LUMINOUS SPIDERWEBS OF HEAVEN

—Benson Fogle, Geophysical Institute, Alaska.

First known photograph of noctilucent clouds in the Southern Hemisphere.

MORE than 1,000 times in the last eight decades, men living in latitudes above 45 degrees (in the Western Hemisphere that would be north of the Great Lakes and south of the Argentine pampas) have seen, high in the heavens on summer nights, clouds of light so dim and wispy as to seem constructed of spiders' webbing.

Into an utterly clear and transparent sky these apparitions have come suddenly, either not long after the sun had sunk under the horizon or not long before it had risen.

The moon has shone clearly through them, nor have the stars been in the least obscured.

Sometimes the light has fled within minutes of its arrival, leaving behind no noticeable trace. Sometimes it has spread across the whole width of the twilight or the dawn, brightening as it grew and hanging in place for hours.

Always white this light has been, occasionally tinged with blue.

Noctilucent.

Visible at night.

That's all that science can say with certainty about these rare, mysterious visitations, which

may be better identified before the end of the winter we are now entering.

The scientific literature reports the first observation in the year 1885, by the Russians, who watched the strange light patterns more closely than anyone else for a number of years. Within a few months of that first sighting, the Germans—also prominent in the earliest observations—calculated the height at which the phenomena were occurring and found it to be a few miles under the bottommost skirts of the aurora. The average estimate was about fifty miles above earth's surface. Since then English, Polish, Swiss, Scottish, Welsh, Irish, Danish, Norwegian, Swedish, Icelandic, Canadian, and American scientists have seen a total of 1,034 patches of noctilucent cloud in the northern hemisphere between forty-five and fifty-seven miles up. So the average altitude today remains (at eighty-two kilometers) where the Germans fixed it eighty years ago.

Apparently the clouds are never visible below a latitude of 45.5 degrees. The Russians (they set up a string of 200 observing stations in 1957, five years before the first American expression of interest) watched through 700 cloudless summer nights at Ashkabad (37.5 degrees) in 1958 with nothing to show for the vigil, and an experienced American observer, Keith D. Baker, had similar luck on a shorter watch at Hanover, New Hampshire. The regions immediately surrounding the pole are likewise barren of noctilucent phenomena, the northernmost of which occur at 77 degrees.

The twilight appearance, plus the altitude and the latitude limits, add to one clear conclusion: noctilucent clouds are lighted by the sun when the sun is 6 to 16 degrees below the horizon (see sketch, page 56).

Of what fabric are the clouds made—what is so filmy and evanescent yet able to reflect light rays?

The most satisfying assumption is an aggregation of crystals.

The clouds that pass overhead every day, casting shadows on the earth below, are formations of crystals. And certain types of them, the *cirrus* and the *cirrostratus*, are textured very much like the noctilucent clouds. But the clouds that float near the earth are plainly not the same as the noctilucent clouds because when the noctilucent clouds appear the commoner clouds can be seen as silhouettes against the dark background of sky.

Now the Russians have seen the distant night-shining wanderers as early in the year as March 5; the clouds have also been observed as late as October 29. But no sign of noctilucence was detected from November to March during a three-year watch at the Geophysical Institute of the University of Alaska at College, Alaska. Statistical analysis of the 1,034 northern hemisphere sightings recorded from 1885 through 1964 shows a peak frequency on July 10, twenty days after the summer solstice, and 78 per cent of all the observations fall after the solstice.

DOES science know of anything special that is happening fifty miles up in the sky during the northern summer?

Yes. Something quite special and seemingly contradictory. Rocket soundings have discovered that at that height the coldest temperatures of the year come in the summertime.

In other words, the circumstances most favorable for formation of ice crystals exist in summer at the very places where the noctilucent clouds flit.

To have ice, however, water must be present, either as liquid or as vapor.

To explain the noctilucent clouds, then, some scientists have inferred, from other observations, a steady upward current of water vapor through the stratosphere and the mesosphere above it into the mesopause.

EVEN if the water vapor is there, though, crystals aren't likely to form except around solid nucleii of microscopic size.

Where would hosts of such tiny particles originate?

They might be strewn by meteors falling through the atmosphere and eroding by friction en route.

Some scientists think the meteor dust alone makes up the noctilucent clouds. It could be true if enough of the dust particles were of the same size as the wavelengths of visible light from the sun.

Those who follow this latter argument do so because they cannot believe that the necessary amount of water vapor would survive the mesopause. For the mesopause lies directly under the thermosphere, which is bombarded incessantly by the fiercest rays of the sun's light—the extreme ultraviolet and the X-rays. In the boiling cauldron of the thermosphere, molecules of the atmosphere's constituent gases (mostly nitrogen and oxygen but also hydrogen,

—Photo by K. Devine.

Noctilucent cloud: Fort Chimo, Quebec.

—Photo by C. Brosnikoff.

Over Ft. St. John, British Columbia.

—Photo by J. Gardey.

Over Anchorage, Alaska.

—Photo by J. Zoller.

Over Anchorage, Alaska.

—Photo by Benson Fogle.

Over College, Alaska.

—Photo by Y. Gotaas.

Over College, Alaska.

helium, carbon, and others) split into atoms and the electrons of the atoms are stripped away from the nucleii. At an altitude of sixty miles, it is estimated that an oxygen atom will remain dissociated for a month before recombining; at seventy miles, the reconstitution process is assumed to take a year.

How could water vapor continue to hold together as water even as far down as the mesopause? Would it not be separated into hydrogen and oxygen before it had time to freeze into crystals?

These are very much more than abstract theoretical questions. They are among the master keys to long-range weather forecasting and understanding of climatic change.

Present-day study of the weather ends for most practical purposes about twenty miles above the earth. The atmosphere below that level works like a convective heat engine, first transmitting sunlight to the planet's surface and then catching the infrared rays as they bounce back skyward. Water vapor does the major heat-trapping job, forming clouds and precipitating rain and releasing energy as heat and light.

The mechanics of the upper atmosphere, insofar as these are known at all, seem to run opposite to the indirections of the lower atmosphere. In the upper atmosphere, in the thermosphere especially, the intense energies of ultraviolet and X-rays are captured directly and put into an enormous storage battery the design of which science has not yet figured out. The chemical elements of the atmosphere are broken up, recombined, and broken up again; energy is transferred in each of these transactions; sometimes heat is released, generating enormously powerful winds that blow in opposite directions very short distances apart; and sometimes light is freed, causing the upper air to glow at night.

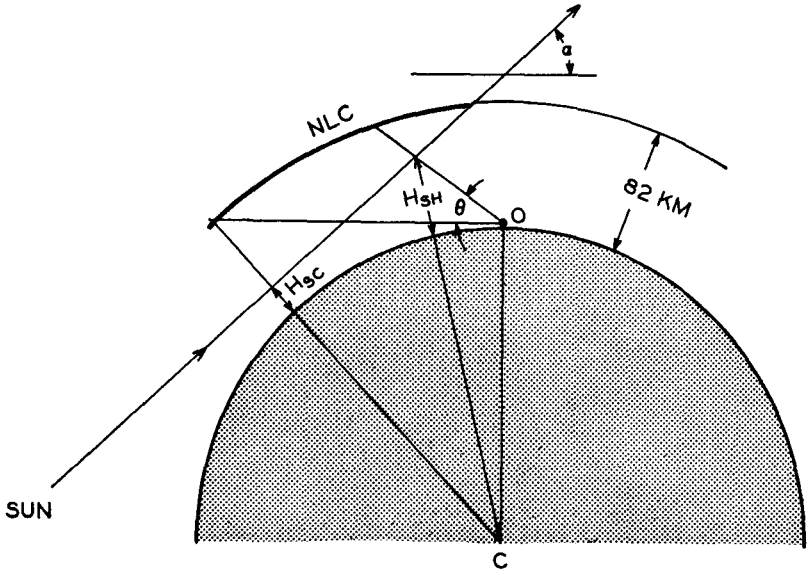
Much has been learned about the contradictory behavior of very high altitude winds and solar-lunar tides through study of the trails of falling meteors. It may be that the delicate filigree of noctilucent clouds, hanging in the little explored realm between the not yet related uppermost and lowermost atmospheres, will be the thread with which science finally ties the two together.

Although last among the major nations of earth to sense the ultimate potential of noctilucent cloud research, American scientists are now engaged in intensive experiments. The National Science Foundation is financing a project headed by Dr. Benson Fogle at University of Alaska's Geophysical Institute. Out of this work has come a historical survey of noctilucent cloud sightings, a report on the current state of knowledge, and a guidebook for noctilucent cloud observers. American, Canadian, and Icelandic weathermen, and pilots of jet planes traveling Pan-American, Alaskan, and British Overseas Aircraft Corporation routes across the northland are cooperating in a continuous watch. Observations to date indicate that at times noctilucent cloud formations may circle the pole.

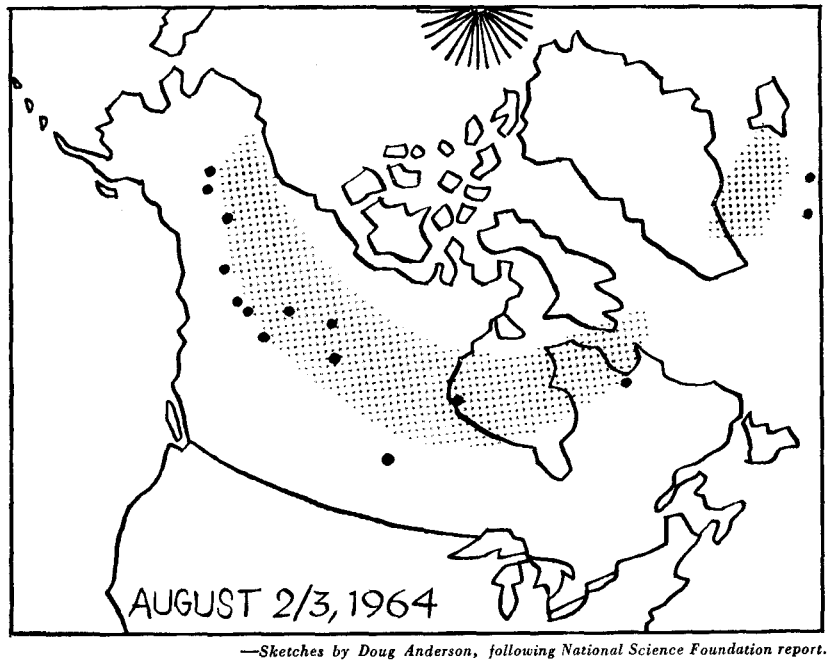
The movement of the clouds has been measured, and found to trend southwest at speeds ranging from one to eight miles per minute. Rocket samples of the clouds contain dust particles, the largest of which are ice-coated.

It is assumed that formation of such tenuous clouds would be impossible without instability of the atmosphere below them and a certain kind and degree of stability above them. But the reason for the veils, bands, waves, and whirls that dominate the cloud patterns are as mysterious as ever. The color photograph reproduced on page 54 of this issue of *SR* is believed to be the first taken in the Southern Hemisphere. Dr. Fogle took it on the night of January 9/10, 1965, at Punta Arenas in Chile. The time was the southern polar summer. The success of this expedition has encouraged the World Meteorological Organization to form a network of fifty-two observing stations between 45 degrees south latitude and the southern pole. Only nine sightings are on record in that vast region. Extensive study will enable comparisons of what happens there with what happens in the north. As always with basic science, no one knows what new knowledge may be shaken out of these lofty, luminous spiderwebs.

—JOHN LEAR,
Science Editor.



ARC OF COLOR in sketch above marks region of visibility of noctilucent clouds. Angle "a" must be between 6 and 16 degrees because sun's rays must clear screen of earth's atmosphere (Hsc) and earth's shadow (Hsh).



—Sketches by Doug Anderson, following National Science Foundation report.

Color band defines zone of noctilucent cloud observations on one night.

A PROPOSAL FOR A YEARLY PRESIDENTIAL REPORT ON SCIENCE

A Strategy Document for the Public Enlightenment

By WILLIAM D. CAREY

IF I were obliged to make a list of the most urgent problems facing the Congress of the United States in the field of its organization and functions, I doubt very much that I would rank science at the head of the list. So much for perspective.

I think we have been more critical of the behavior of Congress in dealing with science than the facts justify. Where the major commitments of the government are concerned—atomic energy, extraterrestrial space, defense, and medical research—by my standards the Congress has acquitted itself well. It is chiefly, I believe, in the less articulate sectors of the research program that some stresses and dissatisfactions have cropped up. Beyond this, we have observed in some quarters a growing passion to focus "science policy"—vaguely defined—in the higher reaches of legislative structure.

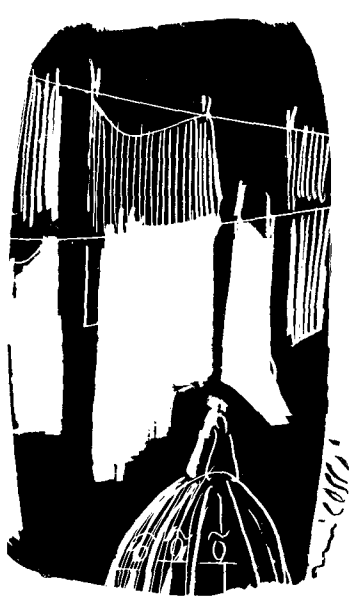
It must be said, sadly enough, that the scientific community itself has not always shown enthusiasm for improving Congressional understanding of the research business. This was brought home to me a couple of years ago when I spoke before a large assemblage of research scientists and administrators. I appeared coincidentally with the first stirrings of the crisis of congressional confidence in the growth and coordination of research. And I remember clearly that one individual after another rose to voice dismay at the prospect of the Congress injecting itself into inquiries into these matters. How can we prevent this from happening? What can be done to head it off? How can we keep research out of politics?

To me this signified a state of mind that regarded research and development as untouchable, to be screened at all costs from legislative caprice. Research was doing nicely under the wing of the Executive, and only trouble could result by tempting Congress to upset the equilibrium. It did not seem to occur to them that Congressional oversight could manifest itself in a constructive form.

I think that much of this mentality has now subsided in the wake of the work of the special committees of inquiry, which took high ground. There have been no scandals, no public executions, and few indictments. There will always be the risk that a member of Congress will show exasperation with the moon program or research into the mating habits of frogs, and that someone may twist an arm or two to influence the location of a plush research facility. But these risks are within the parameters of normalcy.

Still, I take the view that such tensions as have existed between the research brotherhood and the Congress cannot all be blamed on the latter. Some of the cohorts of science appear to have wanted all the prerogatives of a state religion without any of the embarrassments. This, too, I trust, has waned.

In addressing the question of how to equip the Congress to deal effectively with science, I am not bemused with the thought that it is necessary to foist a spate of new committees or institutional innovations on an already overloaded and overstructured legislative body. By my lights, the place to start is at the other end of town.



If the Congress feels starved for facts, if it is baffled at finding science behind every bureaucratic rock, if it fails to see intrinsic merit in the more arcane nooks of basic science, if it hunts vainly for signs of a broad strategy for science, if it cannot identify priorities for scientific choice, we have ourselves to blame. We are simply not providing the answers. And if we are not providing them because we do not have them, then we need to ask whether we are doing enough to get them. In my judgment, Congress is not anxious to take over the policy initiative for scientific research. It merely takes the quaint view that *somebody* should seize the initiative and do it well and thoroughly.

I have long preached, unsuccessfully, for the issuance once each year of a report from the Executive Office of the President on the substance, organization, costs, goals, problems, and progress of science and technology. I have thought of this as a strategy document similar to the Economic Report. A report such as this ought to tell us in highlight form where we have been in science, where we are now, where we want to go, why, and with what rate of investment. It should deal with the roles of both the private and government sectors of support and performance, and it should be qualitative as well as informational. I would be first to grant that a report like this would not solve the entire problem, but I have the feeling that it could supply in great part the element that is now so conspicuously missing—a *framework* for considering the state of science and technology in the larger economy of our public policy.

I should like to see such a report treated by Congress in much the same manner as the Economic Report is treated, with public hearings and testimony from invited outside parties. My preference would be for joint hearings