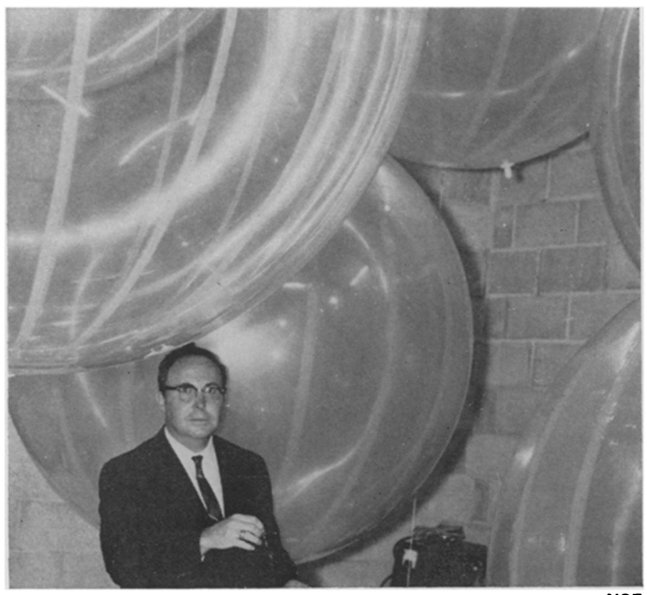
# Adapting the Ghost balloons

## Advanced space technology and poor test results have forced changes in planned world-wide weather balloons

by Kendrick Frazier



NSF

*Dr. Lally and Ghost balloons: A mother may be needed.*

It has been four years since a balloon with the ethereal acronym GHOST set off from Christchurch, New Zealand, on the first round-the-world flight by a constant-level balloon. That particular balloon stayed in the stratosphere for 102 days, circling the Southern Hemisphere eight times.

The flight was one of the early beginnings of a program to test the feasibility of a network of thousands of such balloons drifting slowly around the earth. Posted at various latitudes and altitudes, they would continually monitor atmospheric conditions and relay the information to the ground via orbiting satellites. One projection made at the time envisioned 6,000 balloons airborne simultaneously.

**As a result** of the four years of balloon tests, plus faster-than-expected advances in space technology, the original GHOST concept has undergone major modification. The balloons still have a role to play in the future global observing system. But the role, as now seen by atmospheric scientists, is no longer as grandiose as it once was. Far fewer balloons will be necessary, and their tasks will be more limited and specialized.

The proper generic name for a GHOST (for Global Horizontal Sounding Technique) balloon is superpressure, or constant-level, balloon. Their semirigid Mylar skins keep them at a constant volume, so they rise to the level in the atmosphere at which the mass of the displaced air is equal to their mass, and stay there. Such balloons were first proposed in the late 1950's when the tough Mylar film had just been developed.

Lifetime is the key to whether the balloons are economically feasible as tracers of global winds and platforms for simple measurements in the world-wide observing system envisioned by GARP, the Global Atmospheric Research Program (SN: 4/4, p. 342). The tests carried out during the last four years by Dr. Vincent Lally of the National Center for Atmospheric Research have been only half encouraging.

In the stratosphere, which begins about 35,000 feet up, the balloons have been a pronounced success. One balloon, launched in September 1967, stayed up 441 days, making 35 trips around the world at an altitude of about 60,000 feet. The average lifetime for balloons at that altitude is six months, but Dr. Lally feels that with more care in manufacture, testing and handling the average can be stretched to more than a year even though they suffer deterioration from ultraviolet light, and lose gas both by pinholes and slow diffusion through the membrane.

But in the troposphere, the lower six miles or so of the atmosphere, the balloons have been disappointingly short-lived. Life expectancy has varied from a week to a month, far too short to be feasible. With a two-week life expectancy, world-wide coverage by 600 constant-level balloons at just one altitude would require 15,600 balloons a year. At $2,300 per instrumented balloon, the cost would be more than $36 million.

**Most of the failures** in the troposphere are due to accumulation of ice crystals or supercooled water droplets on the balloon's surface. These increase the balloon's mass so much it falls. No suitable solution has been found.

"We see no clear way to increase life in this region, haunted by supercooled clouds, without introducing hazardous hardware," says Dr. Lally.

While the difficulties with balloons in the troposphere were being encountered, the technology for space-based measurements of the atmosphere was advancing rapidly. The infrared instruments aboard the Nimbus 3 satellite last year (SN: 11/29, p. 509) demonstrated the ability to obtain a temperature profile of the atmosphere. This eroded much of the GHOST balloons' mission. Future satellite-borne infrared sensors will be able to obtain enough temperature soundings to provide a global description of the mass field, which permits computation of the winds in the middle latitudes. But such a calculation is dependent on knowledge of the pressures, temperatures and winds around the earth at one specific altitude—a so-called reference level.

This determination of a reference surface in the Southern Hemisphere is one of two special tasks now assigned to constant-level balloons for the GARP Global Experiment, sometime in 1975 or 1976. As stated in the preliminary report of the GARP planning conference in Brussels March 16-20: "This reference surface could best be determined by a network of approximately 300 constant-level balloons measuring ambient air pressure and the temperature and altitude, with an appropriate satellite location and data collection system."

The United States and France will share responsibility in establishing the reference-surface balloon system. The French EOLE constant-level balloon program is similar to the United States' GHOST program. Discussions in the next few months will determine how the sharing will be done.

The reference level is also needed in the Northern Hemisphere, but a combination of land-based radiosondes, ships and buoys can probably do the

## . . . weather balloons

job. This is more feasible in the Northern Hemisphere because of the greater land area for radiosonde balloon launches.

**The second special** task assigned to constant-level balloons is the direct measurement of winds at many different vertical levels in the tropics. The tropics represent a unique situation. In contrast to the mid-latitudes, winds in the tropics cannot be mathematically inferred from data at a single reference level. The necessary equations have a term known as Coriolis parameter in the denominator. The value of this parameter is 1.0 at the poles, but it diminishes to zero at the equator. This makes the equations unusable.

To test the adequacy of numerical models of the general atmospheric circulation—GARP's goal—winds in the tropics must be measured for at least four levels. Photos of cumulus and cirrus clouds from weather satellites may be effective in determining winds at two levels. Balloons will have to provide the data for at least two more.

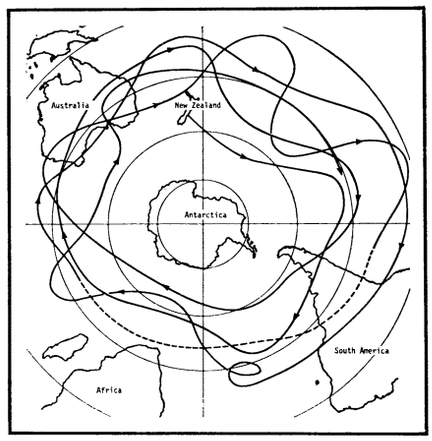
Since the constant-level balloons cannot survive in the lower tropical atmosphere, the novel concept of mother GHOST—or carrier—balloons is now being actively developed at NCAR.

Mother GHOST would drift high in the zonal flow of the tropical stratosphere carrying a brood of 100 or more small dropsondes. On command from a geostationary satellite a dropsonde would be released. Throughout its descent it would receive ground signals from the standard network of OMEGA aircraft navigation stations. These would be relayed to the mother balloon. The mother balloon would relay them to the satellite. The satellite would then transmit them to a ground station where winds would be computed—as well as temperature, pressure and humidity.

"There is no question of the feasibility of the mother GHOST technique," says Dr. Lally. But the expense would be the most expensive add-on to GARP: a $10 million to $20 million investment for two test periods of two months each.

At last month's Brussels meeting the carrier-balloon proposal for the tropics was endorsed as the least expensive system available to make the necessary measurements. But the complexity and cost led to an urgent recommendation for a re-examination of the requirements for tropospheric wind measurements in the tropics. GARP's joint planning committee was asked to look into how requirements may be relaxed and to study all other possibilities.

Two GHOST flights of limited duration will be carried out over the United States in July and August to prove the balloons' capability to carry a heavy payload. Then in November the first long-duration GHOST flights with a heavy payload will begin at Christchurch.




NCAR

*Many loops for stratospheric balloons.*

Also this fall at NCAR's balloon facility in Palestine, Tex., the complete dropsonde system will be tested. Two or three flights will be made. Signals from an ATS satellite will release four dropsondes from 80,000 feet each flight.

**Several other tests** of constant-level balloon systems are imminent.

■ Starting May 1 tests of the electronic interrogation, recording and location system (IRLS) will begin in conjunction with the Nimbus 4 satellite, launched April 8. Three balloons a week will be released from Ascension Island in the Atlantic for five weeks; several months later the sequence will be repeated.

■ A Southern Hemisphere Experimental Operational Program, jointly sponsored by the National Science Foundation, the New Zealand and Australian Governments and the World Meteorological Organization, is to begin in July. The hope is to maintain 50 balloons in the air at all times. The pregram will be testing the ability of the World Meteorological Center in Melbourne to use balloon-tracking data for its operational computer analysis of Southern Hemisphere circulation. The effort could continue for several years.

■ In January 1971 the French EOLE project will begin flying 550 balloons at 40,000 feet in the Southern Hemisphere. They are to be precisely tracked for three months by a French-built EOLE satellite that NASA plans to launch from Wallops Island.

■ A test is planned for 1973 to use the Nimbus F satellite to track 1,000 GHOST balloons with simplified, low-cost electronic packages as part of an experiment to study global circulation. As of now this project is not associated with the GARP Tropical Experiment. ☐