

COMMONWEALTH



OF AUSTRALIA

COMMONWEALTH SCIENTIFIC AND INDUSTRIAL RESEARCH ORGANIZATION

DIVISION OF METEOROLOGICAL PHYSICS

ANNUAL REPORT

1960 - 61

MELBOURNE

JULY 1961

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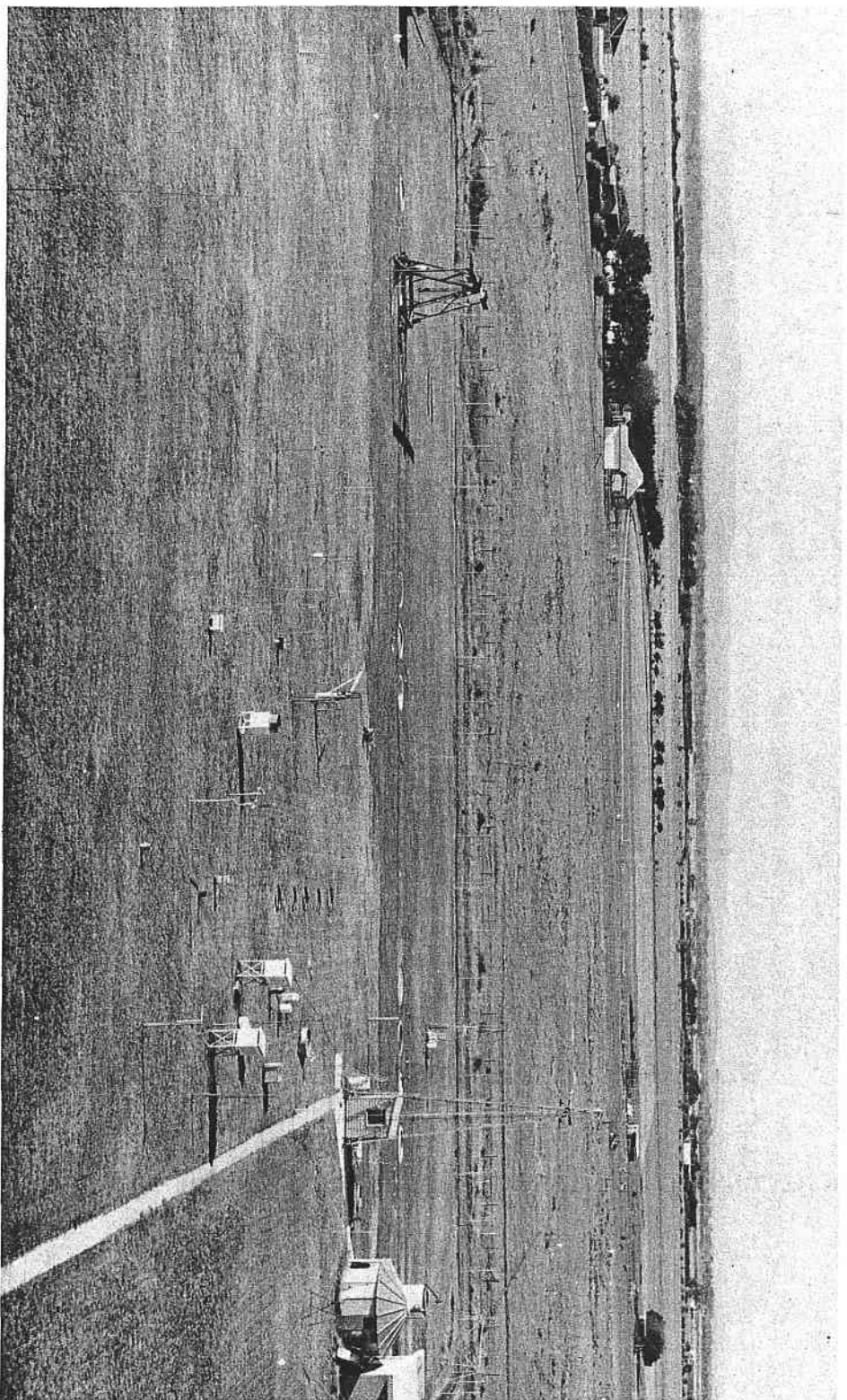
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General view of observational and experimental area at Aspendale.
The lysimeter installation is seen across the middle of the picture

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DIVISION OF METEOROLOGICAL PHYSICS

A N N U A L R E P O R T

1960 - 1961

I GENERAL

Progress made in the Division's principal fields of interest during the past year is reported and summarised in the following pages. Whilst the primary concern is in the study of fundamental processes in meteorology, considerable attention is devoted to the application of meteorological knowledge to problems of economic importance to Australia, more particularly those arising in agriculture and in the efficient usage of water. Many of the results and techniques deriving from the Division's major field of interest, the study of atmospheric turbulence and exchange processes, here find ready application. Similarly, whilst the group working in Dynamic Meteorology is interested primarily in fundamental atmospheric mechanics, an emphasis is given to problems of particular interest and application to Australia.

In the international sphere the Division has continued to be associated with the activities of the World Meteorological Organization, the International Association of Meteorology and Atmospheric Physics (IAMAP), the International Antarctic Analysis Centre and UNESCO. Dr. C.H.B. Priestley, Chief of the Division, is a member of the International Commission for Dynamic Meteorology, Mr. W.C. Swinbank is a member of the International Ozone Commission and of the Evaporation Committee, and Mr. E.L. Deacon is an international representative on the ad hoc Committee on Interaction between Atmosphere and Ocean. The Division has members of the Australian National Committees for Geodesy and Geophysics, Oceanic Research, Hydrology, Antarctic and Space Research.

During the year Mr. M.U. Khan of the Pakistan Meteorological Service visited the Division

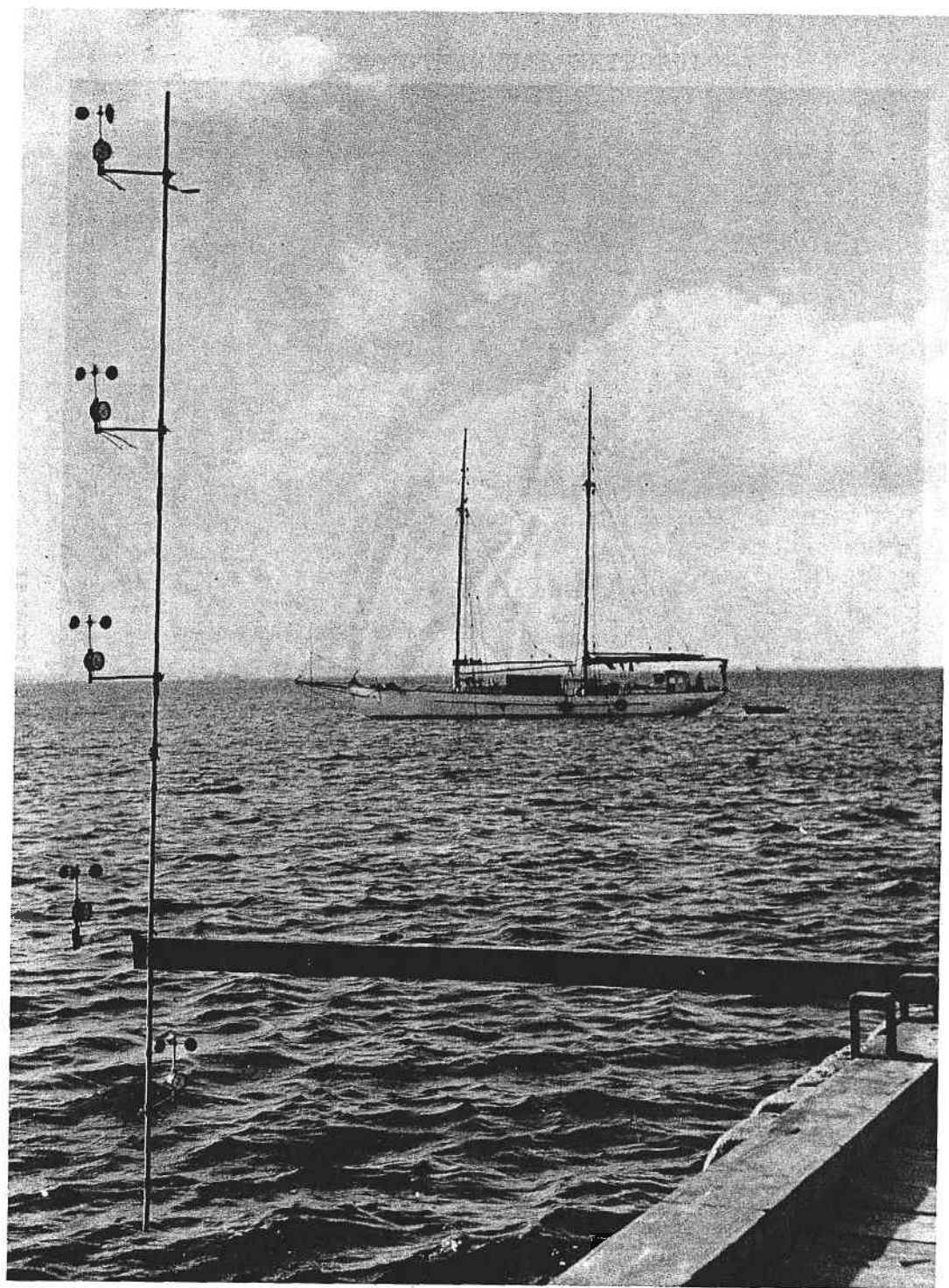
for a total period of five months under a UNESCO Fellowship. Working mainly with the Agricultural Meteorology group, he studied the techniques and instrumentation of micrometeorology in preparation for setting up a micrometeorology section on returning to Pakistan.

Captain Donald Stevens, of the U.S. Geophysical Research Directorate, spent a period of six weeks in the Division, primarily for familiarisation with the micrometeorological and turbulence research.

The Helsinki meeting of UGGI in August, 1960 was attended by Mr. F.K. Ball. After a brief visit to the International Meteorological Institute in Stockholm, Mr. Ball spent four months at the Central Forecasting Office and Napier Shaw Laboratory of the British Meteorological Office at Dunstable, and four months in the Department of Meteorology at the Massachusetts Institute of Technology. The primary interest of these visits was research in dynamic meteorology, including the latest developments in numerical methods.

Mr. I.C. McIlroy went to Cairo in November at the invitation of UNESCO to direct a six-weeks course in micrometeorology, with particular emphasis on agricultural applications. This course, organized by UNESCO in co-operation with the United Arab Republic Department of Meteorology, was attended by thirty graduates from eight Middle East countries. On its completion Mr. McIlroy briefly visited research centres specializing in agricultural meteorology in the United Kingdom, Holland, Israel, Pakistan and India.

Dr. A.J. Dyer left in February for a six months visit to the University of California to collaborate in evaporation studies, as amplified below.



A Schooner equipped for meteorological work at sea

Net Radiometer



II DYNAMICAL METEOROLOGY

Tropical Monsoon

The problem of water resources in Australia provides a strong incentive to understand further the causes of rainfall variability. This is especially so in the tropical regions of Australia where the onset of the monsoon is erratic and characterised by spells of heavy rain. A study of such rainfall in the Northern Territory and its association with the tropical easterly and subtropical westerly jet streams has shown that the monsoon onset tends to be preceded by a rapid displacement southward or development of these streams. Thus, rain inhibiting effects of persisting upper westerlies at this season in the Darwin - Alice Springs region are evidenced by reduced falls in the Territory.

The 'monsoonal' change in the upper flow is a manifestation of atmospheric development on a very large scale, covering considerable areas of the tropics south of the Equator and extending into low northern latitudes. Examination of interactions between the hemispheres is therefore essential for a better understanding of monsoon behaviour and in this connection an assessment of the angular momentum balance in the region has been undertaken. A study has also been made of the interactions of meridional and zonal circulations flanking the equatorial trough in the Australia-Indonesia monsoon region. The principal results indicate that the fully established monsoon appears to be dominated by simple mass circulations, and that in the monthly heat budget a very large proportion of the latent heat released in precipitation is exported by meridional transfer to regions of radiative cooling in both hemispheres. More precise knowledge of these processes, involving information on the vertical transfer of energy in thunderstorm convection, requires measurements of net radiation at various levels in the troposphere, and of evaporation and heat transfer from equatorial ocean areas.

As a complement to the more physical

approach, a purely statistical examination has been started of the year-to-year variability of spring rains at stations in Northern Australia where long records exist.

Secular changes in tropical circulations

An analysis has been made of an occasion of markedly reduced easterly winds at 40,000 feet in the tropical belt extending from Africa to Australia during a month of feebly developed monsoon (January, 1958). This, combined with the discovery of a simultaneous compensating anomaly in the Equatorial Central Pacific, provides an example of the long period trend during the last decade, evidenced in concurrent variations of the strengths of the zonal circulation on both sides of the equator; and also, to a less extent, in displacements of the principal maxima and minima of zonal flow.

A further examination was made of the disappearance or reversal, during the early 1920's, of the correlation between the well known eleven year cycle in solar activity and tropical temperatures. There is evidence that this phenomenon is linked with a secular change in the strength of the tropical circulation, and that it was concurrent with a change in the Southern Oscillation apparent as an eastward displacement of its low pressure centre from the Australian region to the Pacific.

Subtropical temperature inversion

A prominent feature of the subtropical belt is the midtropospheric temperature (subsidence) inversion. Its height over Australia undergoes large diurnal and annual variations which have important bearings on both practical and theoretical problems. Radiosoundings at Giles in the heart of the continent, made twice daily by the Bureau of Meteorology, show a rise of this inversion from winter to summer by 8,000 ft and a diurnal variation ranging from 600 ft in winter to 3,000 ft in summer. It has been found that this latter variation is directly related to surface insolation and is associated with a transfer of air through the inversion.

Theoretical studies of large-amplitude waves and oscillations of fluid layers have continued and a number of exact solutions of the relevant equations have been derived.

Structure of cold fronts

The study of cold fronts and seabreezes has been carried a step further by an intensive summer field programme in South Australia, using observational procedures not previously available. The improved data coverage, apart from making possible an appraisal of earlier deductions, allows a study to be made of the detailed temperature and vertical motion field, frontal distortions, including the development of multiple structure, temporal changes in structure, and possible pre-frontal circulations. The co-operation of the Bureau of Meteorology in aiding these studies is gratefully acknowledged. Abundant data on the weaker phenomena are now to hand, but operational difficulties have precluded attempts to investigate satisfactorily the more violent kind.

As a by-product of the work on fronts, an investigation has been undertaken on the connection between wave development on a frontal surface and the downdraughts occurring in conjunction with mammiform cloud. It is deduced that these downdraughts can impinge on the frontal inversion, and account for observed windspread surface pressure oscillations.

Work continues on the determination of turbulent momentum exchanges and their variation with time of day, on days of strong heating, in the layer from the ground to about one kilometre.

Local windstorms

Related to the violent kind of processes connected with fronts are severe local storms of tornadic nature. Thanks to the co-operation of volunteer observers and government bodies several such storms were tracked down during spring and summer. Damage to trees and structures was investigated and in one case the capabilities of

photographic surveying from a helicopter have been tested. The occurrence of twin storms in parallel paths ten or more miles long and from five to ten miles apart has been established by ground inspections; while the overflight has indicated the existence of striations in the distribution of maximum wind force. Analyses of relevant weather maps and antecedent soundings of the atmosphere is being carried out and the combined information should be valuable (on a non-operational basis) to interested bodies such as electricity undertaking, building standard associations and others.

Convection

A theoretical study of convection has compared the two classical methods of approach, i.e. through the cell and parcel models respectively, and shown how theorems from each can be used with advantage in the other.

III MICROMETEOROLOGY

The central problem in the study of air flow over natural surfaces under conditions of thermal stratification is that of relating the vertical gradient of wind with the height, the shearing stress and the vertical heat flux. A formal solution to this problem, applicable over a wide range of stabilities, has been put forward and subjected to trial by field observations with encouraging results. The experience gained in these trials has emphasised the difficulty of securing the experimental conditions necessary to satisfy the assumptions, explicit or implicit, in this and all other treatments of the problem: these relate to the steady state, constancy of flux with height and, connected with the latter, horizontal uniformity of site and of the various transferable properties. Attention to these factors, largely neglected heretofore, leads to site and operating specifications.

Further progress has been made in understanding the basic processes of atmospheric turbulence by the completion of an investigation of the spatial structure of fluctuations of wind, temperature and

humidity.

The construction of equipment for converting turbulence and other data from analogue to digital form on punched paper tape has been completed. It has already been used in several projects requiring the analysis of micrometeorological or synoptic records. Digital treatment of the Division's data-processing requirements has now been firmly established with the completion of a number of projects using the machine C.S.I.R.A.C.

A transistorised version of the automatic instrument for measuring evaporation from natural surfaces (the "Evapotron") has been completed and given extended field trials during the present year. This is a much more compact, lighter and more portable instrument than its prototype. The field trials have been very satisfactory and an officer of the Division has taken the evapotron to the University of California for further proofing and collaborative evaporation investigations. It is hoped that this may lead to commercial production of the equipment, which is considered capable of meeting a long felt need in many problems connected with the economic usage of water, e.g. agricultural practice and research, irrigation, water storage etc. Meanwhile two further units are under construction in the Division's laboratories for field work next summer.

The principle of measuring flux in the "Evapotron" (eddy-correlation) has been applied in the construction of an instrument for measuring the vertical flux of the horizontal momentum of the wind. A more refined version of this instrument is now under development.

IV METEOROLOGY FOR AGRICULTURE

Lysimeter installation

The main effort in this field has continued in the study of evaporation from natural surfaces by means of a battery of twelve lysimeters at the rear of the Divisional headquarters. These consist of large concrete containers, weighing

approximately six tons when full, sunk flush with the ground, five carrying a pasture cover, three bare soil and the remainder containing water. Evaporation from six of the units is measured by automatic balances sufficiently sensitive to measure evaporation rates over periods less than an hour during conditions of strong evaporation. From the remainder evaporation is estimated from water input and percolation; provision of similar balances for these is in progress.

This year has seen the completion of twenty four months of operation, thus permitting conclusions to be made concerning evaporation rates on a monthly, seasonal and annual basis. The main features to have emerged are, firstly, that evaporation from well irrigated mown grass exceeds that from water, and still more that from moist bare soil. This is thought to be mainly due to the greater roughness of the grass surface, and confirms the view that evaporation coefficients found for particular surfaces will not be appropriate for others of different roughness. Secondly, evaporation rates may exceed those expected from the local energy supply, pointing to the importance of advective effects when the irrigated experimental area is surrounded by drier and warmer terrain.

Blue mould in tobacco

The investigation into the meteorological conditions favouring the sporulation of blue mould in tobacco crops has been continued at Ovens, Victoria in co-operation with the Victorian Department of Agriculture and aided by a grant from the Central Tobacco Advisory Committee. Results indicate the possibility of detecting, from measurements of the ambient meteorological conditions, those nights on which sporulation is most likely to occur and point to the importance of wind speed. Low wind speed has been found to be a dominant factor in producing conditions favourable for sporulation and an attempt is being made to increase the wind speed artificially over a section of the crop by using a large rotating fan. This equipment will be brought into full operation during the 1961-1962 growing season.

Hay curing

Investigation of the rate of water loss from drying hay has again been undertaken in collaboration with the Fodder Conservation Section of C.S.I.R.O. and will be continued next season.

Frost prevention

Work has continued at Merbein, in collaboration with the Commonwealth Research Station and the State Rivers and Water Supply Commission, on the effects of standard irrigation techniques on frost incidence. Comparative trials have been carried out in vineyards. Results so far indicate that the watering has a definite effect in raising temperatures but enough data have not yet been accumulated to discriminate reliably between the various treatments used. The work will be continued in the winter and spring of 1961.

Dew meter

A portable instrument has been developed to measure the amount of dew on a natural grass surface. It has been constructed and tested and results indicate that the amount of water present can be measured with an accuracy of some ten per cent.

V RADIATION

The study of the radiative cooling of the air at night in the lowest 15m over open grassland has been continued. The development of an automatic system for recording the radiative flux divergence now permits the cooling process to be studied in more detail and valuable new material is accumulating on certain aspects of fog formation.

Very high rates of radiative virtual cooling preceding fog occurrence have sometimes been observed and it appears that the difficulties hitherto experienced in predicting fog formation arise, at least in part, from lack of knowledge of the role of radiation which, in the presence of haze and mist, may depart widely from what has formerly been assumed. There are indications that radiative flux

divergence may provide the heat sink necessary for the removal of the latent heat of condensation.

A black ball instrument which some overseas workers have supposed to be suitable for radiative flux divergence measurements has been shown not to agree with observations made on more physically sound principles.

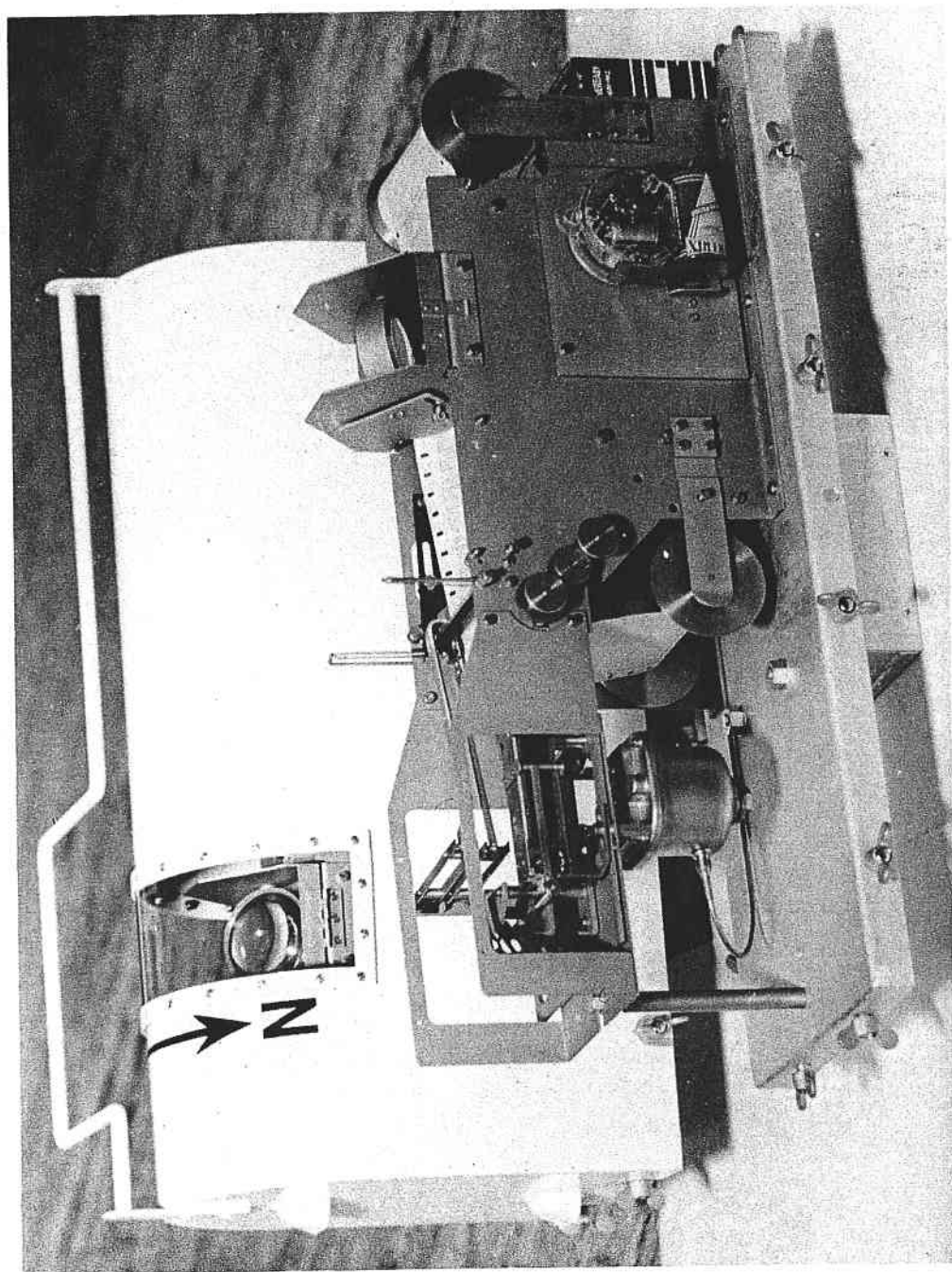
The routine recording of 24 hour totals of radiation income etc. has been greatly facilitated by the development of an integrator attachment for standard types of multi-channel self-balancing potentiometer. This relatively simple device has now operated reliably for nearly a year and eliminates much analysis time.

A newly developed ribbon thermopile, apart from ease of construction, promises either a marked increase in the sensitivity of radiometers or otherwise their miniaturization.

In preparation for the Australian programme of meteorological work to be carried out during the International Indian Ocean Expedition of 1962-64, observations of net and global radiation, state of sky (by automatic camera), sea surface and air temperatures, wind speed etc. were made during a month-long cruise of H.M.A.S. Gascoyne in Bass Strait and the Great Australian Bight. A considerable body of data was secured of a type useful in studies of the heat budget and evaporation of the oceans. The experience gained will enable the techniques to be improved for the Indian Ocean Cruises.

VI OZONE

Ozone measurements have been continued at Aspendale and, by personnel of the Bureau of Meteorology, at Brisbane. Technical aid in setting up an ozone observation station at Woomera was given to the Department of Supply, and measurements are now coming forward from this third station. These form part of a global network instituted for the IGY and continued since. The data are collated at



Sumner Recorder with cover removed



Sumner Recorder mounted in position for use

Aspendale and forwarded to the international centre.

VII MISCELLANEOUS

Measurements of the radioactivity of rain water have continued at Aspendale and give further evidence of seasonal variations in the mean meridional circulation. The level of radioactivity has declined markedly due to the absence of bomb tests, and special low level beta counting equipment is being installed so that observations may continue.

An instrument to measure the temperature gradient to a depth of 200 feet in the ice cap of Antarctica has been designed and built at the request of Melbourne University. The equipment was sent to Wilkes with the last expedition and is now in operation there. Preliminary results reported indicate a considerably greater rate of heat flow into the ice than expected. It is intended that a second instrument will be completed for despatch to Mawson with the next expedition.

The strip chart recorder for long period operation has now successfully completed its field trials. This instrument is capable of operating unattended for periods up to 12 months and is intended for use in remote areas for the recording of river level, rainfall, temperature etc. A batch of twelve instruments have been used experimentally during the past year by various bodies in Australia and New Zealand. On the basis of their reports minor improvements have been made and the instrument has now been released for manufacture under the name of the Sumner Recorder. This equipment has provoked considerable interest and the manufacturers have already received orders for the supply of forty, including six for overseas. The possibility of extending the design to include recording of level of the water table is under examination.

In connection with research on evaporation, and in particular for evaluating the effect of an evaporation-reducing surface film, the provision of improved equipment for recording temperature and

humidity variations above a water surface is now being completed.

The radar installation has reached an advanced stage, and it is hoped that the equipment will be in use later in 1961.

Two types of special radiosonde teler-metering equipment have been designed and built for use with kites. Some of this equipment is in operation in Antarctica in the investigation of katabatic winds, whilst some has been used in studies of cold fronts and sea breezes in S.E. Australia.

An informal advisory service in the field of agricultural and micro-meteorology has continued to be widely used by Divisions of C.S.I.R.O. and other Government departments; special mention should be made of the Snowy Mountains Authority and the Hydro-Electric Commission of Tasmania in the problems of estimating evaporation from existing and potential storages, and the instrumentation required. The State Electricity Commission has been provided with circuit designs for lightning discharge recording. Calibration services for anemometers and radiation instruments, in particular in connection with the Commonwealth Meteorological Bureau radiation survey, have been maintained.

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