THREE McGILL WEATHER OBSERVATORIES

SMALLWOOD
McLEOD
STORMY WEATHER

AUGUST 1968

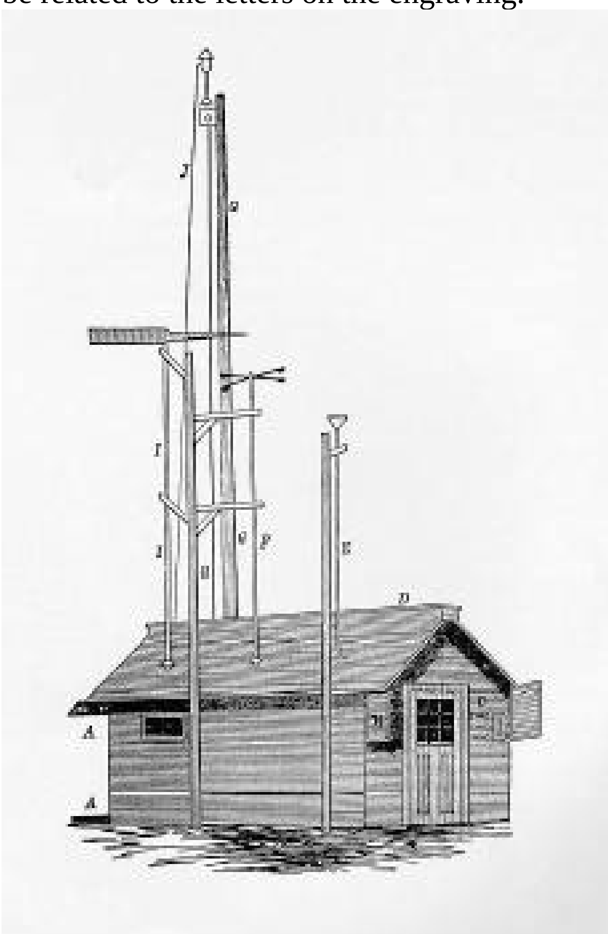
The Smallwood Observatory at St. Martin

Charles Smallwood, M.D., built his own meteorological observatory in the 1840's, at his home in St. Martin, Isle Jesus, outside Montreal. In 1858, when 12 years' records had accrued, Dr. Smallwood wrote as follows:

"Observations for the purpose of Meteorology, are taken by the usual instruments, at 6 and 7 a.m. 2, 9 and 10 p.m. daily, besides extra hours, on any unusual occurrence. Constant tri-daily observations are also taken on the amount and kind of atmospheric electricity, also on the amount of Ozone, and likewise particular attention is directed to the phenomena of thunder storms - all of which observations are regularly recorded. Besides these daily observations, record is kept of the temperature of springs and rivers and the opening and the closing thereof, by ice; also on the foliation and flowering of plants and trees, and the periodic appearance of animals, birds, fishes and insects, besides the usual observations on auroras, haloes, meteors, zodiacal light, and any remarkable atmospheric disturbances.

Many of the instruments, are self-registering and to some the photographic process may be applied, being constructed for that purpose.”

Two wood engravings show the Smallwood Observatory and the disposition of its equipment as described in 1858. Regarding the external view, the small wooden building faces north, and comment can be related to the letters on the engraving.



(C) The thermometers for measuring air temperature and the dry and wet bulb thermometers for humidity are on the north wall, shaded from sun and rain. They have occupied the same position for some years, four feet above the ground, and have been verified twice a year. On summer evenings, of course, the north end of a house is in sunshine. The shading of the thermometers from this evening sun is provided by screens of Venetian blinds on either side of the building, at B.

(A) For measurement of solar radiation, another thermometer is set out from the southern end, its bulb kept blackened with Indian ink.

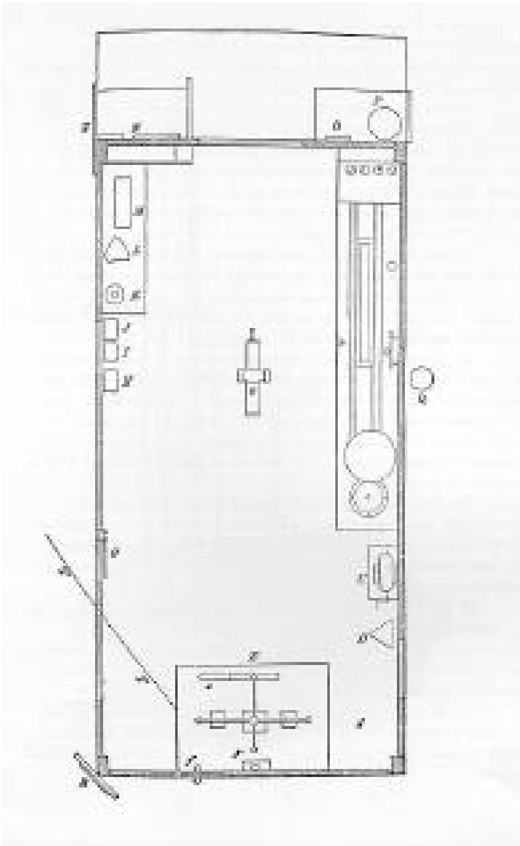
(D) An opening runs along the ridge of the rood allowing use of a transit telescope inside the building for time from the stars. Shutters cover this opening when it is not in use.

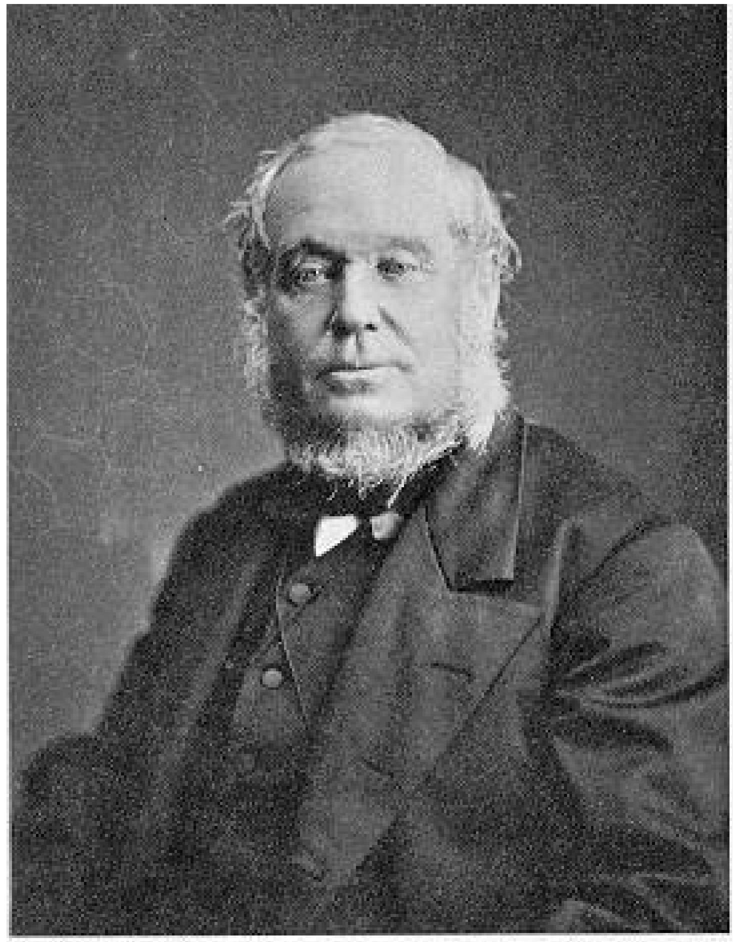
(E) The rain gauge has a receiver 13 inches in diameter twenty feet above the soil. A recording device inside the building shows the beginning and ending of the rain and the amount of precipitation. There is a separate snow-gauge, placed at ground level in an open space. The amount of snow is measured in such a way that it can be reduced to the corresponding amount of water. The wind is recorded continuously both as to speed and direction.

(F) Is the rotating wind-velocity shaft surmounted by three hemispherical metal cups. These are similar in construction to those of the Reverend Dr. Robinson of Armagh, in the northern part of Ireland. The other rotating shaft, at (I), coming down from the large weather vane, gives the wind direction.

At (G) is an eighty-foot mast. A copper lantern is raised to the top of this mast by the cord at (H), for measurements of atmospheric electricity. (The flame of the lantern provides the ionisation around the lantern needed so that an electric current can be exchanged between the atmosphere and the lantern.)

At (J) a conducting wire leads down to a gold leaf electroscope and three electrometers. The Volta’s electrometer, Dr. Smallwood notes, may be rendered self-registering with great facility, by the photographic process.





Dr. C. Smallwood - 1872

The inside of the observatory is shown in plan. Here (A) is the rather large recording machine for the anemometer. (B) is the transit telescope, under that opening along the ridge of the roof. C, D, E, F are all parts of the atmospheric-electricity measuring system. Small (e) is a spark-discharging apparatus with an index playing over a graduated scale, to measure during thunderstorms the force of the electric fluid by the length of the spark.

A visiting committee commented that the whole of this apparatus is the result of Dr. Smallwood's own handicraft. That the whole arrangements of the little room are a signal proof how much a man may do unaided and how well he can effect an object, when thrown entirely on his own resources. The committee took particular note of (T), an iron rod beneath the surface of the ground, connected with the spark discharger to ensure safety. They could not avoid a reflection in this context on an unfortunate Mr. Richman. One presumes that the unfortunate Richman had lacked any such grounding device. H, I, J, K are barometers. (L) is a quadrant and artificial horizon, (M) a microscope for ascertaining forms of snow-crystals. (O) is a chemical ozonometer: one ounce of starch boiled in distilled water, with 10 grains of Iodide of Potassium added, spread on sized paper, which is found better than bibulous or unsized paper. One piece of this paper is mounted at (O), another at the top of the mast, for comparison. Concerning ozone, a paper published by Dr. Smallwood is quite closely *au courant* today.

IN 1856 Dr. Smallwood, M.D. of the University of London, received an honorary Ll.D. from McGill and an appointment as Professor of Meteorology. This was honorary too, in the sense that no salary went with it.

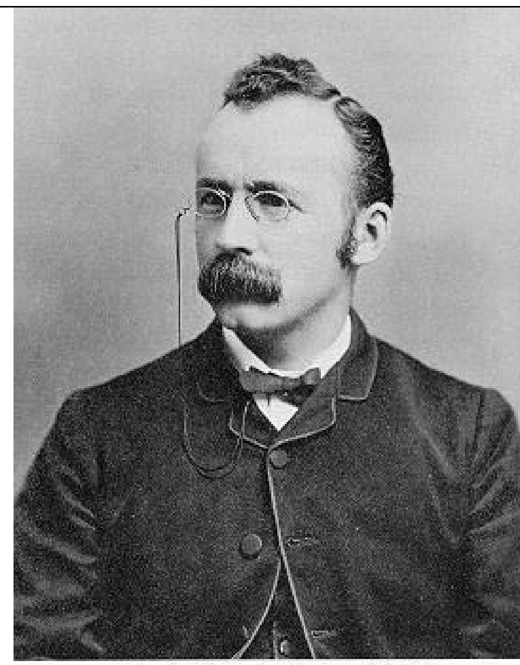
Just a few years later it was proposed by the President of the Grand Trunk Railway that there be an observatory in Montreal, and that the University might offer a sight. All the American railways were proposing observatories in those days, astronomical observatories to provide reliable time-keeping. Dr. Smallwood's meteorological observatory already was taking this time service seriously. In addition to the transit instrument, there was also a seven-inch achromatic telescope, eleven-inch focus. Already, wires from the Montreal telegraph had been laid into the Smallwood Observatory, to connect it with the principal places in the United States.

The McLeod Observatory on Carleton Road

In 1862 Dr. Smallwood offered to move his instruments, meteorological and astronomical, to the University. Before the year was out the stone tower of the McGill observatory had been built, at a cost of about $2000.

Dr. Smallwood was then in late middle age. In the decade remaining to him he continued active, embodying in the McGill Observatory the qualities of his personal establishment at St. Martin and implanting in younger minds the spirit of enquiry of the scientific observer. He died in 1873. The position of professor of Meteorology was allowed to lapse for eighty-eight years.

The work of the Observatory went on without a break, however, thanks to C.H. McLeod who was superintendent of the Observatory for forty years, while progressing in civil engineering, from newly graduating as a member of McGill's first graduating class in engineering, to Professor of Geodesy and Surveying, and Vice-Dean of Applied Science.



Prof. C.H. McLeod - 1889

When McLeod was still an undergraduate, in the last years of Dr. Smallwood's life, the Canadian Meteorological Service commenced to set up a new comprehensive system of observing the weather and reporting it by telegraph to a central forecast office. At McGill, McLeod as an undergraduate was allowed to room in the McGill College building so that he could take observations at the required times at the little observatory next door. A few months after McLeod's graduation Dr. Smallwood died, and Dr. Dawson asked the young graduate to take charge. Next year, McGill became a "chief station" in the new network connected directly to the telegraph, so that observations could be reported without delay every three hours.

Bunty McLeod became a solid citizen and a sound family man. A house was built, from the original little observatory back to Carleton Road, so that neither weather nor family need be neglected. Neither was, and so a few years later the roof of the house was lifted to incorporate an extra storey. Kirkland Mcleod was a member of the first family to be reared in that house. The Marshall children were the last. The whole building was torn down, a hundred years after the observatory proper was built.

Professor McLeod was a civil engineer. His first great achievement in the Observatory was to establish its exact longitude. For this you time the transit of the stars from two stations, far apart, against a single clock. In the 1880's McLeod borrowed telegraph lines to determine longitude in this way, relative to Harvard College. , In the 90's, he borrowed the Atlantic cable to determine it relative to Greenwich. Putting the two together, he was able to improve slightly the figures for Harvard itself, and so for the whole North American continent.

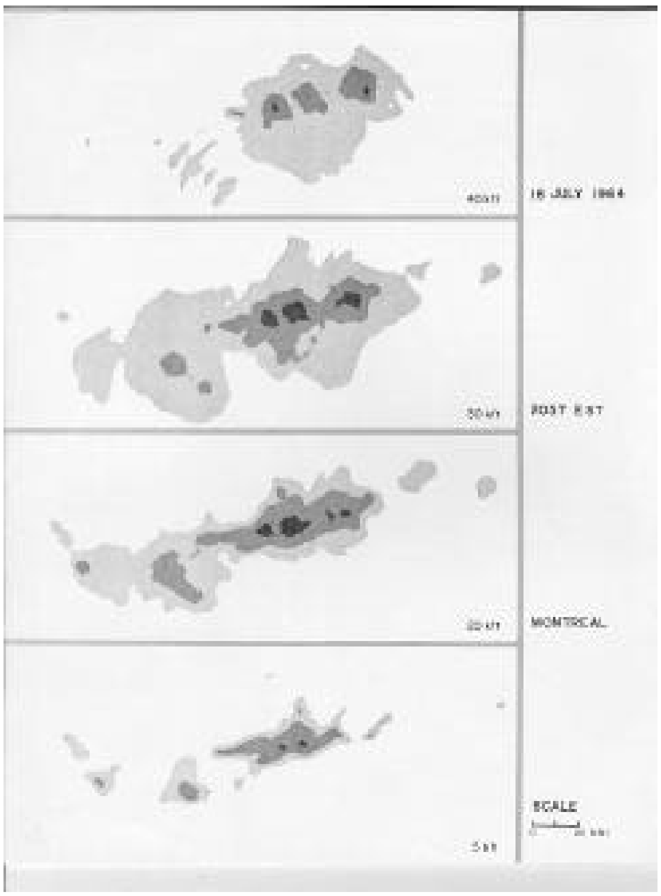
Professor McLeod's meteorological work was done in collaboration with successive Macdonald Professors of Physics. With Callendar, he studied the variation of soil temperature with depth. This was done not far from the present observing compound outside the Physics Building. With Howard Barnes, he measured the temperature difference between the observatory and the top of Mount Royal. They found changes in temperature at the Observatory that were anticipated by corresponding changes at the top of the mountain, anticipated by anything from 4 to 24 hours. This work was ahead of its time, detecting the passage of cold-fronts and warm-fronts before such things had been discovered or conceived.

Because of his work on longitude, McLeod was made a Fellow of the Royal Society of Canada, and his meteorological work with Barnes appears in its Transactions.

Professor McLeod died in 1917. For the next 30 years the activity of the Observatory was limited to continuing the two operational activities that he had instituted: the time service and the official weather observations. In 1963, the building was razed, to make way for the Stephen Leacock building, in which a plaque marks the sight and commemorates Mcleod's work. It seemed appropriate here to refer to the building erected in 1853 and razed just a century later as the McLeod Observatory, because it was he who instituted its important services, and it was with his scientific career that the building was intimately linked.

The McGill Weather Observatory continues active on the McGill campus, relocated in the Physics Building, equipped with new clocks and new weather sensors, and with renewed activity in research. It has moved with the times, to maintain a significant role in the downtown milieu and climate.

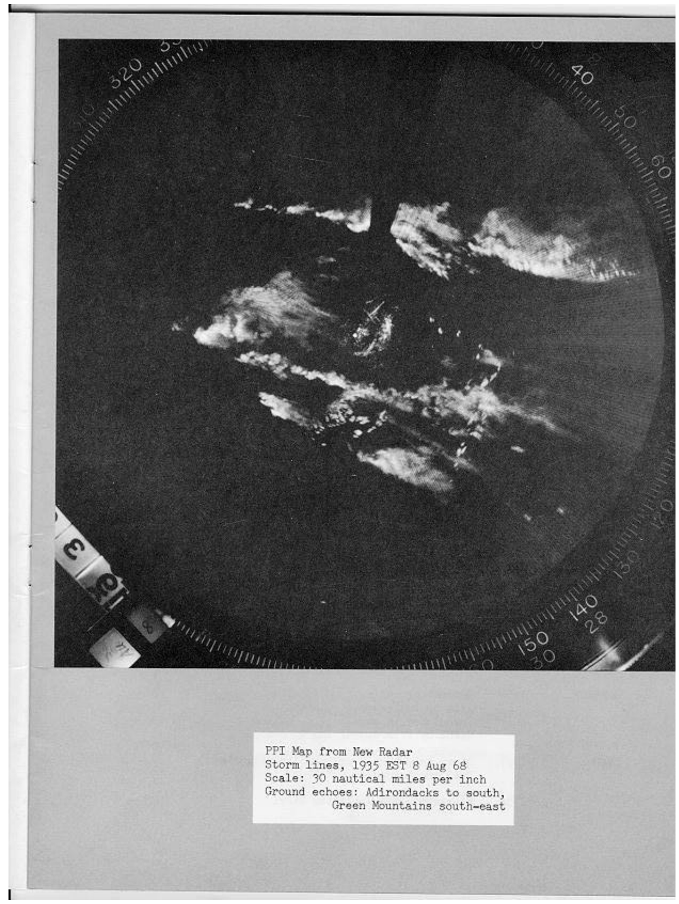
The McGill Radar Weather Observatory



The Stormy Weather Group already has a weather radar that has met its requirements in many respects. Control and display equipment developed by the Group have been added to a CPS-9 weather radar, on loan from the United States Air Force since 1954. The result is a fully automated system that displays the three-dimensional structure of all the rain and snowstorms that pass. It does this on sets of upper-level maps repeated every few minutes. The maps appear in real time (practically) on facsimile paper, with seven shades of grey showing the intensity of the rain or snow. The maps are also recorded on archival film, and most research is done by analysing these maps some time after the event. Sensitivity is very good: rates of rainfall and snowfall down to 0.1 millimetres of water per hour are detected and recorded to a range of about 100 miles. Resolution is good by traditional standards, with a beamwidth of about one-degree.

The CPS-9 is wearing out; our mode of operation is easy on the mechanism, but the number of hours logged has become fantastic. Messrs. Seidenfuss and Claassen (the two senior technicians who maintain the set) have become full-time specialists in geriatrics. A replacement is needed, and the technicians will be happy to change their speciality.

The one change considered vital, in going to new equipment, was to change back from the 3.2 cm wavelength of the CPS-9 to the 10 cm wavelength with which we began 25 years ago. Use of the shorter wavelength had given the CPS-9 its excellent sensitivity and good resolution, but had introduced attenuation. In the course of its passage through a storm, the beam of radiation must be reduced at least a little bit, to yield the scattered-back radar signal. But at wavelength 3.2 cm, the reduction may be by a factor 100 or 1000 or even more. This results in a distorted picture, and correction for this distortion is not quite feasible. We have gone about as far as we can go with radar records of storms that are distorted in this way.



PPI Map from New Radar
Storm lines, 1935 EST 8 Aug 68
Scale: 30 nautical miles per inch
Ground echoes: Adirondacks to south,
Green Mountains south-east

The new radar has been given an antenna three times as big, in linear extent, so that the beamwidth and related resolution of the CPS-9 will be maintained while the wavelength is made three times as long. With the larger antenna and a more powerful transmitter and a more sensitive receiver, the sensitivity too will be maintained, almost. The new antenna and its drive system are better as well as bigger, and they are covered by a radome so that the regular programmed motion is not disturbed by the wind.

The new FPS-18 transmitter, again on loan from the USAF, uses large Klystron tubes in place of the more compact magnetrons of the CPS-9. This makes it fit company for the maze of microwave communication links around and about Montreal. The more sophisticated Klystron circuits allow us to become more sophisticated in our storm studies too.

The new data-processing equipment is still being developed (by us, as was that used with the CPS-9). We aspire to magnetic recording on tapes and perhaps discs or drums, in place of photographic film. (Maintenance of rapid-access film processing has been quite a trail, especially since we depend quantitatively on the grey-scale of the film.) And we hope to improve on the present facsimile writing on paper, and possibly to use television monitors at the display output. Our output must be intelligible to computers, but we are insistent on there being outputs directly meaningful to people, too.

The pedestal of the new antenna rests on a platform at the top of an 86-foot tower, so that the beam is nicely above the treetops. The 48-foot radome is built in the same platform, with a walkway outside it that can be used for sky photography. The adjacent building has two storeys, the lower for equipment and the upper for research offices and data analysis. A word of thanks should go to the architect, Mr. George Eber. The Stormy Weather Group is grateful, also, to its own engineers, Mr. Ernest Ballantyne and Mr. Richard Fetter. Having installed the radar and made it work, they are now immersed in developing the system of data-processing.

The Stormy Weather Group

In 1943, Project Stormy Weather was assigned to Stewart Marshall, of the Canadian Army Operational Research Group. Working with him were Walter Palmer, direct from honours physics at McGill, and R.C. Langille, from explosives chemistry with George Wright in Toronto. J.T. Wilson as Director of Operational Research, and D.C. Rose as S.A.C.G.S. and head of the Group, assigned the project which was to make use of the weather echoes that had appeared, primarily as a nuisance, with the introduction of microwave radar. Project Stormy weather went very well. Availability of prototype MEW and MHF radars at NRC, maintained by NRC, had much to do with the success.

At the end of the war, Marshall went to McGill. Langille and Palmer stayed on with Guy Eon, who had joined the team, and the work they did in the next year demonstrated that weather radar could be quantitative, and so had a scientific future.

Palmer returned to McGill for a Ph.D., his research in weather radar supervised by Marshall. The new defence Research Board borrowed equipment for use at McGill, and provided modest financial support. Two graduate-student contemporaries of Palmer's took masters' degrees with weather radar as their research topic. These were Kendrick Gunn and Walter Hitschfeld, who spurned weather radar for their Ph.D. topics (for after all, the radar was out at Dawson College) and instead worked jointly on laboratory and theoretical approaches to The Growth of Raindrops from Cloud Droplets by Accretion.

In 1950, the air Force Cambridge Research laboratories (as it was to become) undertook substantial support of the work at McGill. Palmer had left for Canadian Celanese by this time, but Gunn and Hitschfeld stayed on as lecturers, and joined Marshall in the Stormy weather Research Group. The gun-laying radar at Dawson College had been replaced by an American AN_TPS-10A, but USAF with their financial support encouraged the group to emphasise theoretical work at that stage. Thus began a long period of parallel support, with USAF supporting theory and analysis, and NRC supporting the radar observations.

Three men have joined the Group and left again. T.W.R. East came from the British radar Research establishment as a graduate student, stayed to become a member of the Group and of the McGill Physics Department, then left for industrial research at Raytheon of Canada. Phillip Langleben came as a graduate student from McGill, but when he subsequently joined the McGill teaching staff he joined Professor Pounder's Ice Research Group. Robert Barklie came from the Admiralty Research Establishment to commence our nucleation studies, then left to join the Tri-Service College at Royal Roads.

R.H. Douglas was seconded to McGill in 1954 by the Canadian Meteorological Service, "to take advantage of the Stormy Weather Group." The advantage was multilateral: Douglas received a Ph.D., contributed notably to the work on snow, spearheaded the Group's contribution to hail research in Alberta (his native province), became a charter member of the McGill Department of Meteorology, finally became Chairman of the Department of Agricultural Physics at Macdonald College.

E.J. Stansbury transferred to the Stormy Weather Group from the Eaton Electronics laboratory in 1959. He has guided our work in freezing nucleation from then until this year. For the past three years he has directed the establishment of our short-range lightning-location network. The nucleation work has led to important findings relevant to hail, especially those made recently by Gabor Vali, who went with Douglas to teach physics at Macdonald College, and whom we welcome now as the newest member of

the group.
R. R. Rogers joined the Department of Meteorology and the Stormy Weather Group in September 1967. As a Texan from M.I.T. and Cornell Aeronautical laboratories, he is the first man to join us after maturing as a radar meteorologist elsewhere.

The commencement of the Alberta Hail Project in 1956 made a great difference to the group. It brought the work on snow to a temporary stop, and led the introduction of laboratory work on freezing nucleation. It absorbed half the attention of the group, principally in the persons of Hitschfeld and Douglas. Formation of a McGill Department of Meteorology made more change. On the negative side, it has led to a physical separation of Hitschfeld and Douglas and their hail people from Marshall and Gunn and their rain, snow and radar. Positively, it has provided a considerable number of M. Sc. And Ph.D. candidates in meteorology who choose research in radar meteorology or something closely related.

Administrative opportunities have fallen to members of the Group (and indeed to members of the Department of Meteorology) with appalling concentration. Marshall became first chairman of Meteorology, then chairman of the senate Committee on Educational procedures, along with responsibility for television-for-teaching; now he seems to be in the clear again. Gunn became the university's timetable coordinator, then space coordinator; now he directs an Office of Research for Planning and Development. Hitschfeld played through the meteorology chairmanship in par-three-years, and now is Vice-Dean of the Physical sciences Division. Douglas is Chairman of the Physics Department at Macdonald College. Stansbury has been Associate Dean of Student Affairs, and now is Vice-Dean of the Faculty (of Arts and Science). Only Rogers and Vali are yet unscathed. These positions are fine avenues of service; we see it as vital to sanity and progress that they be viewed as a service alternative to undergraduate teaching, rather than a joy replacing scholarly activity.

One sees in our present circumstance the desirable use to be made of the research offices in the new radar weather observatory. These must be the eye of the academic storm, where research problems can be approached in the relative quiet of the country, and the Group must have its scientific meetings here, for a change of pace from academic committee meetings. One recalls the late beloved Clifford Purves, after a meeting at which Marshall (yes!) Had been a peacemaker, saying that we should be renamed the "Balmy Weather Group." This shall be our Centre for Balmy Weather.

Stormy Weather Group Chronology

MARSHALL PALMER LANGILLE	1943	Microwave Early Warning Radar, Ottawa Time-lapse films
EON PERRY TIBBLES	1944	Microwave Height Finder, Ottawa MEW's at Clinton, Dorval
HARE	1945	The "Bright band" in melting snow Storm Stearing levels
	1946	First "Journal of Meteorology" paper
GUNN	1947	M-P drop-size distribution

HITSCHFELD		Stepped gain
		Vertical sections in stepped grey
		AN_TPS10-A at Dawson College
	1949	Laboratory and theoretical work on growth of raindrops by accretion
KERKER	1950	USAF contract
		Scattering by aspherical particles
LANGLEBEN1951		AN_TPS10-A moved to Dorval
RIGBY		Development of particle-size distributions
WALLACE	1952	The “3rd Radar Meteorology Conference” at McGill
EAST, T.W.R.		Airline radar study
		Fluctuations
		Microwave properties of precipitation
MELZAK	1953	Theory of snow-crystal habit
BORDAN		Theory of random coalescence
POWER		Correction for attenuation
		Generating level for snow
		Zenith-pointing radar at McGill
DOUGLAS	1954	CPS-9 at Dorval
		Trails and trajectories
		Size-sorting in wind shear
DENNIS	1955	CAPPI (with scissors)
GAHERTY	1956	Generating cells
		Rain by coalescence
		Turbulence in snow
		CAPPI by film conversion
LEGG	1957	Storm height_hail probability (Alberta)
		Hail and tornadoes
	1958	Electronic and automated CAPPI
BARKLIE	1959	Laboratory growth of snow crystals
GOKHALE		Growth by accretion in ice phase
SUMMERS		Convective storms in sever wind-shear
STANSBURY		Freezing nucleation
	1960	CAPPI in stepped grey scale
		Hail size and reflectivity
		The intensity of hailfall
		Is heterogeneous nucleation stochastic?
		Updarught and accumulation in cumulonimbus

HAMILTON	1961	Attenuation estimates from gauge statistics
WEIN		Automatic attenuation correction
		A theory of hail growth
SRIVASTAVA	1962	Theoretical studies of storm dynamics
VALI		Whole-scope storm profiles
EAST, C.	1963	New observing techniques for snowfall and new-fallen snow
CARTE		Continuity and intermittence of hail
SMITH	1964	NRC Capital Grant
HENRY		Facsimile and areal integration
HOLTZ		Thermodynamics of hail-storm masses
WEISS		Time-dependence of ice nucleation
LILLESAETER	1965	Attenuation of light by snow
CARLSON		Hailstone temperature
BALLANTYNE		Large-scale convergence and sever storms
ZAWADZKI		Hailstorm cells within the storm complex
DEROME		
CHISOLM		
ROGERS	1966	Airline radar updated
STRAUCH		Five-dimensional storm census
THYER		Winds near cumulonimbus
WARNER	1967	Loan of FPS-18 by USAF
FETTER		Anonymous gift of observatory building
PELL		Building built, antenna and radome installed
RAO		HARPI
SHAW		Measurement of snowfall by radar
KAPOVITS		Hail intermittency and cells
BARGE	1968	Attenuation reconsidered
HARRIS		Satellite-link attenuation
BOSTON		Life-cycle of a summer storm
		FPS-18 operational
		13th Radar Meteorology Conference