MCGILL UNIVERSITY

A STUDY ON THE SYNOPTIC CLIMATOLOGY OF BAFFIN ISLAND, NORTHWEST TERRITÔRIES

by

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ABSTRACT

The object of this paper is to describe and enlarge upon the climate of Baffin Island, N.W.T., and to relate these features to the overall flow pattern across the area. A brief description of the Island and its observing network, including a short historical summary, are outlined in Chapter I. Climatic controls are dealt with early in the study and some hitherto unpublished information on pressure distribution, cyclonic tracks, and the life cycle of disturbances migrating across the Island are provided. An attempt is made to explain local weather peculiarities which frequently occur at noted stations by referring to particular examples showing characteristic synoptic situations and their effects. Finally, a general summary of the thesis is outlined in the conclusion.

In all, the study attempts to embellish, collate, and synthesize all climatic and synoptic parameters in order to present a more unified and coherent whole and thus contribute to a better understanding of meteorological processes affecting this remote and barren region.

ACKNOWLEDGEMENTS

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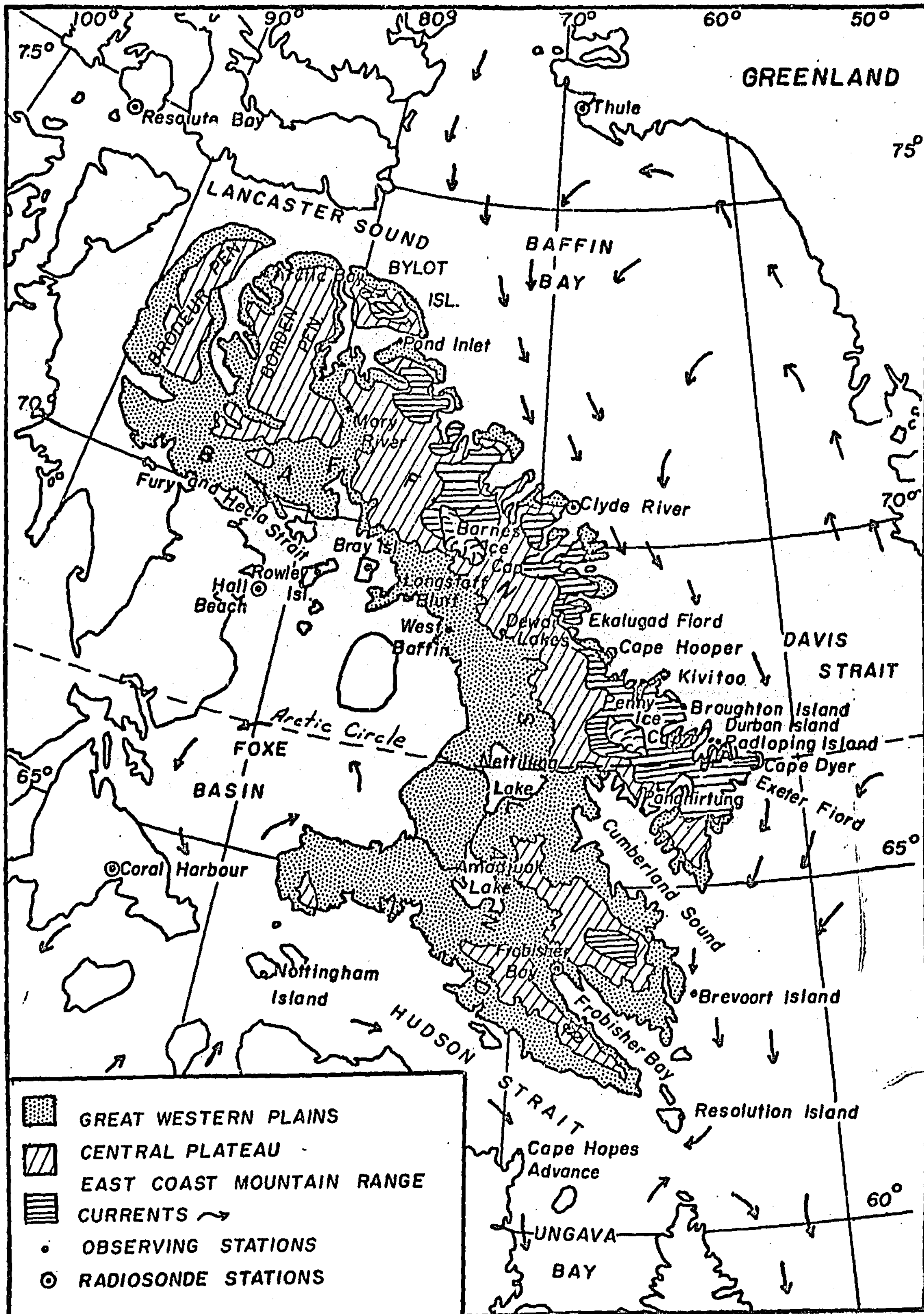

Baffin Island, N.W.T.

CHAPTER I. INTRODUCTION

A. The Physiography of Baffin Island

Baffin Island, with its formidable mountain range, extensive plain areas and fiorded coastline, is the largest and one of the most rugged islands within the Canadian Arctic Archipelago. Its area covers about 190,000 square miles and the Island extends some 1,000 miles from the Borden Peninsula at its most northern extremity to Frobisher Peninsula bordering on Hudson Strait to the south. Mathiassen (1933, pp. 1-2) referred to Baffin Island as "that great island which not only is the largest in the whole of the North American arctic archipelago but also the one that is least known." Flanked along its eastern shore by a formidable mountain range, rising at times to over 7,000 feet in the vicinity of the Penny Highlands, the entire coast is a profusion of long, deep, dark fiords, immense cliffs and glaciated valleys and highlands. West of the east coast mountain barrier, there lies a central region of gently undulating uplands which, in turn, melt slowly into the Great Western Plains. The Great Western Plains are characterized by an extensive system of ponds, lakes, rivers and rivulets. The ground itself is composed largely of a surface layer of broken sedimentary rock in the form of shale, and occasional granite outcrops, while along the shoreline, wide areas of marshes, mud flats and raised beaches prevail. These austere physical features of Baffin Island induce marked fluctuations in the synoptic flow pattern which could only create a host of problems to the practising meteorologist, and no small measure of interest, fascination and, at times, awe.

Hare (in Rand Corporation, 1963, p. 45) describes four fundamental physical environments which are distinctive of Baffin Island: the windswept coastal regions, the fiord indented eastern coastline, the lower plateaus, and finally an area which has undergone some recent detailed investigation, the ice caps. One further division may be added to the above; that of the marine environment, comprising the surrounding water masses of Baffin Bay, Davis Strait, Foxe Basin, etc., plus the great inland lakes: Nettilling and Amadjuak. Each of these five divisions have a somewhat distinct climate of their own, as borne out by meteorological records from selected weather observing stations across the Island.

Baffin Island, by virtue of its location, is synoptically one of the most unique of all the islands in the Canadian Arctic. In winter, the huge land mass is profoundly influenced by cyclonic storms generated over the northwest Atlantic and Labrador Sea. During the short summer months, marine effects play a significant role in the production of coastal fog, whilst the interior climates express a more continental bias with somewhat higher temperatures and less cloud amounts depending on elevation and latitude. The mean isotherm of $+50^{\circ}F$ for the warmest month of the year lies over 300 miles south of Baffin Island; thus it remains well within the limits of the Polar regions.

B. Historical Aspects of Baffin Island

Many of the men who explored the Arctic were very astute observers of nature, and their journals abound with frequent references to meteorological phenomena. To have a sharpened sense in this respect was almost an essential prerequisite for their very lives sometimes depended upon it. In the case of Baffin Island, the expedition of Martin Frobisher provides a number of diary entries of unusual meteorological occurrences. One observation relates:

> In this storme being the sixe and twentieth of July there fell so much snow, with such bitter cold aire that we could scarce see one another for the same ... which somewhat discouraged some of the poore men, who had not experienced the like before, every man perswading himselfe that the winter there must needs be extreme, where they found so unseasonable a Sommer. (Hakluyt, vol. 5, p. 249)

Sir William Parry made three historic voyages to the Arctic in the early nineteenth century and a good portion of the time was spent navigating and exploring the coast of Baffin Island. Meteorological observations were taken at regular intervals, and on one occasion, while wintering at Port Bowden on northern Baffin Island, Parry remarks on the curious effect that surrounding topography had on local wind direction:

> ... the unusual proportion of easterly winds registered in our journals during this winter must, in my opinion, be attributed to the local situation. ... the land on each side of Port Bowden, running nearly east and west, and rising to a height of six to nine hundred feet above the sea, with deep and broad ravines intersecting the country in almost every direction, may be supposed to have had considerable influence on the direction of the wind. (Parry, 1824, p. 69)

On another occasion at Igloolik, N.W.T., Parry (1821) writes on the severe discomfort that is experienced when extreme cold is accompanied by high winds:

> The effect of a breeze upon the feelings is well known to every person, ... but at low temperatures it becomes painful and almost insupportable. Thus with the thermometer at $-55^{\circ}F$, and no wind stirring,

> the hands may remain uncovered for ten minutes or a quarter of an hour without inconvenience, while with a fresh breeze and the thermometer nearly as high as zero, few people can keep them exposed so long without considerable pain.

Eventually in meteorology, the term "wind-chill" was applied to this combination of wind and cold.

While exploring the Gulf of Boothia on March 20, 1831, the intense and persistent winter cold caused Sir John Ross to reflect in his journal:

> The continuance and degree of cold at this period of the present month began seriously to attract our attention. The thermometer sank on this day to minus 52°F and the average of the 24 hours was but minus 49°F. (Ross, 1835, p. 63)

Thus, from the diaries of these early explorers, many facts of meteorological interest can be read. These can be helpful in establishing the existence of various local phenomena, or confirming the presence of large scale movements of air or water such as outflow winds, barrier effects, and ocean currents and tides.

In 1920, Canada established several Royal Canadian Mounted Police outposts across the Arctic, two of which were located at strategic points on Baffin Island. The main purpose of these stations was to establish Canada's claim over the Arctic islands. Pangnirtung, on the Cumberland Peninsula, and Pond Inlet, across the strait from Bylot Island, were established in 1923. Following these initial stations, Arctic Bay and Clyde River were founded by the Hudson Bay Company for the purpose of Eskimo trade. Meteorological records were kept at all these early R.C.M.P. and Hudson Bay Company posts. A number of stations later relinquished the weather observing commitments to the Meteorological Service of Canada.

Airport facilities were built at Frobisher Bay in 1941 to accommodate transient fighter aircraft bound for England. A full meteorological observing program was launched at this station and has continued ever since.

With the intensification of the Cold War between Russia and the West in the early 1950's, it became an operational necessity to establish across the Canadian and American Arctic a network of radar stations in order to provide early detection of hostile aircraft. This line was called the Distant Early Warning Line or, in short, the DEW Line. Another valuable source of meteorological data thus came into being. By the late fifties, the DEW Line weather network was finally operational and Baffin Island enjoyed a complement of six major radar stations with smaller intermediate sites located in between. Weather records from the intermediate sites were sporadic and lacked consistency, and the majority have now been closed by the United States government because their military usefulness can no longer be justified. From the major radar installations, though, a fund of reliable weather data began to accumulate and it is from these records that new and interesting knowledge on the synoptic climatology of Baffin Island will be discussed in this thesis.

C. The Meteorological Network on Baffin Island

1. Arctic Bay

Arctic Bay lies on the northwestern portion of Borden Peninsula (Fig. 1) and is flanked to the west by Admiralty Inlet which permits a high frequency of north to northwest winds to prevail. Since it is surrounded to the south and east by mountains several thousand feet high, there is a low incidence of winds at the station from these directions.

Regular weather observations have been recorded since 1939. A complete radiosonde programme was initiated during the mid-fifties but these were discontinued by the late fifties after responsibility for these observations was transferred to Hall Beach.

2. Clyde River

Regular weather reporting was initiated at Clyde River in 1943 and a full radiosonde programme commenced in the mid-fifties. The station itself is positioned at the eastern end of Clyde Inlet but a few miles from Cape Christian (Fig. 1). The wind frequencies exhibit a definite bias from the north and northwest with secondary maxima appearing from the south and southwest during the mid-summer months.

3. Frobisher Bay

Forbisher Bay Airport is situated on the southern end of Baffin Island at the northwest end of Frobisher Bay Inlet (Fig. 1). Hills rising to 600 feet lie within one-half mile of the runway. The Bay itself is bounded by hills which rise sharply from sea level to about 1500 feet with some areas reaching elevations of up to 3000 feet. The hills to the south extend well to the west, thus providing an effective barrier from excessively strong southwesterly winds. The hills to the north are not as high as those to the south; consequently the barrier against high east and northeast winds is not as effective a block. On the whole, however, the general result of local relief is to channel winds either from the northwest or southeast, depending on the prevailing flow in the free atmosphere.

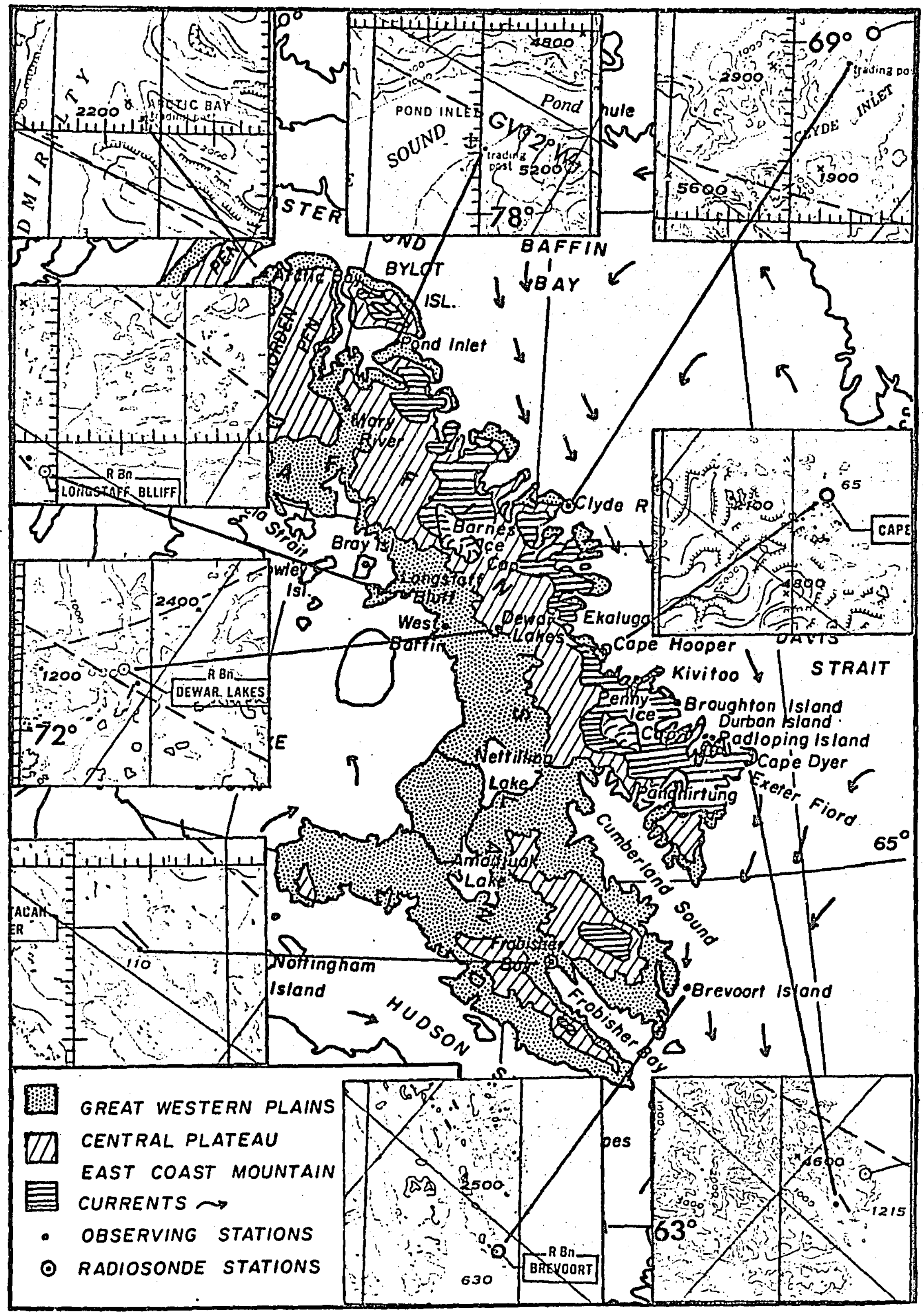

Figure 1. Geographical Features of Various Localities on Baffin Island

Regular weather reports have been recorded since 1942. Radiosonde observations began in the early fifties.

4. Stations Along the DEW Line

a. General Remarks. Perhaps some of the most intriguing and valuable weather data to emerge from Baffin Island in recent years are those originating from the records of various DEW Line stations. It is from these sites that the wealth of additional information has provided some interesting aspects of wind flow and temperature patterns across the Island. Admittedly the initial influx of data was crude and somewhat unreliable at best, but as the DEW Line weather network was perfected, and the personnel taking the observations became increasingly adept and aware of meteorological recording, so the calibre increased. Thus from 1958 on, depending on the individual station itself, accuracy improved and regular four-hourly synoptic reports became a reality. A description of major sites follows. In Figure 1 can be seen an enlargement of the geographical features at some of the DEW Line sites.

b. Longstaff Bluff. The airstrip is some two miles from the radar site and is approximately 40 feet above mean sea level. The radar module itself is stationed 530 feet above mean sea level. The surrounding landscape is typical of that encountered along the Great Western Plains of Baffin Island. Ridges and knolls rise some 300 to 500 feet. Numerous ponds, lakes and small rivers lend interest to an otherwise monotonous terrain.

c. Dewar Lakes. Dewar Lakes is situated some 100 miles east of Longstaff Bluff and provides a good example of a site located in the central plateau region of Baffin Island. The radar site is at an altitude of 1700 feet above mean sea level, and all meteorological parameters are measured at this location. Wind information from Dewar Lakes helps to confirm the "barrier" effect and the dynamic presence of Foxe Basin.

d. <u>Cape Hooper</u>. Further east, situated along the fiord indented east coast, is Cape Hooper. The airstrip extends in a northwest to southeast direction and is wedged between a 1300 foot hill a mile to the northeast, which contains the radar module, and by even higher hills and ridges to the southwest. Home Bay lies on the northern flank of Cape Hooper, whereas Nuduing Fiord lies along the southern shoreline of the isthmus and extends westward well into the glaciated east coast mountain range. It is suspected that Nuduing Fiord is the controlling factor governing the wind pattern of Cape Hooper.

e. <u>Broughton Island</u>. Broughton Island is found 80 miles down coast from Cape Hooper. The aerodrome is situated on the west coast of the Island, and the radar module is perched on a hill, some 1900 feet above mean sea level at the southeastern tip of the Island. Mountain barriers across the narrow strait immediately to the west of the Island airstrip channel the wind flow from a predominately north to northwest direction.

f. <u>Cape Dyer</u>. Cape Dyer lies on the eastern headland of Baffin Island and is surrounded by some of the most imposing scenery to be found anywhere in the Arctic, being bounded by rugged peaks and fiords to the west and by Davis Strait to the east. Nearby Exeter Fiord (Photo 1) is one of the many along the east coast of Baffin Island, and its effect on weather conditions at Cape Dyer cannot be overestimated. The Arctic Circle runs

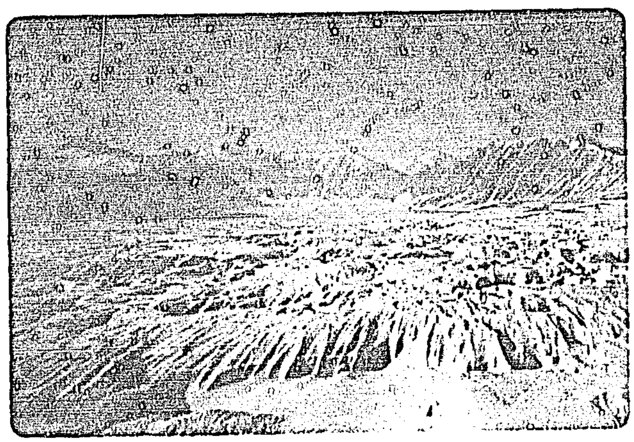

Photo 1. Exeter Fiord as seen from the runway looking west. Note the Sastrugi. (Photo by B. A. Coulcher, March 31, 1959)

almost directly through the Cape.

The weather station is near the aerodrome itself and is at an elevation of some 1200 feet. The station has a full hourly weather reporting program.

g. Brevoort Island. Brevoort Island, a desolate fragment of rock, is located some 130 miles east of Frobisher. The airstrip is only 2000 feet long and extends in an east to west direction with the western end hovering perilously close to a shear 700 foot cliff. The radar installations are at an elevation of 1200 feet.

h. Hall Beach. Hall Beach is situated on the western shore of Foxe Basin and is surrounded by flat, undulating topography. Its importance for the purpose of this paper lies not only in its location but also in the fact that it has had a very reliable surface and radiosonde reporting programme for several years.

5. Additional Sources of Weather Information

Padloping Island and Lake Harbour both provide examples of different climatic conditions at widely varying points on Baffin Island. Padloping Island was established by the United States government in 1941, but has since been abandoned. Lake Harbour, a Hudson Bay Company Post, began weather observations in 1922 which were continued until 1941.

West Baffin, Ekalugad Fiord, and Durban Island are intermediate sites along the DEW Line network. Records of temperature statistics are available at these stations, but for the most part, precipitation, wind and cloud summaries are totally lacking. Information from the above sites is the least reliable of all the stations incorporated in the DEW Line complex, and their length of record is very short.

Nottingham and Resolution Islands provide typical examples of conditions recorded in a stormy, marine environment. Both outposts were established as weather and communication links around 1928 by the Government of Canada. In 1963, the original location of the weather station on Resolution Island was transferred to the extreme eastern end of the Island near the United States Air Force radar establishment.

Private mineral concerns began a three-year summer schedule of reporting weather information at Mary River, northern Baffin Island, commencing in May, 1963. The records are interesting but rather inconclusive, owing to the short period of observations.

Additional meteorological data were obtained by the writer from many civilian, commercial and military pilots, and through conversations with weather observers and travellers alike. The information so gathered over the years confirmed the existence of a number of local peculiarities.

CHAPTER II. CLIMATIC CONTROLS

A. Latitude and Degree of Continentality

To comprehend the climate of Baffin Island thoroughly, it is necessary to discuss a number of controlling factors. This involves a careful consideration of latitude and degree of continentality, topography, and atmospheric circulation.

Baffin Island extends through a wide range of latitude. The extreme southern fringes of the Island commence at 62°N, whereas the northern portions lie well within the central Arctic at approximately 74°N. This produces a distinct contrast in the amount of solar radiation reaching various localities. The northern areas are subjected to long months of perpetual darkness in winter, while the south always enjoys a measure of daylight. In summer the sun is continuously above the horizon over most of the Island with the exception of the fiorded coastlines and mountain regions where shadow effects predominate. The heating effect of continuous solar radiation is therefore lessened considerably, due to low angle of incidence of the sun which causes much of the heat to be reflected back into space. This is in sharp contrast to equatorial latitudes where the rays strike the earth at an angle of ninety, or close to ninety, degrees at noon, thereby permitting a maximum of heat absorption throughout the day. Table I, taken from Bridge (1964) shows that the solar altitude in June is only $43^{\circ}02'$ at its annual maximum.

Yet another factor which decreases the benefit of continuous insolation is the high frequency of cloud cover, particularly

TABLE I

Hours of Sunlight, Angle of Incidence, and Number of Atmospheres Through Which Sun's Rays Must Pass on the 15th of Each Month at 70°N (Bridge, 1964).

Month	Duration of Sun (Hours)	Solar Altitude	Atmosphere
January	0.00	0	-
February	7.20	6°46'	8.25
March	11.33	17°09'	3.50
April	16.09	29°13'	2.00
May	22.41	38°25'	1.60
June	24.00	43°02'	1.45
July	24.00	41°27'	1.50
August	18.15	34°07'	1.75
September	13.26	23°10'	2.40
October	9.06	11°10'	5.00
November	3.52	1°31'	24.00
December	0.00	0	-

along the coast and in the vicinity of large inland lakes. Thus it can be seen that there is an annual deficit of heat, and in order to maintain an equilibrium, heat must be transported into the region. This transport of energy is accomplished through the advection of sensible heat, latent heat, and water vapour by meridional processes, examples of which will be provided later. So, as in the case of the Arctic taken as a whole, Baffin Island exports vast amounts of cold air and imports warm, moist air from the south.

The degree of continentality will now be considered as another factor controlling the climate of Baffin Island. Along the shorelines, a definite moderating influence is exerted by surrounding water masses. In summer, the water is kept to within a degree or two above the freezing point by the persistence of ice packs and a lack of strong solar heating. This, in turn, lowers the mean summer temperatures. In winter, heat flux through the ice cover prevents the temperature from falling to very low levels. There is evidence to suggest that Hudson Strait is never completely frozen over even during the coldest winters and this has been borne out by frequent aircraft reconnaissance.

Comparing average monthly temperatures between Broughton Island and mid-Baffin, a marked difference can be seen (Table XI, p. 92). The lowest temperature ever recorded at Dewar Lakes is $-55^{o}F$, compared to only $-43^{o}F$ for Broughton Island. Mean annual precipitation likewise exhibits the degree of continentality which exists between the two stations, Broughton Island receiving 11.74 inches of precipitation per year compared to 8.55 inches at Dewar Lakes.

The ice caps on Baffin Island no doubt present yet another interesting study of climatic anomalies. Andrews (1963, p. 26) states that the glaciers of north-central Baffin Island are of the Polar type with the Barnes Ice Cap at 1065 meters recording a mean annual temperature of -14°C (+68°F). Orvig (in Rand Corporation, 1963) shows that the summer temperatures on the Barnes Ice Cap run from 26.2°F in June to 33.4°F in July. The warmest day recorded on the Barnes Ice Cap was 38.1°F and over the Penny Ice Cap only 35.6°F, while the average July temperature on the Penny Ice Cap was reported as 25.8°F. It must be remembered that the Penny Ice Cap at 67°N rises to elevations of 6500 feet and higher, whereas the Barnes at 70°N has an elevation of only 2900 feet.

B. Topography

One of the most important and fascinating features of Baffin Island is its varied topography. As mentioned previously, the Island is bounded by a massive mountain range along its eastern approaches, which is indented with deep penetrating fiords, scarred with numerous valleys and rivulets, and flattened at intervals by extensive ice caps. The east coast mountains slowly give way to a relatively flat plateau country which subsides into the lands of the Great Western Plains. The mountain range itself acts as a formidable barrier preventing the free transport of air from one side to the other. It is also instrumental in preventing, for the most part, any strong incursions of maritime air from penetrating any great distance into the north-central Arctic. The eastern mountains, like their counterpart, the Greenland Ice Cap, act as rather destructive barriers to deep cyclonic storms migrating from the south. Intense lows are not infrequently fragmented, disorganized, or even completely destroyed by this formidable obstacle, much of their energy being expended before they reach Baffin Bay or even the central Arctic.

C. Pressure Distribution and Significant Cyclonic and Anti-cyclonic Tracks

1. General Remarks

An understanding of the pressure distribution or atmospheric flow pattern of a particular region such as Baffin Island is paramount if one is to grasp entirely the importance of climatic controls and their respective intricate and complex interrelationships. Referring to flow patterns, both at the surface and aloft, Lee (1960, p. 1) states that the entire problem must be considered in the light of four fundamental physical factors: differential solar heating, the earth's rotation, the effect of mountain barriers, and the geostrophic wind equation. Of these, perhaps the most apparent and noticeable on the climatology of Baffin Island are those relating to topography and differential heating with change in latitude.

Berry, Owens and Wilson (1954) have compiled cyclonic and anticyclonic frequencies for the high Arctic. Klein (1956) has studied the paths of Polar highs and lows and has represented the findings by track charts.

a. Surface and 500 Millibar Features. The average circulation at the surface over the eastern Arctic exhibits a rather ill-defined and somewhat disturbed pattern in summer, whereas in winter the Icelandic Low dominates the entire situation across the North Atlantic, Greenland, and east-central Arctic. The exact location of the semi-permanent features of the surface circulation such as the Icelandic Low, Aleutian Low, etc., have been carefully studied by Smagorinsky (1953).[1]

A map representing the mean sea level pressure distribution over Baffin Island has been constructed from the latest available data for the months of January, April, July and October. Some changes in the average pressure distribution have been introduced for January (Fig. 2) and July (Fig. 4). In January, there is evidence to suggest a closed circulation in Foxe Basin caused by both thermal and dynamic processes. A small high pressure is situated over central Baffin Island and it is of interest to note that it lies in the vicinity of the Barnes Ice Cap.

The July surface pressure map shows the traditional Hudson Strait Low and an elongated high lying across central Baffin Island. The high was incorporated on the basis of six-year pressure averages from the DEW Line weather network; thus its existence can be questioned.

In January (Fig. 6), at 500 mb, a bipolar vortex is the dominant feature with a major closed low circulation situated

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[1]Smagorinsky investigated the relationship between the location of the Aleutian and Icelandic Lows and the Siberian High, and the distance from these centers of the heat sources and sinks in the northern hemisphere. He discovered that the centers of the major pressure cells were displaced some 25° of longitude east of the heat sources and the mean Siberian anticyclone was displaced about 25° longitude east of the cold source. The heat sources were defined as those created by the Gulf Stream in the region just off the east coasts of North America and Asia. In these areas, differential heating in winter is at its most intense. The Siberian high is generated by the cold source further to the west as implied by the average surface isotherms.

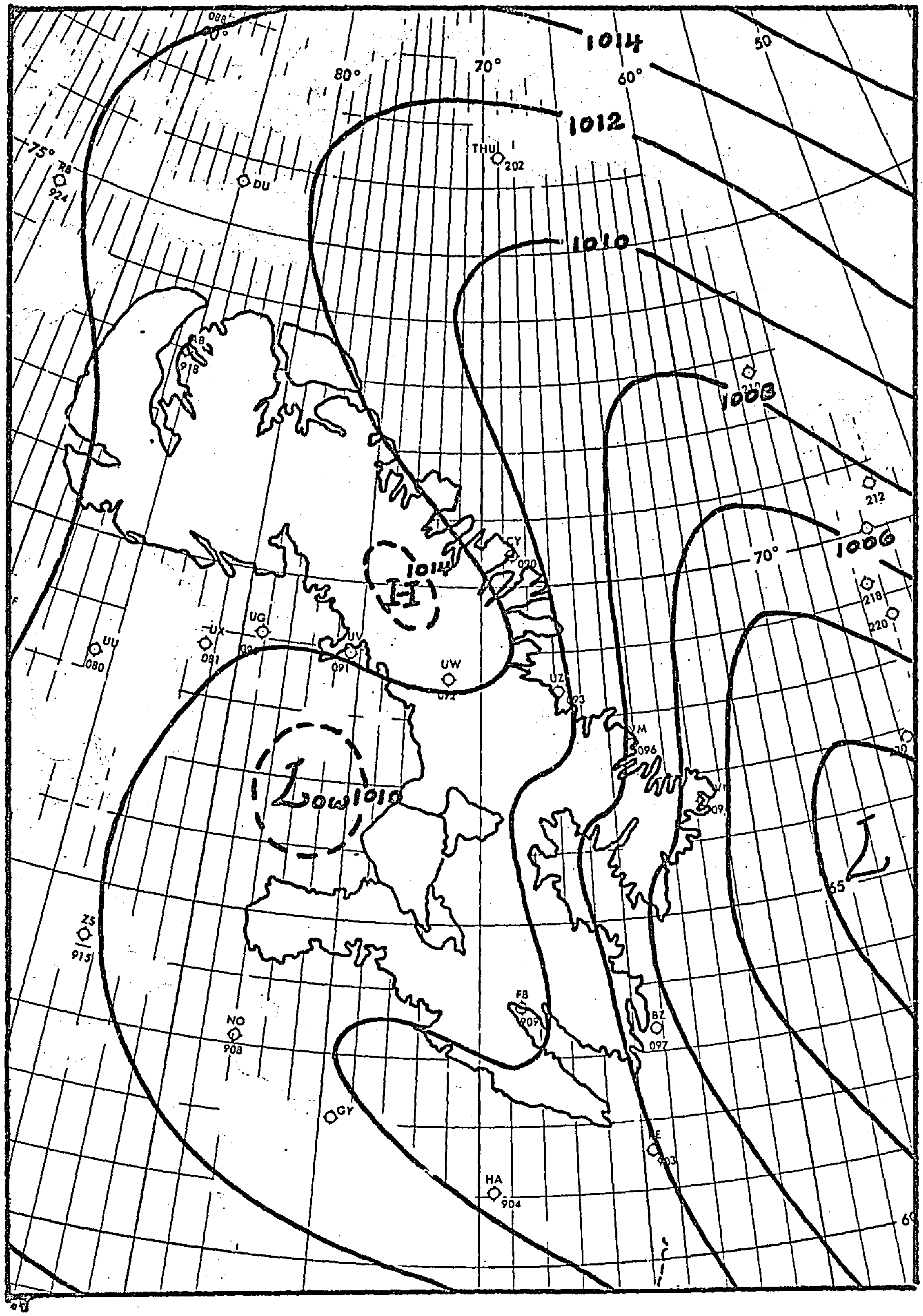

Figure 2. Mean Sea Level Pressure, January

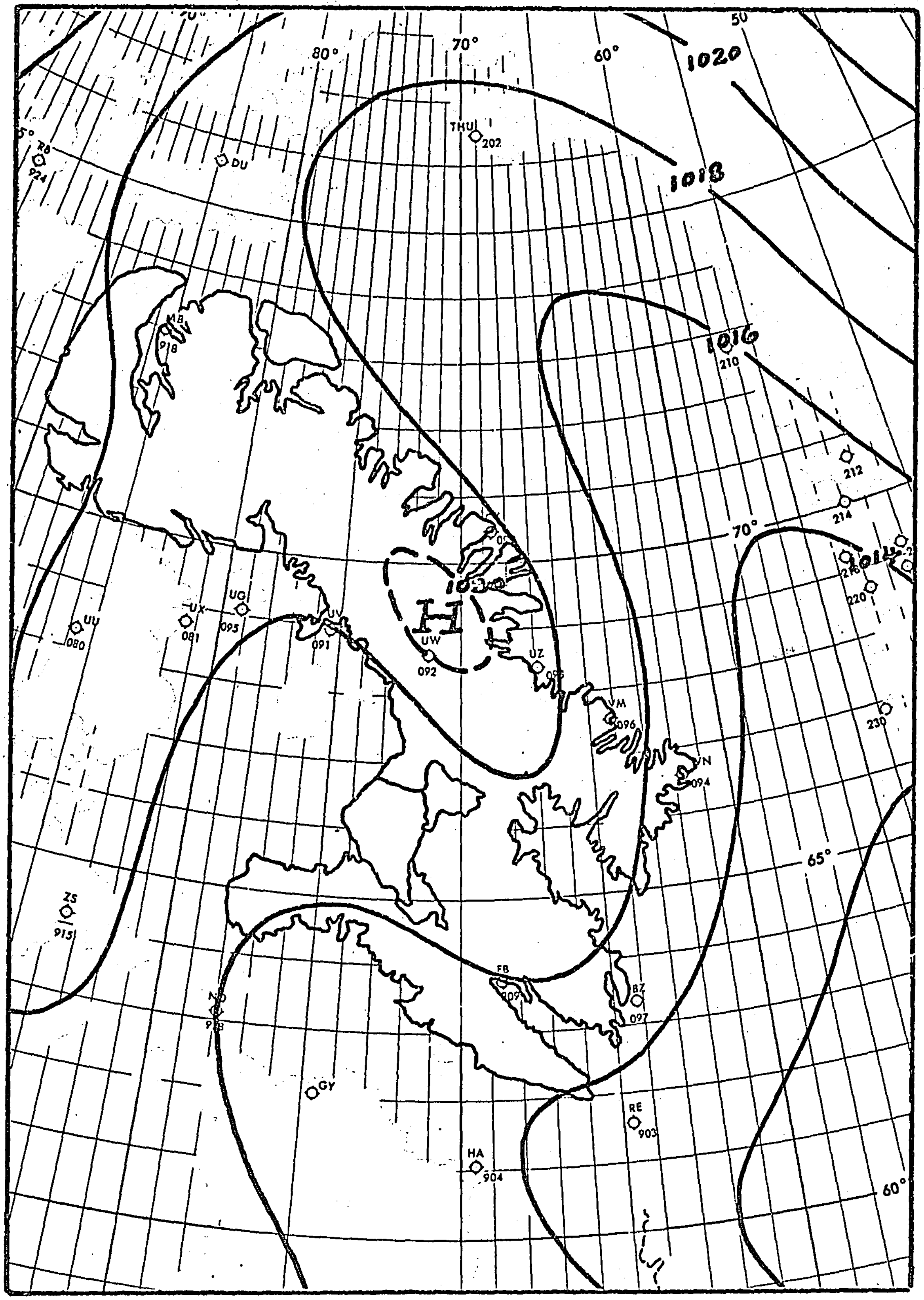

Figure 3. Mean Sea Level Pressure, April

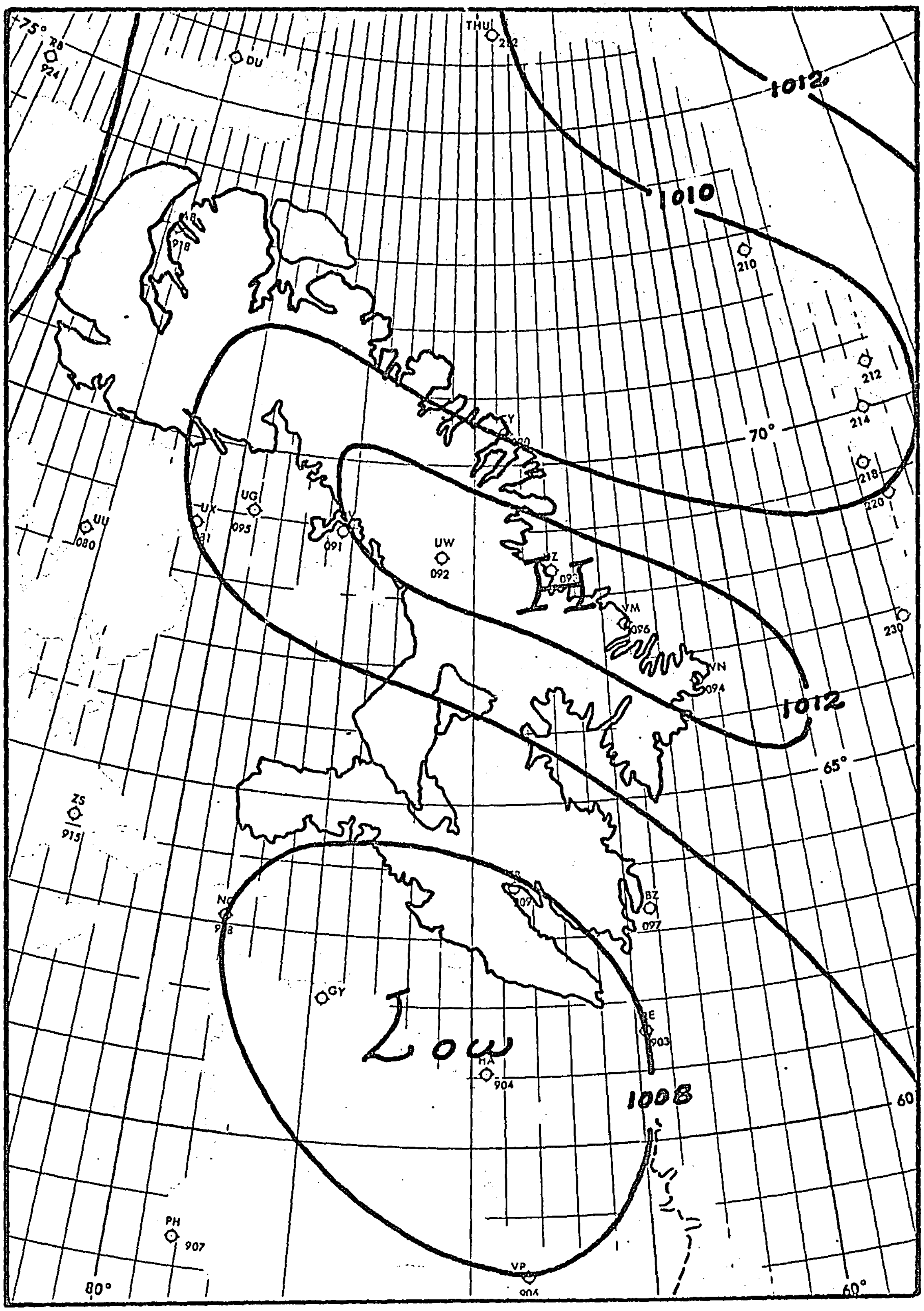

Figure 4. Mean Sea Level Pressure, July

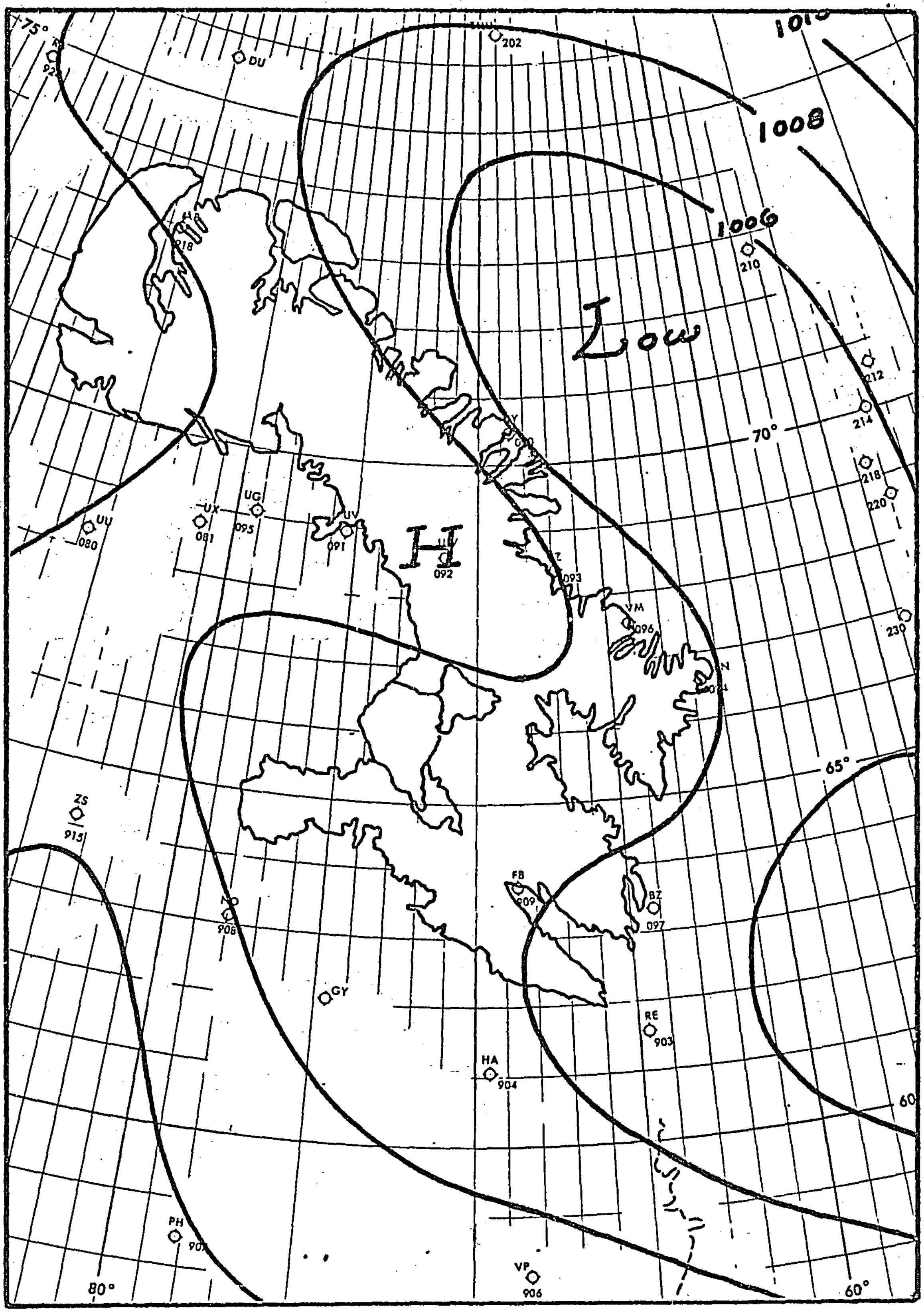

Figure 5. Mean Sea Level Pressure, October

over Foxe Basin. Another elongated trough extends into eastern Siberia from the vicinity of the North Pole. During the summer, the situation changes abruptly. A weak closed circulation centered over Ellesmere and a flat trough protruding southward across Baffin Island combine to produce a relatively quiet circulation across much of the Arctic in July (Fig. 7). It might be noted that at 100 mb, the upper flow is characterized by a cold low centered over Baffin Island.

Embedded in the mean upper flow are long wave and short wave ridges and troughs which themselves are reflected at the surface by migrating cyclones and anticyclones. It is these latter features which are so strongly influenced by differential heating and topography and which over the course of time serve to outline the normal paths of synoptic systems over the hemisphere.

2. Seasonal Variation

a. Winter. Baffin Island lies in the northwestern quadrant of the Icelandic Low and as such comes under the influence of a very cold, dry north to northwest flow of Arctic air with characteristic temperatures of $-25^{\circ}C$ or lower and wet bulb potential temperatures (θ_{ω}) of $+2^{\circ}C$ or less. In January (Fig. 10), cyclones which develop over the Gulf of St. Lawrence and off the coast of Labrador, move northward and eventually split over the southern tip of Greenland, the major portion together with its associated frontal system dies out in the vicinity of Denmark Strait, and the secondary impulse moves northward along the west coast of Greenland into Baffin Bay as a "bubble" low.

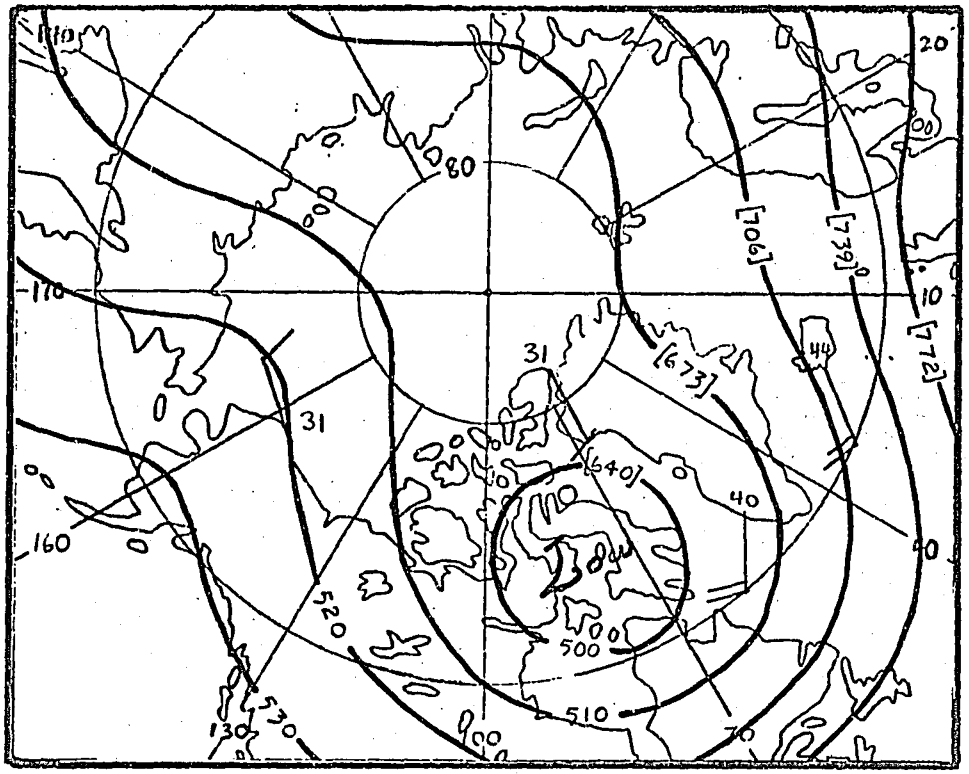

Figure 6
Mean Absolute Topography of the 500 mb Surface, January, 1949-53, after Heastie, Vector Winds: One Full Feather = 5 Knots

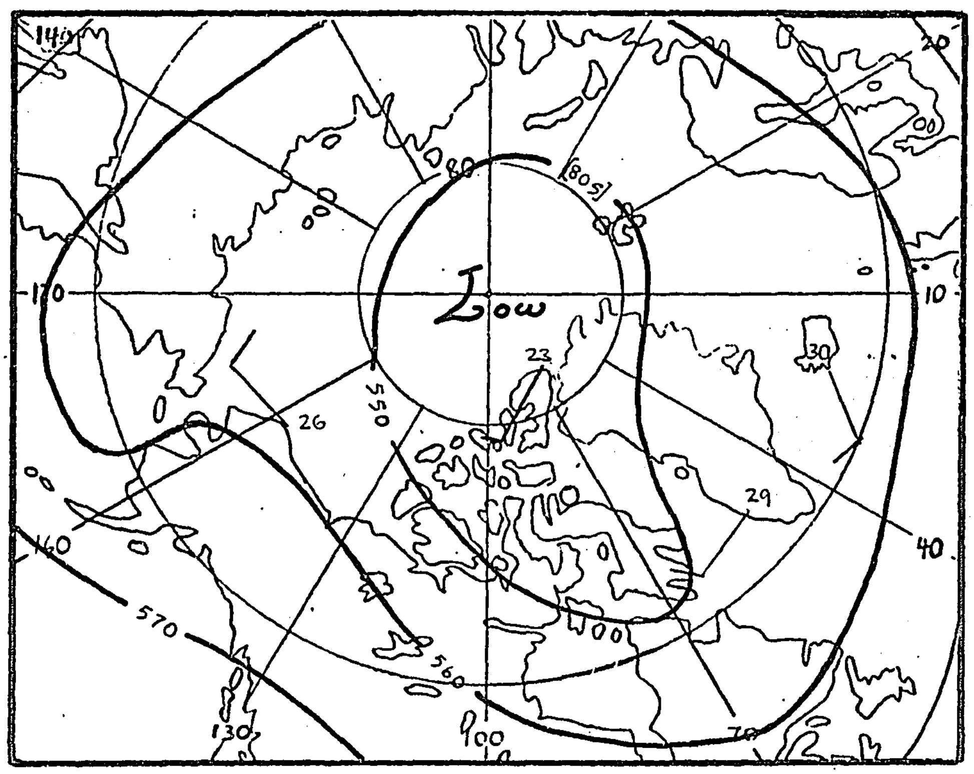

Figure 7
Mean Absolute Topography of the 500 mb Surface, July, 1949-53, after Heastie, Vector Winds: One Full Feather = 5 Knots

Secondary tracks of migrating lows are those which have entered the Western Arctic through McClure Strait and cross northern Baffin Island eventually to die out in Baffin Bay, and those which develop over northern Manitoba move north-eastward over southern Baffin into Davis Strait or Foxe Basin. These pressure areas, particularly the northward migrating lows, are instrumental in transporting vast amounts of latent and sensible heat into the Arctic.[2] During dramatic changes in the index cycle, say from high to low index, low pressures invading the southeastern Arctic can be very intense, bringing with them well above normal temperatures, heavy precipitation and strong winds. The southern part of Baffin Island, in particular the Cumberland Peninsula, can be beset by savagely sustained periods of storm if the cyclonic track is directed in such a manner.

There are no significant anticyclonic tracks over Baffin Island in January as the Icelandic Low is far too well-developed and the persistence of the West Greenland trough precludes the development of any such feature. Instead, the passage of anticyclones occurs further to the west across the Beaufort and Chukchi Seas into the Northwest Territories, the Yukon and Alaska, whereupon they usually intensify before plunging down into central and eastern North America.

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[2]Vowinckel (1964) states that the advection of sensible heat (A_E) or the amount of heat gain through sensible heat advection is a function of the magnitude of the wind component into the area, of the vertical motion in the area, and of the initial saturation deficit of the air. If there is no vertical motion, or if the vertical motion is so weak that the air parcel is not lifted to the condensation level, then no release of latent heat occurs.

Baffin Bay is the graveyard of many a cyclonic storm. This is borne out by Keegan's (1958) cyclone frequency maximum (Fig. 8) and is further substantiated by the ever present trough in evidence at all seasons at sea level. There is a strong winter maximum area for anticyclones over Greenland (Fig. 9). Keegan (1958) found these systems to be slow-moving highs with a 1000/500 mb thickness average of 16,440 feet. They can usually be found at 500 mb and as such can be related to high latitude blocking action.

b. Summer. Continuous daylight prevails over Baffin Island during most of the relatively short summer, and insolation is at its peak. The westerlies which have migrated slowly northward have weakened considerably and seldom breed the deep cyclonic disturbances so typical of winter patterns. The significant features of the surface flow in July (Fig. 4, p. 21) exhibit a flat geostrophic gradient across Baffin Island and indeed over the entire Arctic. A small closed low centered over Hudson Strait, and a northward trough protruding beyond Ellesmere Island, coupled with a weak cyclonic circulation over southern Greenland and Denmark Strait are all that remain of the enormous Icelandic winter vortex. An elongated high cell is situated across central portions of the Island. The mean 500 mb surface flow (Fig. 7) likewise shows a distinct tendency towards disorganization with but one broad low centered near the Pole and an equally broad amplitude trough reaching south over Baffin Island.

The primary storm track (Fig. 12) originates over southwestern Hudson Bay, curves towards Ungava Bay, skirts southern Baffin Bay and terminates once again in Davis Strait and Baffin

Figure 8
Per Cent Frequency of Cyclones in Winter North of 60°N per 100,000 Square Miles, after Keegan, Winter, 1952-57, Sea-Level

Figure 9
Per Cent Frequency of Anticyclones in Winter North of 60°N per 100,000 Square Miles, after Keegan, Winter, 1952-57, Sea-Level

Bay. A secondary route moves directly eastward across the Arctic and northern Baffin Island.

c. <u>The Transitional Periods</u>. The transitional periods in the Arctic are those which embrace the spring and fall months. For convenience, the months of April and October will be considered here.

April can be very stormy across Baffin Island, especially over southern portions where the first effects of seasonal northward migration of the westerlies and subsequent increase in cyclonic activity herald the approach of the warmer season ahead. The Icelandic Low commences to weaken at the surface and over the central Arctic a pronounced high dominates the pressure distribution. Surface flow over Baffin Island is orientated in a more north to northeast direction, while aloft the flow at 500 mb has weakened with the closed circulation of January slowly changing to a well-defined north to south trough extending along longitude 70°W.

The cyclonic tracks become more pronounced in spring. The major track enters Davis Strait (Fig. 11) after following a path originating over southern Quebec and the Strait of Belle Isle. Whereas in mid-winter months the previous storm track was deflected into Denmark Strait in the vicinity of southern Greenland, with but a minor bubble low entering Davis Strait, in April the picture changes somewhat with the more intense low pressure areas tracking across the Labrador Sea towards the southern tip of Greenland, thence moving up into Davis Strait. A secondary cyclonic track originates over northern Manitoba and moves in a northeast direction, crossing southern Baffin Island into Baffin Bay. Systems

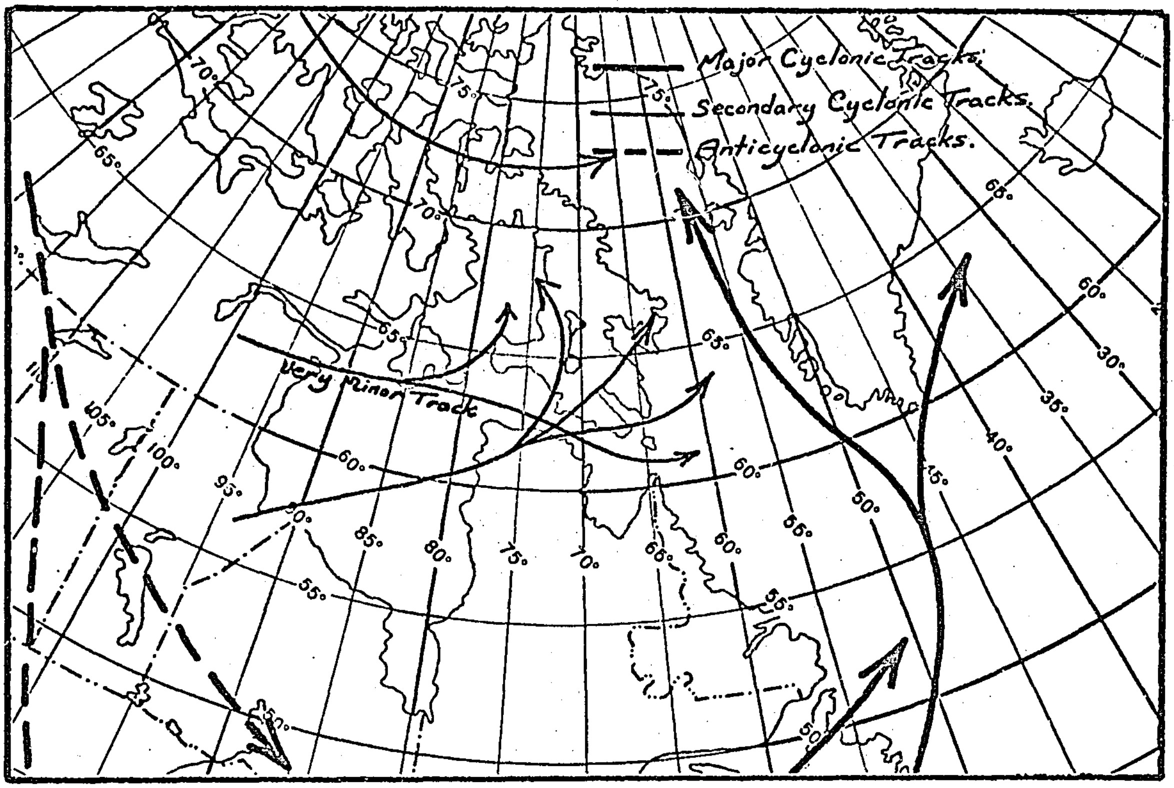

Figure 10 (January)
Principal Tracks of Cyclones and Anticyclones

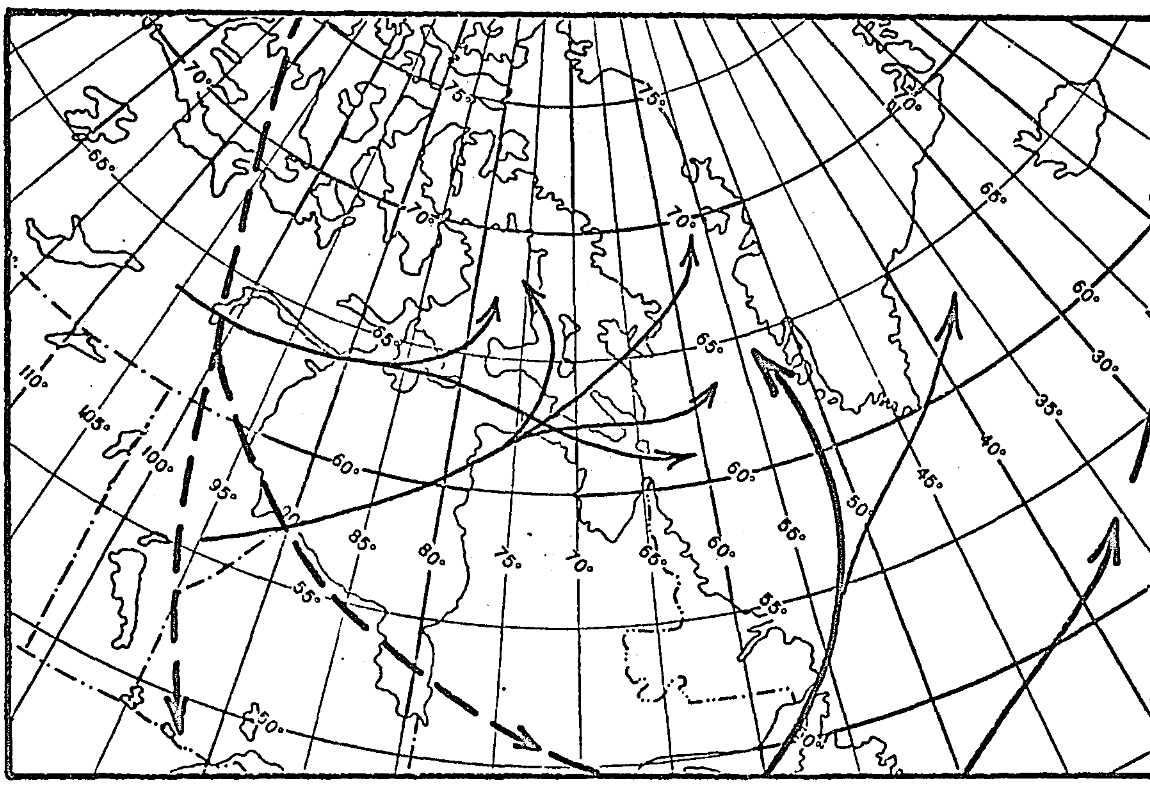

Figure 11 (April)
Principal Tracks of Cyclones and Anticyclones

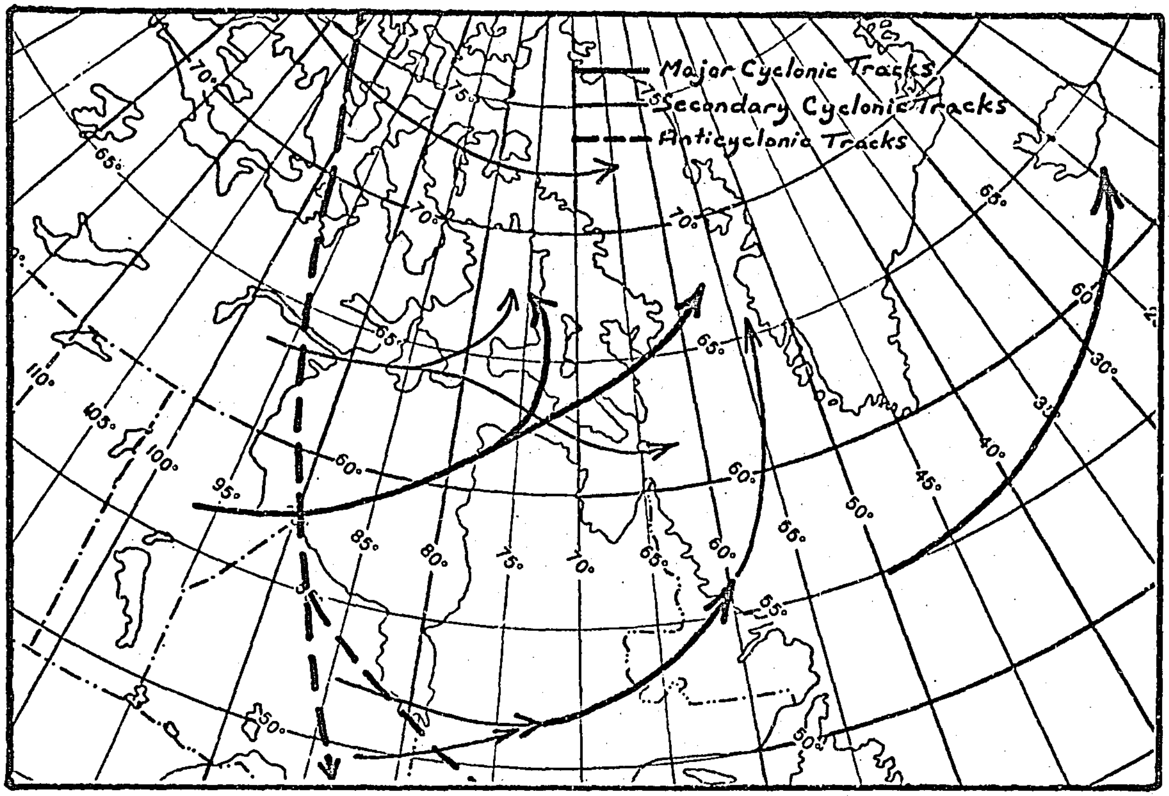

Figure 12
Principal Tracks of Cyclones and Anticyclones, July

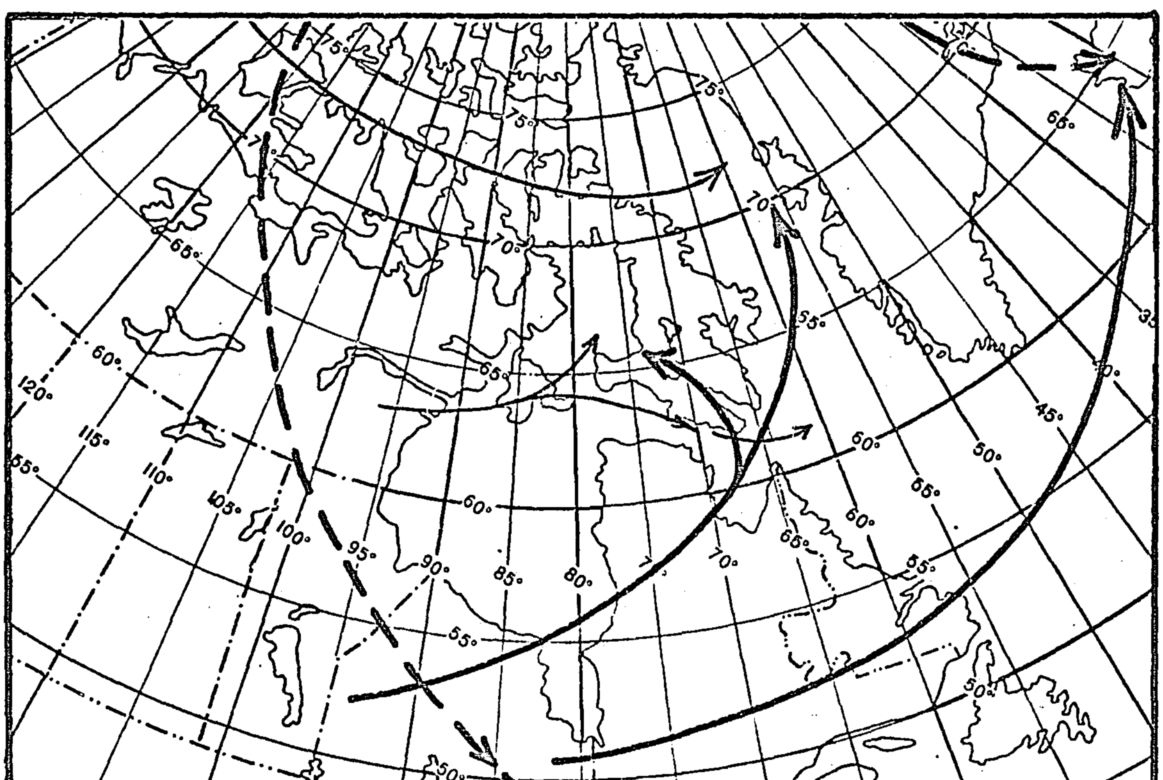

Figure 13
Principal Tracks of Cyclones and Anticyclones, October

travelling along this route are generally deeper as the sources of moisture supply and warm air become more readily available at lower latitudes.

Anticyclonic tracks are almost negligible over the region. The important routes remain well to the west, the majority being steered southeastward across the western Arctic into central North America.

The fall months witness a slow southward retreat of the main westerly wind belt and a distinct strengthening of the thermal pattern as rapid cooling occurs over the entire Arctic. Cyclonic disturbances gain in strength with the gradual deepening of the Icelandic Low. Diabatic heating is perhaps the prime dynamic mechanism present in maintaining a low pressure trough over Davis Strait (Fig. 5, p. 22). The water masses off the west coast of Greenland remain largely free from ice cover, and as such act as a primary source of heat and moisture which are quickly utilized by increasing surges of relatively dry Arctic air moving down from the northwest. Deep convection is thus achieved and a low cell results, creating a relatively strong pressure gradient along the east coast of the Island. Early season low pressure areas enhance this overall effect.

One important cyclonic path is recognized as being perhaps the most representative in the fall. The route stretches from southern Hudson Bay and James Bay northeastward across Ungava Bay, and thence towards northern Davis Strait, terminating in the vicinity of Disko Bay (Fig. 13). Cold northerly air injections coupled with warm air advection from the south provide the ingredients for cyclogenesis and the subsequent first winter snowfalls over Baffin Island as the lows deepen rapidly and head northeastward. Anticyclonic activity remains rather weak with no apparent routes within striking distance of Baffin Island.

3. Evidence of a Secondary Storm Track

Through a study of the month to month evolution of storm paths which directly affect Baffin Island, there seems enough evidence to support the existence of an important secondary track. The evidence is based on an examination of daily surface weather maps from the period January 1958 to December 1960, inclusive. The number of cases where low centers were located in and around the Baker Lake, Chesterfield Inlet area, and which subsequently moved eastward towards southern Baffin Island and Davis Strait were approximately eighteen throughout a three-year period. The low centers when located in the vicinity of Chesterfield Inlet were either in a stage of incipient development or were mature lows already having had a fairly lengthy track. None were recorded during the mid-winter months, December through March. Thus it can be assumed that their occurrence coincided with the shifting migration of the westerlies during the transitional and summer months. An example of such a system can readily be seen in Fig. 30, p.119.

D. A Note on Air Masses

Continental Arctic air[3] dominates Baffin Island throughout the winter months and as such acts as a primary source of

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[3]The surface and topographical features of the Arctic make it an ideal cold air mass source region. The snow surface radiates nearly like a black body, and in winter with an almost total lack of insolation, an intense inversion results near the surface.

cold air advection into the Labrador Sea. Invasions of warm, moist maritime air from the Atlantic have been known to occur on occasions but their frequency is very sporadic. Some notable instances of these will be provided in a later chapter.

"Bubble" or "break off" lows moving northward along the west coast of Greenland involve a cold brand of maritime air, if not so apparent at the surface, then certainly at higher levels. The region of Baffin Island west of the mountain range is seldom subjected to a surface invasion of maritime air in winter. By virtue of its flat undulating and largely low lying features, the central highlands and Great Western Plains act as an ideal basin or source region for the production of very cold Arctic air able to resist in most instances any surface displacement from the east and south. Instead, the Atlantic air rides over the cold, surface variety, the forward advance of the warmer maritime air into higher latitudes being marked by an upper warm front.

In summer, the prevailing air mass is maritime Arctic or even modified Arctic air. The long daylight hours and subsequent seasonal increase in solar radiation are responsible for this physical transition.

In early summer, a high percentage of the solar energy is spent in the actual melting process of ice and snow. Thus by July, this cycle is largely completed and the barren lands are transformed into vast areas of shallow bogs, streams, and low lying marshes, which provide an excellent source region for the production of transitional or maritime Arctic air.

Foxe Basin is yet another important geographical feature which exerts a strong influence on air mass properties. The summer season injects warmth and moisture into the lower levels of the atmosphere and an air parcel gradually takes on the maritime characteristics of the environment. Cooling of the air mass at the surface produces thin layers of fog and stratus. In autumn, increasing cyclonic activity over the North Atlantic intensifies the west Greenland trough creating a moderate to strong northwesterly gradient over Foxe Basin and much of south-central Baffin Island. Increasing surges of Arctic air are thus propelled southward and modification occurs at lower levels as the air mass travels across the largely open stretches of this waterway.

Burbidge[4] (1951) has studied the physical changes of Arctic air masses with broad trajectories over the Hudson Bay in winter and fall. The study shows the extent to which Arctic air is modified while crossing the Hudson Bay. A similar situation seems to exist with respect to Foxe Basin. The Basin is much smaller in area and not as deep, and its effects on air mass modification are therefore not as great. However, indications are that the role played in air mass modification is quite significant as can be seen by visual inspection of average temperature graphs (Fig. 14) between, say, Hall Beach, Longstaff Bluff and Dewar

[4] Burbidge compared average monthly temperatures for Churchill, Manitoba and Port Harrison, Quebec, and showed the extent to which Polar Continental was modified while it journeyed from west to east across the Hudson Bay. A significant temperature difference was realized between the two stations which eventually became negligible after the Bay froze over in January. The air becomes extremely unstable in the early fall, owing to the addition of moisture and heat in the lower levels which creates heavy snowshower activity along the windward shores of the Bay. This abruptly ceases when open water is replaced by fast ice late in December.

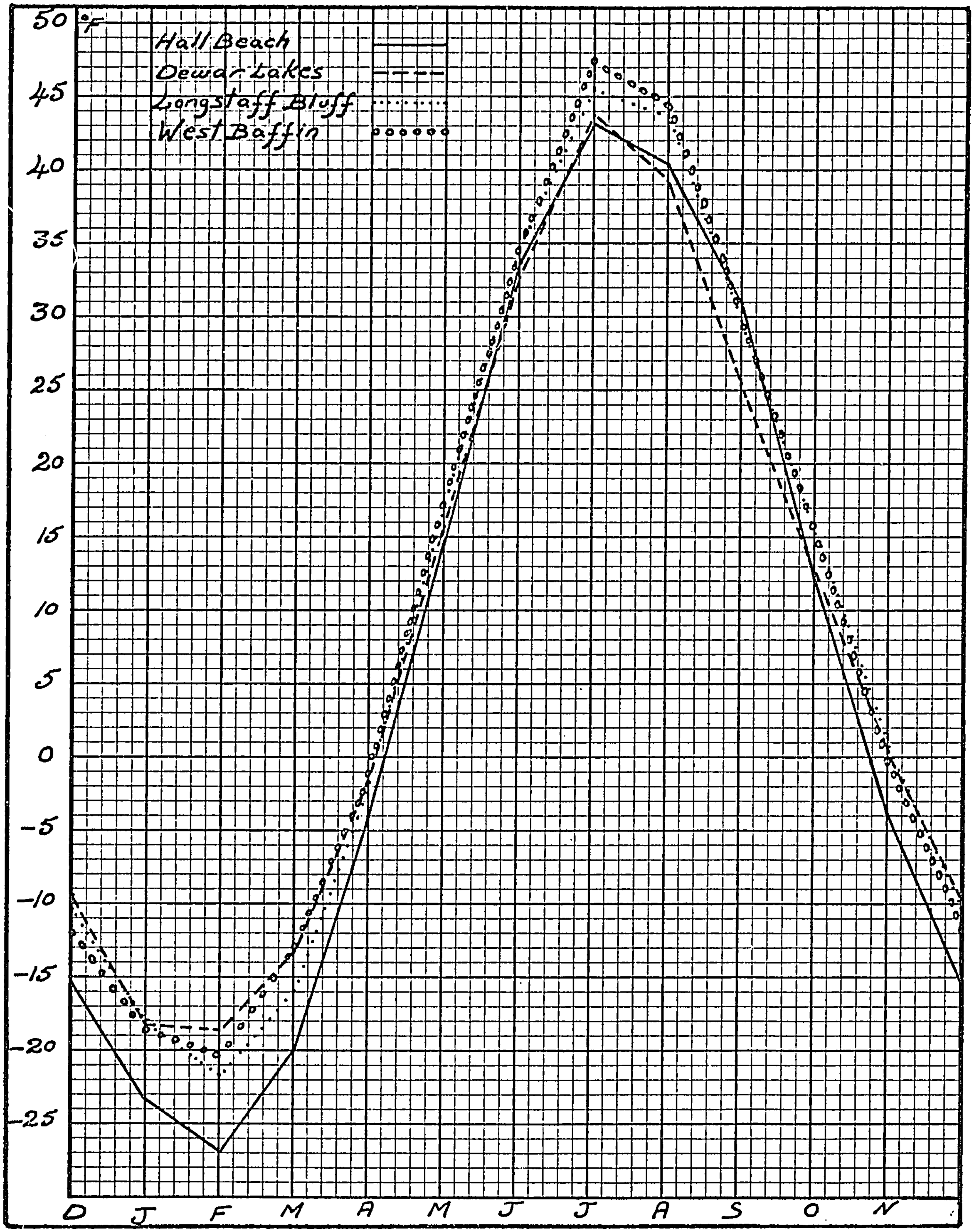

Figure 14
Graph of Mean Monthly Temperatures for Hall Beach and Selected Stations in West-Central Baffin Island

Lakes. All three stations lie approximately on the same latitude, and it is of interest to note the higher average temperatures registered at the two Baffin Island stations. At no time during the winter months does the temperature reach the low values recorded at Hall Beach. The effect is even heightened when it is considered that Dewar Lakes and Longstaff Bluff are at elevations of 1700 feet and 532 feet, respectively. This would imply that Foxe Basin exerts a modifying influence throughout the winter months. In this regard, Markham (1962, p. 6) points out that:

> Mean northerly winds in winter and spring combine with the south-flowing tidal current to produce a persistent polynya in the north-west section of the basin. A smaller clear area is also often observed north of Prince Charles Island but no explanation for it is known.

Coulcher (1959, p. 2) states:

> An unusually large open lead was observed along the eastern shore of Melville Peninsula. ... Primarily caused by a strong neighboring coastal current, ... and its maintenance aided by prevailing north-west winds, the lead is almost always in evidence just offshore.

There is strong evidence, then, that portions of Foxe Basin remain ice free during the winter, and as a result, some measure of modification is forever present.

CHAPTER III. THE CLIMATOLOGY OF BAFFIN ISLAND

A. Introduction

The following chapter treats each of the climatic elements as they apply to the four geographical zones dividing Baffin Island. Weather data accumulated from various stations within a specific zone will be summarized in order to depict the average climate characteristic of that zone. Emphasis will be placed on local peculiarities uncovered from a careful inspection of more recent information, especially those originating from the DEW Line network. In this regard, it might be pointed out that wind patterns across Baffin Island show marked fluctuations from one location to another. This is due largely to topographical influences and pronounced katabatic effects. Other elements such as temperature and precipitation are also affected by topography but to a somewhat lesser extent. The east coast mountain barrier of Baffin Island is instrumental in providing the necessary obstacles for a variety of local meteorological effects. It can also be considered a great divider of weather and climate over the region.

Coverage of the climate of the Arctic has been provided by Hare (1950). Others such as Thomas and Titus (1959) and Wilson (1958) have examined specific synoptic occurrences and related them to local patterns at stations in the eastern Arctic. Kruger (1960) has written a comprehensive summary on Arctic climatology. Thompson (1962, 1967) outlines the major features of Arctic climate and brings much of the records up to date.

Regular publications of the Meteorological Branch which give summaries and reviews are very valuable in providing meteorological data in raw form.

B. The Climate of the Central Plateau and Great Western Plains

1. General Remarks

Dewar Lakes, West Baffin, and Longstaff Bluff are typical sites situated in the area embracing the Central Plateau and Great Western Plains. Observations from West Baffin have not been as frequent as those recorded from the other two major reporting stations, and wind data are completely lacking; however in spite of these deficiencies, the site has provided a few items of interest.

2. The Wind Field

Orographic influences affect wind flow on Baffin Island and are very significant at most stations and dominant at others. The equation of continuity expresses the change an air parcel undergoes in the vertical and horizontal when it is forced over or around an obstruction. An increase in speed is noted where there is compression of the fluid and a decrease when there is expansion.

Wilson (1967) lays down four important rules which can be utilized for operational purposes given a particular topographical situation. The island effect induces anticyclonic flow around an obstacle providing it is more than four miles in diameter. The flow around a bay tends to be cyclonic, providing the bay is more than four miles wide. The flow down a channel or valley is stronger on the right-hand side if the observer is facing down the channel with the wind to his rear. And finally, the highest speed along the side of an outcrop is twice that of the undisturbed flow. It can readily be seen that one or more of these rules can apply to points on Baffin Island.

Wind tabulations for Longstaff Bluff and Dewar Lakes (Table IX, p. 89) readily reflect the dynamic influence of the surrounding topography and of Foxe Basin. Winds from an easterly direction predominate throughout the year, reaching a maximum frequency in July of 32.2 per cent at Dewar Lakes. Secondary wind frequency peaks occur from the west and northwest during the summer and transitional months. These secondary maxima are caused no doubt by two physical processes operating to create the same result. The first, and perhaps the most important, is the development of a very weak anticyclone over the cold waters of Foxe Basin during the late spring, summer, and early fall months. Although this weak circulation tends to be damped out by the "barrier circulation", it has nevertheless a significant influence on wind directions. Superimposed on this effect is the sea breeze mechanism which also contributes its share in producing a light onshore flow. The secondary frequency maximum at Longstaff Bluff of 16.2 per cent from the west in July helps to confirm the existence of these two meteorological processes.

As previously mentioned, winds are favored from the east and northeast in all seasons. By virtue of their location, the sites are subject to the thermal influence from nearby Foxe Basin and also by the barrier effect of the east coast mountains of Baffin Island.

In winter, open leads and sensible heat flux through the ice cover induces a weak thermal low over Foxe Basin and the resulting flow around the basin is cyclonic in nature, producing a high frequency of west to northwest winds along the east coast of Melville Peninsula and easterlies over western Baffin Island. Downshore or katabatic influences influences also enhance the prevailing east to west flow of air over the Central Plateau and Great Western Plains.

The formidable eastern mountain barrier is the indirect cause of yet another phenomenon - strong winds. These winds can occur at any time of the year, and are especially well-developed when cyclonic activity dominates the flow over south-central Baffin Island; however, both stations record maximum winds greater than 40 m.p.h. in the mid-winter months. It is during this period that intense radiational cooling creates strong inversions. The barrier effect further aggravates the situation and a marked increase in surface wind speed results as the air is forced into a constriction, unable as it is to penetrate upward through the inversion and prevented from moving eastward by a high mountain range.

Local topography in the neighbourhood of Dewar Lakes and Longstaff Bluff determines to some extent the directional frequencies of surface winds by inducing minor channeling. The higher percentage of south and north winds at Dewar Lakes can be attributed to the nearby river valley effect. Northeasterly winds at Longstaff Bluff, a high percentage of which are recorded during the colder months, can be traced to katabatic flow originating from the Barnes Ice Cap.

3. <u>Temperature</u>

The annual march of temperature for Longstaff Bluff, Dewar Lakes and West Baffin (Fig. 14, p. 35) show a close parallel. Admittedly, the length of record is short (only four years) but nevertheless, the basic initial trends have been established.

The lower average temperature observed at Dewar Lakes in September and October is likely caused by a higher incidence of clear skies more typical of inland stations. Radiational cooling is not as pronounced at a coastal station such as Longstaff Bluff and West Baffin, owing to the advection of heat from the nearby waterways. Once freeze-up has been accomplished in late November, the differences in average temperature is largely wiped out. It is presumed that the mid-winter air mass modification which is felt at Longstaff Bluff, due to its proximity to Foxe Basin, is also felt at Dewar Lakes.

Although records are sparse, it can be assumed that the lowest temperatures recorded over Baffin Island are found in more isolated locations on the Western Plains. Hare (in Rand Corporation, 1963, p. 82) remarks:

> It is very probable, though unconfirmed, that deeply enclosed inland basins have mean daily temperatures far lower than their reported values.

Boas (1964, p. VIII) while journeying across the northern end of Cumberland Sound, complains:

> We had to stop with thermometer at F.-55^{o} in the cold snow-house with no chance to melt ice for drinking or cooking anything...

Minimum mean temperatures are reached at about the end of February or very early in March and are recorded during a period of returning sun. There is little warmth to be gained from the initial appearance of the sun as the rays are inclined at a very low elevation and thus the heating effect is still not great enough to compensate for the radiation loss from the earth. Within two or three weeks, however, this condition is slowly reversed and temperatures begin a marked rise.

Longley (1958) studied mean daily temperatures for Resolute, N.W.T. and concluded that the lowest temperatures, on an average, are experienced on the third and fourth days of March. As the stations under study are some six degrees of latitude further south than Resolute, it could be expected that the minimum temperatures there would be registered a few days earlier.

The annual maximum temperatures are observed in early August. Some fluctuations can be expected at coastal stations as to the exact date that the mean maximum temperature is recorded, owing to the advection of fog and low stratus from nearby open water which prevent the full quota of solar radiation from reaching the surface.

4. Precipitation

The average annual precipitation at all stations (Table XII, p. 93) is less than ten inches which is typical for cold desert environments. Once again, it must be pointed out that the years of record are relatively short and this inevitably gives rise to unexplained fluctuations which can only be smoothed out through a longer period of assessment.

From September to May, almost all precipitation falls in the form of snow. This is a particularly difficult element to gauge, as high winds so characteristic of tundra regions can remove the snow from one area and pile it up into high drifts, or fill gullies, in another. Melting and evaporation seldom present a problem, as it does in southern latitudes, for there is no heat from the ground after September and insolation from the sun is almost negligible during the winter months. Frost deposits can increase the depth of snow slightly throughout the

the cold season. In short, the recorded amounts of newly fallen snow cannot be considered very reliable.

Rainfall is confined to the summer months, June to September, and provides the Western Plains with its annual seasonal maximum of precipitation.

5. Clouds

Cloud statistics are not too reliable owing mainly to the difficulty in taking observations during the long Arctic nights, and also to the relatively short length of the records. From Hall Beach, however, some fairly good averages have been processed and they are used here as representative of stations in western Baffin Island.

A study of variations in mean cloud amounts at Hall Beach (Fig. 15) reveals an interesting pattern. Three maxima are observed in February, June and September, and three minima in March, July and December. The maximum in February is caused by observers reporting less cloud than is actually present, until with increasing daylight, cloud amounts which have remained unnoticed during the dark season are finally recorded. The second peak in June is caused by the air becoming saturated beneath an inversion layer. Saturation of the air results from the melting snow and ice giving off substantial amounts of moisture to the air which eventually condenses to form fog or low stratus providing turbulence or orographic lift is present to initiate the process.

Once much of the snow and ice has melted, radiation is free to heat the actual surface of the earth. This destroys the inversion through resulting convective turbulence and produces unfavorable conditions for low stratus formation. Cloud amounts,

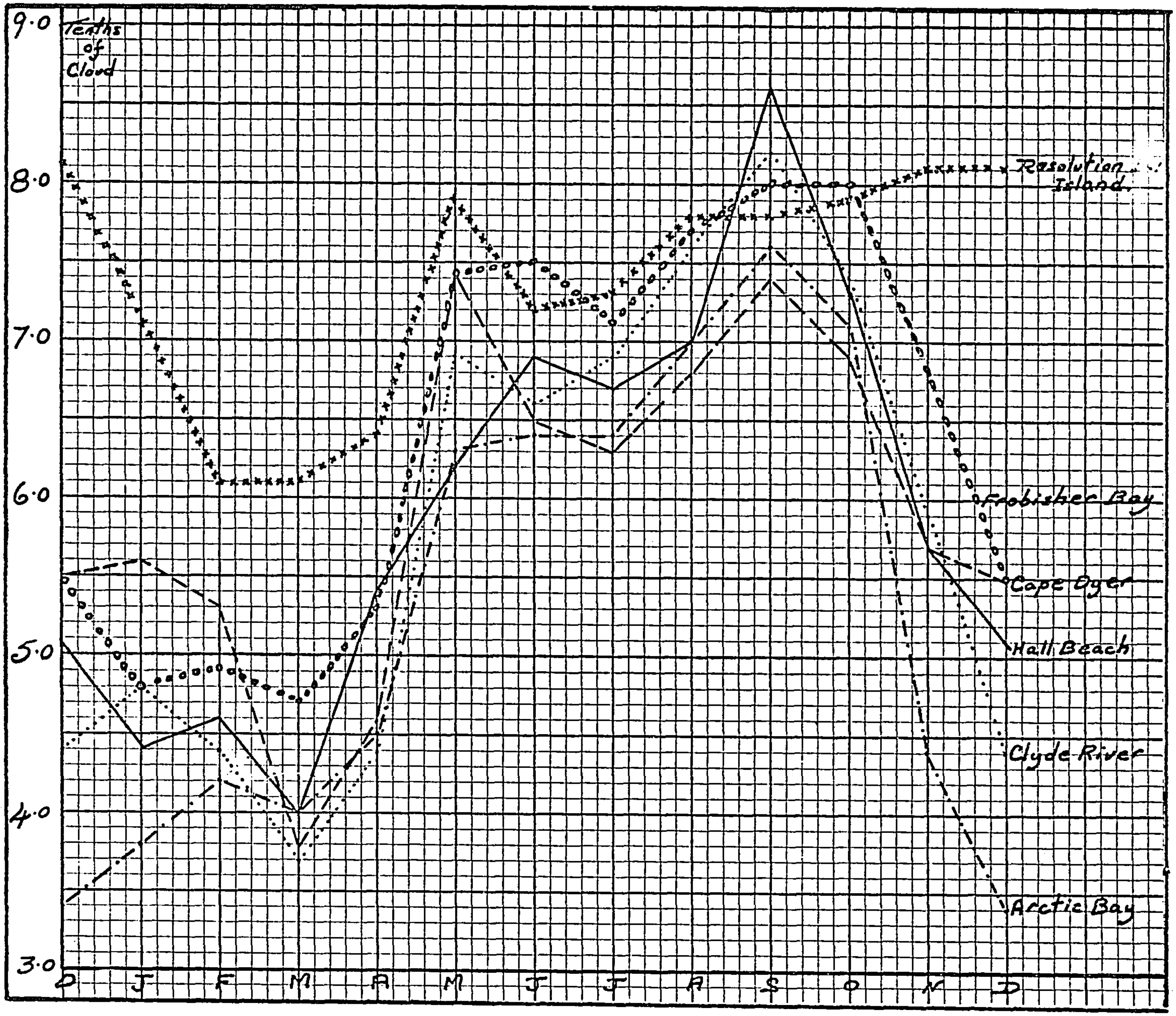

Figure 15. Mean Cloud Amounts for Selected Stations on and Near Baffin Island, N.W.T. (Tenths of Total Sky Covered)

therefore, decrease in July to a summer minimum.

With the approach of fall and rapidly falling temperatures, the interaction between the air and open water areas again plays a prominent role. The contrast between the cold Arctic air and water surface is large enough to create a strong temperature gradient. Convective turbulence results, and as the water provides vast amounts of moisture, extensive cloud and snow showers form. The inversion slowly re-establishes itself over land areas, and with higher than average wind speeds, the cloud is mostly in the form of stratocumulus rather than stratus. Across open water regions, more cumulus cloud is evident because of the increase in convective instability.

Once the freeze-up is completed, the inversion generally extends over all surfaces. A marked decrease in cloud amount ensues and from the annual maximum in September at Hall Beach, the curve drops off to a minimum in December and finally to the overall yearly minimum in March.

C. The Climate of the Fiorded East Coast, Northern and Southern Coastal Bays and Inlets

1. General Remarks

The eastern coastline of Baffin Island presents some of the most spectacular scenery to be found in Canada. The rugged mountains of jagged peaks and serrated ridges rise to great altitudes and are partially covered with permanent ice caps and snowfields. The rock is of Precambrian origin and into it are carved long fiords and deep valleys which rise abruptly from the shoreline and present a formidable and rugged barrier to the eastern entrance of Arctic Canada (Photo 2).

A number of reporting stations afford good meteorological

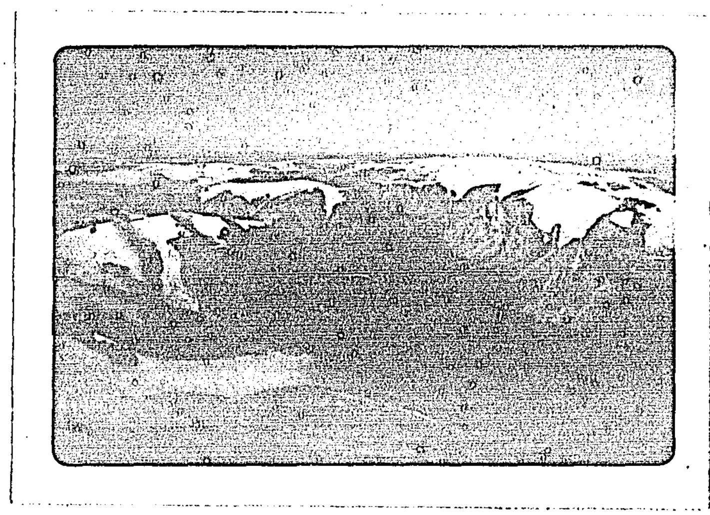

Photo 2. The East Coast of Baffin Island near Cape Hooper, July, 1958. (Photo by B. A. Coulcher)

coverage across this vast, lengthy and sparsely populated area. From Arctic Bay in the north to Clyde River on the 70th parallel, to the stations along the eastern reaches of the Arctic DEW Line, such as Cape Hooper and Cape Dyer, the observing network stretches, finally terminating at Frobisher Bay. Small intermediate sites along the DEW Line have also gathered weather information. Unfortunately, however, their records are of a short duration. Most of the recorded data are very reliable and provide a fund of additional knowledge to the growing awareness that the topography and physical environment of a region is instrumental in producing extraordinary fluctuations in local weather patterns.

2. The Wind Field

The average seasonal wind structure at various points across the area under study exhibits marked local variations caused by surrounding orographic features. Arctic Bay, for example, is situated along the eastern shores of Admiralty Inlet, and as such is protected by high ridges and hills of Borden Peninsula to the west. Wind directions (Table IX, p. 89) favor the north and northwest reaching a maximum frequency of 25.6 per cent from the north in the month of July. Calms also have a high frequency of occurrence, once again demonstrating the protection afforded by nearby hills and mountains. High winds of over 40 m.p.h. are extremely rare.

The eastern coastline of Baffin Island is extremely rugged and the wind frequencies strongly reflect the influence of this feature at most stations. Clyde River is not dissimilar to Arctic Bay in this respect. Tucked away in a shallow valley near the end of a broad peninsula which rises steeply toward the east coast mountains to the west, the outpost has a high percentage of calms at all seasons with the exception of October. At that time, the dynamic influence of the relatively warm waters of Baffin Bay and the deepening west Greenland trough interact to create an intensifying northerly gradient and low level instability.

North to northwest winds have a high frequency of occurrence throughout the year. Only in July are there indications of any marked shift to a more southerly direction. This would tend to confirm the presence then of a weak anticyclonic circulation over eastern Baffin Island south of 70°N latitude (Fig. 4, p. 21).

Owing to its elevation and nearby topography, Clyde River is not a windy place. High winds above 39 m.p.h. occur only 0.4 per cent of the time, with January being favored with a maximum peak of 1.0 per cent. Maximum wind speeds rarely exceed 30 m.p.h. In January, for instance, only once has the wind been recorded over 40 m.p.h. since 1955.

Further along the coast is Cape Hooper, located at the northeastern tip of a very narrow isthmus. A well-marked wind peak from the west is observed at all seasons, although in July a maximum frequency of 14.5 per cent from the southeast once again lends support to the existence of a weak high pressure area centered just off the east coast.

The remarkably high percentage of westerly winds are caused by several factors; the primary one being orographic channeling, provided that the pressure distributions are favorable. Nuduing Fiord represents an ideal flow path for colder outflow winds to travel along and pressure patterns throughout the year are conducive to the maintenance of this steady offshore circulation. Katabatic effects, spawned in the vicinity of the mountainous terrain to the west and aided by the temperature difference between land and sea, are likewise instrumental in producing a west to east gradient. When the katabatic mechanism and a favorable pressure gradient are superimposed, the onset of severe west winds is assured. Once started, these winds have been known to howl for days, producing such turbulent conditions near the surface that attempts to land aircraft on the nearby aerodrome are not contemplated. An instance of such a situation can be seen in Fig. 16. In this case, a small "bubble low" migrated north-westward along the east coast until the center had passed just to the north of the station, whereafter it was likely that strong winds commenced. The prediction of these violent winds is extremely difficult for in many instances there is seemingly no evidence of a meaningful pressure gradient developing.

Super-gradient winds have been studied by a number of people such as Fraser (1959), Rae (1951) and Dewar (1952). Ball (1957) examined fluctuations in katabatic winds at Commonwealth Bay, Antarctica, and notes that periods of violent winds are interspersed with curious periods of lull. Stefansson observed a similar effect near Cape Parry, and states:

> Travelling northward you notice a light breeze at your back, six or eight miles from the edge of the plateau. By the time you reach the edge, about three or four miles from the ocean, and begin to descend there is a terrific gale blowing. This gale may be 60 or 80 m.p.h. on the beach, but if you proceed north along the neck of Parry Peninsula eight or ten miles from the cliffs, you gradually walk out of it and find yourself in calm weather or in a light wind blowing in another direction.
>
> (Fraser, 1959; p. 2)

Fletcher (1958) maintains that one of the most difficult problems at Thule, Greenland, is the forecasting of hurricane force winds of 50 to 80 knots which blow across the approach zone of the runway and which begin and end very suddenly. Not

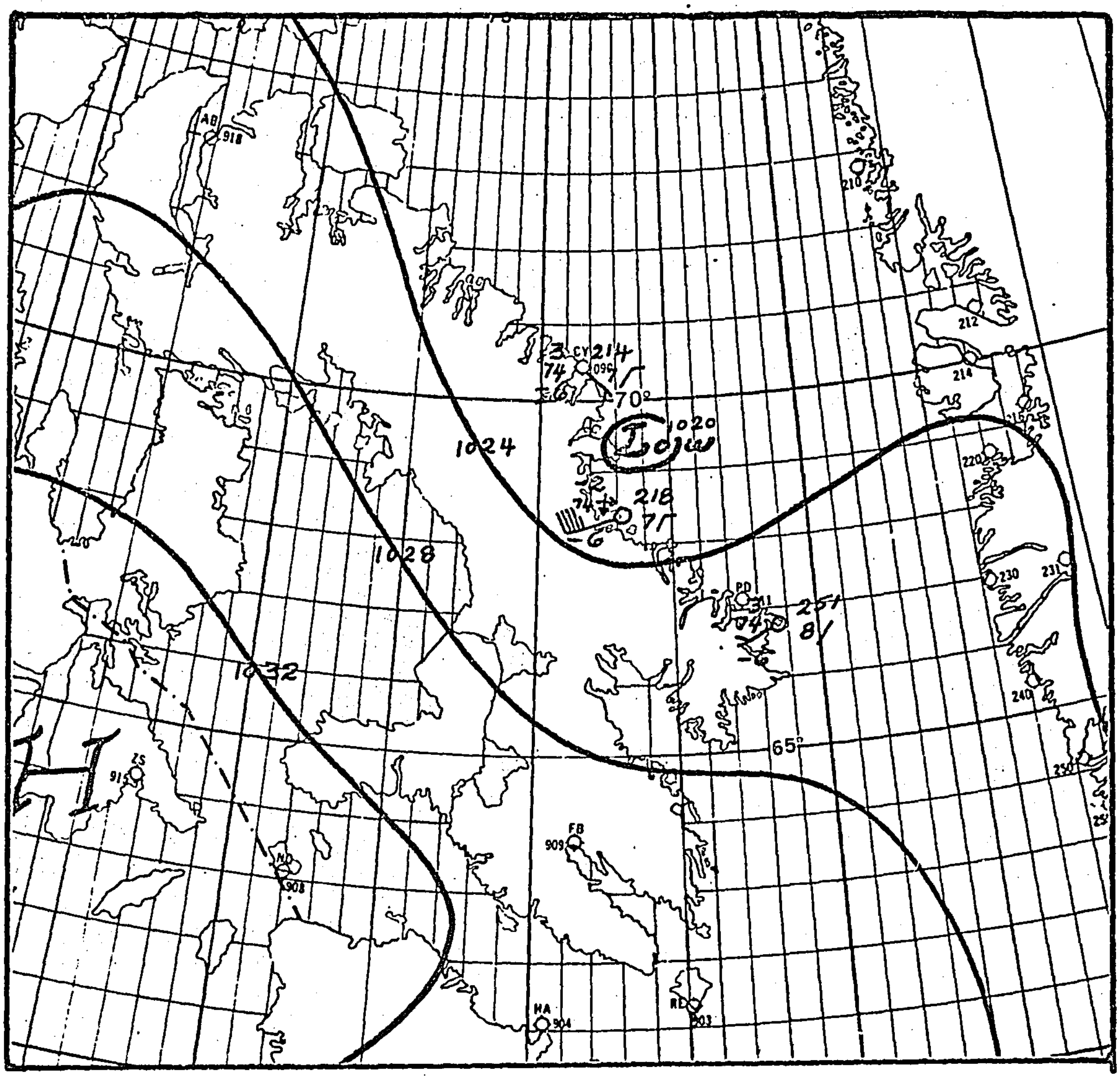

Figure 16. Surface Weather Map for April 19, 1967, 1800 G.M.T.

only the violence but also the direction of these winds is hard to explain.

It would appear that somewhat similar processes are at work at Cape Hooper. Fraser (1959) investigated the unstable characteristics of northeast winds at Resolute Bay and records:

> Northeasterly gradient winds at Resolute are reinforced by a strong katabatic flow off a range of hills immediately east to northeast of the air-strip. When the katabatic flow is confined to a surface layer surmounted by a strong inversion, a jump line may develop at some point on the slope or downstream from it. At the jump, the downflowing cold air undergoes an abrupt increase in depth and decrease in velocity. Landward and seaward motion of the jump line over Resolute causes sudden changes in surface wind conditions. (Fraser, 1959, p. 1)

Defant (1948) found that a slope of 1:100 is the critical point in the drainage of shallow cold air. For slopes less than 1:100, a steady current can be disturbed without the eventual formation of turbulent flow as the propagated wave disturbances of a definite period are eventually damped out by friction. However, given a slope greater than 1:100, the disturbances will grow exponentially with time and the current assumes an unstable and turbulent form.

It is perhaps unwise to state categorically that a parallel situation exists at Cape Hooper. However, it can be assumed that a close similarity does prevail between Cape Hooper and recorded instances of like phenomena at other points in the Arctic and Antarctic. Even local topography and offshore open water at Cape Hooper lends itself to comparison. At any rate, the entire subject of katabatic, or gravity winds can withstand a good deal more investigation, particularly so in that it presents a formidable hazard to aircraft.

Strong winds at Cape Hooper blow almost without exception from a westerly quadrant. January is the favorable month with six per cent of the total number of observations being over 39 m.p.h. Because of its exposure and subsequent lack of adequate protection, the percentage of calms is not as great as those reported from the more sheltered localities of Clyde River, Arctic Bay and Pangnirtung.

Broughton and Padloping Islands, both of which are located on the east coast of Baffin Island, have furnished some fairly reliable wind data. The stations are far enough away from the mainland to permit them a modicum of protection against the fitful outflow winds thought to emanate from the east coast fiords. This fact can readily be seen at Broughton Island where only 0.9 per cent of the wind observations are greater than 39 m.p.h. Unfortunately, no comparable data are available from Padloping. Thus it can only be surmised that conditions here are not entirely dissimilar to those at Broughton, although it is interesting to note that the percentage of calm weather is indeed very low. Data processed by the United States Weather Bureau (Table II) reveals that winds between 32 and 46 m.p.h. at Padloping Island, from the years 1948 to 1951, blow most frequently from the northwest quadrant in winter with a noticeable shift towards the southwest during the warmer months. Winds greater than 46 m.p.h. are rare, but when they do occur, the directional frequencies are much the same.

Table IX, p. 88 shows that throughout the year, the frequency of north and northwest winds are the greatest. A secondary peak from the southeast emerges in the month of July. The strong prevalence of winds from the north and west reflects the dominance of the West Greenland trough throughout the year and also steering

TABLE II

Directions from Which Winds of Higher Speeds Were Reported, Padloping Island, N.W.T.

Speed	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
		N	N	N	N	SW	NW	N	N	N	N	N
			NNE		NNW		NNE	NNE	NNE	ENE	S	NNE
32 to 46	N	NNW	NNW	NE		NNE	WSW	SSE	NE	E	SW	
m.p.h.		W	SE		NE	E	SW	S			WSW	NE
	NW		W	W	W	SW	SSW	SSW	S		W	S
				NW				SW	SW	S	WNW	
						NNW		NW	WSW	SW	NW	W
								NE	W	NW	NNW	NNW
								WSW	WNW	W		
								W		NNW		
		NNW		WNW	WNW	NE		N	N			
Greater				E				S				
than 46								SSW				
m.p.h.								SW				

Data for Padloping has been taken from summaries from punched cards compiled by the U.S.W.B. This is not the hourly wind as used at the other stations but the wind over a period of about a 1-minute interval as reported on hourly weather reports.

induced by topography.

Cape Dyer lies on the extreme eastern headland of Baffin Island. It is bounded by rugged peaks and fiords to the west and is flanked by Davis Strait to the east. These neighboring physical characteristics are instrumental in creating a host of meteorological problems such as turbulence, fog, and low stratus formation and blowing snow. The surface wind element is perhaps the most important single factor to predict accurately as both the severity of local turbulence and the onset of fog in spring and summer and blowing snow in winter, depend upon it.

From wind data accumulated since 1959 (Table IX, p. 88) it can be seen that the prevailing direction is west to northwest with a marked peak of 25.7 per cent from the west in October. Secondary northeasterly maxima are observed in January and April, attaining values of 13.6 and 12.8 per cent respectively. These are probably caused by intense, migrating cyclones travelling into the regions of the Labrador Sea and southern Davis Strait, or by "break off" or "bubble lows" moving up along the west coast of Greenland reinforcing in turn the West Greenland trough.

In July, a higher wind frequency is noticed from the south and southwest which is in keeping with the seasonal changes of the average pressure pattern. Low stratus and fog persistence is very noticeable during the summer months.

The predominance of winds from the westerly quadrant reflect the nearby presence of Exeter Fiord. Not infrequently, violent katabatic winds are reported funnelling out of the fiord inducing gusty winds at the aerodrome, severe turbulence and walls of blowing snow in winter. Here again, as in the case of Cape Hooper, the commencement of these particularly violent winds is subject to minor fluctuations in the local pressure gradient which are difficult to foresee. Pilots have reported hearing the distant moan of the wind while absolute calm prevailed at the aerodrome. Blowing snow accompanied this phenomenon on several occasions, thus providing ample evidence of this strange and ghostly effect. The wind sock at the end of the aerodrome has been seen to strain under winds estimated to be well over 30 m.p.h., whereas near the loading zone, not a breath stirred. In this regard, Fraser (1959, p. 3) remarks with reference to Resolute Bay:

> It was noted that, ... a flag on the shoran radio station, located on top of the hill upwind to the north-east and about 600 feet above the airstrip, barely showed movement at times when the airport winds were in excess of 30 kts.

Cape Dyer is a particularly stormy place in winter. Winds greater than 40 m.p.h. occur almost 8 per cent of the time in January. The January average pressure distribution (Fig. 2, p. 19) shows a relatively steep pressure gradient across southeastern Baffin Island. Percentage of calms is low throughout the year when compared with other localities. Winds of hurricane force are not uncommon during a normal winter and are usually associated with the development of an intense trough along the west coast of Greenland. Some interesting one-minute wind speeds are noted in Table III for January and April.

Pangnirtung, near the head of Cumberland Sound, lies at the entrance of a deep fiord which penetrates the Penny Highlands. It represents still another example of a station strongly influenced by local topography. The dominant wind direction in the winter and transitional months is from the northeast; the flow being channeled down the northeast to southwest oriented fiord by

TABLE III

Wind Direction and Maximum Speed at Cape Dyer, N.W.T.

Year	January		April	
	Day	Direction and Speed (m.p.h.)	Day	Direction and Speed (m.p.h.)
1960	8	WNW 50	14	NW 30
1961	23	NW 80	10	NW 45
1962	29	NNW 80 gusts 100	5	NE 90
1963	29	NNE 70	2	WNW 70
1964	25	WNW 50 gusts 65	1	WNW 68
1965	31	WNW 72	1	WNW 75
1966	14	N 46	28	W 35

the prevailing pressure gradient. In July, a pronounced shift to the southwest is evidenced as a weak cyclonic circulation develops over Hudson Strait. Air is piled up at the northern end of Cumberland Sound and no exit remains other than to infiltrate the upper fiords. The frequency of southwesterly winds is high, approaching a value of almost 50 per cent. Much of the snow at lower elevations has melted and thus daytime heating accentuates the sea breeze effect.

Calm weather is confined mainly to the winter and spring months when strong stabilizing inversions form near the surface. No statistics are available on strong wind occurrences but it is presumed that katabatic influences are ever present.

Lake Harbour lies on the northern coast of Hudson Strait about 80 miles southeast of Frobisher Bay. Fiords are absent and the outpost is therefore more subject to seasonal changes in the pressure distribution rather than pressure and topography combined. Prevailing winds blow from the north and northwest at all seasons. An increase in flow from the south to southeast is apparent in July in conjunction with the formation of the Hudson Bay low and diurnal temperature fluctuations.

Frobisher Bay, an international airport and site of a major forecast office is perhaps the most important center on Baffin Island. A strong relationship exists between the geographical location, the topographical features of the area, and the occurrence of strong winds.

In Table IX, p. 88, it can be seen that throughout the year north to northwest winds are favored directions with south to southeast winds reaching a maximum from July to October only. Northerly winds can be attributed to the channelling effect of topography around Frobisher. The west Greenland trough is the cause of the prevailing northwesterly circulation throughout the year. Wilson (1958) discusses the west Greenland trough and concludes that it can develop at any time of the year, but is likely to be more persistent and deeper during the winter months.

Verge (1962) explains that wind speeds of over 25 m.p.h. occur mostly from the north and northwest in the winter and from the southeast in summer. The summer direction is caused by the thermal trough and preferred cyclonic track which lies over Hudson Strait.

Selected data concerning maximum wind speeds at Frobisher for the months of January, April, July and October (Table IV) show that in January, the strongest winds favor the northeast quadrant. This can only be explained by realizing the fact that the most intense cyclones stall or gradually undergo a decrease in forward acceleration as the system approaches the northern Labrador Sea. Further movement northward leads to a filling of the low and a slackening of the pressure gradient which, by the time the cyclone reaches Davis Strait, has orientated itself along a north to south line over Frobisher Bay. Winds from a northeasterly quadrant blow at a 90° angle across the hills to the east producing severe turbulence at lower elevations.

As spring progresses, so the cyclonic track moves even closer to southern Baffin Island. These systems tend to move rapidly through the region, attaining maximum intensities further to the north and east of Frobisher Bay. Hence wind speeds are strongest from the northwest, yet the initial beginnings of an increased frequency of strong southeasterlies can be seen.

TABLE IV

Wind Direction and Maximum Speeds at Frobisher Bay, N.W.T.

Year	January	April	July	October
1957	NW 45 +53	NW 42 +51	NW 30 +36	NW 40 +60
1958	NW 45 +55	NW 60 +70	SE 50 +73	ESE 45 +64
1959	E 52 +85	NNW 40 +64	E 30 +44	NW 44 +56
1960	ENE 60 +80	NW 44 +59	SSE 27	NE 42
1961	NW 52 +68	NW 38	NW 34	NW 53 +64
1962	ENE 67 +87	NW 72 +95	SE 28 +35	NW 48 +56
1963	ENE 60 +91	NW 36	NW 36	NW 50 +59
1964	NNW 55 +68	SE 50 +67	NW 31	E 47 +61
1965	MSG	NW 38	NW 27	NE 38 +46
1966	NNW 46	NW 40 +52	NW 25 +32	NW 42

+ refers to "gusts".

In summer, the storm track lies directly over Hudson Strait, thus primary deepening of the low creates a southeast gradient over southern Baffin Island. The cyclonic path normally points to central Hudson Strait in July, at about which time the disturbance has reached maximum intensity, whereafter it either curves into Foxe Basin or eastward into southern Davis Strait.

The funnel effect at Frobisher Bay is paramount in maintaining the high prevalence of northwest and southeast winds. Seldom are winds recorded from the southwest.

What part katabatic winds play in the local circulation is difficult to determine. During winter months, with open leads creating a temperature gradient just offshore, the katabatic effect is almost certainly to be present, but certainly not to the extent that it is found at Cape Hooper, Cape Dyer, or Dewar Lakes. Periods of near calm interrupting high northwesterly or northeasterly winds have been reported, thus pointing to the existence of a katabatic flow. Furthermore, it is generally believed that the funnel effect is sufficiently pronounced so that 15 to 20 miles per hour can be added to the gradient wind in a northwesterly circulation.

Calm weather reaches a peak in mid-winter with an average frequency of 42 per cent in January. In October, the percentage of calms recorded is only 10 per cent. This minimum can be attributed to the unstable character of the prevailing northwest flow as it gathers up heat and moisture over the waters of Foxe Basin and larger inland lakes. Thermal effects thus produce a steeper gradient leading to stronger winds.

3. Temperature

The climate of the fiorded east coast, northern and southern coastal bays and inlets of Baffin Island is essentially maritime. The winters are not as extreme as in more sheltered interior locations of Baffin Island, and conversely, the summers are not as warm. Annual temperatures (Fig. 17) show a marked range in values between the northern and southern coastal regions. The average January temperature between Arctic Bay and Cape Dyer, for example, shows a difference of almost 15°F. This is narrowed during the late spring, and from May to September, average temperatures at both stations closely parallel each other (Fig. 17). In autumn, the spread is once again widened, until about December when the difference again exceeds 15°F.

Arctic Bay being well north of the Arctic Circle and being far less exposed than Cape Dyer, records much colder winter temperatures. Its sheltered location and long nights stimulate the formation of low level inversion during the cold season. Cape Dyer, on the other hand, lies at the entrance to the eastern Arctic and is readily exposed to the moderating winds of the nearby North Atlantic. In summer, both stations experience a maximum of daylight, the waterways become largely ice free, and the true maritime influence is then exerted.

The highest July temperatures are registered along southern Baffin Island. Frobisher Bay, for example, has an average July temperature of almost 47°F., while Lake Harbour and Pangnirtung both record July means of 46°F. It is highly probable that mean temperatures of nearly 50°F are found at more interior locations. In this regard, Montgomery (Baird _et al_., 1950) remarks on observations taken at upper Clyde Inlet during the summer of 1950 (p.145):

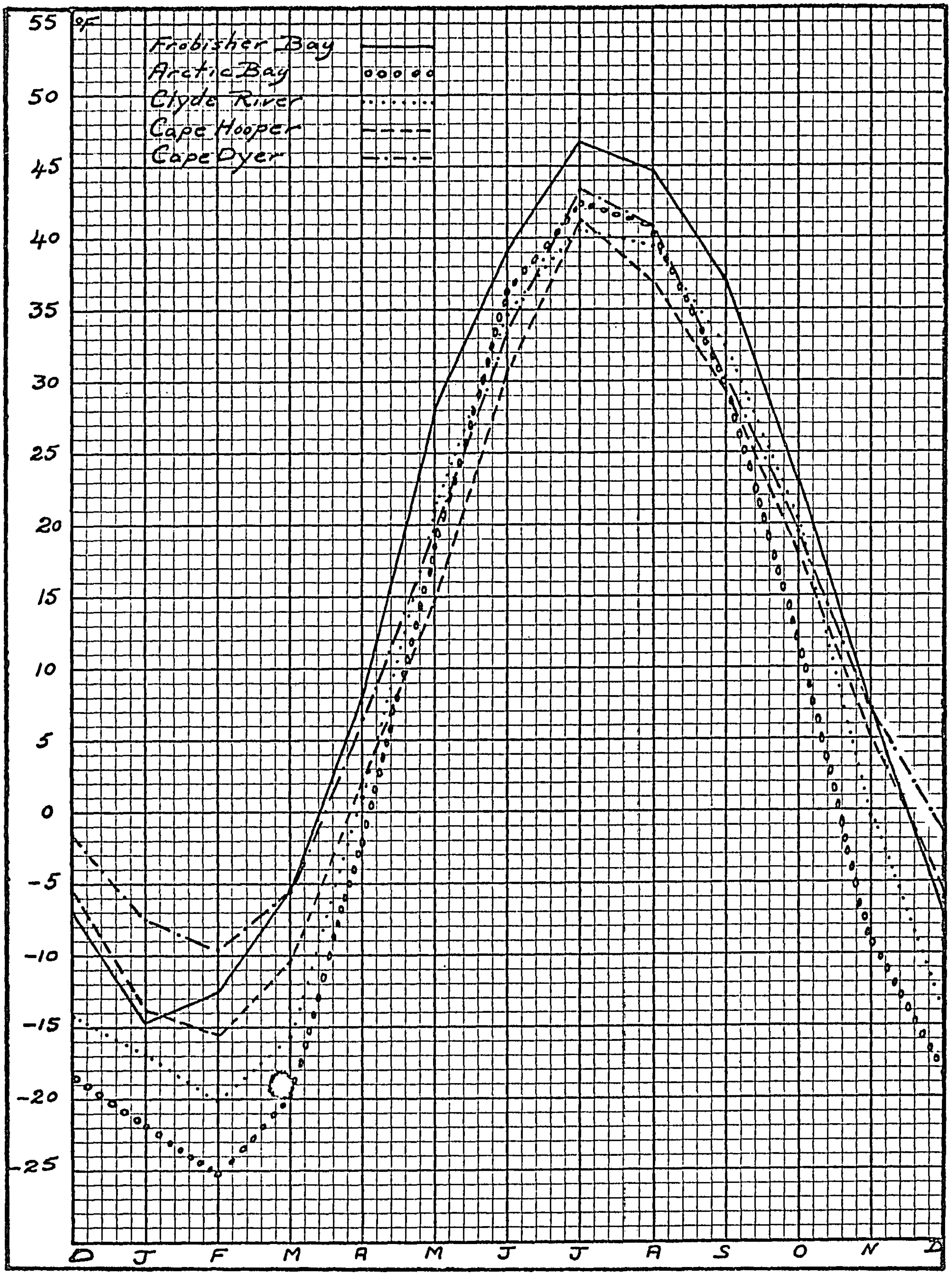

Figure 17. Graph of the Mean Monthly Temperatures for Stations Along the Fiorded East Coast, Northern and Southern Coastal Bays and Inlets of Baffin Island, N.W.T.

> Comparison with reports from camps on neighbouring fiords, however, suggest that conditions ... were decidedly more favourable than at the heads of the more exposed fiords and the station appears to represent a climatic "soft spot" reminiscent of similar protected areas in rift valleys and fiords along the Labrador coast.

Additional data collected in 1950 showed that the only continuous frost-free period was from July 15 to August 20 inclusive, and only eight days did the minimum temperature remain above 43°F. The highest temperature recorded was 71°F in July.

Montgomery (Baird _et al_., 1950, p. 146) further notes that:

> Since the 1950 summer was a particularly unfavourable one according to the records of the regularly established Baffin Island stations, it seems probable that in a "normal" year higher mean temperatures and a frost free period of about six weeks duration might occur.

From Figure 17, it can be seen that the graphs of all stations north of the Arctic Circle have late spring and summertime average temperatures within two or three degrees of each other. In short, there is a sharp decrease in the north to south temperature gradient across the Island as the marine influence reduces temperatures to a more uniform level. Average summer temperatures at Cape Hooper and Broughton Island are for the most part one to two degrees cooler than at most other points. This is likely to be due to the elevation of both sites, although the cold katabatic, or Bora type winds, cannot be excluded as having a decided cooling effect at Cape Hooper.

February is the coldest month for all stations, with the exception of points on extreme southern Baffin Island. Frobisher Bay and Lake Harbour, however, experience their coldest month in

January. This is obviously due to the more southerly location of the two stations. An earlier increase in net solar radiation and slightly higher frequency of cyclonic disturbances invading the southern peripheral or marginal areas of the Island are sufficient to cause the upward trend in temperature.

Temperature extremes are not as drastic as those recorded at more continental localities on the same latitude. The modified marine climate prevents temperatures from falling to low in winter and rising much above 60°F in summer.

In winter, the cold is more persistent than extreme, and although average readings remain well below zero, they rarely, if ever, fall below -50°F. Arctic Bay has recorded an absolute minimum of -57°F; Pond Inlet, -64°F; and Frobisher Bay, -49°F. Sites along the east coast of the Island have reached -48°F at Clyde River and only -43°F at Broughton Island, although it must be made clear that records for Broughton Island exist for only five years. Nevertheless, at Padloping Island, an 11-year period of record discloses that the temperature has fallen to an absolute minimum of only -49°F.

In summer, maximum temperatures well into the 70's have been recorded. These extremes are usually induced by a light offshore circulation created by a favorable pressure distribution sufficient enough to temporarily overcome the sea-breeze mechanism at various points on the island. The air absorbs heat from the relatively snow-free land and, in most cases, is further warmed by subsidence as it flows gently down-slope towards the coast from more upland areas in the interior. Pond Inlet records an absolute maximum of 77°F; Arctic Bay, 75°F; Frobisher Bay, 76°F; and Lake Harbour, 80°F. Records along the outer coast reveal lower values with Padloping Island registering 73°F; Cape Dyer and Cape Hooper, 66°F; and Kivitoo, 71°F.

Maximum temperatures at Frobisher Bay are, without exception, attended by light northerly offshore winds flowing down from the broad upland trough to the northwest. Adiabatic heating of the air also occurs as the air parcel rides down the gently sloping plain into Frobisher Bay.

Abnormally mild temperatures in winter are a direct result of maritime air penetrations into the eastern Arctic from the Atlantic. A notable example of this occurred in January, 1958 when strong blocking action over Davis Strait coupled with a deep cyclonic vortex at 500 millibars, centered over the southern Hudson Bay, pumped warm Atlantic air across Baffin Island. Temperatures during this situation reached unusually high values for mid-winter (Table V). A similar situation developed on January 18, 1959, the following year (Fig. 38, p. 136).

Diurnal ranges in temperature reach a maximum in April, decrease from then on, and increase to a secondary maximum in July. The decrease in amplitude during the early summer is caused by several factors. Stations north of the Arctic Circle receive twenty-four hours of daylight, thus in large part robbing the earth's surface of any significant radiational cooling. Any rapid rise in daily mean temperatures is prevented by the absorption of heat by the melting ice and snow; and finally, a sharp increase in fog and low stratus cloud is evident from April to June. With the arrival of July, the land is largely snow-free and with the sun at its greatest declination, differential heating of the ground produces a noticeable decrease in cloud amounts and a subsequently higher range in the daily temperature cycle.

TABLE V

Extreme Highest Recorded January Temperatures

Station	January 1958	Previous Record	Year
Arctic Bay	40°F	28°F	1945
Clyde River	29°F	31°F	1955
Frobisher Bay	39°F	30°F	1955
Hall Beach	34°F	12°F	1956
Pangnirtung	-	48°F	1931
Resolution Island	35°F	34°F	1940

Adapted from Thomas, M. K., and R. L. Titus, 1958.

Strong inversions in winter at more protected stations such as Arctic Bay, Pond Inlet, and Frobisher Bay are not conducive to significant diurnal ranges in temperature. The marine influence along the immediate coastline also forbids large changes in the diurnal temperature structure at sites such as Cape Hooper, Cape Dyer, etc. Winter cyclonic disturbances through Hudson and Davis Straits can produce large ranges over Baffin Island as Arctic air masses can temporarily become dislodged for short periods of time.

4. Precipitation

The mean annual precipitation varies widely from one end of Baffin Island to the other. Arctic Bay records an annual mean value of 5.91 inches, whereas Cape Dyer measures over 26 inches annually, and Frobisher Bay, 13.3 inches. Pangnirtung, situated approximately on the same latitude as Cape Dyer, has about half the annual total of precipitation, registering 16.18 inches. Protection afforded by the mountains to the southeast plays an important part in reducing rain and snowfall amounts.

There are at present indications that the averages for Cape Dyer will have to be revised upward in view of excessively heavy amounts which fell in the autumn of 1966. The Canadian Weather Review (Meteorological Branch, 1966, p. 1) remarks:

> Snowfall was extremely heavy at Cape Dyer on Baffin Island where a new record fall for any month of 93.1 inches was experienced.

Rainfall is confined to summer months, although southern sections have received precipitation in the form of rain on rare occasions during the winter. Snow can be recorded at any time in summer.

Much of the annual precipitation falls in the summer when cyclonic activity is at its maximum. Even so, stations to the north register small amounts of rainfall compared to locations to the south. Precipitation in July at Arctic Bay is only 0.68 inches. At Cape Dyer, it is 1.06 inches, while Frobisher Bay records 1.80 inches. August totals are significantly higher at most stations as summer cyclonic activity reaches a peak.

On August 19, 1960, record rainfalls were measured on Baffin Island and other centers across the central Arctic. The deluge was primarily caused by a deepening cyclone which moved northward from the west-central Hudson Bay into Foxe Basin (Fig. 26, p. 113). Very warm, moist maritime tropical air was injected into the Arctic at high levels ahead of this system giving up copious amounts of moisture in the form of rain. One day maximum precipitation totals included 1.33 inches at Frobisher Bay, 1.54 inches at Cape Dyer, 1.47 inches at Clyde River, and .33 inches at Arctic Bay.

Other forms of precipitation which deserve mention but which are difficult to measure, include rime, hoarfrost and fine drizzle. Snowfall itself is not the easiest to measure, as high winds are permitted to carry the fine powdery snowflakes into drifts or gullies. This is especially true along the east and south coasts of Baffin Island. In very cold weather, water vapour in the air may condense to form ice crystals, a measurable deposit of which may accumulate at the station. Cold winds blowing onshore across open leads may pick up moisture and deposit it on land in the form of very light snow. Frobisher Bay lends itself to such a phenomenon when a light southeast wind occurs in winter.

5. Clouds and Fog

Published cloud statistics for Arctic Bay, Clyde River, Cape Dyer, and Frobisher Bay (Table XIII, p. 95) resemble those from other Arctic points. The triple maxima and triple minima are clearly depicted in Fig. 15, p. 44). Both Clyde River and Cape Dyer show a January peak in total cloud amount, one month earlier than most other stations. It is felt that open water in Baffin Bay and Davis Strait provides the moisture source for the formation of this cloud which is commonly of the stratus variety. A distinct minimum is reached in March as frigid winter temperatures have all but covered the area with a layer of ice, thus sealing off, to a large extent, the moisture supply.

All four stations report an annual maximum of cloud in September for reasons explained earlier in this paper (see p. 43). A minimum of cloud is recorded in March. Little data are available from other DEW Line establishments along the coast, but it could be said with some confidence that their statistics would closely resemble those of Clyde River and Cape Dyer.

Table XIV, p. 95 gives an indication of cloud amounts that can be expected during the warm and cold months at some of the DEW Line locations. Cape Dyer has the least range between the two periods with 51 per cent in January and 62 per cent in July. Of interest are the two stations in the Great Western Plains area, Dewar Lakes and Longstaff Bluff, both of which record differences of 23 and 24 per cent, respectively. The more continental climate of the latter two stations is contrasted with the marine exposure of Cape Dyer. This is readily displayed in January when the contrast is heightened considerably.

Convective activity in the form of thundershowers or thunderstorms seldom, if ever, reach high latitudes. When they do, it is a rare occurrence and is usually an indicator of warm advection aloft. Summertime air mass buildups are equally as rare but across southern Baffin Island they do appear, as evidenced in Photo 3.

It is not often that jet stream cirrus can be seen in the high Arctic. However, an example of this phenomenon can be seen in Photo 4, taken in early November, 1959.

a. <u>Local Climatic Studies for Frobisher Bay, N.W.T.</u>

i. <u>Fog and Low Clouds</u>. Some interesting statistics on cloud base and visibilities have been computed for Frobisher Bay. Six years, 1955 to 1960, were studied and the results are shown in Table VI and Figure 18. By far the greatest number of instances where ceilings were 400 feet or less and where visibilities were one mile or less, occur with wind directions orientated from the northwest quadrant in winter, and from the southeast or south-southeast in the early spring, through to early fall.

Low ceilings and visibilities have a high frequency of occurrence throughout the year when the gradient is from the southeast, but a maximum is reached in July. This pattern is not surprising, for winter cyclonic disturbances affecting Baffin Island are usually heralded by strong southeast winds and blowing snow, whereas in summer, fog and flow stratus are the major ingredients producing inclement weather. Blowing snow is the important cause of poor weather in winter, and this invariably comes on the heels of strong northwest winds. Low ceilings and visibilities rarely accompany a northwest circulation in summer, as an offshore flow is usually attended by favorable weather.

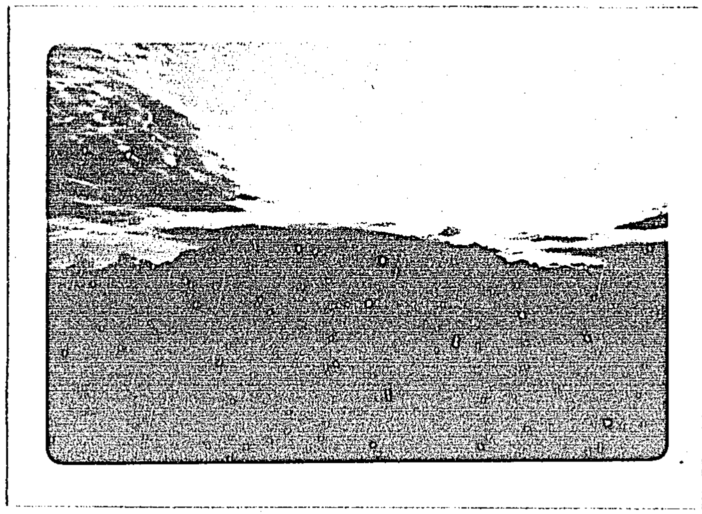

Photo 3. Cumulonimbus at Frobisher Bay, N.W.T. July, 1958. (Photo by B.A. Coulcher)

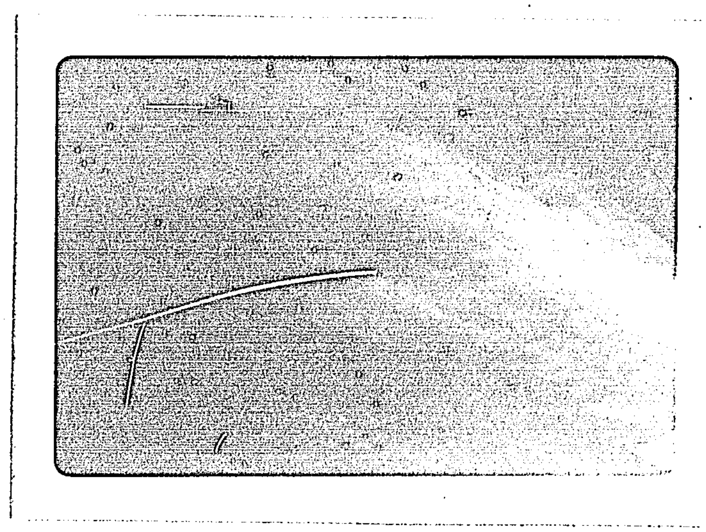

Photo 4. Jet Stream Cirrus at Frobisher Bay, N.W.T. Early November, 1959. Note Aircraft (U.S.A.F. B52) and Contrail. (Photo by B.A. Coulcher)

TABLE VI

Wind Direction Frequencies with Cloud Bases of 400 Feet or Less and/or Visibilities of One Mile or Less

Month	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	Calm	Total	Percentage Frequency by Months
Jan.	6	0	0	2	10	25	28	4	1	0	3	1	2	3	87	9	55	236	5.2
Feb.	17	0	2	8	6	13	38	19	9	0	2	0	2	18	91	41	77	343	7.5
Mar.	12	0	1	3	8	12	24	7	0	0	0	1	0	10	76	36	27	217	4.5
Apr.	3	2	1	2	1	6	11	15	9	1	1	0	0	1	30	47	4	134	2.3
May	2	0	0	0	5	6	26	18	14	0	2	1	3	1	18	3	7	106	2.4
June	0	1	0	0	1	4	47	35	13	3	0	1	1	0	4	4	57	171	3.3
July	1	0	0	0	1	6	60	80	14	0	3	2	1	3	2	0	54	227	5.0
Aug.	3	0	0	0	0	5	43	45	25	7	2	0	0	0	1	0	52	183	4.1
Sept.	1	0	0	0	0	14	63	46	19	2	0	0	0	1	4	2	29	181	4.1
Oct.	0	0	0	0	6	12	40	21	13	0	0	0	0	3	46	8	11	160	3.5
Nov.	15	1	11	6	9	18	31	10	5	1	1	0	2	4	54	29	22	219	4.6
Dec.	32	2	6	2	14	4	26	7	4	0	0	0	1	12	41	39	10	200	4.7
Total	92	6	21	23	61	125	437	308	126	14	14	6	12	65	454	218	407	2377	
Percentage Frequency by Direction	0.18	0.01	0.04	0.04	0.12	0.24	0.80	0.59	0.24	0.03	0.03	0.01	0.02	0.12	0.81	0.42	0.77	4.5%	

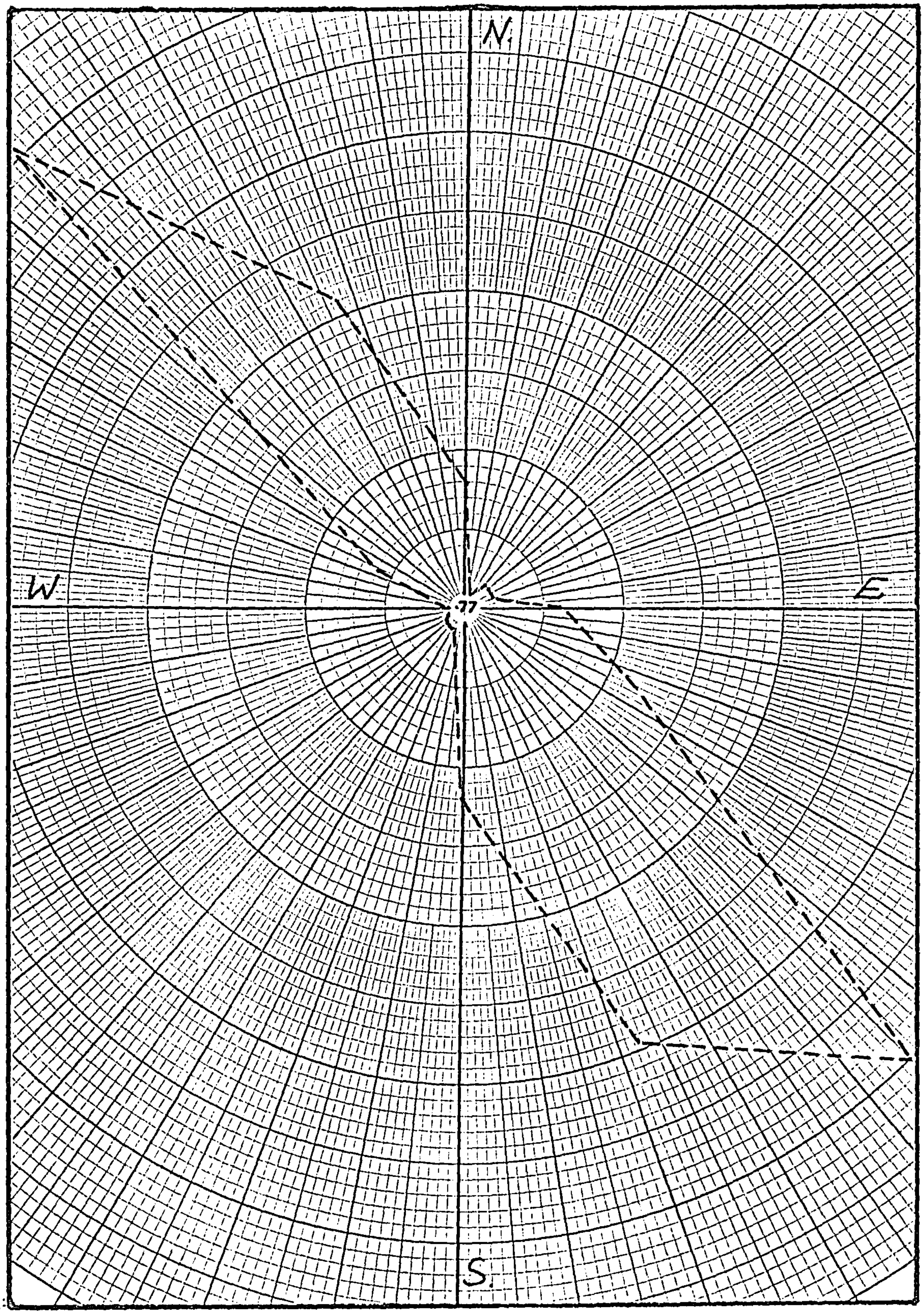

Figure 18. Graph of Wind Direction Frequencies with Cloud Bases of 400 Feet or Less and/or Visibilities of One Mile or Less for Frobisher Bay, N.W.T.

The number of instances of poor weather together with calm conditions is fairly pronounced in January and February. Much of this is due to ice fog or ice crystal formation, reducing visibilities below one mile during very cold temperatures. In summer, fog is the primary impairment to vision and it readily forms under calm winds coupled with a light onshore wind.

A graph of the diurnal frequency of fog is provided in Fig. 19. Reports of fog were abstracted from hourly weather observations at Frobisher Bay for the four summer months (May to August, inclusive) from 1955 to 1960 (six years). The results are interesting as they provide information on the daily cycle of fog formation and dissipation. From the graph, it can be seen that the diurnal fluctuations are well-displayed with pronounced ridges and troughs. The peak frequency (1.84%)[5] is recorded at about 3 A.M., or at the time of maximum cooling. Thereafter, the curve begins to fall as outgoing radiation is curtailed by the actual presence of the fog itself. This, in turn, serves to raise air temperatures and to cause dissipation and clearing skies. Cooling once again sets in and the fog curve rises to a secondary peak at about 7 A.M. Solar heating now becomes well-established and the net result is to overwhelm the cooling effects and to produce a sharp fall in the curve until a minimum of 0.58 per cent is reached at about 3 P.M., the time of maximum heating. Additional water vapour has been steadily injected into the surface layers of the atmosphere during the heating day through evaporation and this, coupled with slight cooling and resulting condensation after 3 P.M.,

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[5]Percentage of all observations taken during the period.

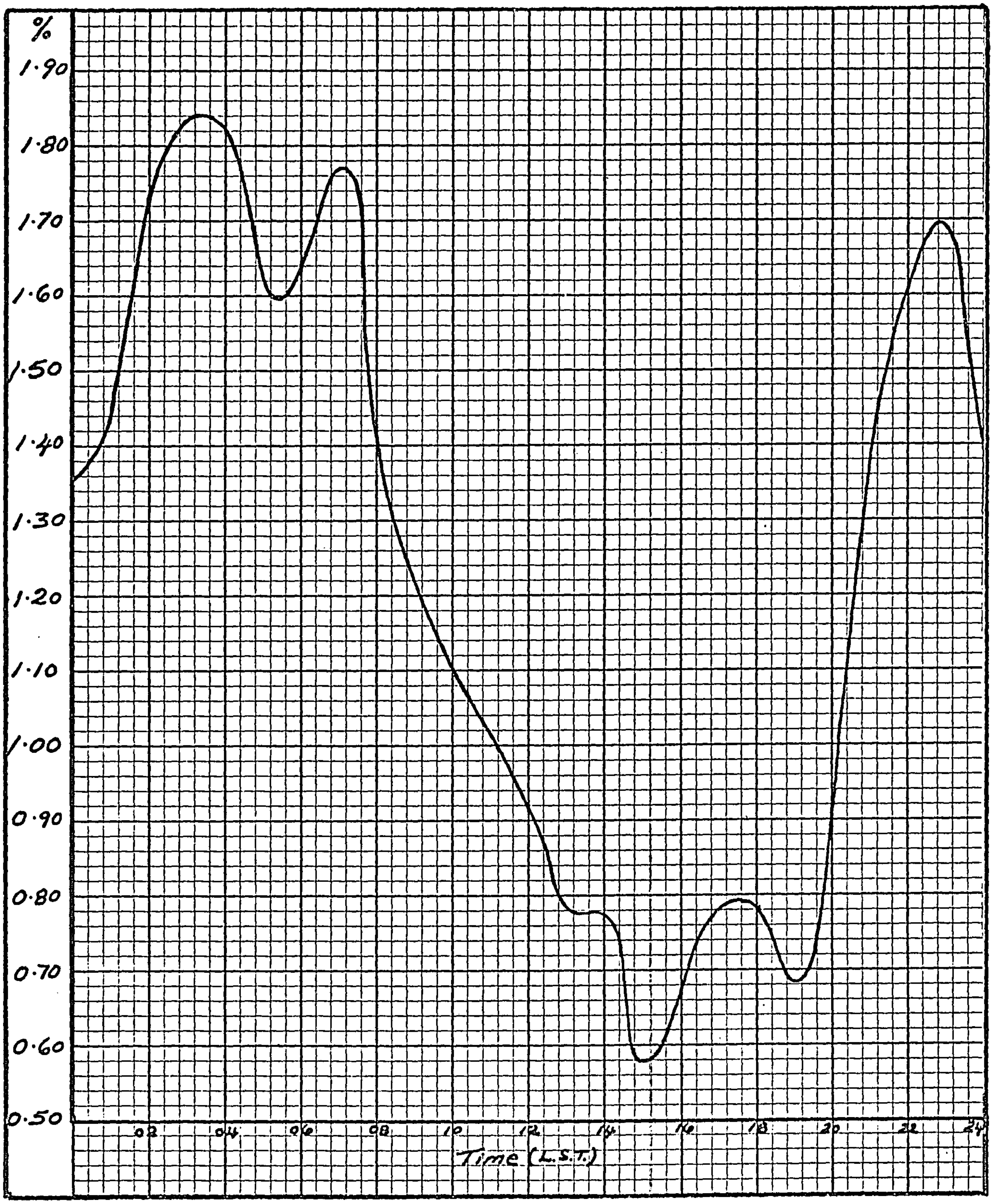

Figure 19. Diurnal Frequency of Fog at Frobisher Bay, N.W.T. (Months of May to August, Inclusive, 1955-1960).

causes a rise in the curve to a small peak just before 6 P.M. Cooling is once again curtailed by fog formation, condensation of water vapour ceases, and the curve declines to another minimum at about 7 P.M. From then on, there is a marked increase as radiational cooling dominates the cycle until the first peak is reached at 11 P.M. Again, cooling is temporarily overcome by the presence of fog, and probably some low stratus as well, and a decline in frequency is noted as the fog temporarily commences to dissipate. The cycle is repeated on two more occasions before the night is over.

It can be assumed that the diurnal fog cycle at Frobisher Bay could well be repeated at other stations in the Arctic with but minor variations.

ii. <u>A Case of Ice Fog Formation</u>. The formation of ice fog, or ice crystal haze, is not unusual at Arctic localities. The important prerequisites such as a well-developed inversion, low temperatures, light winds, high humidities and clear skies are basic features of the Arctic environment for much of the year. It is also generally agreed that ice crystals are created by the rapid freezing of super-cooled water droplets. The inclusion of numerous hygroscopic nuclei trapped beneath the inversion facilitates the formation of ice crystal haze or fog, or at least it contributes to eventual formation providing various other local synoptic parameters are satisfied.

Appleman (1953) has studied the cause of ice fog formation, and Clodman (1956) investigated a specific instance at Goose Bay, Labrador. It is believed that the combination of hydrocarbon fuels from aircraft exhaust produces water vapour which in turn raises the relative humidity of the air and ice fog may result if prevailing ambient temperatures are sufficiently low. The critical temperature usually required for ice fog development is approximately -20°F or less. Yet in some instances as in the present case, fogs or heavy haze have formed at temperatures well above the critical value. A notable example of this occurred at Goose Bay, Labrador, in December, 1954 and has been studied by Clodman (1956).

By seeding the area with condensation nuclei from aircraft exhaust gases, and providing winds are light, the possibility of precipitation modification at low levels and ice fog formation at temperatures above the critical point cannot be overruled. Furthermore, various atmospheric nuclei coalesce into droplets at relative humidities of 80 to 82 per cent.

On February 11, 1958 an unusual case of ice fog formation was observed during several aircraft departures and is well-documented in the hourly and special weather reports, as can be seen in Table VII. Although surface temperatures displayed Arctic air mass values, due to radiational cooling, the air mass aloft constituted a brand of maritime Arctic air, having had a trajectory in previous days across the Labrador Sea. A sharp stable inversion was thus present and is shown by the radiosonde ascent in Fig. 21. The synoptic situation is displayed in Fig. 20.

Visibility deterioration commenced while the first aircraft was warming up its engines at the end of the runway. On takeoff at 1222 G.M.T. (8:22 A.M.), the entire runway became obscured in fog. The writer was fortunate to be on duty at the time and recorded the event with a camera (Photo 5).

TABLE VII

Hourly Weather Observations at Frobisher Bay, N.W.T., 11 Feb., 1958

Time (G.M.T.)	Sky Condition	Visibility (Miles)	Weather	Temp. °F.	Dew Point °F.	Relative Humidity (%)	Wind	Remarks
1200	CLR	3	Fog	2	-3	79	NNW6	
1215	-X12 ⦶	1	Fog				SSE2	VSBY DCRG RPDLY
*First Aircraft departs 1222								
1225	-X12 ⦶	1/4	Fog				SSE2	VSBY NE 2 MI
1228	-X	1/8	Fog				S2	
1231	-X12 ⦶	1/2	Fog				SE3	VSBY NE 2 MI
1240	-XE12 ⦷	3/4	Fog				SSE3	VSBY NE THRU SE 2 MI
1300	-XE10 ⦷	1	Fog	-1	-5	83	S3	VSBY N THRU SE 2 MI
1308	-XE10 ⦷	3	Fog				NNW1	VSBY NW 1-1/2 MI WIND LGT VRBL
1400	-X10 ⦶ 90 ⦶	8		1	-5	75	NNW1	WND LGT VRBL
*Second Aircraft departs 1413								
1420	10 ⦶ 200 - ⦷	2	Ice crystals Fog				NNW1	VSBY S THRU NW 3/4 MI
1435	20 200 - ⦶	4	Ice crystals Fog				Calm	VSBY S THRU NW 1 MI
1500	E18 ⦷	6	Very lgt snow	6	2	83	WSW1	VSBY W QUAD 2 MI
1512	E18 ⦷	2	Fog				E2	FOG BANK APPCG
*Third Aircraft departs 1515								
1520	-XE18 ⦷	2	Fog				ESE2	VSBY S 10 MI WNDS LGT VRBL VSBY ON RNWY 3/4 MI
1600	-XE18 ⦷	2	Fog	6	0	76	N1	VSBY S 10 MI
1645	E20 ⊕	10					NW12	VSBY S 30 MI
1700	E20 ⊕	20		16	12	84	NW15	

-X = thin obscured; ⦶ = scattered clouds; ⦷ = broken clouds; E = estimated ceiling.
⊕ = Overcast

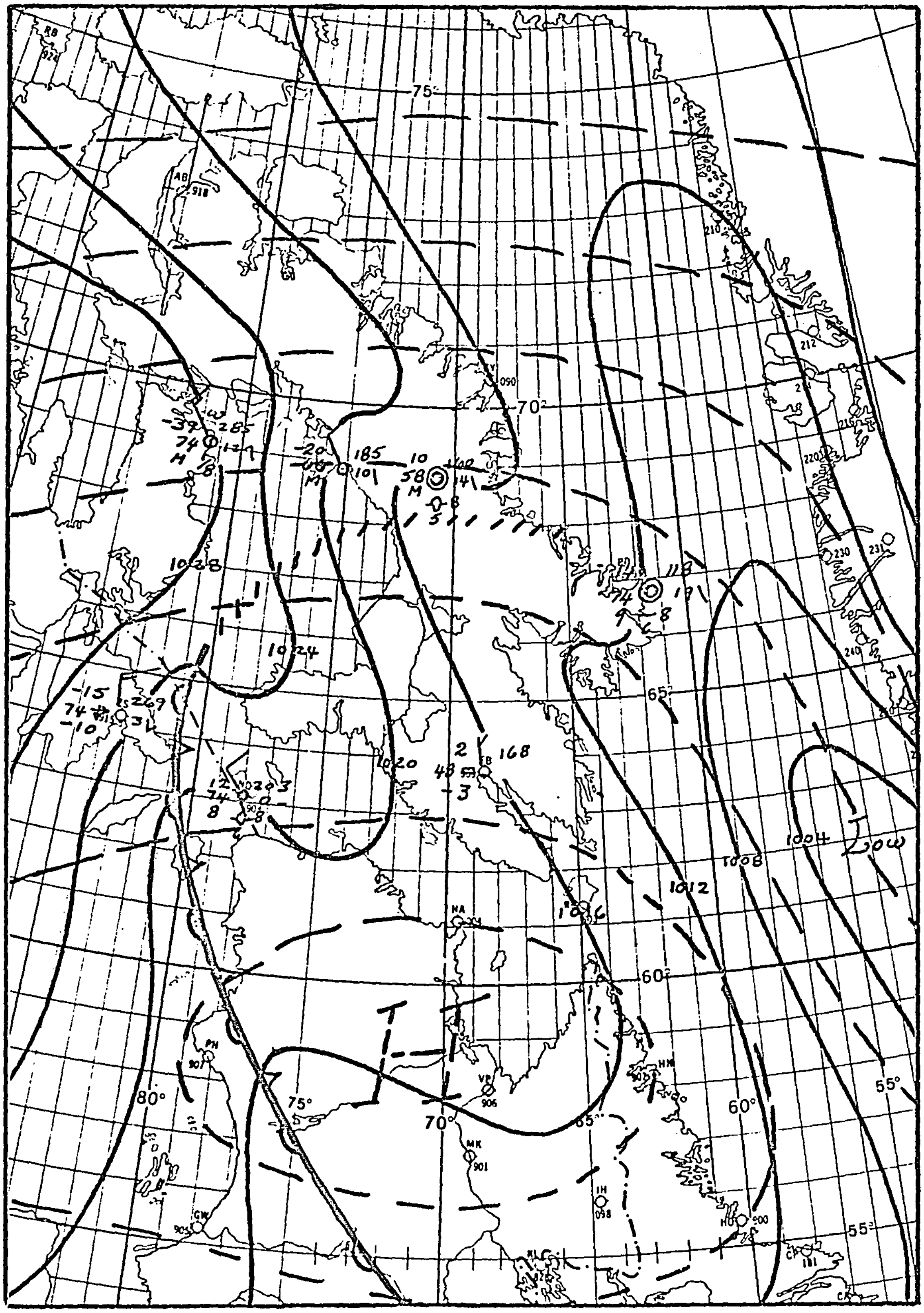

Figure 20. Surface Weather Map for 11th February, 1958, 1200 G.M.T. 500 mg Contours Superimposed by Dashed Lines.

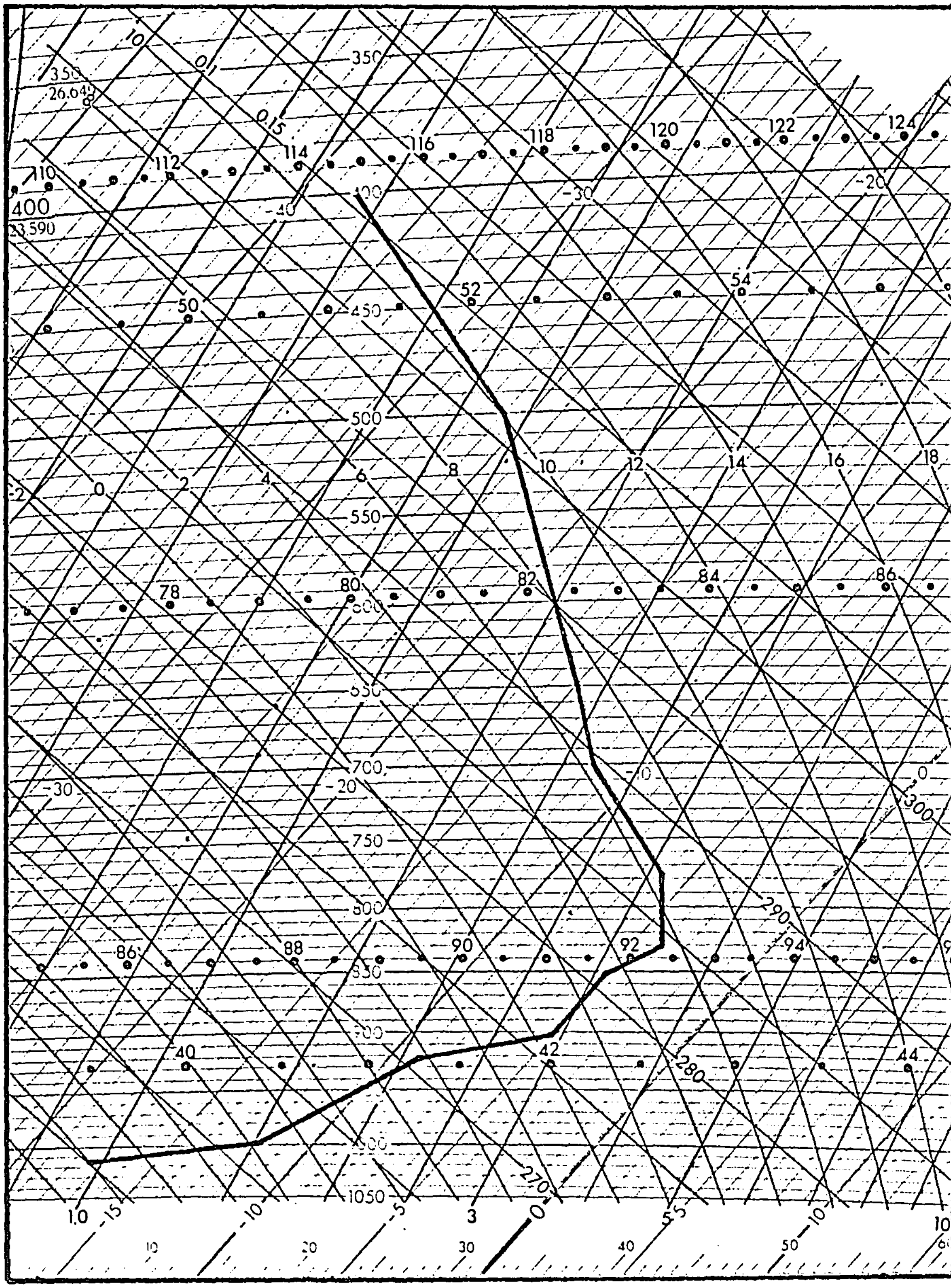

Figure 21. Upper Air Sounding for Frobisher Bay, N.W.T., 11th February, 1958, 1200 G.M.T.

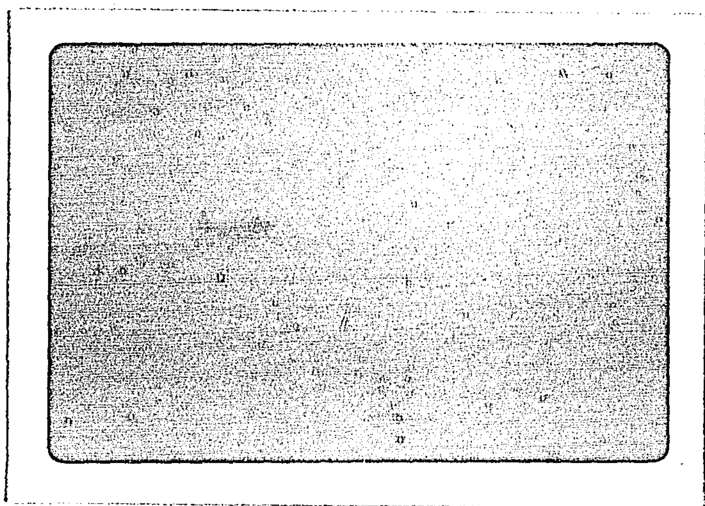

Photo 5. Fog Produced by Aircraft Exhaust at Frobisher Bay, N.W.T. 1230 G.M.T. 11th February, 1958. (Photo by B.A. Coulcher)

The second aircraft departed at 1413 G.M.T. and was immediately followed by another sharp decrease in visibilities. Ice crystals were now reported together with the fog and by 1500 G.M.T., a very light snow had begun to fall.

There can be little doubt that the two aircraft had seeded the area with sublimation nuclei which eventually united with others to produce a short period of precipitation. Relative humidities were ideal, thus providing favorable conditions for coalescence.

A third aircraft departed at 1515 G.M.T. and another deterioration in visibilities set in. This was confined to the vicinity of the runway as can be determined from the remarks column in Table VII.

6. Blowing Snow

In winter, the major obstruction to visibility is in the form of blowing snow. Owing to its lightness, grain size, and structure, snow particles can readily become airborne with relatively gentle winds, and visibilities are lowered accordingly. Sir William Parry, while wintering at Winter Harbour in 1819, observes:

> . . . the snow which falls during the severe winter of this climate is composed of spiculae so extremely minute that it requires very little wind to raise and carry along. (Parry, 1821, p. 128)

The frequency of blowing snow reaches a maximum in January or February at most localities in the Arctic. A decrease sets in during March, whereafter the frequency drops off to zero in May and commences to rise once again in late September. For the most part, blowing snow is a surface phenomenon and very rarely extends above 200 feet. Thus it is not unusual to have practically no horizontal visibility while at the same time stars or the outline of the moon are visible above.

Longley (1958) considers blowing snow to be a function of not only wind speed but also direction, thus taking into account the trajectory of the flow. If strong, cold wintertime winds are blowing across open leads, additional snow particles can be injected into the air, producing a fog effect. This is not an infrequent occurrence at Resolute Bay when large open channels are present to the north of Cornwallis Island. Strong northerly winds with temperatures well below zero carry the moisture from the open water in the form of minute ice crystals. The ice crystal fog combined with blowing surface snow travels downstream towards Resolute Bay where visibilities of one-half mile or less are experienced. It is strongly suspected that a similar situation exists at Frobisher Bay on occasions, with open water in Foxe Basin being the moisture source.

Kruger (1960) provides a table of visibilities in blowing snow with wind speeds as follows:

Speed (m.p.h.)	<15	15-19	20-24	25-29	30-34	>35
Visibility in blowing snow (miles)	Very little	3-6	2-3	<2	3/4	1/2-0

Fraser (1964) shows that at Frobisher Bay, blowing snow frequency ranged from a February maximum of 12 per cent to 2 per cent in May and that northwest winds were the most likely direction for causing low visibilities in blowing snow. The highest frequency of blowing snow is recorded in February at both Frobisher Bay and Nottingham Island (Table VIII).

TABLE VIII

Percentage Frequency of Blowing Snow

Station	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	Avg.
Frobisher Bay	4	7	10	10	12	9	4	2	7
Nottingham Island	5	8	12	12	13	5	6	3	8

Blowing snow is a frequent visitor across Baffin Island in winter. The highest frequency is probably confined to more exposed stations along the outer coast and to sites on the Great Western Plains where natural obstructions are few and the wind can blow at will. More sheltered places such as Arctic Bay or Clyde River report a low frequency of blowing snow as wind speeds rarely attain values much above 30 m.p.h.

D. The Climate of Three South Coast Islands

1. General Remarks

A brief climatic survey of three coastal islands discloses some interesting facts. The three islands are Brevoort, Resolution, and Nottingham Islands, all of which are situated off the southern coast of Baffin Island. They are indeed pictures of desolation, mere fragments of rock, windswept and bare.

Meteorological data have been collected for some years and provide abundant information on the vagaries of offshore marine climate. Brevoort Island, a DEW Line site, commenced synoptic observations in 1960, while both Nottingham Island and Resolution have unbroken records for well over twenty years.

2. The Wind Field

The high frequency of westerly winds at Nottingham Island and Resolution Island (Table IX, p. 91) disclose the effect of large-scale channeling flow throughout much of the year provided by Hudson Strait. In July, Nottingham Island, at the western end of Hudson Strait, has a pronounced peak from the west, whereas Resolution Island near the eastern entrance of the Strait, displays a high frequency of winds from the east. The existence of the summer season low over Hudson Strait is established by average wind directions at two stations situated at opposite entrances to the channel.

The dominant wind direction at Brevoort Island is north to northeast during the entire year. This is easily explained when the location of Brevoort Island and the seasonal variations in pressure gradients are considered. The Island lies just off the east coast of Hall Peninsula and is thus protected by a small mountain range to the west. Channeling is thereby induced from the north at all seasons, although in July a northeast flow into the Hudson Strait low is favored with 27.5 per cent of the winds blowing from this direction. A slight increase in southeasterlies is noted during the summer. Winds from the westerly, or even northwesterly quadrant are reduced to a minimum.

The frequency of calms is very low with both Nottingham Island and Resolution Island recording the lowest percentage of calm weather on or around Baffin Island. The average annual wind speed is 11.0 m.p.h. at Nottingham, and 17.7 m.p.h. at Resolution Island. The higher value in the neighborhood of the eastern entrance is caused by a greater number of cyclonic disturbances migrating across the region and through the funnelling of the prevailing westerlies. A higher frequency of calms is recorded at Brevoort Island, owing to its more sheltered location, although a low value is attained in the fall, usually the windiest part of the year over the Arctic.

3. Temperature

The annual range in temperature (Fig. 22) is not great when compared to more sheltered or inland localities. Resolution Island has the smallest annual range with 39°F. Nottingham Island, by virtue of its location, has a range of 56°F. This compares with Arctic Bay which has a range of 67°F, and Hall Beach, 70°F. The modifying influence of the ocean areas, the higher annual percentage of cloud, and greater average wind velocities all contribute to the reduction of the yearly amplitude.

Every station except Brevoort Island records their coldest month in January. It is hard to explain why Brevoort's temperature should act in this manner. The only conclusion to be drawn is that the reservoir of Arctic air centered over the western plains, near Nettilling Lake, undergoes progressive cooling until late February. Southward incursions of portions of this frigid air mass penetrate southward, down Cumberland Sound and across Brevoort Island, thus lowering average temperatures accordingly.

Extreme temperatures likewise are not as low in winter nor as high in summer when compared to more interior points. An absolute maximum and minimum of only 61°F and -36°F, respectively, has been measured at Resolution Island, and 65°F and -35°F at Brevoort.

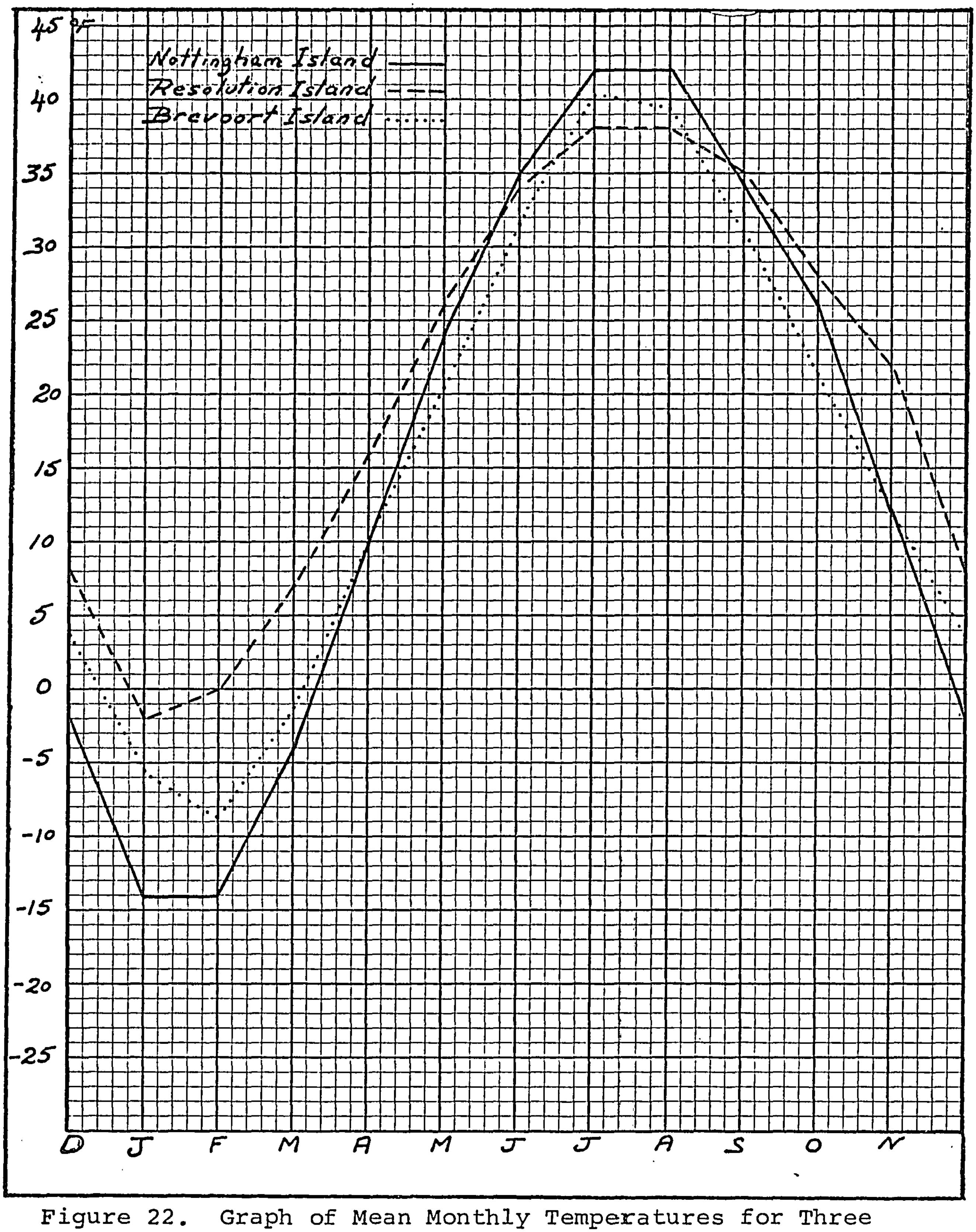

Figure 22. Graph of Mean Monthly Temperatures for Three South Coast Islands off Baffin Island, N.W.T.

4. Precipitation

It is to be expected that precipitation statistics show a slight increase in amounts for marine locations. Brevoort Island has an annual average of 18.26 inches, but this can be seriously questioned when the length of record is considered. Resolution Island exhibits a more representative value of 15.73 inches annually, and Nottingham somewhat less, with 11.79 inches. As with other stations on or around Baffin Island, a maximum of precipitation is observed in the summer months.

5. Clouds and Fog

Marine climates in the Polar regions are notorious for their high prevalence of fog and low clouds, and the Hudson Strait area is no exception (Table XIII, p. 95). Resolution Island with an annual average of over seven-tenths of cloud, registers the highest in the Arctic. Nottingham Island to the west is lower, recording only 6.4 tenths. A winter minimum of cloud amount occurs in March, and the seasonal maximum about the middle of November at Resolution Island, a month later than at other stations. Much open water exists to the north and west of the Island until well into January, thus providing ideal conditions for cloud formation through convective processes. The precipitation amounts at Resolution Island provide ample evidence of this fact with the significant decrease in total monthly values taking place in early January rather than in December.

E. A Note on the Climate of the Ice Caps

1. General Remarks

All the glaciers on Baffin Island, with the exception of the Barnes Ice Cap, lie in the mountain areas or on high plateaus. The Barnes Ice Cap is situated on a low-lying area near the center

TABLE IX

Wind Direction for Selected Months

Station	Observation Period	Month	Percentage Observations								
			N	NE	E	SE	S	SW	W	NW	Calm
Arctic Bay	1954-63	Jan.	12.4	2.6	0.8	2.2	8.6	5.3	6.2	11.6	50.0
	1954-63	Apr.	13.7	3.5	2.2	1.1	7.5	4.1	5.3	9.7	54.0
	1954-63	July	25.6	8.7	2.7	2.1	4.3	4.6	7.1	20.5	25.2
	1954-63	Oct.	15.1	3.6	2.0	7.1	14.5	6.4	16.3	18.7	16.4
Brevoort Island	1961-66	Jan.	20.2	20.3	4.1	2.3	2.5	5.4	5.0	9.1	31.2
	1961-66	Apr.	19.7	19.3	2.7	2.9	6.7	2.7	2.1	3.1	41.0
	1960-66	July	22.5	27.5	3.0	6.4	3.0	3.0	2.6	4.3	27.7
	1960-66	Oct.	22.6	24.0	7.9	3.5	3.7	5.6	6.8	13.5	12.3
Broughton Island	1961-66	Jan.	9.4	2.4	5.7	5.7	7.5	4.5	8.3	18.8	36.9
	1960-66	Apr.	16.0	1.4	1.3	8.0	6.2	1.2	4.0	20.2	41.0
	1960-65	July	14.9	2.6	2.9	7.3	5.8	1.8	7.3	14.2	43.4
	1960-65	Oct.	9.0	3.1	5.3	8.0	4.1	4.9	11.6	18.7	35.2
Cape Dyer	1959-66	Jan.	5.4	13.6	9.4	9.3	8.1	7.2	14.6	12.7	19.6
	1959-66	Apr.	6.4	12.8	9.6	5.4	7.3	7.1	14.4	14.8	22.4
	1958-65	July	8.7	7.1	6.0	6.1	10.2	16.0	19.2	7.8	19.2
	1959-66	Oct.	9.2	9.1	9.1	4.8	6.4	5.5	25.7	14.7	15.6
Cape Hooper	1958-66	Jan.	9.1	11.4	7.4	6.6	2.6	7.6	22.1	9.0	24.4
	1958-66	Apr.	11.5	10.9	6.1	7.2	2.4	7.4	20.3	5.3	28.9
	1958-66	July	8.4	7.3	7.7	14.5	5.8	9.3	14.6	10.0	22.4
	1958-66	Oct.	13.8	12.3	9.6	9.0	4.4	10.0	24.0	8.2	8.7
Clyde River	1954-65	Jan.	15.1	5.7	6.8	5.2	5.6	4.3	3.6	15.6	37.1
	1954-66	Apr.	10.8	6.1	5.8	5.3	4.5	3.6	3.1	16.2	44.6
	1954-65	July	15.6	7.8	7.1	2.5	9.9	9.3	4.7	18.0	25.8
	1954-65	Oct.	11.8	4.0	5.5	8.6	6.2	6.8	17.1	29.3	10.6

TABLE IX (Continued)

Station	Observation Period	Month	N	NE	E	SE	S	SW	W	NW	Calm
Dewar Lakes (Mid-Baffin)	1958-66	Jan.	5.5	17.5	26.1	8.7	11.0	7.0	7.1	2.9	13.2
	1958-66	Apr.	9.6	10.4	25.0	10.3	8.3	8.0	9.7	8.9	10.9
	1958-66	July	3.8	7.1	32.2	8.8	11.2	13.6	10.6	7.2	5.8
	1958-66	Oct.	13.5	18.5	22.8	7.4	6.3	5.1	8.9	6.5	11.3
Frobisher Bay**	1940-60	Jan.	12	2	4	9	3	1	2	25	42
	1940-60	Apr.	17	4	4	5	6	2	2	36	24
	1940-60	July	3	1	2	30	18	1	2	20	23
	1940-60	Oct.	11	4	6	18	13	2	5	31	10
Lake Harbour*	1922-27	Jan.	47	10	4	7	9	1	3	6	13
	1922-27	Apr.	32	10	6	7	16	2	5	6	16
	1922-27	July	13	4	5	2	34	9	15	2	16
	1922-27	Oct.	35	8	8	6	11	11	1	9	11
Longstaff Bluff (Foley)	1958-66	Jan.	4.0	26.7	26.6	8.1	0.9	1.3	6.9	9.6	15.8
	1958-66	Apr.	2.9	18.4	24.2	4.5	1.5	1.4	12.7	11.6	22.8
	1958-66	July	2.2	7.4	21.3	12.4	4.1	2.2	16.2	8.4	24.8
	1958-66	Oct.	10.6	23.8	16.1	3.9	2.5	2.4	12.5	13.7	13.5
Nottingham Island**	1937-57	Jan.	16	5	7	2	15	18	16	15	6
	1937-57	Apr.	12	16	15	2	9	12	17	16	1
	1937-57	July	6	14	12	5	15	15	23	8	2
	1937-57	Oct.	17	11	12	4	9	8	15	23	1
Padloping Island**	1942-56	Jan.	22	5	4	2	2	2	11	42	10
	1942-56	Apr.	28	6	6	4	2	1	7	32	14
	1942-56	July	17	5	8	14	10	5	7	22	12
	1942-56	Oct.	22	8	5	5	8	8	13	26	5
Pangnirtung*	1930-42	Jan.	2	15	7	4	6	13	10	1	42
	1930-42	Apr.	2	19	10	3	5	17	10	1	33
	1930-42	July	1	5	7	1	2	49	21	1	13
	1930-42	Oct.	8	21	9	7	4	16	8	5	22

TABLE IX (Concluded)

Station	Observation Period	Month	Percentage Observations								
			N	NE	E	SE	S	SW	W	NW	Calm
Resolution Island**	1929-50	Jan.	7	12	7	2	2	22	30	15	3
	1929-50	Apr.	9	18	13	3	3	12	26	14	2
	1929-50	July	2	11	30	5	6	7	27	10	2
	1929-50	Oct.	5	14	13	5	4	10	21	26	2

*Adapted from Meteorological Service, Government of Canada.

**Adapted from Hare (in Rand, 1963).

TABLE X

Wind Speeds For Selected Months

Station	Observation Period	Month	Percentage Observations 1-12 mph	13-38 mph	over 39 mph
Arctic Bay	1954-63	Jan.	37.1	13.2	0
	1954-63	Apr.	36.5	9.5	0
	1954-63	July	52.2	22.6	0
	1954-63	Oct.	48.3	35.3	0
Brevoort Island	1961-66	Jan.	32.0	32.8	4.0
	1961-66	Apr.	31.2	25.3	2.5
	1960-66	July	46.4	25.5	0.4
	1960-66	Oct.	43.8	43.6	0.3
Broughton Island	1961-66	Jan.	31.6	30.6	0.9
	1960-66	Apr.	46.7	12.3	0.0
	1960-65	July	50.8	5.8	0.2
	1960-65	Oct.	48.4	16.2	0.2
Cape Dyer	1959-66	Jan.	36.7	35.8	7.9
	1959-66	Apr.	49.8	25.6	2.2
	1958-65	July	58.2	22.1	0.5
	1959-66	Oct.	46.2	36.2	2.0
Cape Hooper	1958-66	Jan.	37.6	32.0	6.0
	1958-66	Apr.	45.0	22.4	3.7
	1958-66	July	57.7	18.8	1.1
	1958-66	Oct.	44.4	42.5	4.4
Clyde River	1954-65	Jan.	48.4	13.5	1.0
	1954-66	Apr.	44.4	10.7	0.3
	1954-65	July	63.0	11.1	0.1
	1954-65	Oct.	40.9	30.7	0.4
Dewar Lakes (Mid-Baffin)	1958-66	Jan.	50.1	32.5	4.2
	1958-66	Apr.	60.9	27.7	0.5
	1958-66	July	48.1	45.2	0.9
	1958-66	Oct.	57.2	28.1	1.4
Frobisher Bay	1955-65	Jan.	27.0	40.3	2.7
	1955-65	Apr.	35.3	39.0	0.8
	1955-65	July	58.7	23.0	0.0
	1955-65	Oct.	37.0	51.2	1.2
Longstaff Bluff(Foley)	1958-66	Jan.	44.3	35.1	4.8
	1958-66	Apr.	48.7	28.2	0.3
	1958-66	July	56.5	18.5	0.1
	1958-66	Oct.	56.4	31.6	0.2
Resolution Island	1954-61	Jan.	24.4	49.6	13.4
	Data Incomp.	Apr.	34.2	47.7	2.8
	" "	July	44.6	44.3	0.4
	" "	Oct.	28.0	57.3	7.4

TABLE XI

Mean Daily Temperature, Extremes, and Annual Range for Localities on or near Baffin Island, N.W.T.

Station	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Year	Extreme Max.	Extreme Min.	Annual Range	Period of Record (years)
Arctic Bay	-21.4	-25.7	-17.7	-3.5	19.0	36.0	43.0	41.0	29.6	13.2	-6.4	-17.0	7.5	75	-57	66.7	23
Brevoort I.	-5.5	-8.8	-1.2	9.9	20.3	31.7	40.2	39.6	31.0	21.2	12.2	3.7	16.2	65	-35	49.0	5
Broughton I.	-11.5	-14.2	-9.2	3.1	16.4	30.6	41.3	38.5	28.8	17.9	5.2	-3.9	11.9	65	-43	55.5	6
Cape Dyer	-7.4	- 9.8	-5.3	6.5	19.6	33.2	43.2	40.8	30.1	19.5	7.0	-1.7	14.7	66	-53	53.0	5
Cape Hooper	-13.8	-15.4	-11.2	2.1	15.0	30.9	41.2	36.9	29.0	17.9	4.9	-5.9	11.0	66	-42	56.6	5
Clyde River	-16.6	-19.6	-14.6	-0.5	20.2	34.2	40.6	39.4	32.2	20.4	1.6	-12.3	10.4	71	-49	60.2	18
Dewar Lakes	-18.2	-18.6	-13.2	-1.6	15.8	32.8	43.8	39.2	25.5	12.6	0.3	-9.4	9.1	66	-55	62.4	5
Durban I.	-10.8	-14.0	-6.6	5.3	18.4	33.3	43.2	38.6	28.8	18.5	6.7	-2.8	13.2	63	-34	57.2	5
Ekalugad F.	-16.6	-16.9	-11.4	-0.7	15.5	30.4	40.0	35.6	25.6	14.2	0.6	-8.5	9.0				5
Frobisher B.	-15.7	-13.9	-6.7	7.4	26.4	38.5	46.2	44.4	36.0	23.5	9.8	-4.9	15.9	76	-49	61.9	18
Hall Beach	-23.2	-27.0	-20.0	-4.2	14.6	33.1	43.0	40.1	39.9	12.2	-4.1	-15.4	6.7	65	-55	70.0	5
Kivitoo	-13.5	-12.8	-8.6	2.6	17.4	31.8	42.0	37.7	28.6	17.7	5.5	-5.6	11.9	66	-35	54.8	5
Lake Harbour	-13	-10	-2	11	27	38	46	44	36	25	12	-4	18	80	-49	59	16
Longstaff Bl.	-18.0	-21.6	-16.0	-1.8	17.0	34.8	45.4	43.8	29.9	15.1	0.3	-10.1	9.9	69	-51	67.0	5
Nottingham I.	-12.8	-12.9	-3.7	9.9	25.1	35.5	42.8	42.5	35.0	25.7	12.7	-2.6	16.4	73	-42	55.6	29
Padloping I.	-14.4	-18.0	-10.8	4.3	23.0	35.5	41.7	40.6	34.3	24.2	9.6	-6.1	13.7	73	-49	59.7	11
Pangnirtung	-16	-16	-7	8	25	37	46	44	37	25	11	-8	15	70	-52	61	12
Pond Inlet	-24.1	-28.2	-20.6	-5.6	17.6	34.7	41.5	40.7	30.8	14.8	-6.9	-19.6	6.3	77	-64	69.7	22
Resolution I.	-0.2	-0.5	6.4	15.4	26.9	33.6	37.8	38.2	35.0	29.1	21.3	9.4	21.0	61	-36	38.7	30
West Baffin	-18.4	-20.4	-13.0	-1.8	17.1	34.5	47.4	44.2	30.0	14.9	-0.2	-11.8	10.2	74	-52	67.8	5

TABLE XII

Mean Total Precipitation for Localities On or Near Baffin Island, N.W.T.

Station	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Year
Arctic Bay	0.31	0.18	0.29	0.24	0.31	0.46	0.68	1.27	0.93	0.70	0.31	0.23	5.91
Brevoort I.	1.22	1.38	0.65	0.51	1.37	0.86	1.75	3.25	2.93	1.83	0.92	1.59	18.26
Broughton I.	0.62	0.36	0.19	0.40	0.90	1.02	0.44	1.09	1.37	2.96	1.34	1.04	11.74
Cape Dyer	2.56	2.12	1.11	0.98	2.02	1.61	1.06	3.05	3.28	3.01	1.99	3.61	26.40
Cape Hooper	0.14	0.72	0.20	0.50	1.09	0.48	0.42	1.11	1.34	1.23	0.51	0.41	8.21
Clyde River	0.35	0.33	0.24	0.24	0.44	0.37	0.94	1.17	0.87	1.29	1.13	0.21	7.57
Dewar Lakes	0.22	0.16	0.11	0.28	0.72	0.48	1.31	2.35	1.67	0.62	0.37	0.26	8.55
Ekalugad Fiord	0.28	0.25	0.06	0.37	0.43	0.44	1.17	0.74	1.23	1.32	0.72	0.05	7.06
Frobisher Bay	0.8	0.9	0.7	0.7	0.7	1.2	1.8	2.0	1.2	1.2	1.2	0.9	13.3
Hall Beach	0.32	0.38	0.21	0.38	0.67	0.32	1.55	1.62	1.02	0.90	0.73	0.38	8.48
Lake Harbour	0.97	1.00	1.00	1.24	1.01	1.36	2.19	1.76	1.85	2.09	2.05	1.21	17.73
Longstaff Bluff	0.09	0.34	0.20	0.15	0.59	0.46	1.75	1.28	1.46	0.85	0.39	0.19	7.75
Nottingham I.	0.47	0.31	0.25	0.45	0.60	1.21	1.60	1.92	1.91	1.51	1.01	0.55	11.79
Padloping Is.	0.38	0.21	0.15	0.17	0.30	0.18	0.30	0.55	1.26	1.40	0.62	0.22	5.74
Pangnirtung	1.00	1.24	0.98	1.55	0.70	0.98	1.39	2.14	1.24	1.83	1.94	1.22	16.18
Pond Inlet	0.21	0.18	0.19	0.29	0.19	0.60	1.22	1.19	0.95	0.72	0.44	0.30	6.48
Resolution I.	1.06	1.03	0.99	0.98	1.18	1.32	1.71	1.64	1.94	1.29	1.24	1.35	15.73
West Baffin	0.07	0.30	0.03	0.09	0.54	0.11	0.46	2.66	0.90	0.47	0.20	0.16	5.99

TABLE XIII

Mean Cloud Amounts (Tenths of Total Sky Covered) for Localities On or Near Baffin Island, N.W.T.

Station	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Year
Arctic Bay	3.8	4.1	4.0	4.5	6.3	6.4	6.4	7.0	7.6	7.1	4.4	3.4	5.4
Cape Dyer	5.6	5.3	3.8	4.6	7.4	6.5	6.3	6.8	7.4	6.9	5.7	5.5	6.0
Clyde River	4.8	4.4	3.7	4.4	6.9	6.6	6.9	7.6	8.2	7.4	5.9	4.4	5.9
Frobisher Bay	4.8	4.9	4.7	5.3	7.4	7.5	7.1	7.7	8.0	8.0	6.8	5.5	6.5
Hall Beach	4.4	4.6	4.0	5.4	6.2	6.9	6.7	7.0	8.6	7.3	5.7	5.1	6.0
Resolution I.	7.1	6.1	6.1	6.4	7.9	7.2	7.3	7.8	7.8	7.9	8.1	8.1	7.3

TABLE XIV

Mean Percent of Cloud Amount for Various DEW Line Stations on Baffin Island, N.W.T. (Jan., July)

Station	Period of Record	January	July	Difference (%)
Brevoort Island	1961-66	47	65	18
Broughton Island	1961-66	45	62	17
Cape Dyer	1958-66	51	62	11
Cape Hooper	1958-66	48	63	15
Dewar Lakes	1958-66	39	62	23
Longstaff Bluff	1958-66	36	60	24

of the Island west of the east coast mountains.

The two largest ice caps are the Barnes and Penny Ice Caps (Fig. 22). There are numerous smaller icefields and notable among these is the Grinnell Ice Cap, located about 100 miles southeast of Frobisher Bay on the eastern side of Hall Peninsula. In the ~~foregoing~~ following paragraphs, only the Barnes and Penny Ice Caps will be considered.

Research on the ice caps of Baffin Island have been carried out by a number of people. Field and Mercer (1958) have collected all the available glaciological literature on the Island, and have summarized the data under seven specific geographical zones. Ward and Orvig (1953) have discussed the heat exchange and meteorological observations on Baffin Island with specific references to the Barnes Ice Cap. A more recent study by Sagar (1966) attempts to determine a relationship between the local climate and the current state of the Barnes Ice Cap by investigating meteorological observations and upper flow patterns. Ward and Baird (1954) describe the physical setting of the Penny Ice Cap during the 1953 expedition and provide a summary of meteorological conditions during the summer. In all, a substantial amount of information is accumulating on the glacial meteorology of the Arctic, and some valuable studies have already been completed on the larger ice fields on Baffin Island.

2. <u>The Barnes Ice Cap</u>

The Barnes Ice Cap was first noted by a Cambridge University expedition in 1934 (Field and Mercer, 1958), although its existence was known for some time by Eskimos who roamed the interior of the island. The ice cap is approximately 92 by 40

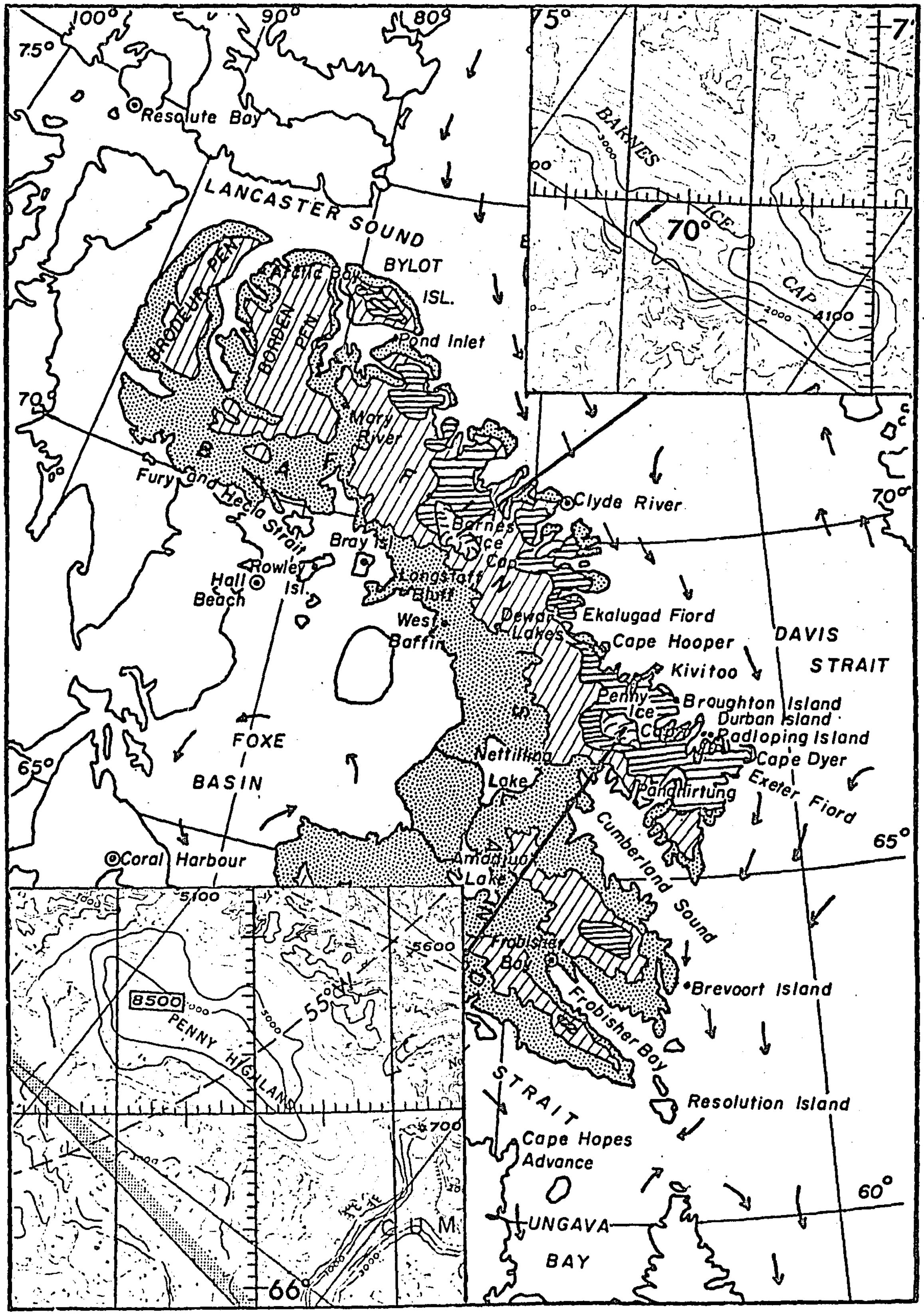

Figure 23. Topography of the Barnes and Penny Icecaps.

approximately 2300
miles and covers an area of ~~some 3700~~ square miles. The icefield rises to a height of about 3700 feet and the maximum ice thickness has been measured at 1533 feet. It is a leftover from the vast icesheet which formerly covered the entire region, and is termed a "Baffin" type glacier (Baird, 1952) as its nourishment is provided by refreezing of meltwater.

Initial meteorological observations were made during the 1950 summer expedition led by P. D. Baird. Orvig (Baird et al., 1950, p. 144) writes:

> The most striking thing on the icecap was the short 'summer'. Only 35 days had mean temperatures above freezing, the first being June 23, and the last August 10. Also unexpected was the heavy precipitation 2-3 inches of rain and 49.9 inches of snow in 87 days.

The summer was apparently slightly cooler than the summer of 1949 as indicated by the radiosonde reports from Clyde River. Humidities were likewise high as was average precipitation. Ablation of the snow surface during the first half of the summer was caused mainly by radiation, and later convective processes played the greater part. The ice surface was bare of snow for only four days at the beginning of August, whereafter accumulation once again set in.

A maximum wind speed of 37 m.p.h. was recorded on the Barnes Ice Cap, and an overall average of 9.7 m.p.h. was measured during the entire season. Blizzard conditions prevailed on 18 days and were caused by the passage of cyclones across the region.

An investigation into the current disposition of the Barnes Ice Cap through mass budget measurements and meteorological observations was conducted in the summers of 1962-64 inclusive and were summarized by Sagar (1966). It was found that the precipitation was less than normal and temperatures slightly higher than normal in 1962, whereas in 1963 and 1964 precipitation was close to the average but the summers were cool. The advection of warm air through cyclonic storms increased ablation in 1962.

3. The Penny Ice Cap

The Penny Ice Cap is situated on Cumberland Peninsula and rises to elevations of 6,000 to 7,000 feet. The existence of the glacier has been known for some time; in fact, ever since Franz Boas explored the region in 1883 and 1884. The Ice Cap covers some 2300 square miles and has a number of outflow glaciers sweeping down from all sides. Temperature measurements within the firn establish it as a cold-type glacier with -13.3°C being recorded near the summit. This compares with a temperature of -10.7°C observed on the Barnes Ice Cap at an elevation of over 3000 feet.

An expedition was sent to the Penny Ice Cap in the summer of 1953 by the Arctic Institute of North America. Meteorological records were taken each day. At an elevation of 2300 feet, Ward and Baird (1954) noted that the snow and ice surfaces froze every night and that "The melting season is brief and intermittent." Orvig and ~~Bornlander~~ Bonnlander (Baird et al., 1953, p. 238) state: "There were only 14 days with maximum temperatures above 32°F. The absolute maximum of 38.5°F was recorded on July 25." Fog seemed quite frequent as was the case on the Barnes Ice Cap. The fog was caused by the surface and adiabatic cooling of moist maritime air while ascending the mountain alopes.

Wind speeds on the ice cap were low and apparently evoked some surprise as the proximity of the Cumberland Peninsula to the northern Labrador Sea and Davis Strait places the region in an area of frequent cyclonic storms. The maximum wind recorded was

36 m.p.h. on May 28. Blizzard conditions prevailed for only nine days out of 85.

Orvig (1954) summarizes the meteorological observations on the Penny Ice Cap and finds that they are much the same as those made on the Barnes Ice Cap. Temperature records especially were similar in this regard.

F. Some Aspects on the Summer Climate of Mary River, N.W.T.

Mining interests have established a site at Mary River, N.W.T. in extreme northern Baffin Island. A summer weather reporting program commenced in 1963 and a few results are found in Table XV.

Monthly temperatures at Mary River were compared to those recorded at Arctic Bay and it was found that all three summers were below normal. The summer of 1965 was particularly cold with temperatures over northern Baffin Island averaging from three to four degrees below normal. July, 1964 and 1965 reported temperatures of three degrees below the monthly average, while June, 1965 had a negative departure of nearly four degrees.

Precipitation was near or above normal with the exception of June, 1963 when only 0.02 inches was measured. July, 1964 was a very wet month with 1.92 inches being recorded. Storm activity across the northern portions of the Island was especially marked in July, 1964.

Strongest winds were recorded from a northeast to southeast direction; channeling flow being the main cause of winds being observed from this quadrant. By all accounts, Mary River can be a very windy location when the area is affected by migrating disturbances. It would seem apparent that the prevailing direction of flow remains from the northeast and south at all

TABLE XV

Meteorological Statistics for Mary River, N.W.T.

	Mean Daily Temperature (°F)			Absolute Max.	Absolute Min.
Month	1963	1964	1965		
June	35.3	34.0	34.7	51	18
July	44.9	42.3	46.5	69	31
August	45.0	44.1	41.6	63	30

	Total Precipitation (inches)		
	1963	1964	1965
June	0.02	1.66	0.97
July	1.48	1.92	0.56
August	Missing	1.78	1.07

1963-65	Wind Direction and Maximum Speed (m.p.h.)
June	SE 25 +30
July	ENE 40 +45
August	NE 40 +45

+ refers to "gusts"

seasons of the year, and this is largely induced by channeling effects.

The short period of observations at Mary River does not lend itself to an accurate climatic study of the area. However, a few points have been noted here from available observations.

CHAPTER IV. SYNOPTIC WEATHER PATTERNS AFFECTING BAFFIN ISLAND

A. Introduction

The object of this chapter is to describe in detail several important synoptic patterns which affect Baffin Island throughout the year. These will be related to the climate of the region and, wherever feasible, local weather peculiarities will be discussed in order to illustrate and enlarge upon points mentioned earlier.

To facilitate the study, various synoptic regimes have been typed and will undergo some detailed examination as to formation, decay, relation to recognized cyclonic and anti-cyclonic tracks, and meteorolgical conditions attending the system. Admittedly, it is somewhat dangerous to proceed in this fashion as there is always the temptation during the assessment to overgeneralize. There is no denying the fact, however, that the synoptic patterns to be described are recurring entities, some much more so than others.

Although many scientists have devoted much energy to an investigation of the Arctic circulation, numerous questions on the synoptic climatology of the region remain unanswered. The tracks of storms over Polar latitudes have been studied by Berry, Owens and Wilson (1954), and Klein (1957), and they provide information on the frequency of various storm paths crossing the eastern Arctic. Dorsey (1951) and Rae (1951) have remarked on the passage of low pressure areas through Arctic regions. The dynamics of the Arctic circulation have been dealt with by Lee (1960), Hare and Orvig (1958), and a score of other writers. Namias (1958) has expressed the view that migratory low pressure systems very similar to middle latitude disturbances are daily features of Arctic flow patterns.

In all, material relating to the synoptic climatology of Baffin Island is not all that easy to find. Hare (in Rand Corp., 1963) has provided good coverage for the area. Few investigations, however, have dealt with local synoptic studies. Much of the field of synoptic climatology still represents a formidable challenge, yet it remains largely unexplored.

An investigation of surface weather charts for four years, commencing in January 1958, over the eastern Canadian Arctic, confirms the existence of several major synoptic regimes which become established over the region from time to time. Notable among these is the West Greenland Trough which has the highest frequency of occurrence. Others such as the Greenland or Davis Strait Blocking Anticyclone are a result of large-scale changes in the planetary circulation, and their formation is dependent to a large extent on the development of a counterpart, usually an intense vortex many hundreds of miles to the southeast.

Other systems such as the Hudson Strait and Foxe Basin Lows tend to migrate along familiar storm paths but with varying degrees of intensity. In fact, it can be pointed out that Hudson Strait lows which have had a lengthy journey from the south show a tendency to split while crossing southern Baffin Island, the main center rotating into Foxe Basin while the frontal wave moves northeast into Davis Strait and Baffin Bay. Hence, a parallel situation can be seen to exist between southern Baffin Island and the southern tip of Greenland. Labrador coast lows are nearly always intense disturbances which periodically stall off the east coast of Labrador during their northward journey.

There is a large variety of cyclonic and anticyclonic patterns which influence Baffin Island and it is well nigh impossible to give detailed coverage to them all. Only those which fall into a convenient category and those which provide an unusual departure from the norm are discussed in the following paragraphs.

B. Cyclonic Patterns

1. The West Greenland Trough

The West Greenland Trough is a familiar feature of synoptic weather maps over the extreme eastern Arctic and its development reaches maximum intensity and frequency during the cold months of the year. In summer, its existence is not so apparent for cyclonic disturbances are weak and thus lack sufficient energy to create the necessary conditions for its formation.

Wilson (1958) discusses the requirement for development of lee troughing along Western Greenland as that mechanism which forces a volume of air across a mountain barrier, thus creating the familiar windward ridge and leeward trough pattern. In this case, a strong easterly flow across southern Greenland produces the troughing effect. The process follows the Rossby principle of conservation of vorticity.[6]

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[6]Rossby's principle of conservation of vorticity is expressed by the equation: $f + \xi = D_x$ (constant), and requires anticyclonic flow due to shrinkage on the windward side and cyclonic curvature on the leeward side where the volume of air undergoes expansion. The terms f and ξ refer to the Coriolos Parameter and relative vorticity, respectively. D is the thickness of the volume of air.

Wilson concludes:

> . . . it is apparent that at least in mid-winter, surface pressures along the whole west coast of Greenland are largely controlled by the flow over the southern third or so of the icecap.

A pronounced trough along the west coast of Greenland in winter produces clear, very cold weather across most of Baffin Island to the lee of the east coast mountain range. Winds for the most part are northerly and vary in strength depending on the intensity of the trough itself. Along the eastern shoreline, however, moderate to strong winds, aggravated by the katabatic effect, can blow for days. Cape Dyer is particularly noted for these violent winds which tear large amounts of snow off the nearby mountains and ridges and deposit it into the valleys below. Wilson (1958, p. 6) notes that:

> . . . Judging by the frequency of occurrence of large differences in pressure across the constriction at 67N, it must be a very windy area, particularly in winter. Over the channel, winds of the order of 60 knots must be fairly common. It appears likely that winds over 90 knots could occur a few times each winter. The direction of flow near 67N during these strong winds according to pilots reports is NNW.

Likewise, Cape Hooper and Clyde River can record moderate northerly winds under these circumstances.

Secondary low pressure centers or "bubble lows", essential features of the West Greenland Trough, periodically migrate northward through Davis Strait and are instrumental in maintaining its intensity. In fact, according to Berry _et_ _al_. (1954), the frequency of this path up the western coast of Greenland qualifies it as a primary storm track. These low pressure areas have warm sector characteristics and usually move in the direction of the 500 millibar contours keeping close to the western shoreline of Greenland during their migration.

Wilson (1958) further indicates that there are several preferred locations for closed low formation in Davis Strait and Baffin Bay area which are governed to a large extent by terrain considerations. They are the Disko Bay Lows at 70°N, the Davis Strait Low near 64°N, the Baffin Bay Low at 73°N, the Thule Low at 77°N, and the Foxe Low at 68°N. The Foxe Basin Low is not dissimilar from the West Greenland Trough, having both the thermal and barrier effects available to assure its development and to maintain its persistence.

The West Greenland Trough creates a northerly component of air in the lower troposphere. This, in turn, produces a ridge of high pressure along the eastern reaches of Baffin Island and enhances the thermal trough over the Foxe Basin (Fig. 24 and Fig. 34, p.126). Surface winds thereby blow from the east or northeast at Dewar Lakes and Longstaff Bluff. For the most part, these winds are fairly light but can become very strong if katabatic flow is present.

Summer months witness a feeble gradient over Baffin Island and at no time can the West Greenland Trough be said to be well-developed. Instead, the situation shifts its emphasis from the surface to upper levels where, on occasions, there are a series of slowly moving cold core lows, with no identifiable features at the surface.

2. <u>The Foxe Basin Low</u>

The Foxe Basin Low, when well-established, is found at all levels from the surface to the tropopause. This is especially true in the summer months when the cyclonic disturbances forming over southern or western Hudson Bay seem to gravitate

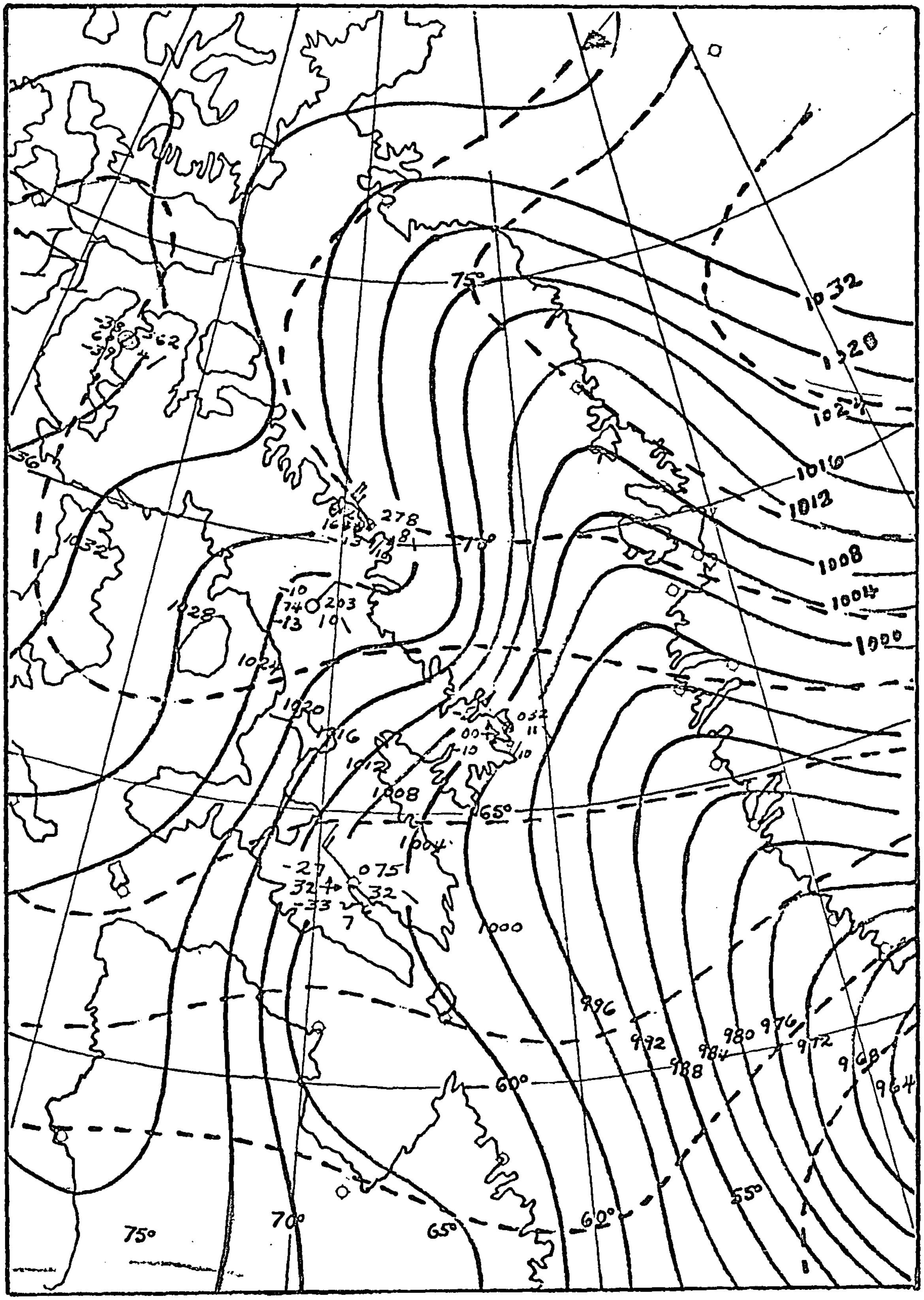

Figure 24. Surface Weather Map for January 23, 1961, 1200 G.M.T. 500 mb Contours Superimposed by Dashed Lines.

towards the region and eventually stall. This is not surprising when it is considered that the principal storm track lies across southern Baffin Island in July. In winter, the low relies almost solely on the thermal temperature gradient and lee troughing effect induced by the Baffin Island mountain range. Low pressure areas during the cold season seldom remain for any length of time in the vicinity of the basin. Instead, the systems follow a track southeastward across Foxe Basin into Hudson Strait and emerge near Resolution Island, whereafter they travel northeast into Davis Strait or towards the southern tip of Greenland. Lows approaching from the south travel north or northeastward across central Baffin Island and into Baffin Bay, the traditional graveyard of storms in the eastern Arctic. In general, it can be said that the development of the Foxe Basin Low is favored when the long wave trough is positioned through central North America.

The principal storm track is directed towards southern Baffin Island in the summer and it is in this area that the low most frequently splits, with the main core rotating into Foxe Basin and its associated frontal systems being deflected off towards the east and north. Thus, as mentioned previously, southern Baffin Island is analogous to the southern tip of Greenland where the classic cases of cyclonic splitting occur. Even in mid-winter months, deepening lows from the south have a distinct tendency to break apart or stall upon reaching northern Hudson Strait.

The presence of the Foxe Basin low produces some of the worst weather to be experienced over the eastern Arctic. Moderate to heavy precipitation and strong north to northeast winds attend these systems as they move slowly into position from more southern extremities.

Very low ceilings, rain, drizzle and fog are reported from stations scattered across the western plains of Baffin Island. These conditions can persist for days together with brisk easterly winds. Precipitation in the form of continuous rain or snow ends abruptly with the passage of the "trowal" (occlusion) structure as it sweeps eastward along a curving arch into Baffin Bay and Davis Strait (Fig. 25). Onshore winds along the east coast of Baffin Island are ideal for fog formation, the creation of which is enhanced by orographic lifting. Cape Hooper and Cape Dyer usually report fog and sometimes light showers as the upper occlusion approaches. Winds, however, remain fairly light over much of the coastline, with the exception of Cape Dyer where exposure alone permits no obstruction to gradient effects.

In winter, Foxe Basin systems are much more intense than those in the summer and, with the exception of extreme northern Baffin Island, no area is spared the effects of such a disturbance. Barrier flow along the Great Western Plains produce gale or even hurricane force winds and blizzard conditions at West Baffin, Longstaff Bluff and Dewar Lakes. Only after the passage of the occlusion does the wind slacken. Along the south coast, Frobisher Bay experiences strong channeling winds from the southeast as does Cape Dyer, but further north, along the east coast, surface winds remain light. Outflow winds along the coast can follow quickly on the heels of the occlusion as it travels rapidly across the mountain ranges creating behind it a shift in pressure gradient.

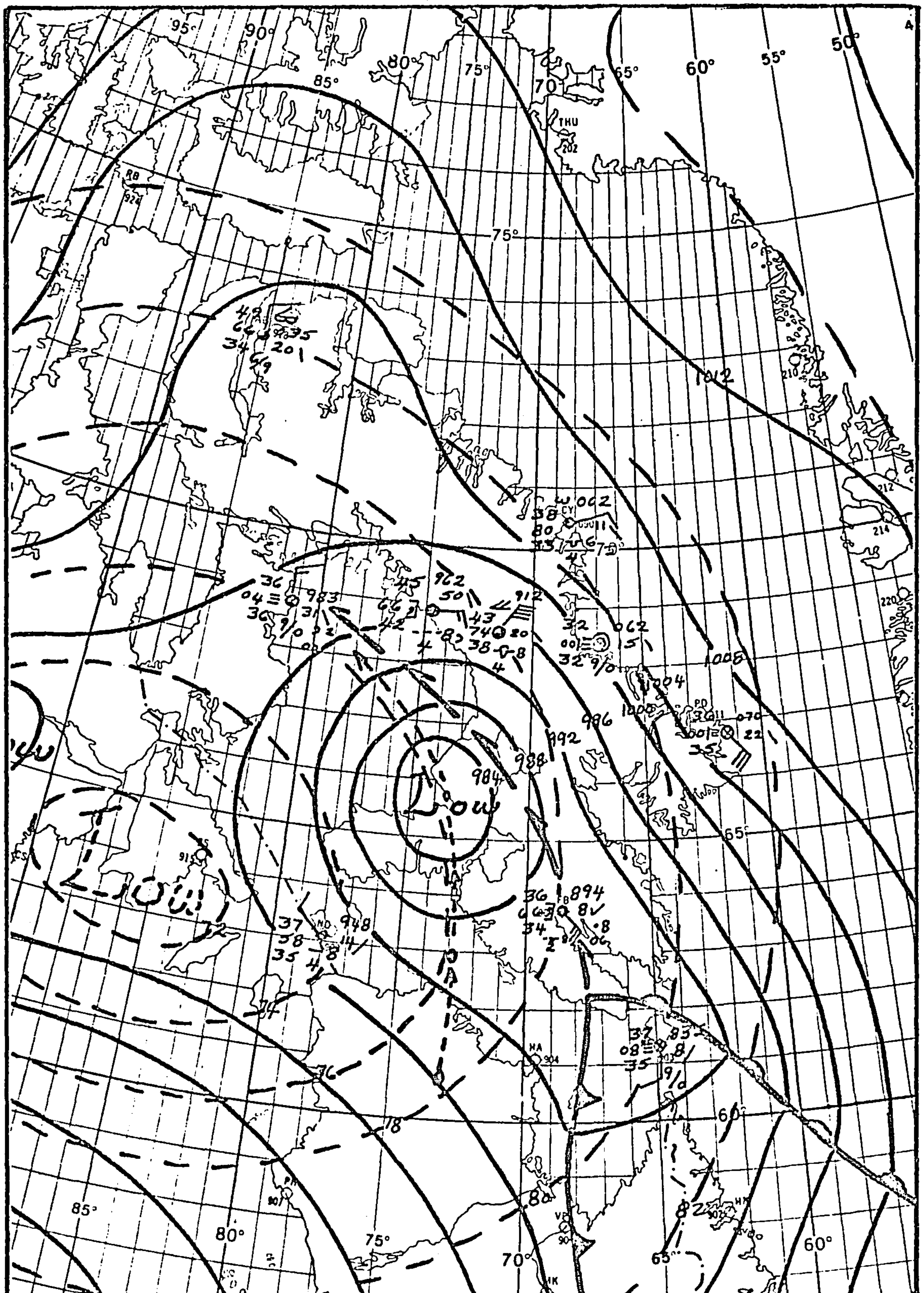

Figure 25. Surface Weather Map for June 29, 1959, 1800 G.M.T. 500 mb Contours for June 30, 0000 G.M.T. Superimposed by Dashed Lines.

The Foxe Basin Low can bring heavy rains over much of the southeastern Arctic in summer, a notable instance of which was recorded between the period August 18 to 21, 1960 when an intense low emerged from the Northwest Territories and traveled slowly into Foxe Basin. Ahead of the vortex which was evident by a strong, closed circulation aloft at 500 millibars centered over Southampton Island (Fig. 26), abundant quantities of warm, moist maritime Polar air were pumped northward. Excessive rainfall resulted over much of the east-central Arctic and well over an inch of rain was recorded in twenty-four hours at Frobisher Bay, Cape Dyer and Clyde River. Other localities such as Arctic Bay and Cape Hooper reported less than half an inch of rain owing probably to the shadow effect of the mountain ranges. Dewar Lakes and Longstaff Bluff measured 0.17 inches and 0.09 inches, respectively, which is surprisingly low when the high totals for other stations are considered. It can only be surmised that the moist southeast flow across Baffin Island gave up much of its moisture to the higher mountains prior to reaching the western plains.

3. The Hudson Strait Low

Hudson Strait never completely freezes over, although the ice may vary in amount and shift from week to week or month to month. Strong and persistent winds, excessive tidal action, ocean currents and latitude, all combine to affect this disposition. The waterway, like Davis Strait and Baffin Bay, thus acts as a heat source and whenever cold Arctic air crosses these regions, the air mass undergoes marked warming and moistening

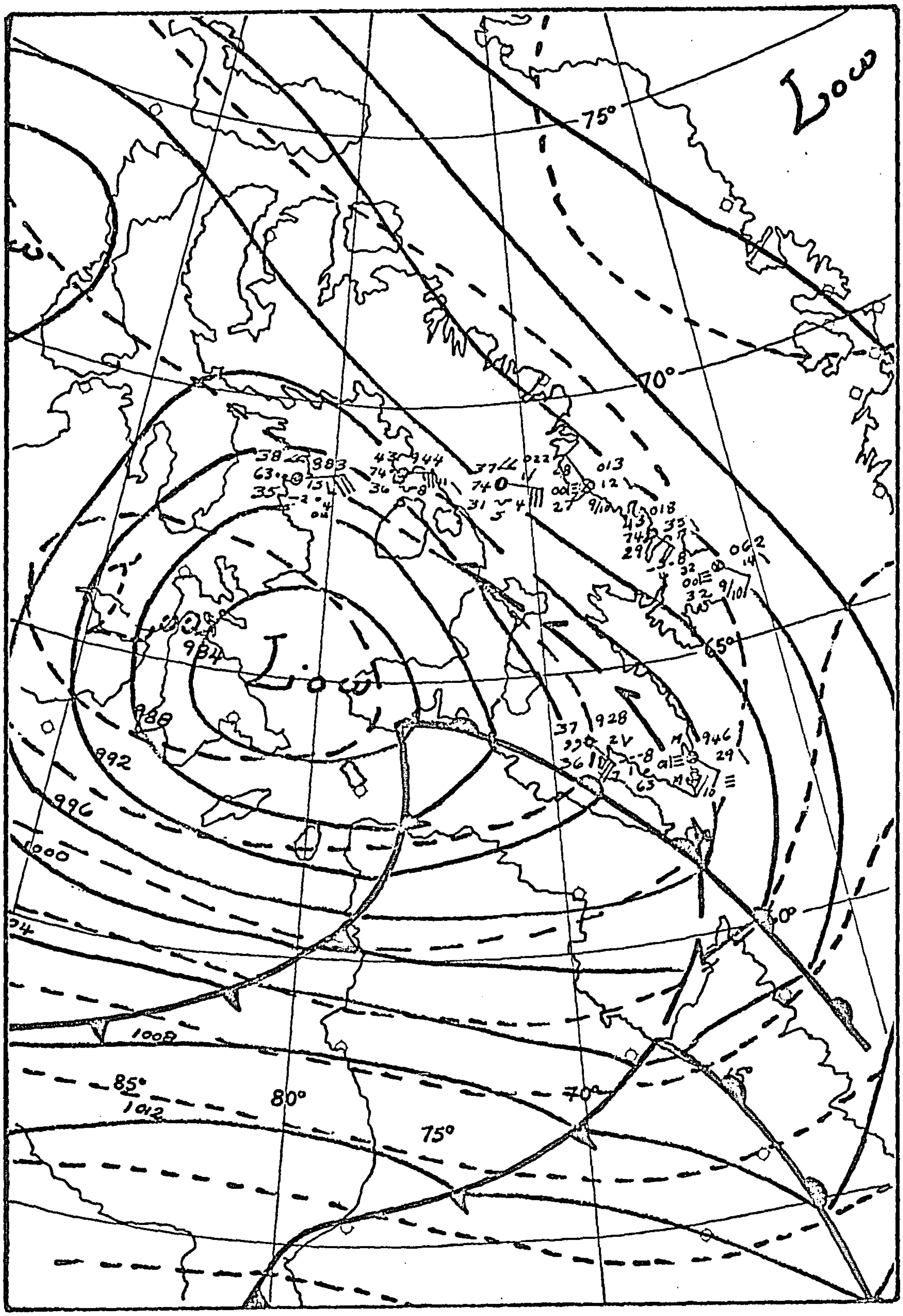

Figure 26. Surface Weather Map for August 19, 1960, 1200 G.M.T. 500 mb Contours Superimposed by Dashed Lines.

from below and vigorous convection is initiated. Hudson Strait is thus an ideal area for promoting cyclogenesis caused through diabatic processes.

The Strait lies on the path of storm tracks which have varying degrees of frequency and importance depending on the time of year (Figs. 10 to 13, pp. 29-30). By far the greatest number of cyclones frequent the area during the summer months, and as the temperature contrast between the water and overlying air mass is such that only stable conditions result, then it is in the winter and transitional seasons that relatively weak Arctic disturbances can sometimes undergo profound deepening when crossing Hudson Strait.

There are numerous examples of small lows intensifying upon reaching Hudson Strait after a long trajectory from points far to the west or south. These cases do not refer to cyclones which have had a history of rapid or slow intensification due to upper air and vorticity considerations but rather to relatively weak impulses, many of which are in an advanced stage of the occlusion process.

The Hudson Strait Low, as it is termed here, covers an area small enough so that only the south-central parts of Baffin Island feel most of its effects. The surface impulse generally manifests itself aloft in the form of a vigorous short wave trough embedded in a westerly or southwesterly flow across the Strait (Fig. 27). In this case, a severe blizzard lashed Frobisher Bay for over 18 hours. Other examples show that the surface low is associated with a cold low at upper levels almost devoid of any baroclinic characteristics as in Fig. 28 for February 27, 1958.

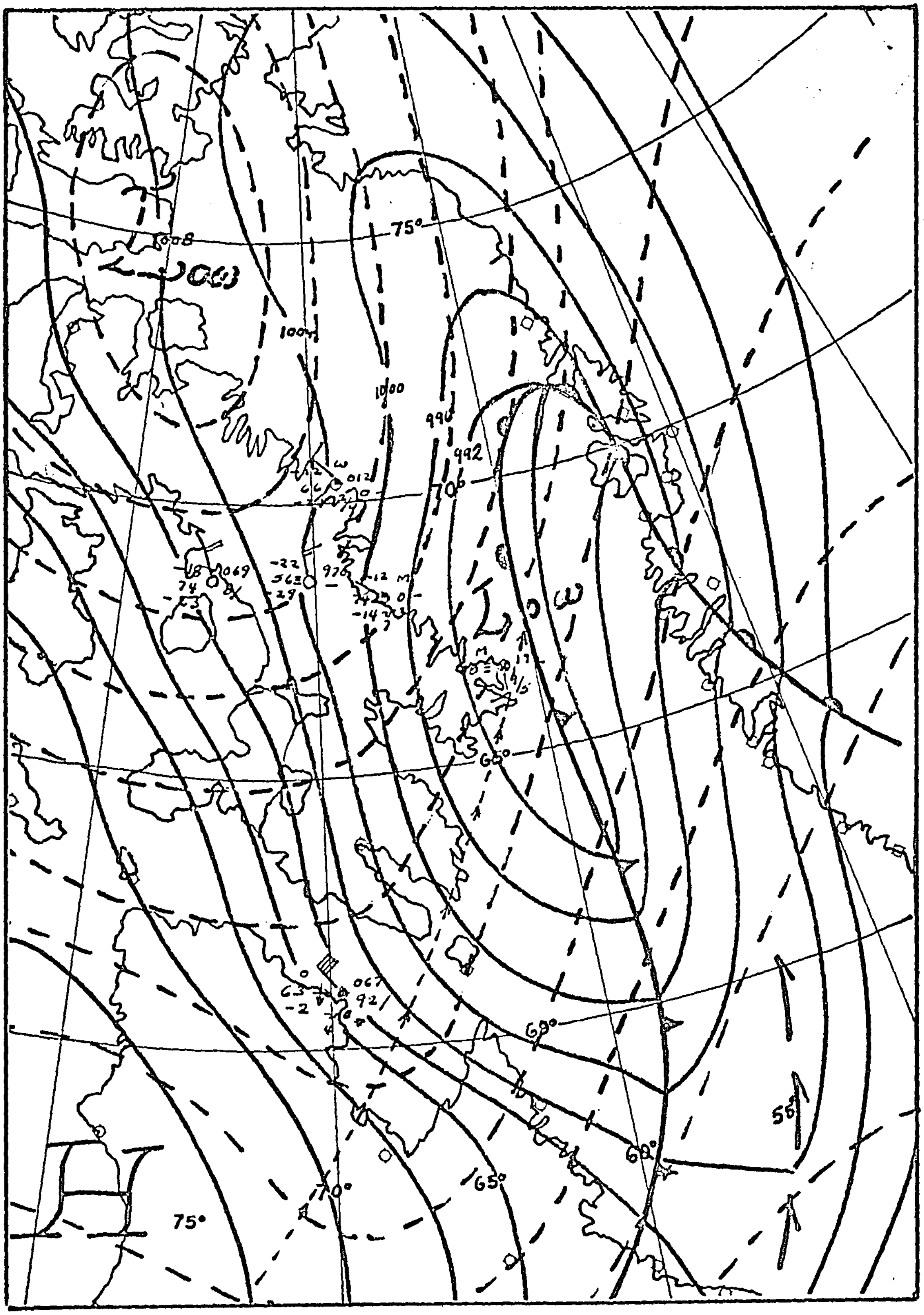

Figure 27. Surface Weather Map for April 17, 1958, 0000 G.M.T. 500 mb Contours Superimposed by Dashed Lines.

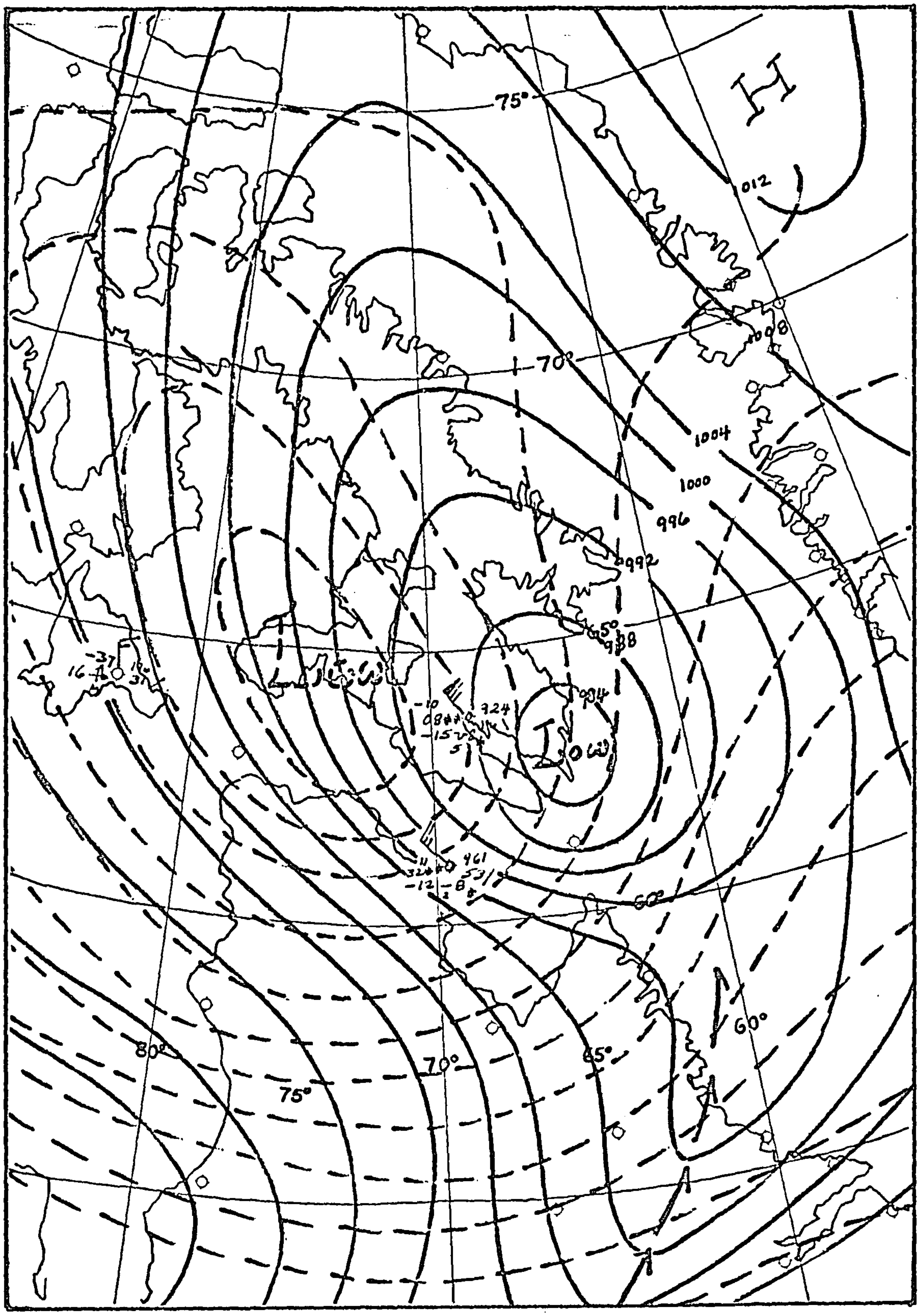

Figure 28. Surface Weather Map for February 27, 1958, 1200 G.M.T. 500 mb Contours Superimposed by Dashed Lines.

One such low, which entered Hudson Strait at the western entrance, had a remarkable history of movement originating in Davis Strait (Fig. 29). It gradually intensified while traveling through Hudson Strait and eventually amalgamated with a northward moving low in the process of deepening over Newfoundland. It may be noted that this low was reflected at 500 millibars by a deep cold vortex centered over Melville Peninsula. Frontal structures were entirely lacking and movement was slow.

Summer systems of this variety seldom deepen unless there is positive vorticity advection aloft. This would imply a surface frontal organization. An interesting instance of this can be gleaned from the synoptic situation in Fig. 30. After rainshowers throughout the night and strong east to northeast winds, the cloud structure displayed chaotic features until about 8 A.M. in the morning when a truly remarkable wave cloud formed, as can be seen in Photo 6. A strong perpendicular flow across the hills to the northeast produced the phenomenon.

Yet another example of an intense summer low can be seen in Fig. 31. Heavy rains and gale force winds heralded the approach of this system at Frobisher Bay. The main center eventually rotated into Foxe Basin while the frontal structures moved off to the east.

Weather accompanying the passage of the Hudson Strait Low is dependent on the actual type of situation involved. In winter, the cold core type must be distinguished from the frontal or short wave feature. In summer as in winter, the frontal low provides the greatest variety of weather.

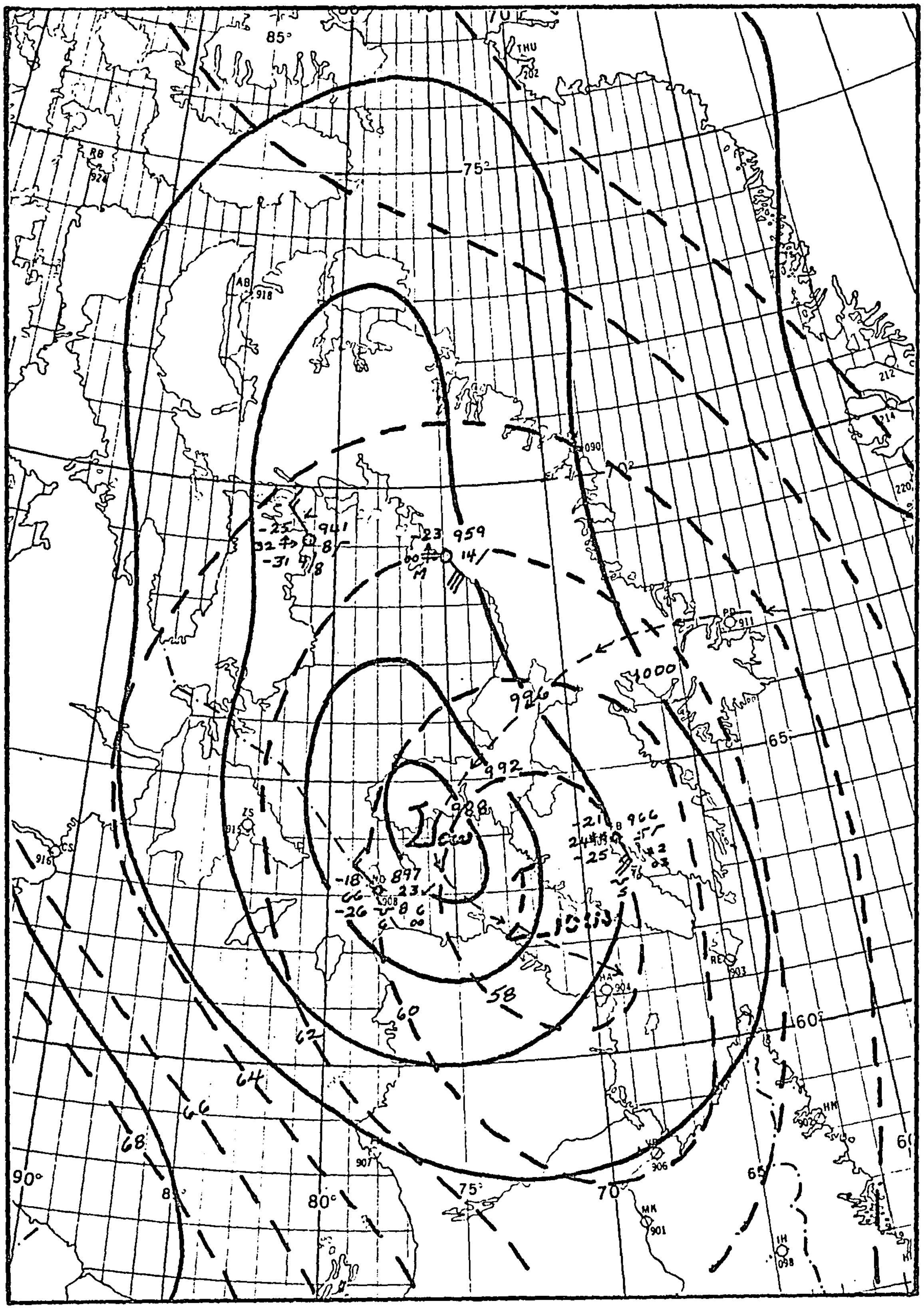

Figure 29. Surface Weather Map for February 23, 1958, 1800 G.M.T. 500 mb Contours Superimposed by Dashed Lines. For 1200 G.M.T.

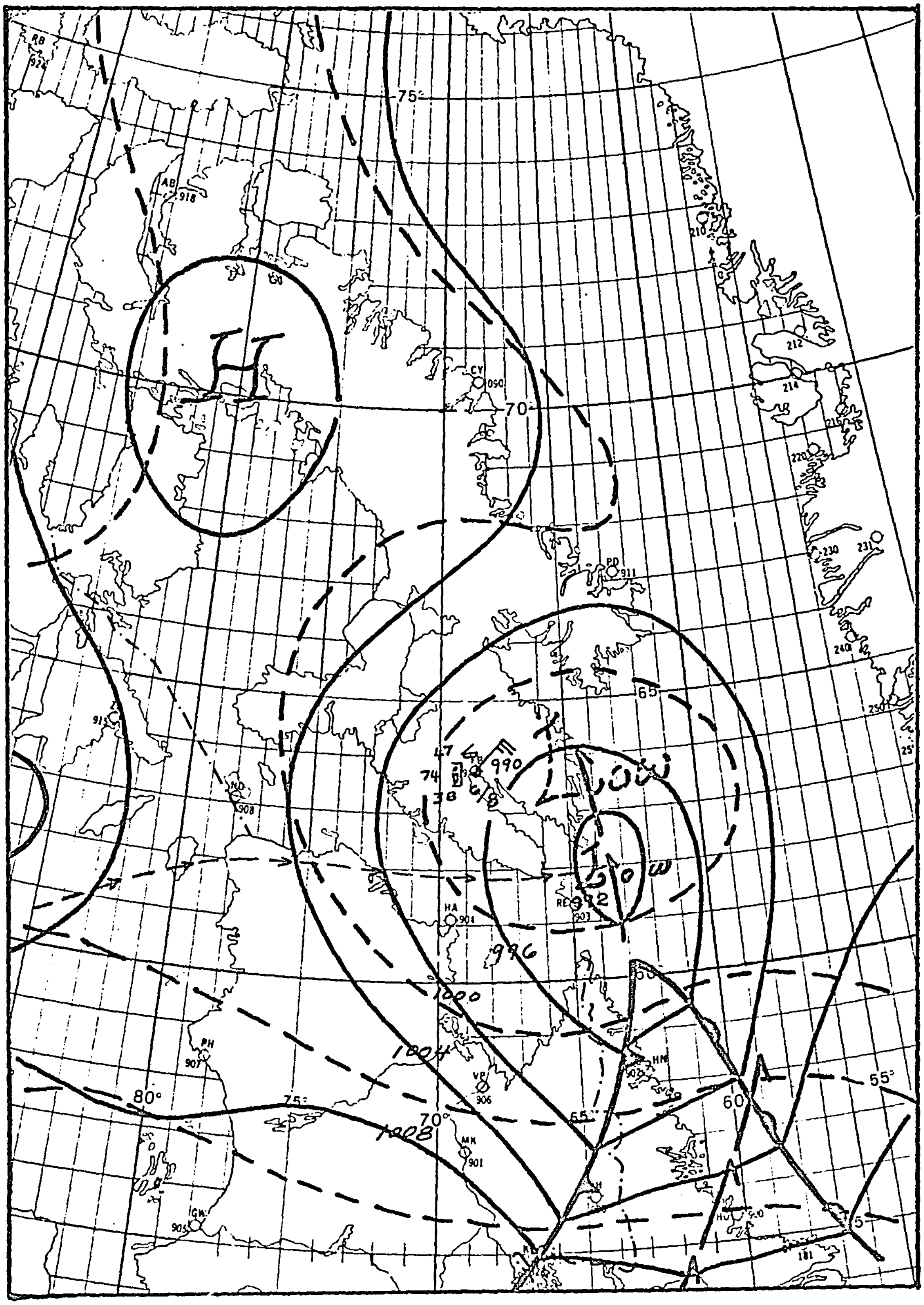

Figure 30. Surface Weather Map for July 16, 1959, 1200 G.M.T. 700 mb Contours Superimposed by Dashed Lines.

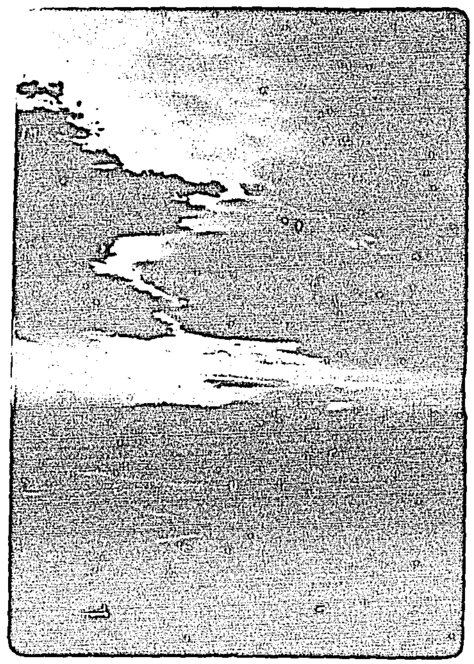

Photo 6. Wave Cloud at Frobisher Bay, N.W.T., on July 16, 1959. (Photo by B.A. Coulcher)

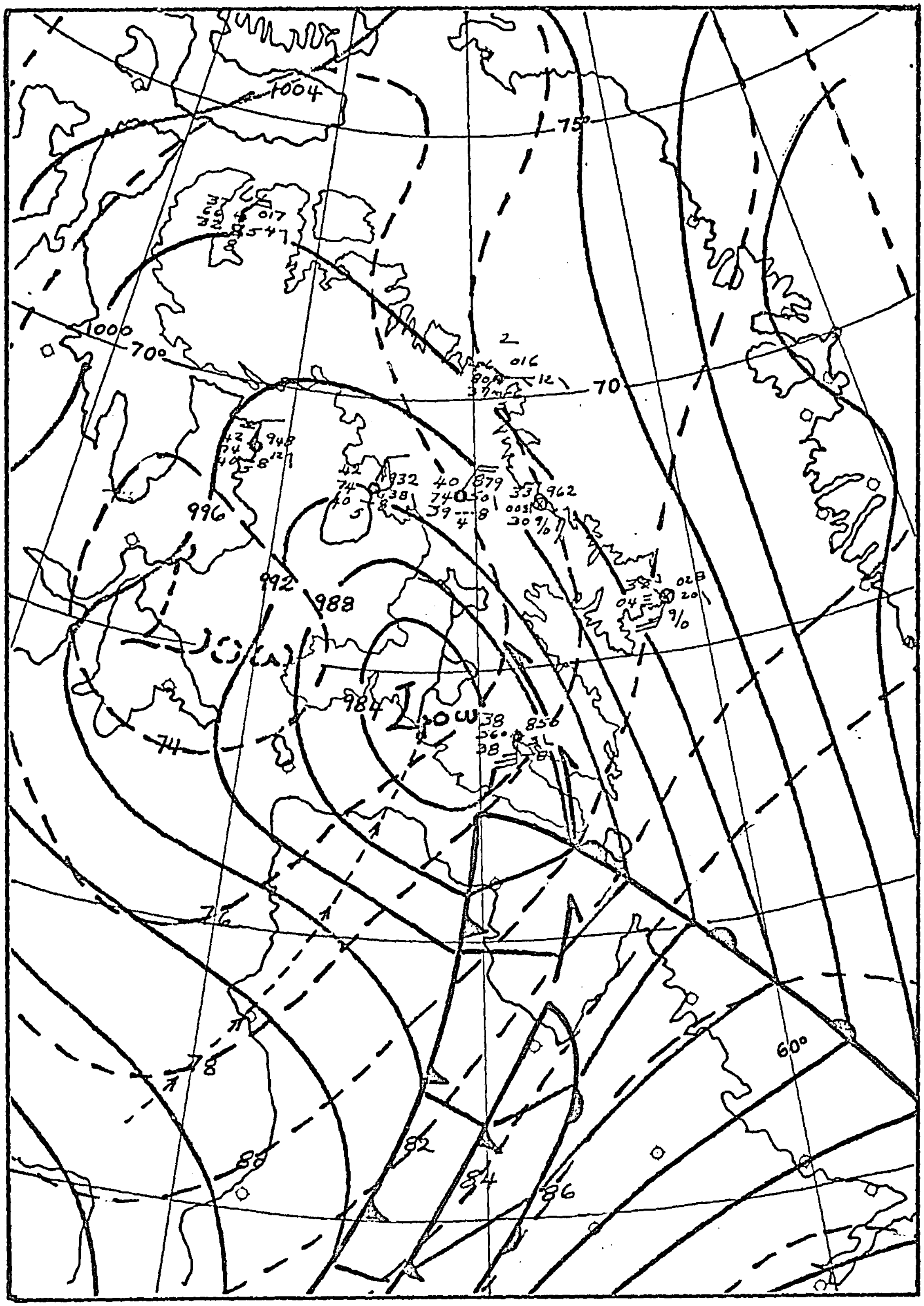

Figure 31. Surface Weather Map for July 15, 1958, 1200 G.M.T. 500 mb Contours Superimposed by Dashed Lines.

Across southern Baffin Island, the frontal low is frequently characterized by an embedded occlusion with southerly winds, clouds and continuous or showery precipitation ahead of it, and generally rapid clearing behind. The cold core low produces mostly a blend of very light snow or ice crystal fall-out, southerly winds and slow clearing as movement of the feature is slow. The band of inclement weather is confined for the most part over the southern portions of the Island as far north generally as Cape Dyer. Dewar Lakes and Longstaff Bluff feel little effects from these lows with the exception of light, occasionally moderate easterly winds.

4. The Labrador Sea Low

The Labrador Sea Low, when fully mature, is one of the most intense storms to affect the outer coast of southeastern Baffin Island. The breeding ground lies off the eastern coast of Newfoundland, an area where the interaction between the ocean and atmosphere reaches a maximum in winter. The cyclone then follows a path northward towards the southern tip of Greenland or somewhat to the left of the dominant storm track, acquiring great intensity en route. Maturity is usually reached over the northern Labrador Sea, whereafter the frontal systems have largely occluded and moved northeast into the Denmark Straits, west of Iceland, leaving behind a formidable cyclonic vortex. The movement of the core of the disturbance becomes erratic and not infrequently backs onto the coast of southern Baffin Island and Labrador (Fig. 32) producing violent winds and abundant precipitation.

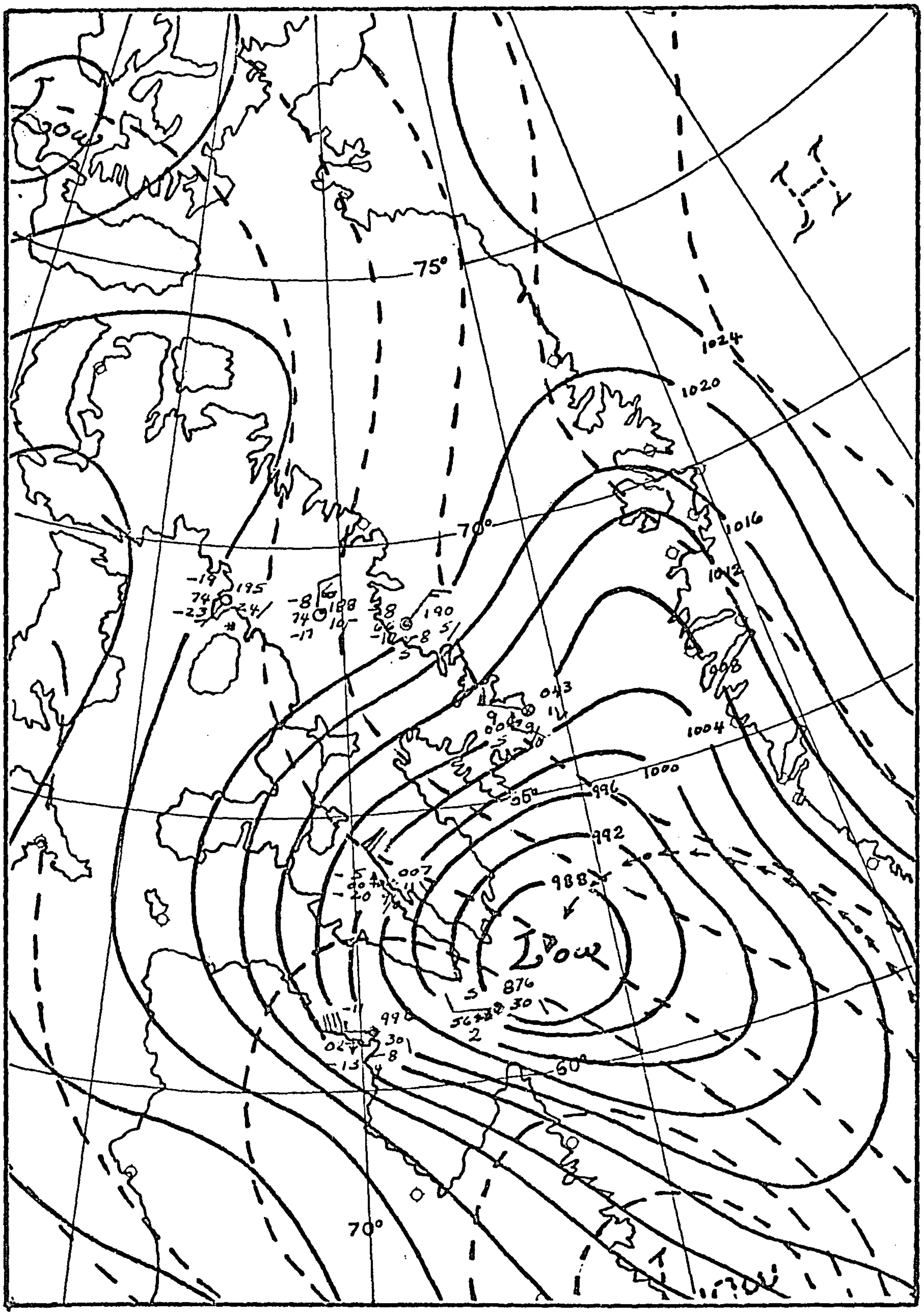

Figure 32. Surface Weather Map for March 29, 1960, 1200 G.M.T. 500 mb Contours Superimposed by Dashed Lines.

The easterly gradient found at all levels in the leading quadrant of the Labrador Sea Low, is often sufficiently strong to produce substantial troughing along the west coast of Greenland. Seldom, however, does the trough deepen beyond 70° north latitude unless the actual low is steered into Davis Strait.

Under favorable circumstances, depressions may develop over the Labrador Sea itself and travel rapidly northward, skirting the eastern shoreline of Baffin Island (Fig. 33), while producing a variety of weather en route. These lows, which move out of the northern Labrador Sea, seldom if ever reach extreme intensities, for during the initial stages of development, the warmth and moisture of the sub-tropical Atlantic is lacking.

The eastern and southern coasts of Baffin Island can receive a severe buffeting from the presence of a deep, stationary, cyclonic storm in the Labrador Sea (Fig. 34). Some of the worst blizzards of the winter accompany this pattern, and owing to the slow and unpredictable movement of the low, these blizzards can last for days (Photo 7).

The frequency of intense Labrador lows is fortunately not great. Many minor systems develop or move into the area throughout the year, and many more travel rapidly eastward. It remains for the occasional two or three, occurring from January to March, to create the necessary conditions which produce these long and violent windstorms across southeastern Baffin Island.

5. Depressions Migrating Across Northern Baffin Island from the Central Arctic

Lows moving out of the central Arctic across northern

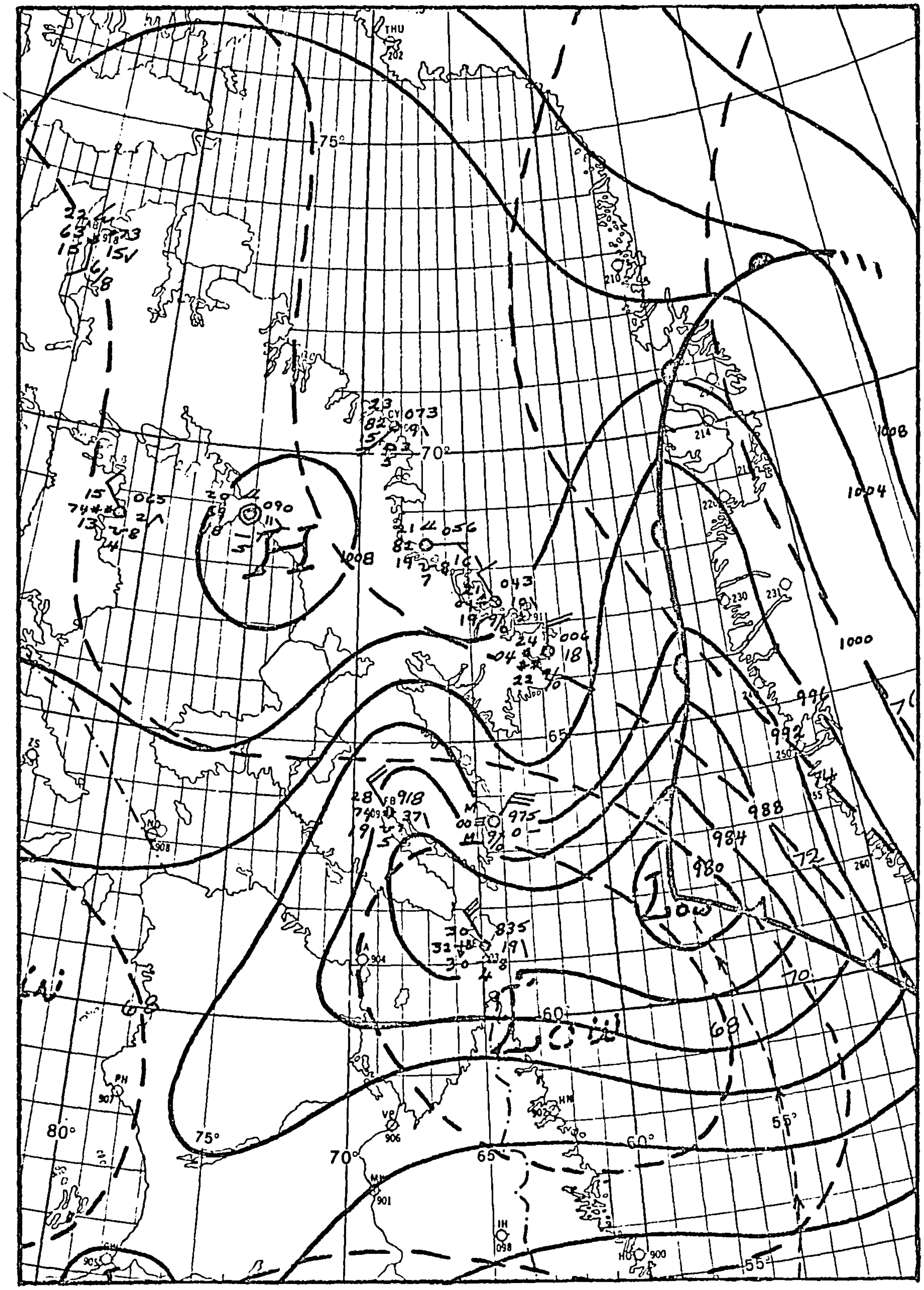

Figure 33. Surface Weather Map for October 22, 1960, 1200 G.M.T. 500 mb Contours Superimposed by Dashed Lines.

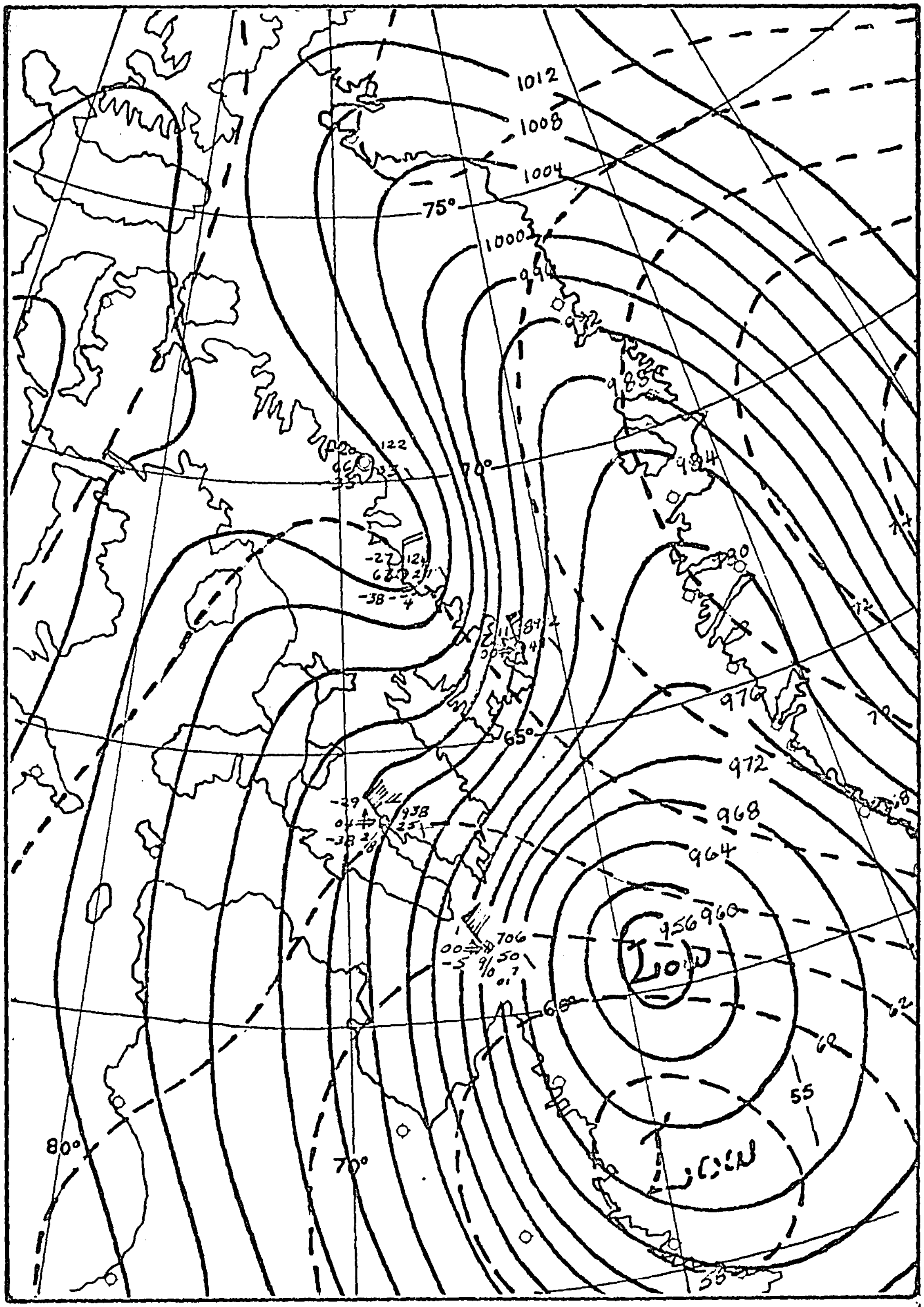

Figure 34. Surface Weather Map for February 21, 1959, 1200 G.M.T. 500 mb Contours Superimposed by Dashed Lines.

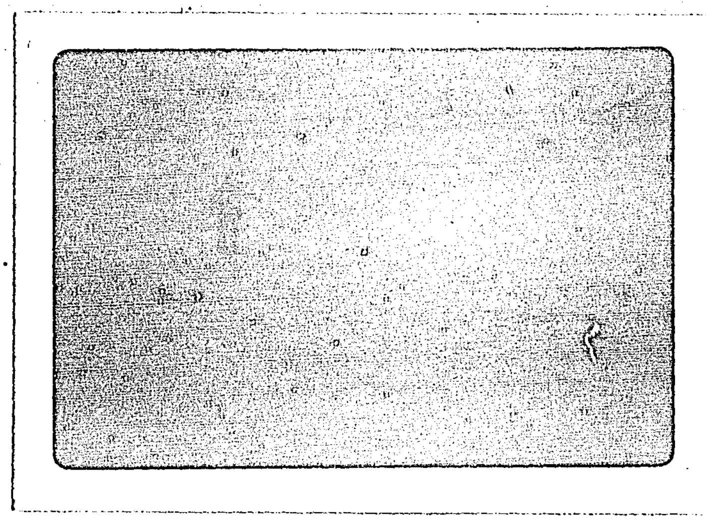

Photo 7. Blizzard at Frobisher Bay, N.W.T., February, 1959. (Photo by B.A. Coulcher)

Baffin Island and into Baffin Bay have been documented by Klein (1956) and by Berry, Owens and Wilson (1954). The storm track is not classed as a major one as the disturbances are seldom vigorous entities. Essentially they are disturbances which have formed only on the Arctic front and thus lack the required degree of warmth and moisture necessary for serious intensification. Even the path they travel across ice and snow and cold land precludes them from acquiring these two essential prerequisites.

The Central Arctic Low, if not intense, is at least persistent at all seasons, with the exception of April and May. In April and May, a major anticyclonic track is centered on a north to south line over the central Arctic and low pressures crossing Baffin Island are rare.

The highest frequency appears to be in the early winter months and it is then that they are at their most intense. Successive surges of increasingly cold Arctic air follow as they move at a uniform rate eastward across the Arctic (Fig. 35).

In mid-winter, the lows are usually associated with a cold vortex aloft and movement thus becomes more sluggish. Weather associated with mid-winter disturbances of this type comes in the form of moderate surface winds and very light, dry snowfall, easily transported by the wind. Frontal lows produce a greater variety of weather. Unlike the cold core low, where cloud structure is basically a haze formation, the frontal low has a definite cloud pattern with much of it being the stratocumulus type. In summer, low stratus, drizzle and fog frequently accompany the meandering Central Arctic low.

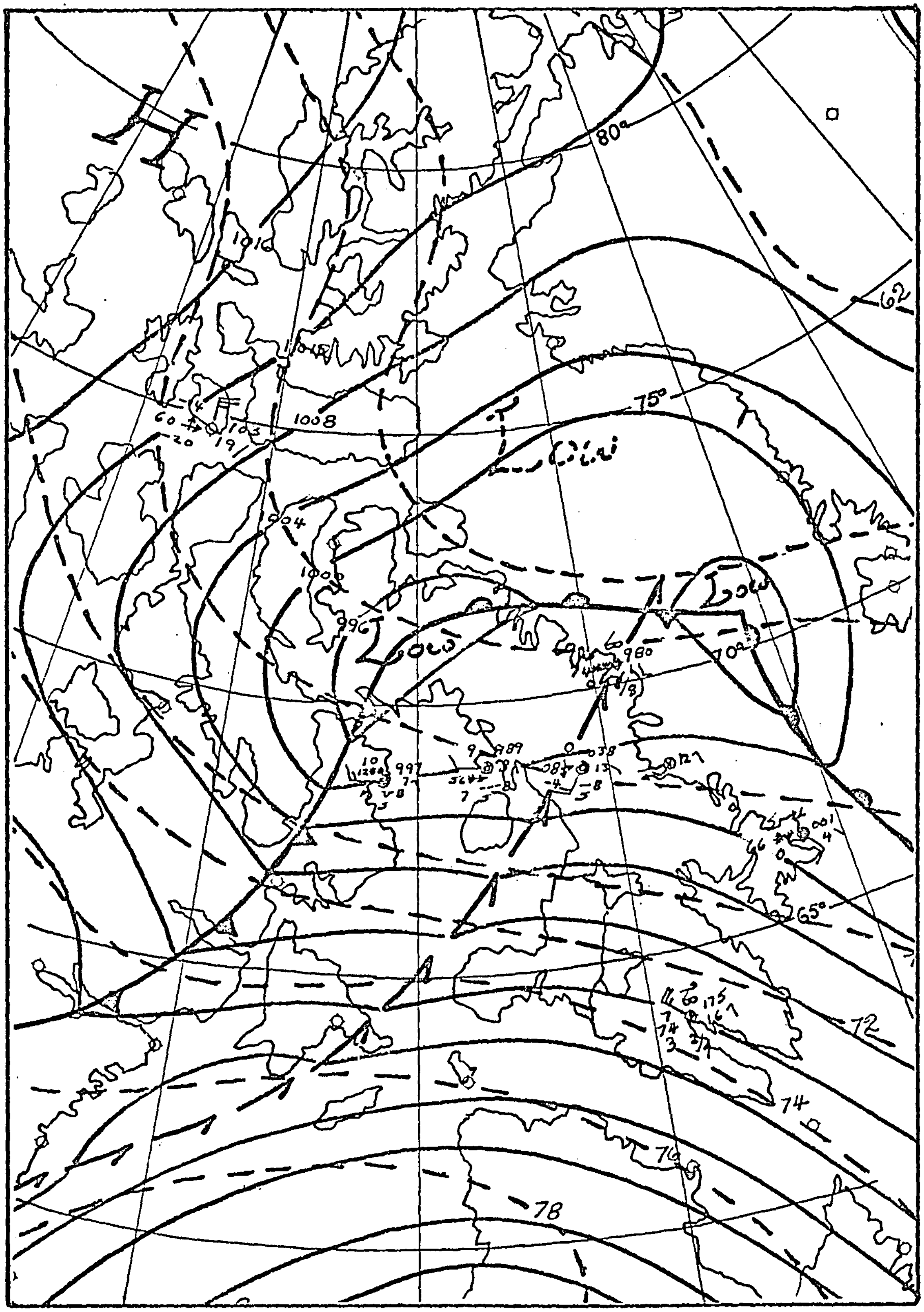

Figure 35. Surface Weather Map for December 21, 1959, 1800 G.M.T. 500 mb Contours Superimposed by Dashed Lines.

6. The Intense "Quebec" Cyclone

The most spectacular storms that affect the east-central Arctic on rare occasions originate in winter across southern Quebec and Ontario and are a direct result of a dynamic readjustment in the planetary circulation pattern. These low pressure areas follow a path northward through central Quebec and gradually recurve northwestward, eventually filling slowly over extreme northern Hudson Bay or Foxe Channel.

The surface feature is reflected aloft by a well-established long wave trough through central North America, coupled by strong high latitude blocking high over Greenland and Baffin Bay. Vast amounts of warm air are transported north and west in the strong southeasterly stream between the two centers, sometimes penetrating the Arctic to great depths. These bursts of warm, moist air are propelled northward ahead of the rapidly deepening systems moving north from southern Quebec. The surface system when fully mature covers an enormous area and few localities on Baffin Island are spared its fury. Fig. 36 provides an excellent example of the Quebec cyclone.

On occasions, disturbances of this type will head directly towards southern Baffin Island and Hudson Strait. Splitting almost always occurs against the "rocks" of southern Baffin Island with the major cold core drifting westward and the associated frontal systems and secondary surface core traveling into Davis Strait and weakening.

The Quebec low produces extremely poor weather across

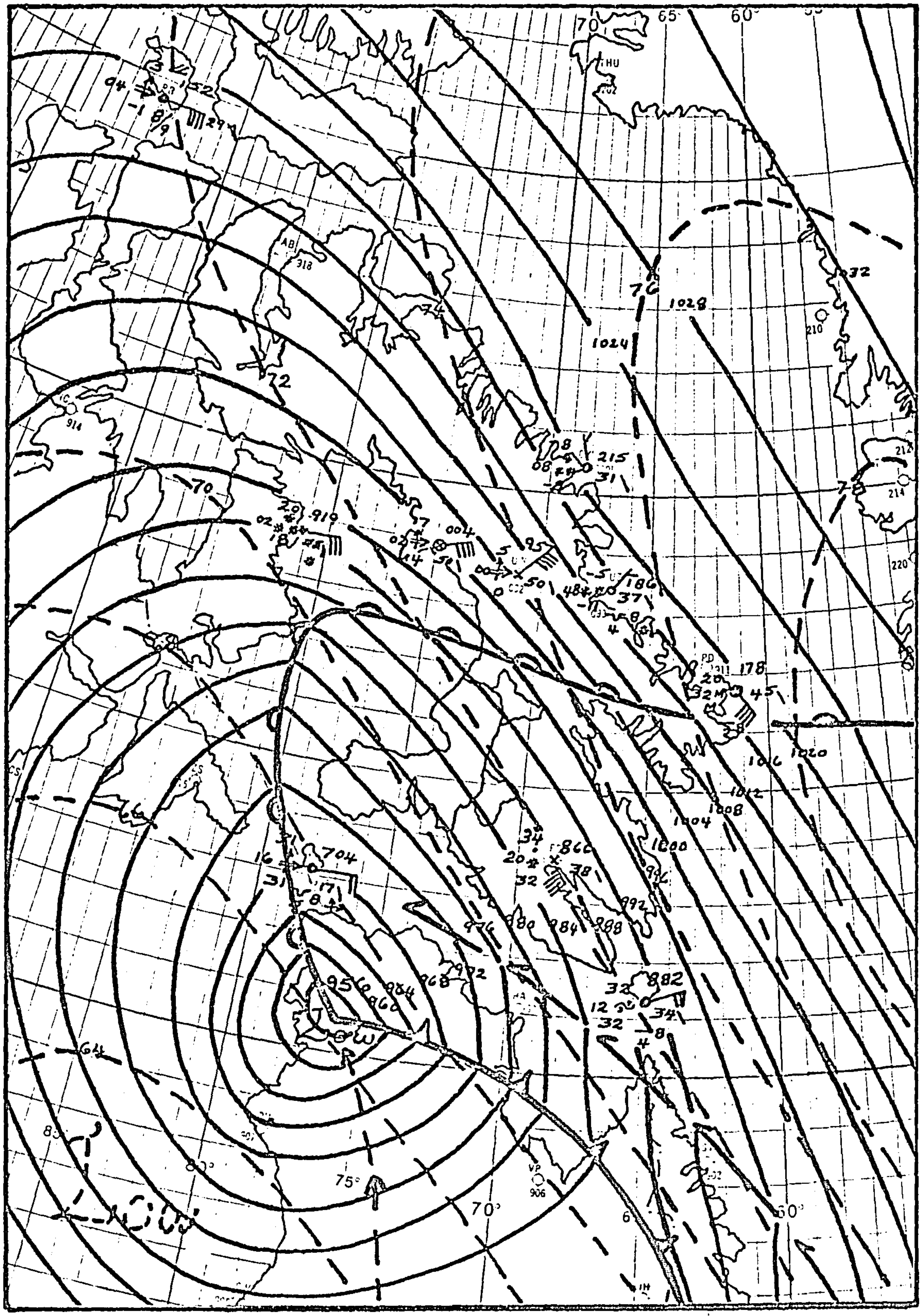

Figure 36. Surface Weather Map for January 18, 1959, 0600 G.M.T.

the Island and Foxe Basin. Severe easterly gales, heavy snow and blowing snow, turbulence, and strong subsidence punish the central plateau and western plains areas. The intense pressure gradient creates similar conditions over southern and eastern coastal regions, although winds are channeled from the southeast at stations such as Frobisher Bay and Cape Dyer. Cape Hooper, Clyde River and Arctic Bay escape high winds by virtue of their location and owing to the fact that being further north, the air near the surface is colder and more dense, thus displacement becomes more difficult to accomplish.

The warm front which is embedded in the forward part of the storm usually invades the deeper portions of the eastern Arctic as an upper air discontinuity. In other words, the Arctic air which is well entrenched at the lower levels and which becomes progressively colder and more dense towards the interior of the continent is reluctant to give way to the much milder Atlantic brand. The warmer air is thus forced aloft, becoming an upper warm frontal system. Along the southeastern coast of Baffin Island, the cold air is replaced fairly rapidly and temperatures rise above the freezing point. Precipitation, which begins as snow, turns to rain or a mixture of rain and snow showers, and a thaw generally sets in. This situation can produce a severe problem on the airport runways as the rain and wet snow freeze on impact and form a sheet of ice, thus prohibiting aircraft operations. Upper air soundings at Frobisher Bay and Hall Beach (Fig. 37) clearly show the different air masses at lower levels of the atmosphere.

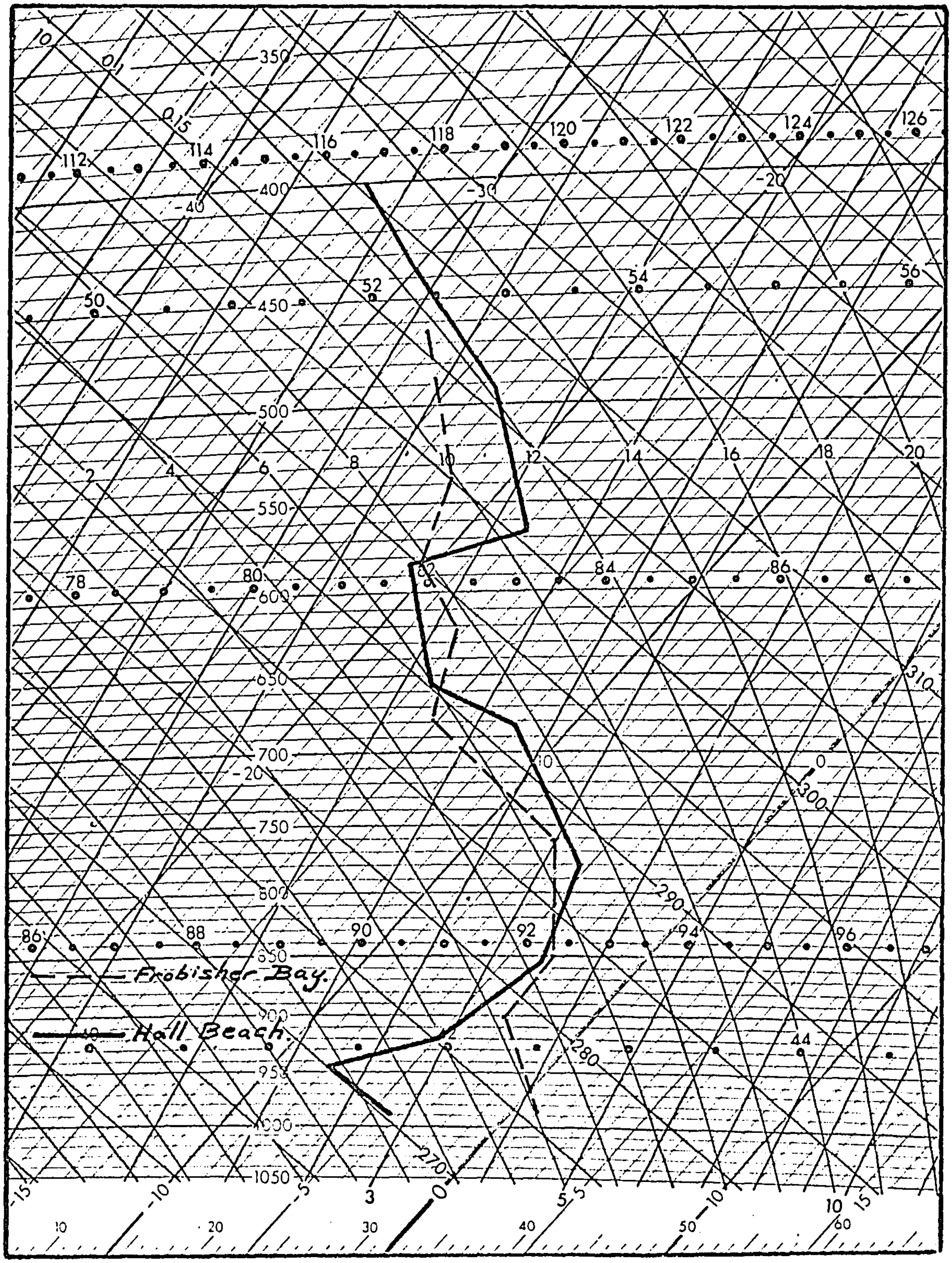

Figure 37. Upper Air Soundings for Frobisher Bay, N.W.T. and Hall Beach, N.W.T. January 18, 1959, 1200 G.M.T.

The huge storm occludes and the main center is left to weaken slowly in the vicinity of northern Hudson Bay. Secondary low pressure areas can form in the southeastern quadrant of the main vortex but they seldom reach the intensities of the original system and their tracks are quite often displaced further to the west.

Storms of this nature are wintertime phenomena and are of infrequent occurrence. In some winters, such a development is totally absent, while others can witness the process on several occasions. They are storms of great violence and produce a variety of weather conditions across Baffin Island. They are also bearers of tremendous quantities of warmth and moisture which are advected deep into the Arctic, helping to maintain the energy balance of the general circulation over the earth.

C. Anticyclonic Patterns

1. General Remarks

Baffin Island does not lie on the path of a significant anticyclonic track. This is clearly shown in mean maps produced by Klein (1956). Berry, Owens and Wilson (1954) examined Arctic anticyclonic charts and state with reference to North America:

> From the charts it becomes apparent that only across northwestern Canada is there any major track along which Arctic highs are fed into the westerlies.

The presence of surface high pressure area over Baffin Island is not frequent, although there appears to be a higher preponderance of highs over Foxe Basin region in the late winter months. Ridges or even small closed high pressure areas tend to form along the east coast, particularly during periods of easterly flow across Baffin Island. A well-developed West Greenland Trough will produce a ridge through the central parts of the Island.

Blocking action over Baffin Bay, Davis Strait and Greenland contribute to surface high pressure development. This pattern can form at any time of the year although the most intense occurrences are recorded in the mid-winter or early spring months.

2. Surface Ridges and Blocking Anticyclones

Ridging extends southward through the center or along the east coast mountains of Baffin Island as far south as Cumberland Sound is a familiar feature of the surface pressure pattern when the West Greenland Trough is well-developed (Fig. 24, p. 108), for this generally implies an easterly flow at higher levels. This is very evident on mean sea level pressure maps in January, April and October. In July, the pattern reduces to a single elongated high pressure cell centered over Cape Hooper. It is thought that the cold Baffin Bay current is instrumental in producing the cell at low levels.

Closed anticyclones are infrequent visitors to Baffin Island. When they do appear, however, they are usually associated with blocking highs aloft over Baffin Bay and/or Davis Strait. The most intense highs are favored in the mid-winter and spring months. An example of strong anticylogenesis can be seen in Fig. 38. The high in this case is kidney-shaped with a

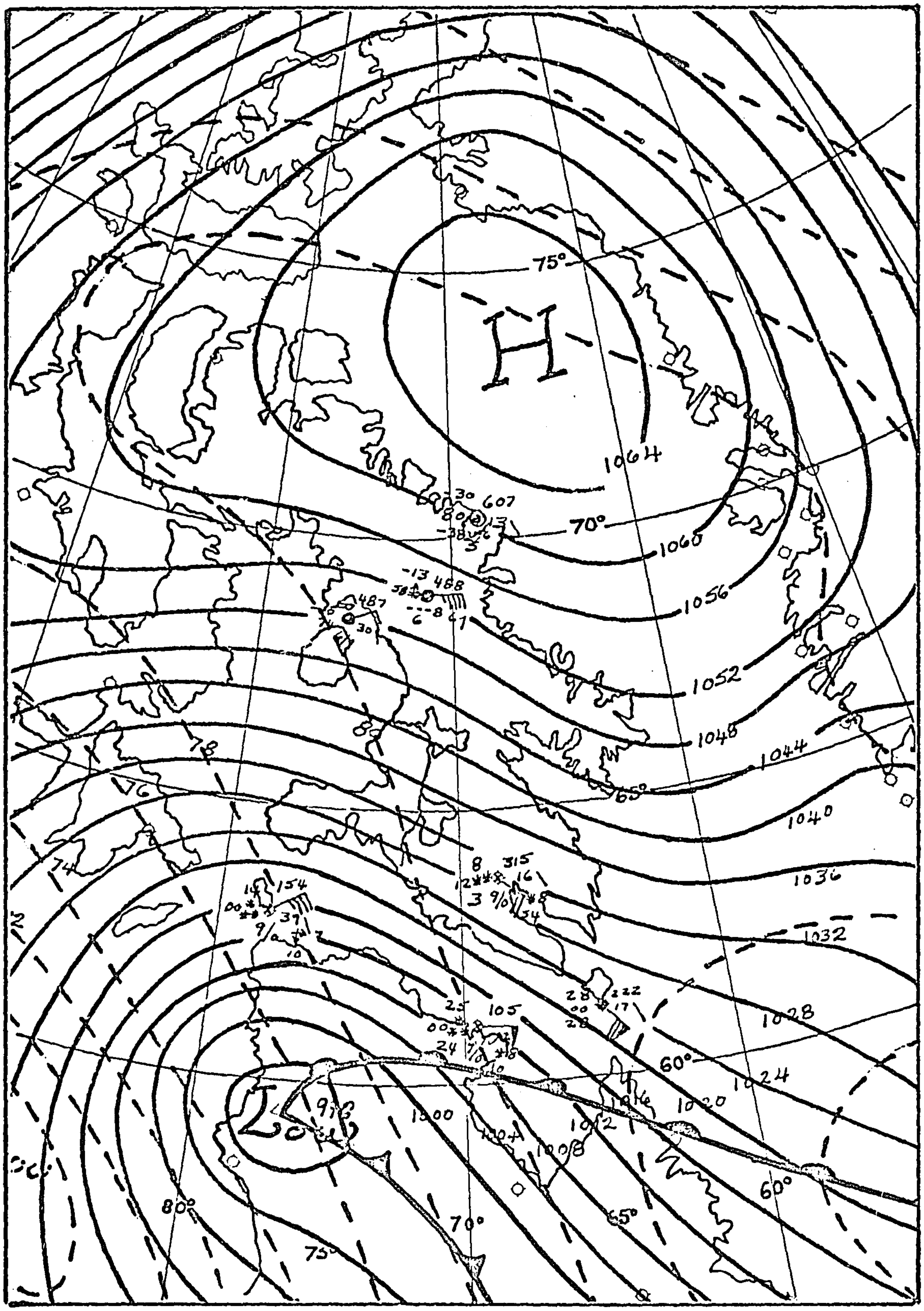

Figure 38. Surface Weather Map for January 18, 1958. 1200 G.M.T. 500 mb Contours Superimposed by Dashed Lines

remarkable central pressure of 1066 millibars.

These patterns invariably produce an easterly onshore flow along the east coast of Baffin Island. In winter, an easterly circulation bears abundant amounts of ice crystals drifting off the large open leads of Davis Strait and Baffin Bay and cause a marked lowering of visibilities.

In spring and summer, fogs have been known to hug the coastline for days. Warmer air aloft and melting sea ice create inversions which are ideal for producing and trapping marine stratus and fog along the coast and in the fiords. Photo 8 provides a striking example of fog shrouded fiords along the east coast of Baffin Island.

It is somewhat unusual for a blocking pattern to form in the fall. However, an example of such can be seen in Fig. 39. The 500 millibar contours for 1200Z are superimposed by hatched lines. The surface map for 0600Z shows a small but fairly intense anticyclone centered southeast of Clyde River. At 500 millibars, a warm high is centered over northwest Greenland. The flow across Baffin Island is in evidence along the west coast of Greenland. A series of inverted low pressure troughs are moving from an east to west direction across southern Baffin Island, pumping warm maritime air across the region.

Weather along the east coast is mostly clear, although patches of scattered stratus and fog periodically drift onshore. Cape Hooper, it is seen, was completely fogged in. Upper air temperatures for the first few thousand feet at Clyde River and Frobisher Bay (Fig. 40) show a striking contrast.

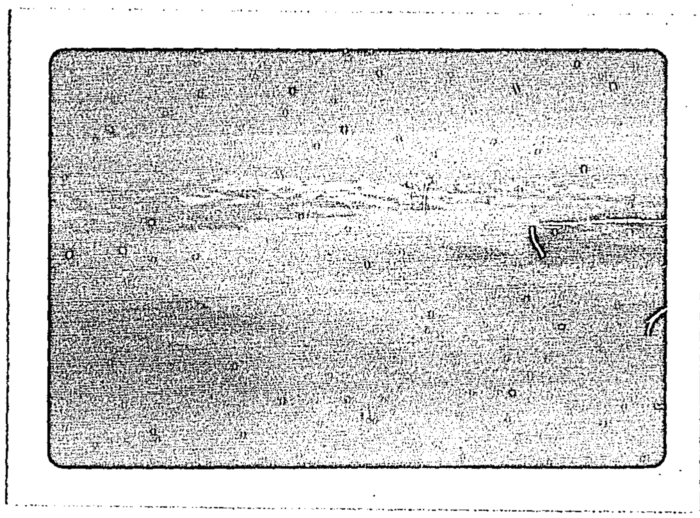

Photo 8. Fog Shrouded Fiords along the East Coast of Baffin Island, N.W.T., July, 1959. (Photo by B.A. Coulcher)

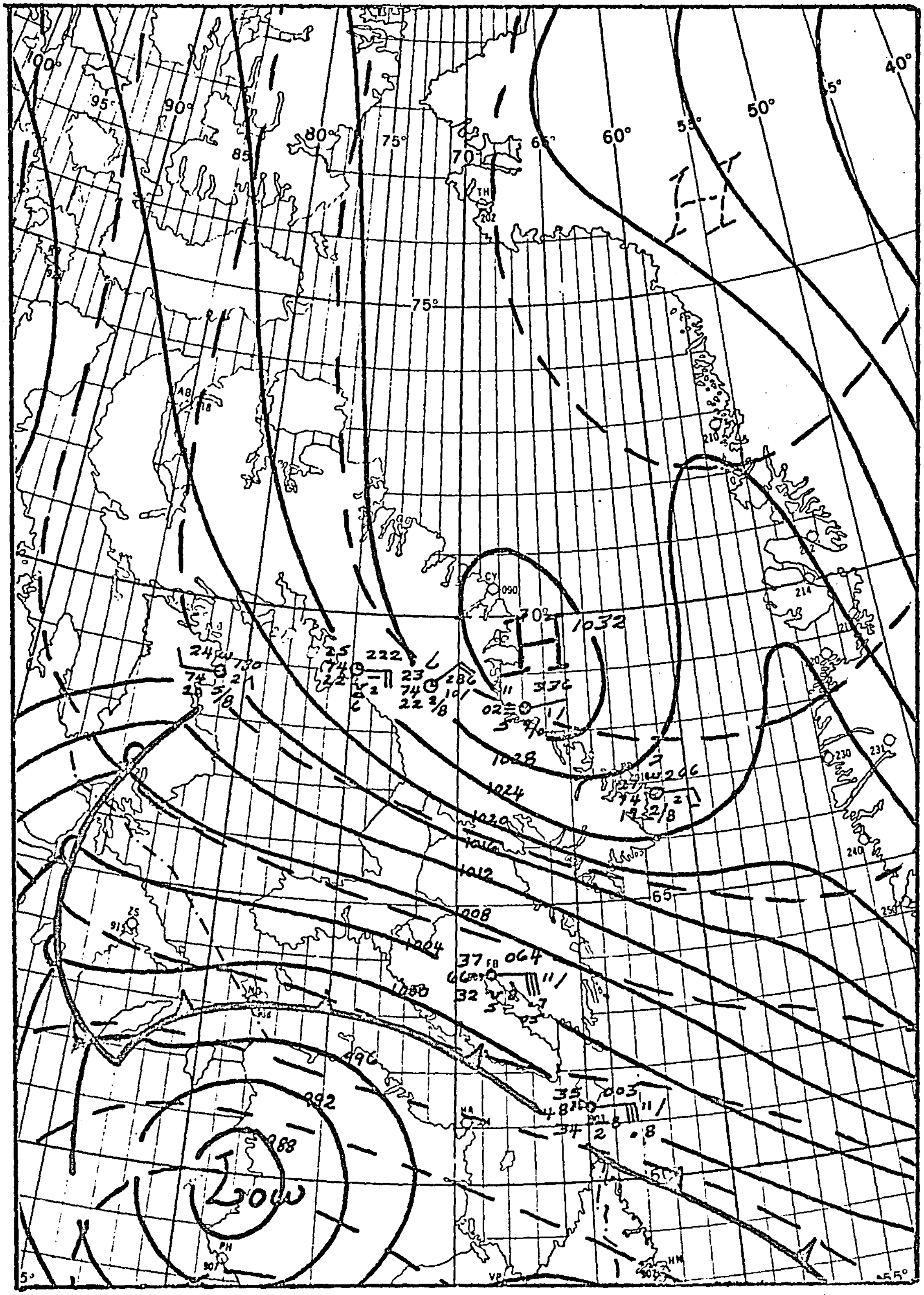

Figure 39. Surface Weather Map for November 20, 1959, 0600 G.M.T. 500 mb Contours for 1200 G.M.T. on the Same Date Superimposed by Dashed Lines.

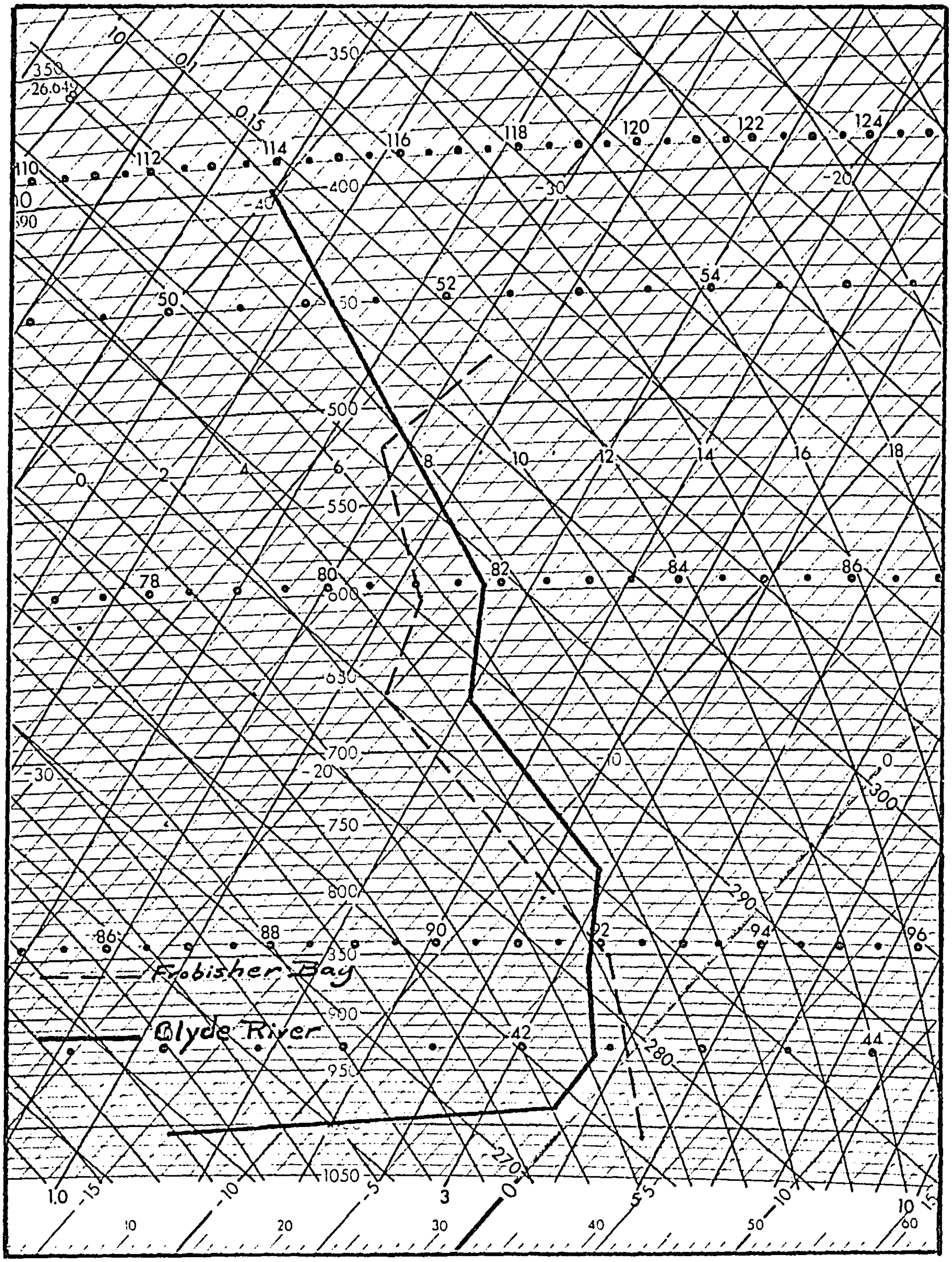

Figure 40. Upper Air Soundings for Frobisher Bay N.W.T. and Clyde River, N.W.T., November 20, 1959, 1200 G.M.T.

CHAPTER V. DISCUSSION AND CONCLUSIONS

Much of the published literature and the climatic data recorded in this review on the synoptic climatology of Baffin Island is for a relatively short period. This is inevitable when one considers the fact that only since the early 1950's has a concerted effort been made to establish a more accurate picture of meteorological processes at work in the eastern Arctic. Baffin Island was fortunate in this connection since a number of new surface and radiosonde reporting stations were constructed there, either through military necessity or operational convenience. The advent of commercial polar flights and growing military awareness were important factors paving the way for this enlarged weather observing programme.

Meteorological papers on the Arctic, although still not abundant, are nevertheless accumulating at a more rapid rate as the synoptic weather network expands and research facilities improve. For the Arctic, there is now a total of ten to fifteen years of reliable synoptic data and charts. Thus it is not surprising that most of the literature consulted in this thesis was written during the past decade. However, only a relatively small part of this output is directly concerned with the synoptic climatology of a given region or locality. The greater part of it refers to studies made on the broad scale flow patterns and descriptive climatology of the area.

The meteorological data acquired for this thesis may be regarded, on the whole, as thoroughly reliable. Most of the stations were staffed by trained technicians, and their observations were enhanced by recent innovations in the field of instrumentation and communications. Observations made during the initial phase of the DEW Line network in the late fifties, however, were open to question as many of the weather observers were not experienced in the task of recording and disseminating this vital information. These difficulties have now been overcome and the wealth of data being collected at the present time will permit an even more exacting study of synoptic climatological processes across Baffin Island.

All available information was utilized in this report regardless of the length of record. Large and small scale features were investigated with emphasis being placed on the interaction between the local topography, the nature of the surface, and the main synoptic weather systems.

Mean sea level pressure maps were drawn (Figs. 2-5, pp. 19-22) with aid from six years of DEW Line weather data, and on the whole the stations fitted well into the overall pattern with but minor adjustments having to be made. Average wind direction frequencies from these localities tended to confirm the existence of dominant pressure features on and around Baffin Island.

The distinguishing characteristics of the January map (Fig. 2, p. 19) lies in the dynamically induced Foxe Basin Low and the small high pressure area over the Barnes Ice Cap. The exact center of the Foxe Basin Low is difficult to determine. Indeed, it may be said that an actual center does not exist, but rather that the feature is merely an extension of the West Greenland Trough. A similar argument can be advanced for the high pressure cell situated over the Barnes Ice Cap. Nevertheless, it would be quite logical to draw in a small high center over the ice cap, thereby establishing it as a shallow glacial anticyclone largely created and maintained by strong radiational processes.

The July mean pressure map (Fig. 4, p. 21) also reflects an interesting pattern. The elongated high pressure across the central portions of Baffin Island bears noting. Up to now, this feature has been omitted from previous mean maps of the area. It is difficult to determine whether the high is broken up into separate cells, or whether it exists as a single elongated entity as shown in Fig. 4. The suggestion is, however, that the northerly Baffin Bay current off the east coast and the large interior ice fields are instrumental in creating this flow pattern.

A careful study of migrating pressure systems over the Eastern Arctic (Chapter II) reveals some additional information on their development, frequency, and paths across Baffin Island. Furthermore, several cyclonic and anticyclonic types are clearly identified as producing specific weather and flow patterns over the Island and they are described at length in Chapter IV.

The secondary cyclonic track traveling across northern Hudson Bay into Hudson Strait, with a minor offshoot into Foxe

Basin, is of interest, as low pressure areas traveling along this route sometimes have a profound effect on the weather over southern and eastern Baffin Island. The frequency of disturbances following this path decreases to a minimum in the winter months with the rapid southward migration of the main westerly wind belt.

The studies of significant cyclonic and anticyclonic types presented in Chapter IV clearly indicate the role played by recurring synoptic patterns and their influence on local wind, temperature, and precipitation elements. The West Greenland Trough and Foxe Basin Low are excellent examples in this respect and are familiar features frequently to be observed on weather maps of the eastern Arctic.

From the climatic information gathered in Chapter III, it can be seen that Baffin Island can be divided easily into two zones of climate: the cold, wet region and the cold, dry region. The southeastern fringes of the land mass fall under the former category, while western and north-central areas come under the latter classification recording less than ten inches of precipitation annually, which is more typical of Arctic environments. Cape Dyer is especially noteworthy as it provides an excellent example of a cold, wet climate having a total annual precipitation of over 26 inches. Southern Baffin Island is profoundly influenced by surges of warmth and moisture off the northwestern Atlantic, and as such cannot be typed as representative of a true cold desert. What effect this additional moisture has on vegetation within hidden valleys and lowlands, and the morphology of the area, is a matter of conjecture.

It is also well within the realm of possibility that small, protected regions exist where average summer temperatures rise above 50°F.

While the large-scale synoptic patterns just described provide the general picture from which local fluctuations can be seen in context, it remains for the actual station observations to bring out the local small-scale features. Much of the material presented in Chapter III fulfills this purpose.

The effects of topography have a marked influence on wind direction and speed at locations such as Cape Hooper and Frobisher Bay. At Cape Hooper, the dense, cold air to the west appears to flow out of the fiord in surges, apparently triggered by shifting pressure gradients in the lower levels of the free atmosphere. The presence of hills and ridges induces pronounced channeling flow at Frobisher Bay, whereas for sites along the western plains, the east coast mountain barrier and the dynamic effect of Foxe Basin combine to produce a particular orientation in flow patterns. At other locations, topography acts as a shelter against excessively strong winds as in the Arctic Bay and Clyde Inlet.

Temperature and precipitation fluctuations are likewise governed to a considerable extent by local relief and the nature of the land surface. Strong penetrations of warm Atlantic air in winter are deflected upwards by the eastern mountains, thus preventing strong rises in surface temperatures over the western plains.

An examination of the annual temperature graph for Dewar Lakes shows a distinctly lower average temperature during the mid-summer and fall months when compared to West Baffin and Longstaff Bluff (Fig. 14, p. 35). The pronounced cooling at Dewar Lakes is attributed to its continental location. Less cloud amounts enhance radiational heat loss during periods of low sun in the summer and during the fall nights. Its distance from the tempering effects of Foxe Basin is also a factor to consider.

This thesis has only touched upon the numerous facets and complicated interrelationships of Arctic synoptic climatology. That Baffin Island lends itself to a study of this field goes without saying. Many aspects, however, still await a more complete meteorological record before final evaluations can be made.

The present work has attempted to establish a firmer base from which to launch an assault on perhaps one of the most important parts of the long-term objective: how to relate the large-scale flow patterns to a systematic measurement of local climates, or, in other words, how to study the lower boundary layer with its many interconnected elements.

An accurate assessment of the complex energy exchanges between the atmosphere, the oceans, and the land masses at high latitudes is only in its infancy and Baffin Island, by nature of its location, provides an ideal laboratory for such endeavors in an Arctic setting.

APPENDIX A

Meteorological Stations On or Near Baffin Island, N.W.T.

Station	Identifier	Station Number	Lat(°N)	Long(°W)	Elevation (ft.)	Length of Record	Weather Observations
Arctic Bay	AB	918	73°00'	85°18'	36	1939-1962	6 Hourly & Intermediate Synoptics
Brevoort Is.	BZ	097	68°26'	66°47'	1316	1958-1966	" "
Broughton Is.	VM	096	67°33'	64°03'	1905	1958-1966	" "
Cape Dyer	VN	094	66°35'	61°37'	1215	1958-1966	Full Hourly Reporting Programme
Cape Hooper	UZ	093	68°26'	66°47'	1316	1958-1966	6 Hourly & Intermediate Synoptics
Clyde River	CY	090	70°27'	68°33'	26	1943-1966	6 Hourly & Intermediate Synoptics. Full Radiosonde Programme
Dewar Lakes	UW	092	68°39'	71°10'	1700	1958-1966	" "
Durban Is.	-	-	76°06'	62°09'	2180	1958-1963	Weather Reports on Request
Ekalugad Fiord	-	-	68°43'	68°33'	2375	1958-1963	" " "
Frobisher Bay	FB	909	63°45'	68°33'	68	1942-1966	Full Hourly Reporting & Radiosonde Programme
Hall Beach	UX	081	68°47'	81°15'	34	1958-1966	" "
Kivitoo	-	-	67°58'	64°55'	1450	1959-1963	Weather Reports on Request
Lake Harbour	LH	-	62°50'	69°55'	54	1922-1927	" " "
						1930-1941	" " "
Longstaff Bluff	UV	091	68°57'	75°18'	532	1958-1966	6 Hourly & Intermediate Synoptics
Nottingham Is.	NO	908	63°07'	77°56'	54	1928-1966	" "
Padloping Is.	PD	911	67°06'	62°21'	130	1941-1950	" "
Pangnirtung	-	-	66°09'	65°30'	43	1930-1942	Weather Reports on Request
Pond Inlet	-	-	72°43'	78°30'	13	1923-1926	" " "
						1931-1950	" " "
Resolution Is.	RE	903	61°18'	64°53'	127	1929-1966	Full Hourly Reporting Programme
West Baffin	-	-	68°37'	73°12'	510	1958-1963	Weather Reports on Request

BIBLIOGRAPHY

Andrews, J. T.: Preliminary Field Report, North Central Baffin Island 1963. Dept. Mines and Tech. Survey, Geog. Br., Ottawa, 1963, 88 pp.

Appleman, H.: The Cause and Forecasting of Ice Fogs. Bull. Amer. Meteor. Soc., 34, 1953, 397-400.

Appleman, H.: A Note on the Effect of Aircraft Exhaust on Airport Visibility. Bull. Amer. Meteor. Soc., 37, 1956, 19-21.

Baird, P. D.: Glaciological Research in the Canadian Arctic. Arctic, 8, 1955, 96-108.

Baird, P. D. and other members of the Expedition: Baffin Island Expedition, 1950: A Preliminary Report. Arctic, 3, 1950, 131-149.

Baird, P. D. and other members of the Expedition: Baffin Island Expedition, 1953: A Preliminary Report. Arctic, 6, 1953, 227-251.

Baird, P. D., W. H. Ward and S. Orvig: The Glaciological Studies of the Baffin Island Expedition, 1950. Journal of Glaciology, 2, 1952, 2-23.

Ball, F. K.: The Katabatic Winds of Adelie Land and King George V Land. Tellus, 9, 1957, 201-208.

Belmont, A. D.: Lower Tropospheric Inversions at Ice Island T-3. Scientific Report No. 2, Contract AF 19(604-1141, Arctic Meteorology Research Group, McGill University, Montreal, 1954, 57 pp.

Berry, F. A., G. V. Owens and H. P. Wilson: Arctic Track Charts. Proceedings of Toronto Meteorological Conference, 1953. Roy. Met. Soc. (Pub.), London, 1954, 91-102.

Boas, Franz: The Central Eskimo. Introduction by Henry B. Collins. University of Nebraska Press, Lincoln, 1964, 261 pp.

Bridge, C. W.: The Barnes Ice Cap. Unpublished B.A. thesis, Toronto University, 1964, 95 pp.

Burbidge, F. E.: The Modification of Continental Polar Air Over Hudson Bay. Quart. Jour. Roy. Met. Soc., 77, 1951, 365-374.

Clodman, J.: Visibility Deterioration Associated with Operations of Jet Aircraft. Bull. Amer. Meteor. Soc., 37, 1956, 338-341.

Coulcher, B. A.: Report on a Familiarization Flight Conducted to Three Major Arctic Centers Along the DEW Line on March 30th through April 1st, 1959. Information Circular, Meteorological Branch, Dept. of Transport, Canada, 1959.

Coulcher, B. A.: Notes and Statistics Gathered on Local Weather Phenomena at Frobisher Bay. Unpublished, 1960.

Defant, F.: Local Winds, in Compendium of Meteorology, ed. T. F. Malone, Amer. Met. Soc., Boston, 1951, 655-672.

Dewar, S. W.: Notes on Arctic Weather Phenomena. CIR-2198, TEC -132, Meteorological Branch, Dept. of Transport, Canada, 1952.

Dorsey, H. G.: Arctic Meteorology, in Compendium of Meteorology, ed. T. F. Malone, Amer. Met. Soc., Boston, 1951, 942-951.

Field, W. O. and J. H. Mercer: Glaciers of Baffin and Bylot Islands. American Geographical Society, New York, 1958, 35 pp.

Fletcher, R. D.: Arctic Weather Forecasting Problems of the Air Weather Service. Polar Atmosphere Symposium, Part I, Pergamon Press, London, 1958, 118-123.

Fraser, D. B.: Unstable Character of Northeasterly Winds at Resolute, N.W.T. CIR-3189, TEC-300, Meteorological Branch, Dept. of Transport, Canada, 1959.

Fraser, W. C.: A Study of Winds and Blowing Snow in the Canadian Arctic. CIR-4162, TEC-548, Meteorological Branch, Dept. of Transport, Canada, 1964.

Hakluyt, R.: Principal Navigations of the English Nation. Everyman's Library, J. M. Dent and Sons, London, 1907.

Hare, F. K.: The Climate of the Eastern Canadian Arctic and Sub-Arctic and Its Influence on Accessibility. Unpublished Ph.D. thesis, University of Montreal, 1950.

Hare, F. K. and S. Orvig: The Arctic Circulation. Arctic Meteorlogy Research Group, McGill University, No. 12, 1958, 211 pp.

Hare, F. K. and M. R. Montgomery: Ice, Open Water and Winter Climate in the Eastern Arctic of North America, Part I, Arctic, 2, 1949, 79-89.

Hare, F. K. and M. R. Montgomery: Ice, Open Water and Winter Climate in the Eastern Arctic of North America, Part II, Arctic, 2, 1949, 149-164.

Hamilton, R. A.: The Meteorology of North Greenland During the Mid-Winter Period. Quart. Jour. Roy. Met. Soc., 84, 1958, 355-374.

Heastie, H.: Average Height of the Standard Isobaric Surfaces Over the Area from the North Pole to 55°N in January. Meteorological Research Paper No. 918, Meteorological Research Committee, Air Ministry, London, 1955, 17 pp.

Heastie, H.: Average Height of the Standard Isobaric Surfaces Over the Area from the North Pole to 55°N in July. Meteorological Research Paper No. 1020, Meteorological Research Committee, Air Ministry, London, 1956, 14 pp.

Hobbs, W. H.: The Greenland Glacial Anticyclone. J. Meteor., 2, 1945, 143-153.

Keegan, T. J.: The Wintertime Circulation in the Arctic Troposphere, in Contributions to the Study of the Arctic Circulation. Scientific Report No. 7, Contract AF 19 (604)-1141, Arctic Meteorology Research Group, McGill University, Montreal, 1958, 22-47.

Keeler, C. M.: Relationship Between Climate, Ablation, and Runoff on the Sverdrup Glacier, 1963, Devon Island, N.W.T. Arctic Institute of North America, Montreal, Quebec, 1964.

Klein, W. H.: Prevailing Tracks of Lows and Highs (Six Articles). Weatherwise, 9, 1956, 83-87, 128-131, 158-161, 205-209.

Klein, W. H.: Prevailing Tracks of Lows and Highs (Six Articles). Weatherwise, 10, 1957, 50-53, 85-89.

Kruger, H. B.: Notes on Meteorology of the Canadian Arctic. CIR-3396, TEC-334, Meteorological Branch, Dept. of Transport, Canada, 1960.

Lee, R.: The Circulation of the Arctic. The Canadian Geographer, 16, 1960, 1-13.

Longley, R. W.: Temperature Variations at Resolute, Northwest Territories. Quart. Jour. Roy. Met. Soc., 77, 1958, 459-63.

Longley, R. W.: Winds and Visibility at Resolute, Northwest Territories. CIR-3039, TEC-269, Meteorological Branch, Dept. of Transport, Canada, 1958.

Longley, R. W.: Super-Adiabatic Lapse Rates in the Canadian Arctic. Canadian Geographer, 1, 1962, 143-150.

Markham, W. E.: Summer Breakup Patterns in the Canadian Arctic. CIR-3586, TEC-389, Meteorological Branch, Dept. of Transport, Canada, 1962.

Mathiassen, T.: Contributions to the Geography of Baffin Island and Melville Peninsula. Report of the Fifth Thule Expedition 1921-24, Gyldendalska Boghandel, Nordisk Forlag Copenhagen, 1, 1933, 105 pp.

Meteorological Branch, 1963: Averages and Extremes of Climatic Data During the 1951-1960 Decade for Selected Canadian Arctic Stations. Publication CDS #2, Climatological Division, Dept. of Transport, Canada, 1963, 21 pp.

Meteorological Branch, Canadian Weather Review, Dept. of Transport, Canada, 4, 1966, 8 pp.

Meteorological Branch, Mean Sea Level Pressure Normals, Publication CDS #1, Climatological Division, Dept. of Transport, Canada, 1966, 7 pp.

Meteorological Branch, Monthly Record of Meteorological Observations in Canada, Dept. of Transport, Canada, 1955-1966.

Meteorological Branch, Normal Cloud Statistics, Publication CDS #3, Climatological Division, Dept. of Transport, Canada, 1966, 8 pp.

Meteorological Branch, Temperature and Precipitation Data from DEW Line Stations, Publication CDS #5, Climatological Division, Dept. of Transport, Canada, 1966.

Namias, J.: Synoptic and Climatological Problems Associated with the General Circulation of the Arctic. Trans. Amer. Geophys. Union, 39, 1958, 40-51.

Orvig, S.: Glacial Meteorological Observations on Ice Caps in Baffin Island. Geog. Annaler, 36, 1951, 197-318.

Parry, Sir W. E.: Journal of a Voyage for the Discovery of a Northwest Passage from the Atlantic to the Pacific - Performed in the Years 1819-20. John Murray, London, 1821.

Parry, Sir W. E.: Journal of a Third Voyage for the Discovery of a Northwest Passage from the Atlantic to the Pacific; Performed in the Years 1824-25. John Murray, London, 1826.

Petterssen, S.: Weather Analysis and Forecasting. McGraw-Hill Book Co., Inc., New York, 2 vols. 1956.

Pogosjan, H. P.: Seasonal Peculiarities of the Temperature and Atmospheric Circulation Regimes in the Arctic and Antarctic, Technical Note No. 28, WMO-No. 90, TP 37, Geneva, 1959, 20 pp.

Polar Record: Royal Canadian Mounted Police Patrols, 1936, Polar Record, 14, 1937, 134-41.

Polar Record: Radio Stations of the Hudson's Bay Company, Polar Record, 3, 1941, 415-18.

Putnins, P. and W. Schallert: Some Meteorological and Climatological Problems of the Greenland Area. Final Report. U. S. Dept. of Commerce, Weather Bureau, Washington, 1959, 262 pp.

Rae, R. W.: Climate of the Canadian Archipelago, Meteorological Branch, Dept. of Transport, Canada, 1951, 90 pp.

Rand Corporation: A Report on the Physical Environment of Southern Baffin Island, Northwest Territories, Canada, ed. J. B. Bird, Memorandum RM-2362-1-PR, Santa Monica, Calif., 1963, 375 pp.

Reed, R. J. and B. A. Kunkel: The Arctic Circulation in Summer. J. Meteor., 17, 1960, 489-506.

Ross, Sir J.: Narrative of a Second Voyage in Search of a North West Passage.

Sagar, R. B.: Glaciological and Climatological Studies on the Barnes Ice Cap, 1962-64. Geographical Bulletin, 8, 1966, 3-47.

Sharp, R. P.: Glaciers in the Arctic. Arctic 9, 1956, 78-117.

Smagorinsky, J.: The Dynamical Influence of Large-Scale Heat Sources and Sinks on the Quasi-Stationary Mean Motions of The Atmosphere. Quart. Jour. Roy. Met. Soc., 79, 1953, 342-366.

Thomas, M. K.: A Survey of Temperatures in the Canadian Arctic. Geology of the Arctic, University of Toronto Press, Toronto, 1961, 942-55.

Thomas, M. K. and H. A. Thompson: Heavy Rainfall in the Canadian Arctic During August 1960. Weatherwise, 15, 1962, 153-158.

Thomas, M. K. and R. L. Titus: Abnormally Mild Temperatures in the Canadian Arctic During January 1958. Monthly Weather Review, 1959, 86, 19-22.

Thompson, H. A.: Temperature Normals, Averages and Extremes in the Northwest Territories During the Period 1931 to 1960. CDS #5, Meteorological Branch, Dept. of Transport, Canada, 1962, 25 pp.

Thompson, H. A.: Freezing and Thawing Indices in Northern Canada. Proceedings of the First Canadian Conference on Permafrost, Associate Committee on Soil and Snow Mechanics, National Research Council of Canada, Technical Memorandum No. 76, 1963, 18-36.

Thompson, H. A.: The Climate of the Canadian Arctic. Article Prepared for Publication in the Canada Year Book, 1967 Edition, 32 pp.

Titus, R. L.: Upper Air Climate of Canada. Meteorological Branch, Dept. of Transport, Canada, 1965, 70 pp.

United States Airforce: U.S.A.F. Jet Navigation Chart, JN-19N, Aeronautical Chart and Information Center, St. Louis, 18, Mo., U.S.A., 5th Edition, 1962.

United States Naval Research Facility: Arctic Forecast Guide, Norfolk, Virginia, 1962, 107 pp.

Verge, R. W.: A Synoptic Study of Wind Patterns at Frobisher Bay, CIR-3700, TEC-420, Meteorological Branch, Dept. of Transport, Canada, 1962.

Vowinckel, E.: Atmospheric Energy Advection in the Arctic. Scientific Report No. 71, Contract No. AF19(604)-7415, Arctic Meteorology Research Group, McGill University, Montreal, 1964, 14 pp. and Illus.

Ward, W. H. and S. Orvig: The Glaciological Studies of the Baffin Island Expedition, 1950; Part IV: The Heat Exchange at the Surface of the Barnes Ice Cap During the Ablation Period. J. Glaciol., 2, 1953, 158-168.

Ward, W. H. and P. D. Baird: Studies in Glacier Physics on the Penny Ice Cap, Baffin Island, 1953; Part I, A Description of the Penny Ice Cap, Its Accumulation and Ablation. J. Glaciol., 2, 1954, 342-355.

Wilson, C.: Climatology of the Cold Regions, Cold Regions Research and Engineering Laboratory, Part I: Environment, Section A3: Climatology, Introduction, Northern Hemisphere 1, U. S. Army Material Command, Hanover, New Hampshire, 1967, 141 pp.

Wilson, H. P.: The West Greenland Trough. CIR-3025, TEC-266, Meteorological Branch, Dept. of Transport, Canada, 1958.

Wilson, H. P.: The Major Factors of Arctic Climate. ed. G. O. Raasch, Geology of the Arctic, University of Toronto Press, Toronto 2, 1961, 915-930.

Wilson, H. P.: Surface Winds Near A Ridge; Unpublished, 1967, 11 pp.

Wilson, H. P. and W. E. Markham: A Study of Arctic Surface Winds. CIR-2923, TEC-251, Meteorological Branch, Dept. of Transport, Canada, 1957, 14 pp.