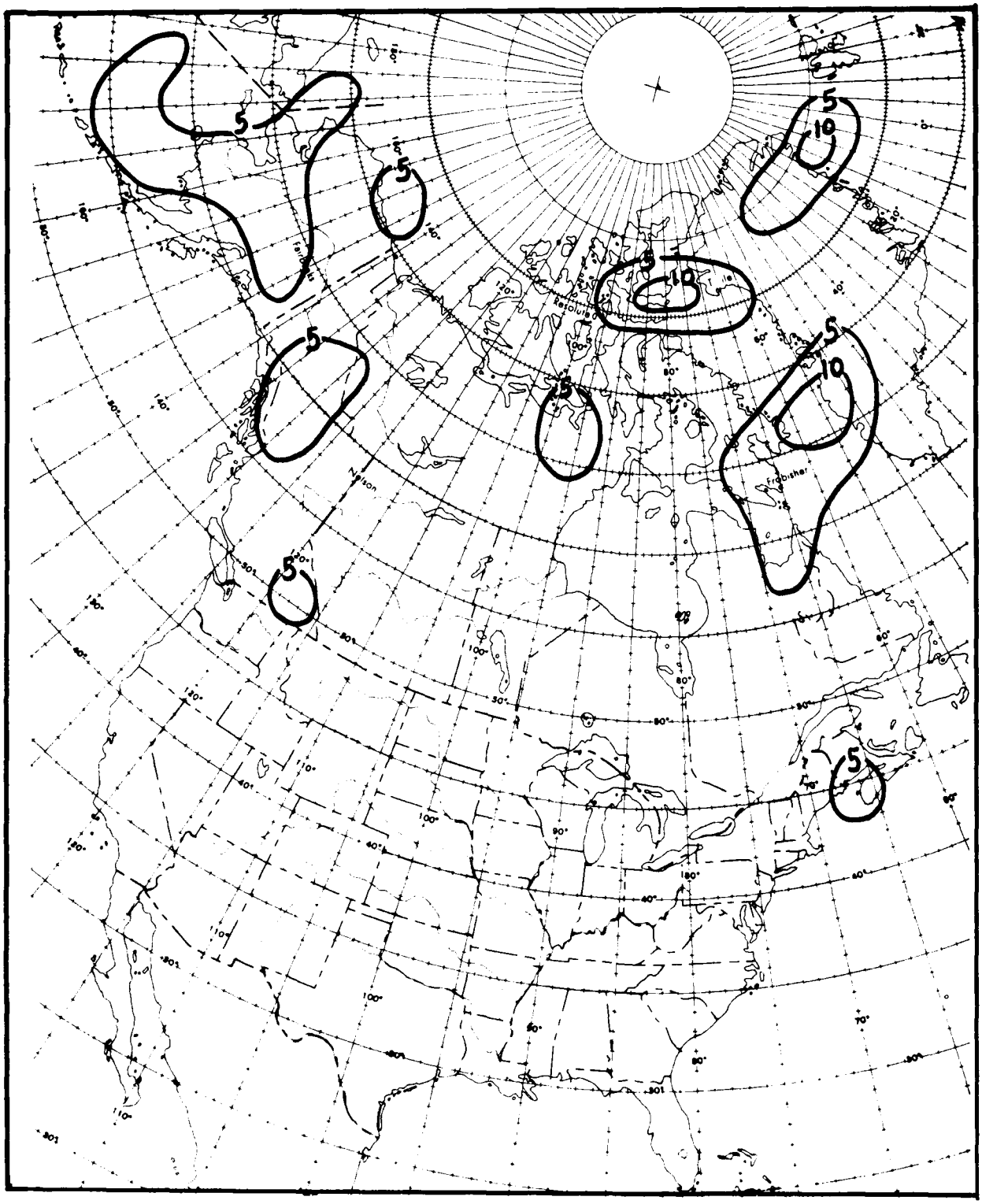

CHART 71 JUNE 1,525 TO 3,048 METERS, CONCENTRATION 1.00 G/M^3

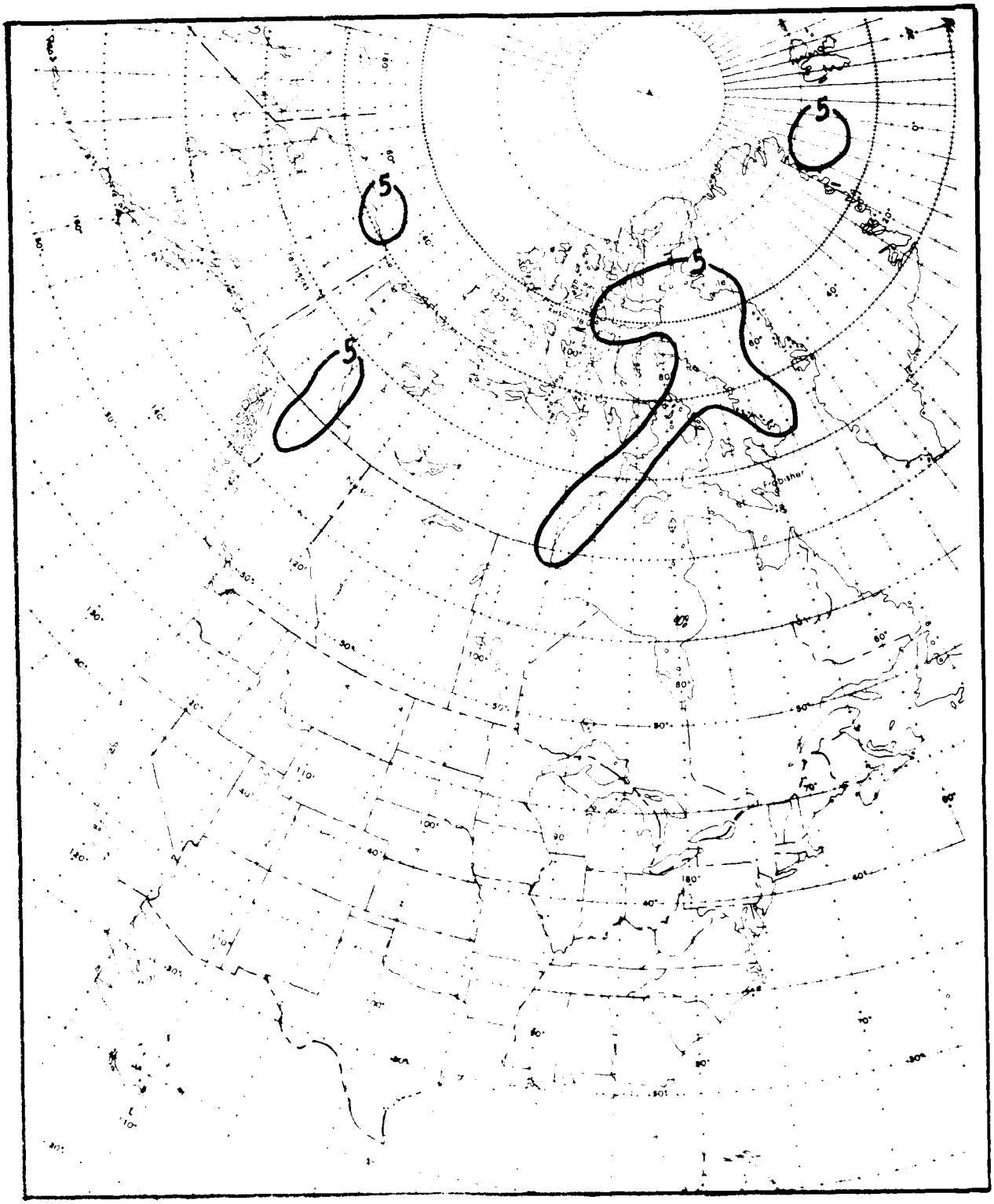

CHART 12 JULY 1,525 TO 3,048 METERS, CONCENTRATION 1.00 G/M^3

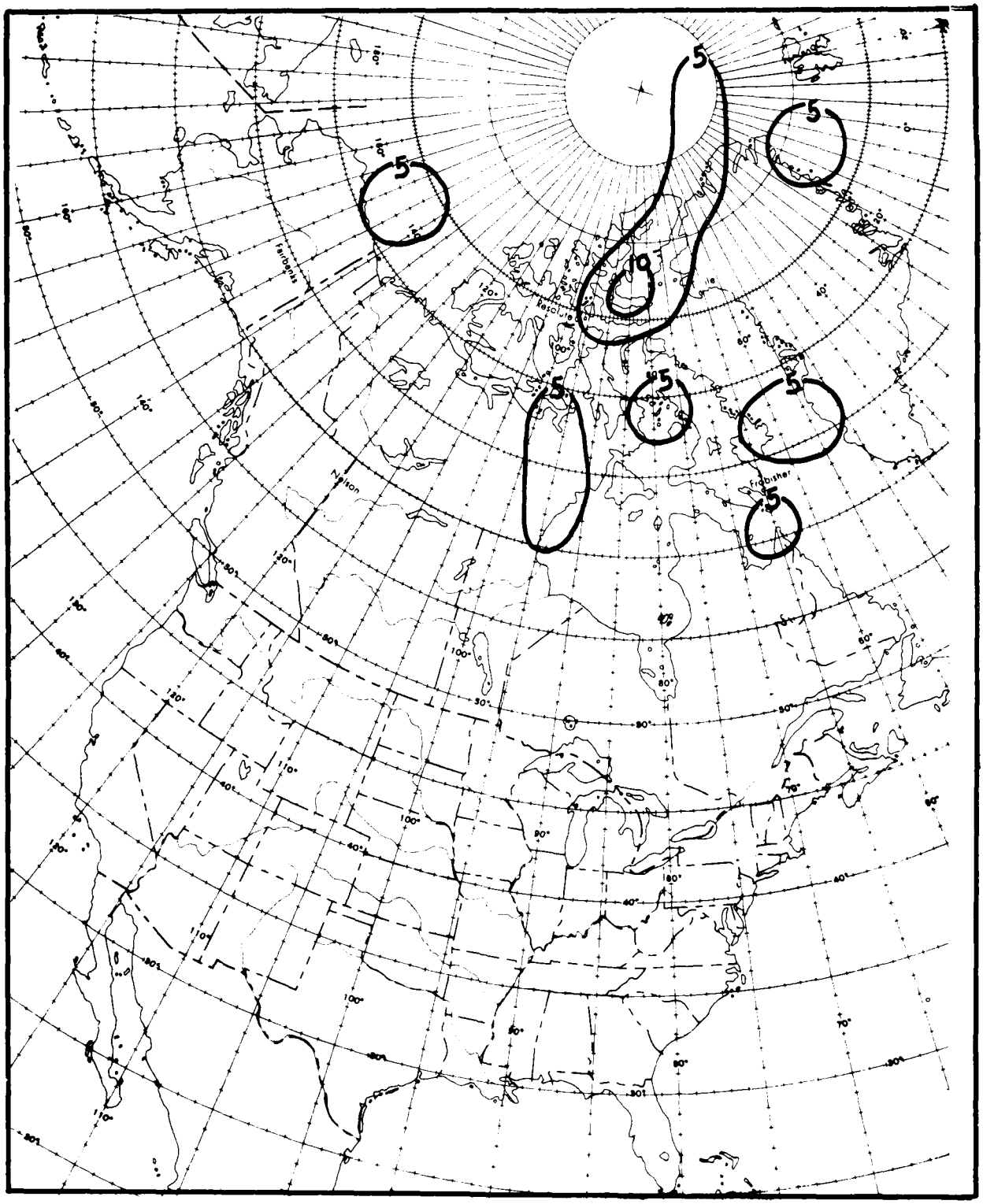

CHART 73 AUGUST 1,525 TO 3,048 METERS, CONCENTRATION 1.00 G/M^3

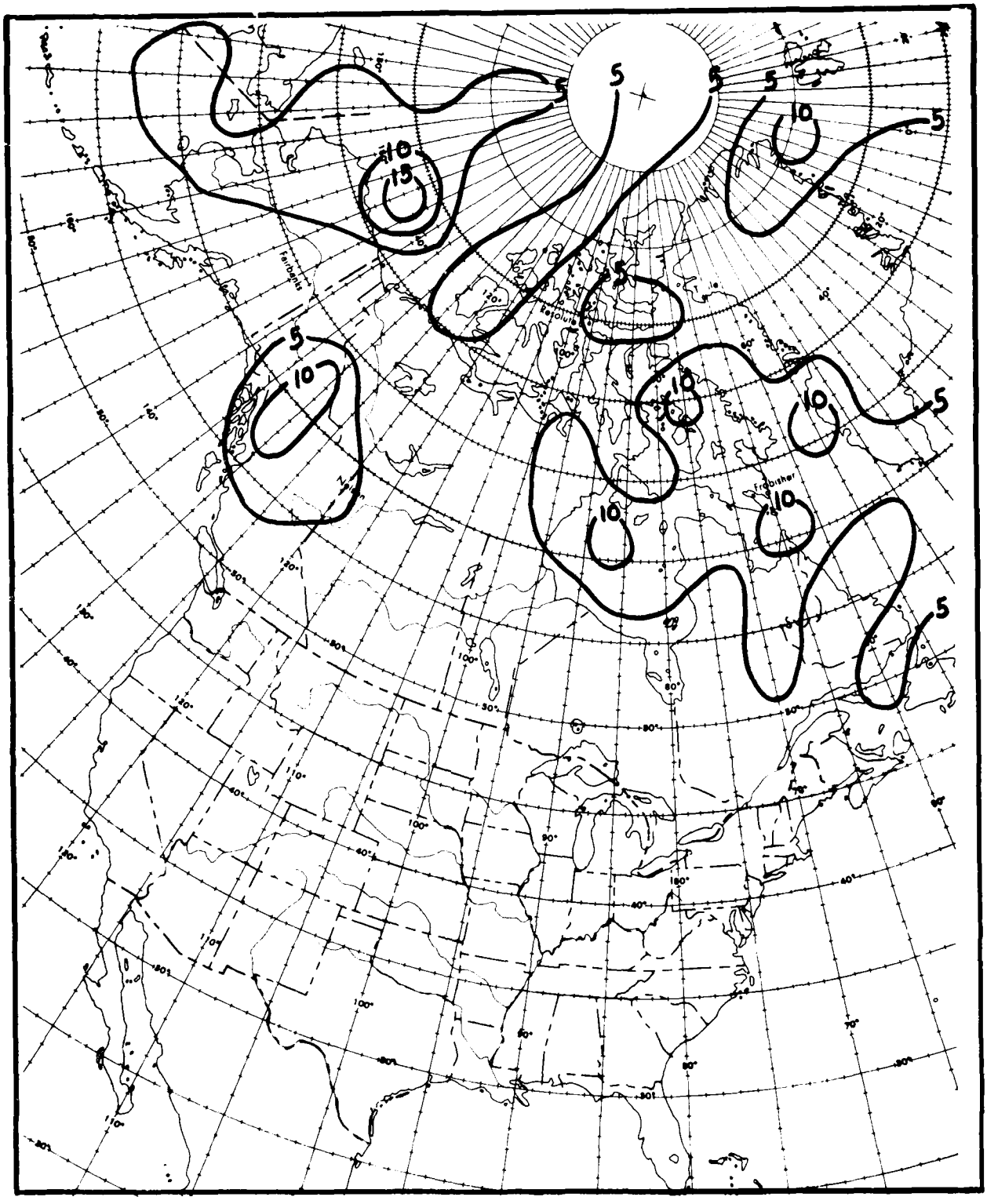

CHART 74 SEPTEMBER 1,525 TO 3,048 METERS, CONCENTRATION 1.00 G/M^3

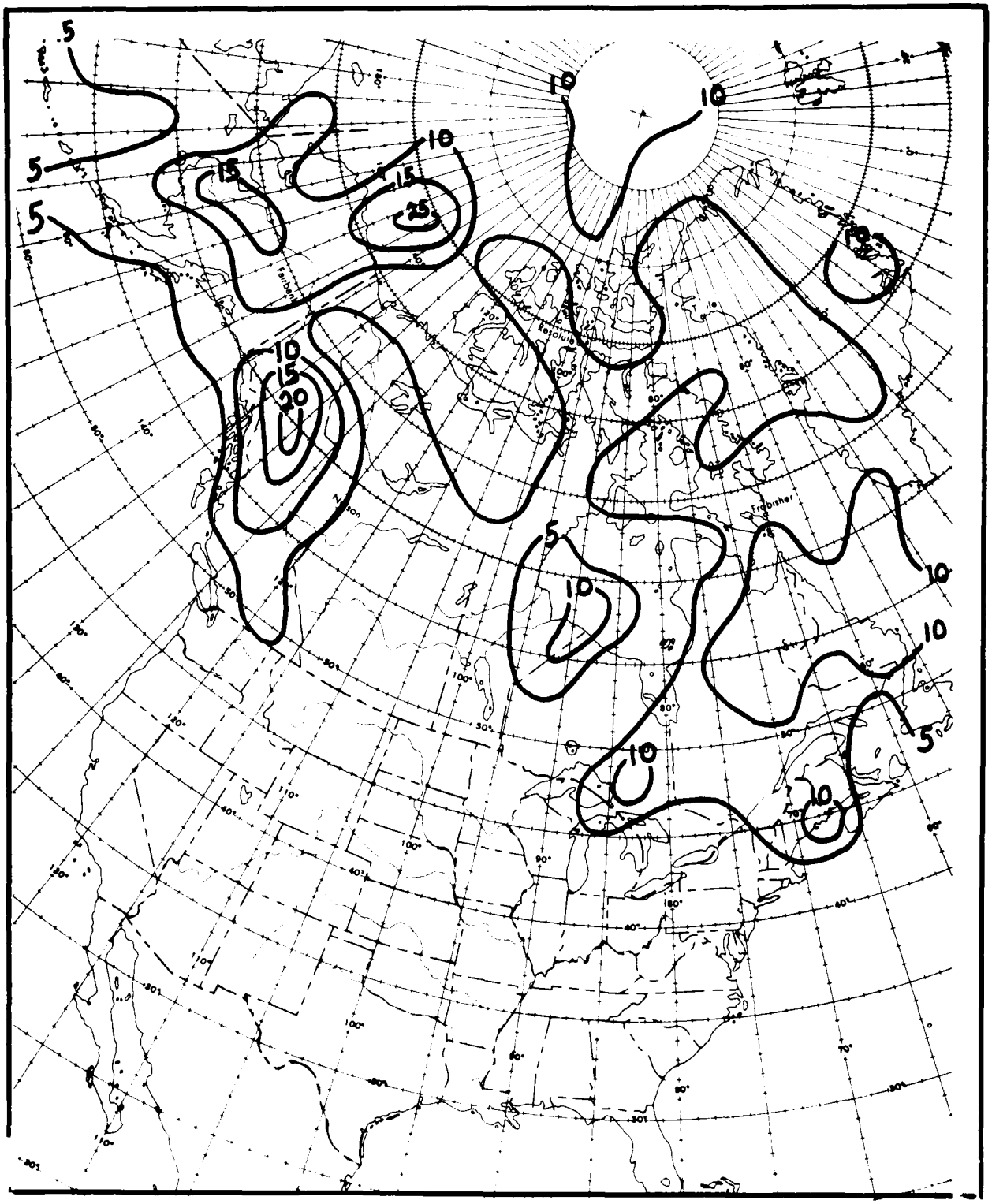

CHART 75 OCTOBER 1,525 TO 3,048 METERS, CONCENTRATION 1.00 G/M^3

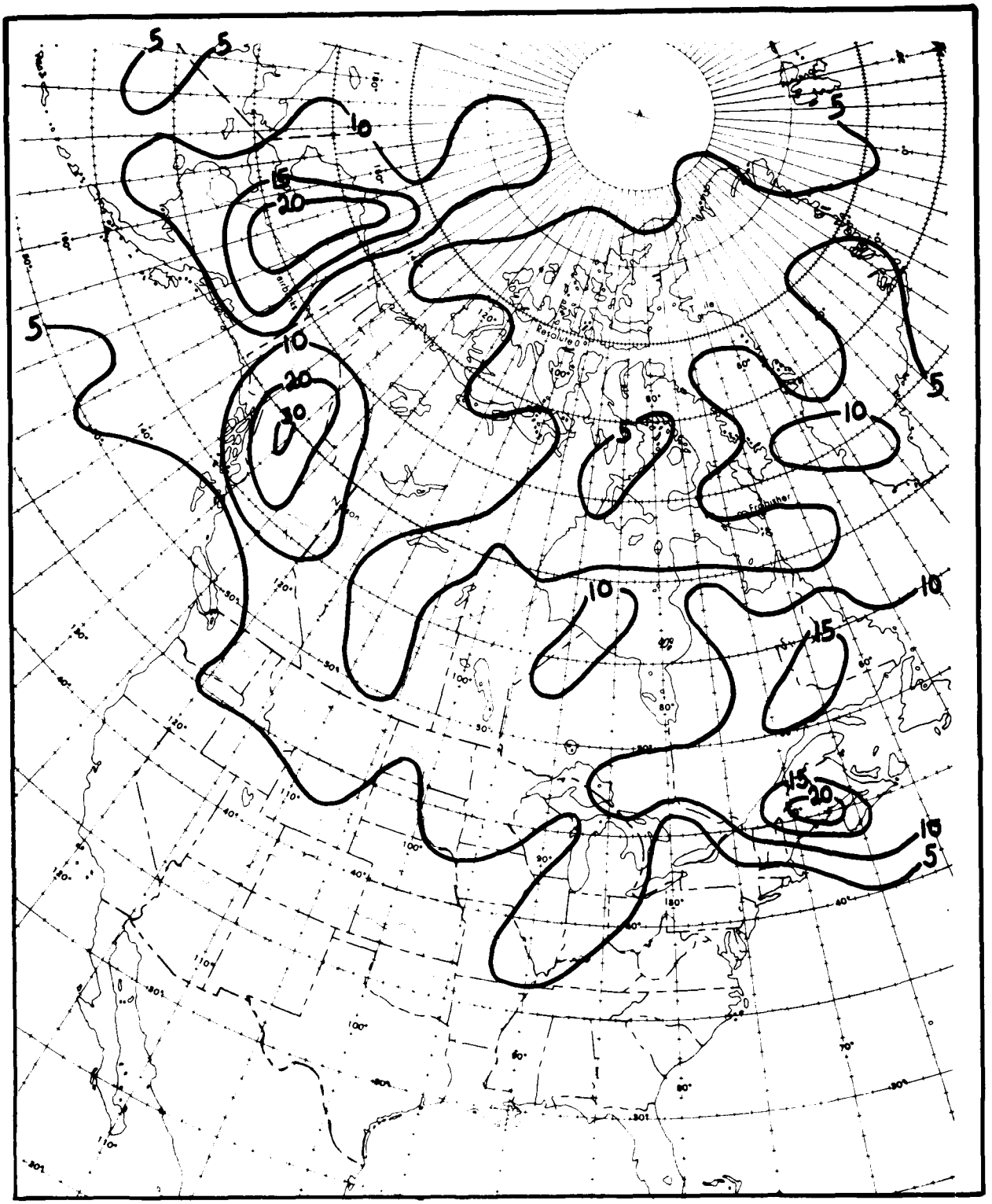

CHART 76 NOVEMBER 1,525 TO 3,048 METERS, CONCENTRATION 1.00 G/M^3

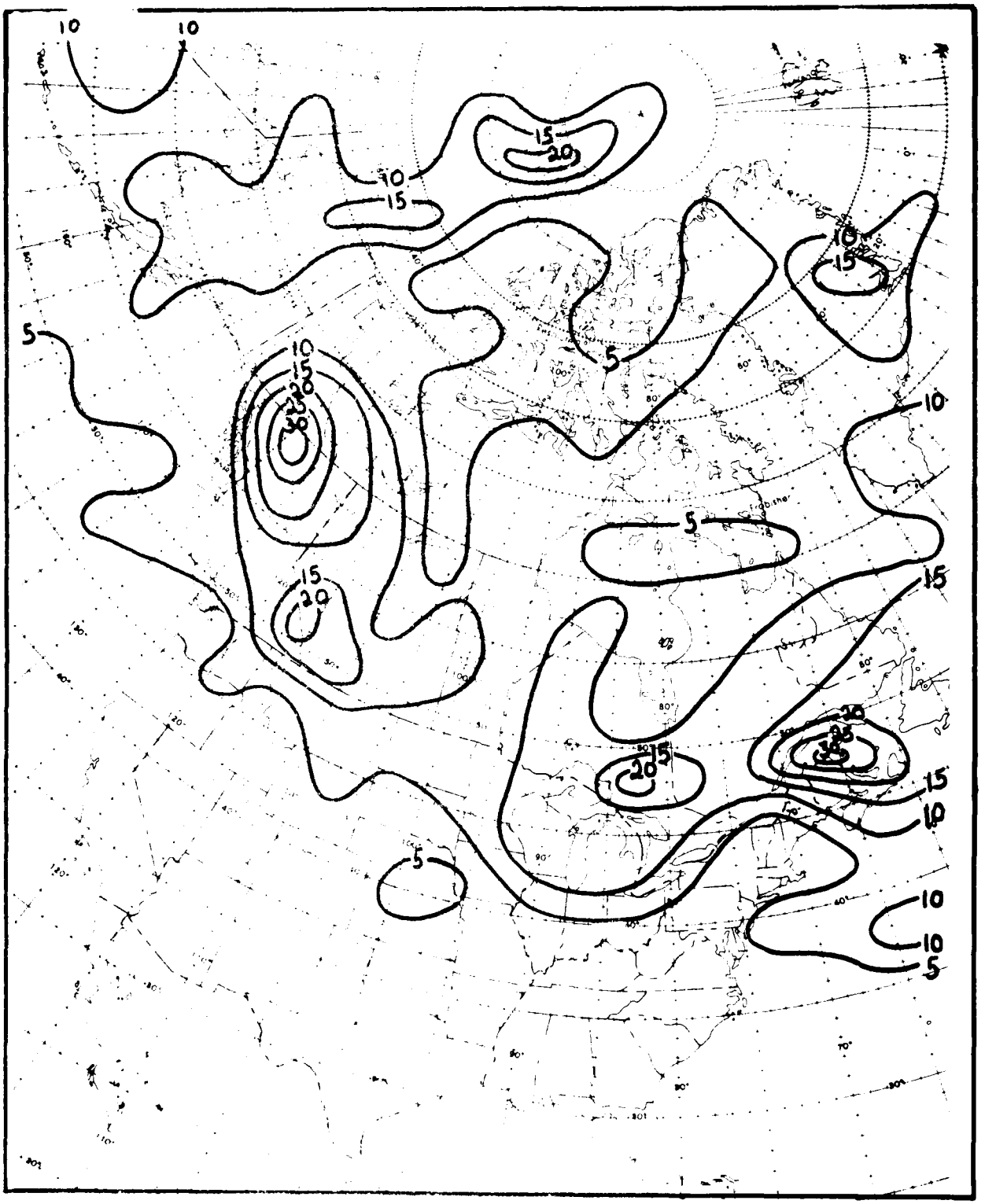

CHART 77 DUSTMIR 1,525 TO 3,048 METERS, CONCENTRATION 1.00 G/M^3

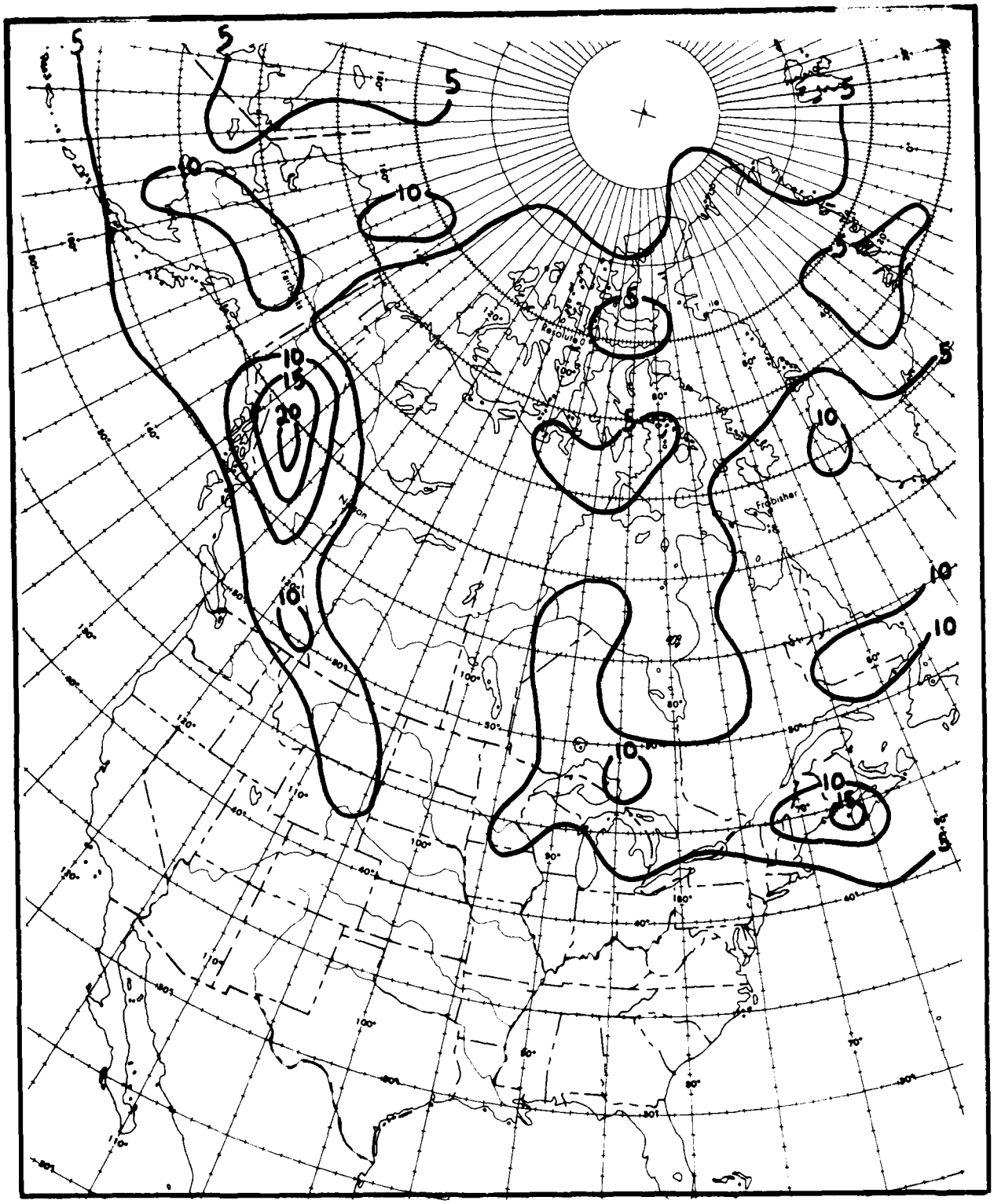

CHART 78 ANNUAL 1,525 TO 3,048 METERS, CONCENTRATION 1.00 G/M^3

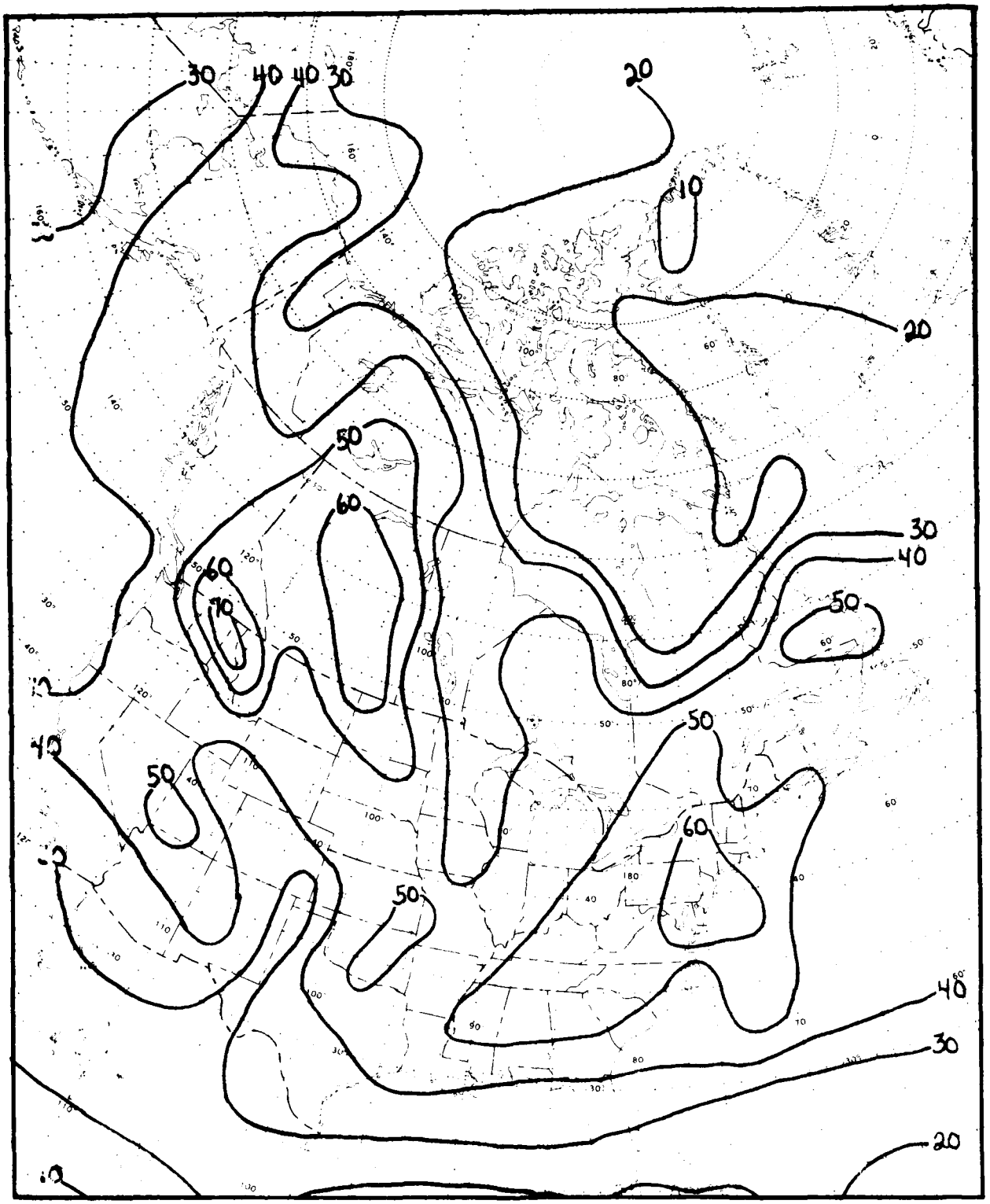

CHART 79 JANUARY 3,049 TO 4,572 METERS, CONCENTRATION .10 G/M^3

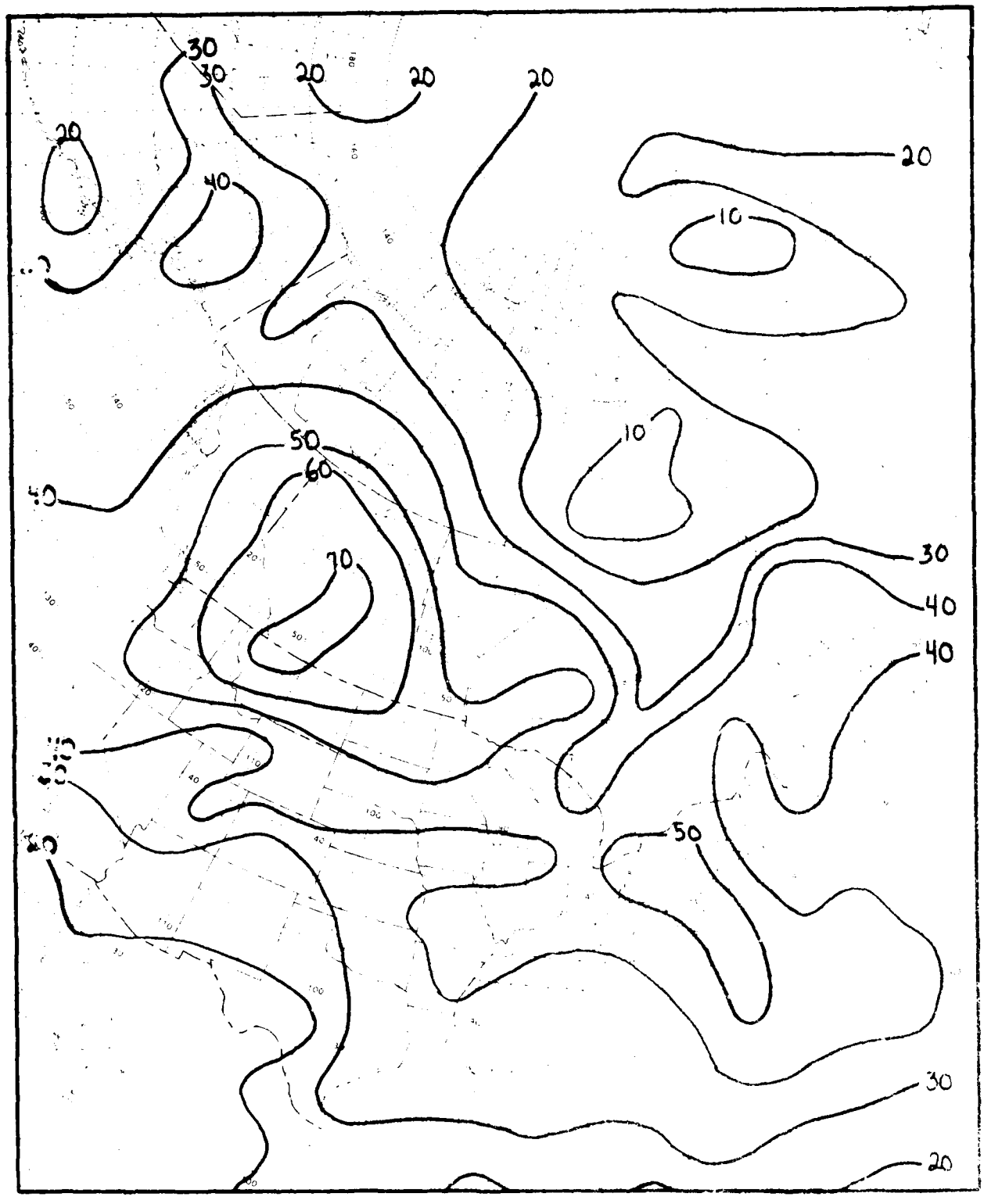

CHART 80 FEBRUARY 3,049 TO 4,572 METERS, CONCENTRATION 10 G/M^3

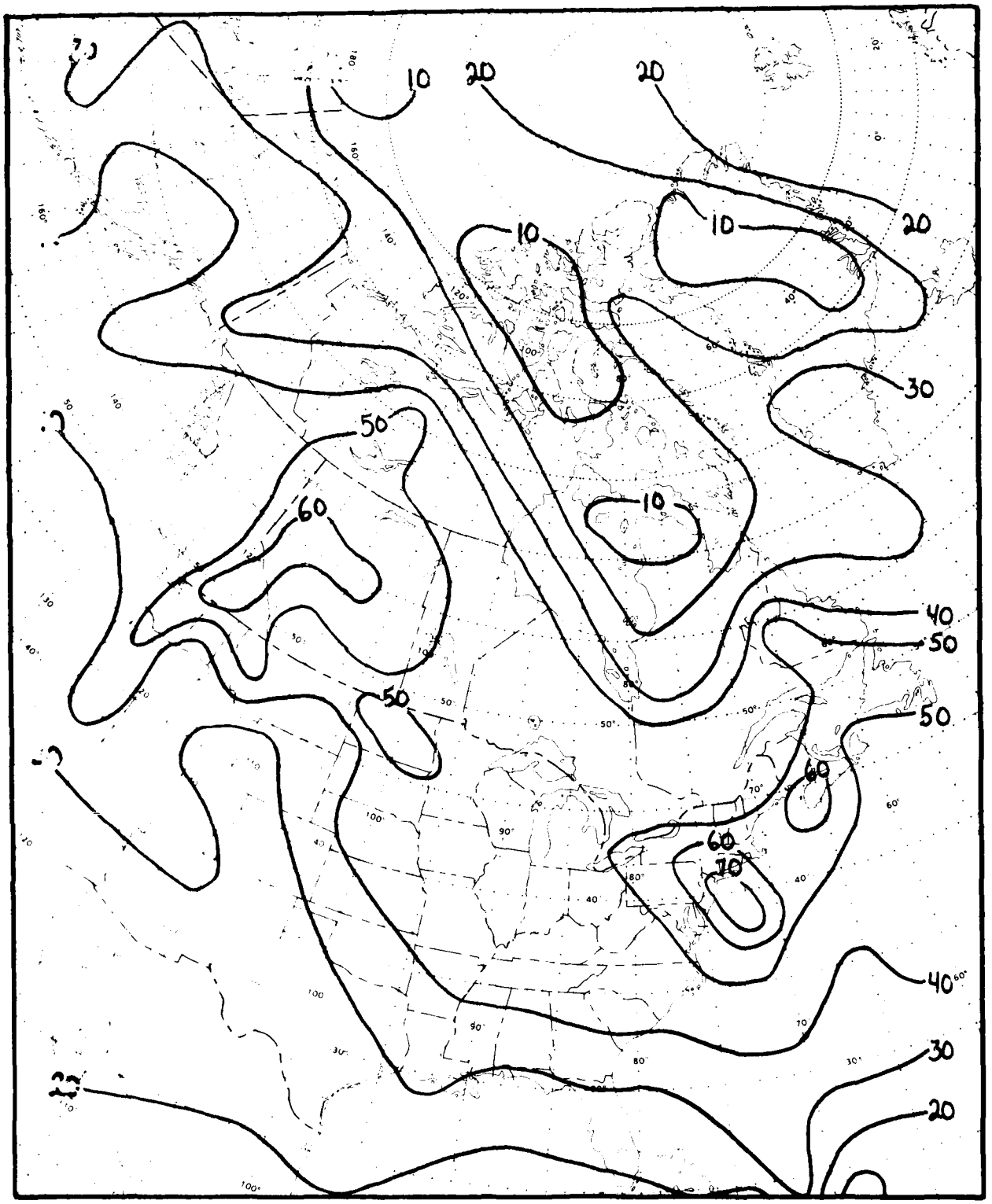

CHART 81 MARCH 3,049 TO 4,572 METERS, CONCENTRATION .10 G/M^3

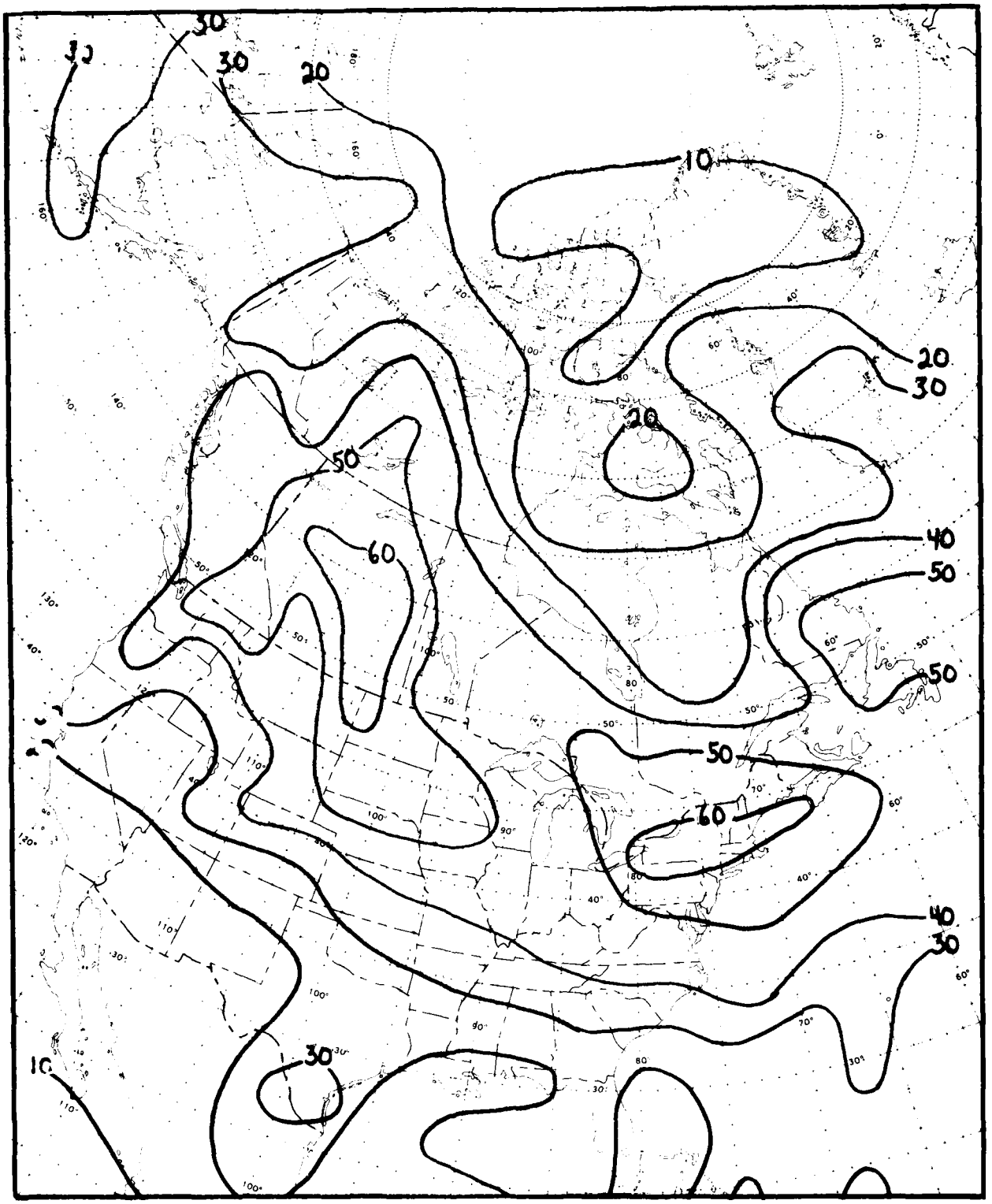

CHART 82 APRIL 3,049 TO 4,572 METERS, CONCENTRATION .10 G/M^3

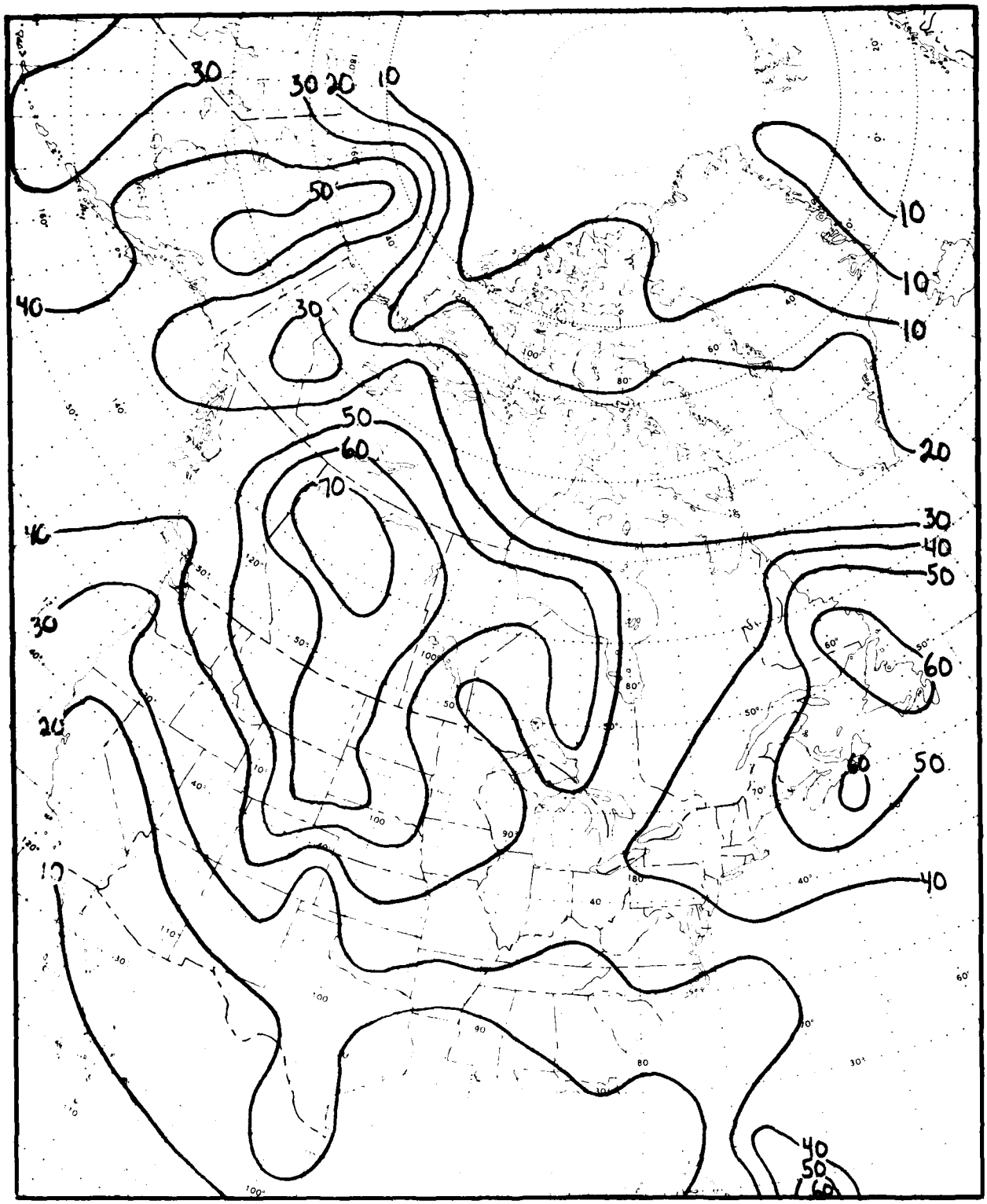

CHART 83 MAY 3,049 TO 4,572 METERS, CONCENTRATION .10 G/M^3

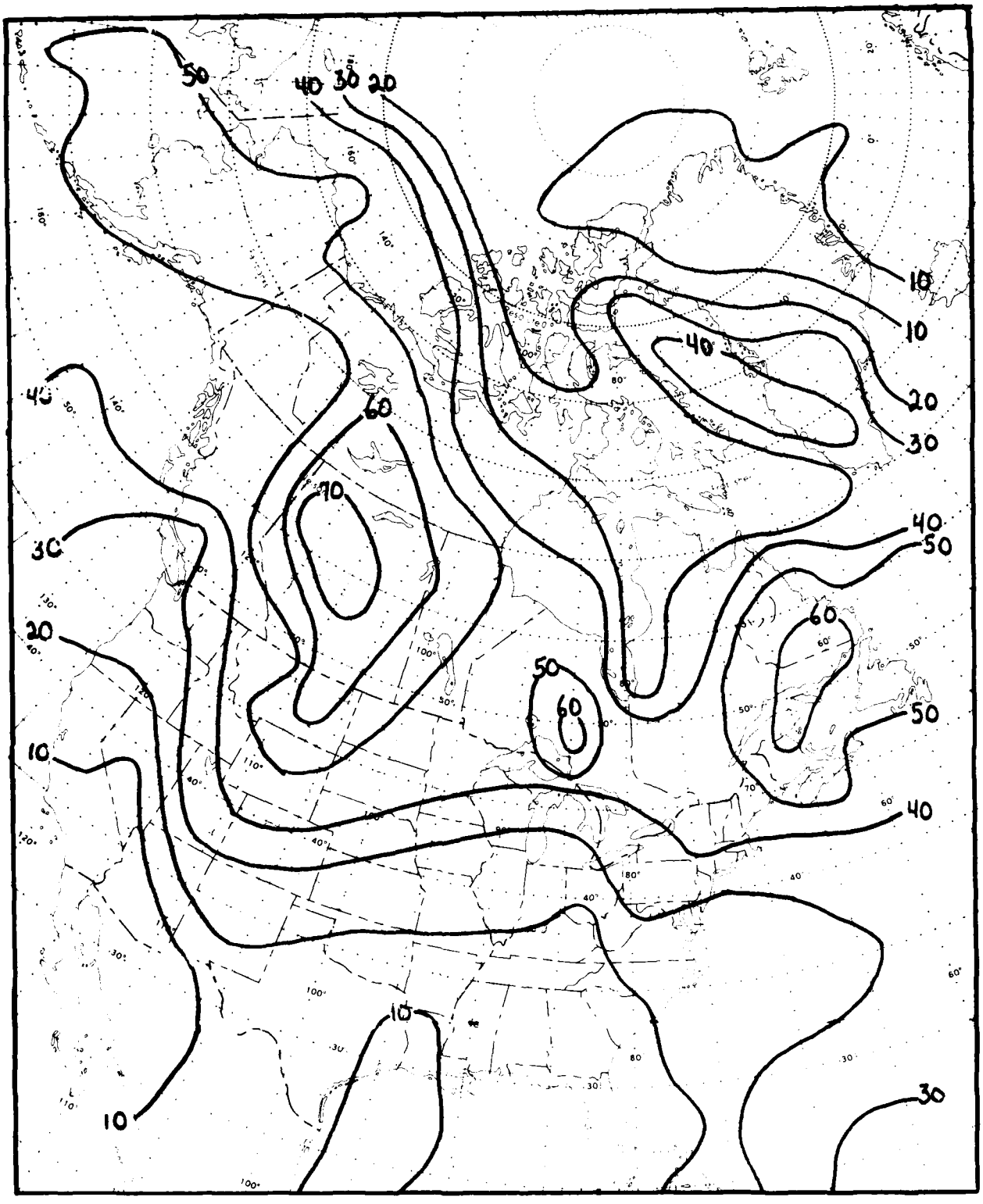

CHART 84 JUNE 3,049 TO 4,572 METERS, CONCENTRATION .10 G/M^3

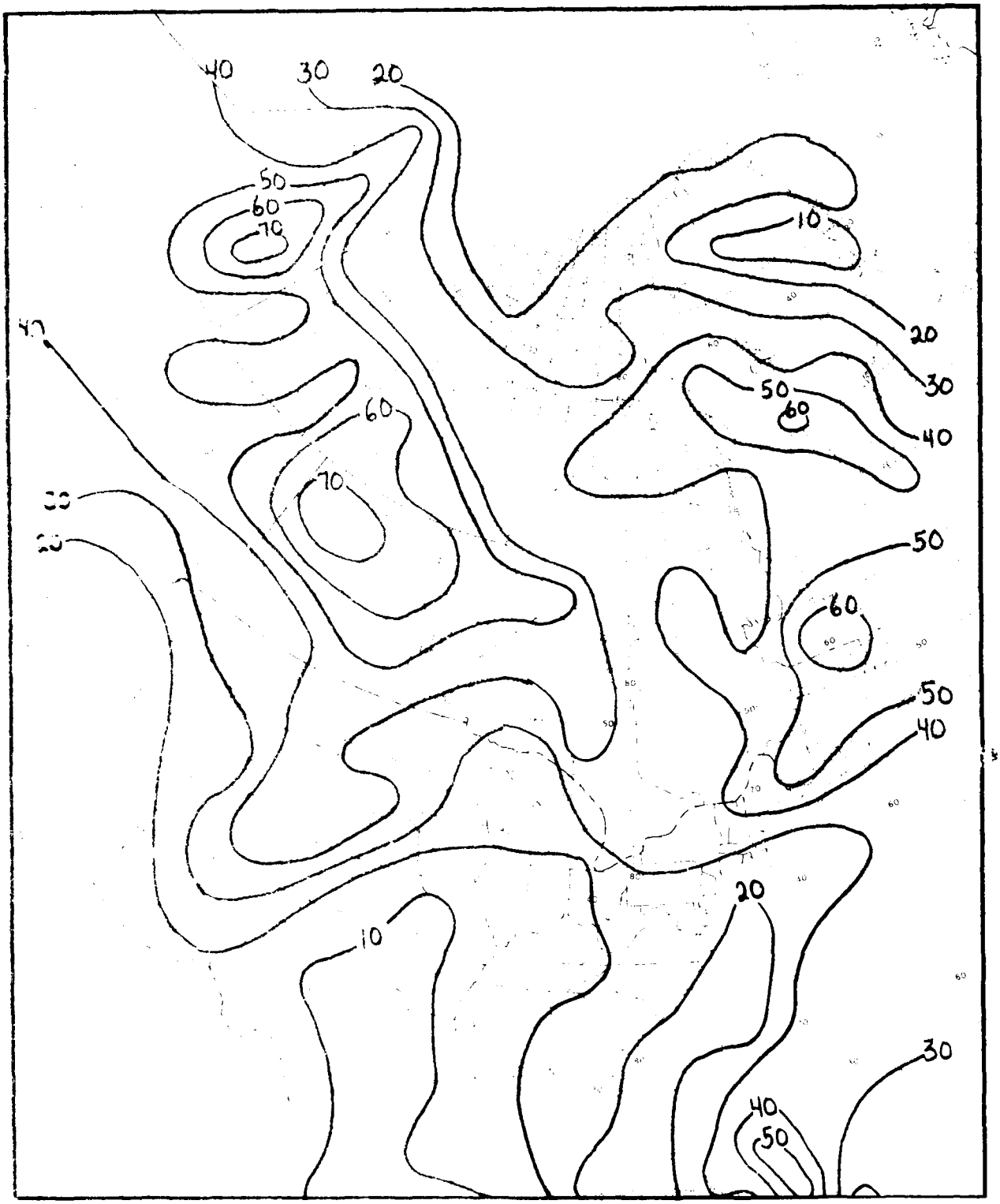

CHART 3[illegible] JULY 5,049 TO 4,572 METERS, CONCENTRATION .10 G/M^3

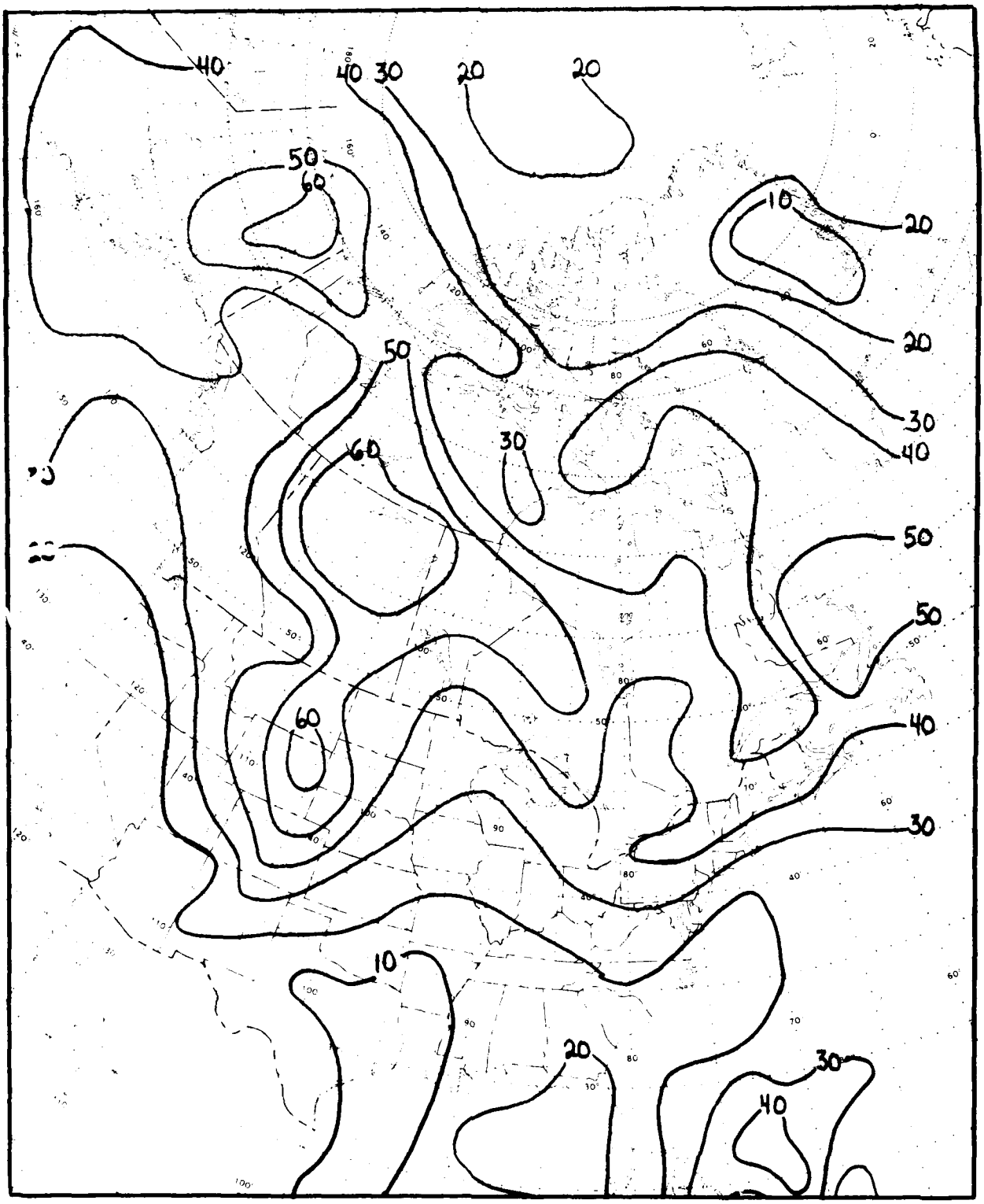

CHART 86 AUGUST 3,049 TO 4,572 METERS, CONCENTRATION .10 G/M^3

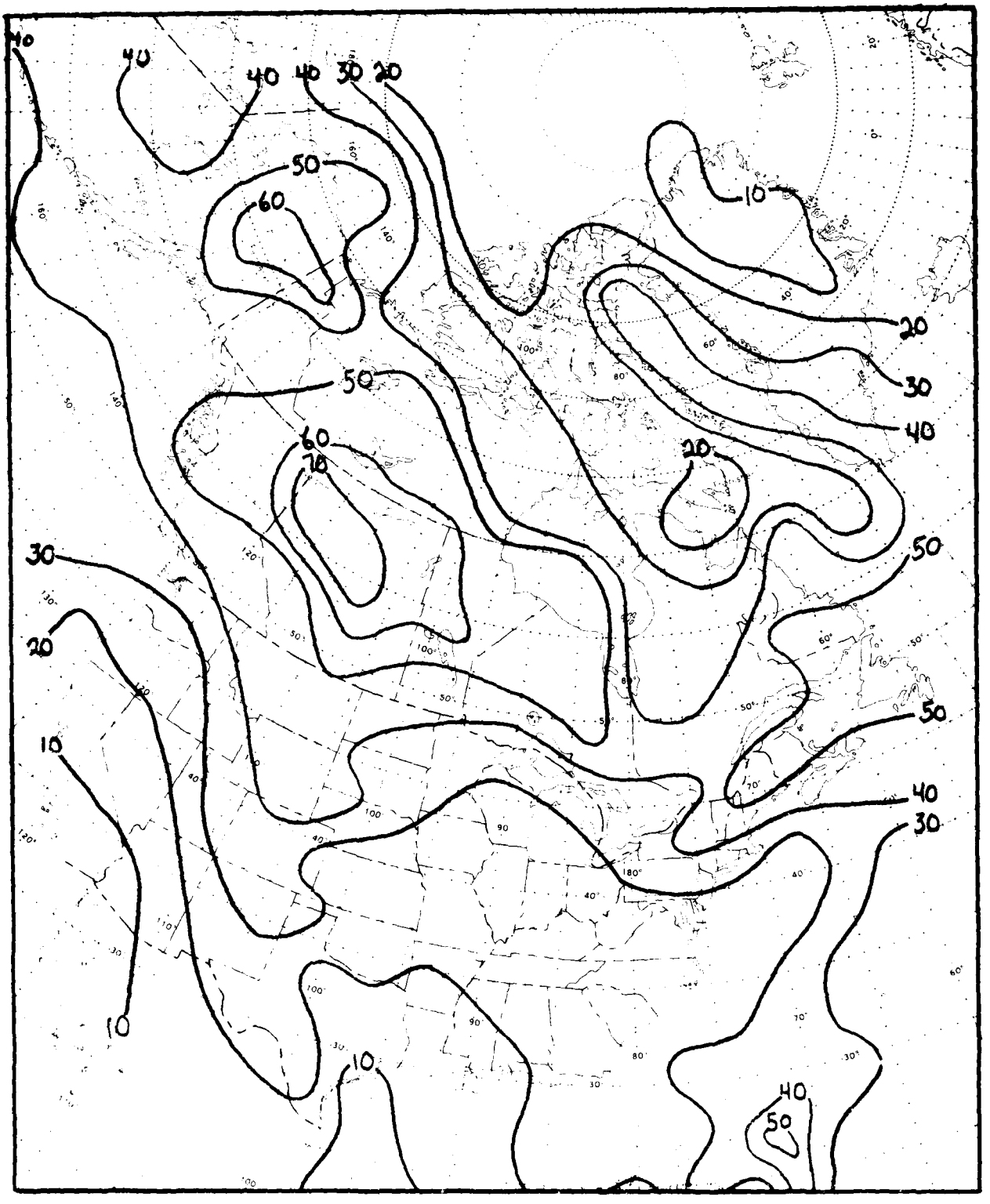

CHART 87 SEPTEMBER 3,049 TO 4,572 METERS, CONCENTRATION .10 G/M^3

AD-A174 260 CLIMATIC ATLAS OF ICING POTENTIAL OVER NORTH AMERICA (U) AIR FORCE ENVIRONMENTAL TECHNICAL APPLICATIONS CENTER SCOTT AFB IL JAN 86 USAFETAC/DS-86/001 2/2

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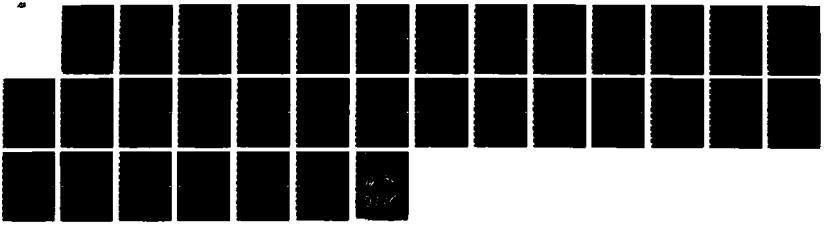

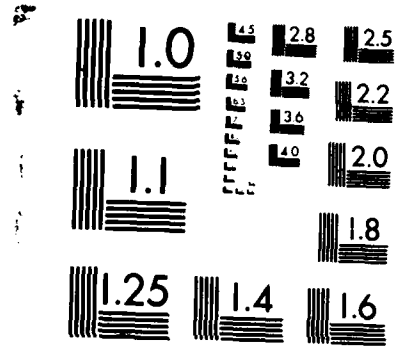

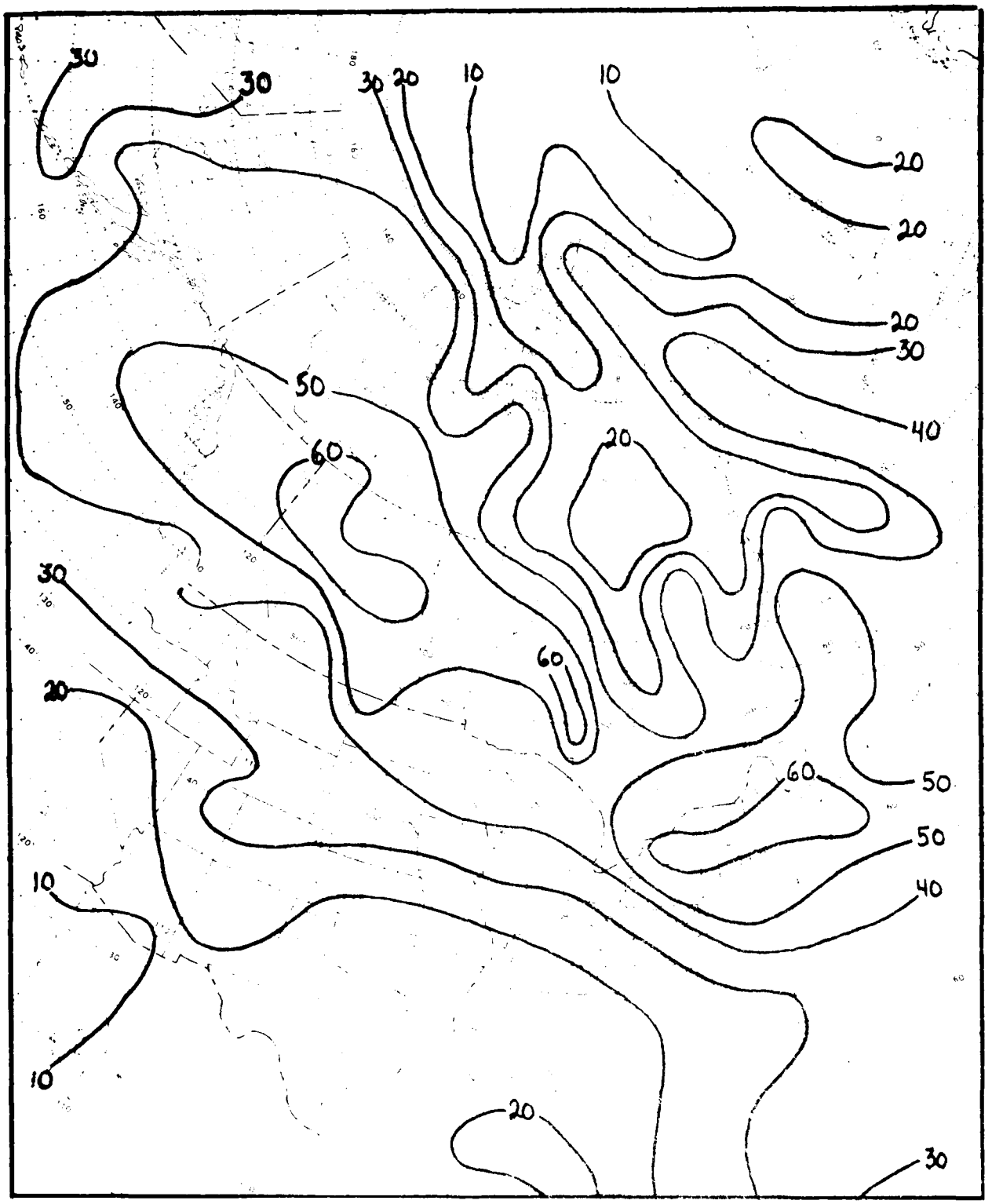

CHART 88 OCTOBER 3,049 TO 4,572 METERS. CONCENTRATION .10 G/M^3

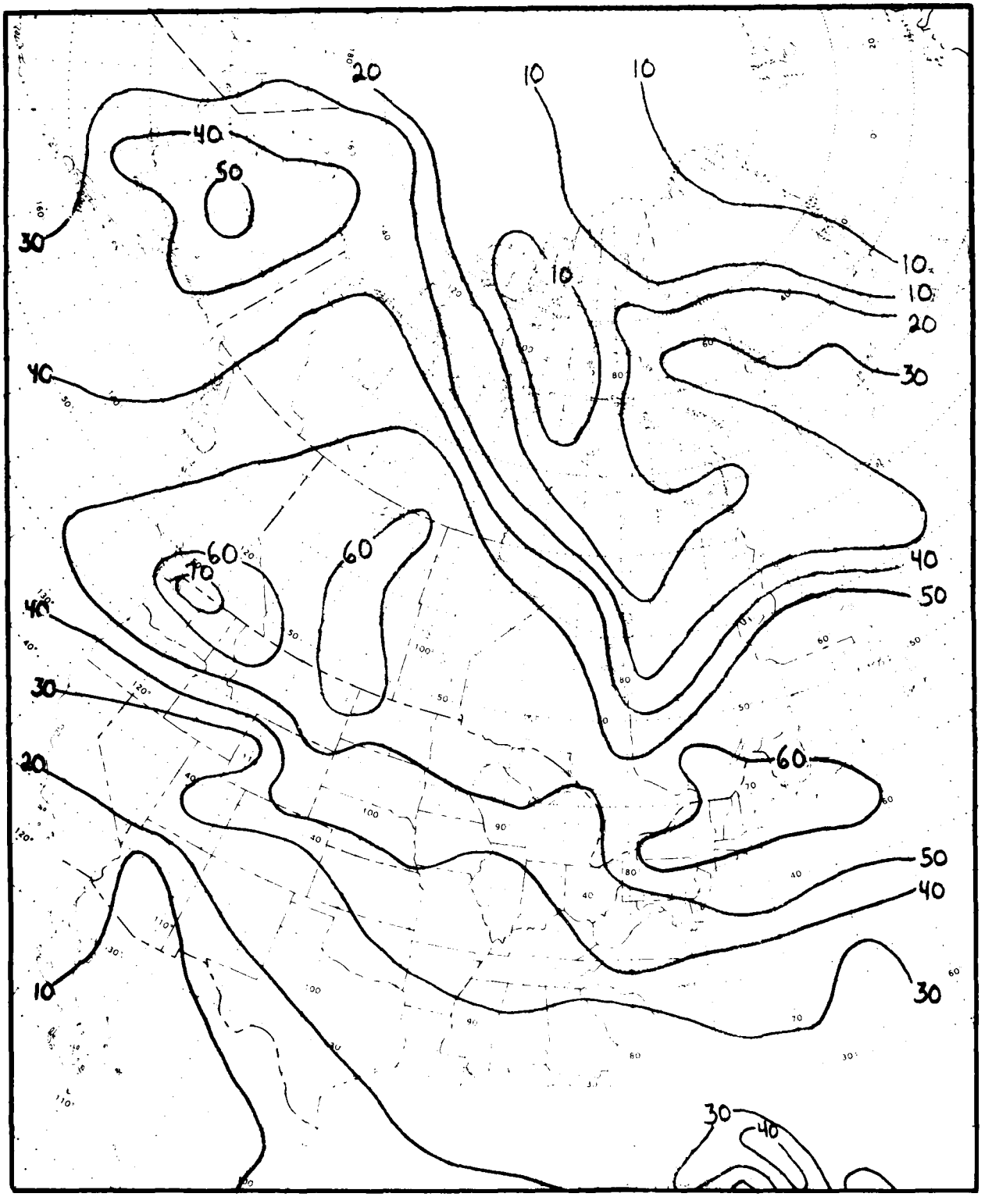

CHART 89 NOVEMBER 3,049 TO 4,572 METERS, CONCENTRATION .10 G/M^3

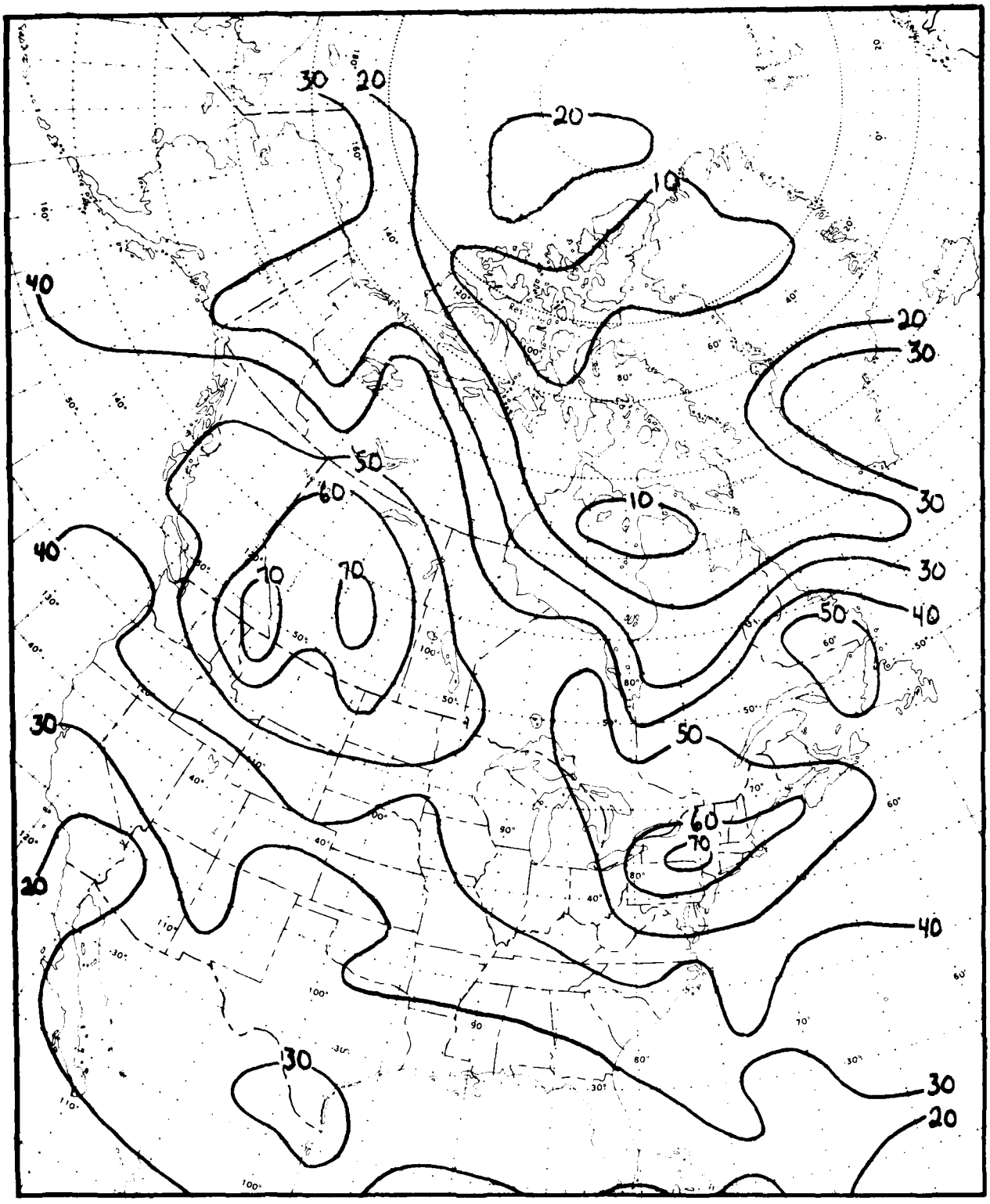

CHART 90 DECEMBER 3,049 TO 4,572 METERS, CONCENTRATION .10 G/M^3

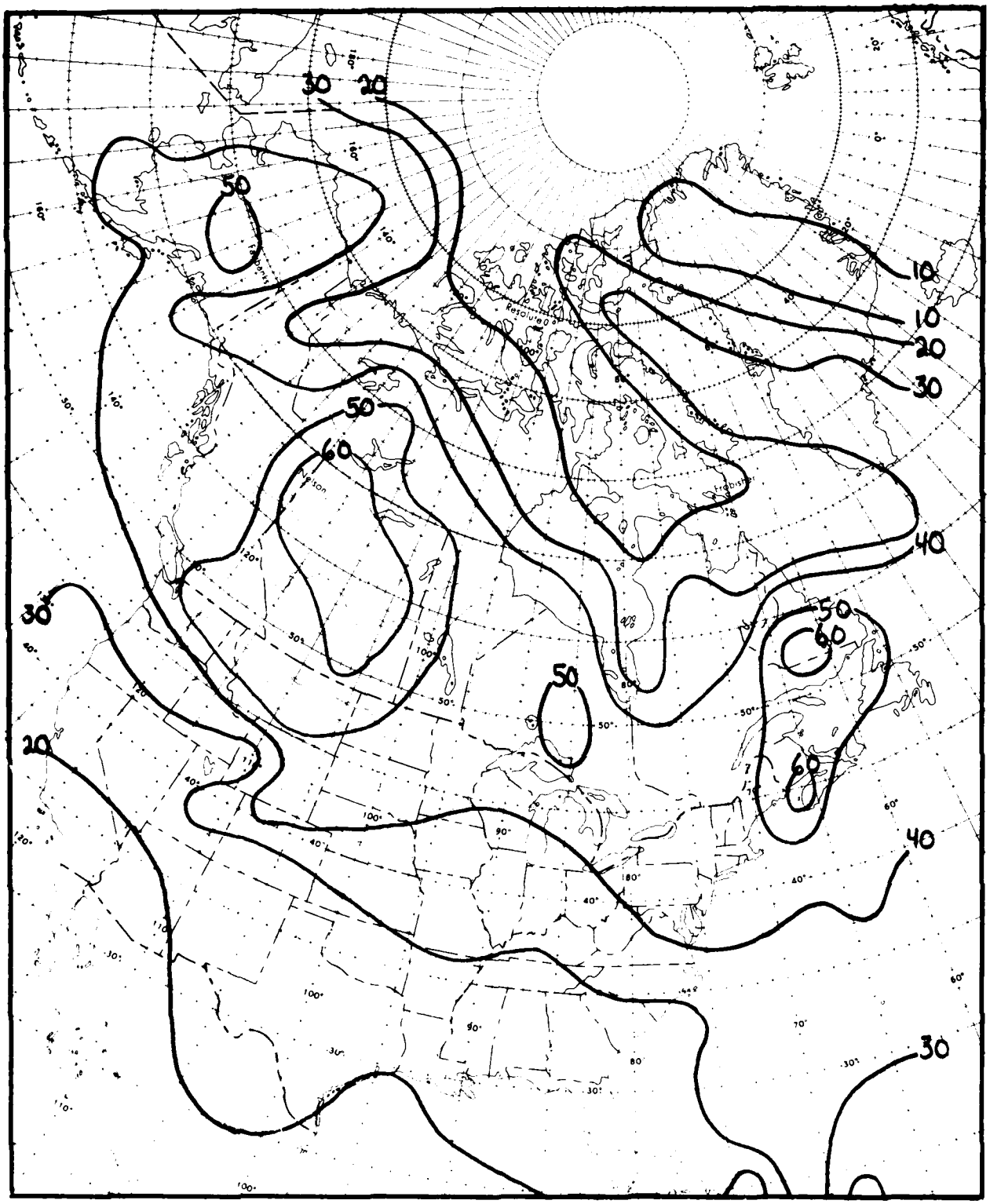

CHART 91 ANNUAL 3,049 TO 4,572 METERS, CONCENTRATION .10 G/M^3

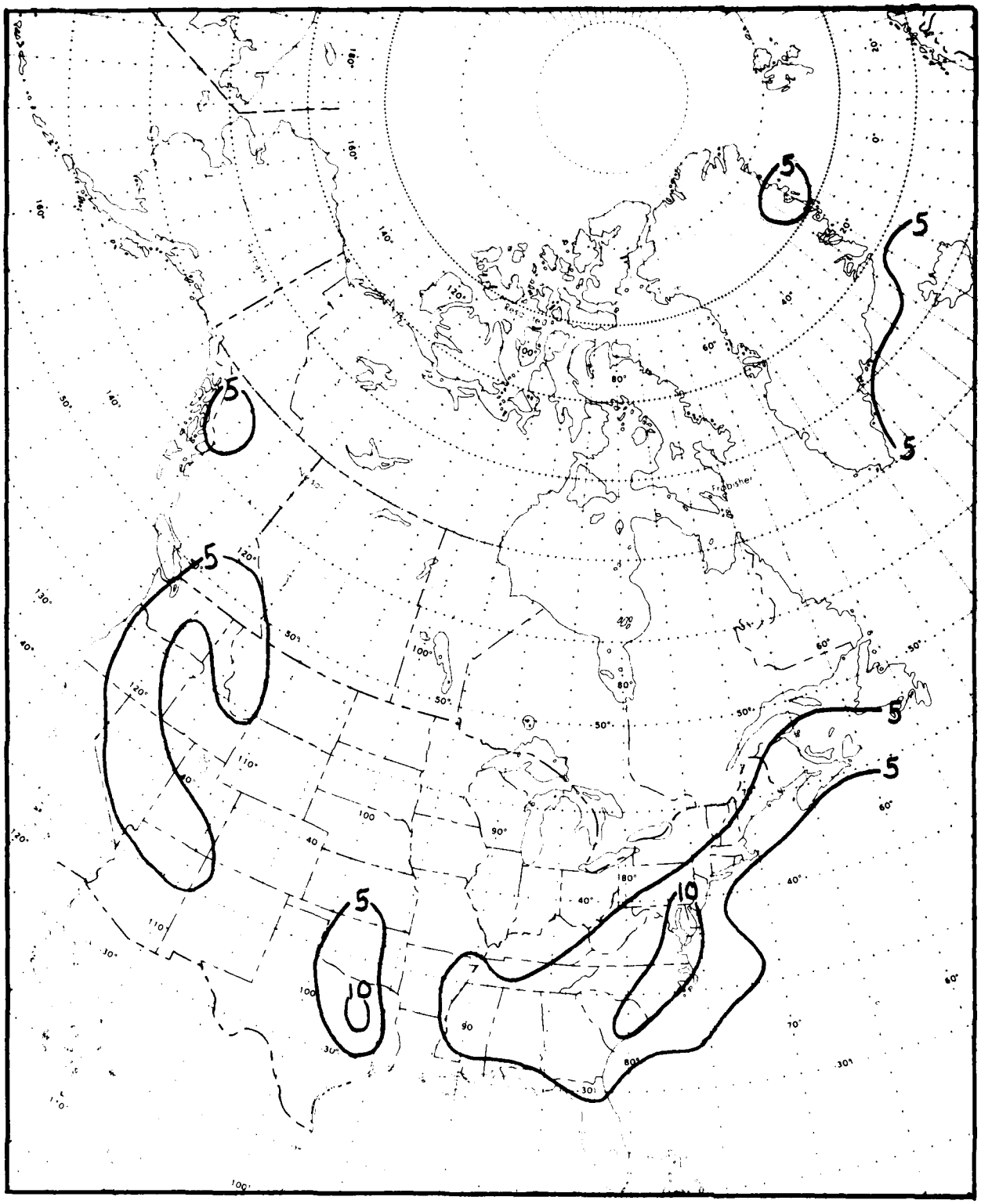

CHART 92 JANUARY 3,049 TO 4,572 METERS, CONCENTRATION .50 G/M^3

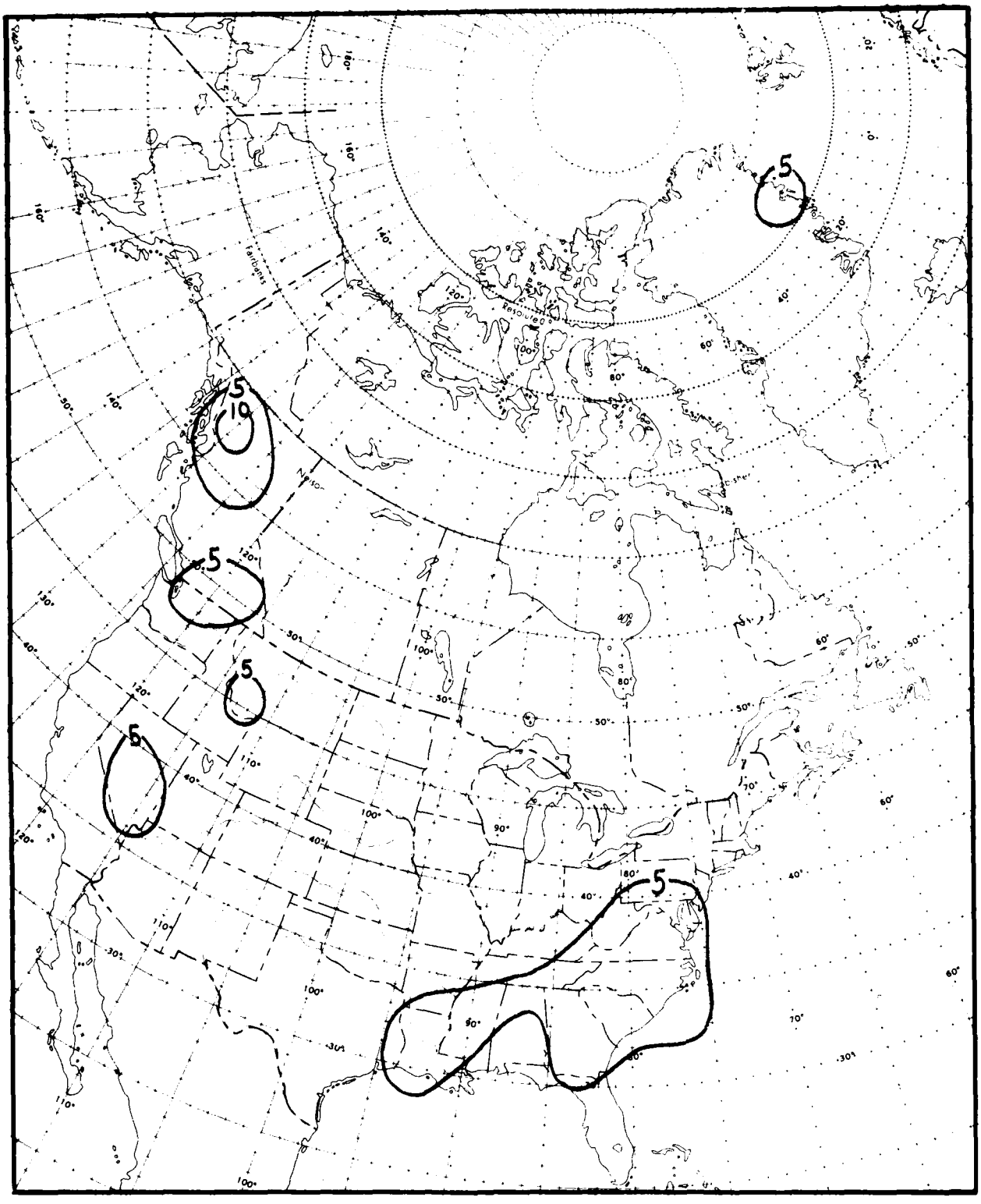

CHART 93 FEBRUARY 3,049 TO 4,572 METERS, CONCENTRATION .50 G/M^3

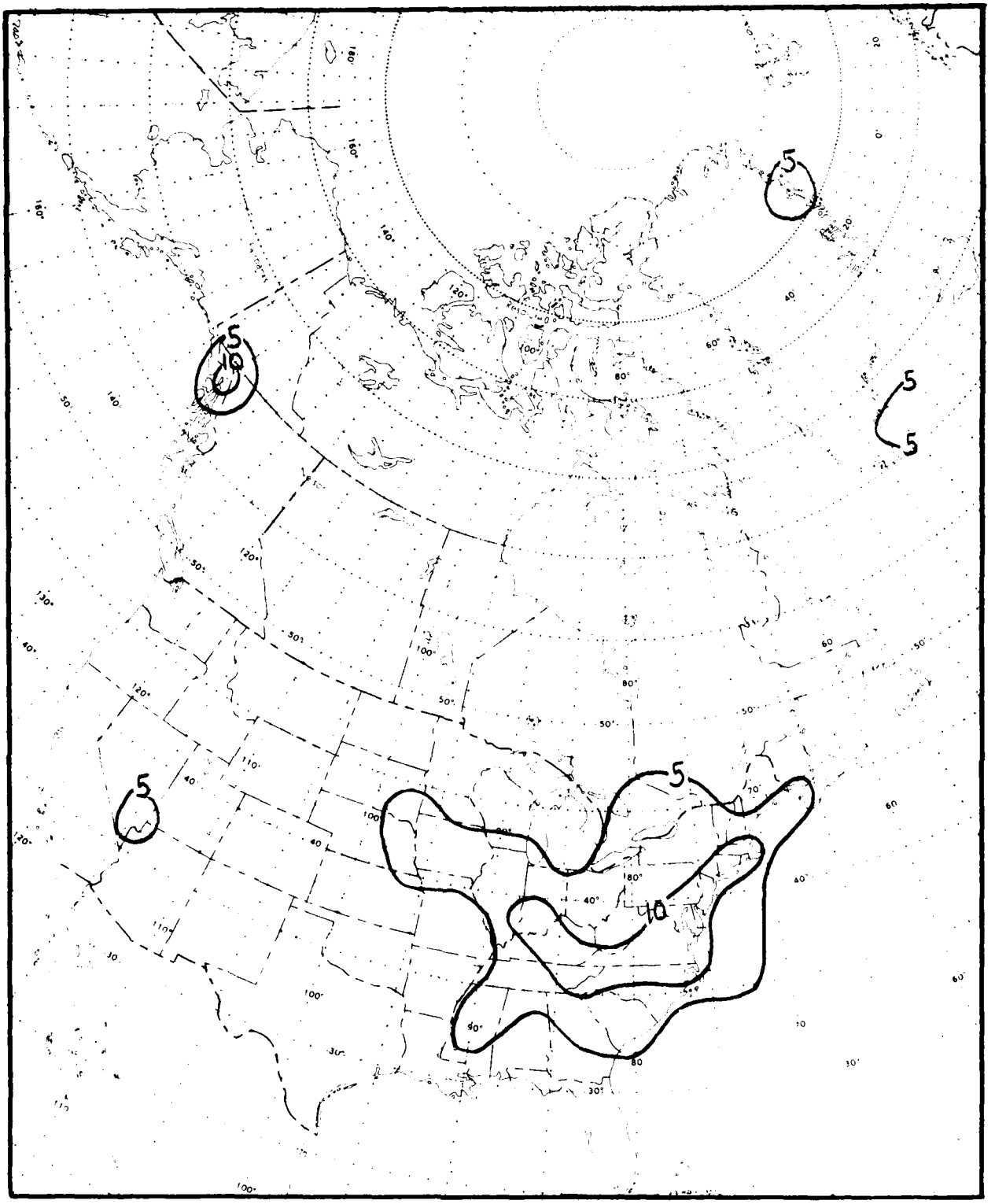

CHART 94 MARCH 3,049 TO 4,572 METERS, CONCENTRATION .50 G/M^3

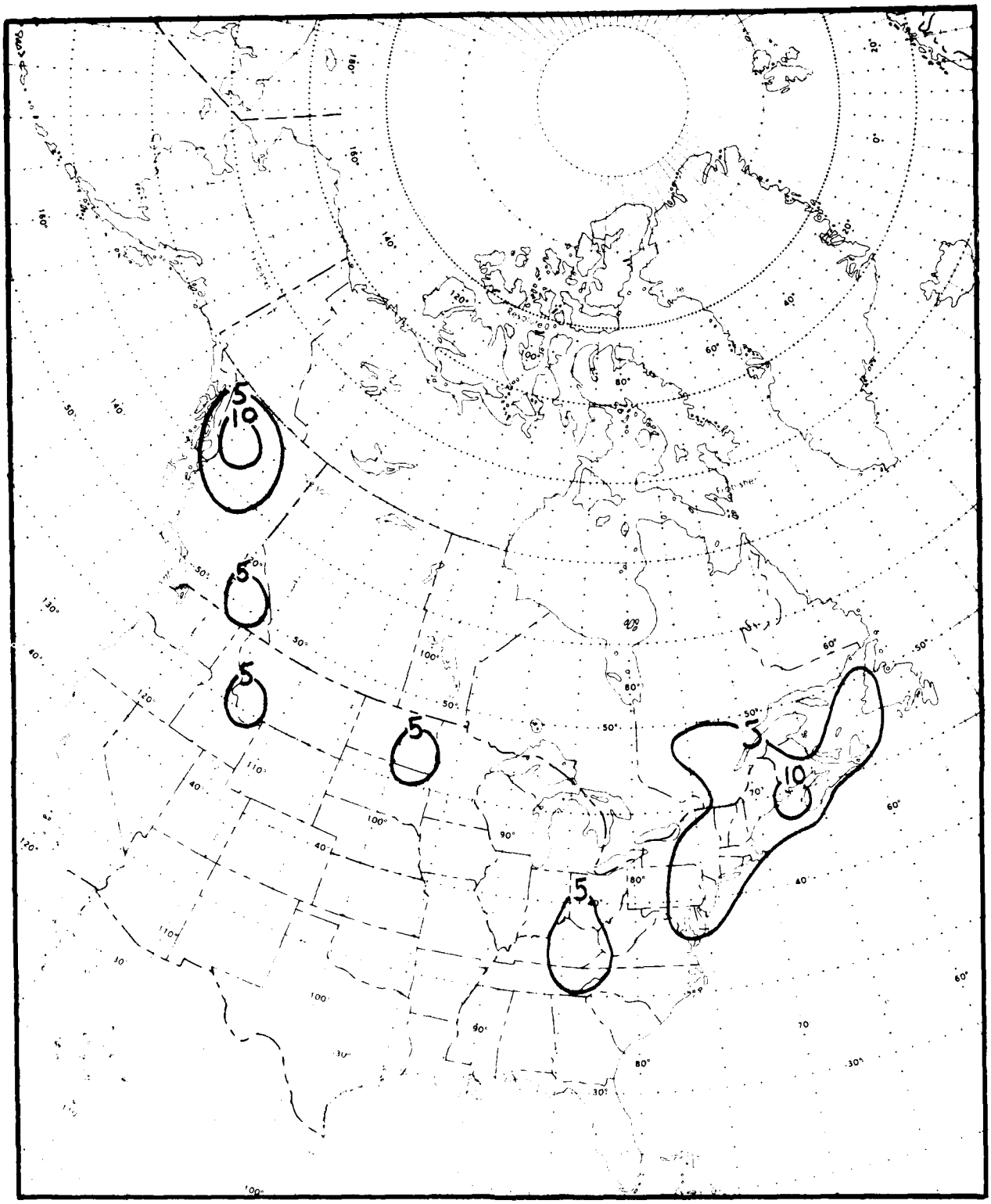

CHART 95 APRIL 3,049 TO 4,572 METERS, CONCENTRATION .50 G/M^3

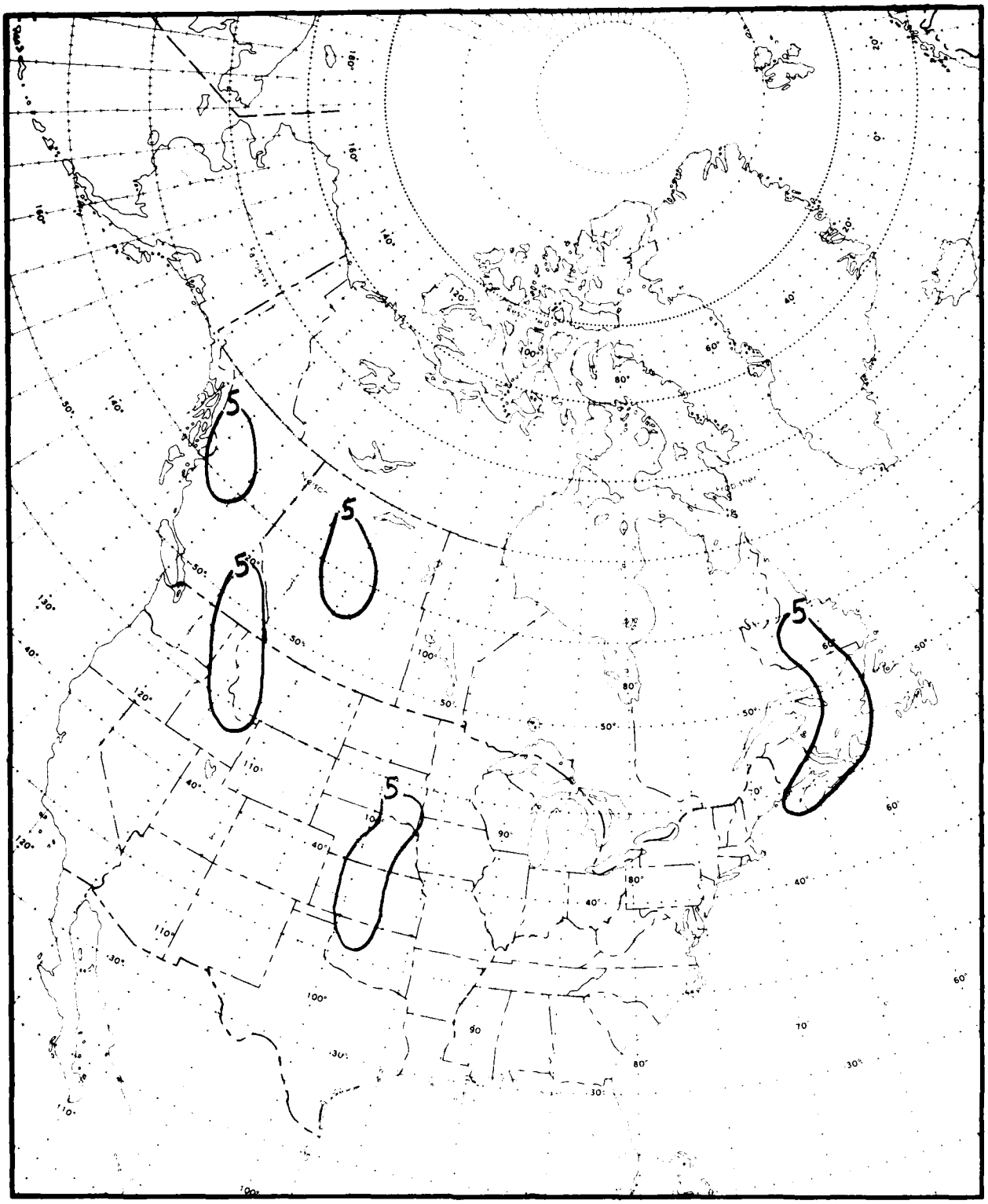

CHART 96 MAY 3,049 TO 4,572 METERS, CONCENTRATION .50 G/M^3

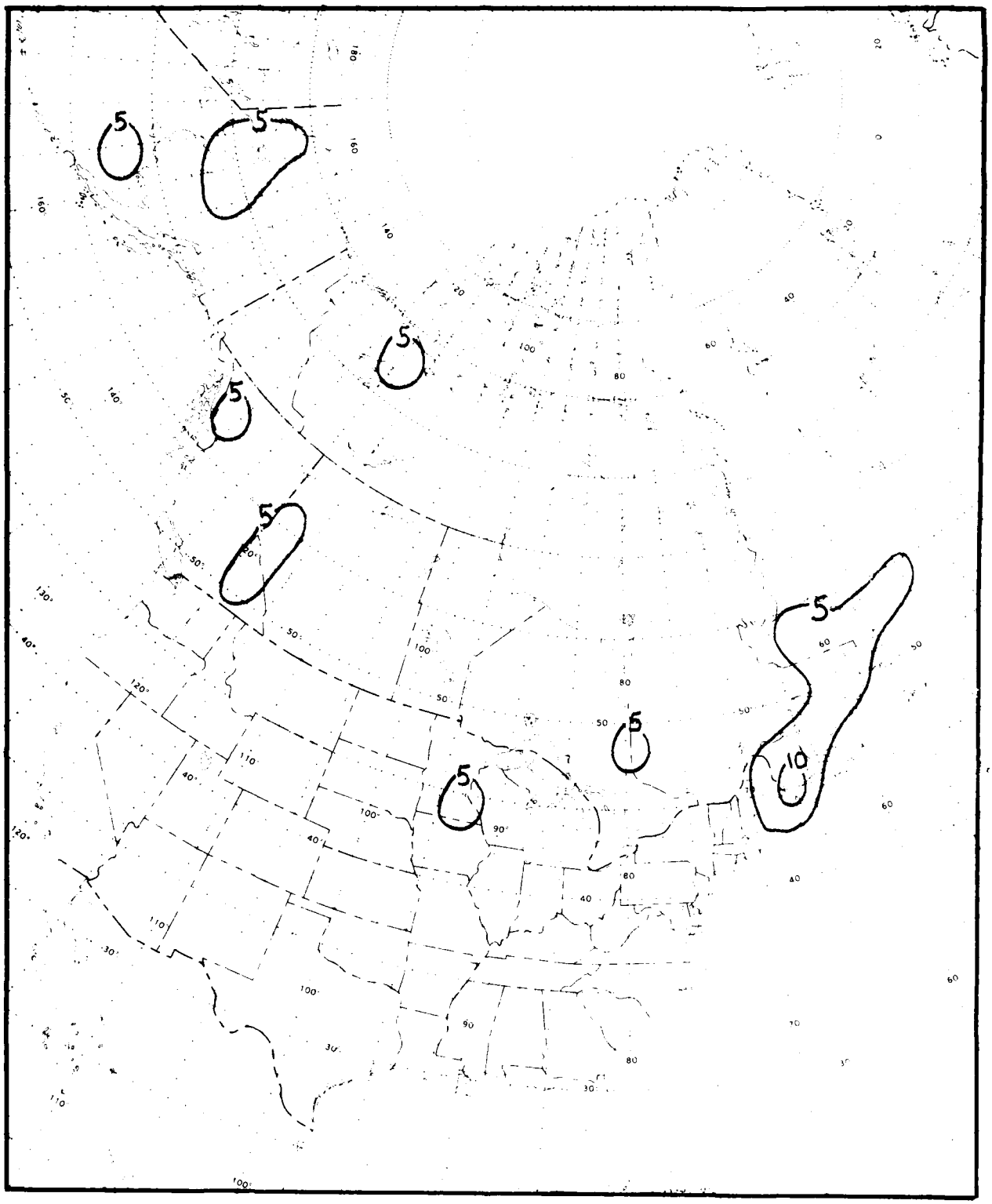

CHART 97 JUNE 3,049 TO 4,572 METERS, CONCENTRATION .50 G/M^3

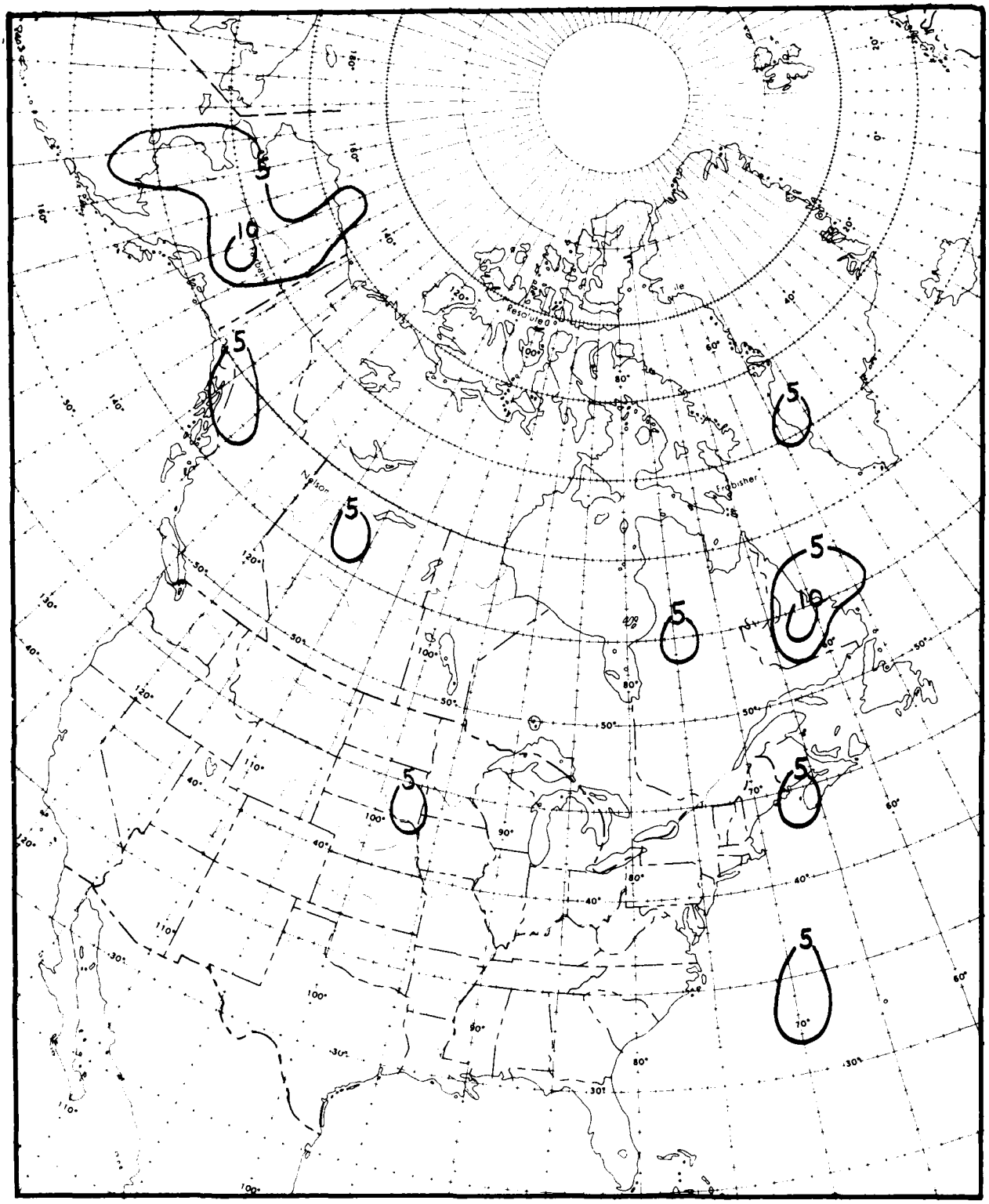

CHART 98 JULY 3,049 TO 4,572 METERS, CONCENTRATION .50 G/M^3

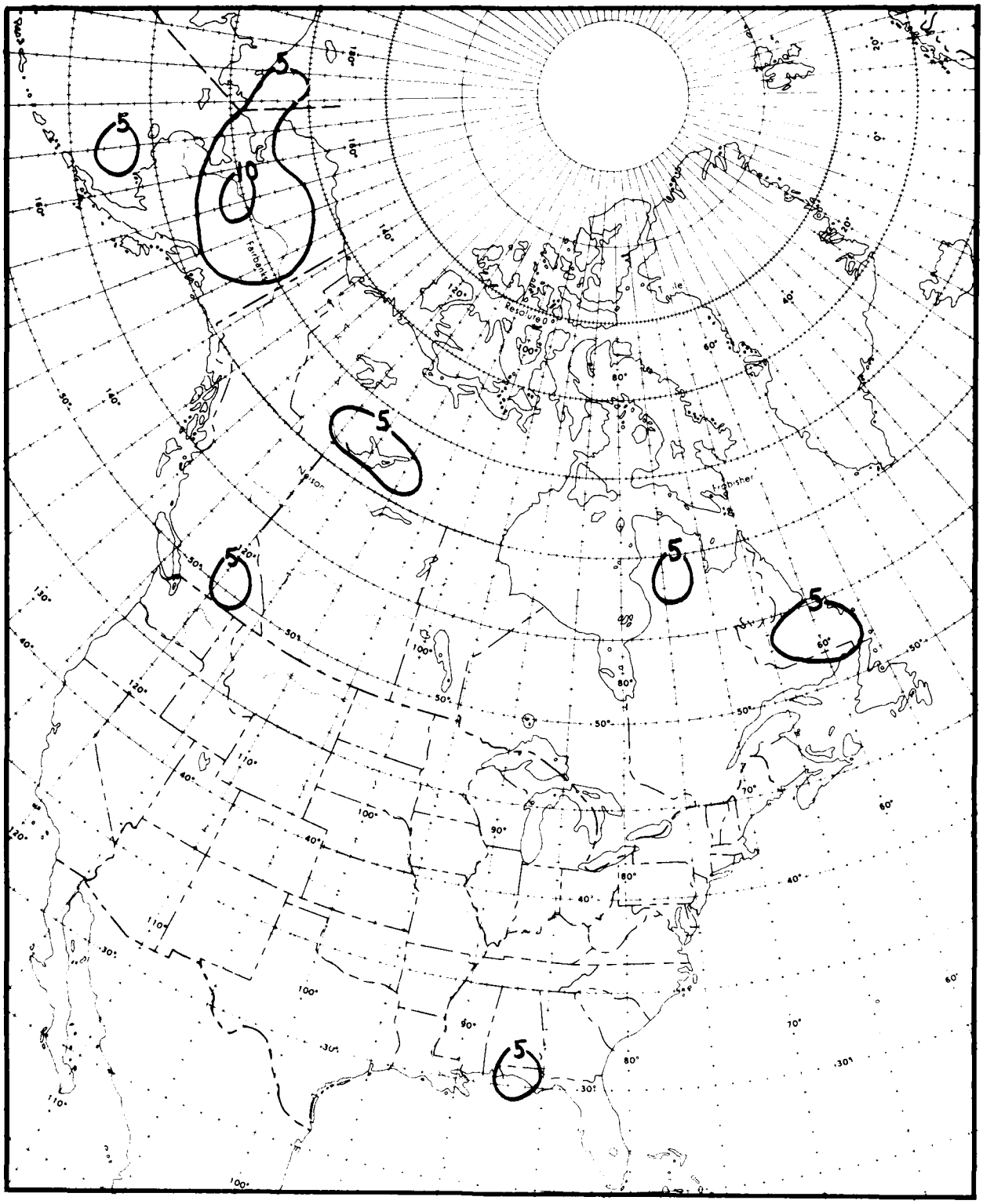

CHART 99 AUGUST 3,049 TO 4,572 METERS, CONCENTRATION .50 G/M^3

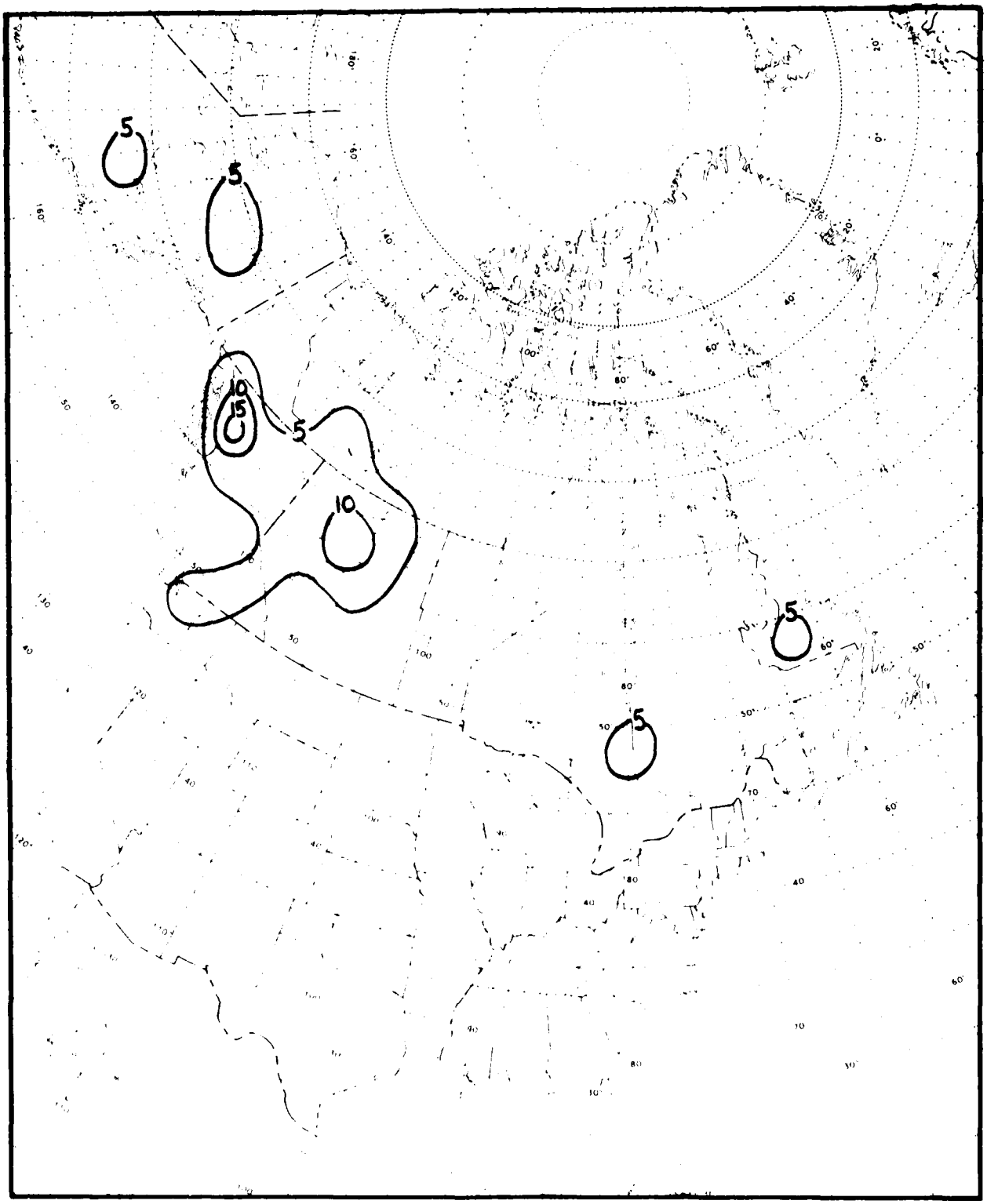

CHART 100 SEPTEMBER 3,049 TO 4,572 METERS, CONCENTRATION .50 G/M^3

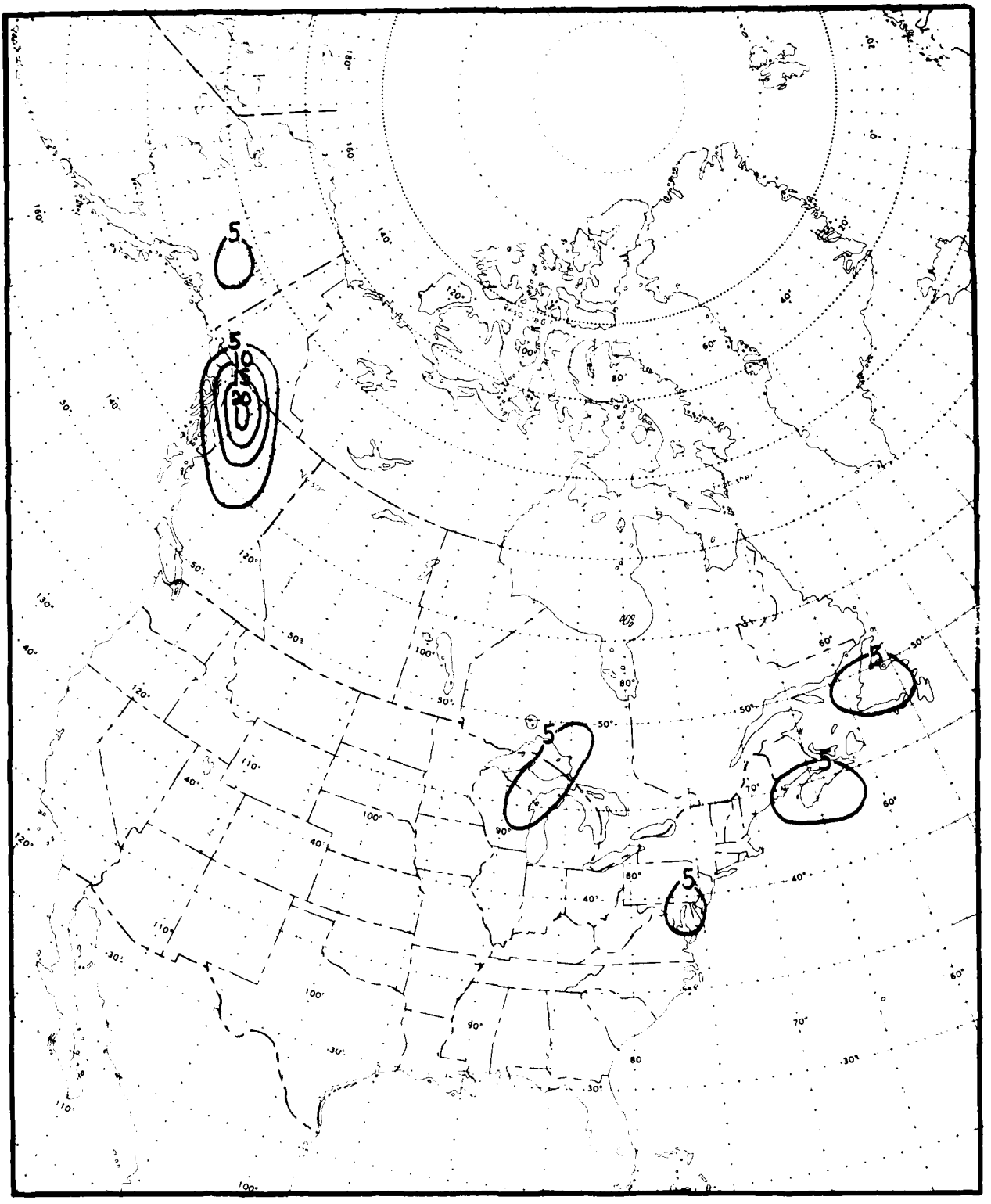

CHART 101 OCTOBER 3,049 TO 4,572 METERS, CONCENTRATION .50 G/M^3

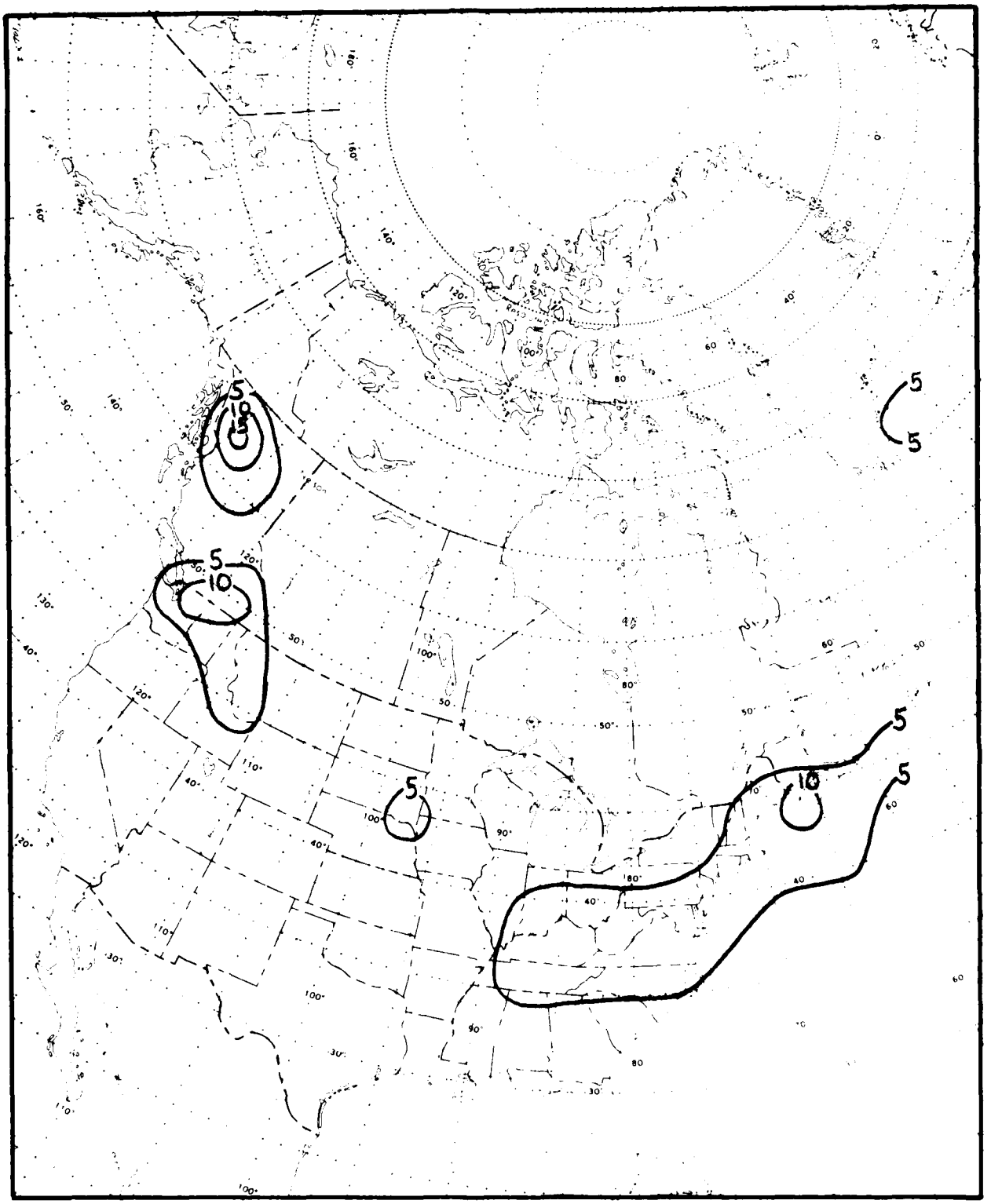

CHART 102 NOVEMBER 3,049 TO 4,572 METERS, CONCENTRATION .50 G/M^3

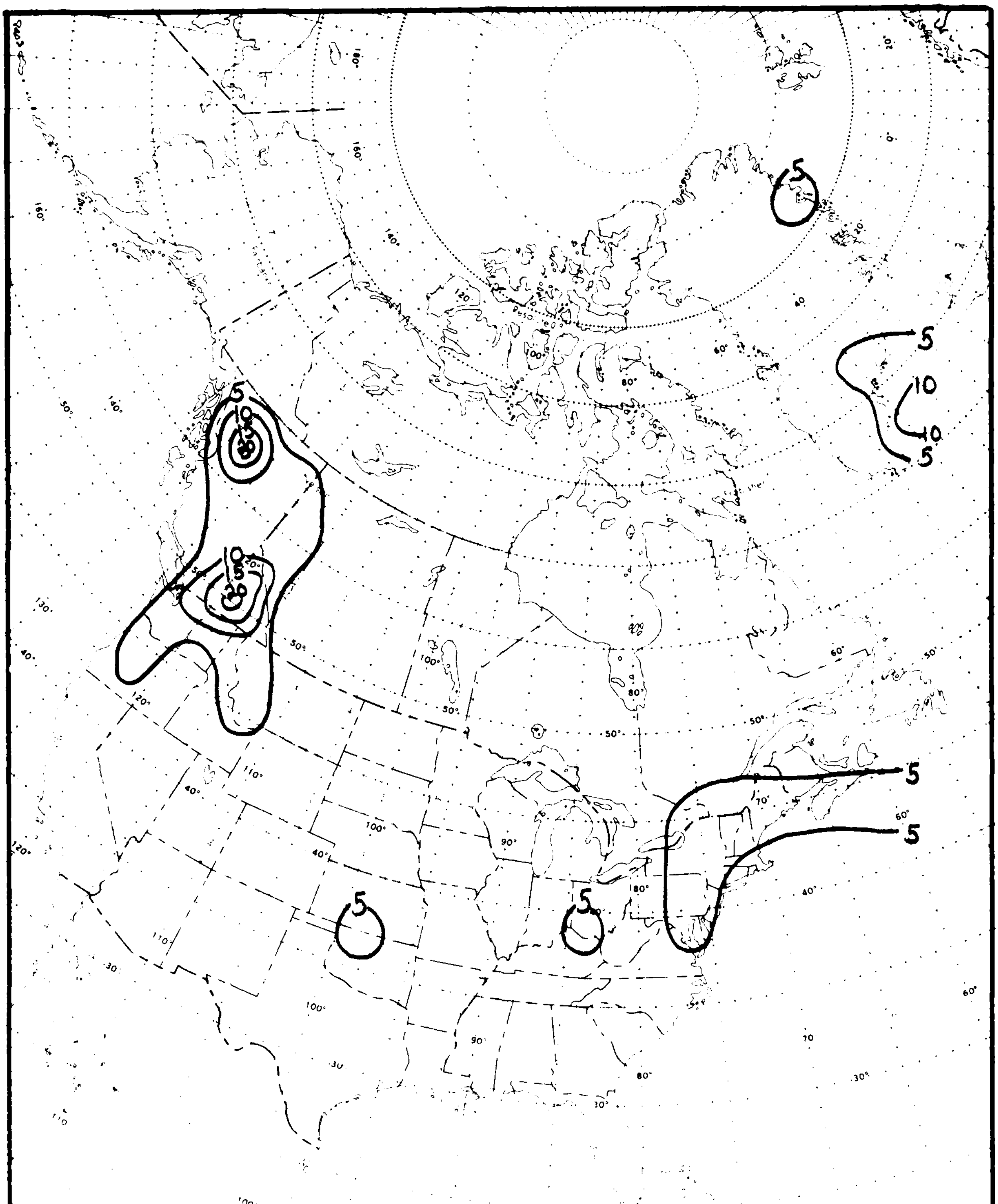

CHART 103 DECEMBER 3,049 TO 4,572 METERS, CONCENTRATION .50 G/M^3

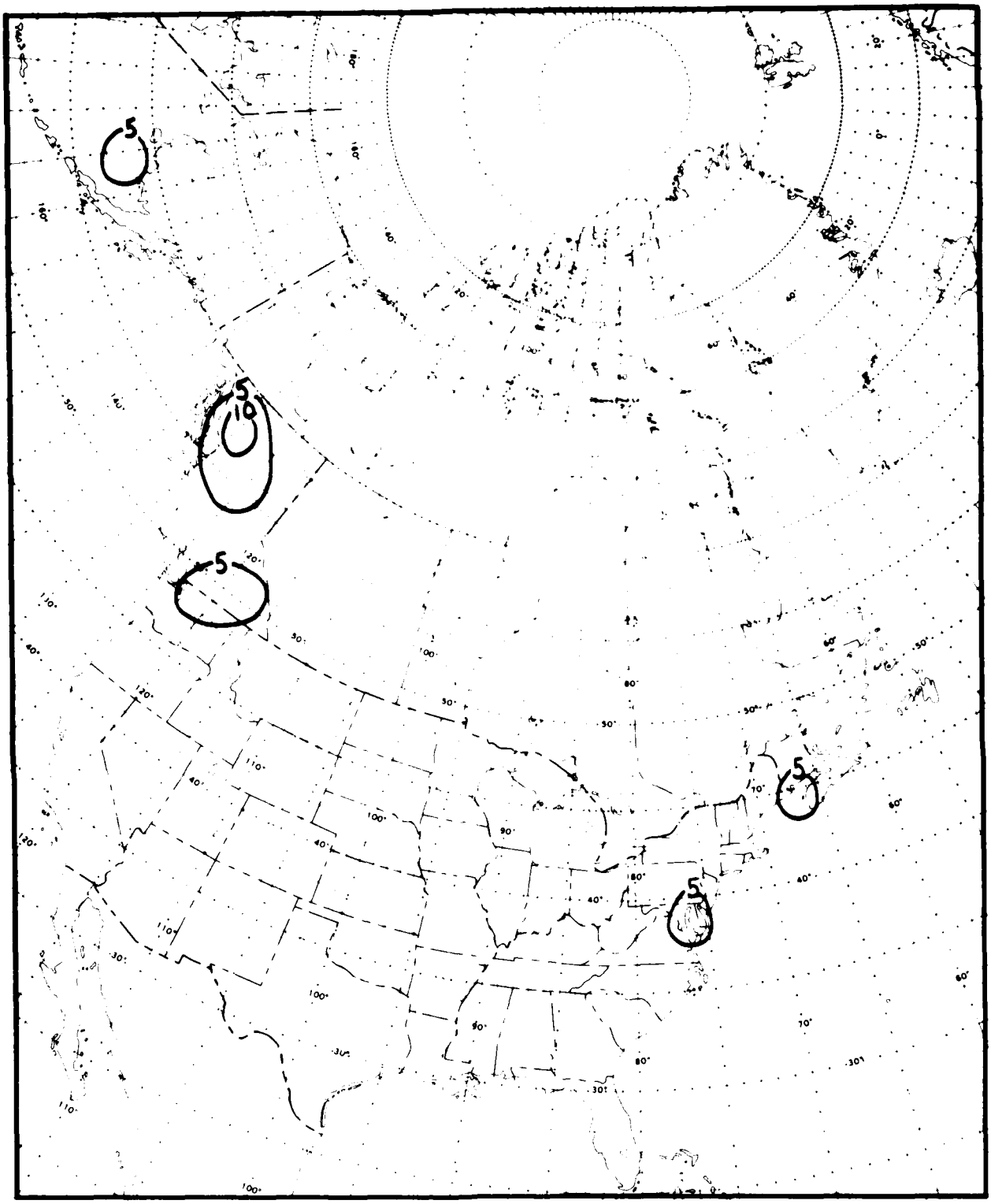

CHART 104 ANNUAL 3,049 TO 4,572 METERS, CONCENTRATION .50 G/M^3

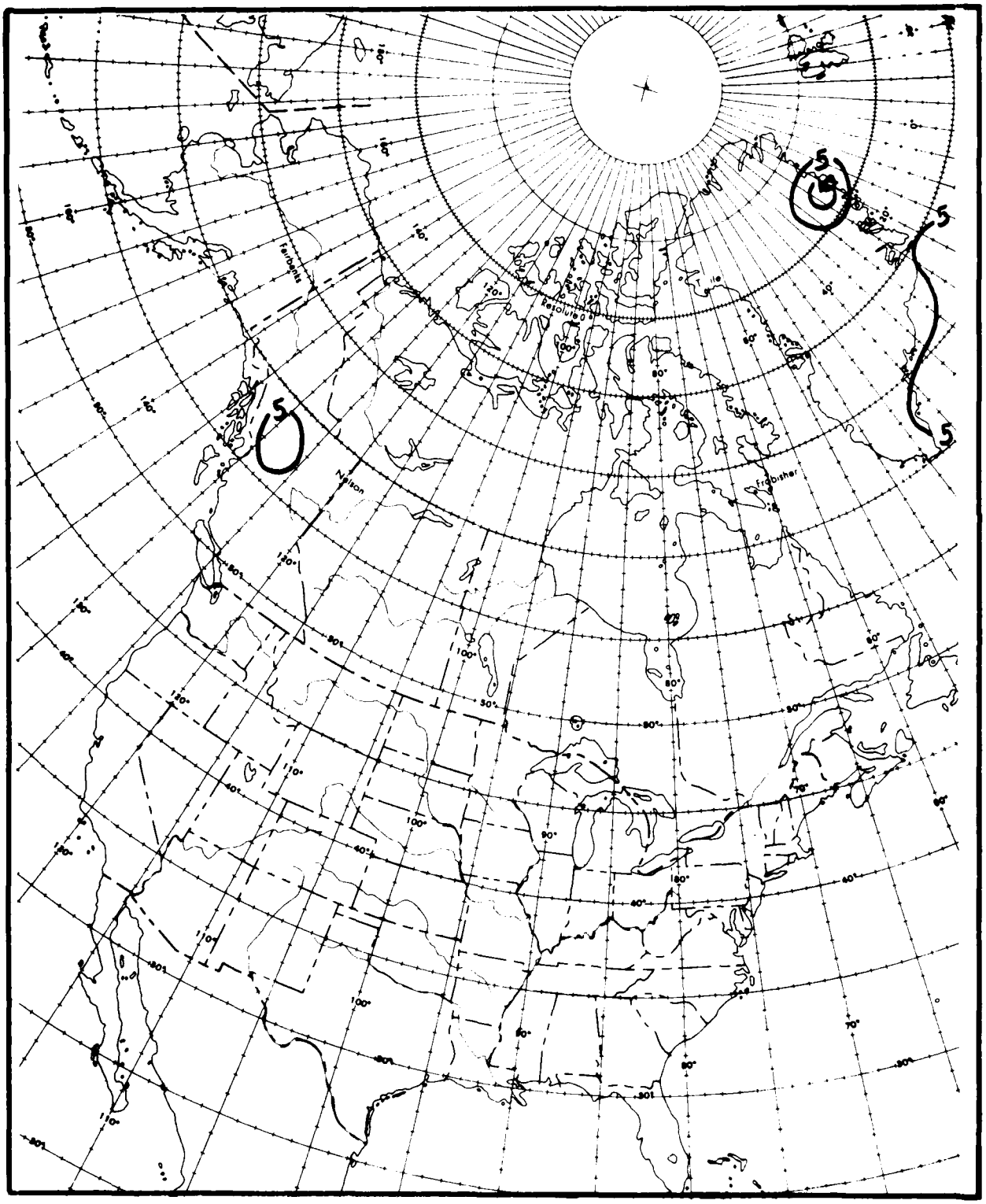

CHART 105 JANUARY 3,049 TO 4,572 METERS, CONCENTRATION 1.00 G/M^3

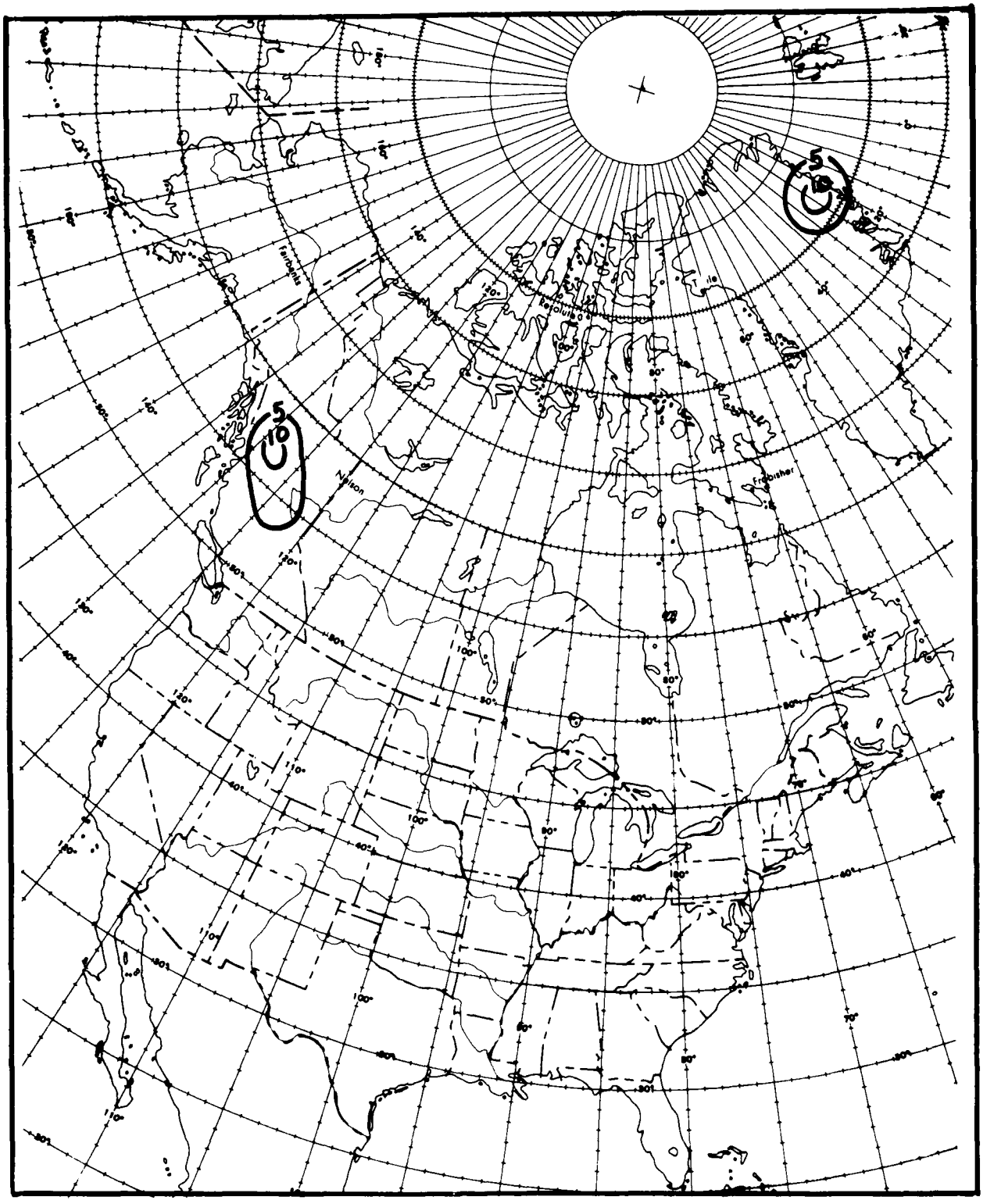

CHART 106 FEBRUARY 3,049 TO 4,572 METERS, CONCENTRATION 1.00 G/M^3

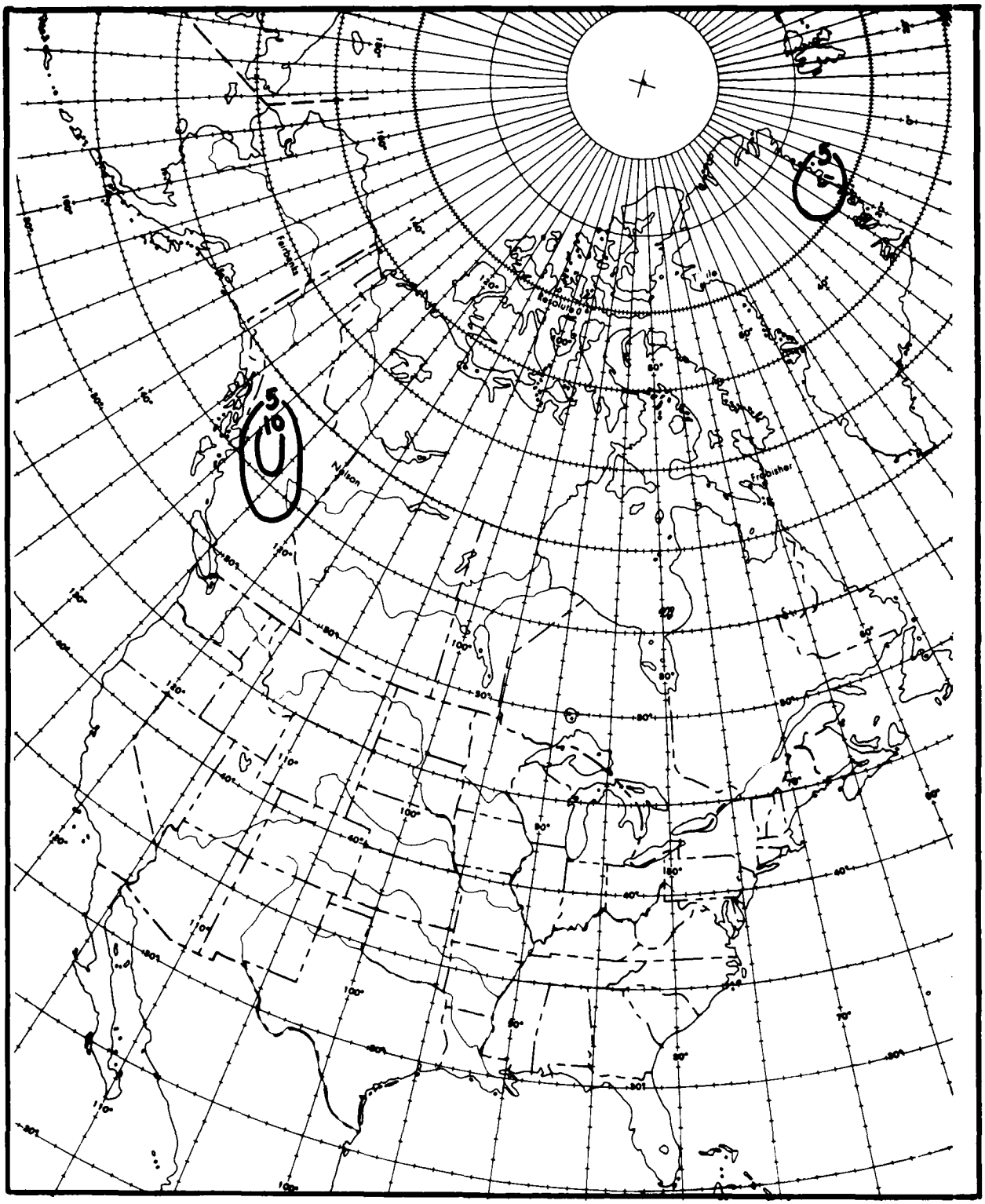

CHART 107 MARCH 3,049 TO 4,572 METERS, CONCENTRATION 1.00 G/M^3

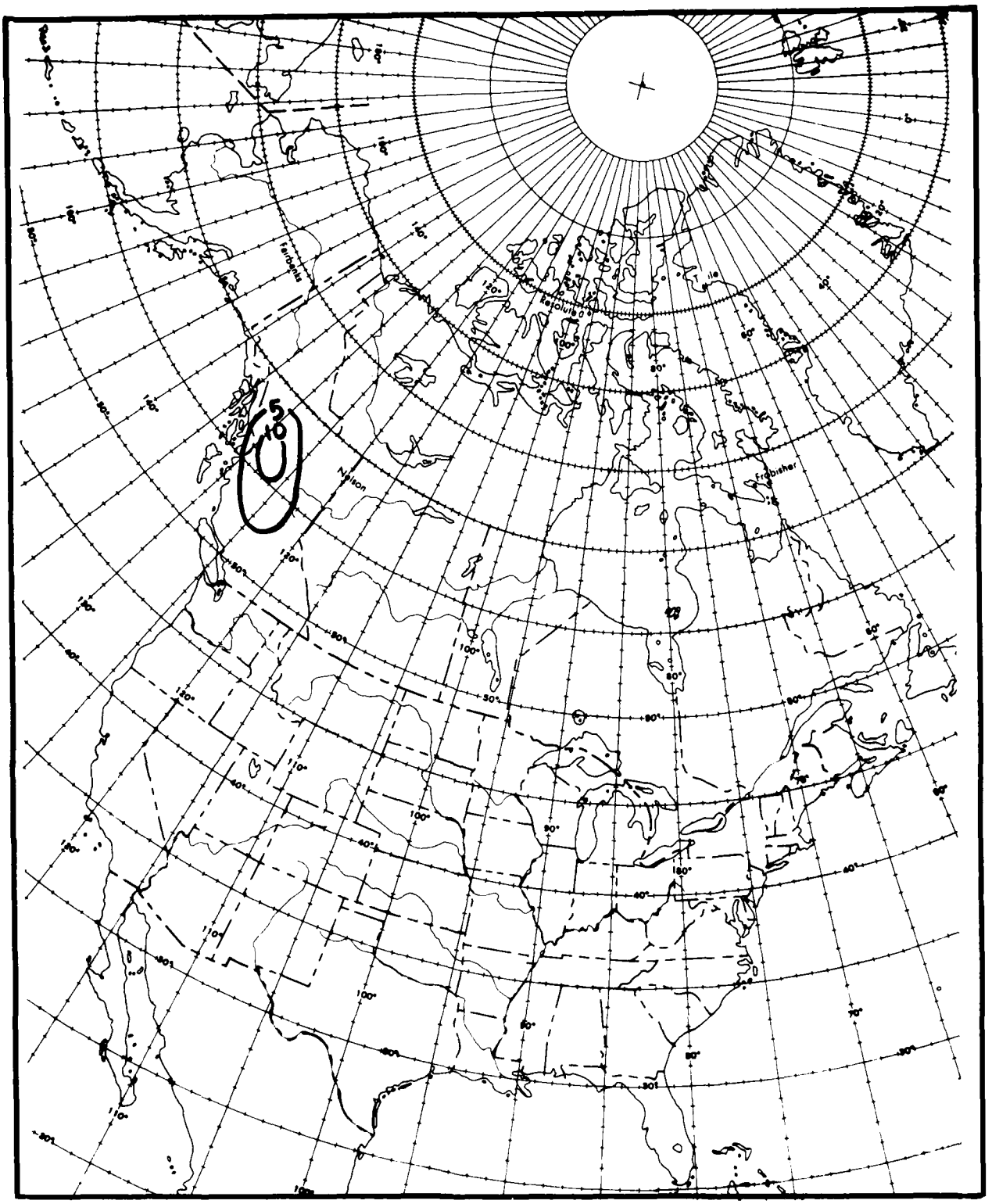

CHART 108 APRIL 3,049 TO 4,572 METERS, CONCENTRATION 1.00 G/M^3

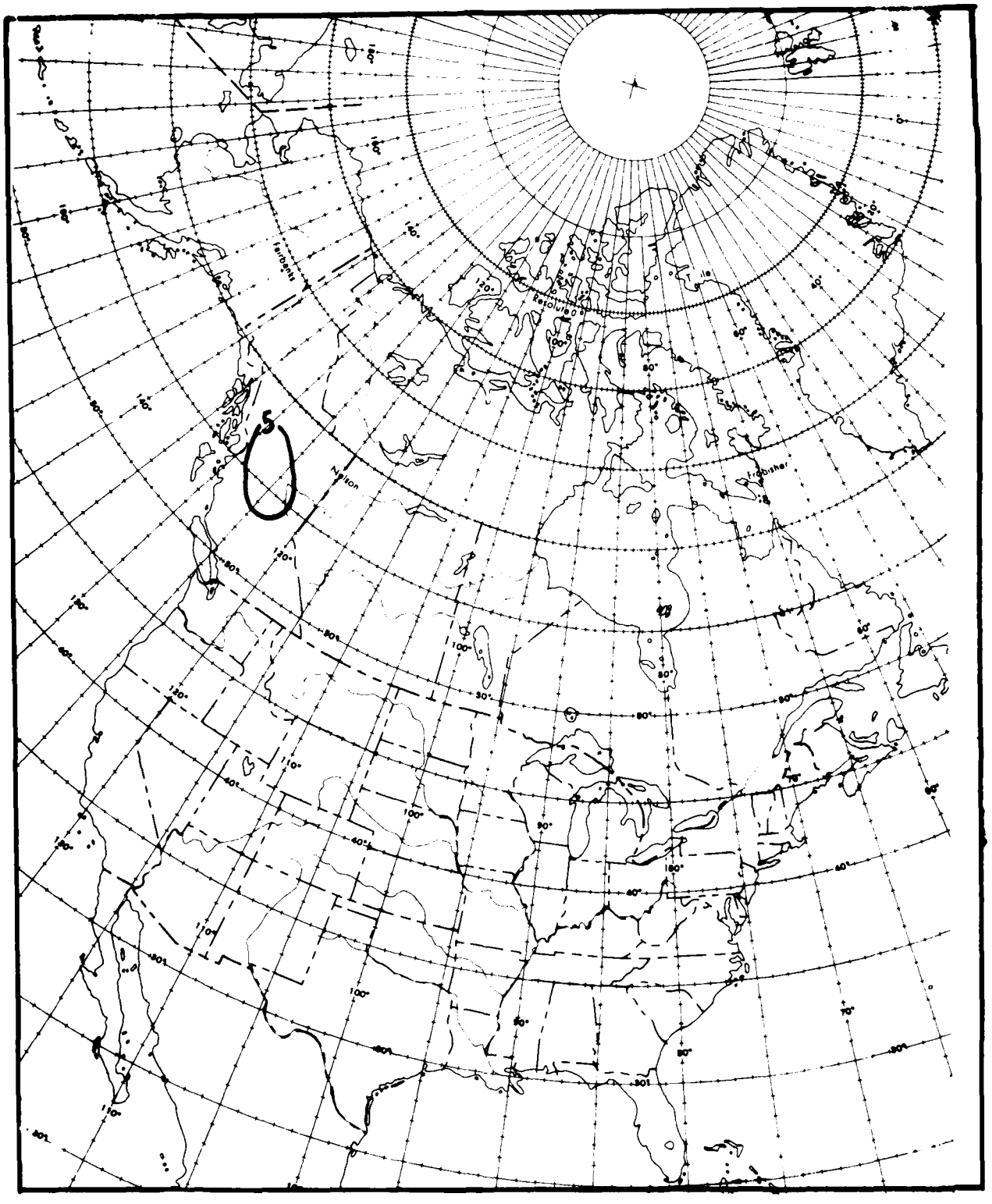

CHART 109 MAY 3,049 TO 4,572 METERS, CONCENTRATION 1.00 G/M^3

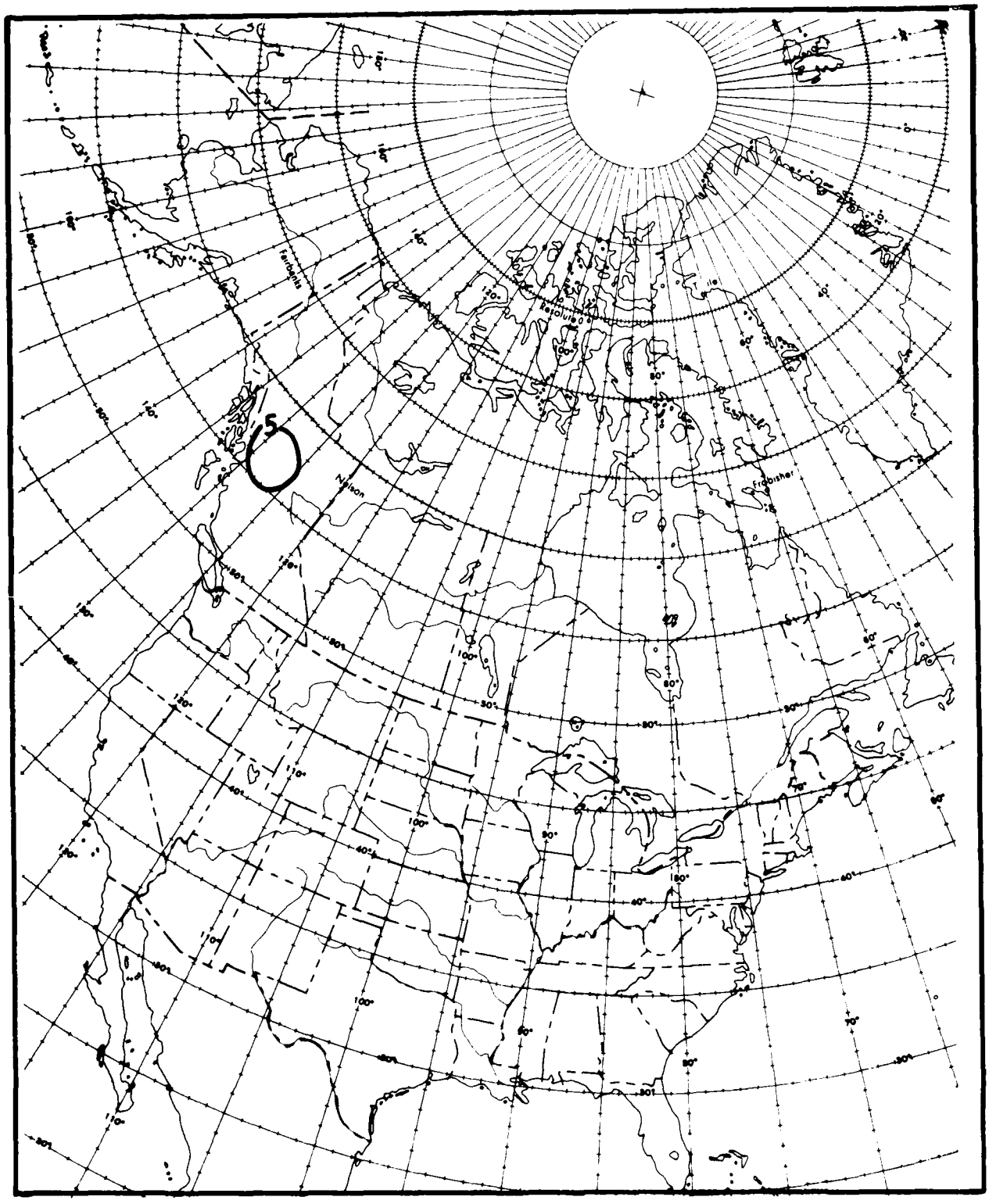

CHART 110 JUNE 3,049 TO 4,572 METERS, CONCENTRATION 1.00 G/M^3

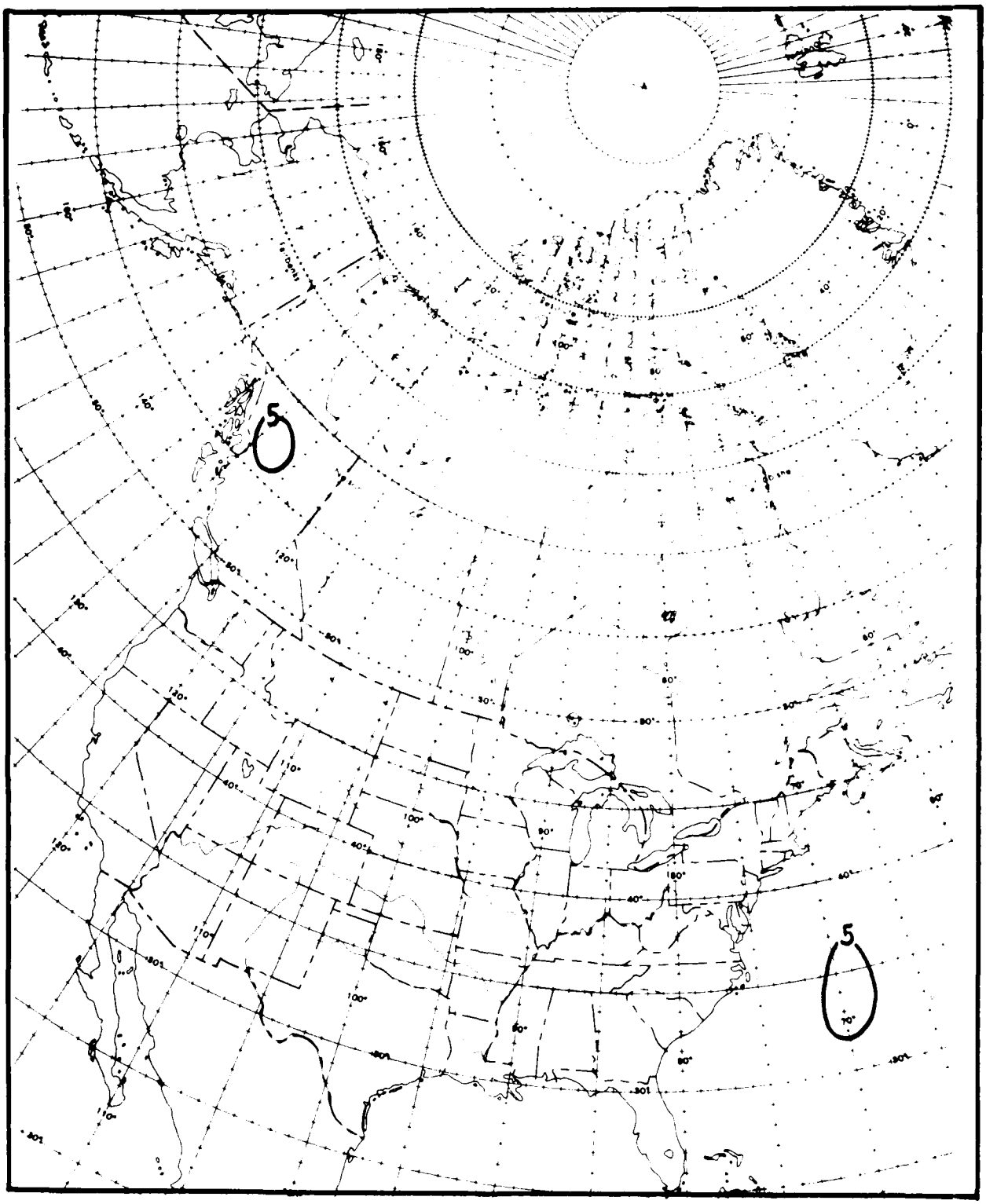

CHART 111 JULY 3,049 TO 4,572 METERS, CONCENTRATION 1.00 G/M^3

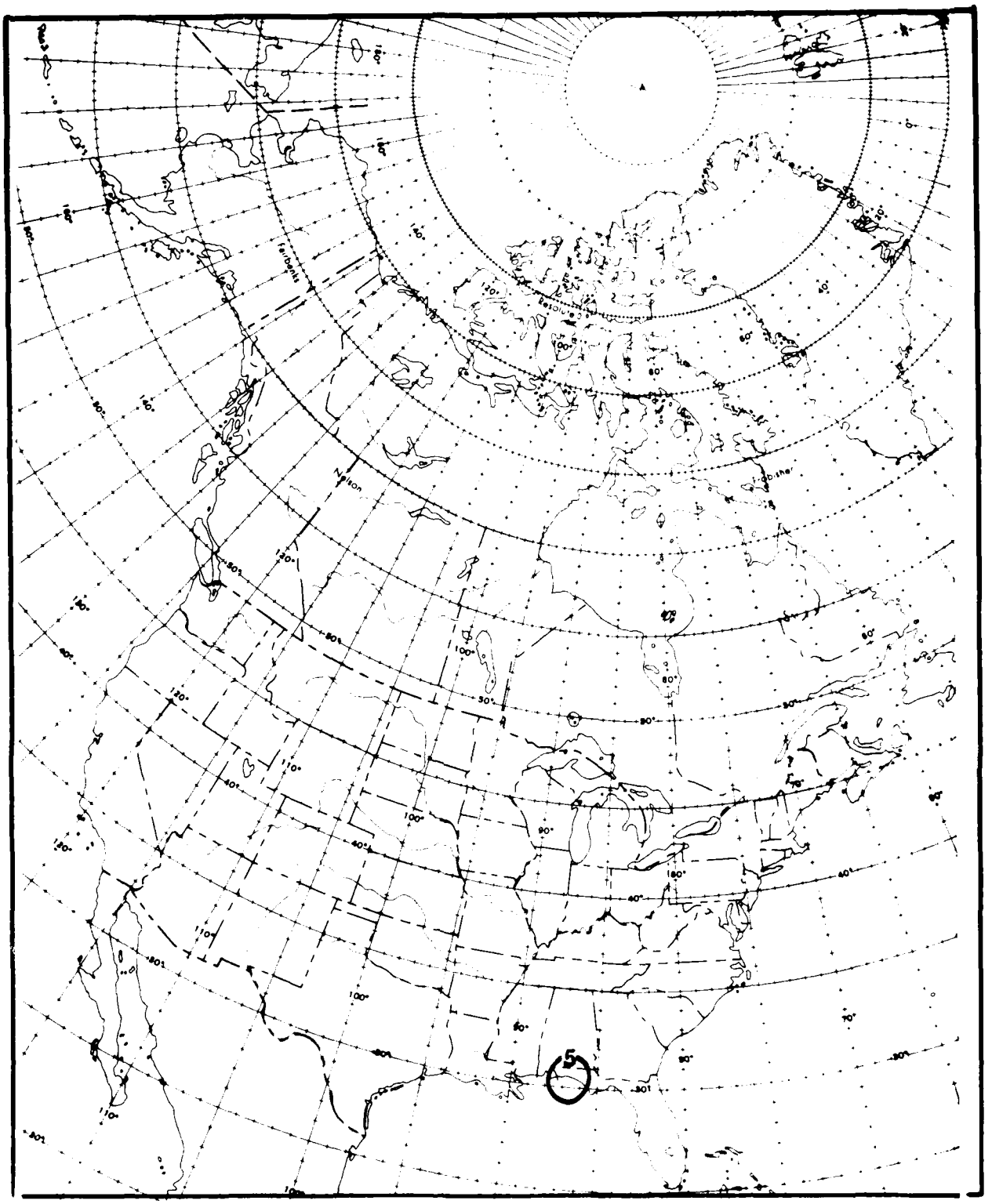

CHART 112 AUGUST 3,049 TO 4,572 METERS, CONCENTRATION 1.00 G/M^3

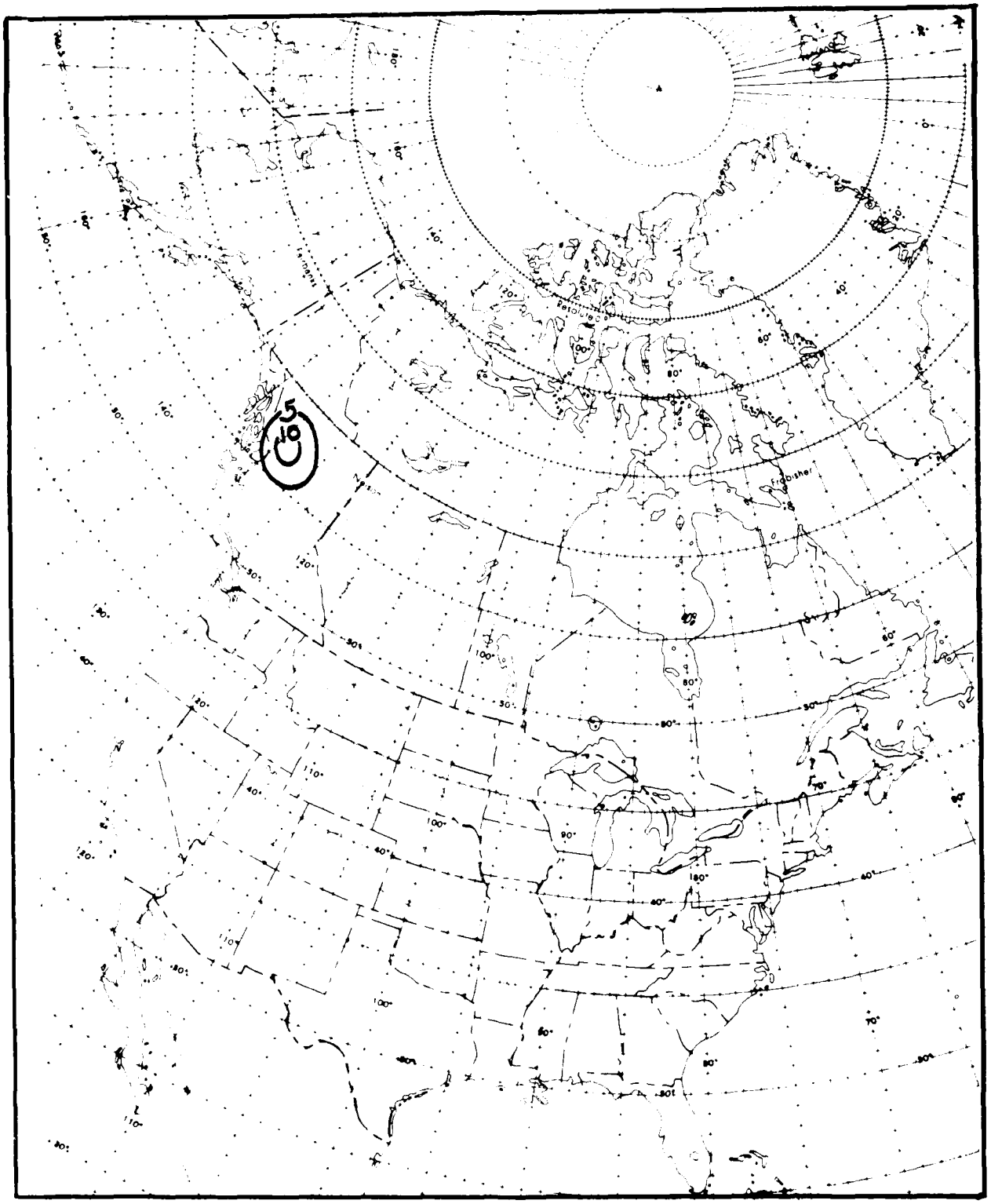

CHART 113 SEPTEMBER 3,049 TO 4,572 METERS, CONCENTRATION 1.00 G/M^3

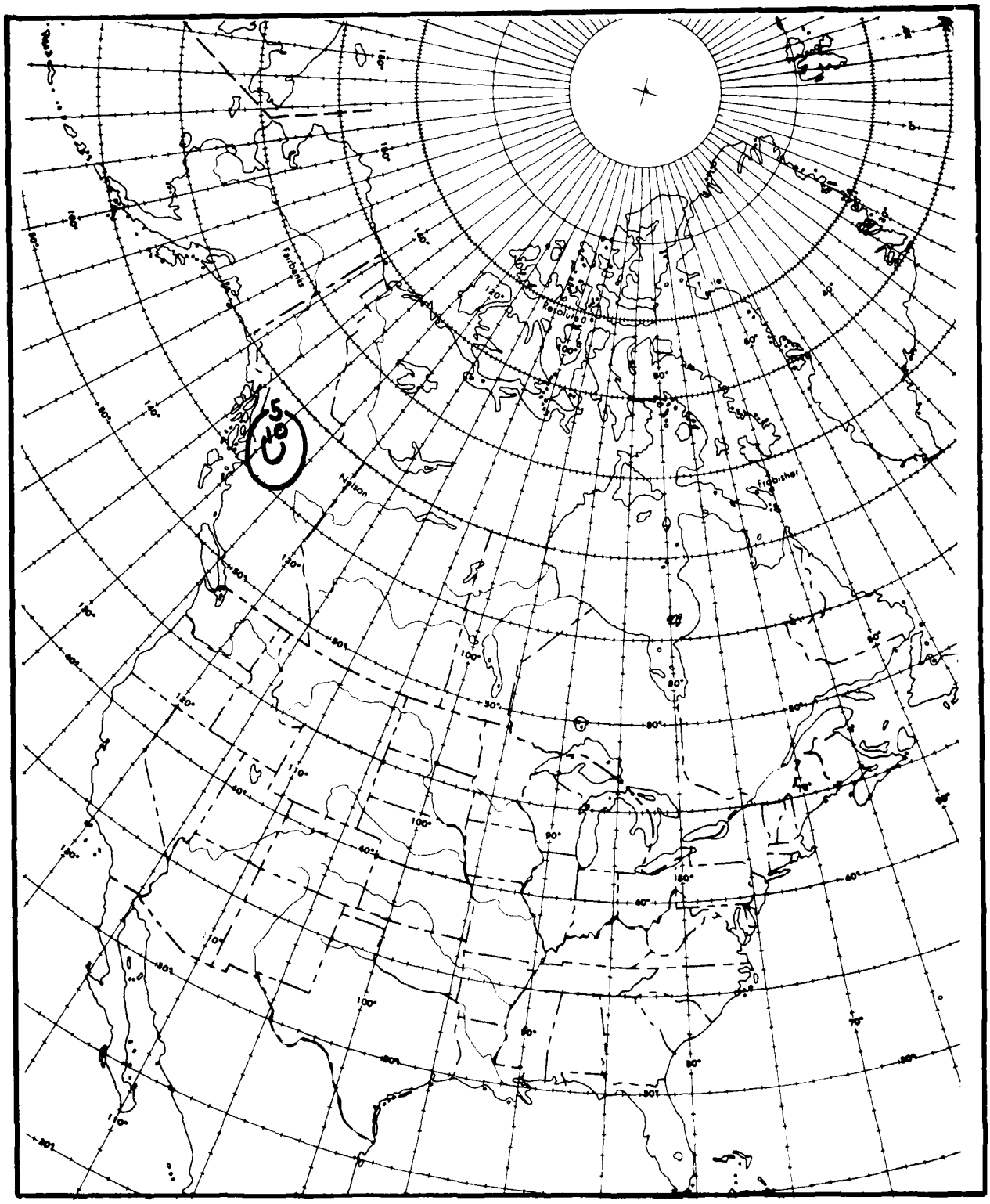

CHART 114 OCTOBER 3,049 TO 4,572 METERS, CONCENTRATION 1.00 G/M^3

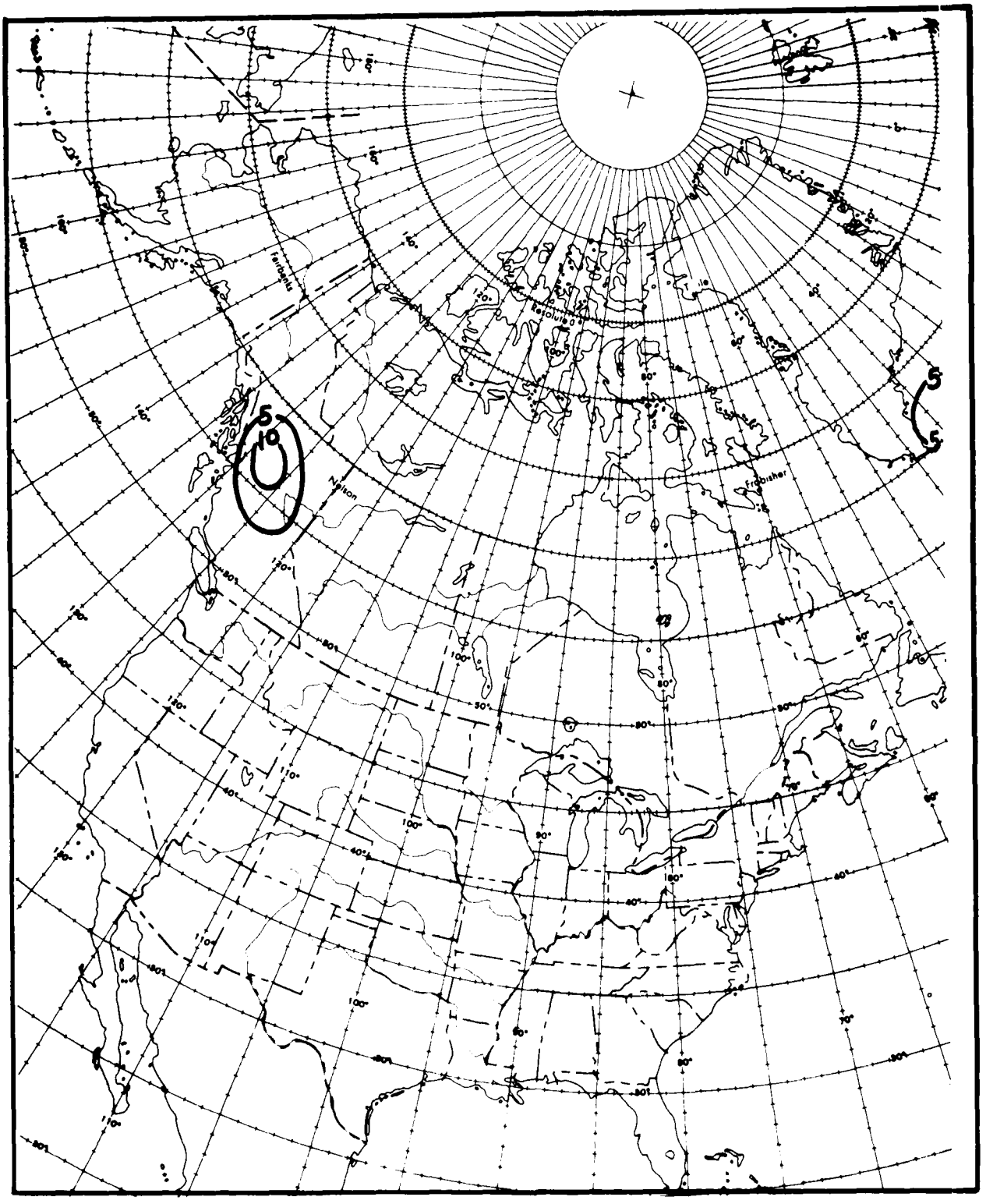

CHART 115 NOVEMBER 3,049 TO 4,572 METERS, CONCENTRATION 1.00 G/M^3

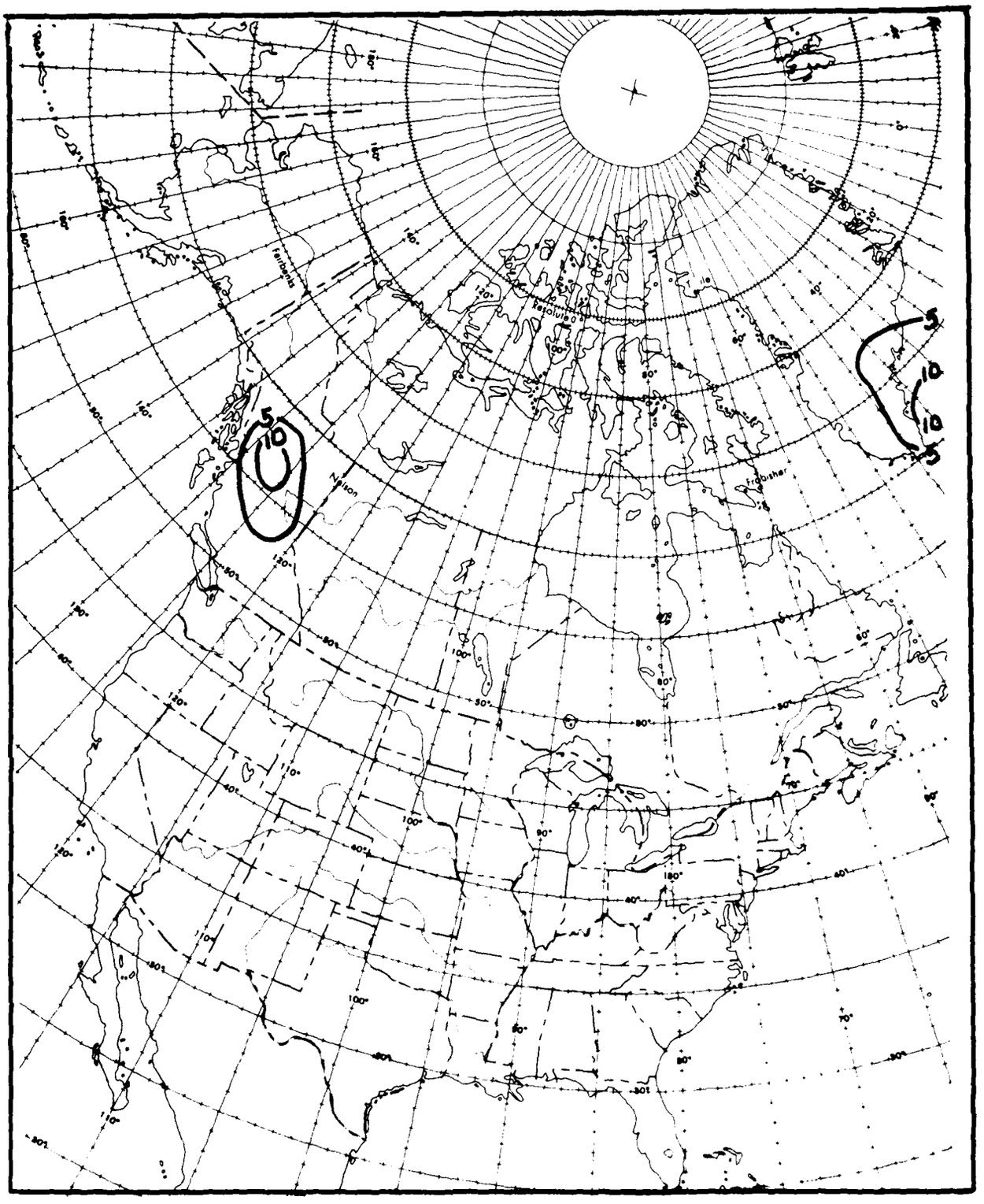

CHART 116 DECEMBER 3,049 TO 4,572 METERS, CONCENTRATION 1.00 G/M^3

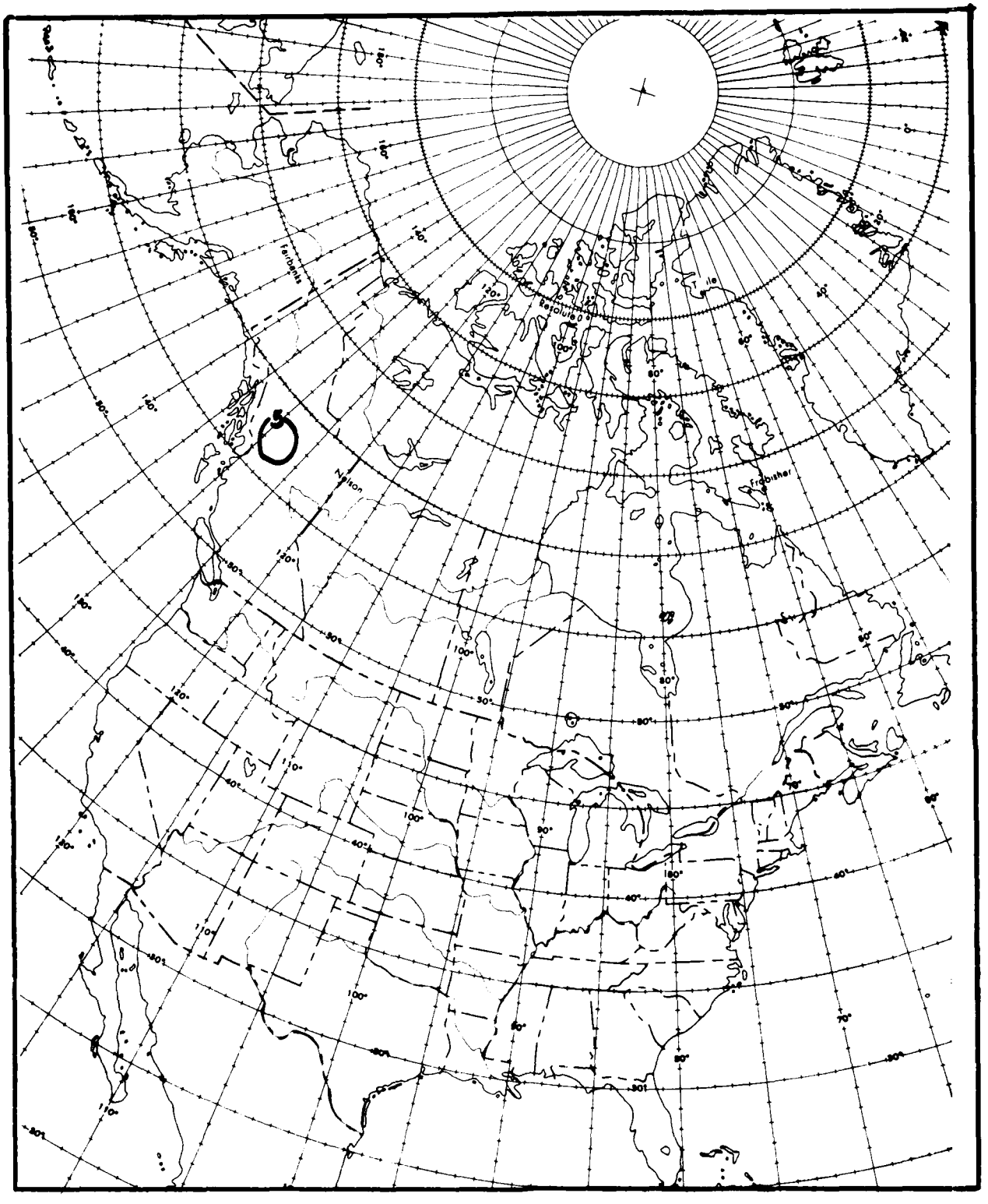

CHART 117 ANNUAL 3,049 TO 4,572 METERS, CONCENTRATION 1.00 G/M^3

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