Royal Meteorological Society

OPERATION ICE CAPADE

by

PERCY SALTZMAN

CANADIAN BRANCH

VOL. I MARCH 1950 NO. 3

Published By

ROYAL METEOROLOGICAL SOCIETY, CANADIAN BRANCH

1950 EXECUTIVE COMMITTEE

President..... P. D. McTaggart-Cowan
Vice-President..... H. W. Halbert
Secretary..... F. W. Benum
Treasurer..... M. K. Thomas

Councillors-at-Large

G. L. Pincock..... Vancouver, B.C.
C. E. Thompson..... Edmonton, Alta.
H. Cameron..... Winnipeg, Man.
Prof. F. K. Hare..... Montreal, Que.
R. A. Hornstein..... Halifax, N.S.

Vice-President for Canada
On Council of Royal Meteorological Society - London - Andrew Thomson

Copies of this publication are obtainable by writing to:

The Secretary,
Royal Meteorological Society, Canadian Branch,
315 Bloor Street West,
TORONTO 5, Ontario.

OPERATION ICECAPADE

(March 2-3, 1950)

by
P. P. Saltzman

AUTHOR'S FORWARD:

On March 30, 1950, before the Royal Meteorological Society, two talks were given. "The first of these", said the Chairman, "will be very interesting". This is the second:

ENTREE.

Mr. Chairman, Ladies and Gentlemen, I have always hankered to talk about my operation, and tonight is my chance. OPERATION ICECAPADE - sometimes known as "Saltzman's Ice Folly" --- will probably be more capade than ice. For, after all, what more can be said than: "Hudson Bay is a dreary waste of ice" - but then, what better way to waste it.

Of course, the view was magnificent---ly monotonous. We flew along the Bay's perimeter and found it solidly frozen over except for a few minor shore leads. There were some interesting pressure patterns - ice-obaric - some devilishly attractive hummocks; and the odd blow-hole for wondering walruses. But, mainly, hour after plodding hour, there was --- just ice.

ICE-O-TERMS.

You might well ask, what did I expect? A great deal. You see, after I had put my neck in the noose and there was no drawing it back, it behooved me to bone up on ice. I got the United States Ice Atlas and Maurstad's Atlas of Sea Ice, and sundry other tomes, and learned to my amazement that there are all kinds of ice - frazil ice, brash ice, slob ice, sludge ice, pan ice, icebergs (which calve), flobergs (which do not), bergy bits, floe ice, fast ice, pack ice, drift ice, growlers (more about growlers later), ice foot, ice blink, ice sheet sugar ice, raft ice, glacon, moutonne, polynya, water-sky, ice rind, ice in cakes, ice in pans and pan-cake ice. Thus, I armed myself with the wisdom of the ice-sages. And after all this, what did I see? I saw nothing but plain ice --- a term not found in the atlases and tomes. What a disappointment!

SURVIVAL.

There were other disappointments. To instance: My good friends, the Admiral Road gang, gave me a red-covered booklet called "Survival in the Arctic". Apprehensively, I latched on to it like a leech and

sucked it dry. Do you know there's a lot to this business of survival in the Arctic? Do you know, for example, there are no poisonous plants in the north (no mention was made of the poisonous food at the Churchill Officers' Mess)? Do you know that old floe ice is fresher than young fresh ice; that snow blindness can occur during a bright overcast just as quickly as in full sunshine; that you shouldn't wear tight shoes - I mean, of course, in the Arctic?

The little red-faced booklet also told me that you can beat the Arctic if you get plenty of sleep and rest (but not in a Lancaster); if you eat plenty of fat and don't lean too heavily on lean rabbits; if you keep dry and warm and avoid carbon monoxide poisoning (impossible in a modified Lancaster); and if you eschew tight clothing (impossible when you wear an RCAF-issue flying suit). It also told me that one should avoid polar bear livers; but, as for seals, there is little preference between the various parts. I have no preference. I found too that you shouldn't suddenly heat a billy full of ice because the bottom layers would melt and, for the rest, you would burn the pot.

I also learned that one shouldn't worry about freezing to death while asleep. But what I found I had to worry about was --- sleeping while freezing to death. To my amazement, I found that one mustn't rub a frozen part with snow or ice, but, rather, say, hold it under one's arm pit. I tried that, but it's a ticklish job --- with a frozen nose. The booklet advised that before bailing out over the Arctic, it would be well to stuff maps, emergency rations, and as much loose equipment as possible into the pockets and empty spaces of one's flying suit. Of course, I never had any empty spaces in my suit; and, moreover, there was absolutely no access to the parachutes. I doubt that, had the emergency arisen, any one would have been able to move from his position in the plane.

KA-BLOO-NAH.

I even picked up a few Eskimo[1] phrases, such as "Eee-mick pee-yuma-voong-ah", which means, "Have you got a spot of tea, old chap?"; or "Kah-poong-ah", --- which is, simply put, "I am hungry". And, finally --- the one I like best, "Eee-ba-goom-moom, me-boom's-noom", which --- freely translated is, "I am cold, may I sleep with your wife?" I regret

ooooo O ooooo

[1] - Eastern Eskimo, naturlich.

to inform you I never had occasion to use this highly exrpessive tongue. In fact, thc entirc booklet was to no avail. Nothing happened to show up or show off my knowledge.

On the contrary, reality gave the lie to this red-faced monstrosity. It failed me --- miserably. Did it, for instance, tell me how to survive in a modified Lancaster of cramped cross-section and thin skin in temperature 30 below --- and above --- and on both sides as well? It did not. Did it tell me how to survive slow strangulation in a too-tight flying suit? It did not. How to manoeuvre one's legs among 26 others, where 10 would have been hard put for leg room? How to prevent the tri-metrogon [1] camera from coming between me and the growlers, especially over the belchers which come just before the sleepers? It did not.

In short, it served me least when needed most - during those 12½ elongated hamstrung hours outward bound, where I was cold and hot by turns, by turns squashed and paralyzed, sleep-ridden and bedsore-burdened, grimy and grumpy and growley.

INSURANCE.

I may as well dispose of all the disappointments at once. Take, for example, insurance on my life, in favour of my wife. It was a bitter blow when I learned that there was some doubt about the official provision to cover me in case I never survived the operation. (Since then I have learned an Order-in-Council passed in December makes provision for such trifling detail). True, Frank Benum pledged half his salary to my family until my estate was satisfactorily settled --- in my absence. But I put little stock in that - he had, I found, already pledged half, under similar conditions, to the Assistant Controller of Forecast Services. After all, how many halves can even a superintendent's salary have? And who has first priority?.....

So I was forced to seek succour in the field of ravening commerce. I found it - wife insurance - at a dollar a thousand. For $20, she could afford to be complacent. I was covered --- like a shroud. Pilots talk of blackout at 5 G. I had 20 G. on me, and never felt better. Anyhow, at the time $20 seemed like a sound investment - until I stepped off the plane at the end of the journey. Suddenly I had nothing. I felt

ooooo O ooooo

*[1] - An amazing device, three cameras, one vertical, two oblique, automatically synchronized, automatic exposure - timing, specially air-conditioned, with one defect-its viewing windows were dirty.

no better when I got home, phoned my agent, and told him I wouldn't need the policy any more, could I get a refund.....

It's a fine policy they write you, Lloyds do; it covers the assured while entering into, alighting from, or riding as a passenger in, a licensed aircraft flown by a certified pilot (we had two certified pilots [1]) and extends to cover death by exposure (very wisely only after a forced landing and not while flying in a modified Lanc). It also covers the assured whilst being transported to and from the airport in the carrier's vehicles (but not in an Ottawa taxicab) and also while on the Airport premises. Try to collect on that after you come back.

There is still a hope, though; this escape clause, for example: "It is agreed that if after a reasonable period has elapsed and Underwriters having examined all evidence available have no reason to suppose other than that an accident occurred, the disappearance of the assured shall be considered to constitute a claim under the policy." I believe I can qualify on that as far as my agent is concerned, in that all evidence points to the fact that I have disappeared. At least, he's still looking for me to collect that premium.

BACKGROUND.

Well, back to the assured and his pre-trip preparations. I decided it would not be a bad idea to read the available literature on previous ice RECCO trips over Hudson Bay. And I learned a lot of interesting things. For example, that Hudson Bay, covering an area of about 500,000 sq. miles, and thrusting itself like a huge semi-polar sea into our back door, not only exerts an important influence on our climate but is also our Maritime gateway - our bay-window --- to the North Atlantic and to cheap sea-borne commerce with the old world. For both economic and meteorological reasons, the navigational possibilities of the Bay and the condition of its surface waters in winter are vitally important.

I found that prior to 1948, little was known for certain about its wintertime ice cover. Information reaching us from explorers, trappers and traders, whose observations were limited in time and space and who had peered into the bay from its shores, led us to believe its

ooooo O ooooo

[1] - Does this give one double indemnity question-mark.

central waters were open the year round. To quote the May 1946 supplement to the United States Navy's Pilot Chart, "Hudson Bay itself, except in the northeastern portion, has little or no Arctic pack. In winter, it freezes out from the coast all around, 3 to 10 miles (sometimes more), while the central portions gradually fill with drifting ice which continually breaks off from the shore ice." The Pilot Chart goes on to say that, since heavy ice closes Hudson Strait from January to June, navigation is possible only from mid-July to mid-October. Similarly, the 1946 U. S. Navy Ice Atlas of the Northern Hemisphere displays handsome maps of the Bay, flatly indicating only a fringe of shore ice in the winter, with the central waters invitingly open.

Even so select a committee as the Select Committee of the Canadian House of Commons, set up in 1884 to rule on the question of navigation in Hudson Bay, and having heard the opinions of various sailors, trappers and traders, stressed that the Bay never completely froze over.

Whence have come such mis-conceptions? Undoubtedly because, in the first place, no one had tried to cross the Bay in winter. Secondly, seen from the shore, steam fog and low cloud that formed over the open water of the shore lead provided false clues as to the conditions of the central areas. Ships did not venture into the central reaches; in fact, making for harbour at freeze-up and becoming frozen in, they extrapolated the crow's-nest vista of fast ice onto the entire Bay --- a classic case of mistaking the part for the whole.

CLIMATIC CLUE.

Strangely enough, a study of the climatology of northern Quebec gave the first clue to the truth of the matter. Professor Hare, and his associates at McGill, noted a seasonal change in temperature and hydrometeor conditions on the east coast of the Bay after the onset of each new year. Whereas during the early months, average temperatures were markedly higher at Port Harrison, as compared to Churchill on the west coast, this difference virtually disappeared by late December or early January. Similarly, in November and December, the McGill group noted heavy precipitation on the southeast coast of the Bay, the interior being relatively dry. At the turn of the year, this difference abruptly disappeared.

For the months of October to December, mean isothermal maps for the Bay disclose a marked warm gulf which vanishes abruptly in the later winter months. It was these facts that pointed persuasively to the conclusion that the Bay is largely open in the fall and winter, freezing over completely early in January.

A large share of the credit for confirming these facts is due to F. E. Burbidge, of the Meteorological Division, who in his April 1949 paper, "The Modification of Continental Polar Air over Hudson Bay", developed the meteorological analysis in considerable detail.

The first published statement of the winter ice cover over the Bay appeared in October 1949 in the Blue Bulletin, a paper entitled "Ice Conditions over Hudson Bay and Related Weather Phenomena", by Arthur H. Lamont, of the Meteorological Division. He suggested the Bay was covered by what is, in effect, a huge ice cake, separated by leads from the shore ice and shifting position with the tides and the winds. He estimated the average thickness of the ice at five feet, but marked by a complex pattern of pressure ridges varying in height from 6 to 25 feet.

Since the views of Professor Hare, Mr. Burbidge and Mr. Lamont, clashed with tradition, it was decided to institute a program of aerial surveys to determine the facts. During 1948 - 1949 and continuing in 1950, flight observations over the Bay, supported by photographic evidence, "completely confirmed the deductive conclusions drawn from the climatic evidence".

RECONNAISSANCE.

The programme of aerial reconnaissance carried out during the past three winters is a monument to the co-operative efforts on the part of the Royal Canadian Air Force, the Defence Research Board, the Joint Intelligence Board, the McGill Research group under Professor Hare, and the Department of Transport's Meteorological Division.

In 1948 three RECCO flights were made - WEE flight in March, ICE CAKE in April, CARIBERG in May.

In March 1949, Operation ICE was effected.

So far this season, four flights have been made - in November, December, January and March.

The November flight, with Mr. J. M. Leaver representing the Meteorological Division, noted the fact that the southern half of Hudson Bay, as well as all of James Bay except the extreme southern tip, was ice free. But north of a line joining Churchill - Port Harrison, the Bay was frozen, although the ice was not thick.

The December flight, Mr. R. G. Stark of Dorval as our observer, found James Bay completely frozen over except at its mouth. Southern

Hudson Bay as far as the Sleepers was ice free, but the northern half was pretty well solid pack, except for the shore leads.

In January, Mr. Longley, flying for Met, found the whole of the Bay frozen over, except for wide shore leads off the southeast and along the northwest coasts.

And in March --- to get ahead of my story a little --- we noted that James Bay was completely frozen over and that the whole of the Hudson Bay ice had seemed to settle to the south and west, so that large, well defined shore leads had to all intents disappeared.

CAPADE.

Well, so much for pre-trip preparations. Ice terminology, insurance, survival manuals, history of ice recco, hotel and train reservations, salary checkery, packing and bundling, - these were but the forerunners. I pride myself on proficient packing and remembered everything, including dark glasses and camera; but, when I got up to shave, one hour out of Ottawa, lo and behold, I had left my shaving stick and cream at home. It was no doubt the beard that prompted the senior meteorological adviser to National Defence Headquarters to state with some glee how glad he was that some one from Head Office was flying this trip. There seemed to be a note of administrative vindictiveness in the remark, but perhaps I was unduly sensitive. In any event, he put me quite at ease with the information that in November, Leaver had to fly on to Winnipeg when Churchill was socked in, whereas in January, Longley lay over in Churchill six days due to mechanical trouble [1].

Preliminary briefings over, we got an early 6 a.m. start for the field; and once arrived there, found that, despite teletype messages regarding height, weight and other vital statistics, no flying clothes or parachute had been prepared. A last-minute --- a last-second - hurried conference got me a parachute and harness, two sizes too small, and flying clothes even smaller. As a matter of fact, the co-pilot lent me his flying clothes when it was found that he had not made the necessary arrangements with Stores to draw sets for the observers.

ooooo O ooooo

[1] - The aircraft's; not Richmond W's.

The crew numbered fourteen, consisting of pilot and co-pilot, two navigators, two radio operators, the engineer, the camera operator, two navigators, two radio operators, the engineer, the camera operator[1], two extra mechanics (who slept all the way both directions) and the four ice observers. These were, in order of size, Miss Margaret K. Montgomery[2], of the Joint Intelligence Board, myself, Flight-Lieut. Greenaway[3], senior observer representing the Defence Research Board, Mr. Sven Orvig[4], of McGill, who is six feet two and built in proprotion. With fourteen people in a wartime aircraft, there's not much room left over for other equipment. But other equipment in quantity, we did carry.

ooooo O ooooo

[1] - Doubletalk.

A Word About the Observers:

[2] - For the especial benefit of the ladies here tonight, I want to pay fervent tribute to Miss Montgomery for her remarkable staying powers. She was a marvellous aeronaut. The cold, the congestion, the fatigue, did not seem to faze her. She may have lost a little lipstick, but not her aplomb. The men kept losing their's all the time.

[3] - F/L Greenaway has flown on all Hudson Bay Ice Reconnaissances. He has flown the Arctic generally, more extensively than any other Canadian. He is an acknowledged expert. I learned a lot from him. E.g., always wear your pyjamas under your flying clothes, but never in bed.

[4] - Mr. Orvig is a genial Norwegian with whom I was paired in the crowded nose. He left me an uncomfortable lebensraum of 30" x 6". He regaled me with milk chocolate and discouraging tales. (Item: how he piloted Sunderlands in Coastal Command 28 hours at a stretch; a 12½ hour trip, ergo, is a pipe (!). Item: how he had lost a nose-bomber, nose and all, on an operational flight). He was very comforting.

[5] - I can't recall the fourth.

There were the parachute sacks, the emergency kits, the sleeping bags, tool boxes, oil drums, ear drums, camera equipment, personal luggage, food, thermos bottles, the growler and sundry items, piled helter-skelter along the floor of the aircraft. We also carried a marked temperature discontinuity between the central section of the aircraft and its head and tail. On takeoff and landing, we were forced to move amidships, and found something like a 30-degree difference (Fahrenheit, that is) between tail and nose and centre. The cold, combined with cramped leg room, made for a very uncomfortable creeping paralysis of the peripheral areas of the body. It also meant that access to observation points was difficult.

During the trip, the observers paired off . Two would hold down the nose position; and two, the opposite end. In the nose, one had an excellent view forward and 90^{o} right and left, of the ice conditions and the weather. One also had an altimeter and a full set of aerial maps, so that pinpointing one's position and getting an impression of the Bay was facilitated. But in the rear, the opposite was the case. In the first place, one had to pretty well position oneself on one side of the aircraft or other and stay there for eons on end. The viewing window was some eight by ten inches, in size, and in some cases, obscured by a healthy layer of grime and oil. You could, with difficulty see an altimeter if you were positioned behind the tri-met camera. However, when this magnificent instrument was in use, your passage to the rear of it was barred. I soon learned to stay behind it for the most of the trip, other than the three and a half hours I spent forward in the nose.

In all of this aeronautical arterio-sclerosis, I noticed that the various electrical and control cables, the valves, the wiring, and so on, ran fully exposed along the inside of the fuselage. With bag and baggage tossing about, with personnel shoving their way through from nose to growler, I thought to myself how little it would take to put the aircraft out of commission - an accidental blow or jar would turn an important valve the wrong way or sever a cable - and we would have it[1].

DIFFICULTIES.

It was under such difficulties that one carried out the observing part of the programme and found that one needed a good deal of experience in order to assess properly what one saw. I found it difficult, for example, to distinguish the treeless snow-covered mainland from the

ooooo O ooooo

[1] - One might conclude, unwisely, that I bear a grudge against Lancs. Not true. In the nose, I looked back to the right, left and marvelled at the smooth roaring of the engines --- in all the 18 hours, never a cough, a sputter, a miss. Sweet inlines!

shore ice; difficult to determine with any degree of accuracy the oblique visibility which was mostly obscured by the ever-prevalent northern haze; difficult to distinguish in this haze the cloud outlines and to determine the horizon, for cloud and sky tended to merge with the snow-cover. When flying over northern Quebec, it was at first difficult to distinguish between blowing snow conditions and the cloud that we were in, over and under.

COMPENSATIONS:

Nevertheless, there were many compensations. It was a thrilling sight to see the steam fog arising from the few open leads, although owing to the lateness of the season, there was none of the welling up or mushrooming described by previous observers. Flying over low cloud, against the setting sun, I saw the Brocken spectre tracking us for many miles, and at one time, a huge parallel array of iridescent rainbows along the cloud-top ridges as far as the eye could see. As the sun was setting on our westward leg at the top of the Bay, the steam fog over the open water of Roes Welcome Sound hung like illuminated draperies over the northland.

The most exciting moment of the trip was the mail and medicine drop we made at Sugluk. After flying for hours over desolate ice and barren land, hunting for this tiny northern settlement through layers of cloud and billows of blowing snow, suddenly we came upon it - a tiny hamlet of some half dozen black, tar-paper huts, the Lilliputian inhabitants madly waving their hands against the snow. As we circled Sugluk and came down to 100 feet, the flight engineer, having previously opened the back door and fortified himself with his parachute harness, tossed out the red package of medicine attached to a parachute. His aim was good, for it landed smack in the middle of the settlement. Another turn around the hamlet and again a drop - this time a free one - of the mail bag. A waggle of the wings, --- good luck Sugluk --- and we were away - probably the first messengers of civilization[1] they had seen this winter, and likely the last before the summer shipping season opened.

THE WEATHER.

It had been planned to fly at 9,000 feet, to enable the observers to see the condition of the ice near the shores and well out

ooooo O ooooo

[1] - question mark.

into the bays, and to facilitate good camera shots. However, low cloud brought the flight level down to 2,000 feet over James Bay. Once past the Belchers, we flew at 5,000 feet, with a temporary let-down over the Sleepers, to look for any signs of Eskimo habitation. No such signs were noted. Not a clue[1]. North of the Ottawa islands, we altered course for Sugluk, but, owing to a heavy overcast, flew at 2,500 feet. The low cloud and extensive blowing snow combined to prevent the pilot sighting Sugluk from the west. So we flew to a point some 130 miles east of Sugluk, where the crew picked up familiar coastal pinpoints. We then turned west and found Sugluk. On this eastward leg a good view of Hudson Strait was obtained. The flight was carried out against strong head winds, which cut ground speed to 135 knots on the northward leg. The westbound and southbound legs into Churchill were less hampered, and we maintained an average of 165 knots groundspeed. The Rockcliffe wind forecast was excellent. Using forecast winds, the flight time was estimated at nearly 12 hours; and, when account is taken of the time lost hunting for Sugluk, the actual flight time of 12½ hours, nearly, may be considered a very good verification of the upper winds forecast. Flight level temperatures varied from minus 30 degrees to minus 35 degrees Centigrade - very close to the forecast values. From Sugluk, we headed for Cape Kendall on the southwest tip of Southampton Island, where we turned for Churchill, landing there at approximately 8 p.m. Central Time, the outbound flight having lasted 12 hours and 25 minutes.

The following day (at 10:30 their time), we took off from Churchill, with snow falling and visibility restricted. The aircraft headed southeast, and a little past Cape Tatanam we flew out of this snow, and thenceforward the weather was good. We proceeded southeast to the turning point near Cape Henrietta Maria, whence we headed down the centre of James Bay, reaching the mainland at Hanna Bay. We flew then to Rockcliffe, where we landed at 4 o'clock in the afternoon, the homeward flight having lasted five hours and 20 minutes.

THE ICE.

We found James Bay solidly frozen over, with only a few small leads and holes, mostly newly frozen. These leads were oriented in an east-west direction. A large newly-frozen lead or array of parallel leads was seen at a line marking the separation of the ice on James and Hudson Bays. There was no well-marked shore lead on the east coast of Hudson Bay, but there were some signs of a displaced lead west of the line

ooooo O ooooo

[1] - not even an igloo.

joining the island chains off the east coast of the Bay (the Belchers, Sleepers, Ottawas). Although there was no open water as far north as Cape Smith, there was an area of small random leads from the north Belchers to the Sleepers. The first big lead was found to the north and west of the Belchers. We had a good view of Hudson Strait and found it to be quite open, there being loose pack ice and many large leads and much steam fog. On the run to Cape Kendall, there were random leads, none larger than 300 yards, and signs of open water to the north over the southern waters of Foxe Channel. There was solid ice in South Bay and a wide lead extending well up Roes Welcome Sound, with an east-west lead running off it east to Cape Low. There was no well-marked shore lead down the west coast, although a number of narrow leads parallel to the coast were noted. Button Bay was frozen over solid. On the run homeward from Churchill, we saw many small leads parallel to the shore, as well as random leads running out into the central waters, but no sign of a well-defined shore lead. We did see a band of disturbed ice separating the pack from the shore ice. In this disturbed area were a number of narrow, irregular leads paralleling the shore.

We hit the mainland at Hanna Bay with terrific force and made the home run on our last leg. It was good to land on firm terra, the operation a success, the patient dead --- tired.

IN SHORT.

To summarize then, it has been established by visual and photographic evidence that, except for shore leads, the whole of Hudson Bay becomes ice-covered, with freezeup beginning in October and ending by December, and with breakup starting in May and ending late in June.

The results of Hudson Bay reconnaissance to date are of great scientific interest and have filled in important detail in our previously sketchy knowledge. Photographs have given valuable permanent records to be used for comparative studies. Much further work will have to be done to accurately date the ice cycle, the ridging cycle, and to determine more closely the average dates and processes of freezeup and breakup. Reconnaissance will have to be continued for a number of years, to determine the "normality" of the findings to date. On such a project, the time, the effort, the money, all are well spent[1].

ooooo O ooooo

*[1] - So too was I.

In summing up my reaction to OPERATION ICECAPADE, the latest in the series of Hudson Bay aerial reconnaissance, all I can say is, I found it in all respects, an ice trip[1].

ooooo O ooooo

[1] - No words of mine can do justice to, at this point, the groans of my audience.

REFERENCES.

To get the job as ice rapporteur, I had excellent references. Here they are:

1. "Ice, Open Water, and Winter Climate in the Eastern Arctic", F. K. Hare and Margaret R. Montgomery, Arctic, Sept. and Dec. 1949.

2. "Ice Conditions Over Hudson Bay and Related Weather Phenomena", A. H. Lamont, B.A.M.S., Oct. 1949.

3. "The Modification of Continental Polar Air Over Hudson Bay", F. E. Burbidge, April 1949. (Unpublished).

4. "Arctic Ice and Its Drift into the North Atlantic Ocean", Supplement to Pilot Chart of the North Atlantic Ocean, May 1946.

5. "Sea Ice:" Terminology, Formation and Movement, The Polar Record, Jan. 1944.

6. "Report of Select Committee of House of Commons, Ottawa, 1884.

7. Ice in the Arctic Ocean and Bering Sea, USN Pilot Chart No. 1400c, August 1943.

8. Atlas of Sea Ice, A. Maurstad, Oslo, 1935.

9. Ice Atlas of the Northern Hemisphere, USN, 1946

10. "Have Proof Hudson Bay Freezes Right Across", press release, April 2, 1950, Globe & Mail, Toronto.

11. Unpublished Reports, Meteorological Division Observers: "Ice Reconnaissance Over Hudson Bay":

A. H. Lamont,	Mar. 1948.	R. G. Stark,	Dec. 1949.
F. E. Burbidge,	Apr. 1948	R. W. Longley	Jan. 1950.
J. M. Leaver,	Nov. 1949.	P. P. Saltzman,	Mar. 1950.

12. Unpublished Hudson Bay Ice Reconnaissance Reports: F/L Greenaway, Senior Observer, RCAF.

13. "Operation Icecapade", P. P. Saltzman, 1950, (Unprintable).

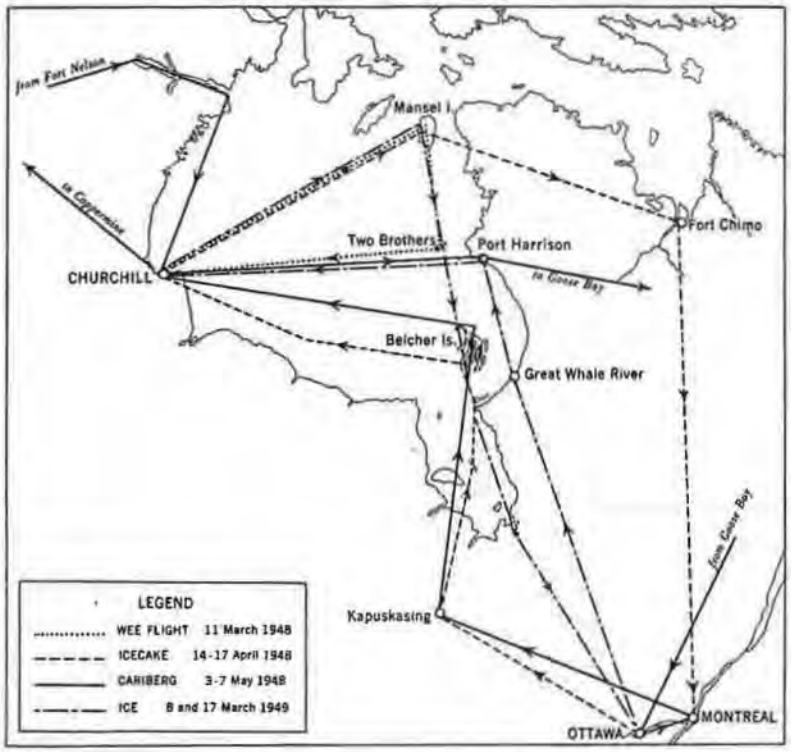

Fig. 1. Routes of ice reconnaissance flights in the winters of 1947-8 and 1948-9. Taken from - Ice, Open Water, and Winter Climate in the Eastern Arctic of North America by F. K. Hare and M. R. Montgomery, Arctic, Sept. and Dec. 1949.

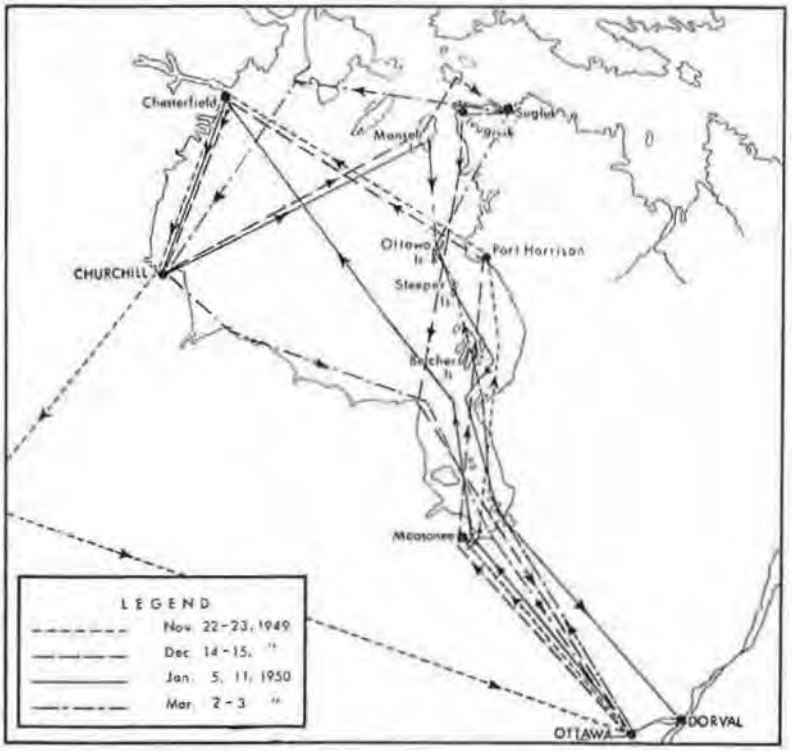

Fig. 2. Routes of ice reconnaissance flights in the winters of 1949-50.