Chinook

VOL. 2 NO. 4 SUMMER 1980

INSIDE *SMOKE PLUME BEHAVIOUR*
WEATHER AND OFFSHORE DRILLING
VOYAGE OF THE "NEPTUNE"

NEWS AND NOTES

THUNDERSTORM FORMATION AREAS IN ALBERTA

Early results from a meteorological field experiment conducted by the **Alberta Research Council** in the foothills of central Alberta suggest that towering cumulus clouds, predecessors of thunderstorms and hailstorms, can draw their energy from heat and moisture pockets within 100 m of the earth's surface. Funded by the **Alberta Department of Agriculture** and conducted in cooperation with the **Alberta Hail Project,** this experiment was designed to locate these pockets and to study their formation.

Known as the Rocky Mountain House Area Genesis Study, or RAGS for short, these experiments took place in July 1978 and 1979 and are planned for July 1980. To meet experimental objectives, frequent wind, temperature, and moisture measurements were made by a University of Wyoming airplane and a network of stations southwest of Rocky Mountain House.

The RAGS analyses appear to support the suggestion that thunderstorms and hailstorms can form in preferred areas of the Alberta foothills. These areas, or pockets, can be explained by channelling of air in the lowest couple of hundred meters by river valleys and by vertical air currents caused, in turn, by solar heating over sloping terrain. Pockets of relatively warm and moist air are theorized to accumulate over higher terrain between the river valleys. On sunny summer days when no storms or fronts are nearby, some of this accumulated air rises eventually resulting in a thunderstorm.

Further analyses and field work are planned to confirm the existence of warm, moist pockets and to relate their location to terrain characteristics and thunderstorm occurrence. Additionally, it may be possible to show for particular cases that rising air currents in convective clouds are based in these shallow pockets.

THE INAUGURATION OF THE METEOROLOGICAL SOCIETY OF NEW ZEALAND (INC)

The **Meteorological Society of New Zealand (Inc)** was inaugurated at a meeting held in Wellington, New Zealand, on October 11, 1979. The objects of the Society are to encourage an interest in the atmosphere, the weather and climate, particularly as related to the New Zealand region. Membership is open to all those with an interest in the objects of the Society, and numbers more than one hundred and seventy.

The Society publishes a Newsletter and a

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VOLUME TWO INDEX

A list of authors, articles and advertisers in Chinook, Volume 2, numbers 1 to 4. An asterisk (*) indicates a column which appears regularly. If the authorship of an article is not shown, it is by the Editor.

AUTHORS

EXPERIMENTERS

ARTICLES

ADVERTISERS

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Articles

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THE COVER

KELVIN HELMHOLTZ BILLOW CLOUD: On the afternoon of December 15, 1979, the sky over Laramie, Wyoming, downwind of the Medicine Bow Mountains was scattered with lenticular wave clouds. Surface winds were about 54 km/h. One cloud briefly exhibited the breaking-wave features of a Kelvin-Helmholtz (K-H) billow which I captured on film using a 300 mm telephoto lens. The waves curled over and the cloud became a flat layer in about 5 minutes. A thin lenticular cloud can be seen in the background above the K-H cloud. K-H billows can be caused by strong wind shear at a layer of abrupt density change such as an inversion.

Brooks E. Martner, Department of Atmospheric Science, University of Wyoming, Laramie, Wyoming 82071. USA.

Further Reading

Scorer, R.S., 1972: **Clouds of the World,** Stackpole Books, Harrisburg, PA.

Reiss, N.M. and T.J. Corona, 1977: **An Investigation of a Kelvin-Helmholtz Billow Cloud,** *Bull. Amer. Meteor. Soc.,* Vol 58, pp. 159-162.

News and Notes, Cont'd

journal *Weather and Climate.* The subscription has been set at NZ $5, although initially members will be invited to make a donation of a further $5. Contact; The Secretary, Meteorological Society of New Zealand, P.O. Box 3263, Wellington, New Zealand.

METEOROLOGICAL HISTORIAN WINS PATTERSON MEDAL

William Edgar Knowles Middleton, F.R.S.C., a meteorologist and historian, was awarded the 1979 Patterson Medal during the 14th., annual Congress of the Canadian Meteorological and Oceanographic Society (CMOS) held in Toronto. Dr. Middleton received the award May 26, 1980 for his outstanding contributions to meteorology over a period spanning nearly fifty years.

Dr. . Middleton joined the Canadian Meteorological Service in 1930, after graduating in physics from the University of Saskatchewan. While with the national weather service, he made contributions to the development of the early Canadian radiosonde, a device sent aloft by balloon to measure upper atmospheric conditions. He worked on the development of weather radar which is used to detect precipitation and severe storms. He also formulated a theory of atmospheric visibility and lectured in meteorology at the University of Toronto during this period. His textbooks on atmospheric instruments and atmospheric visibility have long been classics in their fields.

PLASMA WAVE PHENOMENA OBSERVED BY ISIS

This year marks the 18th continuous year of operation of the Alouette-ISIS series of satellites. The longevity and sustained success of the ISIS program is due, in considerable measure, to the unique facility for plasma wave science that was put on the first Alouette satellite. This facility formed the core around which other atmospheric instruments were built in the later, more complex satellites, ISIS I and ISIS II. In particular, the development in Canada of a satellite-borne radar for sounding the ionosphere, the "topside sounder", assured Canadian scientists of an historic role in the study of the structure and motions of the ionosphere, a layer of ionized gas that stretches upward from about 70 km above the earth's surface.

The ISIS data have been proven to be a rich source of data for research on the fundamentals of wave generation and propagation in a plasma — a fluidlike body of charged particles. In this case, the plasma is the ionosphere, but the plasma wave principles discovered with Alouette and ISIS have wide application to manmade and space plasmas.

SMOKE PLUME BEHAVIOUR IN THE ATMOSPHERE

by F. Fanaki

The purpose of using a tall stack is to help elevate exhausted industrial fumes above man's normal environment at ground level. This, it is believed, reduces the magnitude of the pollution problem. In the past, stacks reached heights of not more than 100 m. Recently however, with increased industrial demands and production there has been an increase in the amount of exhaust wastes and this, in turn, often leads to higher smoke stack heights. By 1960 stacks had reached about 97 m, and by 1970 the height had doubled. At present, the height has increased to about 400 m. The International Nickel Company (INCO) operates a 381 m stack in Sudbury, Ontario.

The plumes are greatly affected by different scales of motion in the atmosphere and by its vertical temperature profile. On occasion, these atmospheric changes may combine to bring the plume to the ground close to the source or to change its shape. Alternatively, they may produce an inversion layer below the plume causing it to loft. When the inversion layer or "lid" is above the plume, it may fumigate, or in other words, increase the concentration of pollutants at the ground.

Thus, in order to make plans for controlling the air quality of an area, one needs to have information regarding the behaviour of the plume under different meteorological circumstances. Its varying shape, due to changing atmospheric conditions is an interesting and curious physical phenomenon.

Plumes from stacks can be categorized into two types. They are either driven solely by their initial momentum (momentum jet type), or else behave according to their momentum and buoyancy forces (buoyant type). On a very calm day both kinds will rise along the vertical in a cone form whose apex is at the stack exit. The apex angle of the buoyant plume is slightly less than that of the jet plume by 6 degrees. Only the buoyant plumes will be discussed in this article. In one model describing their behaviour, the trajectory of a plume during its ascent in a steady wind can be divided into four regions. In the first region, the plume emerges as a jet (jet phase) with a vertical velocity that depends on its exit velocity and buoyancy. Its cross-section is circular and self-generated turbulence dominates its mixing with the environment. At a distance of 2 to 5 times the stack diameter, in the second region (thermal phase), the plume starts to bend downwind at a rate which depends on the strength of the wind. The core of the plume rises faster than its periphery which is sheared off by the wind, and its shape changes from a circular cross-section to a well-defined kidney configuration. Such plumes tend to roll up and form two line vortices downwind from the stack (Figure 1). The vortices are of approximately equal strength but with opposite circulations. The subsequent behaviour of the plume depends on the type of interaction between the two line vortices and the surrounding air. Further downstream the shape of the plume can deform slightly due to mixing. In the last region the plume loses its momentum and buoyancy completely and becomes passive. It is greatly influenced by atmospheric conditions and moves horizontally in a flattened sheet. Alternatively, at a certain distance downwind, relatively large atmospheric eddies may initiate a break-up of the second region or thermal phase. Due to the increased mixing rate in the third region an almost stepwise increase in the plume diameter occurs. The distinct parcels of the plume then tend to merge again and form the last region of the plume (Figure 2).

In fact, the atmosphere does not have steady wind conditions, and is not thermally stable all the time. Depending on the variations of wind direction and temperature profile, the plume may take one of the forms illustrated in Figure 3. A fanning plume (top), occurs under extremely stable atmospheric conditions such as a nocturnal inversion. In this case, the plume is suppressed more along the vertical than the horizontal. Fumigation of the plume is often seen in the morning when the inversion that trapped the plume is eroded by heating of the air near the ground. The lower part of the plume then exists in unstable atmospheric conditions, while the upper part is under stable atmospheric conditions.

Looping of the plume usually occurs when there is a very unstable stratification condition. Such cases are typified by intense solar heating and clear skies, and where a loop reaches the ground, the concentration of pollutants is high.

With a neutrally stable atmophere and a relatively high wind, a plume will take the shape of a cone (coning). The last drawing of Figure 3 shows a lofting plume which occurs when an inversion is building. It is often seen in the early evening. When the air flow is turbulent, the plume loses its symetrical shape and breaks up into puffs that resemble cumulus clouds with sharp edges.

Besides these basic forms of behaviour, other variations frequently occur. As an example, a bifurcated plume is shown in Figure 4. The plume, after leaving the stack, splits into two well developed branches, each of which move downwind as a separate entity. The two branches remain attached at the source and have a relatively clear inter-segment region where the pollution concentration is relatively low. The two branches of the bifurcated plume may or may not move along the same horizontal level, depending on the local meteorological conditions in the area. Wind shear, can affect the branches

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FIG. 6 (Left), BEHAVIOUR OF PLUMES IN A VALLEY, both plumes are along the same direction.

FIG. 7 (Centre), The two plumes are moving away from each other.

FIG. 8 (Right), Plume in a spiral form.

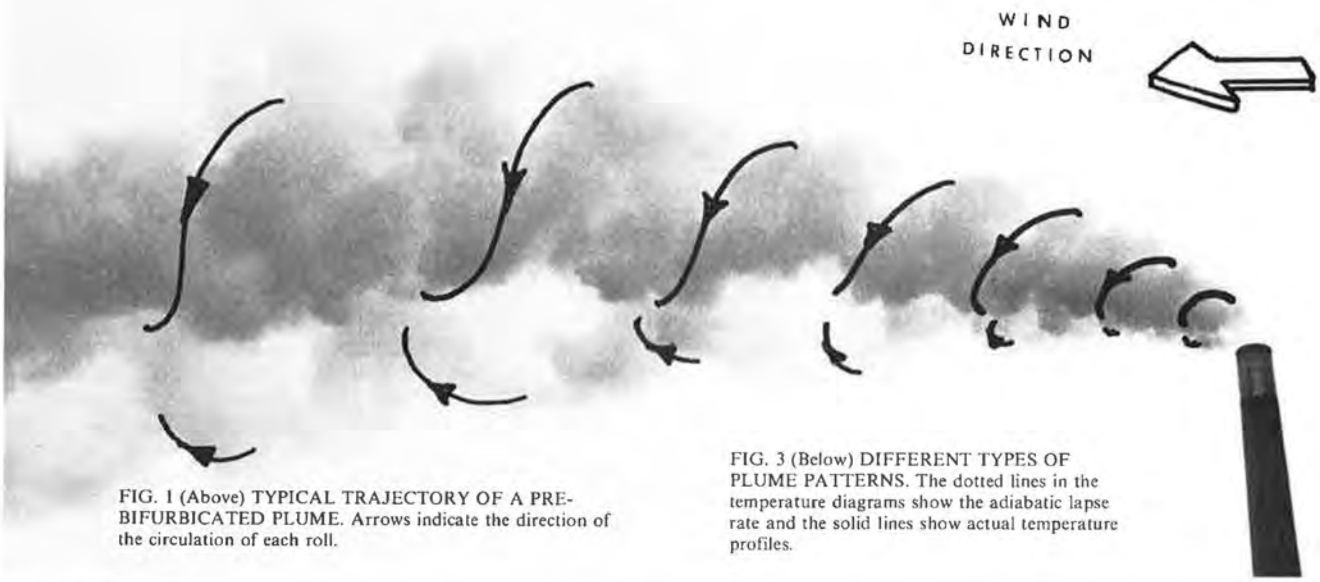


FIG. 1 (Above) TYPICAL TRAJECTORY OF A PRE-BIFURBICATED PLUME. Arrows indicate the direction of the circulation of each roll.

FIG. 3 (Below) DIFFERENT TYPES OF PLUME PATTERNS. The dotted lines in the temperature diagrams show the adiabatic lapse rate and the solid lines show actual temperature profiles.

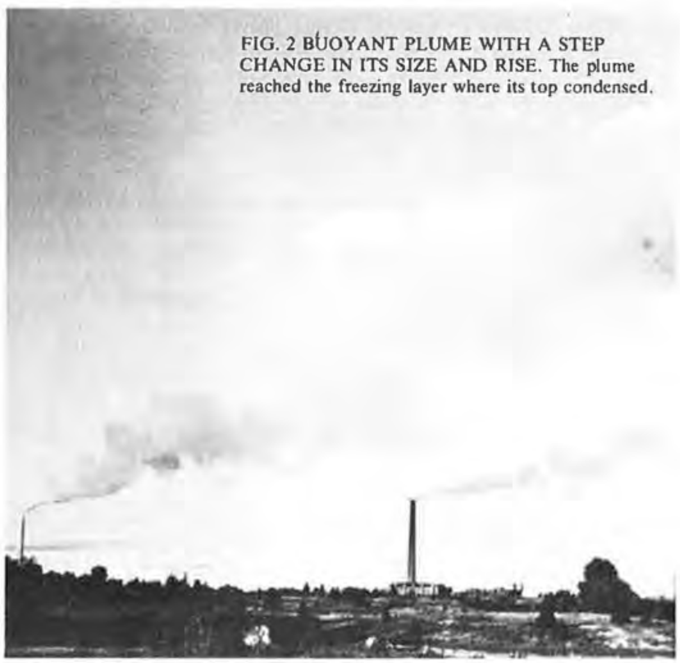
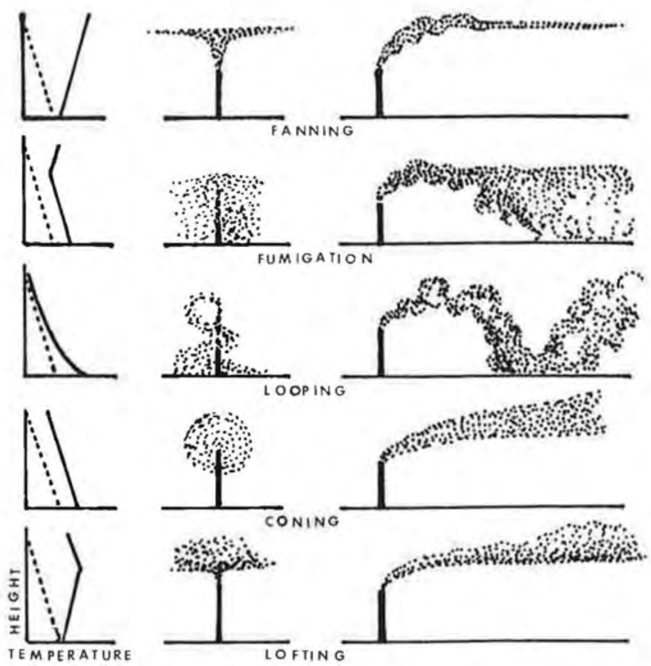


FIG. 2 BUOYANT PLUME WITH A STEP CHANGE IN ITS SIZE AND RISE. The plume reached the freezing layer where its top condensed.



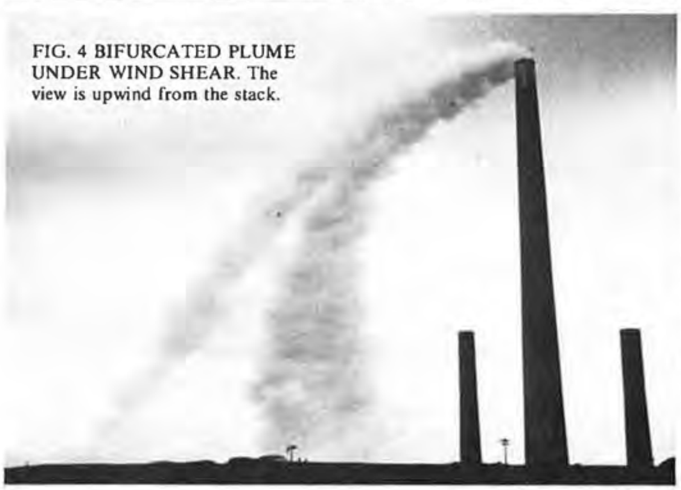
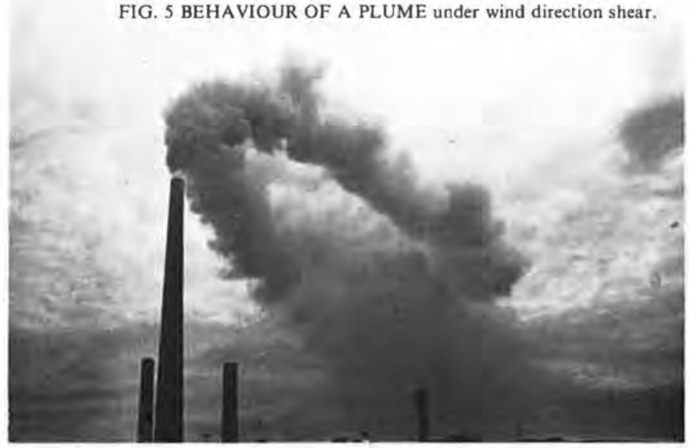


FIG. 4 BIFURCATED PLUME UNDER WIND SHEAR. The view is upwind from the stack.

FIG. 5 BEHAVIOUR OF A PLUME under wind direction shear.



THE WEATHER AND OFFSHORE DRILLING

by R.H. Goodman

Most of the readily accessible and easily extractable petroleum resources in Canada have already been exploited and many are currently in production. In the search for new hydrocarbon production, exploration must be conducted in remote areas and beneath the offshore coastal waters. Such regions are characterized by a harsh environment, with difficult operating conditions. The remote land areas are sparsely settled, while the cold northern ocean areas support very little commercial traffic. As a result there have been few, if any, long term weather observations in these regions.

As far as offshore drilling operations are concerned, the most critical parameter is the sea state, which in turn leads to a requirement for a knowledge of the wind regime. Low temperatures which can cause freezing spray, and hence icing, are also of interest, and a knowledge of visibility conditions is essential in the planning of flight operations.

When a major high-technology, costly industrial activity is planned for such a region, for example the offshore drilling in the Davis Strait between Baffin Island and Greenland as conducted by Esso Resources Canada Ltd., these environmental effects must be carefully studied before any operations are undertaken. One aspect of such investigations is a climatological study of the area, but without a large and detailed historical data set, how can the climate be derived? Fortunately, even in remote areas there exists a historical set of analyzed surface pressure charts. Although they contain little or no actually observed weather detail, they do constitute a historical bank of data interpolated from adjacent land stations. Just as an analysis of predicted pressure patterns is used to forecast wind conditions, the historical charts can be used to predict past wind conditions. This technique is called hindcasting.

Once the winds have been calculated, and their duration and fetch determined, the historic sea climate can be established. From such studies, it was found that it would be possible to drill with safety in the area. Nonetheless, storms do occur. An analysis of the storm tracks revealed a region near 56°N and 60°W with significant storm passage and little of the ship traffic which is the traditional source of weather information. In order to forecast storm arrival in the Davis Strait, observations were required in this area (Fig. 1). Two 10 metre oceanographic discus buoys (see photos) were deployed by Esso in 1979 to fill in the data gap. The buoys were named

PHOTO (Below). A DISCUS BUOY on station in the North Atlantic off the coast of Labrador. Equipped with weather instruments and transmitters, the buoy sends information to the Esso forecast office.

FIG. 1. THE NETWORK OF WEATHER STATIONS used to provide weather information and forecasts for the drilling activity in the "Davis Block" (hatched) area. The standard land stations are those operated by Environment Canada and Greenland as part of their weather network. The weather buoys and supplemental land stations are operated by Esso Resources Canada Ltd.

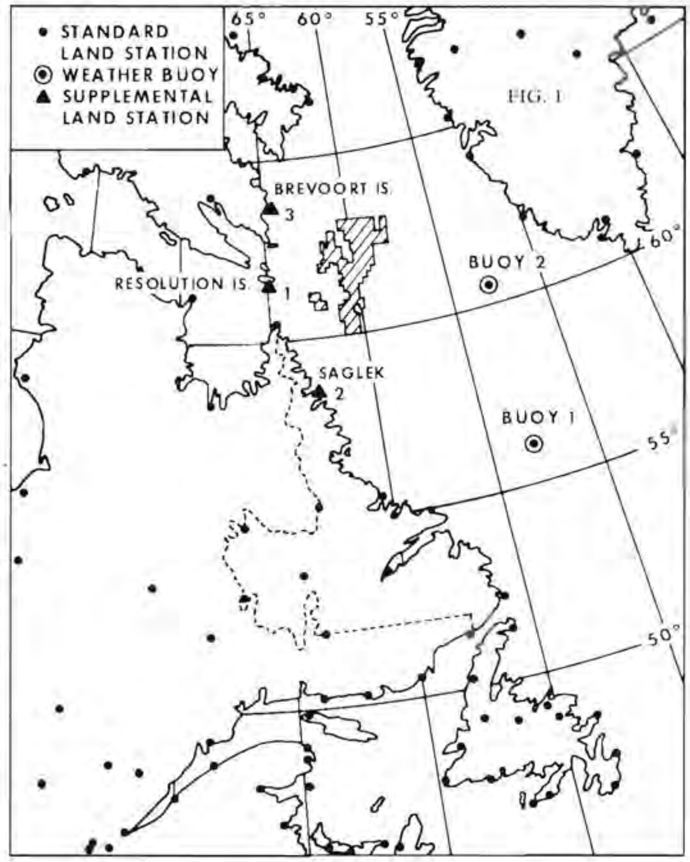


PHOTO (Above). THE DISCUS BUOY *ASIAK* undergoes maintenance.

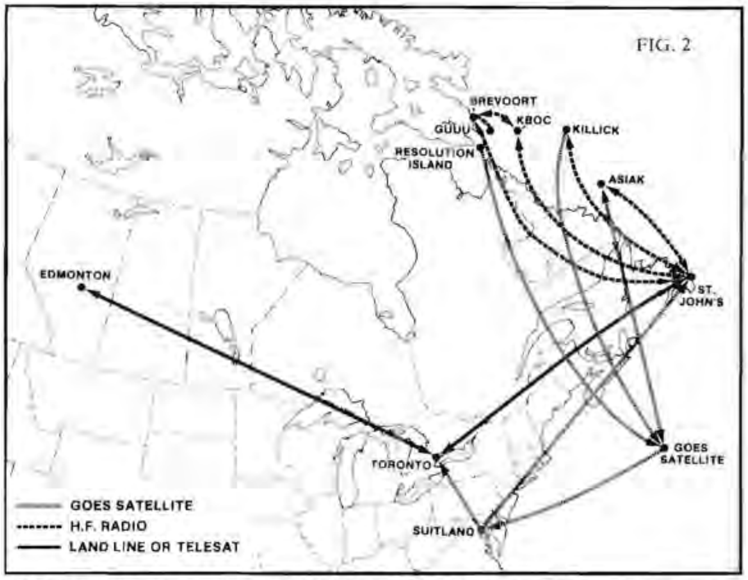


FIG 2 THE WEATHER FORECAST COMMUNICATION SYSTEM operated by Esso in support of their east coast oil drilling activities.

Asiak, which is an Innuit word meaning "goddess of the sea", and *Killick* which is a typical home-made anchor in Newfoundland and Labrador. They measured the wind speed and direction; barometric pressure; sea and air temperature; as well as the significant wave height and period, and reported to the Esso forecasting facility via the Geostationary Operational & Environmental Satellite (GOES). The data was also relayed to the Environment Canada weather network for use in the various weather forecasts provided to the public. The communication system utilized by the Esso weather network is depicted schematically in Figure 2.

In more populated areas with a forecasting tradition, experience and local knowledge play an important role in the prediction of weather events. In a remote area, such a tradition must be quickly developed. Based on the climatology, a weather history of the Davis Strait area was developed which showed the characteristics of the storm tracks and regions of cyclogenesis. This, combined with the observing network, provided a basis for a weather forecast system. Esso established a 24 hour forecast office located at its operations base in St. John's, Newfoundland. Four forecasts per day were prepared in 1979, from May to December, and transmitted to the drilling vessel at the Gjoa well located in an area known as the "Davis Block" east of Resolution Island. This forecasting facility was also used by Aquitaine Company of Canada Ltd., for support of their drilling operations in the same area.

Clearly, the optimum conditions for drilling are calm seas, but this activity can continue in seas up to 8.5 metres. When seas reach 3 or 4 metres, the unloading of supply boats becomes difficult. Waves above 12 metres force the drilling vessel to be disconnected from the well, but such high seas were not experienced in 1979. As for the discus buoys, they withstood the storms very well, and it was only during deployment or retrieval that the weather caused problems. Ice made its first winter appearance in the area during December, but as a safety measure, drilling operations were terminated before the arrival of the ice in order to leave time to drill a relief well should that have been necessary.

Coping with the weather of the Davis Strait is a challenge. So too is the task of developing an understanding of the area's climatology and providing operational weather forecasts for the drill rigs. But if the example of the 1979 season is an indicator, the effort is well worth while in terms of contributing to a safe and efficient drilling program.

Dr. R.H. Goodman, Esso Resources Canada Ltd., Calgary, is a specialist working on the weather and oceanographic problems involved in East Coast drilling operations.

Smoke Plume Behaviour

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differently as shown in Figure 5 which is a bifurcated plume changing in direction during propagation.

One of the challenging problems in the field of air pollution is to predict the behaviour of plumes in a valley. The complex terrain and the local meteorology greatly affect the air flow, and produce nonuniform and unsteady dispersion conditions. Irregularities in both the topography of the valley and convective heating of the air over the sunny side cause local variations in temperature, as well as in wind speed and direction, all of which are controlling factors in behaviour of the plumes.

An example of valley problems is illustrated by Figures 6, 7, and 8. At first, the plumes from the two stacks moved in the same direction (Figure 6). Local changes in the wind direction, however, caused the plume from one stack to behave differently from the other and in this case, they diverged (Figure 7). In a typical case the two plumes may diverge then move back towards each other, and sometimes even combine. Occasionally, the plume from one of the stacks may travel in a spiral path as shown on the right in Figure 8. On cold mornings, plumes are sometimes trapped beneath temperature inversions and fan out to cover the valley from wall to wall, although plumes with enough buoyancy and momentum are able to penetrate and rise until these properties are exhausted.

Pollution has been a consequence of man's activity ever since he first learned how to put fire to use. The days when the atmosphere was considered to be an infinite resource came to an end in Europe with the arrival of the Industrial Revolution. In Canada, the time to study the dilution and ventilation capability and characteristics of the atmosphere is now, before the dispersion of pollutants causes extensive harm, perhaps irreparable harm, to our rivers, fresh water lakes and forests.

Dr. Fouad Fanaki is a research scientist with the Atmospheric Environment Service, Environment Canada.

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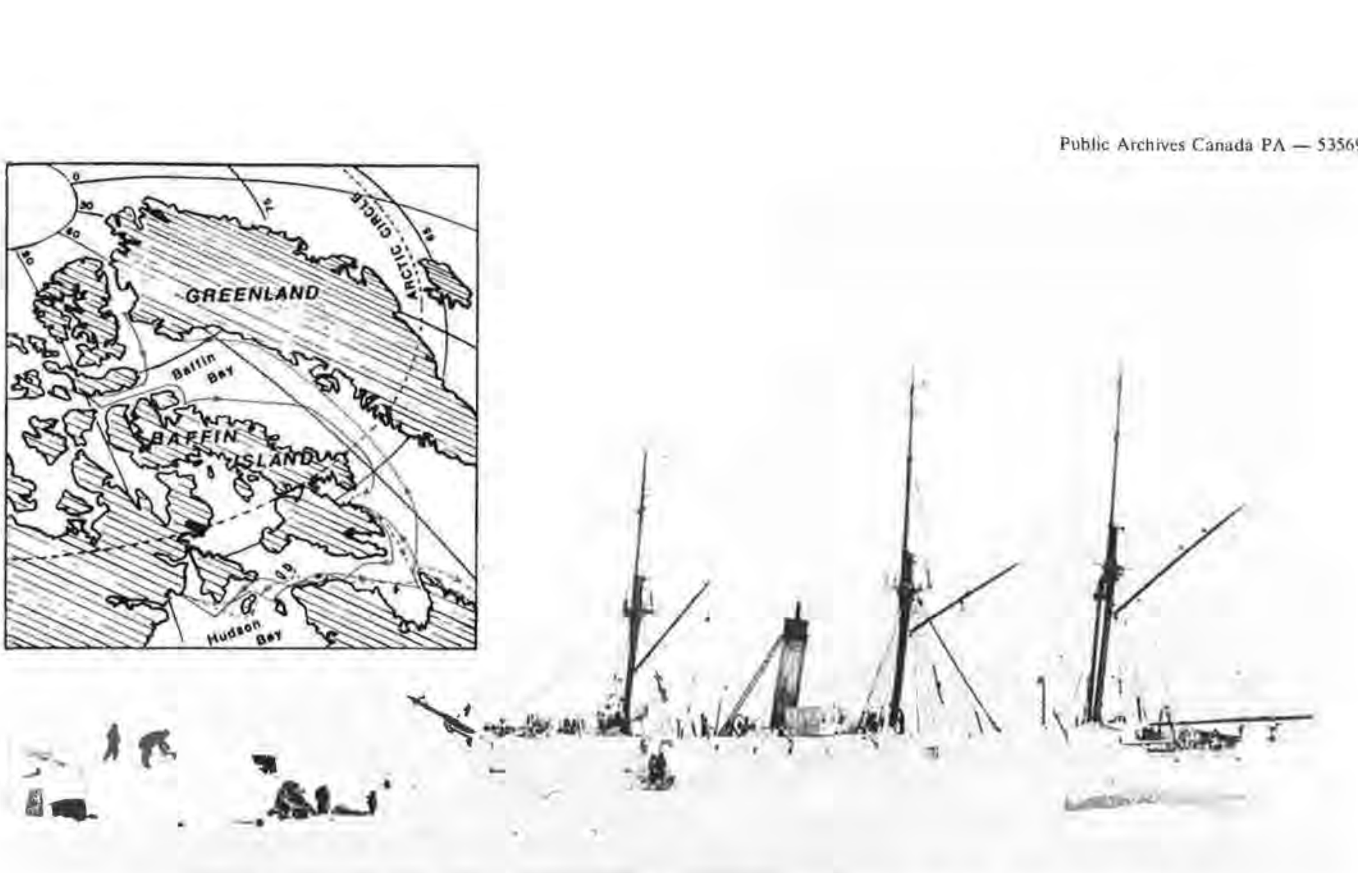


THE VOYAGE OF THE NEPTUNE

Canada's arctic regions are rich in the romance and tragedy of stalwart men who sought a northern route from Europe westward to the wealth of the Orient. The names of the explorers, their rescuers and patrons were bestowed profusely upon every landmark. The hardships and disappointments of the crews who opened the inhospitable area to travel and commerce are commemorated by names such as "Mistake Bay", "Icy Cove", "Cape Storm", and "Bay of God's Mercy". The memory of ships long since wrecked linger in names such as "Fury and Hecla Strait", "Terror Point", and "Phoenix Head".

Beginning with Sir Martin Frobisher's discovery of Baffin Island in 1576 while searching for the mythical Strait of Anian, it took another 330 years before the dream to locate and sail through the Northwest Passage was finally realized. This honour fell to the Norwegian Roald Amundsen, who with six other men in the 70-foot sloop *Gjöa*, entered the passage from the east in 1903. After 3 years they sailed triumphantly through the Bering Strait.

Motivated at first by England's thwarted desire for trade routes with India and China, these expeditions of discovery next turned into attempts to seek out the wealth of the arctic regions. Whalers, traders and even miners sought to exploit the natural resources of the reluctant north. The rigours of the arctic climate exacted a terrible price for the flesh and furs of the animals hunted there, and took a cruel toll of the men seeking the honours of discovery.

The scientific value of the considerable efforts being expended in these ventures was gradually recognized. Looking back at the 12 years from 1847 to 1859 spent by the British Admiralty searching for John Franklin, Admiral Sir F.L.M'Clintock concluded that "the benefits, doubtless, have been very great; to whaling commerce it has opened up all to the north and west of Davis Strait and Hudson Strait; also to the north of Bering Strait. The value of these fisheries alone amounts to very many millions sterling into the pockets of English and American traders. The scientific results are very varied, and ample in almost every department, and peculiarly so in magnetism, meteorology, the tides, geographical discoveries, geology, botony and zoology, as shown by the generous advance in each branch."

An American, Charles F. Hall spent many years in the north. It is due to his efforts that charting of Frobisher Bay was accomplished, and during his attempts to recover the logs and other records of Franklin's *Erebus* and *Terror*, he took meteorological observations, although it is considered that his instruments were not of the best. He died rather suddenly in 1871 after an unsuccessful attempt to reach the north pole in command of the *Polaris* expedition.

Scientific research in the polar regions took its first major step forward in 1881 when as part of the first International Polar Expedition, a number of countries joined forces to set up observing stations in the polar regions of the northern and southern hemispheres. Canada was invited to participate by Dr. F.C. Wild, President of the International Polar Commission located in St. Petersburg, Russia. Mr. Carpmael, Superintendant of the Canadian Meteorological Service was requested to set up a station on Melville Peninsula but to his dismay, the Dominion government could not (or would not) find the $25,000 required to finance the two year project. It was left to the United States government to establish a meteorological station at Discovery Bay on the eastern shore of Ellesmere Island under the command of Lieut. A.W. Greely, U.S. Army.

At about this time, considerable interest arose concerning the establishment of a grain handling port at Churchill, and the navigability of Hudson Bay and Hudson Strait. On February 21, 1884, Dr. Robert Bell, F.G.S., testified before a Special Committee on the question of building a railroad to Hudson Bay, that he had explored the country from Winnipeg northward, and believed that the proposal to build the railway was feasible. Furthermore, he said that he had explored Hudson Strait and believed that it would be open to navigation for 4½ months of the year. A port at Churchill would shorten the grain route from the Prairies to Europe by

1000 miles, and this was a powerful spur for further investigation. The Dominion government lost no time in passing a vote of $70,000 to outfit an expedition to Hudson Bay to find out the facts of the matter. On July 22, 1884, the *Neptune* sailed from Halifax. The task of the expedition commander, Lieut., Gordon R.N. (deputy superintendant of the Meteorological Service of Canada) was to establish seven stations between Cape Chidley at the eastern entrance of Hudson Strait, and Churchill. Each was staffed by two men and an Innuit interpreter, and their job was to obtain meteorological statistics, measure the tide, and keep records of the currents and the state of the ice. Cape Hope's Advance on the northeastern tip of Ungava Bay was considered to be the most important station location, and Mr. Stobart of the Toronto Meteorological Observatory was placed in charge of it.

This was not the first arctic voyage for the *Neptune*, the largest and most powerful ship of the Newfoundland sealing fleet. Two years earlier, during the summer of 1882, the *Neptune* was used in an attempt to relieve members of the Greely expedition who were exploring at latitude 83° 23′ N. the highest attained at that time, and who were in need of supplies. Smith Sound, located where Baffin Bay narrows into Kane Basin, was found to be blocked by ice and the ship was unable to get through.

The *Neptune's* biggest test was yet to come, namely an epic 11,000 mile voyage through arctic waters in 1903-04. Albert P. Low, a geologist from Ottawa was placed in command of this expedition. Its primary purpose was to patrol the eastern arctic and to show for the fist time, the Canadian flag. The *Neptune*, a stout wooden ship of 465 tons net register, was built in 1873 from British oak and sheathed with 'iron-bark' and greenheart. She was specially reinforced for the expedition, to a thickness of 18 inches in all areas where contact with the ice was expected. The bow was further reinforced with iron plates and backed with deadwood, giving it a thickness of 8 feet.

Including Commander Low, the *Neptune* carried six scientists; 30 officers and crew captained by S.W. Bartlett; a non-commissioned officer and 4 constables of the Northwest Mounted Police under the command of Major J.D. Moodie (who was appointed Acting Commissioner of the unorganized Northeastern Territories); and an interpreter. During the 15 month voyage (from Aug. 23, 1903 to Oct. 12, 1904), the expedition gave a good account of itself, claiming for Canada sovereignty rights over Ellesmere, Southampton and other islands; erected a police post at Fullerton (near Chesterfield Inlet); and distributed a proclamation at whaling stations concerning the collection of customs. The scientific work included topographical surveys to correct existing charts, and detailed daily weather and ice observations, both of which were the responsibility of C.F. King; geological surveys and the examination of potential harbours carried out by A.P. Low; anthropological and medical work among the Innuit people by L.E. Borden, M.D., a surgeon, who also helped the naturalist, A. Halkett with botanical work. G.F. Caldwell was attached to the expedition in the capacity of the official photographer, but also helped take the weather observations which were recorded 5 times daily during the enforced idleness of the winter season while frozen in at Fullerton.

At times the temperature fell as low as minus 53°F (minus 47°C), and occasionally there were blizzards. It was during one of these that a tragedy occurred. On the night of December 11, 1903, James O'Connel (described rather callously by A.P. Low as "a cabin-boy of weak mind") left the ship to visit some nearby Innuit snowhouses.

Public Archives CanadaC884434

LEFT TO RIGHT: G.F. Caldwell; A. Halkett; L.E. Borden; C.F. King, scientists on the "Neptune".

He was lost in the snowstorm and was not missed until the following morning. A search was mounted, and on the 15th., his tracks were found leading to an area of open water where it was presumed he had perished. Yet another calamity was to occur. Dr. G.B. Faribault, M.D., the assistant surgeon, had shown signs of mild insanity almost from the time of leaving Halifax, or so it was claimed. On November 1, 1903 he became violently insane and on the advice of Dr. Borden, was placed in charge of the police detachment as a dangerous lunatic. Dr. Faribault was confined to a cell, his condition deteriorating so badly that he died on April 27, 1904.

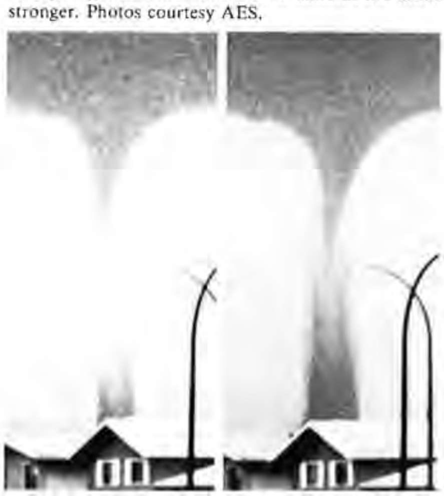
During the summer of 1904, the expedition reached Cape Herschel on Ellesmere Island, their most northerly latitude, and raised the Canadian flag. A copy of a document taking formal possession of the island was placed in a large rock cairn. Turned back by heavy ice they travelled as far west as Beechey Island, the location of the Franklin search party headquarters. On the way they found a cache of provisions left by the whaler *Windward* for the *Gjöa*. Little did they realize that the *Gjöa* sailing in nearby waters, was in the process of making that historic first trip through the Northwest Passage, a feat not to be repeated until 1940-42 when the RCMP Schooner *St. Roch*, skippered by Sgt. Henry A. Larsen, made the voyage from west to east. Two years later he brought the vessel back, becoming the first to negotiate the passage both ways.

From a historical point of view, the accomplishments of the *Neptune* expedition were modest, and now are all but forgotten. The arctic whaling industry is long gone, and with it the need for harbours and customs stations. Modern technology has developed methods of remote sensing from space satellites to collect weather and ice data, as well as automatic unmanned meteorological reporting stations and buoys which can be deployed in uninhabited northern areas. Great strides have been made since World War II in establishing a permanent network of manned weather stations in the Canadian arctic. Police and units of the armed services now regularly patrol and operate there. Oil drilling rigs pump where early explorers once struggled for their lives. The comparative ease with which all this is now accomplished in the hostile northern environment is a tribute not only to man's inventive genius, but also to the manful travail of all those early expeditions. In Albert Low's own words, "all honour should be paid to the memory of these men . . . ; all did their duty, and were faithful unto death."

THE HURRICANE MACHINE conducted by David Greening and Ian Kroll

PHOTO (Above). THE HURRICANE MACHINE in action. It has three sliding glass walls, and one sliding masonite wall painted black to enhance viewing. The walls are made short in order to allow a vertical vent about 3 cm in width on one side of each. With the vents positioned on the right edge as shown, the rotation of the "storm" in the machine is counter-clockwise, or cyclonic. The four wooden blocks lift the machine to allow ventilation around the hot plate which is positioned under the pizza pan. Large diameter holes bored around the base also help prevent over-heating. The light dimmer switch allows an adjustment of the light intensity provided by the four bulbs, and just the right light for viewing can be obtained.

FIG. 1 (Below). TWO EARLY STAGES IN THE LIFE-CYCLE OF A TORNADO photographed in Regina, Sask., June 25, 1975. Taken just seconds apart, the picture illustrates the downward extension of the tornado tuba from the cloud base, and the annulus rising rapidly from the ground to envelope it. When the two were fully merged, they combined into a typical funnel shaped column. Theoretically, the wind speed in the tuba is relatively low, (photogrammetric estimates of 54 km/h were computed by the Alberta Research Council in the case of a 1976 funnel cloud near Red Deer, Alt), while the winds in the annulus are much stronger. Photos courtesy AES.



Cyclones, hurricanes and tornadoes all have one thing in common. They are rotating storms in which the air near the earth's surface spirals towards the centre of lowest pressure. The Coriolis force (a deflecting force due to the earth's rotation) governs the direction in which the air moves, and in the northern hemisphere this is a cyclonic, or counter-clockwise direction when viewed from above in the plan position. (To see what happens if this rotation is seen from below, draw on one side of a thin sheet of paper, an arrow spiralling in on itself. From the other side of the paper, view it against a strong light.) The situation in the southern hemisphere is just the reverse. The smaller the horizontal diameter of the rotating volume of air, the greater the chance of asymmetrical behaviour. Although very rare, there have for example been some documented cases of anticyclonic (clockwise rotating) tornadoes in the northern hemisphere. The speed with which the air rotates varies considerably depending upon the pressure gradient force and the storm's radius. The winds of large diameter, weak cyclones may be as little as 20 km/h, whereas intense hurricanes or tornadoes can generate sustained wind speeds of several hundreds of km/h.

Obviously, the air particles in the windstream spiralling horizontally towards the storm centre cannot all pile up there, and must rise to higher altitudes in the atmosphere. At some high level, most of the air diverges outwards from the central axis finally subsiding to the earth on the storm's fringes in order to complete the convection cycle. It is in the storm's rising core that water vapour is carried upwards, cools and condenses into clouds and precipitation. In hurricanes and tornadoes, some of the high level air actually converges into the very centre of the storm and subsides there, causing the typical cloud free "eye" of the hurricane. In the case of the tornado, this sinking air forms into a tuba which extends itself downwards inside a rising annulus of rapidly rotating air (see Fig. 1). The merging of the tuba and the annulus form the typical funnel-shaped column of the tornado.

A device to model and demonstrate the complexity of these rotary motions is not an easy proposition for the amateur. However, two young students from the Scott Bateman Junior High School, The Pas, Manitoba, won the $100 Canadian Meteorological and Oceanographic Society prize for their entry in the 1979 Canada-Wide Science Fair. David Greening, 13 years old, and Ian Kroll, 14 years, constructed a "Hurricane Machine" (see photo) which in a very simple fashion illustrates the essential air circulation of a rotary storm. The simulation takes place in a box fitted with movable glass sides which allow outside air to flow in through a narrow vertical slot. When the slots are position on the right-hand edge, the air feeds inside in a counter-clockwise (cyclonic or northern hemisphere) fashion. By sliding the glass over in order to move the slots to the left-hand side, the flow is reversed. A hot plate under the base of the box heats a shallow pan of water (a hole is cut in the base to accommodate something like a pizza-pan). The rising steam is less dense than the surrounding air and forms a partial vacuum which draws more air in through the slots. A vent pipe through the roof of the box completes the circulation, allowing the heated air and steam to escape, while light bulbs illuminate the demonstration and make the rotating column visible.

David and Ian calculate that it took a total of about a week's work to build the apparatus, and cost them about $25.00 (excluding the hot plate). Nature gave the two lads a very practical demonstration of the power of intensely rotating storms when a tornado hit their home town of The Pas, Manitoba on July 11, 1979 causing an estimated $100,000 damage shortly after their return from the Science Fair. Neighbours and other townspeople don't hold the "Hurricane Machine" responsible for this misfortune, but who can blame them for being a little apprehensive about future science projects that David and Ian are cooking up in their basements.

ANSWERS TO ARCH PUZZLES 8, 9, 10. (Spring 1980)

8. Latent, extent, intent, portent, content, penitent, impotent, competent, tenth, tentacle, tentative, Stentor, entente, attention, detention.

9. 44, ½¢: 1, 3¢: 5, 5¢.

10. (a) St. Mary's. (b) weather satellite photo used as evidence. (c) smoke from forest fires. (d) temperatures and relative humidity graphs. (e) first spring melt containing highly polluted contaminants. (f) 16 to 38°C. (g) Dr. Joseph Workman and Henry George Vennor. (h) turbulence. (i) Ezekiel Stone Wiggins.

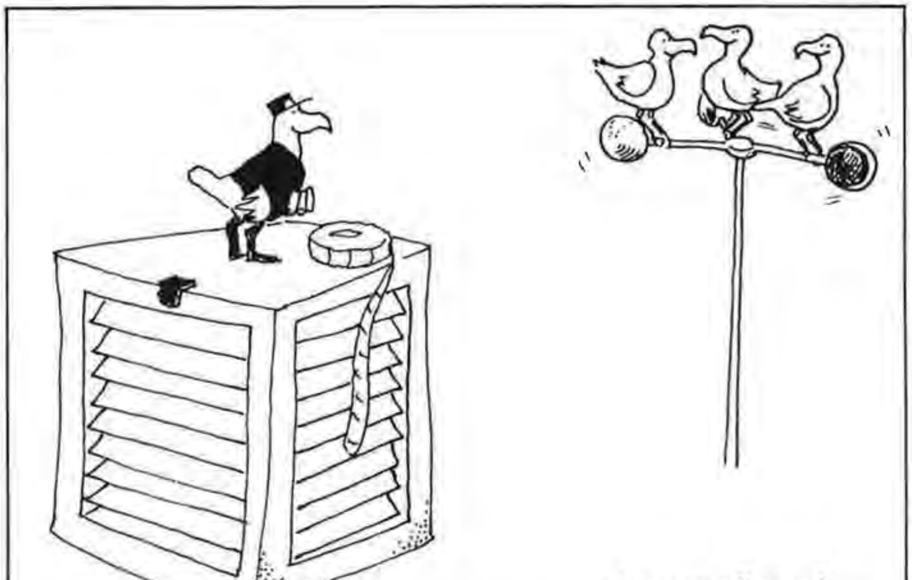
ARCH PUZZLE

We're trying something a little different from the usual type of puzzle offered in this column. Rather than simply presenting you with a puzzle that passively awaits a solution, this time around we are challenging you with an interactive variety, and awarding prizes. The best (in our opinion) and most imaginative responses received by ***Chinook*** in the following three categories will be printed. In each, *The Weather Book* by Reuben Hornstein, will be given as the top prize. So, sharpen up your pencil and try your hand at this latest set of questions posed by our arch-puzzler, **R.G. Stark.** Entries received before September 15, 1980 will be eligible for a prize. Send as many entries as you wish.

11. A Punster's Delight
Make your own weather forecast for a special day, or invent a weather event. For example, a forecast for the weekend of Good Friday might be "Easterly Winds". How about for Doomsday, "There'll be snow tomorrow". Examples of weather events might be; "sucked in by a tornado", "it rained almost as long as Queen Victoria", or "thunderstorms moving with lightning speed".

12. Rhyming Definitions
The task is to create rhyming definitions of a meteorological term. For example, blizzard is a "snow blow", or cirrus is a "high sky".

13. Misplaced Meteorological Items
If you were to lose meteorological items, there are some very unlikely places where they would be right at home. Who, for example, would think of looking in a tavern for a "barograph", or in a night club for a "strip-map". What about finding "growlers" in a dog-kennel? Send us your "misplaced" items and where they were found.



A merry-gull-round

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BOOK REVIEW

Lifeboat

Ken Hewitt

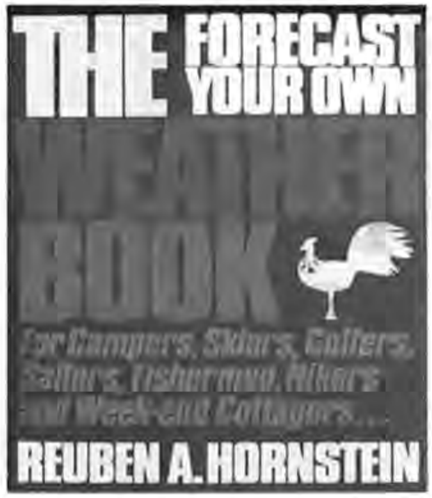
LIFEBOAT by Ken Hewitt. Wiley Publishers of Canada Ltd., Toronto. 1976. 335 pages. Hardcover, $11.50. Review by ***Simon M. Kevan,*** *John Abbott College, Montreal.*

With the 1970's came a general awareness of the magnitude and diversity of Man's impact on his planet Earth. As the decade unfolded, it became increasingly evident that Man's very survival depended upon a greater understanding of the Earth's natural ecosystems. *Lifeboat* is a textbook written so as to introduce senior high school or freshman college students to the intricacies of human ecology, the study of Man-Nature relations. Hewitt examines these relations from a geographical perspective.

This book opens with a discussion of the general concepts which underlie ecological and resource issues. Then details concerning the functioning of the physical and biological environment follow.

Given the vast assortment of information which is pertinent to the study of human ecology, the author must be given credit for his ability to provide a comprehensive overview of those issues central to environmental geography. The information provided, though interesting, is poorly organized. Of graver concern are the problems which can be attributed to poor editorial leadership, e.g. lack of homogeneity in writing style, graphics which range from the sophisticated to the crude and the lack of explanation concerning the usage of numerous figures and plates. Perhaps the most annoying aspect of all is the poor resolution of the monochromatic blue and brown photos.

In sum, I find it hard to endorse this text heartily. It suffers from just too many defects. Such a conclusion is rather unfortunate, because the book left me with the feeling that it had great potential.



THE WEATHER BOOK by Reuben A. Hornstein. McClelland and Stewart in co-operation with Environment Canada, Toronto. 1980. Softcover, 96 pages.

The working of the weather is a complicated scientific process best understood by specialists in the field of atmospheric physics and math. It is no small feat then, to organize and write a fun book about the weather, which at the same time is also authoritative and informative. This however is exactly what Reuben A. Hornstein has accomplished. He takes the reader on a romp through the fact and fiction of traditional weather lore. Starting with folk legends, the author eases into a free flowing discourse on such topics as sky colours, haloes and coronas, auroras, blizzards and chinooks, lightning, dew and frost. Not one weather map sullies the pages, indeed it is filled with delightful illustrations drawn from sources such as Winnie the Pooh and drawings by Leonardo da Vinci. An index would have been useful, but the small size the book (96 pages, approximately half of which are illustrated), and short chapters help the reader locate items of interest fairly easily.

If there is any complaint, it is concerning the sub-title "Forecast your own" (weather), which is rather misleading. Certainly as the cover blurb indicates, the book does provide a wealth of information about the causes of the various meteorological phenomena, but it contains very little explicit advice to the reader intent on formulating his own weather forecast.

When you have read Hornstein's book and fancy yourself as a weather prognosticator, it may serve you well to remember the forecaster's lament;

When I am right; no-one remembers:
When I am wrong, no-one forgets.

MARINE WEATHER by Nathaniel Bowditch. Arco Publishing Inc., New York, 1979. Softcover. 249 pages. $9.95 (Available from Prentice-Hall of Canada Ltd., Scarborough, Ont.)

Here is just the book that Power Squadrons, yacht clubs, sailors and mariners of all kinds have been awaiting It is packed with descriptions and definitions of all types of phenomena. Do you know what 'bummocks' are, or 'growlers' or 'polynyas'? These, and many other terms, are all explained in the 35 page chapter dealing with ice in the sea, an excellent information source for all mariners plying Canadian waters during the cold months of the year. This same chapter however, also suffers from a rather serious oversight in neglecting to mention the ice reporting and forecasting services available from Environment Canada. Topics range from tropical cyclones to ocean currents and waves; breakers and surf, sound in the sea, to tides and tidal currents and weather observations. Numerous charts, diagrams and tables are presented which illustrate everything from the effect of bottom topography in causing wave convergence, to determining a course for avoiding a storm centre.

The appendix which deals with sea state draws heavily upon material published by Environment Canada, yet strangely appears to be ignorant of the fact that the Canadian Coast Guard weather ships *St. Catharines* and the *Stonetown* were replaced years ago by the *Vancouver* and the *Quadra.*

Nonetheless, **Marine Weather,** for all its ignorance of Canadian marine weather services, is still a valuable book for anyone needing a guide to observing and understanding the wind, the waves and the sky.

WINDOW ON WEATHER MT. ST. HELENS ASH CLOUDS

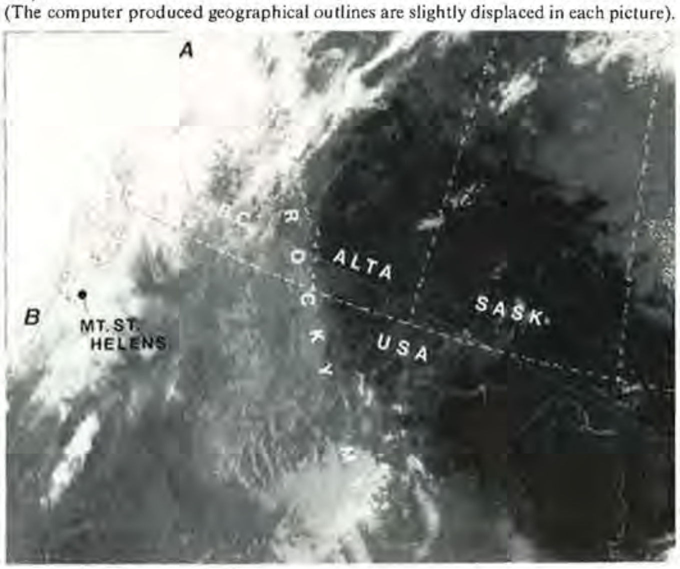
Showers of volcanic ash are not a new phenomenon in British Columbia. Passengers and crew arriving in Vancouver on June 10, 1912 aboard the steamer *Pasosum* from the northwest coast, had been exposed to a steady rain of ash from the eruption of Mount Katmai in Alaska. It had started on the 8th., and fell all day, accumulating more than 25 mm.

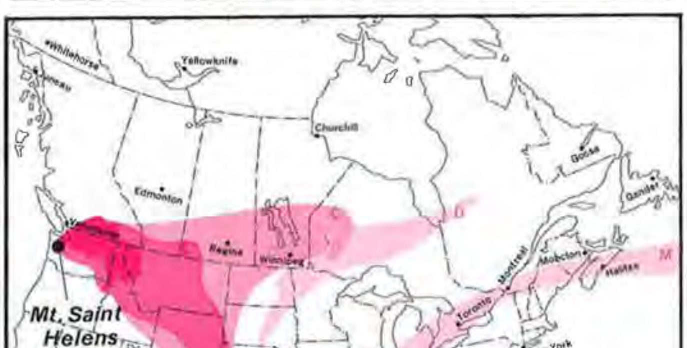
The eruption of Mt. St. Helens in the State of Washington at 1532 GMT on Sunday May 18, 1980 (E-day), shot ash, pumice and noxious gases 25 km up into the stratosphere. There it began spreading eastwards at an average rate of 120 km/h. It also travelled northeastwards, although more slowly, reaching southeastern sections of B.C. by evening. Downwind from the volcano, a steady fallout of fine gray ash soon piled up to 25 mm, while at Ritzville, Washington, about 320 km to the east, ash accumulations of 13 cm had to be cleared away with front end loaders.

Across the Canadian border, only a very thin layer of ash fell from the Okanagan Valley and eastwards in B.C. In southern sections of Alberta, Saskatchewan and Manitoba, no accumulation was reported although the visibility was reduced to a few kilometres with 48 hours (E plus 2 days) of the explosion. The ash cloud split into two arms, with the northern arm splitting off and being carried at high levels as a very thin layer of decreasing width, reaching central Ontario by E plus 4 days. The southern arm at first pushed southwards along the U.S. Rockies, but then curved eastwards in a narrowing ribbon as it streamlined in the wind aloft. By E plus 3 days it too had split away from the source and had streamed 100 to 200 km wide across southern Ontario, southwestern Quebec, extreme southern New Brunswick and western Nova Scotia. Pilots reported that the main concentration of ash lay between altitudes of 8 and 13 km. On the 20th., the windshield of a commercial jet plane located 160 km southwest of Chicago was covered by ash, forcing it to land. By E plus 5 days, only two very narrow ribbons of ash 50 or 60 km wide lingered over eastern north America, one of which stretched in a large curve around a storm centre.

PHOTO (Left). A SATELLITE VIEW OF THE MT. ST. HELENS AREA at 1510 GMT., May 18, 1980 shortly before the eruption. A zone of cloud stretches from A to B. PHOTO (Right) at 2153 GMT the same day, or a little over 6 hours after the eruption. The cloud zone has moved to C, D while the ash cloud has reached Idaho. (The computer produced geographical outlines are slightly displaced in each picture).

FIGURES 1 and 2. THE SPREAD OF THE MT. ST. HELENS ASH CLOUD through the atmosphere, shown at approximately 24 hour intervals. The eastern extremity of the northern arm each morning at about 1200 GMT., is labelled consecutively A,B,C . . . etc., while the extremity of the southern arm is labelled J,K,L . . . . etc.





Photos Courtesy AES.

TRADE WINDS Edited by Claude Labine

TAYLOR NAME JUST A TRADEMARK IN FUTURE

Taylor Instrument Companies of Canada Ltd., would have celebrated their 50th., corporate anniversary on August 1st., 1980, but now the names **Taylor** and **Tycos** will only be encountered as trademarks. This is because, on January 1st., 1980, the functions of Taylor were officially merged into the new parent company of **Sybron Canada Limited.** Sybron's range of products, which includes hospital equipment and medical items, is a far cry from the temperature instruments first manufactured by **Taylor Brothers** in Rochester, New York, during the last century. In 1914, the **Taylor Instruments Company** expanded into Canada with a very modest operation quartered in a small office and storeroom at 28 Wellington Street, Toronto. After a discouraging start, their line of **Short & Mason** instruments from England began selling well. Just after the first world war, Mr. **F.C. Baker** was hired as a stenographer. This young man not only attended to the correspondence but also did the sweeping, packing and shipping. By 1930 he was the commercial Sales Manager of the expanding firm.

As the old quarters became inadequate, new ones were found in the Royal Bank Building. With the establishment of a repair department in Canada, another move was required, this time to the ground floor of the Stevenson Building at 110 Church Street in Toronto. In May 1922, the five-storey brick Stevenson Building was purchased and renamed "Tycos Building". A display room was located at street level, with the remainder of the building given over to the office administration, stock rooms, manufacturing and repair work. On August 1st., 1930, the new Canadian company, **Taylor Instrument Companies of Canada Ltd.,** capitalized at $1 million, was formed with Mr. **Arthur H. Allen** of Toronto as Managing Director.

TYCOS BUILDING, display room about 1930.

With growing emphasis on designing and manufacturing systems for industrial metering, measuring and controlling, now combined with the diversified interests of **Sybron,** the manufacture of weather instruments has ceased. However, **Murray Duncan,** the Marketing Manager (who started his career with Taylor when it was located on Church Street, and before the move to its present address at 75 Tycos Drive in Toronto) says that the sale and repair of imported instruments will continue.

NEW PRODUCTS . . .

Environmental engineers at **R.W. Munro Ltd.,** have just introduced a highly accurate evaporimeter that will monitor evaporation for long periods, unattended. The water surface of a 250 cm^2 evaporation pan is maintained at a constant level by an electronic detection device which supplies water in metered quantities, each corresponding to 0.1 mm of evaporation. Electrical pulses proportional to each metered quantity of water are either counted locally or transmitted to a data acquisition system. **R.W. Munro** say that a high degree of accuracy is achieved, thanks to the frequency of the pulses, and the low friction, hysteresis-free design. Calibration can be checked as desired by the user. **R.W. MUNRO LTD.,** Cline Rd., Bounds Green, London, England. N11 2LY. Tel. 01-368-4422.

ENERCORP recently introduced new humidity and temperature transmitters. The transmitters operate by converting the change of length of the humidity element via a precision slip ring potentiometer. They are available in indicating and non-indicating models. A wide range of electrical ouputs are available to interface with computers, recorders, indicators or controllers. Wind protection, weather and radiation shields, as well as special mounting hardware are available accessories. **ENERCORP Instruments Ltd.** (see p. 63)

VAISALA OY of Finland have a new wind display which shows at a glance both wind direction and speed. The new *WAD 13* wind display is part of the *Vaisala WA Wind Measurement System* which includes optoelectronic sensors, analog displays, recorders and a running average integrator. Wind direction is given by two circles of LED's. The inner circle of red LED's displays the instantaneous direction. The outer circle of yellow LED's shows the wind variance sector of the past 5 seconds. This is given as diminishing LED brightness as a function of time. A two or three digit 7-segment display indicates wind speed. Speed can be given as meters per second, knots, kilometers or miles per hour. **VAISALA OY,** PL 26 SF-00421; Helsinki 42, Finland. Tel. 358 0 890 933.

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Environment

Campbell Scientific Canada Corp. Consultant and Instrumentation. 10429 87 Ave., Edmonton, Alta. T6E 2P4. (403) 439-2771 (see ad p. 64)

Instruments

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