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NATIONAL CENTER FOR ATMOSPHERIC RESEARCH

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NCAR

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Editor: William Dryer
Contributing Editors: Ronald Cox, Robert Masterson, Halka Chronic

Art Direction: Bob L. Wyatt

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Cover: Concepts, technological developments, and agency participation continue to expand as planning for the Global Atmospheric Research Program gains momentum. To the artist this suggests a symbolism of world participation.

GHOST Balloons and GARP

GHOST balloons in the stratosphere will provide a pressure reference level and give data on high-level winds. Mother GHOST carrier balloons release dropsondes to measure tropospheric variables. Both systems relay data via satellite.

During the last four years, over 200 test flights have been made with GHOST superpressure balloons in the southern hemisphere as part of NCAR's Global Atmospheric Measurements Program (GAMP). The balloons have performed well in the stratosphere, staying aloft at preestablished pressure levels for three to five months, reporting their locations reliably (except when they drift into the polar night), and providing an unmatched source of upper-level wind data.

However, within the troposphere the balloons have been forced down after only a few days or weeks by ice accumulation on the balloon skins. It now seems impossible to extend the lives of balloons in the troposphere without introducing complex mechanisms that might endanger aircraft. The GAMP group has therefore had to abandon its original concept of thousands of GHOST balloons drifting at several levels and reporting wind and weather data.

GHOST Reference Level

New uses have been found, however, for GHOST balloons flying in the stratosphere. Experiments with the Nimbus 3 satellite in 1969 demonstrated that satellites can measure vertical atmospheric temperature profiles with infrared spectrometers, but that to relate these profiles to height and pressure we must know the pressure at one reference level. A network of GHOST superpressure balloons, carrying radio altimeters and meteorological sensors, can easily provide the necessary reference data from a stratospheric level.

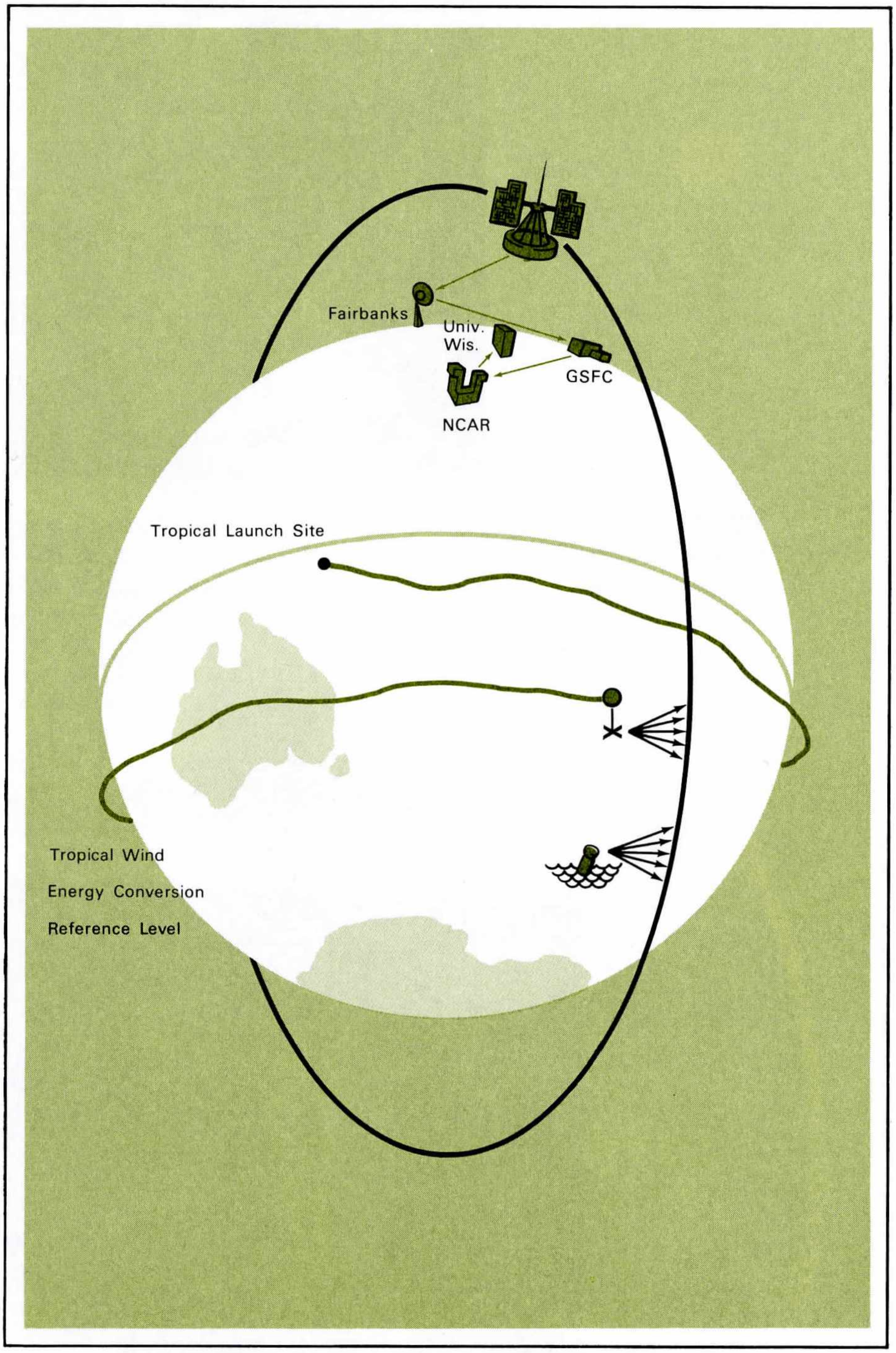
Such balloons, transmitting data to satellites, are part of the design for the Tropical Wind, Energy Conversion, and Reference Level (TWERL) Experiment to be conducted by NCAR, the University of Wisconsin, and NASA's Goddard

Space Flight Center in 1974. The balloons for the TWERL Experiment will randomly transmit their identity and altitude, as well as ambient temperature and pressure, for relay by the orbiting Nimbus F satellite. Balloon signals will be received by the satellite whenever the balloons are within the antenna pattern of the satellite. The balloons will be located by doppler techniques, and wind data will be derived from balloon location on two successive satellite passes.

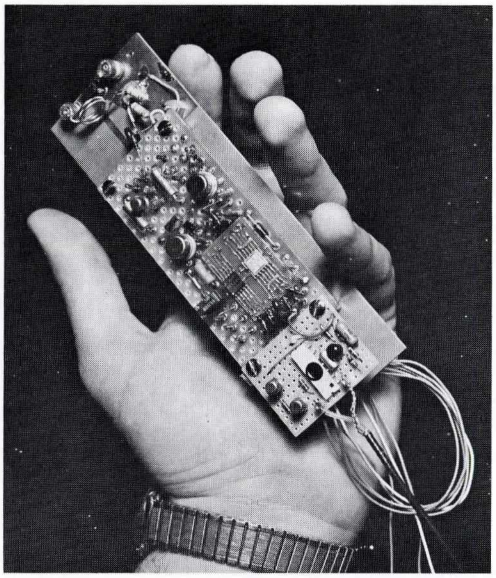
Balloons launched in the tropics will provide data on the dynamics of the tropical wind field. As they drift out of the tropics and into the southern hemisphere middle latitudes, they will provide measurements for a study of energy conversion in the atmosphere and produce a pressure reference level at 150 mb.

Mother GHOST

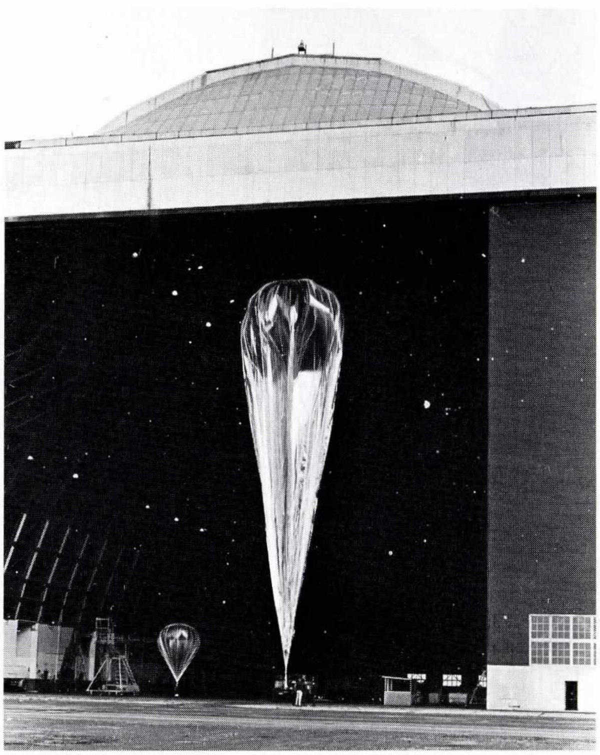
In the tropics—especially at latitudes below about 15°—satellite infrared temperature profiles cannot be used satisfactorily to derive pressure and wind data. However, plans for GARP and GARP-related experiments require that data be obtained in the tropics from at least four tropospheric levels. A new concept in GHOST systems has now been developed at NCAR by Robert W. Frykman, Vincent E. Lally, and Ernest W. Lichfield to obtain wind, temperature, pressure, and humidity data for tropical latitudes. Large superpressure GHOST-type balloons, floating at 30 mb (24 km), will carry packages of small, inexpensive dropsondes which can be released on command. The dropsondes, each of which will weigh only 350 - 400 g, will parachute earthward, taking about 40 min to descend from 24 km. During this time, they will transmit temperature, pressure, and humidity data to the carrier balloon, and will also



GHOST balloons launched in the tropics will later drift into southern latitudes, relaying data for the TWERL Experiment.



A lightweight, miniaturized radio altimeter, developed by Nadav Levanon and Verner Suomi at the University of Wisconsin, will be used with GHOST balloons in the TWERL Experiment. It will give balloon altitude to an accuracy of about 10 m.



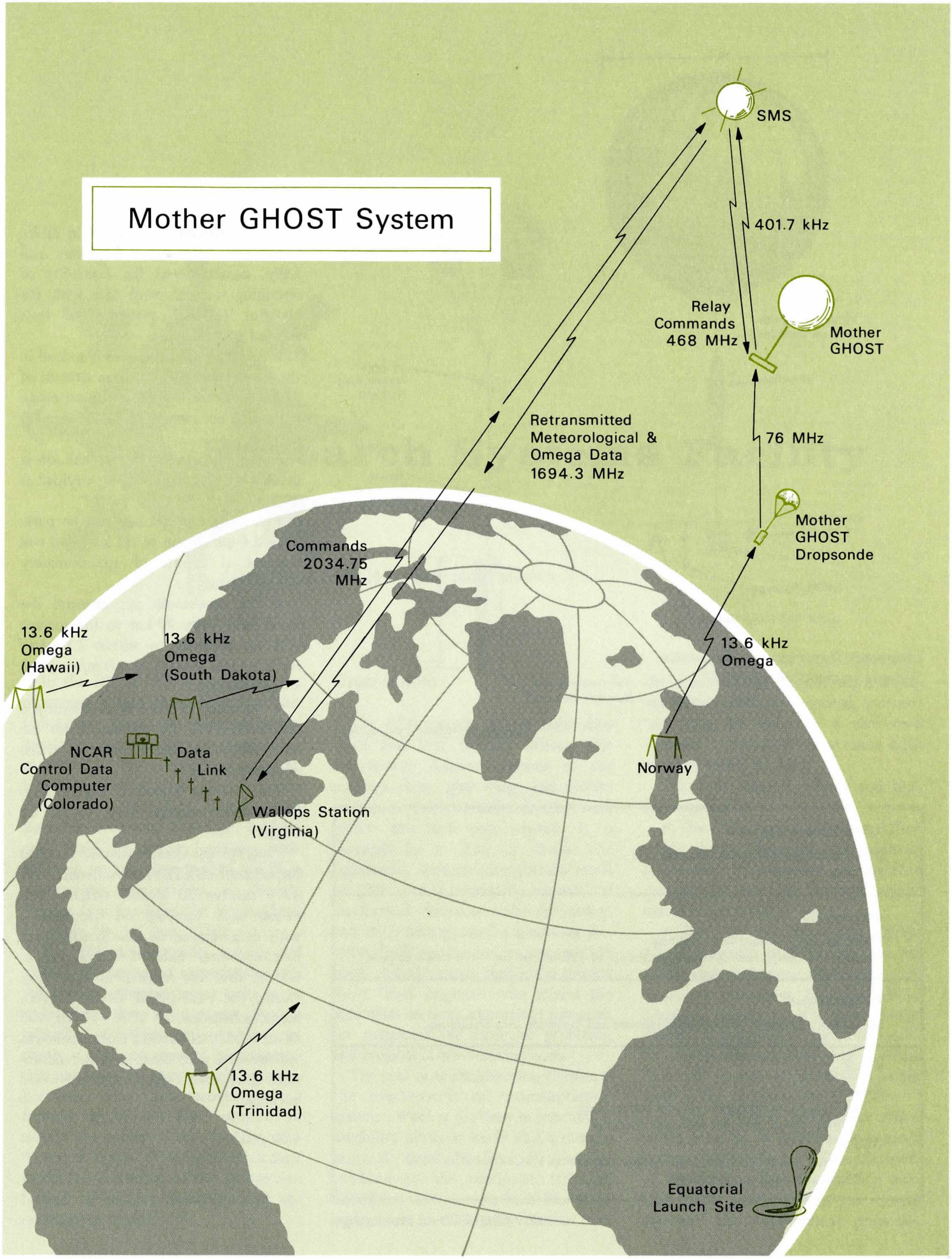
A 22 - m Mother GHOST balloon was tested at Lakehurst, N.J., in July 1970, using a dirigible hangar as an inflation shelter. The small tow balloon at the left gives necessary free lift during early stages of the ascent.

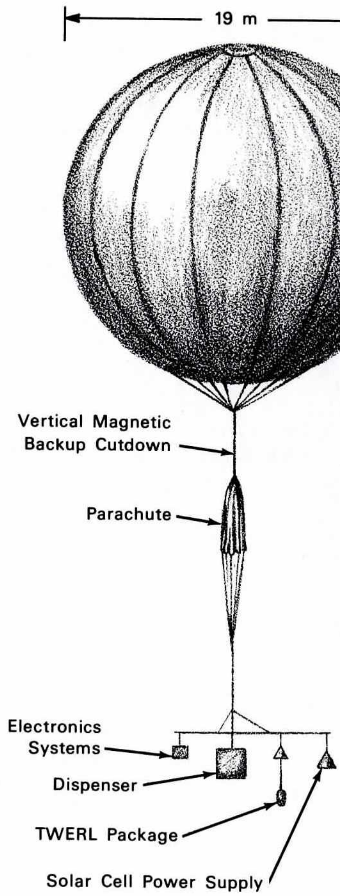
relay 13.6 - kHz signals from Omega navigation transmitters. The VHF signals from the dropsonde will be relayed by the carrier balloon's more powerful wideband transmitter through a satellite link to a ground station——probably the NASA telemetry receiving system at Wallops Station, Va. The temperature, pressure, and humidity data will be used in deriving accurate vertical profiles; sea-level data at the moment of impact will be used as a reference. Phase comparison of signals from three Omega stations will give position readings from which wind velocity can be derived. Mean winds over a 100 - mb atmospheric interval are expected to be accurate to within 1 m/sec.

The carrier balloon, or Mother GHOST, is expected to remain aloft for three to six months when launched in tropical latitudes, and will drift in the zonal flow with only minor latitudinal oscillations. It will release dropsondes as needed——day or night——and no command will be given when the balloon is over land areas where adequate data can be obtained from other sources. The position of the carrier balloon will be determined using the random doppler system planned for the TWERL Experiment. With each dropsonde release, the carrier balloon will rise because of the reduction in weight; for instance, a balloon initially at 24 km will rise to 25.5 km as it releases 100 dropsondes. A simple valve will vent excess gas, preventing excess superpressure.

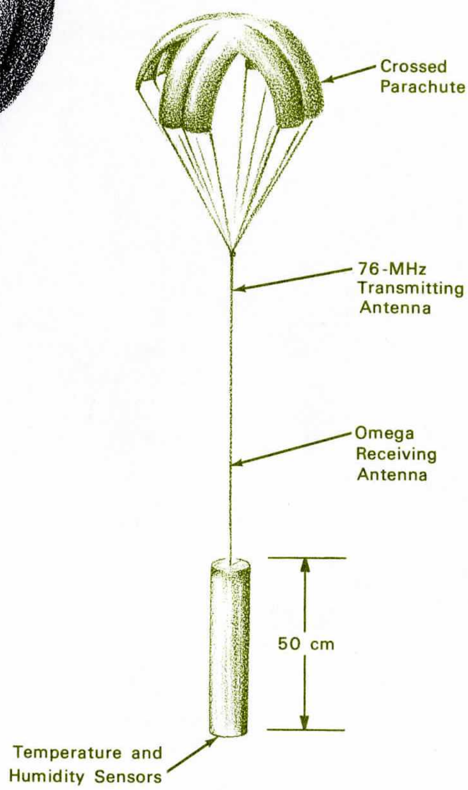
A Mother GHOST balloon with its more complex electronics will be more expensive than the smaller and simpler GHOST balloons used in temperate latitudes. It may be possible to recover these electronics systems by terminating carrier balloon flights on command after all the dropsondes have been released. The cost of using carrier balloons to obtain meteorological data in the tropics is expected to be far below the cost of obtaining the same data by using ships or ship-aircraft-dropsonde combinations.

Mother GHOST System





Dropsonde Dispenser and Electronics Systems on the Mother GHOST



Mother GHOST Dropsonde

Carrier Balloon Vehicle

Digitizes Omega and meteorological data
Transmits to SMS

SMS Satellite

Transfers drop commands to balloon
Retransmits Omega and meteorological data at 100/bit/sec rate on a single channel

Wallops Station

Separation of Mother GHOST data channel and buffering into Dataphone

NCAR

On-line
- Separate meteorological data and Omega data
- Format Omega data and segregate channels

Off-line
- Compute winds and other atmospheric parameters on Control Data 7600
- Retransmit analyses as required

Mother GHOST Data Processing

Tests

A test program conducted in 1970, under the direction of Frykman and Lally, demonstrated the feasibility of obtaining tropical wind data with the Mother GHOST system. The tests showed that:

- Superpressure balloons launched in the tropics and floating at an altitude of 24 km will remain in the tropical circulation for an average of more than 60 days.
- A superpressure carrier balloon is capable of carrying a 100-kg payload at 24 km.
- A simple dropsonde can be parachuted from 24 km to sea level and will descend at a rate of approximately 4 min/100 mb.
- The dropsonde can measure the wind field from 20 km to the surface with an accuracy to within 2.5 m/sec for a 1 - min average or 1.0 m/sec for a 4 - min average.
- Accuracy of wind determination is independent of the distance from the base station or the number of transmission links.

The Omega statellite transmission links have already been tested by NASA.

Plans for the GARP Atlantic Tropical Experiment (GATE) now scheduled for 1974 involve 20 Mother GHOST balloons, each carrying 64 dropsondes, with data relayed by the Synchronous Meteorological Satellite (SMS) which will be over the Atlantic at that time. During the First GARP Global Experiment (scheduled for 1976 - 1978), 100 or more Mother GHOST carrier balloons will be used with three or four synchronous satellites to give around-the-world coverage. ●

Research Systems Facility

Lynn Griffee, NCAR

A brief look at NCAR's new R&D section.

In the fall of 1970 a new group was organized within the NCAR Facilities Laboratory to provide improved instrumentation systems for use in attacking problems in the atmospheric sciences. Engineers and technicians from the Design and Prototype Development, Research Aviation, Scientific Balloon, and Field Observing Facilities were assigned to the new facility which is under the managership of Stig A. Rossby (see *Facilities for Atmospheric Research,* No. 15, Dec. 1970).

The RSF now provides a focus and identifiable center of responsibility for R&D work, allowing larger tasks to be undertaken than in the past by the individual facilities and enabling in-depth studies of present instrumentation needs in the atmospheric sciences. Formerly, when small groups in each facility carried out R&D projects to satisfy the needs of that facility, conflicting priorities often interrupted their work; the scattering of the groups also tended to restrict flexibility and the exchange of ideas.

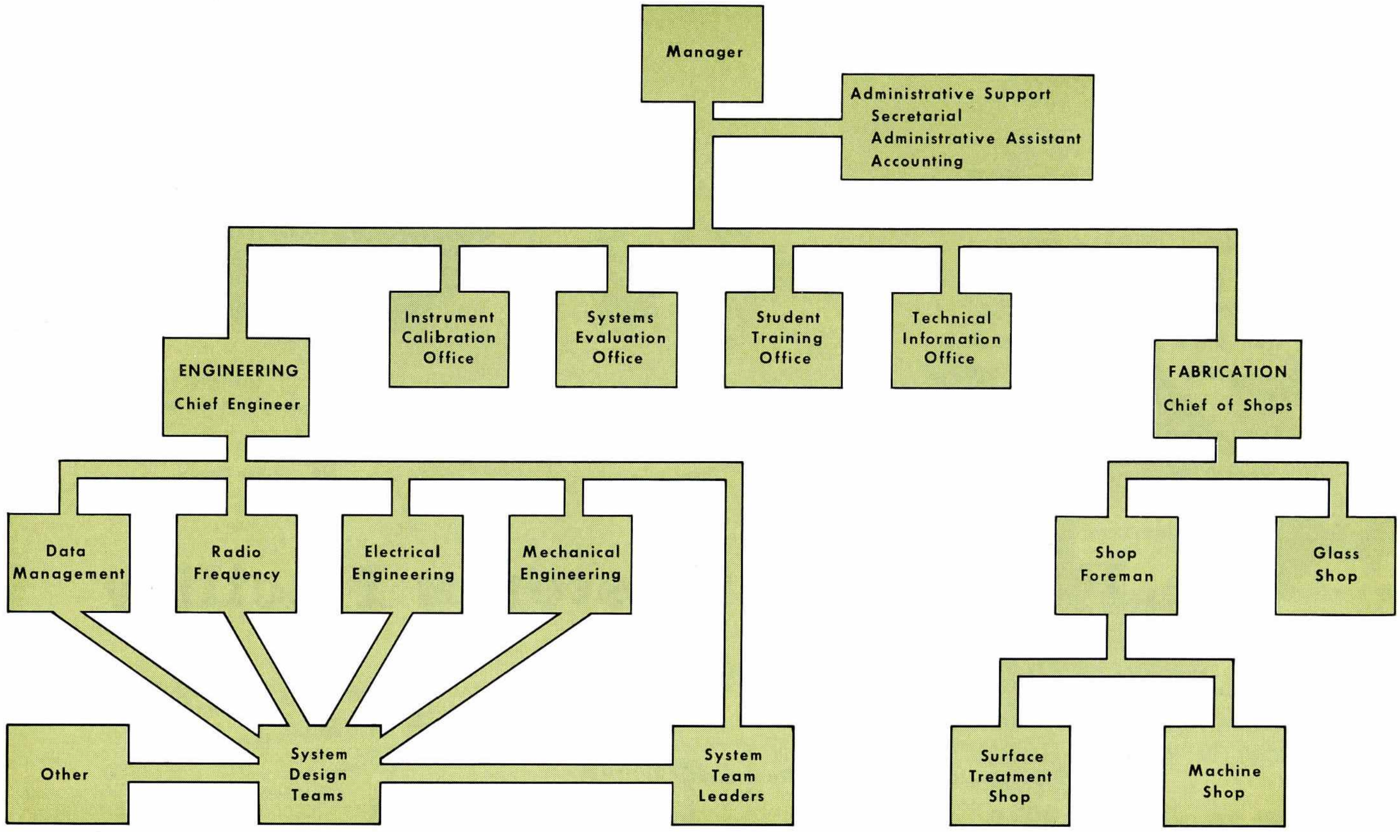
Organization

The RSF consists of two major divisions and four support offices. The fabrication division consists of the machine shop, glass shop, and surface treatment shop, basically as they were before the RSF was created. It is managed by a Chief of Shops. The engineering division (the primary result of the reorganization) consists of mechanical, electrical, radio frequency, and data management engineering sections. Each section has its own section chief and the entire division is headed by a Chief Engineer who guides the individual sections, apportions resources for teamwork on particular problems, and projects future working loads.

The goal of the engineering division is the development of instrumentation systems. When a problem is attacked, a feasibility study is made and a team is gathered from the four sections according to the particular technical disciplines that are required. The team leader must be thoroughly familiar with the area; in some cases, when highly specialized skills are required, a consultant may be hired on a short-term contract or borrowed from some other element within NCAR.

The four support offices and their functions are:

- The *Instrument Calibration Office*, which stores, maintains, and calibrates laboratory measurement instruments, primarily to serve the internal requirements of the facility.
- The *Systems Evaluation Office*, which examines and attempts to improve meteorological observation systems and techniques. Its initial effort, described on page 17, is to develop techniques for assigning a "figure of merit" to multi-element observing systems. This will provide a quantitative assessment of the quality of the final data.
- The *Technical Information Office*, which provides an information retrieval system specifically geared to the needs of RSF, assists in documentation tasks such as the preparation of test reports, manuals, and development proposals,



RSF ORGANIZATION

and performs literature searches as needed within the facility. It will strengthen the documentation of NCAR's R&D projects by recording, for all future RSF systems, instructions for equipment operation, diagnostic information to confirm correct instrument function or to indicate the cause of malfunction, and specifications for manufacture of duplicate instruments.

- The *Student Training Office*, not yet staffed, is intended to provide students with practical experience in the application of their formal training. An example of such application would be the instrumentation of research aircraft or the operation of ground support equipment. Students may be assigned to development teams within RSF to experience and participate in the development of a system from concept to operation. Projects involving the combination of several observing systems will allow students to develop an awareness of the problems encountered in actual field programs.

Current RSF Programs

The development programs presently under way include:

- *Telemetry system* for data transmission and command and control of payloads on large scientific balloons (see page 14).
- *Weather data concentrator* for receiving and storing teletype weather data and producing computer-compatible magnetic tapes (see page 18).
- *Airborne data acquisition and recording system* (ADARS), which will permit real-time processing and display of portions of airborne research data,

and telemetry of data to the ground. Digital magnetic tape will record all data, which will then be converted to computer tape on the ground. The second generation ADARS will probably produce computer tapes in the aircraft.

• *2.75-in. Folding Fin Aircraft Rocket (FFAR) payload system.* The two major sections of this system are a side-ejection parachute section that provides controlled descent of the system for safe impact, and a forward section (including nose cone) that contains the scientific payload, signal-conditioning electronics, transmitter, and a wraparound telemetry antenna. The system will undergo its second series of range tests at White Sands Missile Range this fall; a water-drop impact sensor of the Illinois State Water Survey will also be tested. After these tests have been evaluated, a full report will be made and the system will be available for use as an experiment platform.

Future Programs

Developments that will be initiated in FY 1972 include:

• *Wind-finding meteorological dropsonde,* undertaken at the request of the NCAR GARP Task Group. The system will permit the measurement of wind, temperature, and humidity between aircraft flight altitudes and the earth's surface. Wind-finding will be accomplished by use of the Omega navigation-aid system. The system will be designed to take advantage of the existing dropsonde-releasing capability of the NCAR Sabreliner, and will permit the use of dropsondes in experiments during the GARP Atlantic Tropical Experiment (GATE). The schedule calls for a fully tested prototype system by fall of 1973.

• *Ultraviolet (Lyman α) absorption hygrometer.* Despite numerous experiments in this area, instabilities in the light source and optics have precluded the use of this technique in an instrument to measure absolute values. The RSF will undertake some experiments directed toward improving stability partly through the design of a new source and partly through measuring and compensating for instabilities.

• *Long-duration scientific balloon flight capability.* This effort, in direct response to the Scientific Balloon Facility, will be directed toward two types of balloon flights. The first goal is to extend the duration of zero-pressure balloon flights to 72 hr. The second is to investigate the practicality of using superpressure balloons for heavy (several hundred kilograms) payloads in global flights. Such flights will require the development of a new global data acquisition system or adaptation of an existing system.

The services of RSF's highly skilled staff are made available to universities, to other elements of NCAR, and to other atmospheric research agencies in accordance with UCAR policy. •

NCAR Technical Notes Available

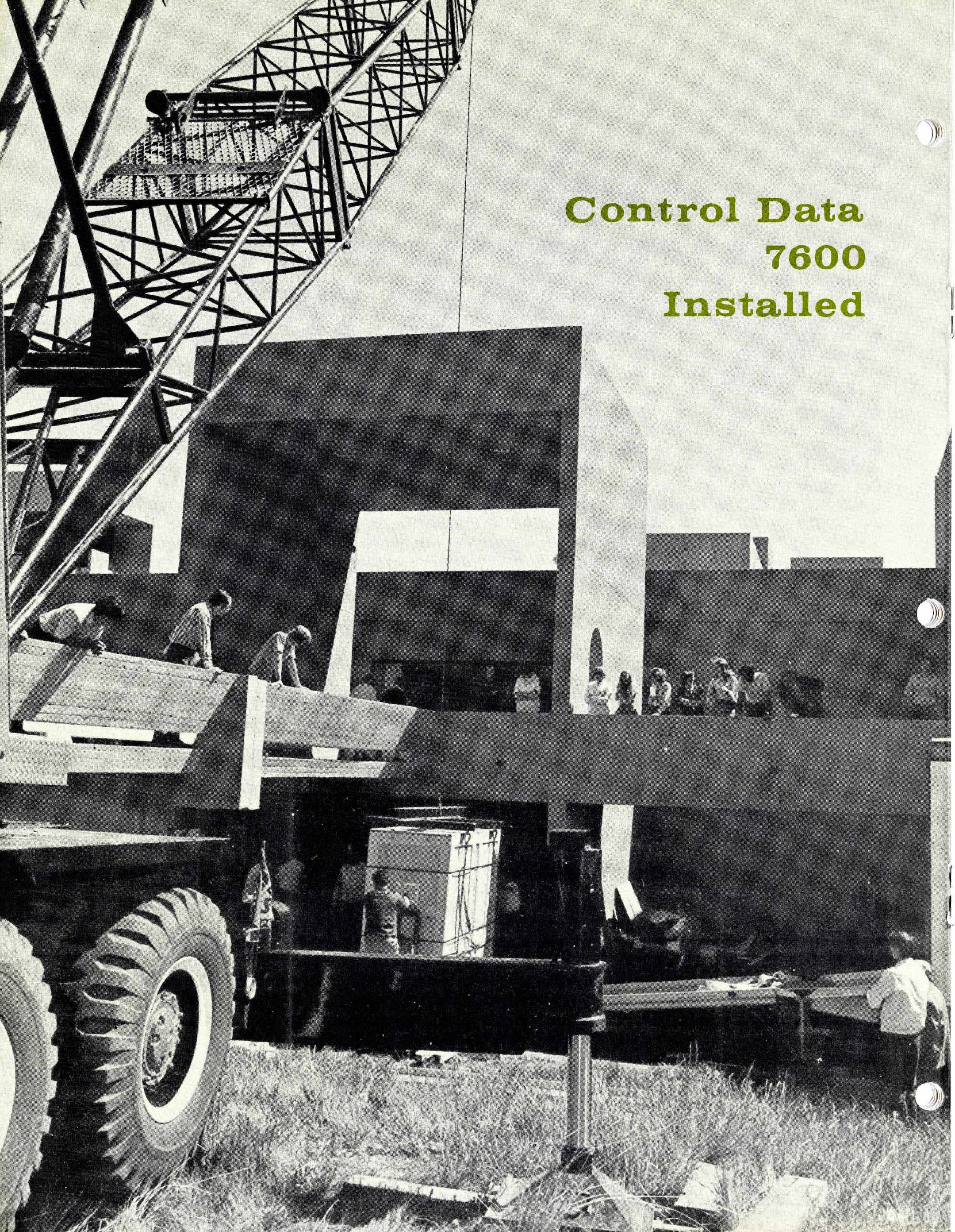
The following NCAR Technical Notes, authored by members of the Facilities Laboratory, appeared during the quarterly period March-June 1971 and are available without charge from the NCAR Publications Department:

Adams, J. C., 1971: *6600/7600 Primer.* Technical Note NCAR-TN/IA-62, Boulder, Colo., 178 pp.

Frykman, R. W., and V. E. Lally, 1971: *A Carrier Balloon for Tropical Soundings.* Technical Note NCAR-TN/EDD-63, Boulder, Colo., 37 pp.

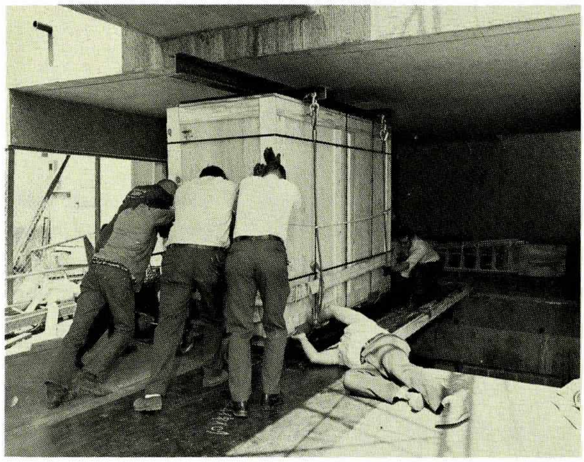
All NCAR Technical Notes and journal reprints are listed in the semiannual *Publications Announcement* which is also available from the NCAR Publications Department.

Control Data 7600 Installed



On 30 June the Control Data Corporation announced that installation of the 7600 computer in the NCAR Mesa Laboratory was complete. Limited operation of the machine has begun and acceptance tests are scheduled to begin in the near future.

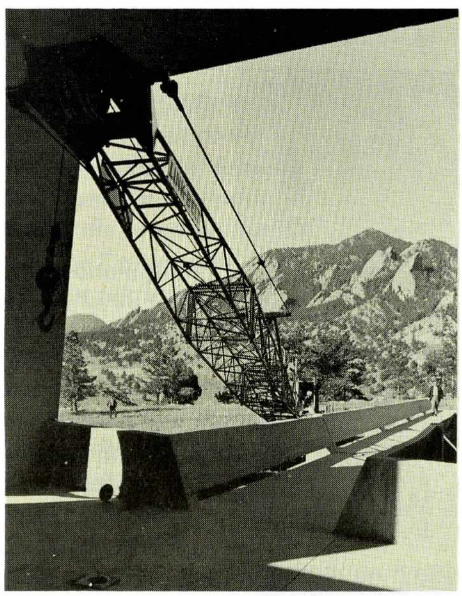
Modification of the computer room, installation of the 7600 components, rearrangement of the 6600 computer components, and final electronic hookup occupied most of the spring. Behrent Engineering Co. of Denver provided planning and design for remodeling of the computer room and installation of the 7600; Paul Moore and others in the NCAR Building Engineering Section, headed by Gary Johnson, provided liaison between Behrent Co. and NCAR. Robert Biro of the Computing Facility planned the arrangement of the 7600 and 6600 components in the computer room and was responsible for maintaining operations on the 6600 with as few interruptions as possible. Bowers Moving and Storage of Denver handled the difficult task of lowering some of the 7600 components through a shaft next to the Laboratory foundation and into the computer area.



Part of the 7638 disk system is rolled over the shaft.

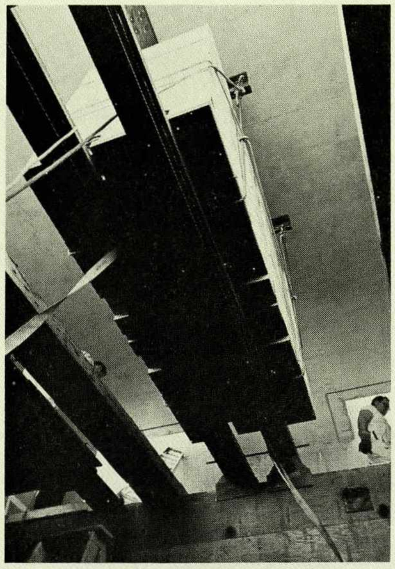
Computer Use Encouraged

Theodore W. Hildebrandt, head of the Computing Facility, states that NCAR welcomes applications for computing time by new university users. The 7600/6600 System offers the greatest computing power now available

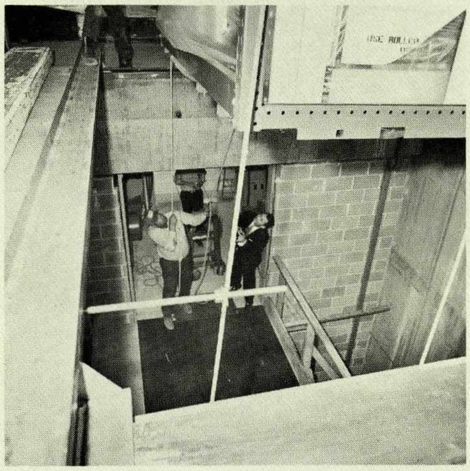


The hoisting cable is lowered through a hole in the west walkway of the Mesa Laboratory.

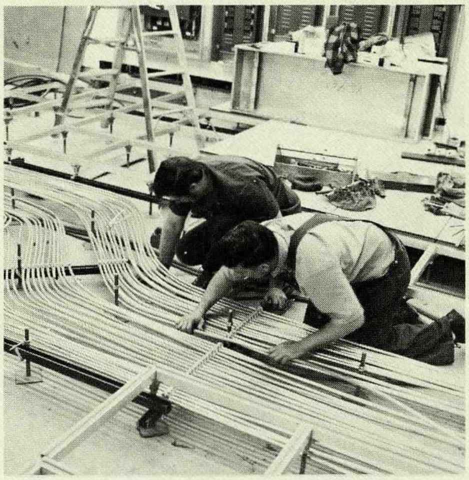
Some 7600 components were rolled from moving vans to a platform next to an open shaft, guided over the shaft on rails, lowered by crane, and then rolled into the computer area. Here a major portion of the 7638 disk system is maneuvered onto the platform.



The disk is suspended by the cable and the rails are ready for removal.

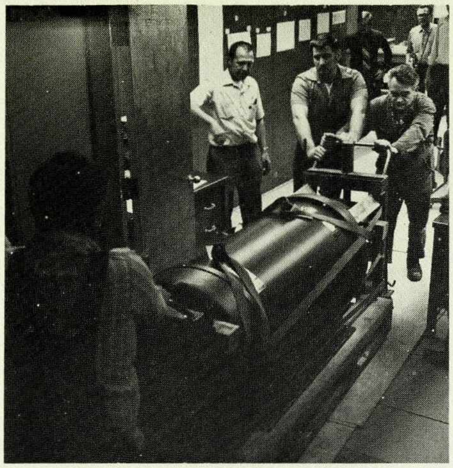


Guy lines prevent twisting as the main frame is lowered.

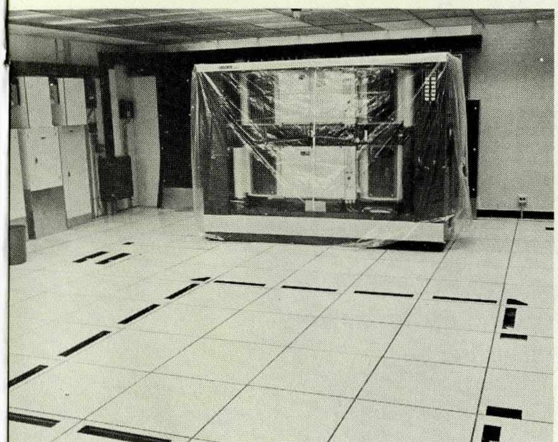


In preparation for delivery of the 7600, electricians installed over 2 mi of aluminum-sheathed cable for 60 - and 400 - Hz electric power. The cable is hand-formed and fastened in place.

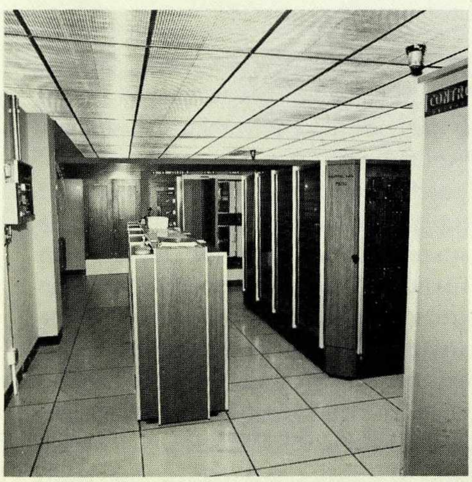
The raised grid structure supports the floor panels and provides an electric ground for all computer components. Fiber glass batting over light fixtures and carpeting on the walls of the computing room were installed for sound deadening.



One of the two 125 - kVA, 200 - hp motor generator (mg) units for the 7600 is rolled into position. The mg room has a suspended floor and lead alloy sheathing on one wall to absorb vibration and noise. Power control cabinets are shown at the top left.



Floor cutouts for cooling hoses and power and signal cables indicate position for the 7600 main frame. The plastic-draped disk file is in the background (with doors removed); the large rotating spindles can be seen.



The disk file (middle rear), main frame (right), and power distribution cabinet (center foreground) in final positions. Behind the power cabinet are two 10 - T condensing units for refrigeration. The complete 7600 installation includes the main frame, two disk files, eight tape drives, a dd80 microfilm plotter, two high speed printers, a card reader and card punch, an 853 disk drive, operation console, and the maintenance control unit's card reader and console.

to atmospheric scientists, and is particularly useful for large models of planetary and solar atmospheres, ocean circulations, and other complex geophysical processes. It serves best those computational tasks which are "compute-bound." The characteristics and computing capabilities of the 7600 are described in *Facilities for Atmospheric Research*, No. 14, Sept. 1970.

Hildebrandt stresses that application procedures are not difficult. Requests for moderate amounts of computer time receive relatively quick response, while applications for large amounts of time are reviewed by the Computing Facility Advisory Panel which meets two to three times a year. A high percentage of applications is approved, the primary requirement being that a proposed project be related to NCAR's broad interests in the atmospheric sciences.

Accounting for computer time is based on "computer resource units" (CRU), and the accounts for all outside users have been converted to this basis. However, scientists may continue to state their requirements in terms of 6600 hours, since this is a more familiar measure of problem size. The computer operating system is designed so that problems programmed for the NCAR computers can be run on either the 6600 or the 7600; the resource units expended will be the same regardless of the choice of machine, which is currently determined by the operating staff. (When the 6600 and 7600 are integrated, problems will be dispatched automatically.) Application forms and a description of the CRU system are available from:

Computing Facility
National Center for Atmospheric Research
P.O. Box 1470
Boulder, Colorado 80302 •

Data Management System for Scientific Ballooning

Richard H. Cormack and
Albury J. Dascher, NCAR

The Research Systems Facility is developing improved airborne and ground station equipment for data telemetry, command, and balloon flight control. The completed system will include a small computer for formatting of digital tapes and for real-time data selection and monitoring.

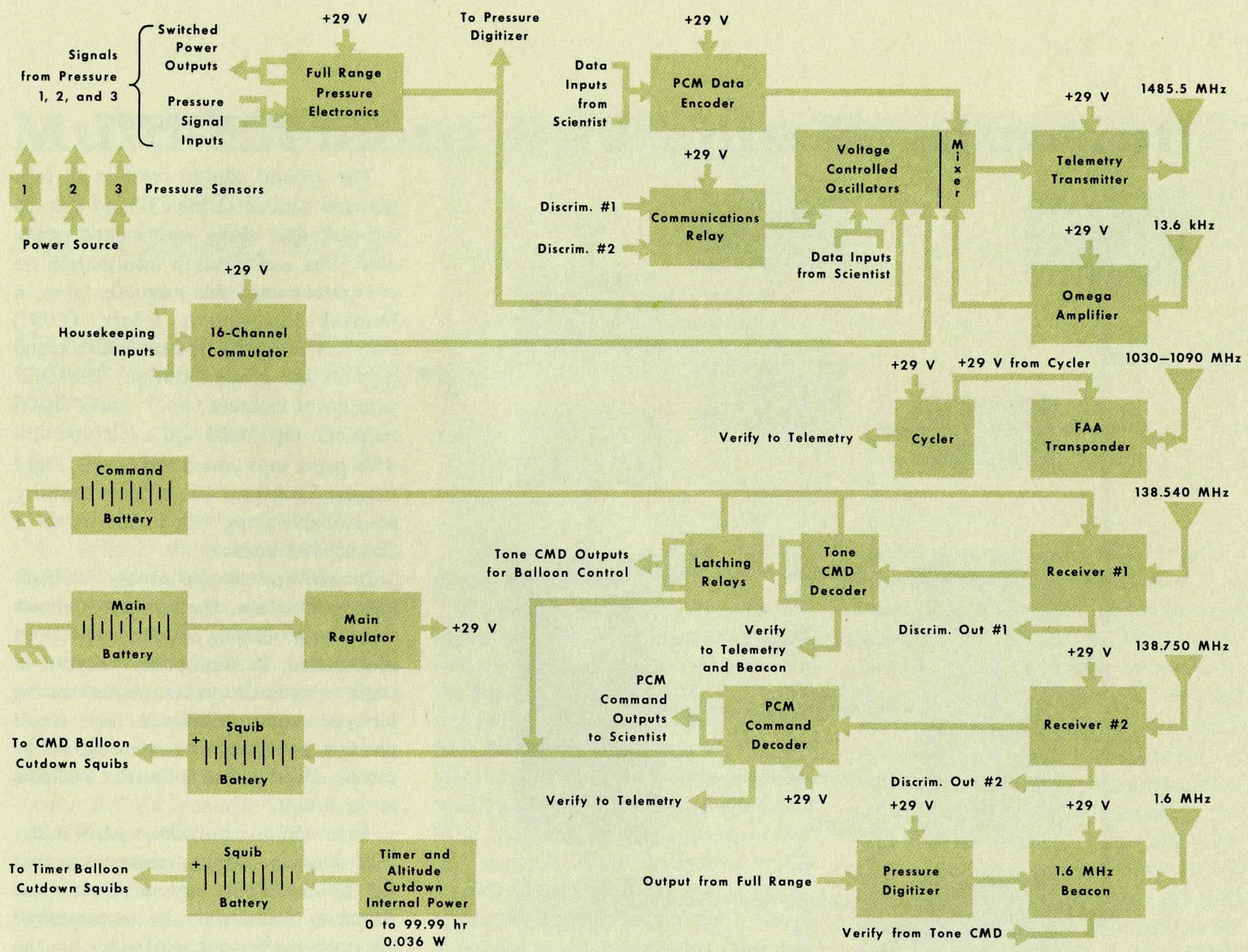
The NCAR Scientific Balloon Flight Station at Palestine, Tex., has been instrumenting and flying scientific balloons since the early 1960s. At first, instrumentation consisted simply of a cutdown timer, a 1,600 - kHz altitude and tracking beacon, and simple tone-command receivers. Since then, scientific requirements have dictated the addition of increased command capability, analog and digital telemetry, more accurate pressure-altitude measurements, and precision tracking.

As refinements have been added to the basic instrumentation packages, a growing number of scientists have turned to balloons as scientific high altitude vehicles. The increasing complexity of the experiments has brought demands for better and faster data handling.

In mid - 1970, preliminary planning was begun in the Scientific Balloon Facility (SBF) for a completely revamped airborne package known as the Consolidated Instrument Package (CIP) and a computerized ground station for data manipulation and generation of computer-compatible tapes. On the basis of a proposal outlining an approach to the system design, fabrication, integration, and testing, as well as a plan for time scheduling, manpower loading, and cost estimates, the Research Systems Facility (RSF) was given the responsibility for completing one system. Two project teams were formed——one responsible for the ground station, and the other for the airborne package equipment. RSF expects to complete the ground equipment by October 1971 and the airborne package by March 1972.

Airborne Package (CIP)

The CIP is designed for easy field assembly and maintenance and can be arranged for side or top access. Scientific data and command programming can be hardwire-performed at the output/input connectors. This allows maximum flexibility with no change to the internal workings of the package and permits CIP interchangeability on the flight line. Battery packs can be changed to meet changes in flight requirements or battery configurations. The package is designed to function



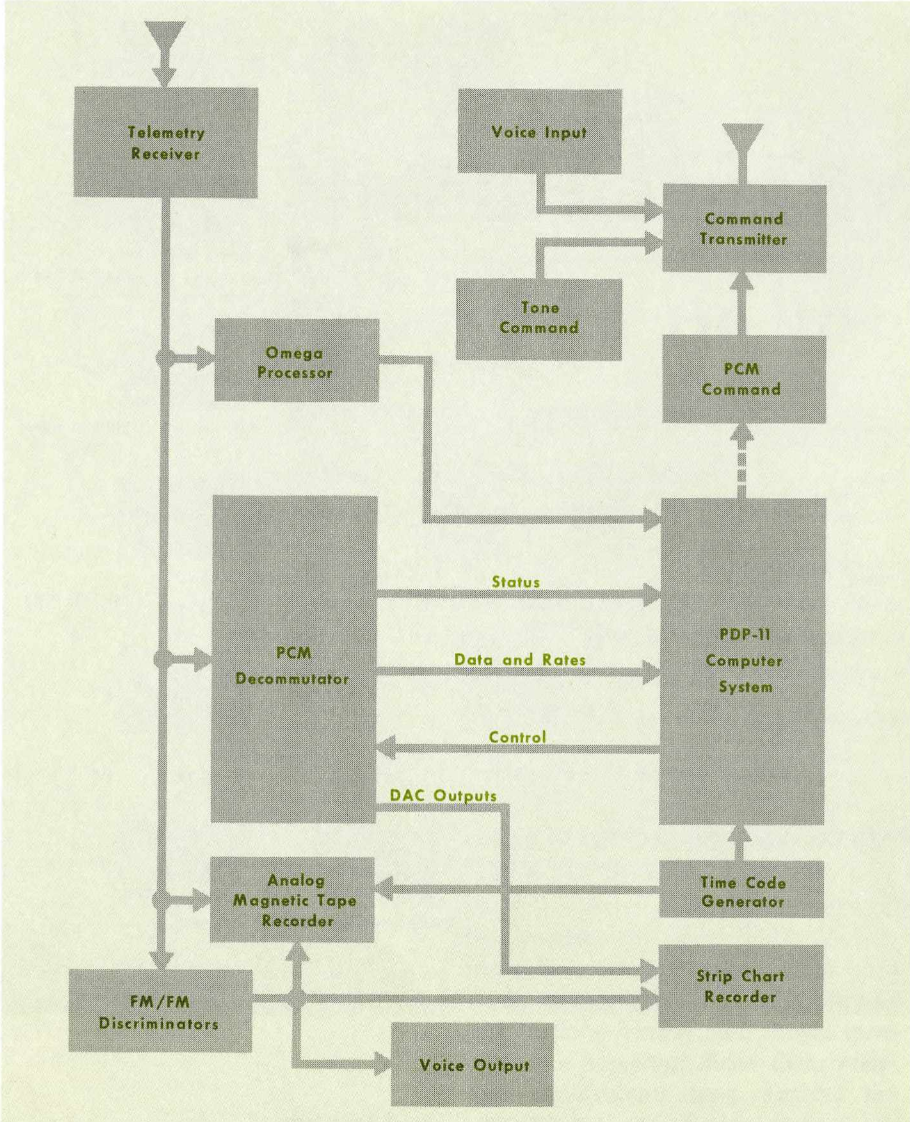
BLOCK DIAGRAM OF CIP

within specifications at a temperature range of - 55 to + 55°C. Normal day/night cycles typical of most temperate latitudes at balloon float altitudes fall within this range. For low altitude tropical flights or high latitude flights where greater temperature extremes will be encountered, simple modifications of the outside shell will be necessary.

The four basic components of the CIP are:

• *Telemetry*. The telemetry consists of a pulse code modulation (PCM) telemetry data encoder, a set of 13 analog telemetry FM/FM voltage controlled oscillators (VCOs), a 16 - channel "housekeeping" commutator, and an L-band, 2 - W telemetry transmitter. The PCM encoder samples up to 64 channels of analog data input and converts each sample to a 10 - bit binary number. Up to 12 channels of digital data input with 10 bits per channel can also be sampled. The encoder can be programmed to allow selection of various sampling rates and numbers of inputs for specific requirements. The VCOs permit continuous telemetering of analog data; they are state-of-the-art miniaturized units and are fully adjustable for changes in flight requirements. The 16 - channel housekeeping commutator allows use of one VCO channel for monitoring the status of such parameters as internal temperatures and battery voltages. PCM and analog data are transmitted through the L-band transmitter to the ground station. Tracking data from the Omega preamplifier are conditioned and also transmitted through this RF link, as explained later.

• *Command*. The CIP has 36 channels of command capability, of which at least three channels are used for command cutdown and ballasting ——two essential balloon flight functions. The remaining channels are available for scientific use. These normally consist of one channel of tone command and 32 channels of PCM command. Future packages will increase command capabilities to 64 channels, if needed. The command links are on 138.540 and 138.750 MHz. Command signals are received and processed by two receivers which independently drive tone- and PCM-command decoders. This allows cutdown command and other command redundancies to be accomplished by simple programming in the CIP.



BLOCK DIAGRAM OF TELEMETRY GROUND STATION

• *Flight Operations Electronics.* Flight operations electronics overlaps the command area in cutdown and ballasting functions but includes other interesting items. Among these are the FAA Air Traffic Control tracking transponder and its cycling circuitry, the pressure altitude transducers and associated switching electronics, and the communications relay which enables the balloon to relay voice communications through its telemetry link. A flight termination timer operating at extremely low power consumption levels and providing 0.01 - hr settings up to 100 hr is included, as well as a recovery beacon operating at 1.6 MHz and transmitting Morse-coded altitude information digitized from the pressure-altitude transducers. Tracking capability is provided by electronics which receive Omega navigation system signals, condition these signals, and send them to the ground station through the telemetry link.

• *Power System.* Power is provided by a silver-cadmium battery pack. Space will be provided in the main package to accommodate battery packs for flights longer than 30 hr with all equipment operating; smaller packs for lesser power requirements may be flown.

Ground Station Equipment

The ground station receives all telemetered data from the CIP and logs the airborne data along with ground generated time and position information on computer-compatible magnetic tapes. A Digital Equipment Corp. (DEC) PDP - 11 computer system is an integral part of the ground station. The DEC equipment includes two 7 - track digital magnetic tape units and a teletype unit with paper tape punch and reader. Eight thousand words of 16 - bit core memory are available along with 65,000 words of 16 - bit disk memory.

In addition to performing the data logging function, the computer allows real-time processing of selected portions of the data so that printed output in engineering units can be provided on the teletype unit. Additional high speed printing and graphics output capability can be added as funds become available in the future.

The computer provides control to the PCM decommutation equipment so that the initial setup for various bit rates and telemetry formats can be accomplished automatically via software to the computer.

The PCM decommutation equipment provides for real-time monitoring of selected channels of raw data on a dual, 4 - decade decimal display as well as in binary form on a 16 - bit display. Also, 16 digital-to-analog converters (DACs) are available to allow quick-look recording of their analog outputs on a strip chart recorder. The digital data fed into the DACs can be raw data from the telemetry or processed data from the computer; the data selection is accomplished by software programming.

When completed, the airborne-ground system will allow a scientist to rapidly complete the interface with the airborne system after his arrival in Palestine, observe his telemetered data in real time, and return home with computer-compatible tapes ready to be computer analyzed. •

Multi-Element Systems Evaluation

P. K. Govind and
Stig A. Rossby, NCAR

The Research Systems Facility has begun a feasibility study of techniques to assure the quality of the derived outputs of multi-element observing systems.

In judging the reliability of data derived from an observational network, the meteorologist is concerned with both the accuracy and the representativeness of the measured atmospheric parameters. Accuracy of measurement is the degree to which a sensor readout agrees with the actual value or a preset standard. Representativeness is not a clearly defined concept, but denotes roughly the extent to which local or temporary variations in a measurement correspond to real variations in the environment. Since both space and time scales are involved, the criterion for judging representativeness depends on what a meteorologist wants the value to represent relative to the environment. In this context, the question arises as to whether the measured signals could be suitably reconstituted to suppress extraneous disturbances so that the data read into the computer correspond as closely as possible to the real atmospheric parameters and their variations.

The total error deviation in a measured meteorological parameter depends not only on the instrument but also on the characteristics of the observational network. The observations must be frequent enough to detect significant changes and the instruments spaced closely enough to distinguish significant features. Therefore, representativeness is a "systems" problem, and a systems-approach to improve representativeness should include the following:

- Uncoupling the interactive elements of the multi-element set
- Optimizing the space-time interval between measurements
- Improving the methods for estimating derived quantities

The NCAR Research Systems Facility began work on the evaluation of multi-element meteorological systems when the Facilities Laboratory R&D program was reorganized last year (see *Facilities for Atmospheric Research*, No. 15, Dec. 1970). One of the practical benefits which we anticipate will follow from the multi-element systems evaluation research is the development of a capability for improving the reliability of meteorological data in the presence of artifacts in the input data during a given observation period.

A meteorological observation network represents a sampled-data system with multiple inputs and outputs. Therefore, techniques commonly used in control systems engineering to examine the behavior of multivariable systems should be of benefit here. For example, the evaluation of the effects of component parameter variations in the subsystems upon the overall output data will be studied by simulation. Digital control techniques are economically attractive because of the availability of a high speed digital computer at NCAR.

The actual input to a meteorological system, the noise interference, and the actual system outputs are usually of stochastic nature and can in general be described only statistically. It is clear that adjustments may be necessary to obtain estimates which best reflect the meteorological quantity of interest. The many adjustments to the "observed" values to produce "new" values will invariably introduce correlations among the errors as well. When different atmospheric parameters are involved, the errors are probably correlated in some unknown manner and it may not be possible to make precise estimates of these correlations. However, we shall adopt a recent approach to error compensation by defining a measure for the error and then seeking a compensation which minimizes this measure. The criterion we shall use is the minimization of the mean-square error (MSE) between the actual output and the ideal output of the system. After the necessary computational tools have been developed, our efforts will be directed toward optimizing the transfer function (a measurement function) of the system to match the output to a preset ideal of minimizing the MSE. (In systems engineering, the outputs and inputs to a system are simply related by a transfer function.) Once an optimum transfer function is determined, the design of the required digital compensator can be carried out by conventional methods of control theory.

The application of our results to real-life systems such as those being prepared for GARP and pre-GARP experiments will depend on model accuracies and our ability to monitor the performance of individual data sources within the system. It might also be possible to apply the evaluation techniques to data records such as those of the Line Islands Experiment and the Barbados Oceanographic and Meteorological Experiment. •

Weather Data Concentrator

Frank A. Brunot and
Howard R. Hansen, NCAR

A new system to receive and store weather data transmitted by teletype is now operational.

One of the primary projects of the NCAR Research Systems Facility during the past few months has been the design, development, and fabrication of a data concentrator to be used by the NCAR Laboratory of Atmospheric Science (LAS) for receiving and storing weather data sent via teletype lines. In addition, the system can convert paper tapes to 7-track computer-compatible magnetic tapes.

In the past LAS has relied on two Model 28 "receive-only" teletype printers, with attached paper tape punchers, to receive and store weather sequence data. In order to load this data into the NCAR computer it has been necessary to transfer the data from paper tape to magnetic tape. This transfer has been unreliable and time-consuming.

To correct these inefficiencies, a new system has been developed which uses computer-compatible magnetic tapes as the storage medium. As the flow diagram shows, the system is composed of four basic sybsystems: memory buffer, magnetic tape recorder, paper tape reader, and input/output (I/O) writer.

Memory Buffer

The memory-buffer system (designed and built by Monolithic Systems Corp. of Englewood, Colo.) and its associated control logic is the heart of the entire system. The inputs to this unit come from three sources: teletype, paper tape, and internal test circuits. Basically, the memory contains four separate 1,024-word 8-bit memories, with each of the two pairs operating in a flip-flop fashion for each channel.

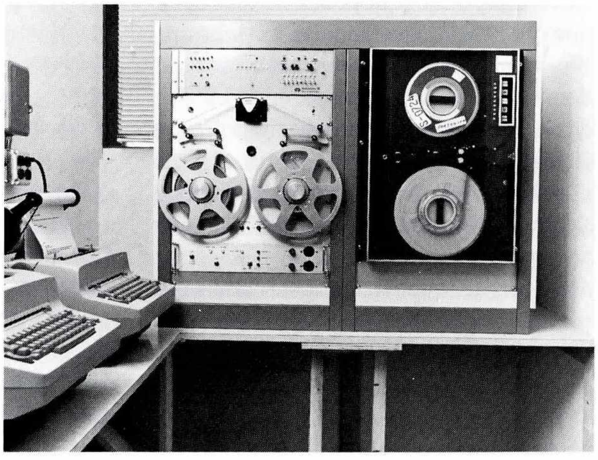
In the *teletype* mode, weather data is received via two separate land lines in a digital serial format, using the Baudot code. At present, NCAR receives data over Circuit C, which transmits national upper air data and local forecasts, and Circuit O, which transmits international data on both upper air and surface conditions.

The serial data are fed directly to a teletype serial-to-parallel converter via an optical isolator circuit which allows voltage-level shifting from the 130- to 260-V teletype lines to the normal 5-V TTL logic levels. After the START and STOP pulses are stripped from the data stream, the 5-level character code is strobed (transferred) to the output in parallel form with a 1-μsec clock pulse. Circuit C data are fed to Memory 1 and Circuit O data to Memory 2.

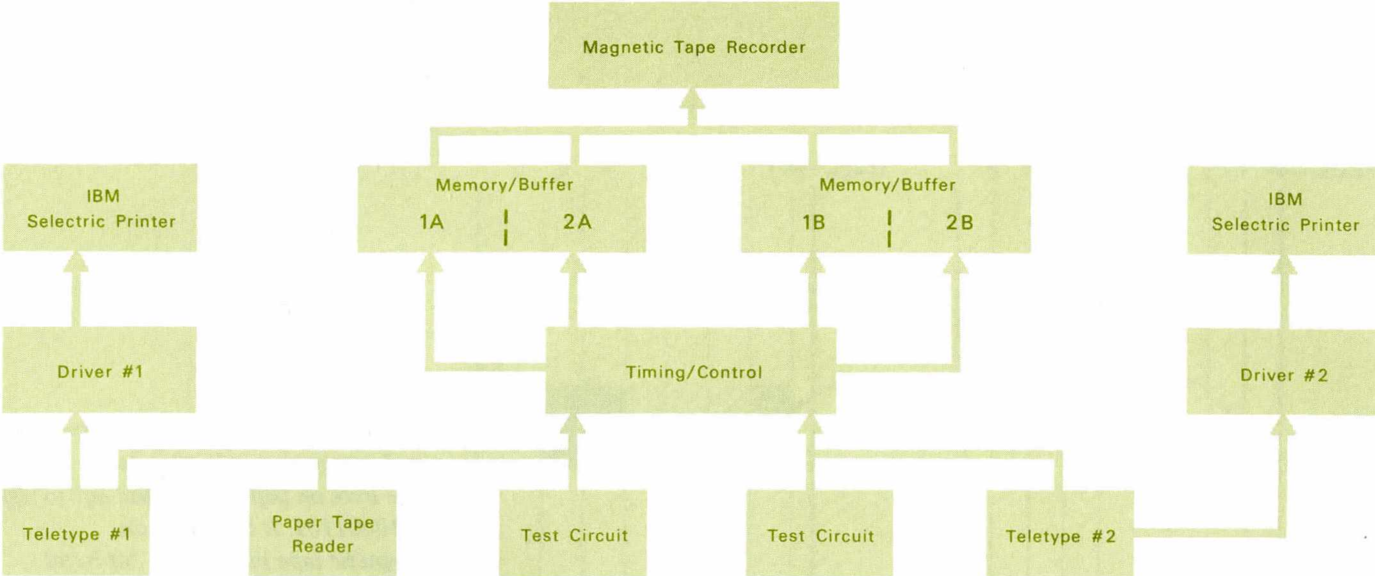
When half of one memory is filled, a command is sent to the magnetic tape recorder to start reading this half of the memory. New data are simultaneously fed to the second half of the memory. In a similar fashion, the second half of the memory is read by the tape recorder while new data are fed to the first half. This flip-flop procedure is continued in both Memories 1 and 2 as long as new data are received.

Each half of a memory pair is 1,024 words in length. However, because the system uses semiconductor memories, the length of each can be increased to 4,096 words by simply inserting additional integrated circuit chips in the sockets provided. Since each memory half is read at one time by the magnetic tape recorder, the memory length also corresponds to the record length on the tape.

At the same time that the parallel data are being sent to the memories, they are also routed to the two I/O



The components of the new weather data storage system include two Selectric typewriters, a memory and control unit, a paper tape reader and spooler, and a magnetic tape transport.



Schematic representation of the weather data concentrator.

writers via an I/O driver interface card. This card provides the decoding necessary to convert from the 5-level Baudot code to a 7-level IBM Selectric code, and also provides the 48-V drivers used to pulse the typewriter solenoids.

In the *paper tape* mode, only Memory 1 is used. Data are received in parallel format from a high speed paper tape reader, with a clock pulse. The memory, however, operates in the same fashion, each half flip-flopping between the read and write modes. No hard copy is provided by the I/O writers in this mode since the speed of data transfer is too great.

The *internal test* mode is provided as a method of checking the operation of the entire system. A high or low bit rate can be selected so that data rates for either teletype or paper tape can be simulated. The I/O writers can be run when the lower data rate is selected.

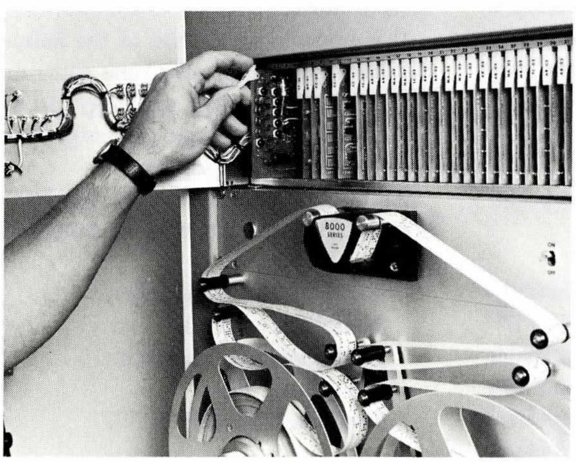
Magnetic Tape Recorder

The magnetic tape recorder used in the system contains an internal controller, and is formatted for 7-track operation, with 556 bytes/in. and 25 in./sec. In the present system configuration, the recorder is run in the synchronous mode. However, it can also be run in a stepping mode at 1,000 steps/sec.

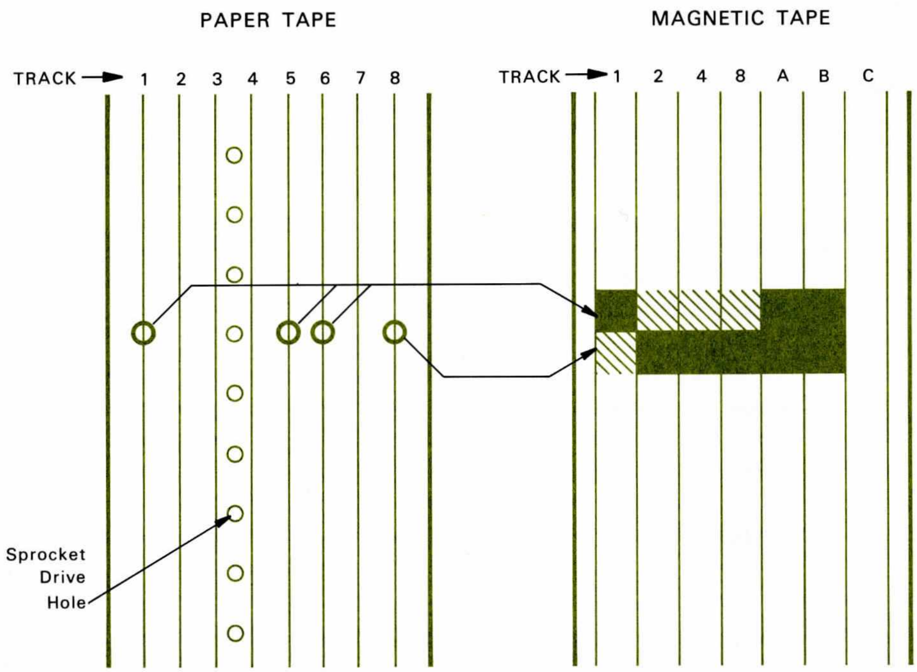
One byte on the recorder contains six bits of binary information plus an internally generated parity bit, which may be even or odd. The system now uses odd bit parity for compatibility with the Control Data 6600. In the event input data contain more than six bits per character, the memory control logic will divide the character into six-bit bytes, and strobe the character out in two bytes. Any excess bits not used in the second six-bit byte will appear as ones on the magnetic tape. However, computer programming can drop these bits during the character-recognition routine.

In addition to the formatted write electronics, the recorder also contains complete electronics for read and gap detect. In the read mode, the tape has a data transfer rate of 83.4 kilobits/sec. It can also detect interrecord and end-of-file gaps, so that partly used tapes can be loaded and the remaining tape used to increase tape efficiency.

The recorder is equipped with 10.5-in. reels (7- and 8.5-in. reels are also available). Using 1.5-mil computer tape, 2,400 ft of tape can be loaded on one reel. In the teletype mode with both circuits operating continuously at a rate of 10 characters/sec, the recording time will be 158 hr, or 6.5 days



The front panel of the memory and control unit is hinged for easy access to the printed circuit cards.



Conversion of 8 - track paper tape data to 7 - track magnetic tape data. The byte on paper tape (read left to right) is 10001101. It is divided on magnetic tape into two 6 - bit bytes with the excess bits of the second byte (4, 8, A, and B) appearing as ones. (Solid squares represent ones; hatched squares, zeros.) Track C of the magnetic tape is reserved for a parity check and is unmarked in this example.

of uninterrupted operation before the magnetic tape must be changed.

Paper Tape Reader

The paper tape reader used in the system is a high speed reader and spooler; the reader uses a photoelectric fiberoptic head and can read 5-, 6-, 7-, or 8-level tapes at a synchronous speed of 400 characters/sec (40 in./sec) or asynchronously at a speed of 0 - 300 characters/sec. Rewind rate is 200 in./sec.

The spooler uses 10.5 - in. reels with NAB hubs, and can carry up to 1,450 ft of 0.004 - in. - thick paper tape or 2,300 ft of 0.0025 - in. - thick Mylar tape. The spooler is controlled by, and speed-compatible with, the reader.

The use of a synchronous read mode enables a full 10.5 - in. reel of paper tape to be transferred to a computer-compatible magnetic tape in 7.25 min. The data contained on such a tape totals 1.39 megabits. If Mylar tape is used, the transfer time is 11.5 min, with a data content of 2.21 megabits. At a density of 8 bits/character, 73 and 116 ft of magnetic tape are required, respectively, to store all the data contained on one 10.5 - in. reel of paper or Mylar tape. In other words, data storage on magnetic tape is 20 - 33 times more efficient than paper or Mylar tape. For 5 - 6 bits/character the efficiency is doubled.

The currently used formatting of paper tape information on the magnetic tape formatting assumes that the highest numbered paper tape track is also the highest ordered track. For example, if the paper tape entry (starting with track 1) is 10001101, then the first byte on the magnetic tape (starting with track 1) will be 100011, and the second byte will be 011111 (excess bits on the magnetic tape are filled with ones). Parity bits are not shown.

If a magnetic tape dump routine is now called, the octal printout will be 6176 because the Control Data tape transport will read track B first (since it is the highest ordered track).

I/O Writers

For hard copy output of the teletype data, two IBM Model 731 Selectric I/O writers are used. These units are capable of typing approximately 15.5 characters/sec, which is equivalent to an input data rate of 110 baud (using Baudot code). However, the signals now being used are received at a rate of 75 baud.

The chief problem encountered with the I/O writers was to find a Selectric type font which had the necessary weather symbols. Type fonts were finally obtained from Camwil, Inc., of Honolulu, Hawaii, which produces type heads for various special purposes.

Paper is supplied to the typewriter and the hard copy stored on a spooling device designed by H. Paul Johnson and built in the NCAR Machine Shop by William Dombrowski. The spooler is friction-driven from the typewriter platen and requires no external connections or power.

It is hoped that the use of the Selectric I/O writers will overcome some or all of the mechanical reliability problems experienced in the past with conventional teletype equipment.

Additional information on the Data Concentrator System may be obtained from:

Research Systems Facility
National Center for
Atmospheric Research
P. O. Box 1470
Boulder, Colorado 80302