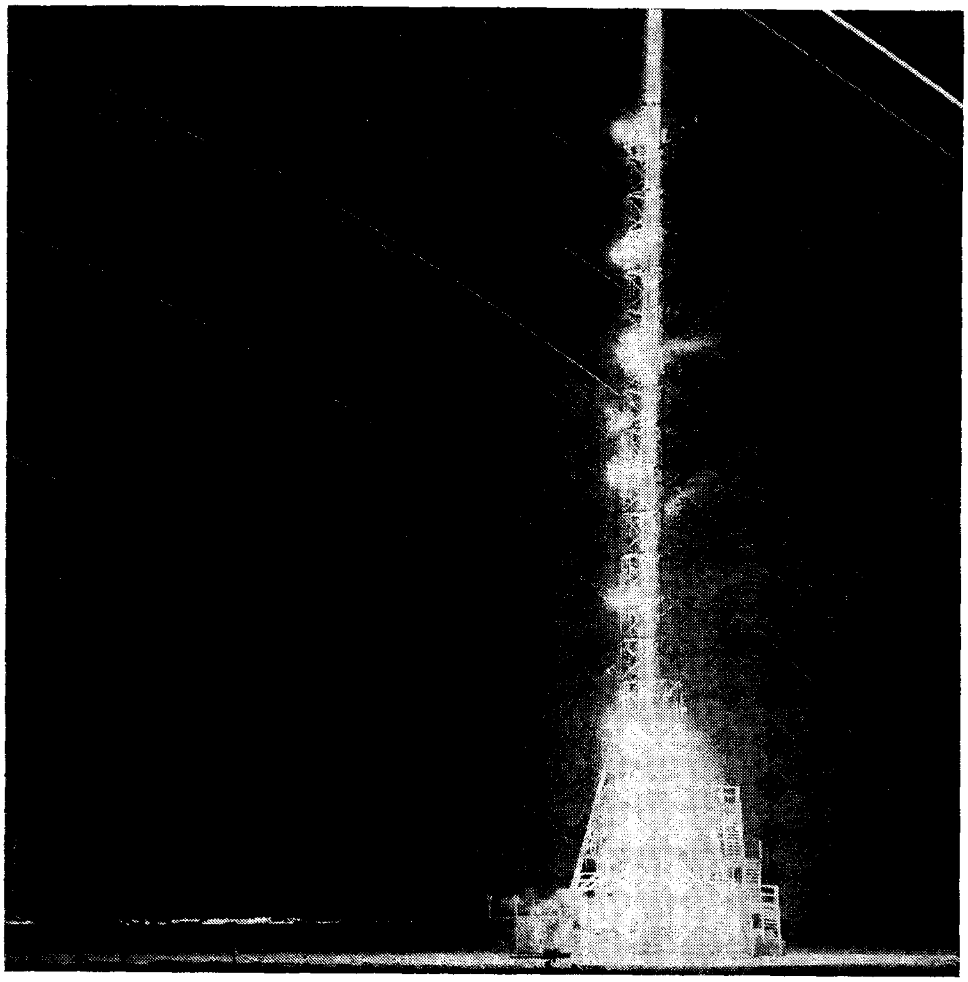
MINERS OF THE SKY



—*Official USAF Photo.*

Sky mining shaft is marked off by light of rising rocket's fuse. Angled streaks are paths of stars.

By JOHN LEAR

SUNSPOT, NEW MEXICO.

THE LIGHT appeared above the desert floor five minutes and a fraction of a second after 1 o'clock on the morning of Saturday, February 2. From this snow-dusted 9,000-foot peak in the Sacramento Mountains, I saw it hanging like an enormous lantern, low in the midnight sky.

At first it seemed utterly still. Then, almost imperceptibly, it rose as though it were being drawn aloft by the hand of a patient giant. Probing the dark with amber shafts as broad as the unrimmed spokes of a stilled wheel, it dimmed the brightest constellations to insignificant twinkles.

As it climbed it dwindled and reddened. Up, up, straight up. Tinier, redder, dull at last as a dying coal. Blip! Along the path of its disappearance into the zenith, the sky once again was adazzle with stars.

I had witnessed the passage of an awesome miner's lamp sent into the heavens by man in one of his first attempts to find and tap invisible lodes between the earth and the sun.

Having kept fire alive as his servant for centuries by collecting fallen sticks, chopping down trees, digging peat from bogs, invading the earth beneath his feet for coal and oil and uranium, the human explorer now is turning his eyes overhead and reaching into the air for the fuel of the future.

That power can be extracted directly from sunlight has already been demonstrated by Bell Telephone Laboratories' solar battery and by solar furnaces that are being built of mirrors in homes and public buildings of the Southwest. But only a small fraction of the available energy is being captured by these devices. Here at the Sacramento Peak Observatory, solar astronomer John W. Evans shows his visitors motion pictures of the sun's corona, taken by the green light of iron atoms whose temperature he estimates must be somewhere between 1,000,000 and 2,000,000 degrees on the absolute (K) thermometer scale. Since hydrogen explodes in volcano-like flares on the sun's face at only 10,000 to 30,000 degrees, he assumes that vast electromagnetic forces in the corona are pulsing at incredible speeds in all directions—including earth's.

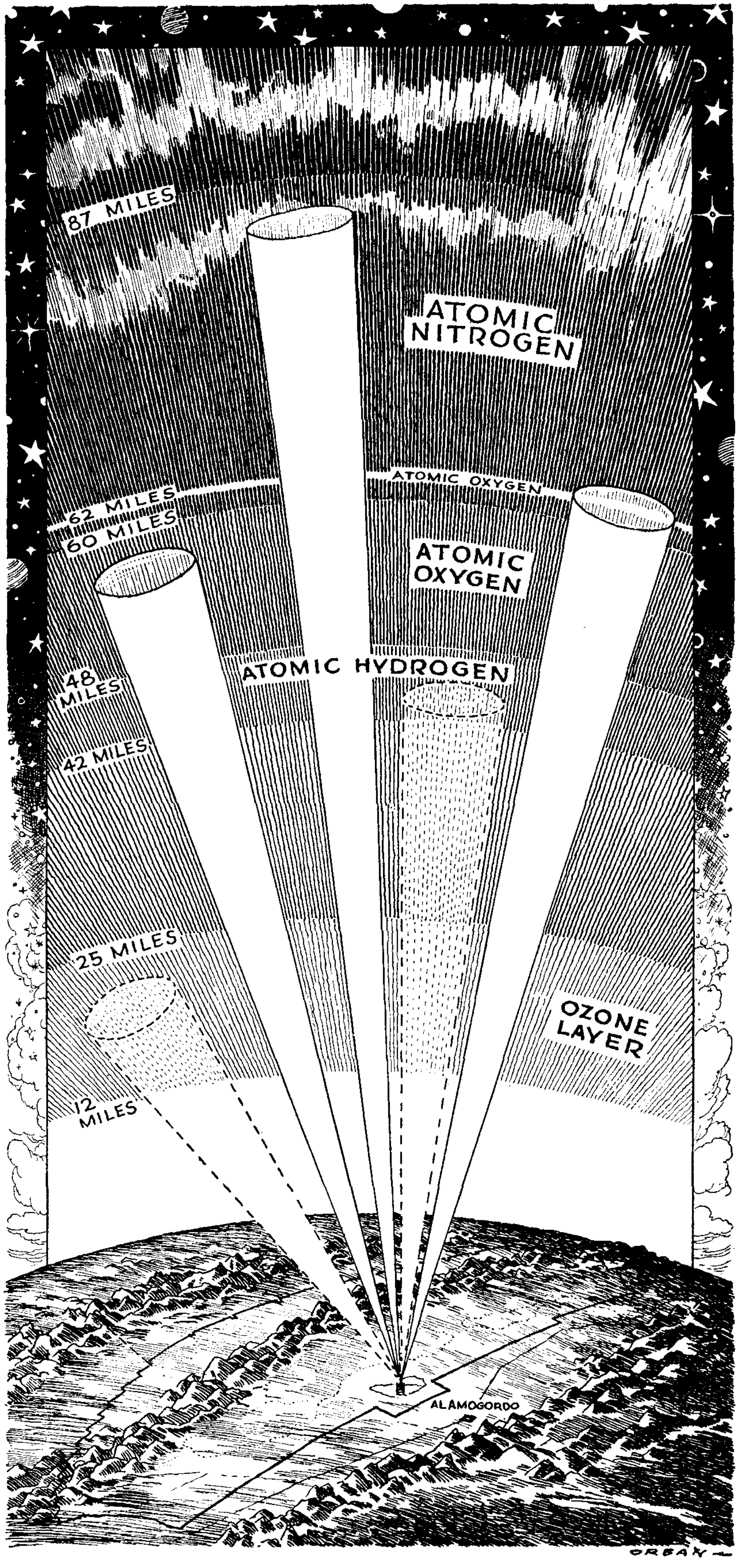
Scientists have long supposed that most of the original solar power is trapped at different levels of the sky just as oil is pooled in subterranean domes where the stratification of earth takes particular shape. There is, for example, the ozone layer, where three-atomed molecules of oxygen are heavily concentrated twelve to twenty-five miles above us. Ultraviolet light too violent for us to survive is caught there, and this energy is somehow stored for appreciable periods of time. Higher up, molecules of various constituent elements of the atmosphere are split into atoms by the sun's shafts, and each free atom carries with it a certain amount of photochemical charge.

What looked from this mountaintop to be a slowly ascending lantern was actually the fulminating fuse of a rocket cutting upward through the air at several times the speed of sound. Its purpose was to drill an exploratory shaft in search of nitrogen atoms.

At the surface of the earth, and more or less uniformly to the sixty-mile height within which 99.99 per cent of the atmosphere is contained, nitrogen makes up approximately 79 per cent of the air (compared to roughly 19.5 per cent oxygen and minute amounts of argon, helium, carbon dioxide and water vapor). Nitrogen is a constituent of all the amino acids from which life is built, a component of all the proteins in animal muscle, a base for the best fertilizers on which green plants thrive. Without nitrogen, the human being would be an impossibility.

So far as our daily comfort is concerned, then, it is reassuring for nitrogen to be a very stable element, so stable that it is almost inert. It cannot be set afire. It cannot be used to poison living things. The atoms in its molecules can be torn apart from each other in the laboratory only by ultraviolet light carrying 9.764 electron volts of energy—almost double the power needed to split the atoms in a molecule of oxygen.

But these very characteristics make discovery of nitrogen atoms a tedious undertaking. They have never been observed in the air we breathe. Since sunlight in the upper air is known to include rays far more powerful than 9.764 electron volts, it has been assumed that nitrogen atoms are loose high in the sky. Signs of their pres-



Above is an artist's conception of the sky mine in New Mexico. "Borings" actually made by rockets are represented by the solid-lined cones. The dotted lines mark explorations which, on the basis of present knowledge, seem feasible for future.

ence have been detected in the light of the aurora, whose dancing curtains of many colors hang anywhere from 600 miles up to sixty miles down in the atmosphere near the North and South Poles. But there has never been confirmation which a majority of scientists are willing to accept as conclusive.

THE Aerobee rocket whose launching I have described was fired for the purpose of obtaining the missing proof. It took off from the desert rocket range of the Holloman Air Force Research Center. The scientific aspects of the enterprise were in charge of Dr. Murray Zelikoff, photochemistry lab chief of the Geophysics Research Directorate at the Cambridge Air Force Research Center in Massachusetts.

Globular bottles of woven piano wire and glass fiber were nestled in the rocket's nose and then filled with ethylene gas, an oil well waste that has been turned to valuable use as an anesthetic and refrigerant. In the test tube, ethylene reacts with free nitrogen atoms in an unmistakable way, giving off light in distinctive shades of red and blue. Consequently, it was logical to believe that if ethylene were released in air where nitrogen atoms were present, a reddish blue light would appear.

Each of the two glass bottles of gas was stoppered by a valve that could be opened by a time clock. The valve on the first bottle was timed to turn when the rocket reached an altitude of sixty miles, the lowest hem of the aurora. The valve on the second bottle was timed to open at eighty-seven miles, the approximate height where virtually all oxygen molecules are broken apart into atoms and where the atoms of nitrogen might consequently be expected to begin to dissociate.

According to theories worked out by Jerome Pressman, a physicist-mathematician on Dr. Zelikoff's staff, the probability of many nitrogen atoms at sixty miles was low. Most likely there would be merely enough to cause a light. But at eighty-seven miles there was hope of finding enough of them to burn the ethylene with the brightness of a second magnitude star.

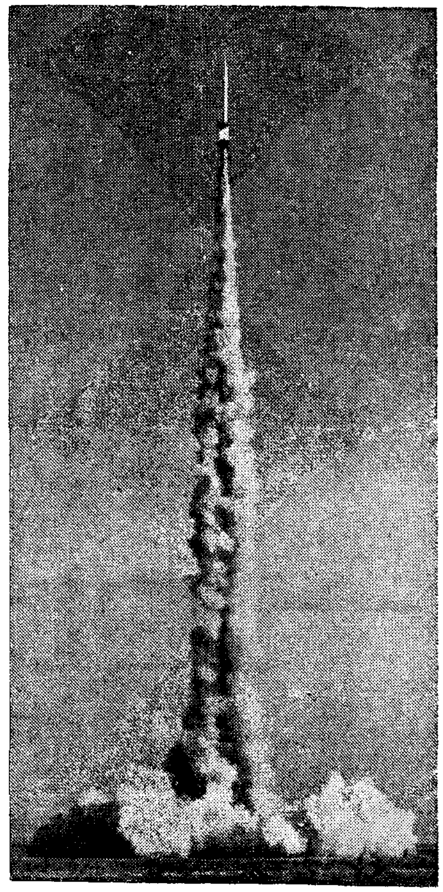
After watching the astonishing brilliance of the lantern effect until the rocket burned out in the midnight blackness, my eyes were not sufficiently acclimated to see what happened when the majestic light blipped into extinguishment. Astronomers around me and on Mayhill's Top across the valley saw, however, the momentary flitting of two strange wraiths near the faint star cluster Praesepe. I had to content myself with munching sandwiches left from a party the women on Sacramento Peak held earlier that Friday night—munching and waiting until 3 a.m., when negatives were developed from films in keen-eyed, wide-lensed, fast-winking meteor cameras. On those negatives I finally saw the ghostly lights the astronomers had seen. The upper light was recorded as a thin gray blob spanning two degrees of sky. It was not of the second magnitude of brightness, but of the fourth, just about the dimmest patch of diffused light an earthling could readily detect at such a distance. Had I been privileged to stand ninety miles further aloft than I was when the illusion of the rising lantern enthralled me, I would have missed the rocket's take-off glow but would have been blinded by the sudden precipitation in the sky about me of a scintillating cloud probably two-and-a-half miles across.

That shimmering cloud lasted only fifteen seconds or less. But the fact that there was a cloud at all is almost certain evidence that the nitrogen atoms are available and can be tapped for energy if we go high enough to find them.

How rich the nitrogen lode is, and what use can be made of it, are fantastic engineering problems for the fantastic future that lies ahead of us. We can afford to wait for their solution because oxygen atoms are plentiful and earlier rocket explorations leave no doubt at all that the energy stored in the oxygen can be released at will.

The idea behind sky mining was first expounded in 1950 by Dr. David R. Bates, professor of applied mathematics at Queens University in Dublin, Ireland. An Hawaiian scientist, Dr. K. Watanabe, worked out theoretical support for it in 1952, and his imaginative approach in turn inspired others around him at the Geophysics Research Directorate of the Air Force. One of those who worked with him was Dr. Zelikoff.

AF Capt. James Hurst (left), rocket boss.



The automatic miner in action in daylight.

It was almost exactly a year ago—on March 15, 1956—that Dr. Zelikoff and his laboratory crew (Jerome Pressman, Dr. Frederick Marmo, Dr. Edward Manring, Dr. John Bedinger, Leonard Aschenbrand, Adolph Jursa, Frank Le Blanc) struck unmistakable sky paydirt for the first time. They staked a claim around the scientific fact that there is light in the sky at night even when there is no moon. The story of their search for the cause of "the air glow" was one of the first reports published by SR/RESEARCH (April 21, 1956). But at that time the practical significance of the experiment was only dimly hinted.

BEGINNING with the postulation that "the air glow" was a delayed effect of sunlight, they first accumulated laboratory evidence that the daytime sun's rays struck oxygen molecules in the upper atmosphere with such enormous force that the two atoms of each molecule were driven apart. The strength of the blow caused a transfer of molecular energy, each of the separated atoms carrying along with it a share of the charge from the sun. When nitric oxide (its molecule has an atom of oxygen and an atom of nitrogen) was admitted to the presence of these lonely oxygen atoms, the oxygen joined it and formed nitrogen dioxide, freeing the solar energy from the atoms again in the form of light.

By sending a rocket loaded with nitric oxide to a height of sixty-two miles and releasing the gas at that point, the Cambridge scientists proved that energy is indeed stored in atomic oxygen at that level of the sky. In fact, eighteen and a half pounds of the gas released more than 100 horsepower.

That was as exciting in its way as a runaway oil well once was in Texas. And last fall still another rocket went drilling up to determine where the oxygen atoms were thickest. This time the probing chemical was sodium, which burns with a spectacular yellow light in the presence of oxygen. The sodium was emptied into the air continuously from a height of thirty miles onward. No light appeared until the rocket was forty-two miles above the desert. At forty-five miles the glow brightened. Between forty-five and forty-eight miles the burning continued for ten seconds before dying out. From forty-eight to fifty-seven miles there was intense light, which lasted for a minute and a half. At fifty-seven miles, the glow dimmed and was extinguished at sixty miles.

By that time, the art of sky mining was considered sufficiently advanced to plan a vehicle that could fly at an altitude of fifty to sixty miles, using oxygen atoms for fuel. Working principles were sketched on the basis of one simple, decisive fact: Oxygen atoms are naturally attracted to any surface. Men who think this atomic flying machine is eminently practical smile at the notion of capturing the energy freed by oxygen atoms in the upper air and conveying them to earth for use as power. But transmission of electricity over hundreds of miles of earth's surface was also considered impossible not very long ago, and if the first oil well drillers had been told that pipelines someday would carry their black gold across a continent, they would have laughed out loud.

Sky mining is, of course, in its infancy. There are at least two obvious veins of theoretically great promise that have not even been touched yet. One is the ozone layer between twelve and twenty-five miles up. The other lies between forty-two and forty-eight miles, where the breakup of water vapor should produce free hydrogen atoms along with hydroxyls, the so-called "radical" combinations of hydrogen and oxygen.

Balloons can and undoubtedly will be used by prospecting parties of the future. But due to its greater range, the rocket will almost certainly be the preferred instrument. Since its possibilities in exploration are so vital to man's advancing conquest of his environment—not only in using the sky's energy for fuel but in controlling weather and creating layers of ionization to deflect TV communication over the horizon—a recitation of my own experience leading up to the rocket launch of February 2 may help to convey a better understanding of this new science.

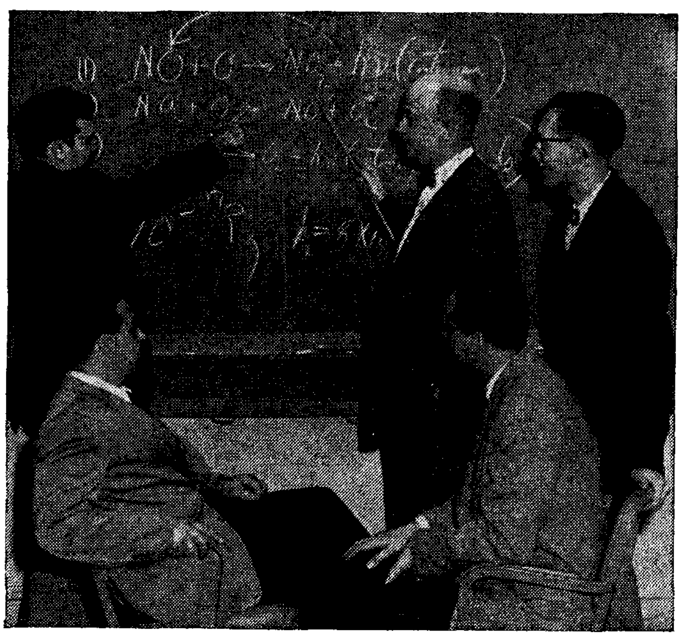
An utterly false sense of the present state of rocketry has been spread abroad by the announcement that sometime during the International Geophysical Year (July 1, 1957-December 31, 1958) scientists representing the United States will place an artificial moon in an orbit 300-to-1,000 miles out in space. It is commonly supposed that the major problems involved in this enterprise must have been solved before the announcement, that the remaining details are mere quirks of engineering, and that this new-fangled firework will be up there racing around us on the night of next Fourth of July. What is almost entirely overlooked is that the scientists assigned to the job have persistently refused to promise anything prior to the final minute of the twenty-fourth hour of the last day of *next year.*

It is not necessary to doubt the ultimate success of the earth satellite in order to point out that the rocket vehicle for it is a three-stage buggy. Today's rockets are two-stagers. The most reliable of them for scientific purposes is the Aerobee, custom-made by Aerojet in California. Roughly three out of four Aerobees reach the intended altitude, instruments in two of those three accurately record the information they are sent for, and one of the two completes a perfect performance. This is no derogation of the Aerobee. It is merely a matter of limited experience.

Aerobees are fired principally from two rocket ranges in the United States: Patrick Air Force Base on Cape Canaveral in Florida, and Holloman's desert sands here in New Mexico. Cape Canaveral offers the advantage of over water firing, and the disadvantage of difficult recovery of parachuted instruments. Holloman gets most of the instruments back, but is a safety engineer's nightmare.

The towns of Alamogordo (ten miles to the east), Las Cruces (sixty miles to the west) and El Paso (ninety miles to the south) could all become reluctant hosts to a sky truant if the wind and trajectory were right. Holloman takes no chances. Every launching must be plotted within the confines of a column of air corresponding to the 128x38 mile rectangle corraled on the ground by the San Andres and Sacramento Mountains. Every rocket is required to carry within it at least one high explosive charge, and if its radar track passes beyond the established limits of air space, a radio signal blasts the offending vehicle to bits in midsky.

Wind, then, is a constant hazard of prospecting the upper atmosphere. One instrumented Aerobee costs in the neighborhood of $100,000, and scientists cannot afford to have that investment exploded without promise of return. Where chemi-luminescence (creation of light by a chemical reaction) is involved, there is also a



Dr. Murray Zelikoff (baton) with aides (left to right) Jerome Pressman, Dr. Frederick Marmo, Adolph Jursa, and Leonard Aschenbrand. Missing: Dr. Edward Manring, Frank LeBlance, and John Downing.

The Pilot Is Not for Burning

IN MINING the sky for energy, prospectors of the upper atmosphere are also tapping new stores of knowledge. The free atoms they seek exist naturally only at temperatures destructive to human life. These temperatures, however, happen to be the very temperatures through which man intends to fly in the decade now beginning. There is no way to escape them as long as man persists in traveling progressively faster than sound. Rather than risk incineration on his journeys, then, man must understand how such unearthly heat is generated and what he can do to contain it for his own protection.

"Above ten times the speed of sound, at which . . . even man-carrying hypersonic (any speed greater than five times the speed of sound) gliders may fly, our understanding . . . respecting aerolynamic heating . . . is still imperfect, to say the least," Walter Bonney, press spokesman for the National Advisory Committee for Aeronautics, told *SR*'s Science Editor during the 1956 official inspection of Langley Aeronautical Laboratory in Virginia.

"In essence, aerodynamic heating is the conversion into heat energy of the kinetic energy of the air through which the airplane is flying. This conversion takes place in the area of the shock wave (set moving in the air by an advancing object) and in the boundary layer (of air immediately surrounding the plane) where the air velocity is slowed as it approaches the (plane's) body. The temperature increases as the square of the velocity. At a Mach number of 3 (Mach number 1 is the speed of sound), about 2,000 miles per hour at altitude, the temperature would be about 660 degrees Fahrenheit. At a Mach number of 20, about 13,000 mph, the temperature would be above 20,000 degrees F, far hotter than the surface temperature of the sun.

"The heat energy which is generated by high speed flight first appears in the boundary layer surrounding the surface of the aircraft. Then it is transferred through the boundary layer into the aircraft structure. At the same time that this heat energy is being absorbed, radiation is dissipating some of the heat. The desired goal, of course, is to maintain a balance between heat input and outgo low enough so that the aircraft will not be destroyed.

"In conventional aerodynamics, the atmosphere is considered to be composed of stable molecules of the various elements in air. The molecules move about in three-dimensional space. But at the velocities where aerodynamic heating becomes a serious problem, the molecules in the air no longer behave in the orderly way postulated in the 'ideal gas' laws.

"At temperatures above 500 degrees F, the molecules begin to vibrate. At temperatures exceeding 5,000 degrees F, a part of the heat energy within the molecules is changed into chemical energy; some of the molecules dissociate or split apart into free atoms. New molecular combinations appear, notably nitric oxide. At even higher temperatures, approaching 20,000 degrees F, ionization or electronic excitation of the atoms and molecules occurs. In thermodynamic studies already made, some forty reactions have been noted and must be explained."

Whatever the sky miners learn about the dissociated atoms whose energy they are tapping is bound to be useful to the NACA, top research center for aviation in America, in its primary current goal: "Airplanes speedy enough to shrink the globe until any two points will be within a comfortable day's journey."

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menace in every cloud that flits the night sky.

I flew to Alamogordo from New York on a Friday, to be ready for the scheduled nitrogen hunt at 10 p.m., Mountain Standard Time, on the following Monday. When Monday came the sky was heavily overcast, so heavily that the rocket firing was cancelled at breakfast-time. On Tuesday, the overcast had lightened but by midafternoon it was plain we would cancel again. On Wednesday, the clouds were broken. There was a fifty-fifty chance. I jounced in a jeep with Dr. Zelikoff to the top of a nearby butte when the stars came out, and we listened to the countdown while we watched the drifting sky. At X minus five minutes the count was suspended for an hour and three quarters. At fifteen minutes to midnight, clouds still obscured the zenith, so we jounced down off the butte and gave up for the night. On Thursday the sky was clear as crystal. But the radar trackers who stand watch in the hills for every launching had stayed up so late the night before that safety control wouldn't allow us to ask them to do it again. By Friday, my hope being exhausted, I abandoned the concrete blockhouse behind the launching tower (the rockets are fired like bullets from a rifle) on the rocket range and drove twenty-odd miles to this observation point on Sacramento Peak. Here, from sunset onward, I could see bright stars wherever I looked. There seemed no conceivable reason why the rocket should not go up at last.

But this time the countdown did not reach X minus five minutes. It was suspended at X minus fifteen. An open phone line to the blockhouse below told us that high winds had set in suddenly from the southwest. We waited an hour and thirty-five minutes. At intervals the radio croaked. "Aerobee is holding at X minus fifteen minutes." Then, down beside the blockhouse, a tiny finger of light appeared. The launching tower had been lighted. Something had gone wrong. What? We grabbed the telephone and called down. The temperature of the air at the tower had dropped to thirty-seven degrees, and the ethylene gas on which the experiment depended would condense into liquid at forty-seven degrees if the bottles in the rocket's nose should cool to that critical point. While the wind was up, a hair dryer was lugged out and plugged in to keep the bottles warm.

Silence followed for a half hour. The finger of light blinked out. We knew then that the gas was still gas. New word came up on the telephone. The wind was falling. Weather balloons were soaring aloft to measure its strength and direction as fast as they could be filled.

Fifteen minutes went by. Three Oboe, a radio tracker, got the word on the radio from Five Oboe: "We're running short of time. Might as well put on your coat." Ten minutes more. Five Oboe to Three Oboe: "Better take your coat off."

FIFTEEN minutes after midnight, the countdown was resumed at X minus fifteen minutes. At X minus five minutes, the count was suspended again. The thick black hands of Ed Manring's clock crept round the dial. Eighteen minutes until one. "Winds are improving rapidly," the phone said. Ten minutes until one. "Our estimated impact point is still seventeen miles off range." One o'clock. "Aerobee is resuming at X minus five minutes," croaked the radio. In the blockhouse down on the desert floor, they were tilting the launching tower on its three hydraulic-powered legs to offset the wind. And they were continuing to tilt it at X minus ten seconds. In the blockhouse, at the control board, Fred Marmo sweated it out. Before he became a scientist, he had been a night-club entertainer. But he had never come so close to stagefright as he did before he turned the key and pushed the firing button.

Me? I was so excited I dreamed that night of owning a nitrogen mine. I called it, Praesepe Placer.