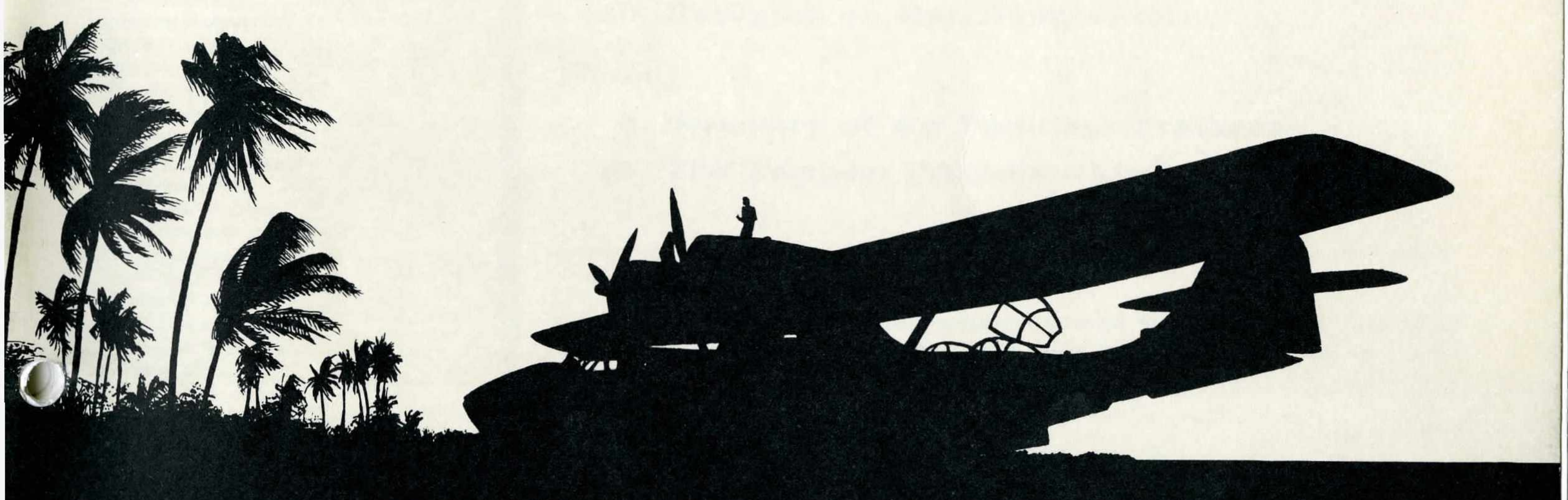
FACILITIES FOR

NO. 2 WINTER 1966/67

atmospheric research



NATIONAL CENTER FOR ATMOSPHERIC RESEARCH

FACILITIES FOR

atmospheric research

No. 2 Winter 1966/67

NCAR

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Cover. The Line Islands Experiment brings meteorologists into the tropics for systematic short-term studies. See page 16.

Airborne Infrared Radiometry Study

Measuring the surface temperature of Lake Superior

Robert A. Ragotzkie (Department of Meteorology, University of Wisconsin) has recently used a relatively new remote sensing technique — airborne infrared radiometry — to investigate the thermal structure and circulation of Lake Superior. The primary purposes of this study were (1) to demonstrate validity of using airborne infrared radiometry to map the surface temperature patterns of large bodies of water and (2) to develop the technique of using the surface temperature patterns thus obtained to detect subsurface features.

To determine the surface temperature pattern of the lake, Ragotzkie used a thermistor bolometer (Barnes Radiation Thermometer, Model 14-312/27), which is sensitive to radiation in the 8 to 14 micron band. This instrument picks up radiation emitted by the surface of the water, compares it with radiation from a thermostatically controlled, constant-temperature, black-body reference cavity, and produces a signal which is directly proportional to the temperature of the upper 0.02 mm of water.

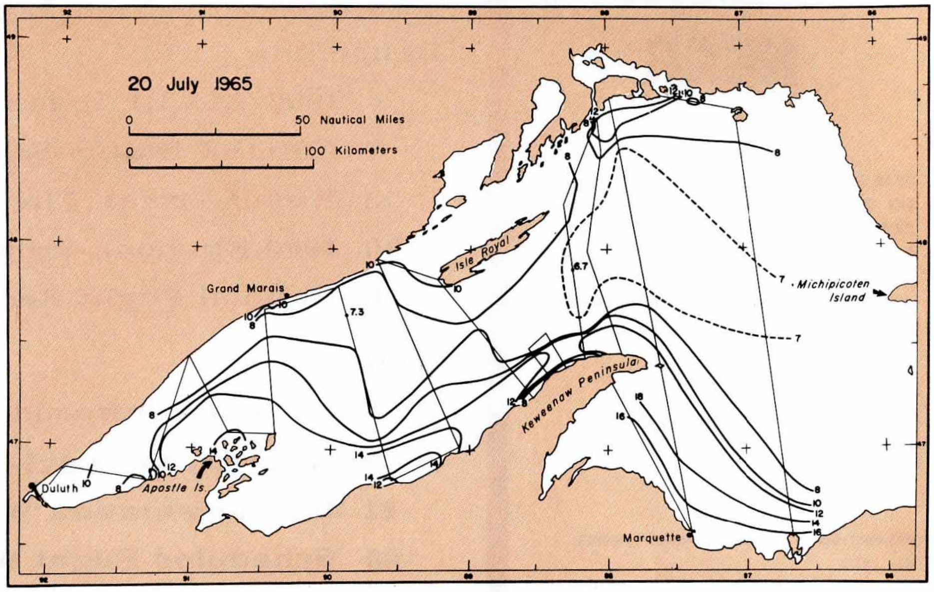


Fig. 1. Surface-temperature pattern of Lake Superior obtained by airborne infrared radiometry, 20 July 1965.

Research Procedures

Before each aerial temperature survey the sensing head of the calibrated bolometer was mounted vertically above an open port on the under side of an aircraft. The signal from the bolometer was recorded on a Westronix Recording Potentiometer and on a Precision Instrument, Model PS 107A, 7-channel FM tape recorder. Temperature data were read off the data rolls at 1-min (approximately 3-mi) intervals, or more frequently when rapid changes in temperature were apparent. Visual observations of waves, slicks, foamlines, and meteorological phenomena were recorded by observers in the aircraft.

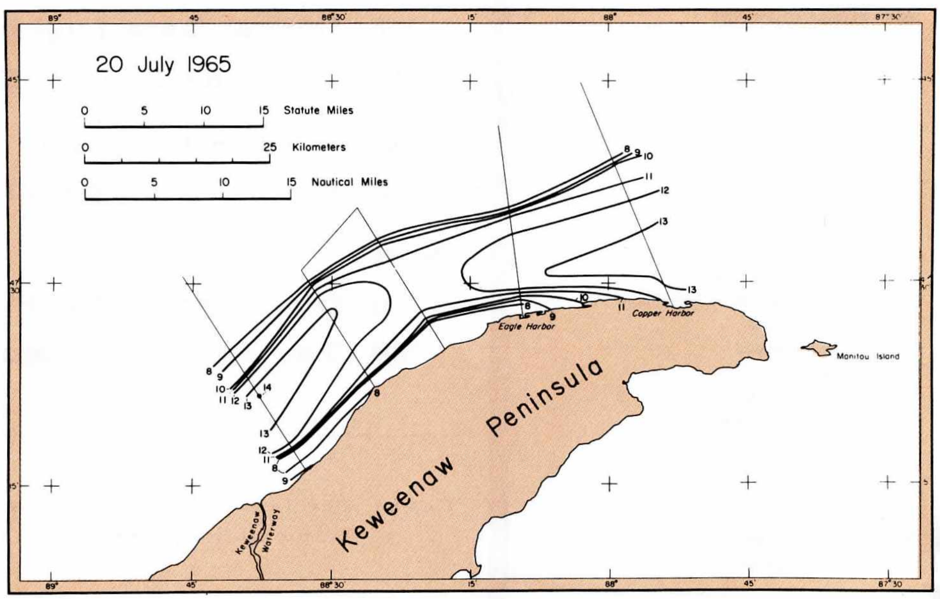


Fig. 2. Detailed pattern of part of Lake Superior near the north coast of the Keweenaw Peninsula.

In addition to the airborne measurements, temperature measurements using conventional immersion techniques were also made from a ship to verify the surface temperatures indicated by the bolometer. Although direct comparison between ship and airborne measurements was impossible because of the difference in the length of time required to complete the two kinds of measurements, spot checks were made.

Each aerial survey took 6 to 8 hr. Flight tracks ranged from 700 to 99 n mi in length and crossed the lake 8 to 10 times in a north-south direction, the scale providing a compromise between synoptic coverage and resolution. Flight altitude was 1000 ft above the surface of the water, and ground speed was approximately 150-175 knots. Some of the flights were made by a Lockheed Neptune P2E patrol aircraft, provided by the United States Naval Air Test Center, Patuxent River, Maryland and by the Navy Air Station, Glenview, Illinois; others were made by a Beech Queen Air 80 aircraft, provided by NCAR.

Observations made during the summers of 1964-66 indicate that certain features of the thermal structure of Lake Superior occur regularly every summer. For example, there are two areas of unusually cold water in the central portion of the lake and a narrow, swift current, which flows northeastward along the north coast of the Keweenaw Peninsula.

During this study Ragotzkie and his students investigated the effect of diurnal heating on the surface temperature of the lake. They found that the local gradients were not significantly affected because of the short time intervals involved, and even the overall pattern was not substanially affected because horizontal temperature differences across the lake were 10°C or more and the diurnal heating rate was only 0.21 to 0.27°C per hr.

Capabilities and Limitations

Ragotzkie feels that airborne infrared radiometry is a valid and powerful remote sensing technique for examining the surface temperature patterns of large bodies of water. He has found that the bolometer readily detects temperature differences of 0.1 to 0.2°C and that at altitudes up to 1000 ft the absolute accuracy of the instrument is ± 0.5°C. One of the greatest advantages of this technique over conventional measurements made from ships is the much shorter time required to obtain more or less synoptic coverage of a large body of water.

However, there are certain limitations to use of this technique. For example, fog, dense haze, precipitation, and reflection due to the effective radiation temperature of the sky introduce errors into the measurements. Moreover, because heat transfer and evaporation at the surface of the water strongly affect the temperature gradients in the upper few millimeters, the effective radiation temperature or "skin temperature," as measured with the bolometer is usually different from the temperature of the upper few centimeters, as measured with a conventional immersion thermometer.

In spite of these errors, Ragotzkie found that the skin temperature is usually within 1°C of the temperature of the upper 10 to 25 cm and rarely differs by more than 2°. Since the horizontal temperature differences are almost always several times greater than this, Ragotzkie believes that surface temperature patterns obtained with the bolometer are meaningful.

Research Applications

In addition to demonstrating the validity of using airborne infrared radiometry to map the surface temperature patterns of large bodies of water, Ragotzkie feels that he has also shown that in many cases the surface temperature patterns can be interpreted as "signatures" of subsurface thermal structure and boundary currents. For example, a sharp horizontal gradient in the surface temperature often indicates the existence of a boundary current, although other factors, such as shallow water, river outflow, or onshore winds, must also be taken into account. When the existence of a boundary current or other feature is suspected, its presence must be verified and it must be investigated in detail by conventional measurements from ships or buoys. After the existence of a feature is confirmed, airborne infrared radiometry can be used as a surveillance technique to follow its movements. Thus, by first detecting an interesting feature and then maintaining surveillance of it, airborne infrared radiometry can greatly enhance the effectiveness of surface observations. ●

New NCAR Advisory Panel Member

Joshua Z. Holland, Chief, Fallout Studies Branch, Division of Biology and Medicine, U.S. Atomic Energy Commission, was recently named a member of the NCAR Research Aviation Facility Advisory Panel. Holland succeeds Roscoe Braham, Jr., University of Chicago, who resigned from Panel membership.

In addition to Holland, present panel members include: Charles E. Anderson (Chairman), University of Wisconsin; Fred C. Bates (Vice Chairman), St. Louis University; R. Cecil Gentry, National Hurricane Research Laboratory; Robert A. Ragotzkie, University of Wisconsin; Herbert Riehl, Imperial College, London (on a one-year sabbatical from Colorado State University); and Irving H. Blifford, Jr., NCAR. ●

1966
AFCRL Balloon Symposium

The 4th AFCRL Scientific Balloon Symposium, held at Portsmouth, New Hampshire, 12-14 September 1966, attracted more than 100 specialists from industry, the military, and various balloon operations units, as well as some scientists whose research projects require balloon platforms. The 1965 symposium had been dominated by the topic of tropopause failures, but the 1966 meeting did not have any single focus of attention. The sessions did, however, demonstrate that scientific ballooning is currently involved in a great deal of innovative technology, affecting balloon materials and design, instrumentation and flight operations, with important possible benefits for scientific users.

Materials and Design

The problem of failures has abated but not disappeared, and several papers did present results of laboratory, theoretical, or field work relating to balloon failure mechanisms. Some of these papers dealt specifically with materials problems. *Arnold D. Kerr, New York University,* a theoretician with a background in elasticity and thin film structures, found that to approach the theory of failure in thin plastic shells he had to devise experiments to secure basic data for analysis. He reported experiments on viscoelastic deformation in neoprene balloons, and other experiments to investigate the quite different mechanisms of deformation found in plastic balloons. He stressed the importance of biaxial rather than uniaxial tests on plastic film. *Ray Hauser, Hauser Research and Engineering Co.,* reported the results of round-robin testing of StratoFilm and VisQueen X-124 balloon films for cold brittleness. The study revealed a wide variation in results of cold brittleness tests among different laboratories, and indicated that the "drop" test is more severe than the "skiball" test. Hauser felt that a uniform definition of "cold brittleness failure" is needed and that total length of tear appears to be a good criterion. *Eric Nelson, Kaysam Corp.,* reported two developments in neoprene sounding balloons, which promise to provide higher altitudes and more reliable and useful flights. One is a new balloon which, for daytime flights, can reach 140,000 ft with good consistency, and can frequently reach 150,000 ft (extreme altitude to date, 168,000 ft). The other is a carrier balloon system, in which the sounding balloon is partially folded and enclosed in a carrier balloon which ruptures at around 50,000 ft, leaving the main balloon free to complete the ascent. The advantages are ease of handling and a more rapid rate of ascent which helps to insure successful completion of the flight within practical time and space limitations. *Don Williams, Winzen Research, Inc.,* reported on a series of flights with balloons made of Winzen StratoFilm, indicating that of 225 flights, 204 were successful. The series includes 32 successful flights at Ft. Churchill, of which 18 were 10.6 million cubic ft balloons, and 23 were greater than 5 million cubic ft volume. In spite of this record, Williams expects that polyolefin materials may not be satisfactory for higher altitudes and larger payloads, and Winzen is currently evaluating polyurethane and nylon materials as balloon films for future use.

Another group of papers was concerned with environmental conditions and balloon design factors. *Alvin H. Howell, Tufts University,* discussed AFCRL-sponsored development of an instrument complex designed to be flown with high-altitude balloons to collect information about turbulence encountered in flight. The instruments included accelerometers, acoustic recorders, electrometers, and a current density meter to detect motion. Howell is deliberately looking for turbulent rides, in search of useful data, and will hitchhike his instrument package wherever possible on future flights. *Harold Baker, NCAR,* reported on a successful field test program to photograph in-flight failures with tandem balloon systems which carried cameras aloft. The photographs unexpectedly revealed the presence of circumferential stress bands in certain balloons which failed catastrophically in flight. The failure mechanism appeared to be related to the deployment of excess material in the balloon envelope, and it seemed likely that variations in balloon design might reduce or eliminate the stress band. *Justin Smalley, NCAR,* reported on a study of balloons at off-design conditions, including over- and under-loads at float altitude, and stresses on ascending balloons before reaching float altitude.

Flight Operations

I. A. Lund, AFCRL, discussed an exercise in statistical meteorology, in which a computer program produced estimates of trajectories of balloons flown at 50 mb. The grid points were taken from radar observations of pilot balloons, made by Hq 3rd Weather Wing, Omaha, and gradient winds were computed from the grid point data. Computed and actual trajectories are sufficiently close to indicate that this method is operationally useful for flights of perhaps two days duration. It provides useful statistical data for planning purposes over longer periods. *Major Robert J. Reddy, AFCRL,* described an improved in-flight method for rapidly lowering instrument packages to known distances below the balloon by paying out line from a fluid-braked reel. *J. R. Nelson, Winzen Research, Inc.,* discussed thermal radiation effects in helium-filled balloons. He cited one arctic flight in which the balloon apparently reached float altitude at 2.5 mb, although the design altitude was 1.7 mb. The altitude penalty was exacted by the warmer stratospheric temperatures of the arctic occurring concurrently with a balloon gas temperature which was kept much colder due to radiative heat losses. The solution was to provide more free lift for such flights, which was done by putting in the normal 8% free lift, and then providing ballast to be dropped en route. *I. W. Dingwell, Arthur D. Little, Inc.,* reported a daytime flight experiment to measure helium and outside air temperatures by thermistors hung both inside and below the balloon envelope. The measured gas temperatures correlated closely with temperatures predicted by computer.

Instrumentation

Major Chester Czepeyha, AFCRL, discussed a number of developments in balloon instrumentation made under AFCRL sponsorship. A UHF communications relay developed by Sylvania extends line-of-sight communications for a balloon at 100,000 ft to as much as 350 n mi radius. A VHF-HF directional balloon locating system provided close fixes for the great majority of extended flights in a series of tests. A chicken-wire-mesh radar reflector, which rolls down like a windowshade, gives good reflection for balloon tracking. A wireless FM command system to be mounted on top of a balloon allows balloon systems with long trains to avoid excessive cabling problems. *David Murcray, University of Denver,* described instrumentation for obtaining high-resolution infrared spectra from a balloon platform during ascent. *W. C. Wagner, AFCRL,* described a pressure gage developed for balloons in the altitude range beyond about 15 mb, where aneroids no longer function accurately. The gage depends on a thermistor bead, kept at constant temperature, and accuracy at present is within 2 to 3% of actual pressure.

Balloon Uses and Capabilities

Major Jack Cook and Capt. Michael Tavenner, AFCRL, described a balloon-borne optical beacon which should provide a useful means of incorporating new stations into the World Geodetic Satellite network. The beacons, carried at altitudes up to 100,000 ft, are photographed against the stars by camera systems located at the corners of triangles with sides 100 to 125 mi long. The objective is to determine the coordinates of an unknown station, and thus to incorporate it into a network. *George Ellerton, Vitro Corp.,* in a paper read by Payne Jackson, Vitro, reviewed the history of the Stratoscope balloon-borne telescope project, a development which imposed unprecedented balloon design and operational requirements. *J. C. McFall, Jr., NASA, and J. Payne, AFCRL,* reported the design and initial successful flight tests of a 26 million cubic ft balloon to be used to test planetary entry parachutes for NASA, in connection with the Project Voyager Mars exploration program. The design conditions call for lifting 2,250 lb to 130,000 ft. *Vincent Lally and Ernest Lichfield, NCAR,* described the current flight tests of the GHOST balloon program, being launched from New Zealand. The tests indicate a highly successful future for the GHOST program.

The deviations of these balloons from expected performance all appear to be amenable to correction with reasonable cost and effort.

Scientific Results

Samuel Solot, NCAR, presented some meteorological results derived as a by-product from the GHOST operational tests, which have already given new information about southern hemisphere 200 mb mean wind directions and velocities. *Norman Sissenwine, AFCRL,* discussed humidity in the stratosphere as determined by alpha-radiation hygrometers carried on balloons launched from Chico, California.

Balloon Offshoots

The general principle of enclosing a special gas in an envelope or barrier has application beyond its specific use in balloons, and technology is developing ingenious devices and methods which might be termed "balloon offshoots" or "quasi-balloon" uses. Several of these were described at the Portsmouth Conference: *J. J. Graham, Goodyear Aerospace Corporation and J. B. Wright, AFCRL,* described the Ballute (BALLoon-parachUTE) retardation device for slowing the descent of falling rocketsondes. They indicated that the Ballute should also have application for meteorological sounding. *J. D. Nicolaides and C. F. Knapp, Notre Dame University,* described the Para-Foil, an aerodynamic wing made of nylon fabric, and embodying a Jalbert Airfoil Section. The wing maintains its shape by ram pressure entering the leading edge, and can carry payloads to moderate altitudes. *S. Stenlund and C. Dahlgren, G. T. Schjeldahl Co.,* described the design and manufacture of the Pageos satellite, an inflatable metallized sphere which is the successor to the Echo satellites. High quality standards, resulting in an exceptional product, may have some application to balloon manufacture. *M. J. Balzerac, General American Transportation Corp.,* described what must surely be a unique application of balloons: their use as explosives when filled with detonatable gas, to study blast and shock effect up to 500 psi maximum overpressure. The advantages claimed over condensed explosives include clean, predictable shock waves; no debris; predictable pressure, distance, and time relationships; no tower needed in air bursts; and relatively inexpensive tests.

Needs Expressed

As usual at technical meetings, some provocative ideas and suggestions turned up in casual conversation between the formal sessions. One group of research scientists pointed out that they are flying lightweight expendable instrument packages, in which physical recovery is not essential, since they secure their data by telemetry and the instruments are relatively inexpensive. The balloons themselves range up to ¾ million cubic ft volume, and are launched as far north as possible, from auroral zone considerations. The using scientists do their own launching, and they expressed the need for an operations manual specifically addressed to scientists who want to handle their own launches and data recovery for such small-balloon expendable package flights.

Conference Proceedings

As with previous Conferences, AFCRL plans to issue a volume of the Proceedings of the 1966 Conference within a few months. ●

Directory of Air Pollution Trainees

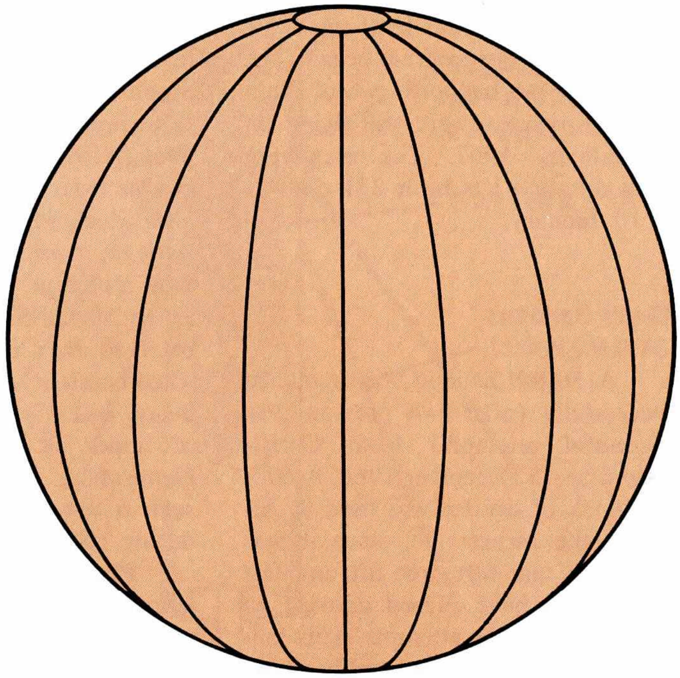
The Center for Air Environment Studies of Pennsylvania State University offers three separate educational programs (a graduate training program, an administrative training program, and a technician training program) for students who want special training in the field of air pollution control. Because of the novelty of this kind of training and the lack of a nationwide placement mechanism for students in this field, the Center for Air Environment Studies has published a "Placement Directory of Air Pollution Trainees, 1966-67," which provides pertinent information, such as major field, degree sought, and thesis topic, on the students enrolled in each training program.

The Directory is available on request to:

The Center for Air Environment Studies
Pennsylvania State University
University Park, Pennsylvania 16802 ●

GHOST

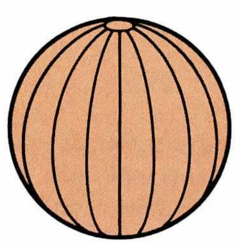
Southern Hemisphere Test Program



30-mb balloons, *about 7 m in diameter. Testing of balloons of this size is difficult and expensive, so most balloons are not tested before release. Failure rate has been high.*

Testing of GHOST (Global HOrizontal Sounding Technique) superpressure balloons continued during the last third of 1966. From Christchurch, New Zealand, balloons were flown at 500, 200, and 30 mb, or approximately 20,000, 40,000, and 80,000 feet. A number of 200-mb balloons were launched also from McMurdo Station, Antarctica.

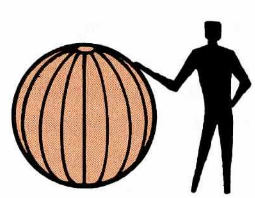
In spite of an abundance of adverse weather in New Zealand, three flights were launched successfully in September, six in October, two in November, and three in December. Four additional November launches from McMurdo Station, Antarctica, have been interesting in that two of the balloons have tended to remain at very high latitudes, one has moved out of the Antarctic and then back to within 400 km of the Pole, and one has stayed in mid-latitudes.



200-mb balloons *are 2.26 m in diameter. These are the most successful of the balloons, and a number of them have made many successive circuits in the Southern Hemisphere.*

500-mb Balloons

Two balloons at 500 mb, reinforced and treated with silicone wax in an effort to control icing and icing damage, were launched successfully



500-mb balloons *are about 1.5 m in diameter. They are often reinforced and coated with silicone in efforts to prevent them from icing. So far, none have remained aloft for longer than two weeks.*

from Christchurch, but flew for less than one week.

200-mb Balloons

Twelve 200-mb balloons were launched, including four in the Antarctic. This brings the total to 38 balloons launched at this level since last March, when the program began. Ten of the 200-mb balloons, two of them in the Antarctic, were still flying on 10 January 1967. The maximum flight duration has been 231 days as of 10 January.

30-mb Balloons

A 30-mb balloon was launched successfully (after two previous unsuccessful attempts) from Christchurch on 15 December 1966. A 600-gm block of dry ice was used to decrease the ascent rate, since it was suspected that high free lift and fast ascent may have caused damage on one of the earlier attempts. This balloon is flying well, and unlike those at lower levels is moving westward; it completed its first circuit on 9 January 1967.

Future Plans

While present phases of the GHOST program are involved primarily in testing GHOST balloons, test-balloon trajectories can provide much meteorological information. With rapid communication to a computer in Boulder, Washington, or Melbourne from three readout stations (in New Zealand, South America, and Africa), trajectories, and the winds they represent, can be computed for up to 50 balloons. Data can be fed back to the Southern Hemisphere, when necessary, with only a few hours delay, and would double the volume of upper air data in the Southern Hemisphere. It is to be hoped that such a program can be established during 1967.

Plans for 1967 also include some launches from Canton Island in the tropical Pacific. Low-latitude balloons may ride the counterjet, and travel westward along the equator at considerable speeds. In an effort to solve the icing problems encountered at 500 mb, balloons will be flown above icing levels while telemetry packages on long tethers probe the icing conditions below.

Flights at 10 mb and 30 mb are also planned for 1967. Planned flights have an excess capacity of 2 kg which is not used at present. Vincent Lally and his associates would consider "piggyback" experiments by other scientists who wish to make studies of seasonal or annual variations in incoming radiation, ozone, or other factors that can be measured from platforms at 80,000 or 100,000 feet. Flight durations should be in excess of one year. Telemetered data will be recorded during daylight hours for the complete flight. Packages will not be recovered. For information please contact:

Mr. Vincent C. Lally
Facilities Laboratory
National Center for Atmospheric Research
P.O. Box 1470
Boulder, Colorado 80302

GAMP

A gamp, in country English, is a large umbrella, its name being an allusion to the umbrella of Mrs. Sairey Gamp in Dicken's *Martin Chuzzlewit.*

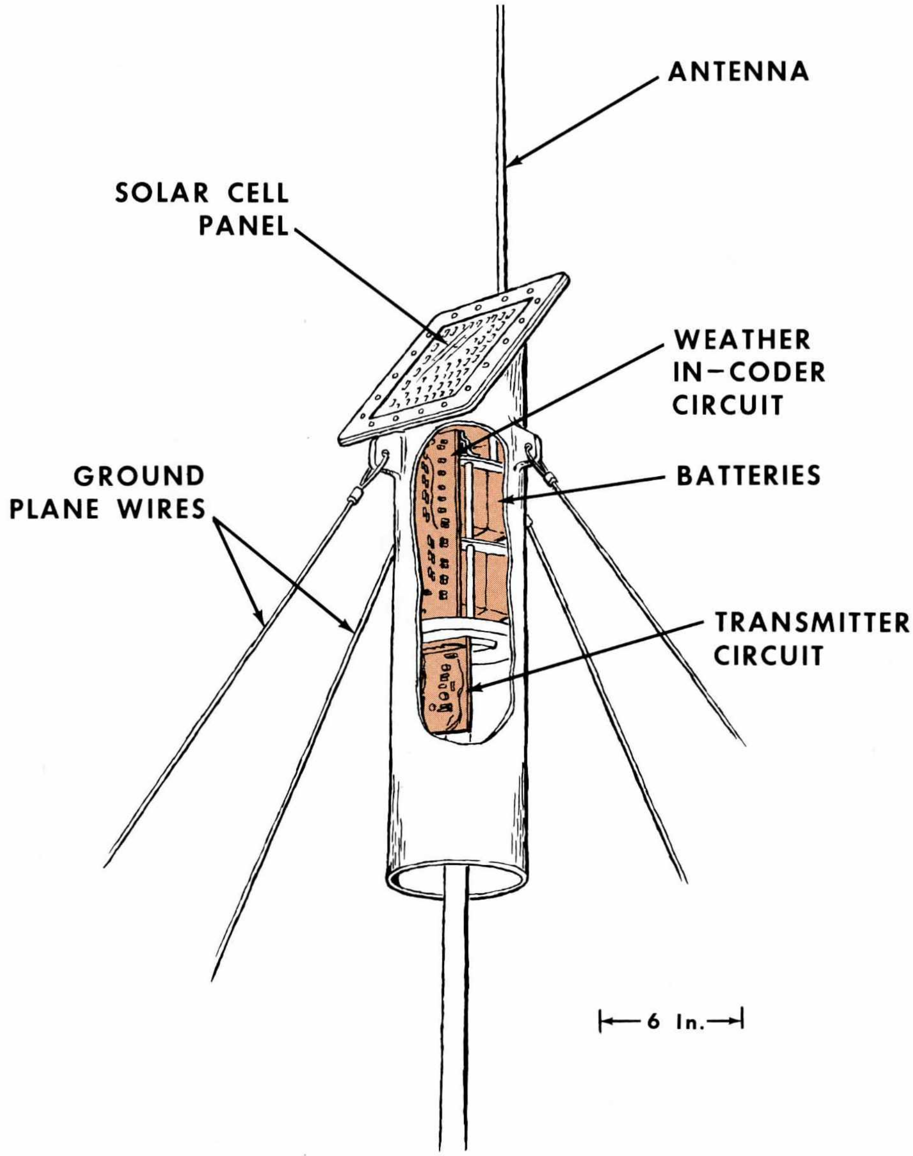
GAMP, or the Global Atmospheric Measurement Project, was formed recently as a split-off from NCAR's Scientific Ballooning Facility. It is involved in developing new techniques for obtaining atmospheric data, techniques which will serve the entire meteorological community. Currently it is occupied with three endeavors:

The GHOST program of constant-density meteorological balloons, the current status of which is described above;

The development of MINISONDE, a radiosonde instrument weighing just a few grams (in contrast to the 6-lb radiosonde in use at present) and designed so as to be of no danger to high-speed jets and other aircraft; and

MOSES, or Meteorological Observing Station, Extremely Simple. This program results from efforts to monitor the performance of GHOST balloons, which now carry electronic packages powered by solar cells and capable of reporting air and gas temperatures, air pressure, and balloon superpressure.

MOSES



The ideal simple, reliable, automatic weather station is one which can be transported into remote areas by helicopter, small boat, or backpack. It should contain no moving parts or elements which can be damaged or change calibration with shock or vibration, and all parts should be capable of withstanding long periods without servicing. Field erection of the station should be as simple as possible, so that two or three men can assemble and test it in two or three hours. Every effort should be made to use reliable, uncomplicated, low-cost components. Data should be relayed automatically to central, manned stations for processing.

Ernest W. Lichfield, of NCAR, has designed a prototype MOSES, for use anywhere except in polar regions, and has tested it at Christchurch, New Zealand, with readout in Melbourne, Australia. It is similar to the electronic package on GHOST balloons, but has an added nickel-cadmium storage battery to allow continuous 24-hr use. The solar-cell panel, sealed beneath a glass cover, is tilted in accordance with latitude to obtain maximum energy absorption. The rest of the system is encased in an aluminum pipe 6 in. in diameter, raised 4 m above the ground on an aluminum mast; guy wires form the ground plane for the antenna. Two thermistors, to measure air temperature and package temperature, a reference resistor, and a battery voltage monitor are being used as sensors for testing; later operational systems will monitor air temperature, pressure, and wind direction and velocity. A simple, reliable wind velocity transducer is being sought.

Additional channels can be added without undue complication. If a single system does not have enough channels, two systems may be installed. In locations so difficult of access that even minimum maintenance is not practical, two parallel systems can be used to increase the probable useful life of a station. Continuous transmission permits monitoring of a number of stations by personnel who may have other functions as well, since they are not committed to listen at any exact transmission time. Readout could also be handled by automatic timing circuitry.

MOSES installations could be made on small islands or remote desert or mountain areas where it would be difficult to maintain conventional stations. Modifications using a wind-driven power source would be practical for areas such as the arctic. The use of MOSES will permit the establishment of a finer network of land stations, at a lower cost, than can be obtained by other means, and will reduce the predicted expense of gathering meteorological data on a global basis. ●

Research on Hail Suppression

The destructiveness of severe local storms in temperate regions has created widespread interest in programs for modifying such storms. Perhaps the greatest immediate interest centers on hailstorms, because they are comparatively easy to study and may be more susceptible to suppression than other severe storms, such as tornadoes. Since these severe storms constitute a family with significant underlying characteristics in common, it seems probable that much of the knowledge gained in studying hailstorms can eventually be applied to understanding other kinds of severe storms.

First National Symposium On Hail Suppression

In April 1965 the Interdepartmental Committee on Atmospheric Sciences, a coordinating group for federal meteorological activity, asked the National Science Foundation (NSF) to develop a plan for the establishment of an expanded national research program on suppression of hail. NSF then invited NCAR to help organize a symposium on hail suppression to develop guidelines for a national effort in hail suppression research. This symposium, the First National Symposium on Hail Suppression, was held in Dillon, Colorado, in October 1965, under the chairmanship of Professor Verner E. Suomi of the University of Wisconsin.

Thirty-one basic research scientists, commercial operators, and representatives of government agencies participated in the symposium. They reviewed the state of knowledge and activity in hail suppression, both in the United States and abroad, and considered both the short- and long-term steps that would bring about the most effective possible national effort in hail suppression.

The participants in the symposium agreed that the problem of suppressing or modifying hail would be difficult to solve, although recent developments in atmospheric science and technology offer promise that a solution can be found. However, they noted that the solution will require long-term, large-scale field programs coordinated with intensive laboratory and theoretical studies. They concluded that research on hail suppression should have high priority in the nation's efforts in the atmospheric sciences and that an integrated and comprehensive National Hail Suppression Research Project should be established.

National Hail Suppression Research Project

The principal tasks of this Project, when organized, will be to mount a vigorous attack on the problems involved in suppressing or modifying hail and to assess the social, economic, and legal implications of such a program. The ultimate goal of the Project will be to increase our knowledge of the processes which lead to the formation of hailstorms and, in the light of this knowledge, to develop techniques for influencing the formation of hail in the atmosphere. The desired effect in most cases will be to decrease the size, amount, and core hardness of the hailstones without seriously affecting total precipitation. A by-product, however, may be development of techniques to increase hail in situations where it would be beneficial.

To help plan the means of accomplishing the long-range objectives of the Project, the participants in the symposium authorized Chairman Suomi to appoint a steering committee. In addition to Suomi, the members of this committee are: W. Boynton Beckwith (United Air Lines), Guy G. Goyer (NCAR), Peter H. Wyckoff (NSF), Walter Hitschfeld (McGill University), David Atlas (University of Chicago), and Vincent J. Schaefer (State University of New York at Schenectady). Earl G. Droessler (NSF) and Keith Browning (AFCRL) also served on the committee for a short time.

Technical and organizational support for the Steering Committee study, was provided by 16 subcommittees, which explored problems in three general areas: scientific basis; tools; and socioeconomic and safety considerations. The subcommittees and their respective chairmen are:

• Climatology, Glenn E. Stout (Illinois State Water Survey)

• Hailstorm Dynamics and Theory, Harold D. Orville (South Dakota School of Mines and Technology)

• Hailstorm Cloud Physics and Electrification, Bernard Vonnegut (Atmospheric Sciences Research Center)

• Laboratory Studies, Roland J. List (University of Toronto)

• Meso-Synoptic Network, Tetsuya Fujita (University of Chicago)

• Facilities, William S. Lanterman, Jr. (NCAR)

• Mobile Field Observation Units, Helmut Weickmann (ESSA)

• Airborne Instrument Development, John W. Hinkelman, Jr. (NCAR)

• Indirect Probe Development, Edwin Kessler, III (ESSA)

• Ground Instrument Development, John Marwitz (Colorado State University)

• Design and Evaluation of Field Experiments, Richard A. Schleusener (South Dakota School of Mines and Technology)

• Forecasting, D. C. House (ESSA)

• Public Relations and Communications, Wallace E. Howell (W. E. Howell Associates)

• Social, Economic, and Ecological Considerations, Harold R. Steele (U. S. Department of Agriculture)

• Safety, Edmund Bromley, Jr. (FAA)

• Legal Aspects, John C. Oppenheimer (NSF)

The Steering Committee and subcommittee chairmen have held two meetings, in July and in September, 1966. At these meetings they presented their findings and discussed recommendations for the most effective way to carry out the National Hail Suppression Research Project.

The Steering Committee work will culminate in a report containing the group's recommendations for establishment of an integrated and comprehensive national program of hail suppression research. This report is to be submitted to NSF early in 1967.

Project Hailswath

In addition to formulating guidelines for a long-range attack on the problem of hail suppression, the participants in the First National Symposium on Hail Suppression agreed that a one-month field program should be conducted during the summer of 1966 as a pilot study. This program, which was called Project Hailswath, was carried out independently from, although in coordination with, the longer range planning of the National Hail Suppression Research Project. Project Hailswath was conducted between 10 June and 10 July, primarily in the Rapid City area of South Dakota. It was coordinated by a steering committee composed of Schleusener, Goyer, Howell, Schaefer, and Patrick Squires (Desert Research Institute).

The primary objective of Project Hailswath was to determine what practical and scientific problems are encountered in carrying out certain lines of hail suppression research in the field, especially those involving the collaboration of many groups of scientists. Other objectives were: to provide the necessary logistic support and facilities for an observational project in hail research; to study the feasibility of a mobile and multi-disciplined approach to hail research; to arrange for the exchange of research data among the participants; and to recommend procedures, instruments, and techniques for future hail studies.

Seven instrumented aircraft, eight mobile ground stations, and several radar installations were used in Project Hailswath. Some of the aircraft were used for cloud seeding, while others were used for meteorological observations in and around clouds. During the four weeks available for field work there were ten "go" days (days for which severe local storms and possible hail were predicted). On five of those days hail fell somewhere within a 50-mi radius of Rapid City.

The major logistic problem encountered during Project Hailswath was getting the ground crews to the hailstorms in time, since the storms are relatively short-lived and the system of roads around Rapid City was found to be inadequate for a project of this kind. However, a great many data were obtained, hailstone samples were collected, and the participants gained experience which will prove valuable in future field observation programs. The major accomplishments of Project Hailswath were that it brought together leaders in hail suppression and cloud physics research, showed the feasibility of a multi-disciplinary approach to studying hailstorms during an intensive period of field work, and provided experience which will help the leaders of the National Hail Suppression Research Project in planning the long-range program. ●

Notes on a West German Balloon Flight Program

Since 1961, balloon flights for nuclear research have been conducted by the "Institut für Reine und Angewandte Kernphysik" (Institute for Pure and Applied Nuclear Physics) of the Christian-Albrechts University of Kiel, Schleswig-Holstein, Federal Republic of Germany. Information on these flights has been received from H. Röhrs.

Permission for each series of flights must be obtained from the local governments of Schleswig-Holstein and Niedersachsen. Flight conditions are set forth by the Flugsicherungsleitstelle (Air Safety Control) at Hannover Airport. This control is necessary because of the large volume of air traffic over this part of Germany.

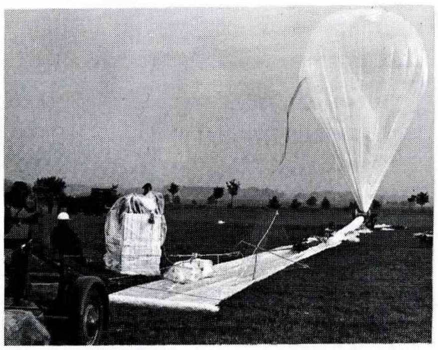
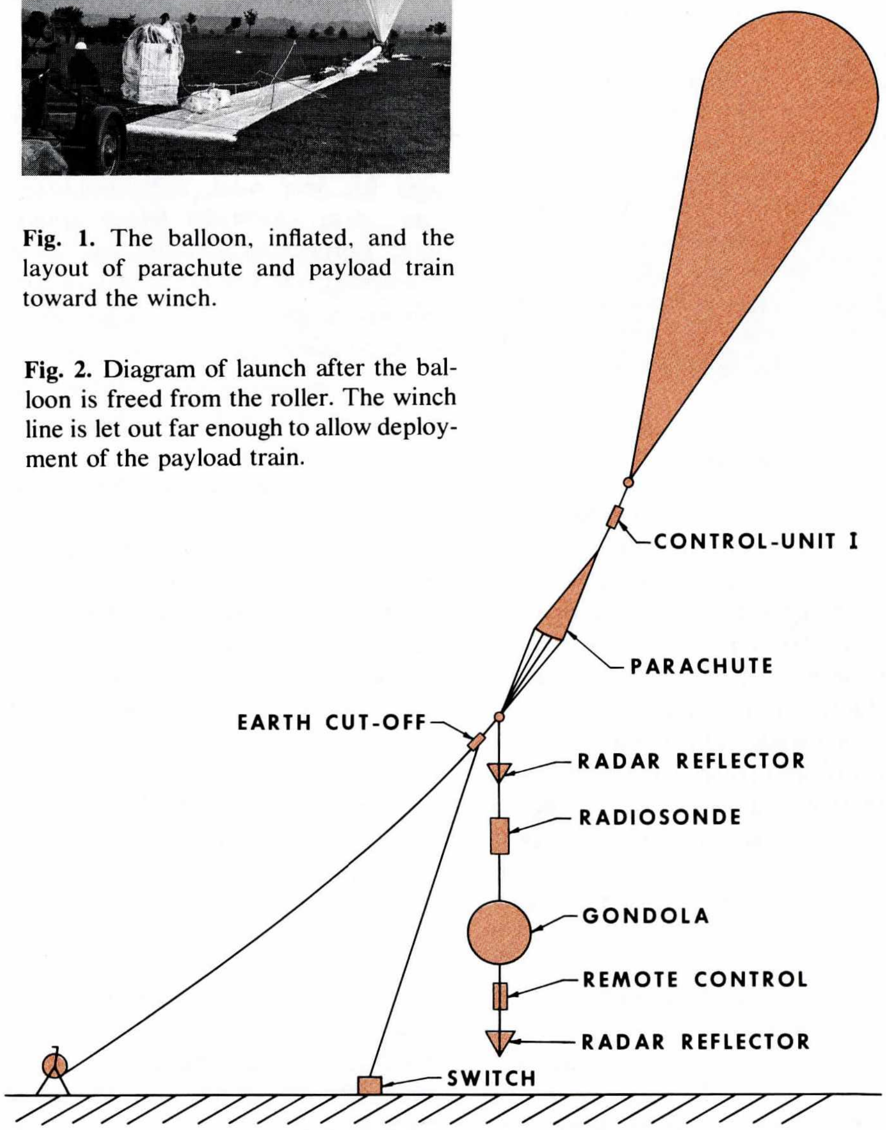


Fig. 1. The balloon, inflated, and the layout of parachute and payload train toward the winch.

Fig. 2. Diagram of launch after the balloon is freed from the roller. The winch line is let out far enough to allow deployment of the payload train.



Planning the Flights

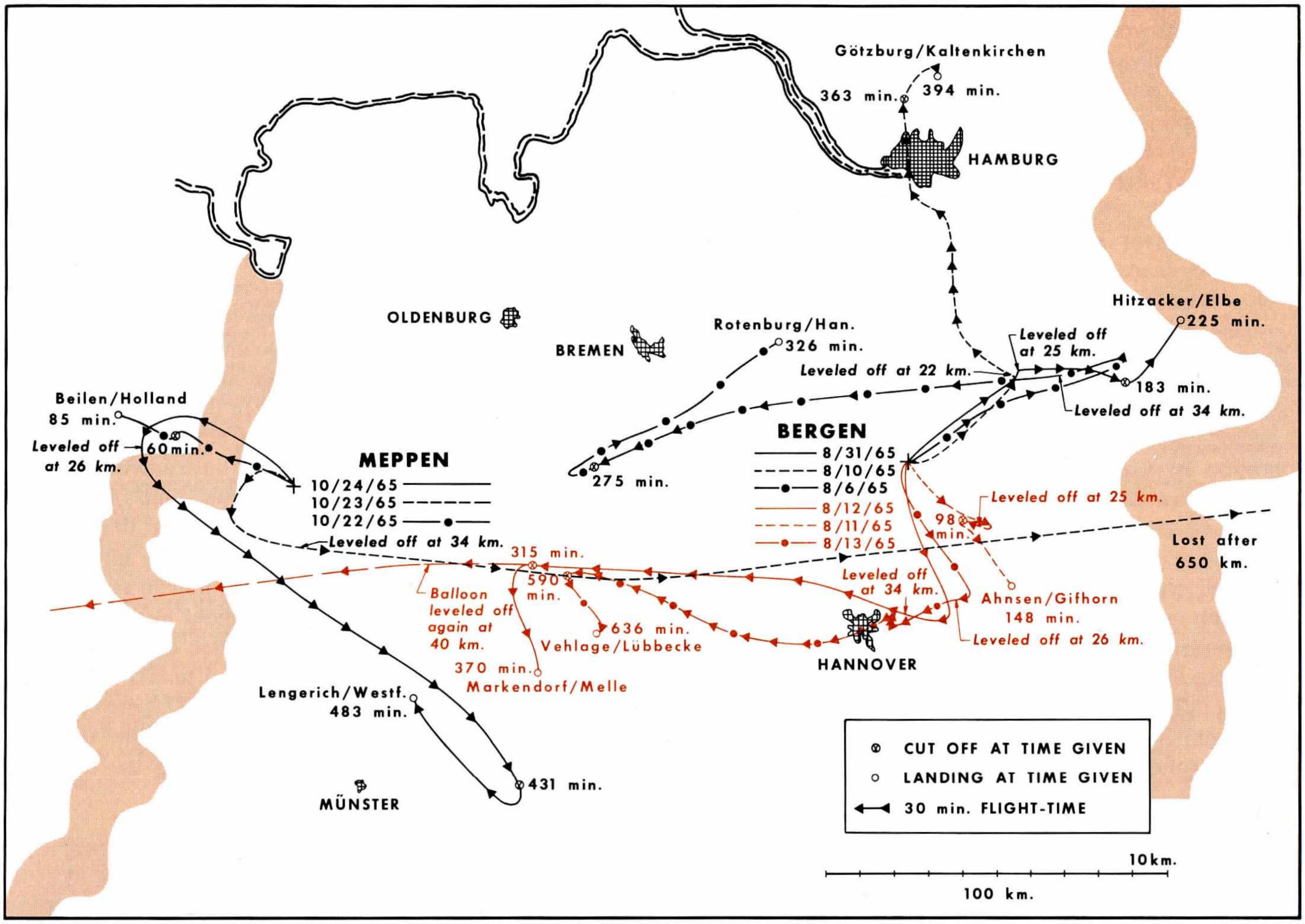
Each series includes three types of flights: (1) control-system test flights, flown mostly on rubber balloons from the Kiel-Holtenau Airport; (2) summertime (May-August) scientific flights, with polyethylene balloons launched from Bergen-Hohne, east Niedersachsen, which float westward; and (3) similar scientific flights launched from Meppen, near the western boundary of Germany, in the fall (September-November), which float eastward.

In planning these flights the usual considerations apply: development and construction of launch equipment; development of suitable pressure-height and temperature transmitters, cut-off mechanisms, and remote control systems; procurement of balloons, parachutes, ropes, and other accessories; as well as consideration of weather conditions.

Launch Procedures

A pilot-balloon is launched first. Based on its trajectory, an expected flight course for the scientific load is filed with the air safety control group at Hannover and permission for the flight is obtained. The plastic balloon and its train are laid out against the wind. To minimize sailing of the inflated balloon in the wind, only that amount of the balloon that will be filled completely by the calculated volume of hydrogen protrudes through the roller of the launching device. The lower part of the balloon is attached to a cutdown control device and then to a parachute, which

1965 FLIGHT PATHS



is anchored to the ground by means of a winch. The payload train is also attached to the lower end of the parachute.

The launching roller is made of polyurethane with a skin of glass fibre and plastic to give a roller that is smooth and light in weight.

The launch takes place in three steps: (1) The launching roller is opened, freeing the balloon which, along with the parachute, is held close to the ground by the winch line. (2) The winch line is let out, deploying the payload train. (3) When the system seems to be successfully deployed, the anchoring winch line is severed close to its point of attachment to the parachute.

Immediately following launch, the balloon is tracked by radar and, if possible, by theodolite.

When the flight is completed, the balloon is cut free automatically or by remote control, and the payload descends by parachute.

Radar tracking locates the landing place to within a few kilometers; but in most cases the load is immediately recovered by local residents who have seen the parachute descending.

Calculation of Gas Requirements

The volume of hydrogen required for the flight is calculated from the gross lift, G, which is the sum of the payload weight, L, the balloon weight, W, and the free lift, F. L and W are determined by weighing; F is calculated from the relationship:

$$F^{3/2} - 1.3F = 1.3\,(L + W)$$

where L, W, and F are all in kilograms. This value of F gives an ascent rate of 320 m/min, a rate which moves the balloon through the tropopause fast enough to minimize damage but does not cause excessive overdriving upon reaching float altitude.

Knowing the volume and pressure of the gas supply affords a convenient means of measuring G in terms of volume, since a cubic meter of technical hydrogen gives about a kilogram of lift. ●

Digital Data Logging System

The NCAR Field Observing Facility has recently purchased a Digital Data Logging System from Redcor Corporation of California. This system converts raw data into more usable form, and records the data for later use.

The system can sample sequentially ten analog inputs, converting the samples into binary numbers and recording them on magnetic tape in a form suitable for computer use. The equipment is designed so that it can at some future date be used directly with a computer, bypassing the recorder, a capacity which may be useful when decisions about data must be made in real time.

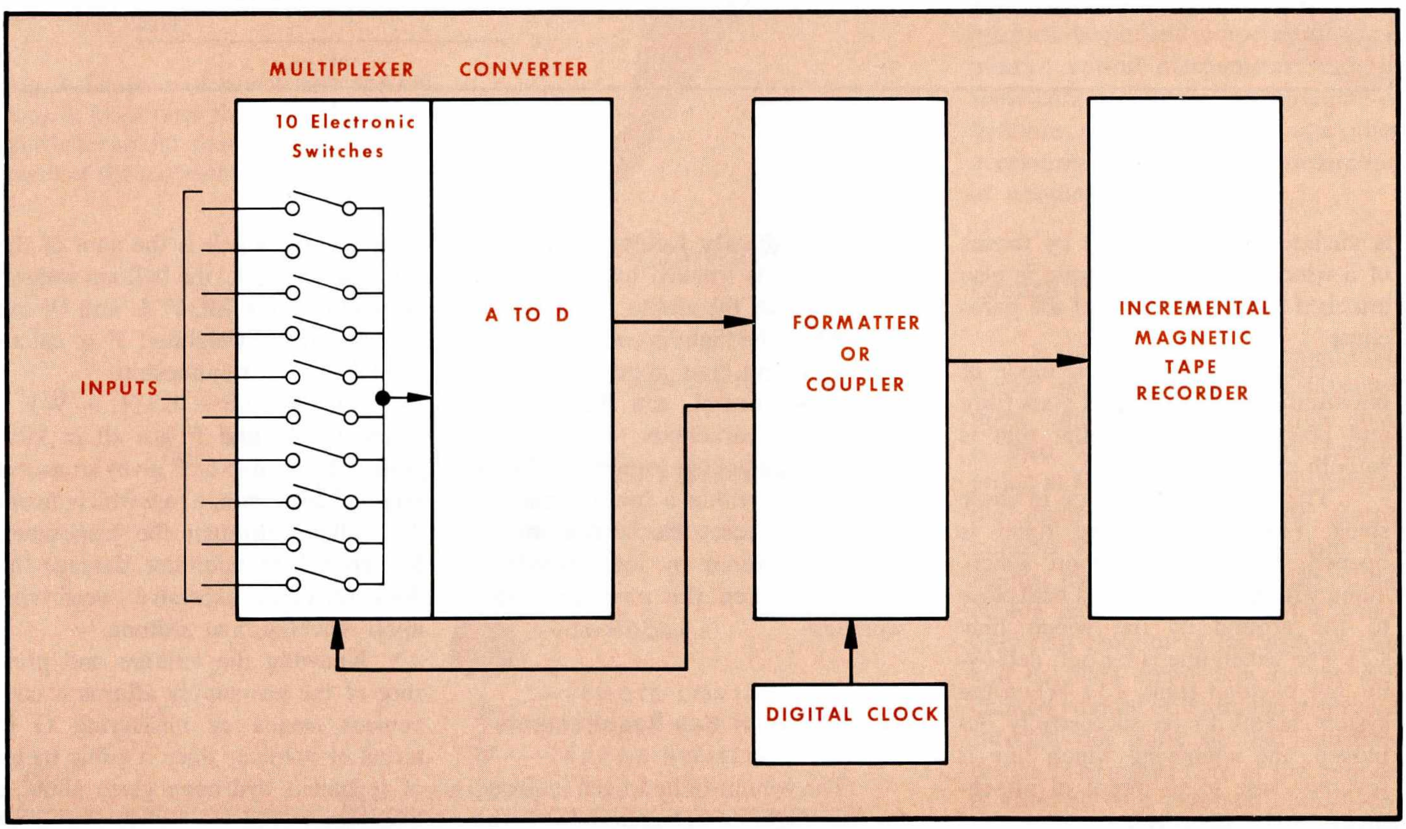
The system, which will be housed in a standard 19-in-wide, 5-foot-high rack, is composed of four basic units:

1) multiplexer and analog-to-digital (A-to-D) converter,
2) formatter and coupler,
3) incremental magnetic tape recorder,
4) digital clock.

Operation

Analog data entering the multiplexer are switched sequentially into the A-to-D converter, where they are converted into binary equivalents. The multiplexer-converter unit can handle a wide range of input voltages, including those in the mv range — most of the voltages employed in standard meteorological instruments are acceptable. Aperture time of the A-to-D unit is 22.5 μsec, but the converter has a sample-and-hold input amplifier, enabling the user to sample up to 80-cps data without loss of accuracy.

The formatter and coupler provide coupling and timing information between the A-to-D converter and the tape recorder. The unit has switches for arranging the format in



which information from the converter is to be put on tape, as well as means for manually inserting digital header information on the tape. It can also accept digital information from an external source, such as the digital clock.

Capabilities

The incremental magnetic tape recorder, a seven-channel device (six channels plus one parity channel), is capable of recording seven binary bits each step, at 400 steps per second, a density on the tape of 200 bits per inch. This recording capacity amounts to 133 samples per second, and limits the maximum speed of the entire system. A readback capability is planned, to allow check of the tape to insure against loss of data due to malfunction; temporarily a flux check will indicate that something is being recorded and an analog recorder on the input data will insure against actual data loss.

The digital clock, based on a very stable 100,000-cps oscillator, will provide timing for the system. Outputs in binary form of minutes, hours, and days may be inserted on the tape if desired. An alternate capability will allow single scans of any or all of the channels previously selected, initiated by the clock at intervals of 0.1 to 60 sec.

Availability

The Data Logging System will be available for research use by NCAR participants and other qualified scientists after about mid-March, 1967. Since this system is not meant to be field portable, analog tapes made in the field will be processed at NCAR. In the future a microwave link may be developed to NCAR's Marshall, Colorado, field observing site; data from this site could then be fed directly into the system and handled in real time.

A number of uses for the Data Logging System have already been proposed. Among these are the processing of records of atmospheric parameters in the University of Texas Seabreeze study, converting and recording radar position data from Douglas Lilly's mountain wave study (NCAR), and data reduction for Julian Pike's Marshall site rain measurements (NCAR). The equipment may also be used in attempts to automate radiosonde data conversion, and in logging temperature, humidity, pressure, and other atmospheric variables measured by the NCAR Boundary Profile System (see *Facilities for Atmospheric Research,* No. 1, Fall, 1966).

Inquiries concerning use of the Data Logging System should be addressed to:

Field Observing Facility
National Center for Atmospheric Research
Boulder, Colorado 80302 •

1967
Summer Computing Work-Study Program

NCAR has observed an extremely rapid growth in the use of large-scale computers in scientific work. Some field experience in this area is virtually a "must" in the training of students in meteorology and related fields. In recognition of this need, the NCAR Computing Facility held a small work-study program last summer, with excellent results. The eight students who participated were skilled scientific programmers by the end of the session and were unanimously enthusiastic about their experience here.

This year, again, NCAR will invite eight or nine students to come to Boulder to work in the Computing Facility. The major part of the workshop will consist of direct programming experience for the student, rather than didactic classroom situations. Orientation suited to the experience and interest of each participant will occupy the first few weeks. Subsequently, the student will be assigned scientific programming for an NCAR scientist. Depending on the student's skill with the computer and the free time he has, he may engage in his own research using the Computing Facility at the discretion of the instructor.

He will be encouraged to attend a variety of lectures and seminars on current research, given by NCAR staff and by visiting scientists. In addition, he may also participate in the Advanced Study Colloquium held during the summer.

Students will be considered who are planning careers in meteorology or related fields. They should have completed at least three years of work at an accredited university. Their salaries while at NCAR will range from $375 to $550 per month, depending on their year in school. Transportation expenses to and from Boulder will be provided.

Applications will be accepted through the end of March; selections will be announced on April 15th.

Write to:

Glenn E. Lewis, Head
Computing Facility
National Center for Atmospheric Research
Boulder, Colorado 80302 •

The Line Islands Experiment

A short-term field research program, known as the Line Islands Experiment, is under way to make island-based meteorological measurements in the equatorial Pacific early in 1967. Supported by the National Science Foundation and coordinated by NCAR, the experiment is designed to produce a great deal of useful information in a previously little-studied area, and is planned so that value of the field work will be greatly enhanced by concurrent data from the new Applications Technology Satellite, ATS-1, launched on 6 December 1966.

Satellite Photographic Coverage

ATS-1 is now stabilized in a synchronous orbit, in a stationary position 22,300 mi above the equator at 155° west longitude, almost directly south of Honolulu. Its camera, specially designed by Verner Suomi of the University of Wisconsin, obtained and transmitted high-resolution photographs a few days after launch. In spite of the great distance involved, ground resolution on these photographs is just about as good as that from low-orbiting satellites such as those of the Tiros series, so that clouds and other features 2 mi or more in diameter can be seen. Excellent contrast resolution should facilitate cloud type identification.

The satellite is capable of photographing the visible surface of the earth, essentially the entire Pacific, at 20-min intervals during daylight hours. For measuring and photographing time sequences of cloud development, motion, and decay, ATS-1 will be without previous parallel. Series of pictures from this satellite will give a broad view of daytime diurnal and semi-diurnal cloud cycles over the sea, and since images will be transmitted as they are taken, for immediate readout, it will be possible to follow tropical disturbances closely as they develop. In addition to the ATS-1 pictures, three pictures per day of the area will be available from ESSA's operational satellite system and from Nimbus-2.

Combined Observations

Only by interpreting information from ATS-1 in the light of direct measurements within the troposphere can we hope to establish associations between various cloud systems and patterns of development and meteorological parameters. A combination of surface-based, airborne, seaborne, and satellite observations will in addition enable us to begin an attack on fundamental meteorological problems of tropical convection, cloud systems, synoptic scale disturbances, and effects of islands; observations in combined form will clearly be far more valuable than the same observations developed and pursued separately.

The Line Islands Experiment, under the leadership of Edward Zipser of the NCAR Laboratory of Atmospheric Sciences and Colin Ramage of the University of Hawaii, will make an intensive study of the Equatorial Trough Zone or Intertropical Convergence Zone in the mid-Pacific. Three of the Line Islands, which are almost directly under the ATS-1 position, have been selected as observation sites: Palmyra and Fanning Islands for observations of weather in the trough zone, and Christmas Island for observations south of the trough zone.

Logistics and Planning

The NCAR Facilities Laboratory is handling logistics, planning, and field project management for the Line Islands Experiment. The main base will be on either Palmyra or Fanning Island. Camps will be established at abandoned military sites and, on Fanning, at an old cable station (now also abandoned) which has been leased by the Research Corporation of the University of Hawaii for a long-term observation site. Conventional meteorological equipment will be erected for surface observations on windward, lagoonal, and leeward parts of the islands, where possible using existing towers and buildings. Rawinsonde launch sites have been selected; further clearing will be carried out where necessary and inflation shelters erected. Radar sites will also be established. Existing airstrips on Christmas, Fanning, and Palmyra are to be equipped with functional lights and radio beacons to assure their usability. Most materials and equipment necessary to the experiment will be shipped by freighter or seagoing tugs and barges, and personnel will follow by air.

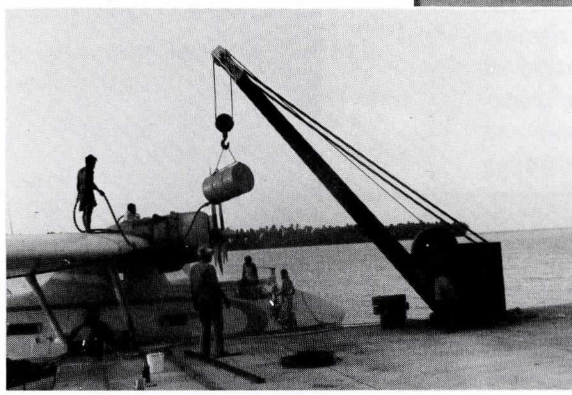
Time-lapse photography of clouds from island sites and aircraft is planned, and still photographs will be taken of the entire sky every hour. All pictures will be in color.

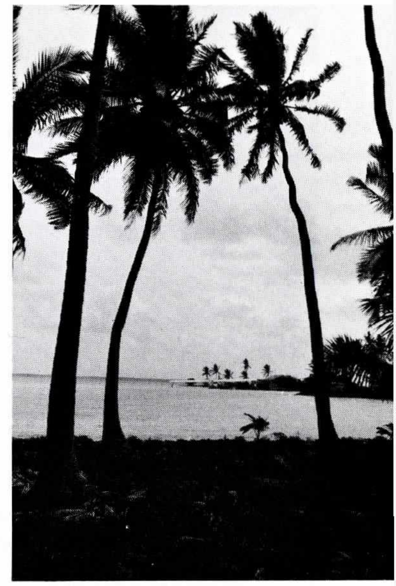
Television pictures from operational ESSA and Nimbus satellites will be received directly in the Line Islands. Some ATS-1 pictures will be received there also, by transmission from the readout station at Goldstone, California. When "sighted" by the ATS-1, a variety of tropical cloud systems and disturbances will be investigated and their development and movement studied with all available equipment.

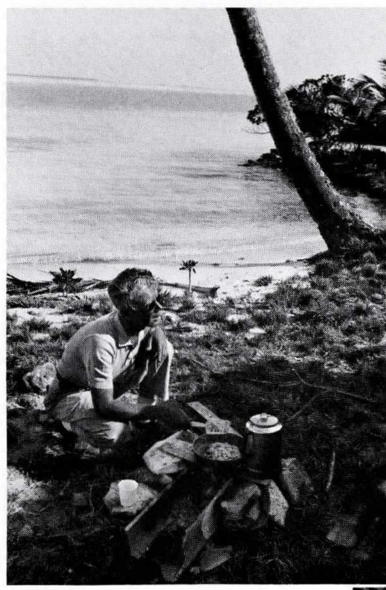
Intensive island-based surface, airborne, and seaborne observations will be made from 15 February to 15 April.

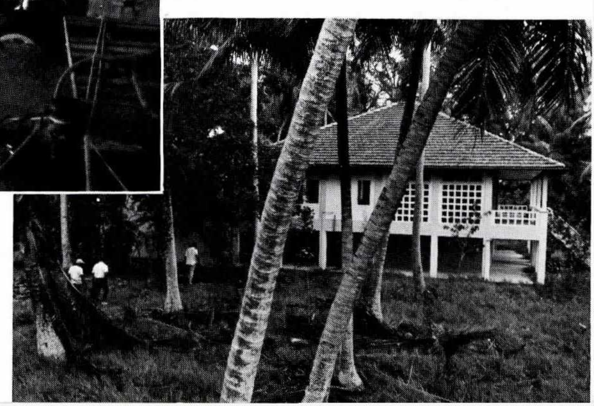
Participants

In addition to National Science Foundation sponsorship, the program is receiving logistic and scientific support from several other agencies. The U.S. Air Force will contribute three mobile rawinsonde stations and crews to the experiment, and will probably also supply two C-130 aircraft for daily observational flights between









Hawaii and the Line Islands. The U.S. Army plans to operate a double-theodolite pilot balloon program for boundary layer measurements, and to contribute surface observing equipment and observers. The ESSA research vessel, Surveyor I, will operate with the experiment for a period of seven weeks; among its other capabilities, it will carry equipment and crew for an upper-air sounding system.

Scientists from NCAR and a number of affiliated universities are planning to participate in the research program. Some of the projects to be undertaken are as follows:

• Edward Zipser, scientific coordinator of the program, will join with Henry van de Boogaard of NCAR in studying tropical disturbances.

• Colin Ramage and Ronald Taylor, of the University of Hawaii, will study tropical dynamics and the effects of atolls.

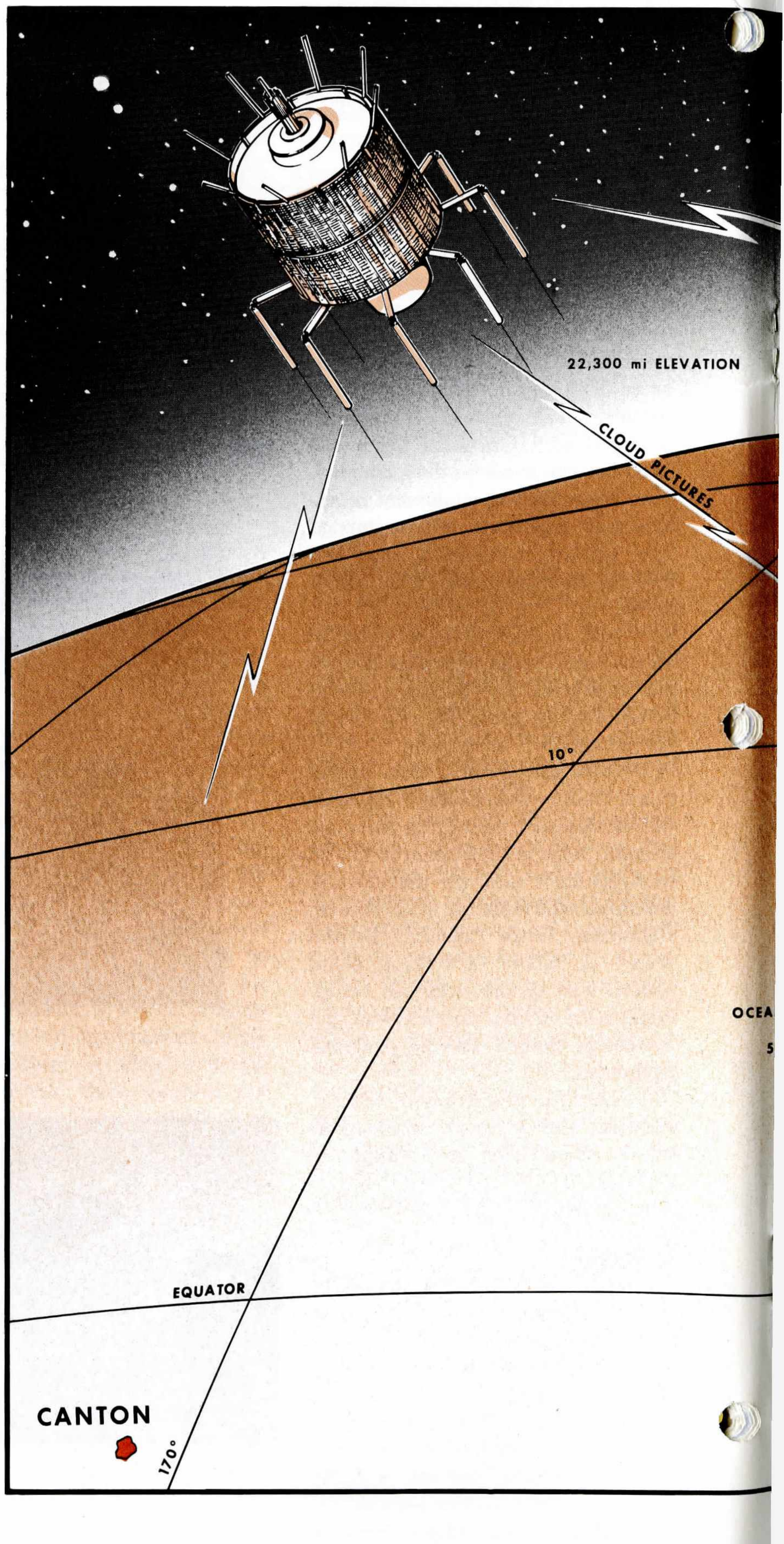
• Verner Suomi will head a University of Wisconsin team studying the effectiveness of the synchronous satellite as a meteorological instrument, and at the same time will study cloud motions and development. A group under Clifford Murino of Saint Louis University will work with the Suomi team.

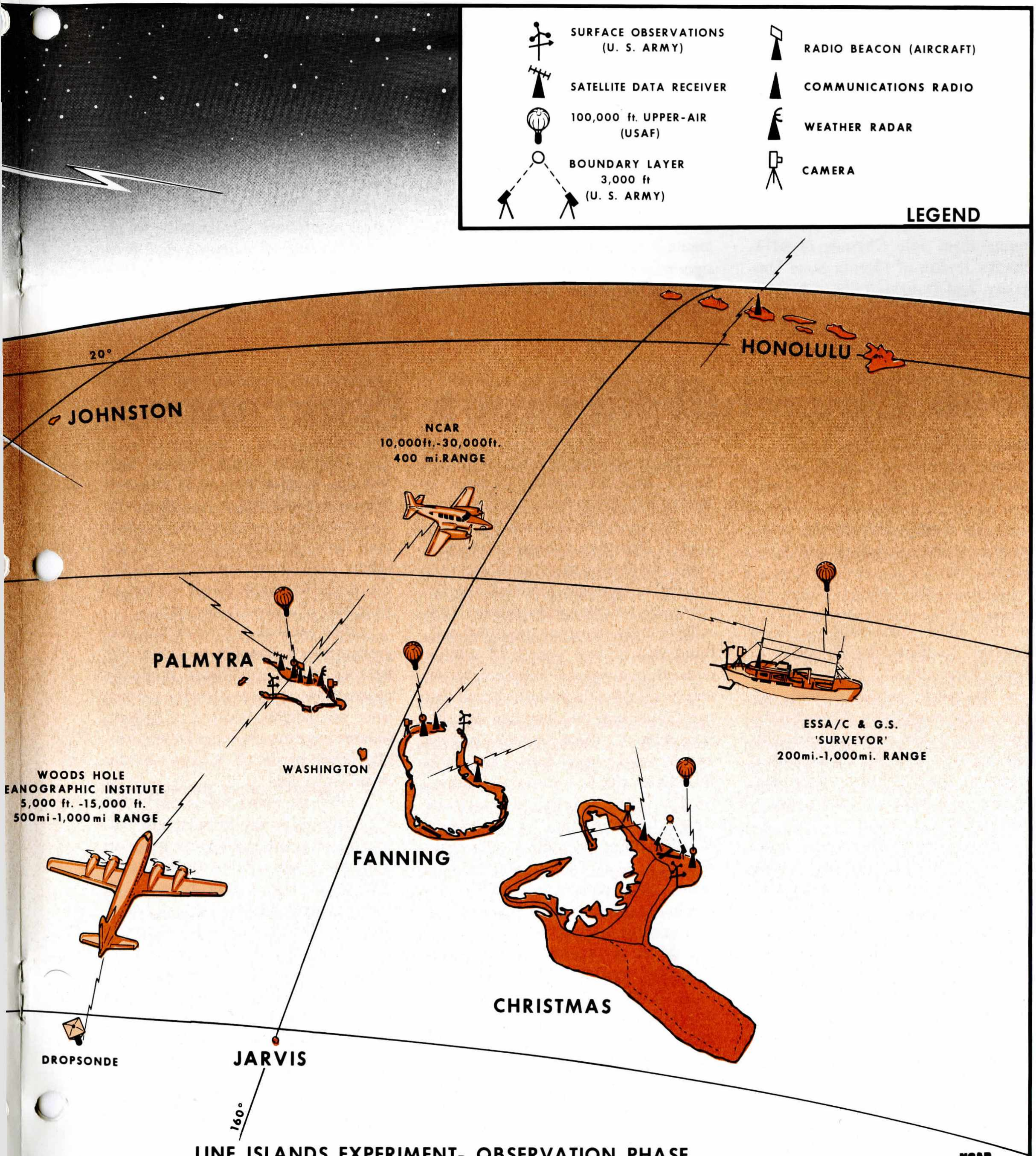
• Robert Ragotzkie, also of the University of Wisconsin, will lead a group studying temperatures of the sea surface. This research will utilize an airborne radiometer on an NCAR Queen Air, which is being flown to the Line Islands for use in meteorological missions.

• Aylmer Thompson, of Texas A & M University, is planning to use satellite data in an investigation of large-scale meteorological phenomena of the Equatorial Trough Zone.

• A study of the boundary layer, designed by Mariano Estoque, of the University of Miami, will be conducted by the U.S. Army.

• The Woods Hole Oceanographic Institution research aircraft C-54Q will participate in the program,





LINE ISLANDS EXPERIMENT- OBSERVATION PHASE

NCAR

with Andrew Bunker directing a comprehensive series of observations; the studies will embrace many aspects of tropical weather, including development of convective clouds.

• William Marlatt of Colorado State University will make radiometric measurements from the Woods Hole aircraft, and William Gray will engage in a study of sea temperatures and boundary layer data.

• A number of other scientists, among them Jule Charney of MIT, Charles Jordan of Florida State University, and Douglas Lilly of NCAR, have expressed interest in studying some of the data resulting from the Experiment, even though they are not participating directly.

Scientific Contribution

The Line Islands Experiment will, it is hoped, contribute to the evaluation of the ATS-1 and other satellites as meteorological instruments in the tropics. It will also obtain significant information on many equatorial atmospheric processes which are at present poorly understood. In the event that the ATS-1 fails before completion of the field program, the Line Islands Experiment will proceed with little modification, its object still being to obtain as many quantitative surface and upper air data as possible during the observation period. Such data will be related to information from the two or three available performing satellites, and will in themselves contribute significantly to an understanding of meteorological phenomena in the Equatorial Trough Zone. ●

1966 Churchill Skyhook Program

by Henry Demboski, Research Engineer, ONR

In the 1966 Churchill Skyhook Program, conducted by the Office of Naval Research, 32 balloon flights were launched and recovered. All flights were completely successful excepting for one in which the scientific package was lost in Hudson Bay. However, since the data were telemetered, this flight achieved its scientific objective.

During the 58 days available for operations, from 10 June to 7 August (the time period was determined by clearing of ice on lakes in the recovery area in June and by the reversal of the stratospheric winds in August), balloon flights were conducted on only 20 days. Three flights per day were launched on three separate days, two flights per day were launched on six days and on eleven days one flight was launched. On the 38 remaining days, either scientific packages were not available or the weather was bad. One of the most difficult aspects of a program involving many scientific groups is scheduling their arrival to insure that a scientific package is ready for every possible launch time.

The magnitude of the 1966 program is shown by the size of the balloons, weights of payloads flown, and the flight durations achieved. Of the thirty-two balloons, eighteen were 10.6 million cubic ft, three were 6.0 million cubic ft, two were 5.25 million cubic ft, one was 4.0 million cubic ft, one was 2.94 million cubic ft and five were small balloons less than 0.5 million cubic ft. Float altitudes desired and attained ranged from 151,000 to 69,000 ft, with float durations as long as 19½ hr. Scientific payloads weighed from 631 to 84 lb. A total of 7,210 lb of scientific instrumentation plus 9,300 lb of safety equipment, flight control equipment and ballast was successfully launched and flown on the 32 balloons.

Most of the scientific packages were recovered near Lake Athabasca. Four flights were permitted to travel several hundred miles west of the normal recovery area to provide the scientists with additional desired time at altitude. Many of the payloads were recovered within a few hours and delivered to Uranium City Airport for transport back to Churchill by the C-47 tracking aircraft.

The success of the 1966 program was due in large part to preliminary planning, which began almost exactly a year before the date of the last balloon flight. Reliable balloons and excellent field services provided by the Churchill Research Range personnel were also of critical importance.

The unusual success of this program made it possible to reduce the number of balloon flights originally requested by certain scientific groups, since no reflights because of balloon failures were required and flights actually flown produced a large amount of scientific data.

ONR personnel feel strongly that the state-of-the-art in scientific ballooning is sufficiently advanced to normally allow a high success ratio. The close coordination between all agencies involved and the yearly symposia conducted by AFCRL do much to ensure that the balloon as a research vehicle will keep increasing in its capabilities and reliability and thus be utilized for more and more scientific investigations. Analysis of the 1966 Churchill Skyhook Program shows that the cost of carrying scientific instrumentation to balloon altitudes for durations as long as 19 hr was reduced from $100 per lb on previous programs, to $80 per lb. ●

Aircraft Instrumentation Workshop and Symposium

Practical applications of new technology, new instrumentation techniques under development, and problem areas in aircraft instrumentation for atmospheric research were discussed by approximately 175 meteorologists and engineers at the Atmospheric Research Aircraft Instrumentation Workshop and Symposium, held at Will Rogers Airport, Oklahoma City, Oklahoma, 17-18 November 1966. In addition to technical sessions on measurement of air motions, cloud physics and kinematics, and data handling, the symposium featured a research aircraft fly-in and display of research equipment.

Measurement of Air Motions

Elmar R. Reiter (Colorado State University), chairman of the first session, enumerated some of the general questions regarding the atmosphere that meteorologists would like to be able to answer, such as:

- How do convective motions feed energy into the general circulation of the atmosphere?
- What kind of feedback mechanism exists between potential and kinetic energy along the whole spectrum of atmospheric motions?
- What kinds of energy levels are there in the atmosphere?

He mentioned the problems meteorologists have had in the past because of the lack of reliable instruments and measurements and stressed the need for good turbulence measurements, in particular, and for development of remote sensing techniques.

Elmer J. Frey (Massachusetts Institute of Technology) discussed the application of inertial technology, developed for military and space programs, to measurement of air motions. At present the performance of the more advanced inertial systems is covered by government security classifications. However, within the limits of security, Frey indicated the accuracy levels that are possible with presently available inertial systems and some of the problems associated with angular, azimuth, and vertical stabilization.

For economic reasons the atmospheric sciences will have to use the fallout from technology developed for space programs for some time to come.

Helmut Schlitt (Litton Systems, Inc.) reported on advances in development of sensing probes. He described the advantages, limitations, and estimated cost of various doppler systems, pure inertial systems, and inertially augmented systems that are available now or will be available in the future. There is no sharp line between inertial systems and other systems which use accelerometers, because they merely vary in the number of accelerometers they contain and the number of axes they measure. In general, inertially augmented systems are the most accurate.

One of the problems encountered in using inertial systems for atmospheric research is that they were developed for navigation purposes and not for making atmospheric measurements. Navigators are interested primarily in determining aircraft position with great precision, while meteorologists are interested primarily in measuring velocity.

Schlitt posed the question: "What accuracies do meteorologists require?" It is difficult for instrument manufacturers to design systems for meteorologists unless they know the meteorologists' requirements. The discussion that ensued showed that there is no simple answer to this question. Different accuracies are required for different kinds of measurements, depending on the time and space intervals involved.

The problem of parameters to be measured and accuracies required was considered further by the next speaker, *Harold Klieforth (Desert Research Institute),* who noted that relatively crude measurements are sufficient for exploratory investigations of the atmosphere, whereas high-accuracy measurements are essential for detailed studies of atmospheric processes.

In any study of atmospheric motions in which an aircraft is used as the research platform, the parameters that must be measured are: true heading, true air speed, ground speed, drift angle, position (latitude and longitude), time, and D-value (the difference between geometric altitude and pressure altitude). In investigating vertical motions, certain supplemental measurements, such as aircraft attitude and acceleration, must also be made.

Gilbert Robinson (NASA) described a non-inertial terminal guidance system that NASA is now testing. He hopes that this system, which gives aircraft position with great accuracy, will enable pilots to make zero/zero landings. The system uses two or three transponders on the ground and a digital computer and radar altimeter in the aircraft. Once they get the bugs worked out of it, Robinson thinks the system could be applied to measurement of air motions.

Cloud Physics and Kinematics

Helmut K. Weickmann and Heinz Grote (ESSA) were co-chairmen of this session. Weickmann gave a brief introduction. Cloud physics and dynamics is a complex field. To describe clouds it is necessary to measure a great variety of parameters, including temperature, humidity, solid and liquid water content, particles (nuclei, drops, crystals, precipitation particles), motions (updrafts, entrainment of outside air, downdrafts, turbulence), visibility, electric parameters, and radiation. He feels that an aircraft is the best instrument available today for probing the mesoscale, the scale on which most of the severe weather takes place. However, meteorologists need aircraft which have been designed specifically for making atmospheric measurements.

Robert M. Cunningham (AFCRL) discussed the advantages and disadvantages of various techniques that are currently available for measuring two micrometeorological cloud parameters: temperature and particles. For temperature measurement Cunningham mentioned both direct and indirect techniques. Direct techniques include the use of vortex thermometers, reverse-flow thermometers, and half-reverse-flow thermometers; indirect techniques include infrared and sonic measurements. Liquid particles are sampled by jet impactors and electromagnetic devices. Solid particles are collected on films.

Patrick Squires (NCAR; now with Desert Research Institute) discussed techniques for measuring humidity and liquid water content. A great variety of techniques has been used to measure humidity. Many scientists think that the old wet and dry bulb thermometer is the most practical method. In clear air, water vapor can be treated as any other gaseous constituent of the atmosphere, but in the high atmosphere, because of the extremely low vapor pressure of the water vapor, dew point apparatus is generally used for measurement of humidity. In clouds measurement of humidity is even more difficult. Possibly the only technique in sight is use of a direct measure of Lyman alpha absorption over a short path (1 cm or less).

Measurement of liquid water, or more properly condensed water, is an important and classical question. The capacity of clouds to produce precipitation depends directly on their concentration of condensed water. Although inertial separation and evaporation present certain problems, three instruments have been devised for determining the condensed water content of clouds: a porous metal plug (by Vonnegut), a paper tape device (by Warner), and a hot wire device. The porous plug is probably the most direct and most promising.

Heinz Kasemir (ESSA) briefly described the various kinds of airborne instruments that are used at the present time to measure each of the following electric parameters: electric field, electric conductivity, air-earth current density, space charge, precipitation charge, corona discharge, and lightning discharge. Since many of the instruments are "homegrown," it is often difficult to compare measurements made with different instruments. Thus, it is essential that comparison tests be made.

Larry G. Davis (Pennsylvania State University) discussed investigation of mesometeorological cloud parameters by proximity soundings and application of airborne radar. Proximity soundings by aircraft, ascending balloons, rockets, or dropsondes are used to measure such parameters as relative humidity, lapse rate, and the mean distribution of temperature. The major problem with all proximity soundings is instrument lag. Remote temperature-sensing devices, such as infrared radiometers, show some promise as an alternative to proximity soundings. Airborne radar gives meaningful data in concurrent time and is used for qualitative analysis of circulation and hydrometeors.

Another approach to understanding atmospheric processes is to develop numerical models of clouds, based on the following parameters: vertical velocity in the cloud, height and extent of the cloud base, wind, temperature, water vapor and liquid water content, and height of the top of the cloud.

Techniques for measuring cloud turbulence were discussed by *Paul MacCready (Meteorology Research, Inc.)*. When an aircraft is used for cloud turbulence studies, two kinds of measurements must be made: measurement of air flow relative to aircraft motion and measurement of aircraft motion relative to the ground. For measurement of atmospheric motions with short wavelengths MacCready feels the aircraft, itself, can be considered a stable platform, but for longer wavelengths a stable platform inside the aircraft is required.

Good, but expensive, systems are available today for measuring turbulence in clouds. MacCready thinks it is possible for a meteorologist to put together a relatively good system quite inexpensively by making some of the components himself. Such a

A

ESSA DC-6. Temperature probe and Johnson-Williams liquid water content probe mounted on top of the aircraft, and two radomes.

B

Meteorology Research, Inc. Aztec. Foil precipitation particle sampler on the under side of the wing and an electric field mill on the nose cone.

C

South Dakota School of Mines and Technology Apache. A universal turbulence indicator and a Johnson-Williams liquid water content probe on the upper side of the nose; reverse-flow temperature units and potential gradient probes mounted on the wing.

D

Apparatus mounted inside NCAR Queen Air 80 for sampling water vapor in the atmosphere. Air is pumped through cold traps consisting of copper U-tubes coated with a mixture of dry ice and butyl ether. The water vapor condenses on the walls of the U-tubes.

E

NCAR Queen Air 80. Venturi tubes mounted on the side, intakes on top of the aircraft for air-sampling equipment inside, and a radome on the nose.

F

North American Aviation Sabreliner. Boom-mounted gust probe.

G

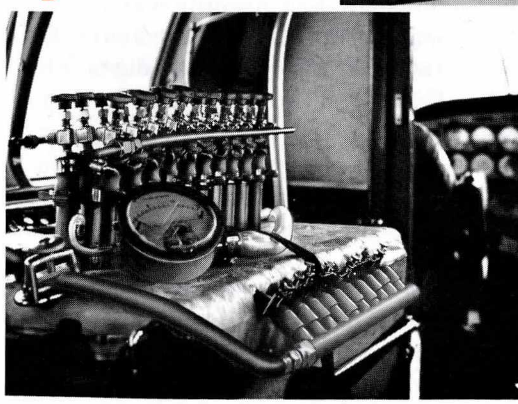
NCAR Queen Air 80. Zinc sulfide particle detectors (belonging to E. Bollay Associates, Inc.) protrude from the nose.

A

B

C

D



E

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system would be sufficiently accurate for measuring wavelengths of 2-3 km or less.

MacCready's report was controversial and stimulated much discussion. Many people thought he had oversimplified the problem of measuring cloud turbulence.

Data Handling

This session was chaired by *Stig A. Rossby (University of Wisconsin).* Rossby feels that a major problem faced by meteorologists today is the problem of communicating their needs to engineers. Since it is impossible for meteorologists to be entirely competent in the field of engineering, it is essential that they define their problems and requirements and communicate them to engineers in language that the engineers can understand.

Eugene V. Kosso (Desert Research Institute) described a real-time telemetry system, which was actually used on a Desert Research Institute twin-engine Beech aircraft last summer. The system, which has a total of 32 channels, uses an M-33 radar unit on the ground, a 16-channel multiplexer, a demultiplexer, an analog to digital (A-D) converter, and a digital plotter on the output. The advantage of real-time telemetry, as opposed to on-board recording, is that a scientist on the ground can receive information from airborne equipment about an atmospheric phenomenon at the time it is occurring.

Earl V. Peterson (NASA) gave a brief description of the NASA Convair 990 research aircraft and discussed management of data on it for scientific research programs. The Convair 990 is a four-engine jet transport, which is capable of flying at 40,000 ft and has a range of approximately 3300 n mi. It has been specially modified for use in aeronautic and space science research. Many different experiments can be conducted simultaneously and up to 40 people can be accommodated on board the aircraft at the same time. On each flight NASA tries to bring together experimenters with common interests and the same flight requirements.

The Convair 990 can be instrumented with a variety of probes, but when several experimenters are interested in measuring the same parameter, an attempt is made to use just one instrument. Certain standard data are always recorded, time-lapse photographs of cloud cover are taken throughout each flight, and a central means of time synchronization is provided. This information is available to all experimenters following the flight. Each experimenter records all other data on his own equipment.

Albury J. Dascher (NCAR) described NCAR's Aircraft Research Instrumentation System (ARIS), an on-board data acquisition and recording system. ARIS accepts four different types of input data: digital data, low-level analog data, high-level analog data, and voice comments.

Standard half-inch, eight-track magnetic tape is used, with four tracks for digital data, three for analog data, and one for voice comments. The magnetic tape generated by the airborne portion of ARIS is brought back to the laboratory and run through the ground portion of ARIS, which produces three kinds of permanent output records: strip charts, printed-page digital records, and computer-compatible magnetic tapes.

The computer-compatible tape is then sent to the Control Data 6600 computer where the data are analyzed and the output is automatically recorded in graphic or tabular form by a dd80 high-speed output recorder. If a computer program has previously been prepared, the time from the end of the flight to receipt of analyzed data can be as short as two hours.

Pleasant T. Cole (NASA) gave a brief history of some of NASA's instrumentation problems and described some of the devices NASA has developed or helped to develop, such as long-life tape heads, brushless motors, and tapes with extended packing density.

Evening Session

The speaker at the evening session was *Professor Hans G. Müller, Director, Institute for Atmospheric Physics, Munich, Germany,* who briefly described some of the atmospheric research programs that are currently being conducted at the Institute.

Research Aircraft Fly-In

Following the technical sessions of the symposium the participants had an opportunity to inspect the atmospheric research instrumentation installed in the following aircraft:

- ESSA DC-6
- Litton Systems, Inc. B-17
- Meteorology Research, Inc. Aztec
- Mitre Corporation C-54
- National Research Council of Canada T-33
- NCAR Queen Air 80 (two)
- North American Aviation Sabreliner
- Pennsylvania State University Aero Commander
- South Dakota School of Mines and Technology Apache
- Weather Science, Inc. Aztec

One of the major accomplishments of the symposium was that it brought together meteorologists and engineers to discuss a variety of problems related to the design and application of aircraft instrumentation for atmospheric research. It also made the meteorologists aware of new technology which may be applicable to atmospheric measurements and, finally, it provided an opportunity for furthering basic understanding between meteorologists and engineers of each other's language and problems.

The symposium was sponsored by ESSA, NCAR, and the American Meteorological Society. The Federal Aviation Agency Aeronautical Center at Will Rogers Airport was the host organization. ●

Scheduled Flight Support

NCAR Research Aviation Facility

Flight support scheduled by the NCAR Research Aviation Facility for January through August 1967 is listed below. An asterisk indicates continuing programs in which the experiment remains essentially unchanged.

Investigation of the Kinematic and Dynamic Structure of Lee-Wave and Wind Patterns; D. Lilly (NCAR). Temperature, pressure, humidity, air speed, and wind parameters will be recorded. Boulder, Colo.; 20 flights, 15,000 to 25,000 ft.; Jan.-Mar.

Thunderstorm Electrification Study; W. Evans (University of Arizona). Instrument package will be ejected from the aircraft into active thunderstorms to collect data on the electric field and conductivity within the clouds. Tucson, Ariz.; 50 flights, 25,000 ft. to aircraft ceiling; Jul.-Aug.

Investigation of Cumulus Convection Associated with Sea Breezes and Other Larger Scale Circulations; J. Levine (University of Texas). Galveston-Port Arthur area, Tex.; Jun.

***Sampling of Natural Ice Nuclei and Ice Crystals;** J. Rosinski and G. Langer (NCAR). Background data will include temperature, humidity and altitude. Boulder, Colo., and Bemidji, Minn.; Jan.-Aug.

***Investigation of Diffusion Characteristics in Mountainous Terrain;** E. Bollay Associates, Inc. (Boulder, Colo.). Aircraft observations of ground-released ZnS tracer and AgI seeding nuclei will be recorded as well as temperature, pressure, humidity and wind. Steamboat Springs, Colo.; Jan.-Mar.

Line Islands Experiment; Universities, NCAR, and Government Agencies. Temperature, pressure, humidity, air speed and wind parameters will be recorded on magnetic tape while a visual record is being made by time-lapse cameras. Line Islands region, Pacific Ocean; Feb.-Apr.

Observational Study of Texas Gulf Coast Sea Breeze; A. Eddy (University of Texas). Temperature, humidity, pressure, and wind will be recorded. Galveston-Port Arthur area, Tex.; 15 flights, ground level to 20,000 ft.; Jun.

***Infrared Radiometry for Water Surface Temperature Mapping and for Ascertaining Whether Moisture Structure can be Determined by IR Techniques;** R. Ragotzkie (University of Wisconsin). Line Islands region, Pacific Ocean; Feb.-Apr.

Cloud Electrification Study; C. Moore (New Mexico Institute of Mining and Technology). Temperature, altitude, position, heading, air speed, potential gradient, and conductivity will be recorded. Socorro, N. Mex.; Jul.-Aug.

***Flight Test and Evaluation of Equipment for the Measurement of Liquid Water Content, Humidity, Radar Altitude, Wind and Radar Cloud Echoes;** E. Brown (NCAR). Boulder, Colo., and other geographic areas; as required.

***Thunderstorm Studies Using a Dropsonde System;** R. Bushnell (NCAR). Temperature, pressure, altitude, air speed and position will be recorded. Dropsondes will be ejected from the aircraft into the tops of thunderstorms and growing cumulus. Northeast Colo.; Jun.-Jul.

***Sampling of Aerosols, Radioactivity, Water Vapor and Trace Gases;** I. Blifford, D. Ehhalt, J. Shedlovsky (NCAR). Background data will include temperature, humidity, altitude, and air speed. Vertical sampling flights to 30,000 ft are conducted over the eastern Pacific Ocean, near Death Valley and near Scottsbluff, Nebr.; Jun.-Aug.

***Investigation of Feasibility of Determining Vertical Ozone Distribution and Total Ozone Content from the Atmospheric Albedo in the Ultraviolet;** R. Bettinger (University of Maryland). Spectral measurements of the earth's surface albedo will be obtained. Palestine, Tex.; one flight (coordinated with a high-altitude balloon flight), about 30,000 ft.; Aug.

Investigation of Use of Radon and Radon-Daughter Ions as Tracers in the Convective and Electrical Environments of the Atmosphere; M. Wilkening (New Mexico Institute of Mining and Technology). Radon and radon-daughter ions will be collected and potential gradient, conductivity, and temperature will be recorded. Socorro, N. Mex.; Jul.-Aug. ●

Balloon Flight Record

Date (1966)	Location	Sponsor	Investigator	Flight operation conducted by	Balloon specs (volume in cu ft; polyethylene unless specified)
(1966) Jun 10	Palestine	NASA	J. Arnold (UCSD)	NCAR	360,000; 1.5 mil
" 12	"	AFOSR	R. Haymes (Rice U.)	"	10.6 million; 0.7 mil
" 14	"	NASA	K. McCracken (SWCAS)	"	5.25 million; 0.70 mil
" 16	"	"	"	"	5 million; 0.75 mil
" 21	Holloman AFB	"	J. Payne (AFCRL)	AFCRL	250,000; 0.5 mil
Jun 22	Chico	AFCRL, RADC	Nolan (AFCRL)	AFCRL	360,000; 2.0 mil
" 23	Palestine	NASA	J. Arnold (UCSD)	NCAR	190,000; 1.5 mil
" 24	Chico	AFCRL, RADC	Nolan (AFCRL)	AFCRL	360,000; 2.0 mil
" 28	"	"	"	"	"
" 30	Holloman AFB	"	R. Howard (AFCRL)	"	803,000; 2.0 mil
Jul 1	Palestine	ONR	J. Waddington (U. Minn.)	NCAR	6 million; 0.5 mil
" 6	"	NASA	G. Frye (Case Inst.)	"	10.6 million; 0.5 mil
" 6	Holloman AFB	AFCRL	A. Howell (Tufts U.)	AFCRL	803,000; 2.0 mil
" 8	Carrizozo	"	D. Murcray (U. Denver)	"	242,186; 1.5 mil
" 9	Palestine	NASA	W. McDonald (Cal Tech)	NCAR	5 million; 0.75 mil
Jul 9	Palestine	NASA	G. Clark (MIT)	NCAR	9 million; 0.75 mil
" 10	"	"	W. McDonald (Cal Tech)	"	5 million; 0.75 mil
" 12	Holloman AFB	AFCRL, Georgia Tech.	R. Toolin (AFCRL)	AFCRL	4.85 million; 0.75 mil
" 12	Palestine	NASA	J. Lord (U. Wash.)	NCAR	600,000; 0.75 mil
" 15	Holloman AFB	AFCRL	Giannetti (AFCRL)	AFCRL	1.154 million; GT-12 scrim
Jul 18	Holloman AFB	NASA	J. Payne (AFCRL)	AFCRL	26 million; GT-111-1, GT-12 scrim
" 18	Palestine	"	G. Clark (MIT)	NCAR	10.6 million; 0.50 mil
" 18	"	"	G. Frye (Case Inst.)	"	"
" 20	Holloman AFB	AFCRL	A. Korn (AFCRL)	AFCRL	125,426; 2.0 mil
" 23	Chico	"	L. Grass (AFCRL)	"	904,780; 1.5 mil Mylar
Jul 23	Palestine	NASA	L. Alvarez (U. Calif.)	NCAR	2.94 million; 1.0 mil
" 26	"	"	G. Frye (Case Inst.)	"	10.6 million; 0.5 mil
" 28	"	"	K. Frost (GSFC)	"	10.6 million; 0.7 mil
" 29	Chico	AFCRL	L. Grass (AFCRL)	AFCRL	904,780; 1.5 mil Mylar
" 31	Palestine	NASA	G. Frye (Case Inst.)	NCAR	9 million; 0.75 mil

States or Provinces for Flight Record locations:

Camp Atterbury, Indiana
Carrizozo, New Mexico
Chico, California
Clifton/Morenci, Arizona
Fallon, Nevada
Flin Flon, Manitoba
Ft. Churchill, Manitoba
Holloman AFB, New Mexico
Lordsburg, New Mexico
Palestine, Texas
Roswell, New Mexico

Float altitude (ft)	Flight duration (hr)	Payload (lb)	Experiment	Remarks (* Successful flight)
30,000	8.6	516	Measurement of micrometeoritic dust	*
128,000	3.2	1005	Gamma ray study of Crab Nebula	Flight terminated early; power failure in gondola
--	--	538	"	Normal ascent to about 8000 ft, then descent; ballasting produced no noticeable effect; beacon antenna did not deploy
125,000	7.5	558	"	Payload damaged after parachute impact
128,000	6	10	Voyager pathfinder balloon test	*
--	2.2	990.5	Minimum wind investigation	Balloon burst at 54,750 ft
70,000	1.0	501.5	Measurement of micrometeoritic dust	Collection screen did not deploy; command cut down
70,000	30	989.5	Minimum wind investigation	*
--	1.7	986	Minimum wind investigation	Balloon burst at 47,000 ft
87,000	3	606	Balloon destruct tape test	*
138,500	9.0	326	Nuclear emulsions	Emulsion stack torn from support bracket in gondola
139,000	10.8	644	Gamma ray spark chamber	Scaler or gondola malfunction shortly after launch; command cut down 10 min before programmed cut down
81,500	25	1000	Causes of tropopause balloon failures	*
64,500	4.5	1010	IR analysis of rock formations	*
--	--	613	Cosmic ray measurements	Launch malfunction
135,000	3.5	617	Gamma ray telescope	Flight terminated early; malfunctioning beacon indicated balloon floating at unsatisfactory altitude
126,000	5.8	615	Cosmic ray measurements	*
118,000	7.5	911	Measurement of spectral distribution of natural sky radiation	*
108,000	8.7	229	Emulsion stack test	*
58,000	2.5	6628.5	Parachute and balloon wire destruct tests	*
126,200	7.5	3627	Balloon test for Voyager program	*
132,000	7.6	730	Gamma ray telescope	Deteriorating weather conditions forced early termination; main scientific objectives achieved
134,000	3.6	659	Gamma ray spark chamber	Flight terminated early to avoid Mexico
59,400	1.0	661	Balloon destruct and UHF relay test	*
100,000	4.6	300	Superpressure balloon evaluation	Balloon leaked
95,000 - 103,800	6.9	1280	Measurement of high energy particles	*
135,000	5	656	Gamma ray spark chamber	Flight terminated early to avoid Mexico
136,000	6.7	609	Gamma ray study of Crab Nebula and Sun	*
97,909	106	250	Superpressure balloon test	*
135,000	11.2	697	Gamma ray spark chamber	*

Balloon Flight Record

Date (1966)	Location	Sponsor	Investigator	Flight operation conducted by	Balloon specs (volume in cu ft; polyethylene unless specified)
(1966) Aug 4	Palestine	NASA	J. Overbeck (MIT)	NCAR	5 million; 0.75 mil
" 5	"	"	E. Chupp (UNH)	"	3 million; 0.55 mil
" 6	"	"	L. Peterson (UCSD)	"	"
" 8	Holloman AFB	AFCRL	J. Essex (AFCRL)	AFCRL	2.01 million; 1.5 mil
" 10	Palestine	AFOSR	R. Haymes (Rice U.)	NCAR	10.6 million; 0.70 mil
Aug 14	Palestine	NASA	C. Hemenway (Dudley Obs.)	NCAR	1.25 million; 1.0 mil
" 15	Chico	AFCRL	D. Cunningham (AFCRL)	AFCRL	803,000; 2.0 mil
" 15	Holloman AFB	"	Clemenson (AFCRL)	"	40,575; 2.0 mil
" 16	Palestine	NSF	R. Huggett (LSU)	NCAR	3 million; 0.75 mil
" 17	Chico	AFCRL	A. Howell (Tufts U.)	AFCRL	803,000; 2.0 mil
Aug 17	Holloman AFB	AFCRL	Clemenson (AFCRL)	AFCRL	40,575; 2.0 mil
" 17	Palestine	NASA	A. Barrett (MIT)	NCAR	5 million; 0.75 mil
" 19	Flin Flon	ONR, NSF	K. Anderson (U. Calif.)	GTS	250,000; 0.5 mil
" 22	Chico	AFCRL	D. Cunningham (AFCRL)	AFCRL	802,000; 2.0 mil
" 23	Flin Flon	ONR, NSF	K. Anderson (U. Calif.)	GTS	250,000; 0.5 mil
Aug 23	Flin Flon	ONR, NSF	K. Anderson (U. Calif.)	GTS	3 million; 0.5 mil
" 25	Ft. Churchill	"	"	"	100,000; 0.5 mil
" 26	Holloman AFB	NASA	C. Fichtel (NASA)	AFCRL	10.575 million; 0.7 mil
" 26	Flin Flon	ONR, NSF	K. Anderson (U. Calif.)	GTS	250,000; 0.5 mil
" 26	Palestine	NASA	A. Barrett (MIT)	NCAR	5 million; 0.75 mil
Aug 26	Palestine	NCAR	H. Baker (NCAR)	NCAR	9 million; 0.75 mil
" 29	Holloman AFB	AFCRL	D. Murcray (U. Denver)	AFCRL	2 million; 1.5 mil
" 29	Ft. Churchill	ONR, NSF	K. Anderson (U. Calif.)	GTS	100,000; 0.5 mil
" 29	"	"	"	"	"
" 29	"	"	"	"	"
Aug 29	Flin Flon	ONR, NSF	K. Anderson (U. Calif.)	GTS	3 million; 0.5 mil
" 29	"	"	"	"	"
" 30	Roswell	NASA	J. Payne (AFCRL)	AFCRL	26 million; GT-111-1, GT-12
Sept 1	Flin Flon	ONR, NSF	K. Anderson (U. Calif.)	GTS	250,000; 0.75 mil
" 1	"	"	"	"	3 million; 0.5 mil
Sept 2	Holloman AFB	NASA	E. Boldt (GSFC)	AFCRL	10.575 million; 0.75 mil
" 2	Flin Flon	ONR, NSF	K. Anderson (U. Calif.)	GTS	3 million; 0.5 mil
" 2	Ft. Churchill	"	"	"	100,000; 0.5 mil
" 2	Palestine	AFOSR	R. Haymes (Rice U.)	NCAR	9 million; 0.75 mil
" 3	"	NASA	L. Peterson (UCSD)	"	3 million; 0.55 mil

Float altitude (ft)	Flight duration (hr)	Payload (lb)	Experiment	Remarks (* Successful flight)
129,800	6.4	543	Gamma ray measurement from star remnants	Command cut down; explosion of insulation caused ascent of balloon above float altitude and disappearance of telemetry
127,600	3.6	403	Measurement of high energy neutrons	*
129,000	8.6	353	Measurement of gamma rays	*
100,000	6.1	792	Albedo measurements, UHF relay test	*
132,500	5.4	1047	Radioactive debris in star remnants	*
112,000	11.0	257	Collection of meteoric dust particles	*
80,000	28	379.5	Balloon control test	*
75,000	5.2	7	Reflectivity of aluminum foil radar targets	*
107,000	0.8	1267	Ultrahigh energy nuclear physics study	Early termination; power failure and loss of pressurization in gondola
83,400	6.4	1007	Causes of tropopause balloon failures	*
75,000	4.1	7	Test of radar reflective materials	*
125,000	6.2	694	Measurement of oxygen spectrum	*
110,300	14	42	X-ray counter	*
80,000	30.3	1203	Balloon control study	*
73,000	1.54	41	X-ray counter	Balloon burst at 73,000 ft
129,600	38.5	156	X-ray counter	*
111,000	12	23	X-ray counter	*
131,000	12.1	756	X-ray study of Crab Nebula and other sources	Reel-down of payload
47,000	2.15	38	X-ray counter	Leaker; climber to 47,000 ft before descending
125,000	6.5	688	Measurement of oxygen spectrum	*
--	--	589	Vista-Dome operational capability test	Balloon burst at 62,000 ft
98,000	3.4	1036	IR measurements	*
111,000	17	23	X-ray counter	*
47,000	1	23	X-ray counter	Balloon burst at 47,000 ft; 90-knot winds at 25,000 ft
25,000	0.5	23	X-ray counter	Balloon burst at 25,000 ft; severe shear winds at 25,000 ft
130,000	85	155	X-ray counter	Timer failure; 85-hr telemetry received
131,000	38	167	X-ray counter	*
128,180	3.6	3562	Voyager parachute test	*
107,000	37.15	40	X-ray counter	*
126,400	54	154	X-ray counter	*
129,000	11.5	809	Cosmic ray measurements	*
128,300	54	149	X-ray counter	*
111,000	20	24	X-ray counter	*
130,000	1.1	1082	Radioactive debris in Crab Nebula	Flight terminated early; damage to telemetry antenna at launch caused telemetry failure
--	--	380	Measurement of x-ray flux from star remnants	Balloon ripped at launch

Balloon Flight Record

Date (1966)	Location	Sponsor	Investigator	Flight operation conducted by	Balloon specs (volume in cu ft; polyethylene unless specified)
(1966) Sept 4	Ft. Churchill	ONR, NSF	K. Anderson (U. Calif.)	GTS	100,000; 0.5 mil
″ 4	Flin Flon	″	″	″	250,000; 0.75 mil
″ 5	″	″	″	″	3 million; 0.5 mil
″ 5	Palestine	NASA	J. Lord (U. Wash.)	NCAR	360,000; 0.75 mil
″ 5	″	″	L. Peterson (UCSD)	″	3 million; 0.55 mil
Sept 6	Ft. Churchill	ONR, NSF	K. Anderson (U. Calif.)	GTS	100,000; 0.5 mil
″ 6	″	″	″	″	″
″ 6	Flin Flon	″	″	″	3 million; 0.5 mil
″ 7	Holloman AFB	NASA	C. Fichtel (NASA)	AFCRL	10.6 million; 0.7 mil
″ 7	Ft. Churchill	ONR, NSF	K. Anderson (U. Calif.)	GTS	250,000; 0.5 mil
Sept 7	Flin Flon	ONR, NSF	K. Anderson (U. Calif.)	GTS	3 million; 0.5 mil
″ 7	″	″	″	″	250,000; 0.5 mil
″ 8	Ft. Churchill	″	″	″	″
″ 8	Flin Flon	″	″	″	3 million; 0.5 mil
″ 8	″	″	″	″	″
Sept 9	Flin Flon	ONR, NSF	K. Anderson (U. Calif.)	GTS	3 million; 0.5 mil
″ 13	Palestine	NASA	L. Peterson (UCSD)	NCAR	3 million; 0.55 mil
″ 16	Ft. Churchill	ONR, NSF	K. Anderson (U. Calif.)	GTS	500,000; 0.5 mil
″ 17	″	″	″	″	250,000; 0.5 mil
″ 18	″	″	″	″	″
Sept 19	Palestine	NASA	J. Overbeck (MIT)	NCAR	5 million; 0.75 mil
″ 20	″	″	L. Peterson (UCSD)	″	3 million; 0.55 mil
″ 21	Holloman AFB	AFCRL	D. Murcray (U. Denver)	AFCRL	2 million; 1.5 mil
″ 21	Palestine	NASA	L. Peterson (UCSD)	NCAR	4 million; 0.70 mil
″ 25	″	NCAR	A. Kruger (NOTS)	″	180,000; 0.55 mil
Sept 27	Holloman AFB	AFCRL	J. Ely (AFCRL)	AFCRL	4.85 million; 0.75 mil
Oct 5	Chico	″	J. Dwyer (AFCRL)	″	3.34 million; Mer Fab scrim
″ 6	Palestine	NCAR	J. Sparkman (NCAR)	NCAR	110,000; 2.0 mil
″ 6	″	U. Bristol	P. Fowler (U. Bristol)	″	5 million; 0.75 mil
″ 7	Chico	AFCRL	Crummie (AFCRL)	AFCRL	2 million; 1.5 mil
Oct 12	Lordsburg	AFCRL	L. Grass (AFCRL)	AFCRL	1.6 million; scrim
″ 12	Chico	″	Crummie (AFCRL)	″	2.01 million; 1.0 mil
″ 15	Palestine	NASA	G. Clark (MIT)	NCAR	9 million; 0.75 mil
″ 16	″	ONR	J. Waddington (U. Minn.)	″	10.6 million; 0.5 mil
″ 18	Chico	AFCRL	Crummie (AFCRL)	AFCRL	2.94 million; 1.5 mil

Float altitude (ft)	Flight duration (hr)	Payload (lb)	Experiment	Remarks (* Successful flight)
111,000	20	24	X-ray counter	*
108,600	37	38	X-ray counter	*
130,600	54	127	X-ray counter	*
102,000	– –	210	Emulsion stack test	Command and termination timer failure
128,000	10.0	380	Measurement of x-ray flux from star remnants	Only partial scientific data obtained due to gondola malfunction
– –	20	24	X-ray counter	Unsuccessful flight
111,000	20	24	X-ray counter	*
64,000	3	130	X-ray counter	Leaker; descended from 64,000 ft
134,000	13.2	750	Gamma radiation study	*
– –	20	51	X-ray counter	Unsuccessful flight
13,000	4	126	X-ray counter	Rain squall at launch; balloon rose to 19,500 ft then descended to 13,000 ft before cut down
121,000	36	36	X-ray counter	*
117,000	20	51	X-ray counter	*
130,000	36	130	X-ray counter	*
122,000	37	137	X-ray counter	*
128,500	37	74	X-ray counter	*
128,000	5.5	397	Measurement of x-ray flux from star remnants	Flight terminated early; telemetry link failed; partial data obtained
– –	0.25	60	X-ray counter	Balloon burst at 17,000 ft
– –	20	57	X-ray counter	No radar available for tracking
– –	20	57	X-ray counter	No radar available for tracking
128,000	10.5	575	X-ray measurements	*
128,000	7.6	373	Measurement of x-ray flux from star remnants	*
98,000	5.2	1034	IR study of rocks	*
128,000	15.0	404	X-ray study of star remnants	*
113,000	3.0	32	Ozone detector test	*
– –	1.4	500	Cosmic radiation measurements	Balloon burst at 64,000 ft
112,000	6.5	115	Evaluation of dacron reinforced polyethylene	*
– –	– –	4418	Inflation and launch test	Unsuccessful flight
124,500	14.5	780	Emulsion stack test	*
98,000	27	1000	Test of VOR balloon locating system and HF antenna	*
75,500	7	3173	Raven scrim balloon system test	*
96,800	30	1000	Test of VOR balloon locating system and HF antenna	*
– –	– –	840	Gamma ray telescope	Balloon burst at 44,800 ft
137,000	4.9	1003	High energy gamma ray measurements	*
128,000	23	900	Test of Voyager data link system and VOR balloon locating system	*

Balloon Flight Record

Date (1966)	Location	Sponsor	Investigator	Flight operation conducted by	Ballon specs (volume in cu ft; polyethylene unless specified)
(1966) Oct 19	Holloman AFB	AFCRL	R. Howard (AFCRL)	AFCRL	804,000; 2.0 mil
" 19	Chico	"	L. Lloyd (U. Calif.)	"	3 million; 0.55 mil
21	Holloman AFB	"	R. Howard (AFCRL)	"	804,000; 2 mil
" 25	"	"	K. Greisen, J. Delvaille (Cornell U.)	"	5.025 million; 1 mil
" 25	Palestine	NASA	T. Gehrels (U. Arizona)	NCAR	3.98 million; 1.0 mil
Oct 27	Clifton Morenci	AFCRL	H. Prevett (AFCRL)	AFCRL	10 million; 0.5 mil
" 27	Palestine	NASA	J. Lord (U. Wash.)	NCAR	1.11 million; 0.75 mil
" 31	"	NCAR, NASA	K. Kiepenheuer (Fraunhofer Inst.)	"	147,000 and 3.2 million; Mylar scrim
Nov 2	Holloman AFB	AFCRL	J. Payne (AFCRL)	AFCRL	1.6 million; GT-99 scrim
" 2	Palestine	NASA	W. Hoffmann, N. Woolf (GSFC)	NCAR	360,000; 0.75 mil
Nov 10	Holloman AFB	AFCRL	R. Howard (AFCRL)	AFCRL	511,000; 2.0 mil
" 10	Palestine	NASA	C. Hemenway (Dudley Obs.)	NCAR	1.25 million; 1.0 mil
" 17	Fallon	NASA	C. Czepyha (AFCRL)	AFCRL	1.15 million; 2 mil scrim
" 17	Palestine	NASA	C. Hemenway (Dudley Obs.)	NCAR	1.25 million; 1.0 mil
" 18	Holloman AFB	"	Serlemitsos (GSFC)	AFCRL	10.575 million; 0.7 mil
Nov 20	Palestine	NSF, NASA	K. Kiepenheuer (Fraunhofer Inst.)	NCAR	147,000 and 3.2 million; GT-12 Mylar scrim
" 28	Holloman AFB	AFCRL	Steinke (AFCRL)	AFCRL	511,000; 2.0 mil
" 29	"	"	D. Murcray (U. Denver)	"	2 million; 1.5 mil
" 30	"	"	Crummie (AFCRL)	"	2.01 million; 1.0 mil
Dec 3	Camp Atterbury	NOL	G. Martin (NOL)	Raven	80,000; Egyptian cotton
" 8	Holloman AFB	AFCRL	Aube (AFCRL)	AFCRL	125,426; 2.0 mil
" 9	"	"	Crummie (AFCRL)	"	2.01 million; 1.0 mil

Float altitude (ft)	Flight duration (hr)	Payload (lb)	Experiment	Remarks (* Successful flight)
60,000	1	673	Internal balloon pictures of rip tape action	*
105,000	9	350	X-ray measurements	*
61,400	2	534	Internal balloon pictures of rip tape action	*
108,500	29	1608	Study of high energy cosmic photons	*
119,000	9.3	685	UV, brightness, and polarization measurements of sky	Telemetry link failed; no useful scientific data obtained
145,000	4	212	Balloon performance test; altitude measurements	*
109,600	7.1	412	Emulsion stack test	Flight terminated early to insure safe recovery
– –	– –	4479	Test of photographic system	Flight aborted before launch; wind at top balloon level
88,000	4	1656	Balloon recovery system test	*
97,500	4.5	232	IR study	*
80,300	3	642	Rip tape and camera system test	*
113,400	8.5	238	Collection of meteoric dust particles	*
65,900	3	4183	Balloon test; development of balloon-borne instrumentation deployment system	*
113,000	7.3	225	Collection of meteoric dust particles	Collector failed to close
132,000	13.5	545	X-ray and cosmic ray study	*
84,500	5.7	4489	Fraunhofer Zeiss telescope test	*
81,200	2.2	756	Balloon destruct test	*
95,500	4	1106	Telluric absorption spectrum	*
62,000	5.2	982	VOR test flight	*
8,000	24	560	Tethered balloon test	Winch pulley failure severed fiberglass cable; balloon destroyed
55,500	5.18	804	Evaluation of reel	*
98,000	7.2	422	VOR test flight	*

Balloon Flight Record

	Date (1964-66)	Location	Sponsor	Investigator	Flight operation conducted by	Balloon specs (volume in cu ft; polyethylene unless specified)
(1964)	Jul 31	Bergen-Hohne	FHG	O. Allkofer, H. Fox	**	135,000; .75 mil
	Aug 21	"	DFG	R. Krieger, G. Wibberenz, G. Green	**	600,000; .75 mil
	" 23	"	FHG	O. Allkofer, H. Fox	**	135,000; .75 mil
	" 23	"	"	"	**	"
(1965)	Jul 17	Kiel-Holtenau	DFG	H. Röhrs, H. Selk	**	2 x 925 gr Darex, 1 x 800 gr Darex multiple balloon
	" 21		"	"	**	"
	Aug 6	Bergen-Hohne	FHG	O. Allkofer, H. Fox	**	600,000; .75 mil
	" 10	"	"	"	**	58,000; .75 mil
	" 11	"	"	"	**	135,000; .75 mil
	" 12	"	"	"	**	600,000; .75 mil
	" 13	"	"	"	**	135,000; .75 mil
	Aug 31	Bergen-Hohne	DFG	D. Köhn, K. Röhrs	**	135,000; .75 mil
	Oct 22	Meppen/Ems	"	H. Röhrs, H. Selk	**	2400 gr Darex balloon
	" 23	"	"	H. Hasler, G Wibberenz	**	600,000; .75 mil
	" 24	"	FHG	O. Allkofer, H. Fox	**	135,000; .75 mil
(1966)	Jun 22	Kiel-Holtenau	DFG	H. Röhrs, H. Selk	**	2 x 925 gr Darex, 1 x 800 gr Darex
	Jun 24	Kiel-Holtenau	DFG	H. Röhrs, H. Selk	**	2 x 925 gr Darex, 1 x 2400 gr Darex
	Aug16	Bergen-Hohne	"	D. Köhn, E. Wildgrube	**	58,000; .75 mil
	" 17	"	"	"	**	"
	" 18	"	"	K. Beuermann, H. Röhrs	**	1 million; .75 mil
	" 19	"	FHG	O. Allkofer, M. Simon	**	135,000; .75 mil
	Upcoming Flights 1966					
	Sept/ Oct	Meppen/Ems	FHG	O. Allkofer, M. Simon	**	135,000; .75 mil 58,000 28,000
		"	DFG	K. Beuermann, H. Röhrs	**	1 million; .75 mil
		"	"	D, Köhn, E. Wildgrube	**	58,000; .75 mil
	Oct/ Nov	"	"	D. Köhn, J. Müller-Glewe	**	1 million; .75 mil

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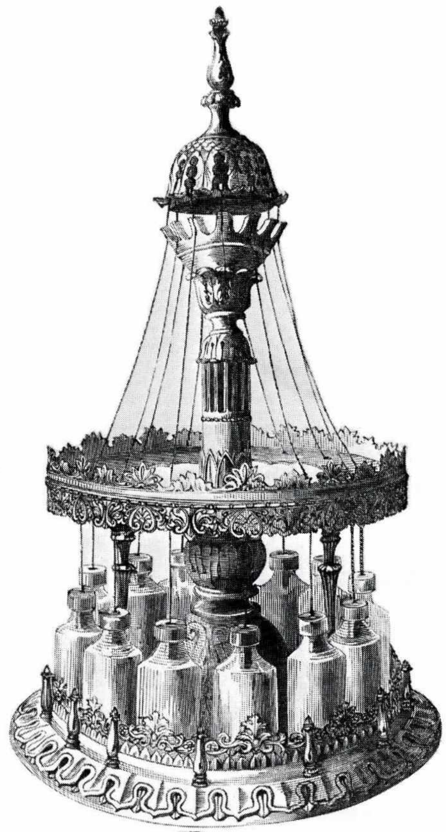
Float altitude (ft)	Flight duration (hr)	Payload (lb)	Experiment	Remarks (* Successful flight)
--	--	123	Dust collector	Cut off at launching
115,000	11.5	90	Charged particle detector (e,p)	*
92,000	5.5	123	Dust collector	*
88,000	6	"	"	*
66,000; up-down flight	2	40	New type of radiosonde and remote control system	*
"	"	"	"	*
112,000	5.5	175	Dust collector	*
72,000	6.5	138	"	*
82,000	2.5	170	"	Balloon leveled off at 82,000 ft and descended; Cut down
112,000	6	"	"	*
87,000	10.5	"	"	*
85,000	3.5	227	Gamma ray detector	*
66,000; up-down flight	1.5	24	Radiosonde and remote control system	*
113,000	8	143	Charged particle detector (Z=2....9)	*
85,000	8	170	Dust collector	*
72,000; flight up-down	3	45	Radiosonde, remote control ballast system	*
91,000	3	25	Radiosonde, remote control ballast system	*
--	--	95	Gamma ray source detector control system	Balloon burst at 43,000 ft
--	--	"	"	"
--	--	122	Low energy particle detector	Balloon leveled off at 125,000 ft and descended, cut down
--	--	170	Dust collector	Balloon burst at 50,000 ft
88,000	10	170	Dust collector	2 flights
72,000	7	"		"
59,000	5	138		
125,000	10	95	Low energy particle detector	
82,000	5	"	Gamma ray source detector control system	
110,000	10	380	High energy gamma ray detector	2 flights

** All flight operations were conducted by the balloon group of the Institute; leader H. Röhrs.
Sponsors were Frauenhofer-Gesellschaft (FHG) and Deutsche Forschungsgemeinschaft (DFG).

The Tempest Prognosticator



TEMPEST PROGNOSTICATOR

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George Merryweather designed this unusual "weather instrument" in 1851. While the inventor's own last name may or may not have implications for the seriousness of the proposal, if his premises are accepted, the design is logical enough. Merryweather began with the assumption from folklore that leeches are sensitive to thunder. By his own observations he concluded further that "It is not the thunder which acts upon the leech, but the electrical state of the atmosphere, which precedes thunder; and for that state of the air, all my experiments tend to prove leeches have the most remarkable sympathy . . . I found . . . that before a storm could take place, there must be a preparatory process in the atmosphere, of which the leech gives unequivocal evidence: and this I found it to do when the weather was fine and undisturbed . . . I took it into my head to surround myself with a jury of . . . twelve leeches, each placed in a separate pint bottle of white glass . . . I invented a metallic tube . . . to insert into the neck of the bottles; to which it would be somewhat difficult for a leech to enter; but which it would enter, and make every effort to do if a storm were preparing . . . Having thus far advanced . . . I found I had a difficulty to contend with, and that was to know if the leeches entered the tubes during my absence, or in the night time; . . . I made a simple contrivance, by placing a bell upon a pedestal, erected on the centre of a circular platform; which bell was surrounded by twelve hammers. From each of these hammers was suspended a gilt chain; each of which played upon a pulley, which was placed in a disk, that was a little elevated above the circle of bottles. By this method every leech could have communication with the bell. One half of the metallic tubes was left open, so that the interior was exposed: across the entrance of each was placed a small piece of whalebone, which was held up by a piece of wire attached to its centre: these wires were passed through the aperture at the top of each tube, and then hooked on to each chain. After having arranged this mouse-trap contrivance, into each bottle was poured rain water, to the height of an inch and a half; and a leech placed in every bottle, which was to be its future residence; and when influenced by the electro-magnetic state of the atmosphere a number of the leeches ascended into the tubes; in doing which, they dislodged the whalebone, and caused the bell to ring.

"The apparatus being now ready for action, I beheld an Atmospheric Electro-magnetic Telegraph, which would communicate to me, at all times, the processes that were taking place in the higher regions of the atmosphere, and for hundreds of miles in extent, and would enable me to foretell, with unerring certainty, any storm that was preparing to take place. The leeches appear to be invited to mount into their respective belfries, to participate in that discharge or descent of free caloric, termed electro-magnetism, which had previously been carried up into the atmosphere by evaporation and radiation. . . ."