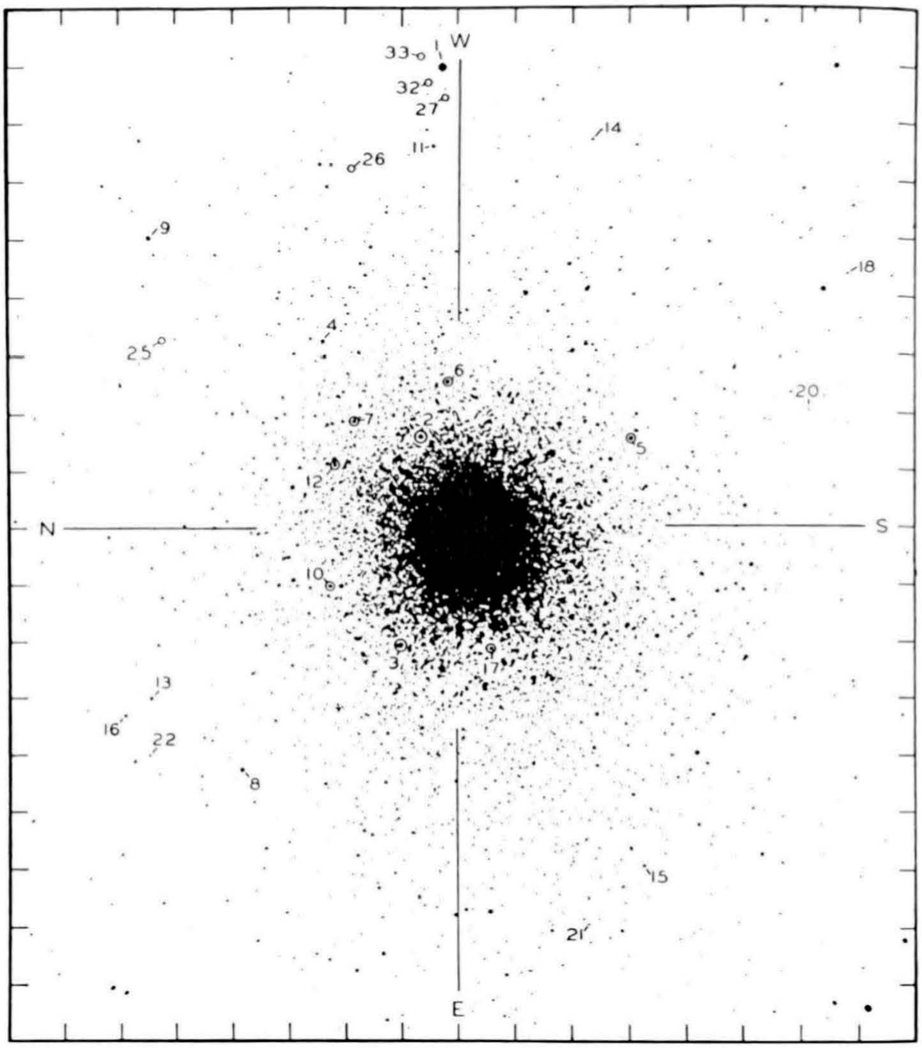
based. The extensive photometry of distance indicators, such as Cepheids and novae, belonging to these nearby systems can be handled fairly well by photographic methods if the data are properly calibrated on a correct scale of magnitudes. For this purpose, very faint standard sequences have been established with the photon counter in three of the Kapteyn selected areas. W. Baade has already used these sequences, along with a revised Cepheid zero point, to estimate a new modulus for the Andromeda galaxy of 24.2 magnitudes, corresponding to a distance of about two million light-years. This result has been tentatively confirmed by direct photoelectric observations of red giants in the southeast halo of that galaxy, including the star for which counts are given in Fig. 10.

The counter has also yielded an important result bearing on stellar populations. It has shown that the main sequences of globular clusters are comprised of subdwarfs. This was discovered from the photometry of faint stars in Messier 13 (featured in the center of this issue), and it has now been confirmed in Messier 3. Further work on other clusters is in progress. The result apparently means that the familiar main sequence for stars in the solar neighborhood is only a particular case lying near one edge of a main-sequence band embracing dwarfs and subdwarfs together.



This chart of M13 is from a 200-inch photograph, and can be used as a key to the feature picture on the following pages. Numbers identify stars measured photoelectrically by Dr. Baum. The yellow magnitudes for the numbers included on the chart are: 1, 10.74; 2, 12.03; 3, 12.04; 4, 12.14; 5, 12.15; 6, 12.43; 7, 12.64; 8, 12.81; 9, 12.85; 10, 13.14; 11, 13.28; 12, 13.46; 13, 13.49; 14, 14.50; 15, 14.84; 16, 15.01; 17, 15.07; 18, 15.47; 20, 16.05; 21, 16.10; 22, 17.03; 25, 17.86; 26, 17.99; 27, 18.33; 32, 21.14; 33, 21.40. The marks at the edges represent minutes of arc. Adapted from the "Astronomical Journal."

ASTRONOMICAL SCRAPBOOK

Other Satellites of the Earth

ONE of the most famous meteoric phenomena on record happened on February 9, 1913. This was long believed to have been a procession of about 50 fireballs, moving very slowly from horizon to horizon in nearly the same path, seen from western Canada, across Minnesota, Ohio, New Jersey, and Bermuda to the equator—a distance of over 5,600 miles.

It was, however, established by C. C. Wylie in 1939 that these widely spaced observers had not viewed the same meteors, so what really occurred was an intense but ordinary meteor shower rather than a true meteoric procession.

Even so, there are some interesting consequences of the original idea of a procession of meteors. For if the course and velocity with which such bodies approach the earth were favorable, they could be captured as satellites, circling far enough above the earth's surface to avoid destruction by the atmosphere—the fate of all ordinary meteors. They would then be the type of body looked for in C. W. Tombaugh's intensive photographic search now under way at the Lowell Observatory. His is the first sustained effort, with modern optics and careful programming, to discover additional satellites of the earth.

How a hypothetical satellite would appear to an observer was discussed in detail by W. H. Pickering in 1923. He showed that a meteorite one foot in diameter, revolving in an orbit 200 miles above the earth's surface, could be as bright as 10th magnitude at times, shining by reflected sunlight. It would resemble an unusually slow-moving telescopic meteor. Objects of this sort may well be picked up in Tombaugh's search.

Controversy about earth satellites dates back at least to 1821. The British meteorologist, John Farey, held that many meteors were small terrestrial satellites traveling in eccentric orbits, dipping deep into the earth's atmosphere at every perigee passage. This view was rebutted by Dr. William Burney, of Gosport, England. Nevertheless, the idea lingered, and in 1867 the British amateur, W. E. Hickson, argues for their existence. You can find a meteoric satellite in science fiction as early as Jules Verne's *From the Earth to the Moon* (1865).

Is it possible that a meteoric satellite has already been observed? The unfounded report of last August is explained in last December's *Sky and Telescope*, page 51. There was rather more justification for the momentary suspicion that one had been found in 1938, but the rapidly moving object discovered on Koenigstuhl Observatory photographs turned out to be a new asteroid, Hermes, passing within 440,000 miles of the earth.

There is, nevertheless, a classic case where the discovery was reported by a

(Continued on page 351)

(Continued from page 334)

prominent professional astronomer in a leading scientific journal, together with full details and a complete orbit computation. The man was F. Petit (1810-1865), director of the Toulouse Observatory, whose communication to the French Academy of Sciences was printed in its *Comptes Rendus* of October 12, 1846.

Three observers saw the body, Lebon and Dassier at Toulouse, and Larivière at Artenac, 26 miles away, on March 21st of that year, at 6:45 p.m. When Larivière first noted this luminous object, it was low in the south, near Sirius; it moved slowly past Orion and into the northwestern sky, where it vanished behind a low cloud bank. It stayed in sight for 10 seconds, and its apparent diameter was half that of the moon.

First supposing this object to be a meteor, Petit calculated its track, and found to his surprise that the observations indicated an elliptical orbit around the earth with a period of revolution of 2 hours 44 minutes and 59 seconds. The mean distance from the center of the earth came out 6,180.1 miles, and the orbital eccentricity 0.36007. Therefore, at perigee—the time of observation—the body would have missed the earth's surface by only 7.1 miles. Why this conspicuous object was not earlier recognized was easily explained by Petit: At less favorable apparitions its much greater distance from earth would make it correspondingly fainter.

In the audience at the French Academy when this paper was read sat the great Leverrier, codiscoverer of Neptune. He commented that the orbit calculation should be revised to take air resistance into account.

Hindsight is easy, when an additional century of experience by meteor astronomers is available to us. In 1846 the calculation of meteor heights and paths was still a novelty, and Petit had not realized that the observations were too rough to support such an elaborate superstructure of computation. His orbit depends very critically upon the uncertain estimates of the duration of visibility. The 10-second duration reported by Larivière leads to an elliptic orbit that intersects the earth's surface twice; the six seconds of the Toulouse observers makes the orbit around the earth a hyperbola. Petit had arbitrarily averaged these durations for his calculations with seven-place logarithms!

Petit's similar discovery of a second supposed earth satellite on July 23, 1846, also appears invalid, from uncertainty in the duration of visibility. There can now be hardly any doubt that both these objects were merely ordinary fireballs. Clyde Tombaugh need not fear having been anticipated 109 years ago, if he finds a satellite of the earth.

J. A.

NICAP SPECIAL BULLETIN

Published by the National Investigations Committee on Aerial Phenomena –

DONALD E. KEYHOE, Director & Editor | OCTOBER 1960 | RICHARD HALL, Secretary and Associate Editor

UFO SURVEILLANCE LINK WITH SPACE

The Office of the Secretary of the Air Force has made two important admissions about UFOs, in a private "policy letter" to all AF commanders:

1. The AF maintains a "continuous surveillance of the atmosphere near Earth for unidentified flying objects—UFOs."

2. The Air Force's interest in space surveillance is related to this constant alert for UFOs.

The policy letter from Secretary Dudley Sharp's office, dated Aug. 15, 1960, was signed by Maj. Gen. Arno Luehman.

As in the UFO surveillance, the space watch is on a round-the-clock basis, the policy letter stated. Tracking of both known and unidentified space objects is carried out by the National Space Surveillance Control Center, aided by "a selected scientific group under the supervision of the Air Force."

The Space Surveillance Control Center, on Air Research and Development grounds at Bedford, Mass., receives data on satellites and unknown space objects from over 100 sensor stations in the U.S. and abroad. Positions of both known and unidentified space objects are indicated on a luminous map of the world. The Center has a computer with data on all known earth-launched satellites, orbiting boosters and rocket parts, so that any strange object reported in orbit can be quickly recognized as such.

Recently, the Center tracked an orbiting mystery object which also was seen by observatories and Moonwatch teams. The director of Adler Planetarium publicly declared the object was a UFO, faster than any known earth satellite. (See Mystery Object story.)

To date, the AF has been silent about this strange space object; the usual answers could not explain away factual reports by well-known professional astronomers. Instead of the usual brush-off, the AF now has announced plans for two systems to detect and identify unknown objects and relaying images to earth. The other program, labeled "Project Saint," will involve "big brother" satellites also designed to identify strange orbiting objects. An AF spokesman has stated these inspection-satellites probably would be equipped with TV and telemetering devices to provide descriptions of unknown satellites.

The AF has publicly implied that these detection devices are mainly intended to spot secretly launched Russian satellites. But the private AF admission in the Aug. 15th policy letter strongly indicates they will have another purpose equally vital—perhaps even more important:

To detect and identify space-machines coming from other

False AF Answer in Red Bluff Case

In utter disregard of astronomical records, the AF has issued an impossible explanation of the August 13-14 UFO sightings in the vicinity of Red Bluff, Calif. The Red Bluff case included a dramatic encounter by State police, visual reports by other witnesses, and an AF radar station's admission that it had tracked "an object" at the time of the State police sighting.

Answering a NICAP request for the AF conclusions, the official spokesman on UFOs, Lt. Col. L. J. Tacker, sent this signed statement:

"The individuals concerned witnessed a refraction of the planet Mars and the two bright stars Aldebaran and Betelgeux (Correct spelling: Betelguese) . . . . . Not only was there a temperature inversion but during part of the time double inversions existed."

A check of August 13-14 star positions by a NICAP astronomical adviser reveals these facts:

1. Mars and the two stars were below the horizon, invisible, when police sighted the UFO at 11:45 p.m., August 13.

2. Mars did not appear until an hour later. Aldebaran was just visible above the horizon at 1 a.m., August 14, and Betelguese did not rise until nearly 3 a.m.

It is absolutely impossible for Mars, Aldebaran or Betelguese to have been the UFO seen from 11:45 to 12:45, Aug. 13-14, nor could they in any way explain the relatively low-altitude radar tracking.

Apparently the AF gambled that no one would check the star positions when they risked this answer. Probable reasons:

1. To kill this important new report and stop the growing press interest in the new wave of sightings.

2. To avert any speculation that the Red Bluff UFO came from the orbiting "mystery object" tracked by astronomical observatories and the Space Surveillance Control Center. (See separate story.)

The importance of this case is shown by the key points:

At 10:30 p.m., Aug. 13, a large, oval-shaped object was seen maneuvering over Hollywood, Calif. At about 11:45, State Policemen Stanley Scott and Charles A. Carson, cruising near Corning, south of Red Bluff, sighted the same or another UFO. At first they took it to be an airliner in trouble. Then they saw it had no wings. A red light showed at each end, with several white lights on the side. The strange machine was moving at a low altitude.

continued on Page 4

CONGRESSMEN AID NICAP IN FIGHT AGAINST SECRECY

Direct Congressional support for the release of hidden UFO information — possibly before next session — has developed rapidly in the last few weeks. The increased Congressional concern has resulted mainly from the first submission of NICAP's Confidential Report, which was photo-copied and sent to a selected group on Capitol Hill.

All the remaining legislators are now being sent copies of the documented evidence, thanks to the aid of NICAP members. Answers will be reported in the next UFO Investigator. Meantime, here are a few statements and actions by members of the first Congressional group:

1. In a letter to AF Secretary Dudley Sharp, Sept. 19, Congressman Edgar W. Hiestand, Calif., asked that AF policy on UFOs be re-examined, with a change to "complete frankness."

"I am apprehensive," stated Congressman Hiestand, "that right now, in the middle of a campaign, some concrete and well-documented incident may occur, and a sensational revelation could really hurt.

"After all, although the UFOs are unknown devices, there seems to be enough evidence available to convince that they are real rather than imaginary . . . . . Therefore, what harm could complete frankness do?"

2. On Aug. 31, Congressman Leonard G. Wolf, Iowa, Member of the Science and Astronautics Committee, told the House of Representatives:

A. "There is real concern by many Members of Congress."

B. "The conclusions of these experienced NICAP officials should be given careful consideration."

C. "A thorough study of the UFO problem should be made. Pending such action, I believe that publication of the NICAP Report (with confidential Section V deleted: NICAP note) will help to reduce the dangers cited by Vice Admiral Hillenkoetter and the other NICAP officials." (See Sept. 2 Congressional Record, Page A 6714.)

Detailed excerpts from Congressman Wolf's statement include the following:

"Admiral Hillenkoetter's request that Congress inform the public as to the facts is endorsed by more than 200 pilots, rocket, aviation and radar experts, astronomers, military veterans and other technically trained members of the National Investigations Committee on Aerial Phenomena." (Typical examples were listed, with names.) "I believe the conclusions of these experienced NICAP officials should be

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WATERMAN, Alan Tower, physicist; born Cornwall-on-Hudson, New York, June 4, 1892; son Frank Alan and Florence (Tower) W.; A.B., Princeton, 1913, A.M., 1914, Ph.D., 1916, D.Sc., 1952; Sc.D. (hon.), Tufts Coll., 1952, Northeastern University, 1953, U. Vt., 1955; LL.D., Cornell College, 1956; m. Mary Mallon, Aug. 1917; children—Alan Tower, Neil John, Barbara (Mrs. Joseph R. Carney), Anne (Mrs. William C. Cooley), Guy van Vorst. Instr. U. Cincinnati, 1916-17; instructor physics, Yale, 1919-22, assistant professor of physics, 1923-30; National Research fellow, physics, King's Coll., London, 1927-28; asso. prof. of physics Yale University, 1931-48; dep. chief and chief scientist Office Naval Research, Navy Department, 1946-51; dir. Nat. Sci. Found., 1951—. Dir. Center for Advanced Study in Behavioral Sciences; trustee Atoms for Peace Awards. Member science advisory com. ODM; mem. Adv. Com. on Weather Control. Served from private to first lt., Science and Research div. Signal Corps, U.S. Army, 1917-19; served as vice chmn. div. D, Nat. Research Defense Com., 1942-43; dep. chief office of field service, OSRD, 1943-45, chief, 1945. Chief reader, physics, coll. entrance examination board, 1935-41, chief examiner, physics, 1937-49. Fellow A.A.A.S., Am. Phys. Soc., Am. Assn. Physics Teachers; mem. Am. Inst. E.E., Washington Acad. Sci., Philos. Soc. Wash., American Association Univ. Profs., Scientific Research Soc. Am. (governing bd.); Phi Beta Kappa, Sigma Xi. Clubs: Graduates, (New Haven), Cosmos (Wash.). Medal for Merit, 1948. Editor: Combat Scientists, 1947. Mem. editorial bd., Am. Jour. of Sci., 1934-42. Contbr. sci. papers to The Phys. Rev., Am. Jour. of Sci., Philos. Mag., Proc. Royal Soc. Home: 5306 Carvel Rd., Westmoreland Hills, Washington 16. Office: Nat. Science Found., Washington 25.

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ORVILLE, Howard T(homas), naval officer retired, meteorological consultant, corp. executive; born Saratoga, Wyo., June 16, 1901; s. William and Lucy D. (Wiant) O.; student Army and Navy Prep. Sch., 1918-19; B.S., U.S. Naval Acad., Annapolis, 1925; student Navy Post Grad. Sch., 1928-29; S.M. in meteorology, Mass. Inst. Tech., 1930; m. Lillian L. Duvall, June 5, 1926; children—Howard Thomas, Harold Duvall, Richard Edmonds. Bank clk. Stockgrowers State Bank, Saratoga, Wyo., 1917-18, Rawlins Nat. Ban, 1919-21; commd. ensign U.S. Navy, 1925, and advanced through grades to capt., 1944, ret. 1950; assigned to battleships and destroyers, 1925-28; officer in charge aerographer's sch. Naval Air Sta., Lakehurst, N.J., 1930-31, 1934-35; copilot nat. and internat. free balloon races, 1934-35; aerolog. officer U.S.S. Langley, 1931-32; force aerolog. officer on staff comdr. battleships, Battle Force, 1932; fleet aerologist on staff comdr. in chief, U.S. Fleet, 1926-38; lighter-than-air pilot, head aerolog. dept. and sch., Lakehurst, N.J., 1938-40; head naval aerology, flight div. Bur. Aeronautics, 1940-43, transferred to dept. chief Naval Operations (Air), 1943-50; during these yrs. served on numerous commns. and coms. working in meteorol. field; served as del. or mem. delegations several internat. confs.; ordered to North Atlantic Treaty Orgn., 1950; mem. vis. com. Blue Hill Obs., Harvard, and dept. meteorol., Mass. Inst. Tech.; cons. to gen. mgr. Friez Instrument Div., Bendix Aviation Corp., 1950—. Awarded Legion of Merit; Commendation Ribbon; Officer Military Order of British Empire; Cravate Blue of Yun Hwei (cloud and banner) (China). Mem. several profl. and scientific orgns. and assns. Author instrn. manuals and numerous articles on meteorology. Home: Long Green, Md. Office: Friez Instrument Div., Towson 4, Md.

7 May 54

On May 15th, General Nathan Twining's remarkable remark at Amarillo.

On May 17th, four veteran National Guard pilots in jets over Dallas, Texas, engaged in a game of high-altitude tag with sixteen UFOs before the jets were outmaneuvered and outdistanced. Reported in *Dallas Herald* on May 25th. Not reported by any news service.

On May 31st, Fifth Air Force officials in Japan confirmed reports that U.S. jet fighter planes in Korea had been pursuing and shooting at UFOs.

On June 9th, Colonel Frank Milani, Director of Civil Defense in Baltimore, issued public demand that Air Force lessen its secrecy regarding UFOs.

June 10th. Air Force denies Colonel Milani's implications of secrecy and censorship; claimed only eighty-seven UFO reports received in first four months of that year. ATIC at Dayton refuted Air Force claim when Deputy Commander of Intelligence Colonel John O'Mara admitted that more than a thousand scientists were working on the problem and added that more than seven hundred UFO cases were being received each week ". . . heaviest rate of sightings on record."

July 9, 1954. Front-page headline in the *Wilmington* (Delaware) *Morning News:* 100 MYSTERY OBJECTS SPOTTED HERE—"Air Force permits Ground Observer Corps to release data on phenomena sighted here and confirmed elsewhere." The article disclosed that the ground observers had been watching these objects and reporting them to the Baltimore Filter Center where the Air Force studied the reports (and where Colonel Milani got the material for his blast!). On July 5th, just four days before the *Wilmington Morning News* broke the story, the Air Force

had officially identified one of the things as "an Unidentified Flying Object."

From South America in 1954 came a flood of sighting reports, to be added to the hundreds which poured in from Europe, North Africa, the Near East, and Japan. Germany, Italy, Sweden, and Yugoslavia in 1954 joined the list of nations which were admittedly engaged in serious probes of these objects.

A study of these reports indicates that the UFOs were conducting a systematic and cautious study of man's modes of travel. They also visited every radar base, communications center, and industrial complex of importance—and demonstrated an increasing interest in electric generating installations.

All in all, a summary of UFO cases from credible sources in 1954, after the advent of the double-convex type of craft, leads to the conclusion that they were indeed engaged in the estimates of what the briefing had specified as Phase Four—but with overtones of Phase Five.

By 1955, it had been well established that we were dealing with specialized craft of unknown origin and purpose. There had been no indication of any hostility on their part nor had there been any indication of any apparent desire to establish communications with man. We were aware of their presence, of their general appearance, of their program of intensive surveillance. But where they came from—and why—and how they propelled themselves were matters which eluded us then—and to a large extent—still do.

Dr. Hermann Oberth, father of the German rocket program, investigated these UFOs for that country, and at a news conference he declared:

San Jovane

Stigmata

"There is no doubt in my mind that these objects are interplanetary craft of some sort. I and my colleagues are confident that they do not originate in our solar system but we feel that they may use Mars or some other body as a sort of way-station."

During the summer of 1954, hundreds of professional astronomers flocked to the southern hemisphere to view Mars under optimum conditions. From that portion of Earth the telescopes can be pointed toward Mars without having to scan it through the distorting layers of atmosphere which bother the viewing from the northern hemisphere. It is for this reason that most of the astronomers who have reported seeing the lines on Mars have done so while viewing the planet from our southern hemisphere. During this study of Mars in 1954, Dr. E. C. Slipher of Lowell Observatory used the fine big telescope at Bloemfontein, South Africa, and at the conclusion of his work he declared that there could no longer be any doubt that life of some kind existed on Mars. Slipher and other astronomers took thousands of pictures during the study. But the official statement from the Mars committee was delayed for months because the scientists could not agree on what they had seen—or what it meant.

The upshot of it was that a program which had been instituted with the possible goal of settling the controversy ended in an equivocal statement which settled nothing; it merely postponed "the next big episode," as they used to say in the movie serials. We were led to believe that once we could get some close-up pictures of Mars—ah! Then we would be able to tell——.

If you will bear with me for doing so, I should like to digress here from our study of the UFO procedures and the seven-phase program discussed at the briefing—to develop the Martian study and its peculiar twists and turns.

We have just seen how the 1954 Mars Program ended in disagreements among the scientists involved.

As a fascinating and perhaps important portion of our multibillion-dollar space program, we launched a device designed to photograph Mars and to transmit the pictures back to Earth. Officially designated as Mariner 4, it took off from Cape Kennedy in November, 1964, on a curving flight which put it alongside Mars in July, 1965. Its phenomenally accurate path was a marvelous scientific achievement. The pictures it sent back by television were equally remarkable, another scientific milestone.

But Mariner 4's performance—and the subsequent performance of some of the scientists involved—left fresh mysteries to be resolved.

As the probe neared Mars, the public was told that it might be months before any of the pictures would be released! The uproar which followed that inept statement brought a prompt follow-up which stated that "selected" pictures would be released shortly after they were received.

Then came the official declaration that the cameras on Mariner 4 would be turned off after Picture No. 7 to avert possible erasure. Instead, the cameras continued to take and transmit, without interruption, at least twenty-two pictures.

Unmentioned in the public statements, and unexplained to this day, is the fact that something very strange happened to Mariner 4 as it passed behind the planet Mars.

The speed of the probe was carefully controlled; it had to be very precise to be at the right place at the right time —and it was. Mariner 4 was moving at eleven thousand

Behind UFO Secrecy

I'm not blasting all of the AF. Most AF debunkers disliked their jobs and tried to explain away UFO reports without deliberate ridicule. But too often strict orders forced them to belittle and discredit honest and impressive witnesses. Some of the victims were fired from their jobs. The ridicule embarrassed the families of witnesses, even causing divorces. And in at least one case a serious researcher committed suicide.

In 1953, a new discovery jolted the Pentagon. A giant spaceship was tracked orbiting the Earth between 400 and 600 miles out. The censors already had one report of a giant ship. In '52, pilots and crewmen of a B-29 bomber had sighted a number of UFOs over the Gulf of Mexico. Tracked by radar, they climbed steeply and merged with a huge object, evidently a carrier ship, which then speeded up to 9,000 miles an hour and went off the radarscope. Its size was estimated as 1200 feet in length. The AF publicly debunked the smaller UFOs as meteors and ignored the carrier ship.

At first, the AF was able to hide the discovery of the orbiting giant ship. But in a revision of AF Regulation 200, it made a surprising statement: "Section A-3. Since the possibility cannot be ignored that UFOs reported may be hostile or new foreign vehicles of unconventional design, it is imperative that sightings be reported rapidly, factually and as completely as possible."

Later, a second giant was tracked orbiting at 400 miles from Earth. Once it left its orbit, descending to about 70,000 feet, jets were scrambled, but were unable to reach the huge spaceship.

On Nov. 22, 1953, an F-89 jet was scrambled to chase a UFO over the Soo locks (Sault Ste Marie). AF ground radar tracked the jet and the UFO out over Lake Michigan. Then suddenly their blips merged on the radarscope and disappeared. For an unknown reason, Truax AFB told the AP (Associated Press) that the jet had merged with an object over the lake. At AF HQ, some officers feared the jet had been taken aboard the UFO -- or else completely destroyed. No trace of the plane or the pilots was ever found. Privately, some AF investigators believed this was a warning to stop capture attempts. But to HQ this was impossible. Besides the Soviet; France, Brazil, the South African Union, Canada and several other nations were now trying to down UFOs. To end capture attempts could be disastrous.

In 1954, two more orbiting giants increased Headquarters tension. They still had no idea of the aliens' motives. One speculation: Their world might be losing its atmosphere, so they were planning to migrate to a suitable planet. Earth might be their choice. The huge spaceships could land or else launch scores of smaller UFOs for test landings. Even if no attack was intended, it could cause nationwide panic.

When reports of the strange objects leaked out, the AF hastily explained them as large asteroids, which had come in from space and gone into orbit. Though this was utterly impossible, most people did not

8 Satellite Search

On the first day of March, just one week after Frank Edwards' broadcast, Paul Redell gave me a call. He told me he had flown in from the Coast after a stop at Albuquerque.

"I've got some hot news," he said. "Word has just leaked out about the secret search for the unknown satellites. The censors at White Sands are running around in circles trying to figure out what to do."

The information, he told me, had come through Dr. Lincoln La Paz, director of the New Mexico Institute of Meteorites, who was assisting Dr. Clyde Tombaugh in the search. In the February publication of the Astronomical Society of the Pacific, La Paz had mentioned plans for the satellite search. Quoting Tombaugh as his source, he indicated that special telescopic equipment was to be used.

"But La Paz is in on the project," I said. "How did he dare 'break' it?"

"In the first place, he wrote this article before the project was even approved. Also, he mentioned natural objects like asteroids, and he didn't specify that the search was for artificial satellites."

"Then I don't see why White Sands is so worried."

"They've got good reason to be," said Redell. "The press usually overlooks technical articles like that, but a few days ago reporters started asking White Sands a lot of questions. They wanted to know if the satellites really existed, how

many there were, and who they belonged to. Army Ordnance Research—they're the ones in charge—started to deny everything. Then someone—I think it was probably Tombaugh—advised them to make a statement instead of covering up."

"What are they going to say?" I asked.

"I don't know, but they can't hold off much longer. I think the AP is after them now."

Just two days later, on March 3, the story broke. The official White Sands statement admitted the Armed Forces were making a sky-sweeping search for "tiny moons" which we could use eventually as space bases and also for launching missiles in time of war. It avoided any hint that the unknown objects were actually interplanetary bases.

The satellites, Dr. Tombaugh explained, could be following orbits near the equator. There the scarcity of observatories would make them harder to locate. Also, since these fast-moving objects would give off very little light, ordinary telescopic cameras would not reveal them. The only way to locate them, Tombaugh stated, would be to use automatic-tracking cameras moving at the same speed as the satellites.

This statement implied that the satellites were natural objects from outer space which had come in and—uncontrolled by intelligent beings—had assumed the exact mathematical courses necessary to orbit the earth.

As soon as I saw the news story, I called Redell.

"Well, it was the only way out," he said. "The idea of natural objects suddenly coming in and orbiting is ridiculous, and they know it. However, it will cover up the thing for a while."

I had some other questions, but Redell was tied up. We made a date to meet that evening.

That afternoon I learned that the Air Force was blaming me for the increase in UFO sightings. Quoting the Air Force, *American Aviation* magazine made this statement:

"The Pentagon definitely attributes the latest rush of saucer reports to Major Donald Keyhoe's book, *Flying Saucers from Outer Space.*"

Only minutes later Bob Stirling of the United Press called me.

"We just got a story from Senator Francis Case," he said. "He wrote Secretary Talbott and asked if they were really hiding UFO information, as you said in your book. General Joe W. Kelly answered for Talbott. Here is what he said:

" 'All information on sighting of aerial phenomena, including our conclusions, is unclassified and available to the public.' "

"Bob, that's absolutely untrue! The lid has been down since the end of December."

"Well, since we're running this, you can answer if you want to."

"All right," I said. "You can quote me: I believe a group in the Air Force is misleading the public. There is a blackout on all UFO reports and the Air Force is still withholding the Utah picture analysis."

That night, when I saw Redell, I told him about General Kelly's attack.

"Well, what else can you expect? You're bucking the National Security Council, some of the Pentagon brass, and God knows who else. This is a big deal, Don, maybe the biggest thing that has ever hit this world. Some of those top people are really worried."

We had gone to Redell's office after dinner. On the way he picked up a late paper with news of the White Sands sky search.

"I bet a lot of astronomers laughed when they saw that," Redell commented. "There may be some very tiny asteroids between us and the moon. But just consider the odds against even one big asteroid coming in from outer space and orbiting the earth."

"How many satellites have they tracked?" I asked.

"They've picked up two visually, for a few minutes at a time, but they still don't have the special cameras. They're also having trouble building the radar-tracking gear; but they'll do it eventually. In fact, they started on three special stations, but they had to stop work."

"Where are they?" I said.

"One's in New Mexico, one is outside of Berlin, and the other, I think, is in Arizona. Let's hope they just stop at tracking them," he added drily. "The next time one leaves its orbit and comes down close, some idiot may order the Nike guided missile batteries to cut loose."

"Wait a second," I said. "You mean these satellites have left their orbits?"

"I'm not positive, but I've reason to believe that one came down to about 60,000 feet, ten days ago, over the Atlantic."

I thought back for a moment. "It was ten or 11 days ago when those 14 discs were seen at York. There were several other sightings about that time too."

"It may be only a coincidence," said Redell. "But it's possible, of course, that the big ship came down for a rendezvous, as in the Gulf of Mexico case the Air Force gave you."

"It's plain they've stepped up their observations, moving those bases in so close." I looked across the desk. "Paul, what do you think is back of all this?"

He hesitated for a second.

"There could be a dozen answers, but there's one I've never heard mentioned publicly, though Intelligence certainly must know it. Do you know about Dr. Fritz Zwicky's artificial meteor experiments?"

"No, but I know that he's one of our greatest rocket designers."

"Well, this goes far beyond rockets. I'll give you the main points on the way back to my hotel. It goes back about eight years."

It was only a few blocks to Redell's hotel and we decided to walk.

In 1946, Redell told me, Dr. Zwicky and several Army Ordnance experts had worked out a plan to bombard the moon, Mars, and other solar system planets, with tiny bullet-like projectiles. Under Zwicky's plan, huge rockets would carry scores of the tiny projectiles high into the ionosphere. Near the peak of the main rockets' flight, special explosives called "shaped charges" would hurl the miniature projectiles up into empty space.

It was calculated that these projectiles would have velocities of 50 times the speed of sound or even higher, depending on the peak of the main rocket's flight. Their tremendously high speeds would enable them to escape from the earth's gravitational pull. Passing through the ionosphere, many of these artificial meteors would become electrically charged, causing them to "flash" on impact with the moon. An analysis of these flashes by spectroscopes would provide a means of exploring the moon's surface, determining its chemical elements and atmosphere. After this, similar tests with larger projectiles would be carried out on Mars, Venus, and the other solar-system planets.

We had stopped for a traffic light at 14th and New York Avenue as Redell finished. He gave me a curious glance, waiting for my reaction.

"Were those projectiles actually fired?" I asked him.

"Yes, I'm fairly certain they were," Redell answered. "The first test failed. That was in December of '46, when they used a V-2 rocket to launch them. But Zwicky said they were going to try again. And they've had eight years."

"Paul, this could be deadly serious," I said. "If there is anyone on the moon——"

"Yes, exactly." Redell waited until we crossed the street. "To get the picture, just reverse it. Suppose projectiles like that suddenly bombarded the earth. Even if they didn't hurt anybody or cause any damage, they would set off a scare. A lot of people would take it for a hostile act."

"You're right, and it's possible their bases might be set up so that even small pellets could cause serious trouble."

"That's not the worst of it," Redell said. He stopped as we passed through a crowd in front of Keith's Theater. "After the first test failed, Zwicky suggested a new firing method. They would launch the projectiles from huge balloons sent up to about 100,000 feet. The tiny missiles would be guided, he said, by electronic controls here on earth.

"Once out of our atmosphere, they would travel at about 25,000 miles an hour," Redell went on. "And here's what worries me. Zwicky said some of them might detonate on contact with the moon or solar planets and possibly set off nuclear explosions."

"Good Lord! Missiles like that could cause real trouble. If they hit an inhabited planet—say Mars—the people would certainly believe we were trying to attack them. I'd think that if they did it to us."

"There's another bad angle," said Redell. "If these tests have been carried out recently, the saucer people may think we're trying to hit their satellites. That's why I mentioned our Nike batteries. So far this UFO race hasn't retaliated, though our jets have fired at them several times. But adding up the projectile angle, jet attacks, and then Nike guided missiles, it could be the last straw. I'd hate to think what might happen."

"But if there's any proof of a base on the moon or Mars the government would surely have stopped the tests."

Redell shook his head. "The damage may have already been done."

After I left Redell, I soberly thought over what he had said earlier about the attack on me.

I had felt, since 1950, that the flying-saucer problem was of tremendous importance. But until recently I still had seen no proof of hostility. Now, even if the new developments did indicate possible danger, I still felt the National Security Council and the Pentagon were wrong to hide the facts from the public.

The next morning I received a letter from a Yale professor who had asked the Air Force two questions about my book:

1. Did the Air Force actually clear the 41 Intelligence reports Major Keyhoe listed in his book?
2. Were the Utah flying-saucer pictures secretly analyzed, as Keyhoe says? If so, what did the analysis show?

"Here is what the Air Force sent me," he wrote. "Who is lying?"

The Air Force answer was a mimeographed letter with a Department of Defense letterhead:

DEPARTMENT OF DEFENSE
Office of Public Information
Washington 25, D. C.

Dear Mr. ——:

In reply to your recent letter, the publication to which you have reference was not submitted to the Air Force for authentication prior to publication. There is no official recognition and the Air Force does not choose to comment upon it.

It is not our policy, nor would it be possible, to review all publications which have been written on this subject. We continually supply unclassified information to various media, and it is entirely possible that some of this information contained in the publication referred to, was supplied by us.

However, we are in no way responsible for the author's interpretation of this material, and of course, his opinions and conclusions are his own. . . .

Sincerely yours,

Robert C. White
1st Lt., U.S.A.F.

Before calling White I tried to reach General Kelly. I phoned his office twice; neither call was returned. Later I phoned White.

"I'd like to see the last three months' UFO reports, since General Kelly says everything is open to the public."

"There is no new policy," said White. "No one can see those reports."

"Then General Kelly deliberately misled Senator Case?"

"No, it was an error."

"General Kelly knows better than that," I said. "He's the Director of Legislative Liaison and he's supposed to be a top expert on military law. Unless he's incompetent, he certainly should know about JANAP 146 and AFR 200-2, as well as the penalties for violating those orders."

White was silent.

"Well, since it's not true, he should retract it," I said.

"That's up to him. For heaven's sake, don't drag me into it."

"All right. But there's one thing you're in on already—that Air Force letter denying my book was authorized."

"That's not aimed at you," White said quickly. "That was drawn up to answer queries about those writers who claim they've talked with space men."

"That may be, but it's being used against me. I've one letter right in front of me which you signed. I'm not blaming you—I know this was done under orders. But it's absolutely misleading. The Air Force not only authorized my using those Intelligence cases, they invited me in there and asked me to name what I wanted. It was all on the level."

"I know that," said White.

"Then this trick letter should be stopped."

"I—well, all I can do is pass on what you say."

After this I went to Senator Case's office, but he was on the Senate floor. So I talked with Rodney Moulton, his press

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BIOCHEMISTRY

Canals in Body Cells Act as Storage Cisterns

➤ SOME CELLS of the body have within their microscopic selves systems of canals. These canals apparently serve as cisterns for temporary storage of materials destined for distribution to other parts of the body.

The materials might be the hormones and enzymes that play vital roles in body chemistry and functioning.

Such canals in some cells of the pancreas, big gland best known because part of it produces anti-diabetic insulin, have been made visible under the microscope by a method developed by Dr. Owen Lewis Thomas of Napier, New Zealand.

The method was to inject the canals with a mass consisting of laked blood medium. After the cells were sliced thinner than paper, they were stained and examined under the microscope. Details of the method and findings are reported by Dr. Thomas in *Nature* (Nov. 19).

Science News Letter, December 3, 1955

ASTRONOMY

Ask Search for Moons Of Earth and Planets

➤ THE EARTH and other planets may have small moons not yet discoverd, Dr. Robert S. Richardson of Mt. Wilson and Palomar Observatories believes.

Searching for the satellites by eye rather than through telescopes might be the most likely way of finding them, he reports in the *Bulletin of the Astronomical Society of the Pacific* (Sept.).

Small moons of other planets, such as Phobos and Deimos that circle Mars, are valuable for revealing a planet's mass more accurately than otherwise possible.

"Among the most useful discoveries that could be made in the solar system would be satellites for Mercury, Venus and Pluto," Dr. Richardson says. The masses of these planets can be found only by their effects on other bodies, extremely difficult to spot.

Dr. Richardson has calculated the maximum distances and periods of satellites for each of the sun's nine planets. The greatest distance at which the earth's gravity would keep a natural satellite circling and prevent it from escaping into the sun would be 927,000 miles. The moon's distance varies from 221,463 miles to 252,710 miles.

A search for small satellites between the earth and the moon is being made for the Defense Department by Dr. Clyde Tombaugh, who discovered the ninth planet, Pluto.

Tiny earth satellites, if they exist, would not have been spotted before because of their extremely rapid motion, too fast to be caught on the usual photographic plates.

Another reason possible small earth moonlets have not been seen yet is that they would spend most of their time in the earth's shadow, and would not shine since they have no light of their own.

Although the chances of finding undiscovered satellites of planets are not great, they are "not quite as dim" as might be thought, Dr. Richardson states, noting that three have been spotted in the last six years.

Dr. Gerard P. Kuiper of Yerkes Observatory, Williams Bay, Wis., discovered a close satellite of Uranus in 1948 and a distant satellite of Neptune in 1949. In 1951, Dr. Seth B. Nicholson of Mt. Wilson and Palomar Observatories discovered the twelfth satellite of Jupiter, the fourth he had found since 1914.

Science News Letter, December 3, 1955

ANTHROPOLOGY

People of Inland Asia Are Pretty Much Alike

➤ INLAND ASIANS, of which there are more than 15,000,000, have a surprising uniformity of body build, Dr. Marshall T. Newman of the U. S. National Museum told the American Anthropological Association meeting in Boston.

Nearly all inland Asians are shorter than average in height, heavy in body weight, with long trunks and short legs.

It is difficult to separate the influence of environment from that of race, Dr. Newman suggested. Thus, the inland Asians of the core area are large-headed and large-faced, because they are predominantly Mongoloids.

Mongoloids probably have large heads and large faces, just as they have small noses and padding of fat on their faces, because such features have a survival value in extremely cold climate.

Some parts of inland Asia are colder than others. Average January temperatures range from 27 degrees Fahrenheit in the Fergana Valley Kirghiz to minus 39 degrees in the Viliui Yakut. This is greater than the temperature difference between Salt Lake City, Utah, and Churchill, Hudson Bay, Canada.

Yet Dr. Newman noted no gradations in body build. He accounts for uniformity of body size and shape by the extraordinary amount of large and recent movements of peoples. The people did not stay long enough for natural selection to bring about adaptation to the specific climatic conditions.

Although new environmental conditions can produce definite physical changes, these are limited, Dr. Newman said. The major agency for gross change is natural selection. This takes generations.

The movement of the peoples of inland Asia would also lead to racial intermixture that would tend to have a leveling effect on the physical characteristics.

Science News Letter, December 3, 1955

ENTOMOLOGY

Scientist Tricks Females Into Revealing Age

➤ A FEMALE'S TRUE AGE can be uncovered at last.

The new technique, worked out by a zoologist with the University of Durham, England, requires complete dissection of the female. Up to now it shows promise only for flies and mosquitoes.

Determining the age of mosquitoes and flies is important in studying their habits, especially those connected with disease transmission. To make them yield their secret, zoologist L. Davies dissected female black-flies, *Simulium ornatum*, which suck the blood of cattle.

He found the younger flies contain visible fat-bodies, particularly in the forward abdominal segments; while the older flies had none, except in small amounts in the last abdominal segments.

Up to 10% of the female flies, however, maintained their feminine secret by falling into neither group. Examination of flies of known age showed that those with fat-bodies were not more than seven to ten days old, Dr. Davies reports in *Nature* (Nov. 19).

Residual ripe eggs were found only among the older females. Since a blood feed is necessary before ripe eggs are produced in this species, the scientist concluded that some, and probably most, of the flies without fat-bodies had taken their share of blood, while none of the youngsters had.

Science News Letter, December 3, 1955

ANTHROPOLOGY

Teen-Agers Are Problem In Africa as Well as Here

➤ TEEN-AGERS are a problem in Africa as well as in New York, Dr. Hortense Powdermaker, anthropologist of Queens College, New York, told the American Anthropological Association meeting in Boston.

In Africa, the difficulty is caused by a conflict between a conscious desire for modern ways of life and conveniences and an unconscious longing for a simple, un-pressured life in their native tribes.

Dr. Powdermaker collected essays written by boys and girls in elementary school in Northern Rhodesia, in the heart of a booming copper mining area.

Both boys and girls said they wanted to live where they could have a good job, sports and movies, an automobile and radio. in other words, in one of the European towns of Africa.

On the other hand, when asked what they would prefer to be if they could have a non-human life, three-fourths of the boys and half the girls said they would like to be a bird. This was interpreted by Dr. Powdermaker as an unconscious desire for an easier or tribal, life with less pressure from ambition.

Science News Letter, December 3, 195

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ews Letter, January 19, 1957

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News Letter, January 19, 1957

—Questions—

AGRICULTURE—In the drought of the 30's with what did birds build their nests? p. 35.

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ENGINEERING—What is the new fuel being used in submarines? p. 42.

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GENERAL SCIENCE—What is one advantage of underground storage of water for use during "water short" years? p. 38.

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MEDICINE—From what are the fatty acids used in treating multiple sclerosis extracted? p. 38.

How can the measles virus be made harmless? p. 40.

□ □ □

PUBLIC SAFETY—What class of compounds is being used to prevent skidding on highways? p. 41.

□ □ □

PHOTOGRAPHS: Cover, Woods Hole Oceanographic Institution; p. 35, British Information Services; p. 37, All American Engineering Company; p. 39, New York University; p. 42, U. S. Navy; p. 48, Eastman Chemical Products, Inc.

ASTRONOMY

Find No Natural Satellite In Space Around Earth

➤ WHEN MAN FLINGS the first artificial satellite into space later this year, the chances are high the tiny sphere will not compete with any natural earth satellites farther out in space than it is.

Three years of an intensive search of much of the space around earth by Clyde W. Tombaugh, discovered of the solar system's most distant planet, Pluto, show it is empty of relatively large material from 1,600 to 22,200 miles above the earth's surface. The space from 300 miles out to 1,600 miles is now being scanned for possible natural earth satellites from a site in Ecuador.

The first major phase of the work, supported by the Army's Office of Ordnance Research in Durham, N. C., was conducted at Lowell Observatory, Flagstaff, Ariz.

The equipment used by Mr. Tombaugh was so sensitive it could detect a clean white tennis ball only half illuminated to the observer at 1,000 miles above the earth's surface, or record a dark meteorite about one foot in diameter at the same height.

Mr. Tombaugh reported that his search disclosed a few "suspects," most of which were later found not to be natural satellites. Those not yet eliminated are being checked again from Ecuador.

The basic principle of Mr. Tombaugh's technique is the use of a Schmidt or other fast camera of wide field, moved at a rate to conform with the angular speed the supposed satellite would have across the sky. If a satellite actually existed, its image on the photographic film would be concentrated in a point image or dot, or a short trail.

The techniques he developed are expected to have definite significance in making observations of man-made satellites, which the United States and probably Russia are planning to launch in connection with the International Geophysical Year starting next July 1.

A determination that the space near the earth is free of debris up to a certain size would also be useful to long-range missile experts and to proponents of space travel.

Mr. Tombaugh's report notes that the surface of the moon may provide "grim evidence" of scars produced by collisions with matter flying about in space. Whether these scars were produced by asteroids or left-over debris from some process involved in the birth of the moon, or by some other method, is not known.

The earth has probably suffered from a comparable number of hits in the past, but vigorous action of water erosion has erased most of the evidence. On the moon, there is no appreciable erosion and thousands of craters, whose origin is still not settled, are easily seen with small telescopes.

Science News Letter, January 19, 1957

PALEONTOLOGY

Its Hoots Long Stilled, Fossil Owl Gets Name

➤ SOME long dead owl bones have been named and identified as a new fossil species closely related to the Barn Owl.

Dr. Loye Holmes Miller, emeritus professor of biology at the University of California at Los Angeles, has proposed as the scientific name of the bird, *Lechusa stirtoni*.

The fossilized bones of Stirton's Owl were among a collection of bone fragments discovered by Joseph Arndt in age formation in San Diego, represent a shallow-water mar lation on tidal sand bars tha resting ground for marine bir probably roosted in a nearby cl

Dr. Miller gives his reasons *ceedings of the California Sciences* (No. 26, 1956) for name, *Lechusa stirtoni*:

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25 November 1955, Volume 122, Number 3178

SCIENCE

Satellite Program

Joseph Kaplan and Hugh Odishaw

The surge of interest in the earth satellite program had its basis in the assemblies of some 40 nations, meeting to plan and integrate the unprecedented study of man's physical environment known as the International Geophysical Year, 1957–58. This world-wide study primarily embraces those fields of geophysics in which observations must be conducted simultaneously over the earth if we are to achieve significant progress in our understanding of the earth and its atmosphere. Problems to be studied include aurora and airglow, cosmic rays, geomagnetism, glaciology, gravity measurements, ionospheric physics, longitude and latitude determinations, meteorology, oceanography, seismology, and solar activity. Two additional areas of activity are of special interest: rocket studies of the upper atmosphere and the recently announced satellite studies, which represent a logical extension, technically and conceptually, of the rocket program.

How the satellite program came into being, the present status of plans, and the type of experiments under consideration are some of the questions of current interest. Since the announcement of the program on 29 July 1955, by the President, questions on these points have been asked often, by scientists and laymen alike. This article attempts to tell the story of the program.

The interest of the U.S. National Committee for the International Geophysical Year in earth-circling research satellites began with the adoption of resolutions, during the summer and early fall of 1954, regarding the desirability of such vehicles. These resolutions were adopted by three international scientific bodies: the International Scientific Radio Union, the International Union of Geodesy and Geophysics, and the Special Committee for IGY of the International Council of Scientific Unions (CSAGI). The resolution of most immediate interest is the one adopted on 4 October 1954 by the CSAGI:

"In view of the great importance of observations during extended periods of time of extra-terrestrial radiations and geophysical phenomena in the upper atmosphere, and in view of the advanced state of present rocket techniques, CSAGI recommends that thought be given to the launching of small satellite vehicles, to their scientific instrumentation, and to the new problems associated with satellite experiments, such as power supply, telemetering, and orientation of the vehicle."

In view of these international recommendations, and in view of the advanced state of U.S. rocketry developments, the Executive Committee of the U.S. National Committee for the IGY (USNC-IGY) considered the possibility of constructing, launching, and observing an instrumented satellite. A special group was established for this purpose, composed of various members of the USNC Executive Committee and the USNC Technical Panel on Rocketry.

On the basis of recommendations made by the special study group, the Executive Committee decided that an instrumented satellite program not only was of scientific importance but was feasible, and it adopted a resolution which reads in part as follows.

"The Executive Committee of the USNC-IGY feels that a small artificial satellite for geophysical purposes is feasible during the International Geophysical Year if action is initiated promptly, and that the realization of such a satellite would give promise of yielding original results of geophysical interest."

The Executive Committee authorized the chairman of the U.S. National Committee to transmit the aforementioned findings and resolution to the president of the National Academy of Sciences and the director of the National Science Foundation. This was done on 14 March 1955.

Meanwhile the scientific and technical studies of the committee's special satellite group continued. By the early part of May, a preliminary program had been developed, and the committee directed its chairman to transmit the proposed program to the Federal Government through the National Science Foundation. This was done on 6 May 1955.

Late in July, the Government's approval of the satellite program permitted the chairman of the USNC to notify the CSAGI of our plans. In his letter of 26 July 1955, to Sydney Chapman, president of CSAGI and one of the world's most distinguished geophysicists, Kaplan said:

"The Committee on behalf of the National Academy of Sciences wishes to inform you at this time that, in response to the CSAGI resolution, the program of the United States for the International Geophysical Year now includes definite plans for the launching of small satellites during the International Geophysical Year.

"The United States National Committee believes that significant scientific data may be gathered as a result of this program in such fields as geodesy, atmospheric physics, ionospheric physics, auroral physics, and solar radiation. The participation of other nations engaged in the International Geophysical Year is invited, and to this end we shall provide full scientific information on the orbiting vehicle so that other nations may monitor the device and make appropriate observations. The United States National Committee looks for-

Dr. Kaplan is professor of physics at the University of California, Los Angeles, and chairman of the U.S. National Committee for the International Geophysical Year. Mr. Odishaw is executive secretary of this committee. The committee was appointed by the National Academy of Sciences to plan and direct the United States International Geophysical Year program.

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hoc basis, calling upon members of the USNC Executive Committee and the Technical Panel on Rocketry, as well as various consultants, it now became appropriate to establish a Technical Panel on the Earth Satellite Program. The membership of this panel is as follows: R. W. Porter, chairman (consultant, Communication and Control Equipment, Engineering Services Division, General Electric Company); Hugh Odishaw, secretary (executive secretary, U.S. National Committee-IGY, National Academy of Sciences); Joseph Kaplan (professor of physics, University of California at Los Angeles; chairman, U.S. National Committee-IGY, National Academy of Sciences); H. E. Newell, Jr. (acting superintendent, Atmosphere and Astrophysics Division, Naval Research Laboratory); W. H. Pickering (director, Jet Propulsion Laboratory, California Institute of Technology); A. F. Spilhaus (dean, Institute of Technology, University of Minnesota); Lyman Spitzer, Jr. (professor of astronomy, Princeton University); J. A. Van Allen (professor of physics and head of department of physics, State University of Iowa); F. L. Whipple (director, Smithsonian Astrophysical Observatory; professor of astronomy and chairman of the department of astronomy, Harvard University).

The functions of this panel are analogous to those of the other 12 technical panels of the USNC in the various IGY disciplines. The Technical Panel on the Earth Satellite Program, with such additional membership and consultants as are necessary, will have fundamental responsibilities, acting on behalf of the USNC, in further developing, coordinating, and directing the over-all scientific satellite effort. The panel expects to utilize contributions from many scientists and institutions, a feature that has characterized the planning of all IGY programs under the auspices of the USNC.

At the same time, the Government's support made it desirable to begin certain technical phases of the effort immediately if launchings were to be realized as early as possible during the 1957–58 IGY period. The committee had taken cognizance, in its 6 May proposal, of the need for logistic support from the Department of Defense: only through the use of this agency's facilities and rocket experience could the program be attempted economically and realistically. Accordingly, the committee called for this type of assistance.

In making this request, the committee had two major precedents: first, the Antarctic Program which requires extensive expeditionary and logistic support and, second, the rocket program. In both of these areas, the Department of Defense has responded and is making substantial contributions to the IGY program.

Following the President's approval on 29 July the committee's request for logistic support in the satellite program was granted. This support will be provided jointly by the three military services under Navy management. A group has already been established, directed by John P. Hagen of the Naval Research Laboratory, for the conduct of Project Vanguard, the name assigned to Defense's effort. Two contracts have already been issued for propulsion rocket vehicles, and Project Vanguard will conduct the operations necessary to get the satellite on orbit, following much the same pattern established for the IGY rocket program.

The satellite program, then, is already under way. Although it is clearly an exciting and significant endeavor, one should not lose sight of the difficulties of the enterprise. The committee's studies indicated that existing rocket technology provided a sound basis for the feasibility of the proposal. Yet the venture is truly a pioneering one, and partly for this reason the committee's 6 May document called for some ten instrumented satellites, with the hope that at least five or six would be successfully launched into their orbits.

The growing realization of the technologic feasibility of a satellite endeavor in recent years provided the impetus to international considerations of such a program. The German V-2 rocket developments of World War II, the high-atmosphere research rockets (for example, the Aerobee and the Viking) of the United States, and related rocket efforts of other nations created a body of literature and a technology that provided the foundations for a new departure. During the last decade or so the concept of small, research satellites for study of the high atmosphere has occurred to many thoughtful individuals. Members of the Upper Atmosphere Rocket Research Panel, an informal group of leading U.S. rocket and upper atmosphere scientists and engineers, have considered just such prospects. One of the most widely publicized recent proposals was that of S. F. Singer's MOUSE.

Such, then, was the climate at the Rome meeting in the autumn of 1954 when representatives of various nations met to coordinate the IGY programs, and out of it grew the CSAGI resolution advocating the satellite venture. This venture not only has grown out of the world-wide IGY Program but is a substantial and promising part of it. The intensity of effort to be devoted by more than 40 nations, investigating phenomena in some 12 geophysical disciplines, is augmented now by the results that the satellite program promises: observations of high atmospheric and interstellar events unhindered by the earth's lower masking atmosphere.

In this venture, other nations and other observers will share, for, as the President indicated, the satellite will be public. Its design and instrumentation will be made known. The frequencies of the telemetering system, which will radio back to earth the scientific observations, will be revealed. The results of observations will be published. These provisions, in keeping with the peaceful and cooperative spirit of IGY, will permit the satellite to be followed and observed throughout its course about the earth.

One year after the Rome meeting and some 2 months after the President's announcement, the nations of the world met again at Brussels, to integrate further their respective IGY efforts. The inspiring character of the President's announcement was clearly revealed. The scientists of the 40 or more other nations participating in the IGY received the news of the proposed U.S. satellite program enthusiastically. This reception was based in part on the great admiration by scientists of other countries for the past achievements of American rocket scientists. More important, however, this reception was based on the knowledge that the value of geophysical observations made during the IGY would be enhanced greatly by the addition of extensive, direct data obtainable only from research satellites.

Participation of scientists in this endeavor falls within the purview of the National Academy of Sciences, which established the U.S. National Committee for the IGY. This committee, with its subcommittees and panels, is charged with responsibilities for planning, directing, and executing the U.S.-IGY effort. The Government has cooperated extensively in the realization of the program, both program-wise and fiscally. The National Science Foundation, at the request of the academy, has assumed responsibility for the fiscal aspects of the program and has played a major role in the coordination of Government interests. Federal funds totaling $12 million have already been appropriated for the over-all IGY effort.

l to the interest and cooperation of
· nations in what it hopes will be one
ıe great scientific achievements of
ime."

ı 29 July 1955, Chapman released
letter to the public at Brussels
ıgh CSAGI's secretary general, M.
let. A few minutes later, the Presi-
's endorsement of the program was
e public at the White House by
:s C. Hagerty, the President's press
tary:

)n behalf of the President, I am now
uncing that the President has ap-
ed plans by this country for going
d with the launching of small, un-
ıed, earth-circling satellites as part
e United States participation in the
national Geophysical Year which
place between July 1957 and De-
ıer 1958. This program will, for the
time in history, enable scientists
ıghout the world to make sustained
vations in the regions beyond the
ı's atmosphere.

he President expressed personal
fication that the American program
provide scientists of all nations this
rtant and unique opportunity for
ıdvancement of science."

ıapman replied to Kaplan on 3 Au-
1955. The substance of Chapman's
· is contained in the following three
:d paragraphs:

)n behalf of the CSAGI I wish to
:ss great satisfaction that it was in
:quence of the CSAGI resolution
quote, that your National Commit-
rranged for a study of the possibili-
ınd value of the construction of a
lite vehicle for upper atmospheric
other scientific exploration.

am glad to know that this study
so successful that your Committee
able to resolve to construct and
:h small satellites as a part of the
:d States contribution to the Inter-
nal Geophysical Year, and to an-
ce these plans publicly. The long
rience of your scientists in rocket
:hing and construction, and the bril-
scientific use they have made of
:ts for upper atmospheric and solar
ıration, gives confidence that the
. so announced will be fulfilled.

**his will indeed be one of the great
tific achievements of our time, and
give occasion and opportunity for
ooperation of other nations in this
ınding part of the great enterprise,
nternational Geophysical Year."**

***ese, then, were the early steps in
evelopment of the academy's satel-
rogram: the international resolu-
recommending such an effort;
ıs of preliminary study and plan-
by the U.S. National Committee
e IGY, culminating in the 10 March
recommendation of the committee
6 May program proposal to the***
Government; the exchange of letters be-
tween the chairman of the USNC-IGY
(26 July 1955) and the president of
CSAGI (3 August 1955); and the Presi-
dent's endorsement of the program on
29 July 1955, signaling the actual under-
taking of the program.

The scientific basis for the satellite program is to be found in the need for basic, directly observed data, which ground-based experiments are unable to provide. The lack of such data is probably the single most important factor accounting for present incomplete explanations and theories regarding such fields as auroral and ionospheric physics.

Rocket soundings of the upper atmosphere have yielded significant results, and the IGY program includes a major rocket research effort. Some hundreds of rockets will be fired during the IGY, ranging from the relatively small balloon or aircraft-launched devices to high-performance Aerobees capable of reaching approximately 200 miles. The results of these experiments are expected to contribute to a better understanding of atmospheric events in two ways: First, rocket observations will provide direct data of various phenomena which can be used, so to speak, to calibrate ground-based observations. The latter, as with ionospheric soundings, provide rather conveniently and inexpensively extensive indirect data. Second, new discoveries may well be made, particularly of events screened by the earth's atmosphere.

Thus rockets permit us to make direct measurements of quantities that are either only indirectly observable or are not observable at all, from the ground. They also provide a technique for measuring the altitude dependence of various geophysical parameters. Unfortunately, rockets have two serious disadvantages: (i) their total flight is extremely short and the time spent in a particular altitude range is even shorter; and (ii) their flight paths are restricted in terms of geographic coverage.

Thus, in spite of the very great value of rocket data, much of which is attainable only by rocket methods, there exists a need for a device that can provide synoptic data over the earth, at high altitudes, over appreciable periods of time. As examples, one can cite the following: fluctuations in such solar effects as ultraviolet radiations and x-rays, cosmic-ray intensities, current rings encircling the earth, and particle streams impinging on the high atmosphere. These and other phenomena are among the most important problems connected with the physics of the upper atmosphere and with solar-terrestrial relationships.

Clearly an earth satellite would permit observations of the kind indicated in the foregoing paragraphs, and the value of these studies convinced the USNC of the merit of responding to the invitation of CSAGI. In its report last October to CSAGI, the committee indicated that the following types of experiments were under consideration: (i) determination of outer atmosphere densities by observation of the air-drag effect on the satellite's orbit; (ii) obtaining of more accurate measurements of the earth's equatorial radius and oblateness and of intercontinental distances and other geodetic data than are presently available; (iii) long-term observations of solar ultraviolet radiation; (iv) studies of intensities and fluctuations in intensity of the cosmic and other particle radiations impinging on the atmosphere; (v) determination of the density of hydrogen atoms and ions in interplanetary space; (vi) observations of the Störmer current ring; (vii) if possible, determination of the distribution of mass in the earth's crust along the orbital track.

How many and what experiments will be undertaken cannot be specified at this time. In part, these depend on the number, size, and pay-load capacity of the satellites. In part, they depend on choices yet to be made by the USNC, in collaboration with interested scientists, for in all probability more experiments will be proposed than can be fitted into the IGY satellite program.

Work on technical details of the satellite is currently under way. Information now available may be stated briefly: the satellites will be small; they will contain scientific instruments; they will be trackable from ground by optical and radio techniques; they will probably be visible to the naked eye under optimum conditions at dawn and dusk and certainly observable under good atmospheric conditions by means of binoculars and wide-field optical equipment.

In size the satellite may be described as about that of a basketball, although the shape has not yet been fixed. Each satellite will weigh more than 20 pounds but probably less than 50 pounds. The satellite will travel about the earth in an elliptical orbit, with a perigee distance of at least 200 miles and an apogee distance of some 800 miles. It is expected that the satellite will remain in its orbit for at least several weeks and perhaps for months: the greater perigee and apogee distances, the longer the life of the satellite as a result of reduced atmospheric resistance. The velocity of the satellite will be approximately 18,000 miles per hour, giving a period of about an hour and a half, depending on the precise perigee and apogee values.

The Government's endorsement of the academy's satellite proposal permitted the committee to proceed beyond the preliminary plans outlined in its 6 May document. Whereas the studies of the committee had been conducted on an ad hoc basis, calling upo
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The Baker-Nunn Satellite-Tracking Camera

KARL G. HENIZE, *Smithsonian Astrophysical Observatory*

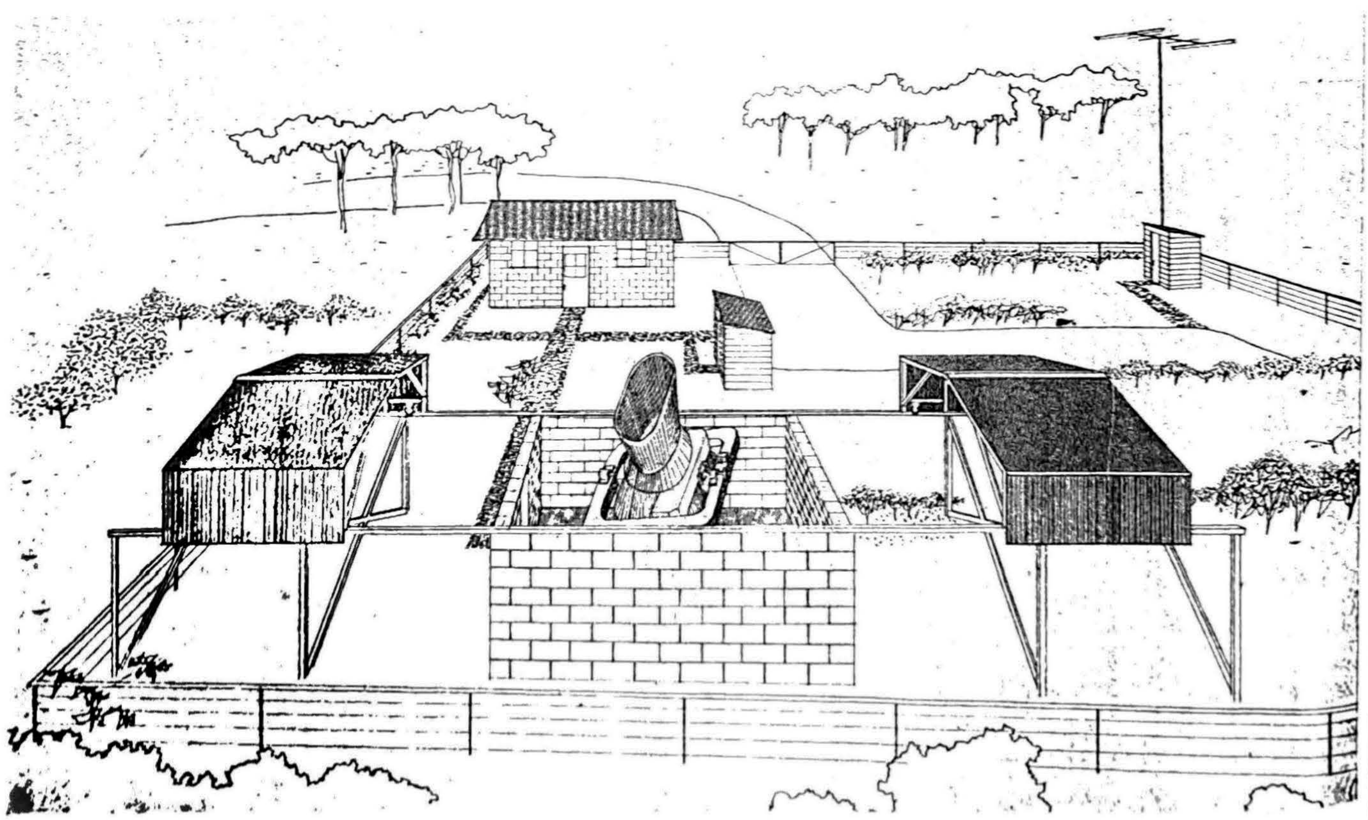
IN THE FALL of 1957, the first earth satellite of the International Geophysical Year is scheduled to be launched, in what is commonly called "man's initial step toward the exploration of interplanetary space." But paradoxically, astronomers will use the first earth satellites principally for studying the earth itself, not interplanetary space.

Why is this? Because, once a satellite is in free flight, its motion and orbit are determined by the gravitational field of the earth and by the density of the upper atmosphere. In the course of days, the orbit and motion will slowly change, and these changes will provide accurate measures of important geophysical quantities. For instance, the tenuous gases of the atmosphere at the height of the satellite orbit will impede the motion of the satellite and cause it to spiral slowly inward toward the earth. The rate of spiraling will indicate the density of the upper atmosphere.

As another example, if the earth were a perfect sphere the satellite orbit would maintain a constant orientation in space, but since the earth is slightly flattened the plane of the orbit will slowly turn, or precess, in the same way that a toy gyroscope precesses. The rate of precession will provide a measure of the amount of the earth's flattening. Other quantities that may be measured by orbit changes are the radial distribution of mass inside the earth and unevenness of mass distribution within the earth's crust.

The satellite will also provide important geodetic information. The nearly perfect great circle that the satellite orbit traces over the earth's surface will provide a hitherto unmatched reference plane for the measurement of precise geodetic positions at widely separated geographical points. With the Baker-Nunn satellite-tracking camera, which is the subject of this article (see front-cover drawing), the position of the satellite can be measured to within two seconds of arc. Taking into account several factors, some of which are not yet well known, the position of each observing station will be determined to about 30 feet. Thus, the distance between two stations, which may be on different continents, will be measured to about this accuracy—nearly 10 times better than that of present measures of transoceanic distances.

There are three distinct phases in the IGY satellite-tracking project. First, Minitrack stations will receive radio signals from a small battery-powered transmitter in the satellite. Next, MOONWATCH teams will use low-power wide-field telescopes for visual tracking. And, finally, precision photographic tracking will be accomplished by a dozen Baker-Nunn cameras. The radio-tracking program is administered by the Naval Research Laboratory, while the latter two programs are the responsibility of the Smithsonian Astrophysical Observatory, under the supervision of its director, Dr. Fred L. Whipple, and Dr. J. Allen Hynek, associate director, in charge of the satellite-tracking program. These two men were responsible for the general plans for the satellite-tracking cameras.



An artist's conception of the layout for a typical satellite-tracking camera station. In the foreground, the camera is seen in observing position. The roof of the camera shelter, which measures 14 by 14 feet, divides into two parts. These slide far apart so there is no obstruction to quick pointing of the camera in any direction. In the background is the combined office-shop and a power shack; in the upper right is the radio antenna, just behind a small fuel-storage building. Smithsonian Astrophysical Observatory drawing by Naibu Akashi.

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The table gives data on the two characteristics of a satellite that affect the tracking problem: apparent brightness expressed as stellar magnitude, and angular velocity relative to the observer. Both depend on the height of the satellite above the earth's surface; the table is computed on the assumption that the orbit carries the satellite from 200 to 1,500 miles high.

At perigee, the point in the orbit near-

Height (miles)	*Photo-visual Mag.*	*Orbital Velocity* (km./sec.)	*Angular Velocity* (′/sec.)
200	5.7	8.2	88
400	7.2	7.9	42
600	8.1	7.6	27
800	8.7	7.3	19
1,000	9.2	7.0	15
1,200	9.6	6.7	12
1,500	10.1	6.3	9

The table above applies to a 20-inch specularly reflecting spherical satellite with a reflectivity of 0.6. Its photovisual magnitude in the zenith is computed from $m = 5.7 + 5 \log d/200$, where d is distance from observer. The orbit is taken to have a semimajor axis of 4,810 miles.

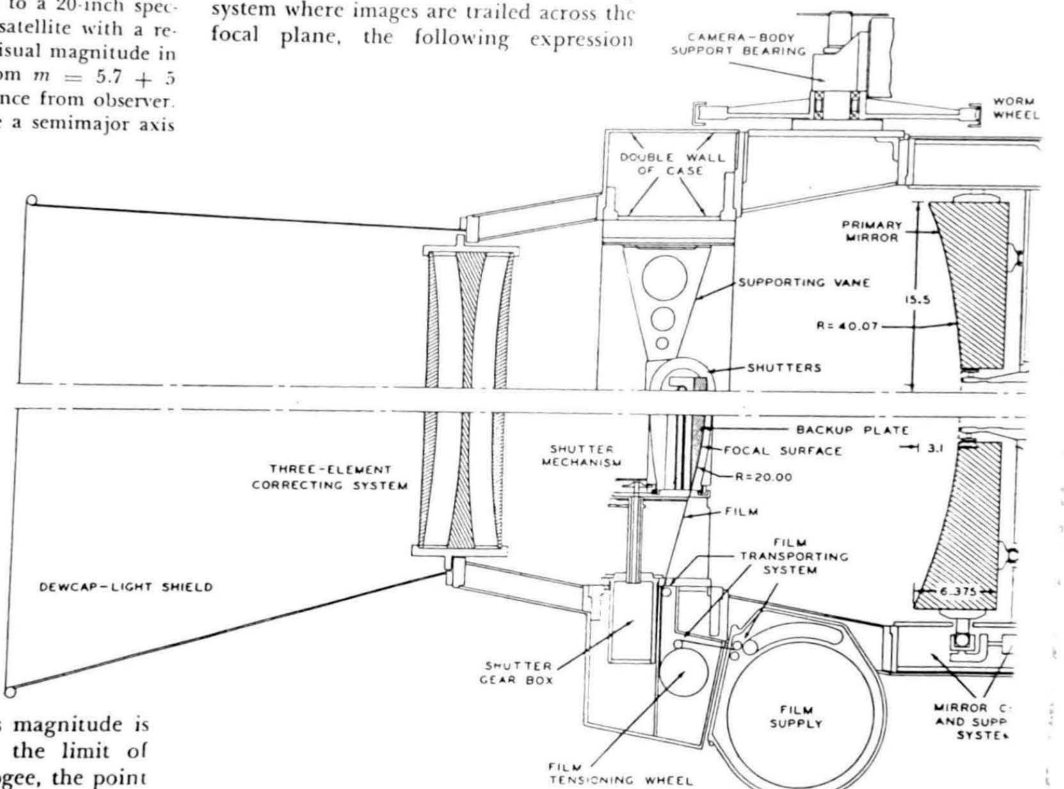
able to have an even greater field along the direction of motion. The image quality must be of uniform excellence over the entire field in order to maintain the optical speed of the system; thus it is clear that a Schmidt system or modification of it is required. The Baker-Nunn camera has a field of 5 by 30 degrees, which is photographed on a strip of 55-mm. Cinemascope film about one foot long.

In order to achieve a measuring accuracy of two seconds of arc, it is necessary to have a focal length of 16 inches or greater. Since significantly longer focal lengths would make the tracking camera unwieldy, a value of 20 inches has been selected. This focal length gives a film scale of 406 seconds of arc per millimeter.

The most difficult problem is to obtain sufficient optical speed to record an image of the faint, fast-moving satellite. In any system where images are trailed across the focal plane, the following expression

and is taken as about 0.5 for the sat
tracking camera; A is the aperture o
correcting plate of the Schmidt sy
F is the focal length; and d is the diar
of the image spot (A, F, and d are in
meters).

The above expression shows that
optical speed for a trailing image i
rectly proportional to the square of
aperture and inversely proportional t
focal length and also to the imag
ameter. Under the present requirem
the focal ratio can hardly be slower
f/1.0, which would require an apertu
at least 20 inches. (A focal ratio
faster than f/1.0 would lead to grav
sign difficulties.) If we substitute
values for F and A, together with the
gee values of ω and L, we may calc
the image diameter that is necessa



Two cross sections of the Baker-Nunn satellite-tracking camera, showing the film-transport and shutter mechanism. The two halves are at right angles to each other, and all dimensions are in inches. The double-walled camera case is in sections (right to left), one holding the mirror, the next the support trunnions, the next the focal surface and film-transport system, and the last the three-element Schmidt correcting plate.

est the earth, the satellite's magnitude is expected to be 5.7, near the limit of naked-eye visibility. At apogee, the point farthest from the earth, the magnitude will be about 10. These values assume that the satellite is observed in the zenith, but, away from the zenith, it will lie at a greater distance from the observer and will be fainter. At a zenith angle of about 50 degrees, this reduction in brightness amounts to one magnitude. As for the angular velocity, it will vary from nearly 1¼ degrees per second at perigee to about one tenth that value at apogee.

What are the general requirements of an optical system designed for tracking such an object? Field of view, focal length, and optical speed are of prime importance.

Since it is not expected that the predicted positions for such a rapidly moving object will be more accurate than about ± 1 ... we will need a field of view

determines the limiting magnitude of the trails:

$$\frac{\omega}{L} = \frac{3{,}438}{E} k \frac{A^2}{Fd}.$$

Here ω is the angular velocity in minutes of arc per second; L is the illumination in meter-candles cast by the satellite on the earth's surface; E is the exposure in meter-candle-seconds required to produce a "usable image" on a given emulsion (the term "usable" is open to wide interpretation, but for our purposes a value of 0.003 meter-candle-seconds seems reasonable for the fastest emulsions now available). Also, k is the transmission coefficient of the system, which accounts for blockage of the incoming light beam by the photographic film and shutter mechanism, as well as for

photograph the satellite at perige
the camera held stationary. This
practical lower limit for the optical
because even when the camera is n
track the satellite it is still neces
record the trails of background
least down to the 5th magnitude.

The required image diameter i
millimeter, or 30 microns. Althou
performance is not too difficult to
on the optical axis, at the edge o
degree field it is nearly 50 times th
classical f/1.0 Schmidt. The prob
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was given to Dr. James G. Baker, o
Inc., who is well known for his de
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such as the famous super-Schmidt
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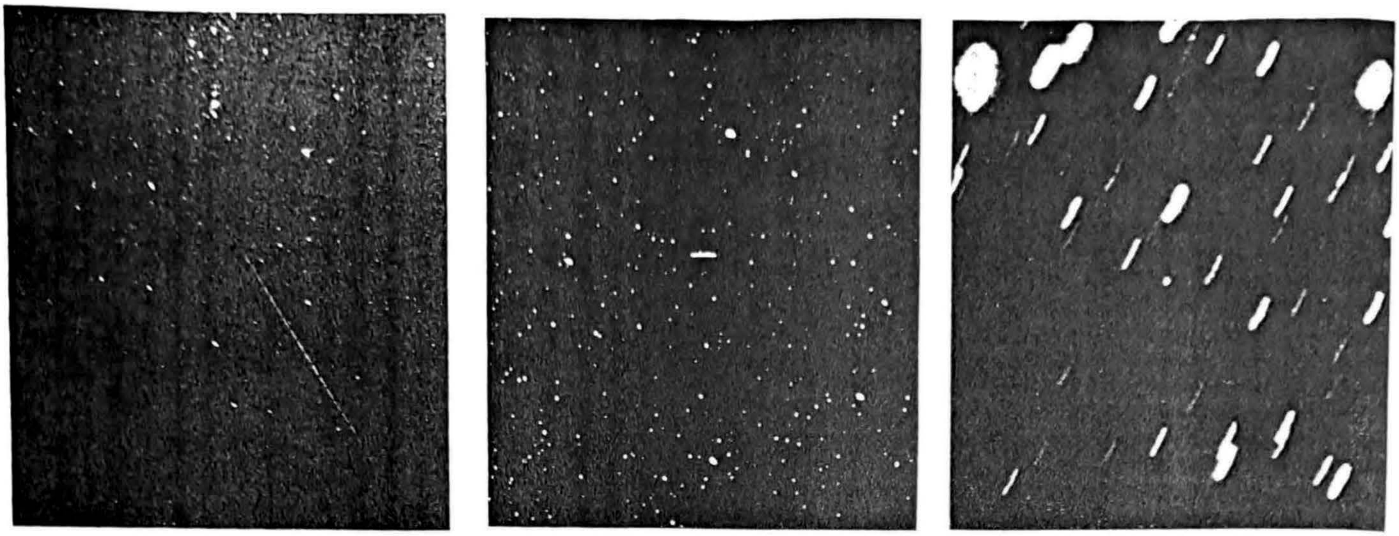

Three examples from astronomical photography illustrate some of the principles of observing the satellite. At the left is a Harvard photograph of a Geminid meteor whose trail has breaks caused by a rotating shutter in the camera; the meteor's motion can be measured from these breaks. In the center, the trail of an asteroid is recorded on a long-exposure photograph guided on the stars, but for a fainter object, as in the third picture, it is better to shift the camera to follow the moving asteroid, which then appears as a bright point while the star images are trailed. Photographs from Harvard Observatory and Goethe Link Observatory.

in the drawing on page 109 of the principal camera parts. Its correcting plate has three components, of which the two outside surfaces are spherical while the four inner surfaces are aspherical. However, only two distinct types of aspherical surfaces must be produced, because the first and fourth are alike, as well as the second and third. These components have greater optical power than the classical Schmidt correcting plate and, as a consequence, considerable chromatic aberration would occur. To overcome this and to achieve a truly apochromatic system, a combination of unusual glasses must be used: Schott KzFS-2 for the two outer elements and Schott SK-14 for the central element. These reduce the chromatic aberration to zero at three distinct wave lengths.

The mirror is spherical, with a 31-inch diameter. The focal surface has a 20-inch radius of curvature, but with slight deviations from a perfect sphere. These deviations are figured into the glass backup plate against which the film is stretched during an exposure.

A detailed ray-tracing analysis has been made for this system by Dr. Baker, who finds that 80 per cent of the light from ultraviolet to deep red is focused into a 20-micron circle of confusion (effective image diameter) at all points in a 30-degree field.

In operation, the telescope's motion will track the satellite with an accuracy of one per cent, thereby increasing the effective exposure time ideally by a factor of 100 and the limiting magnitude by five magnitudes. The table shows the limiting magnitudes when the camera is stationary and when it is tracking. It is seen that under the most difficult circumstances, when the satellite is at apogee, its brightness will be about three magnitudes above the film limit.

Angular Velocity ('/sec.)	*Limiting Magnitude* *Stationary*	*Tracking*	*Satellite Mag.*
87.8	5.8	10.8	5.7
42.1	6.6	11.6	7.2
19.4	7.4	12.4	8.7
8.9	8.3	13.3	10.1
0.25*	12.2	17.2	—

*This is the sidereal rate at the celestial equator. In this table, it is assumed that 80 per cent of the light falls in a 30-micron image. The satellite-tracking camera is expected to achieve this efficiency.

The mounting of the telescope, illustrated on the front cover, consists of three axes which permit the camera to track in any direction across the sky. Two axes are altazimuth: a vertical one about which the yoke swings and a horizontal one about which the gimbal ring swings. These axes are clamped in fixed positions during tracking, which is accomplished by swinging the camera body about the third axis, in the plane of the gimbal ring.

Traditional astronomical methods of measuring image positions relative to star images on the film will be a necessity in order to achieve the precision of two seconds of arc. But, if we track on the satellite when it is at perigee, the stars must trail and only those brighter than magnitude about 5.8 will be recorded. Fortunately, on the average two or three stars of this brightness will fall in the 5-by-30-degree field. If we must measure across several inches of film, however, from the star image to the satellite image, stretching of the film and distortion of the emulsion will introduce greater errors than can be tolerated.

To avoid these pitfalls, it is planned to cause the camera to oscillate so that it will alternately track at the satellite rate and at the rate of sidereal motion parallel to the satellite orbit. In this way exposures on the satellite and on the background of faint stars can be made on a single film. The satellite can then be measured relative to nearby star images. We can take account of the satellite motion between the two exposures by measuring the distance between the "star-exposure" images of the bright stars and the "satellite-exposure" images of these same stars. This distance will never exceed one inch; the problem of film stretching is thus minimized.

It is important to provide sharp breaks in the trail as reference points for measurement and for time determination. These breaks will be produced by a rotating barrel shutter with all but two "staves" missing. This shutter is shown in the upper part of the camera diagram as the cylinder that encloses the film backup plate. Concentric with the barrel shutter and just outside it is a clamshell shutter which snaps open and shut to begin and terminate each exposure.

We may describe the operation of the satellite-tracking camera in terms of a basic cycle in which the tracking rate varies from sidereal to satellite and back again. The length of this operating cycle may be set at 2, 4, 8, 16, or 32 seconds. If we begin the cycle just at the end of the star exposure, the following events occur in the order given:

The tracking rate accelerates until the satellite rate is reached. The clamshell shutter snaps open for an interval of 0.1 cycle, during which the exposure is chopped into four segments by the continuously rotating barrel shutter (which turns 20 times per cycle). At the instant of some one chop, a stroboscopic flash illuminates the time-display unit attached to the camera and the time is photographed on the following strip of film through a small auxiliary optical system. After the clamshell closes, the tracking rate decelerates to the sidereal rate and the clamshell

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ate deceler-

opens again for 0.1 cycle. This star exposure is likewise chopped into four segments but the time is not recorded. After the shutter closes again, the film is automatically changed and the cycle repeats.

Power for these operations is delivered by two $\frac{1}{4}$-horsepower synchronous motors. One motor drives the camera at a constant rate. The other drives the oscillating motion, the shutter rotation, the film-transport mechanism, and the stroboscope firing trigger, all of which are connected by a direct mechanical linkage.

The settings of the mean tracking rate and of the amplitude of oscillation are continuously variable and may be made with an accuracy of one per cent. To achieve this, ingenious design must be combined with precision machine work. The design of the mounting, tube, drives, and other mechanical parts of the Baker-Nunn camera is the work of Joseph Nunn, Los Angeles, California.

At its greatest angular velocity, the satellite will move some 5,300 seconds of arc per second of time. A measuring accuracy of two seconds of arc along the direction of motion would thus require time determination to 1/2,500 second of time in this extreme case. It is impossible to achieve this precision in field operations but, clearly, we must strive for the greatest possible accuracy. The main component of the time unit installed with each telescope will be the Model 111 crystal clock manufactured by Ernst Norrman Laboratories, Williams Bay, Wisconsin. Modifications and additions to this basic unit have been made chiefly by Robert J. Davis at Harvard Observatory.

The main additions are a radio receiver for WWV time signals, a system of time presentation readable to 1/10,000 second, and a "slave" clock that will duplicate the time presentation within the body of the telescope where it can be photographed during every operating cycle. The time presentation includes a rotating dial for 1/100 second, and an amplitude-modulated circular-sweep oscilloscope which can be read to 1/10,000 second. This will display the 10-kilocycle output of the clock and compare it with the signal received from WWV. If daily comparison with WWV can be made, the error of this time system may be held to 1/1,000 second. In the "slave" clock, which is a miniature duplicate of this time presentation, it is necessary to fire the stroboscopic flash and to admit a brief pulse to the oscilloscope once during each camera cycle. E. A. Halbach, of Milwaukee, Wisconsin, assisted in the design of the "slave" clock.

The satellite-tracking cameras and the timing equipment are now under construction. The basic contractors are Perkin-Elmer Corporation, Norwalk, Connecticut, which is producing the optical components, and Boller and Chivens, Inc., South Pasadena, California, which is making the mechanical components. The

ing built by the Norrman Laboratories. The correcting-plate glass is being produced by the Schott optical glass works in West Germany, while the mirror blanks are coming from the Corning Glass Works, Corning, New York. Several mirror blanks have already been delivered, and the first glass from Germany is expected this month. The first optical system and its camera body and mount are all expected by early July.

This first camera will be erected at the prototype satellite-tracking station at White Sands, New Mexico, where it will be subjected to intensive shakedown trials. The remaining cameras, to be delivered at the rate of one per month, will be erected at tracking stations scattered over the globe. Sites that have been selected include central Florida; Mauna Loa Observatory, Hawaii (see page 116); Tokyo Observatory, Tokyo, Japan; central Australia; Curacao, Netherlands West Indies: Boyden Observatory, Bloemfontein, South Africa. Other sites being considered include Cadiz, Spain; Teheran, Iran; Dehra Dun, India; Cordoba, Argentina; and Arequipa, Peru.

It is estimated that each station will be able to photograph the satellite on the average of at least once a week. Not only must the station be located near the satellite's path in order to make an observation, but it must be in the twilight zone at the same time. Several hours before the expected transit, the latest data on the orbit will be radioed to the station, giving the settings of the yoke, the gimbal ring, and the camera, the brightness of the satellite, its angular velocity, and the moment when tracking must begin. Appropriate settings will be made on the telescope and, at the appointed instant, the tracking mechanism will be engaged. Subsequent operation of the camera will be automatic.

Between 10 and 100 separate photographs of the satellite may be made during each transit, depending on the particul circumstances. These photographs will developed immediately and a rough p sition for the satellite will be measur for transmission to the computing cen in Cambridge, Massachusetts, where will be used in improving the predictio of the satellite's flight. The film its will be shipped to the computing cen for high-precision measurement. After o servations of all the IGY satellites ha been completed, these precision measu from all stations will be combined in t solution of complex orbit equations yield the geophysical and geodetic d mentioned at the beginning of this ticle.

NOTE: Personnel to man the optical tra ing stations discussed in this article alrea are being recruited. These men must reliable and resourceful, and should have least an elementary knowledge of astronon Preference will be given to applicants w practical experience in telescope operati in maintenance and repair of mechanical i struments and electronics equipment. Int ested persons should submit their qualifi tions to Satellite-Tracking Program, Smi sonian Astrophysical Observatory, 60 Gard St., Cambridge 38, Mass.

YERKES OBSERVATORY LOSES NIGHT ENGINEER

Frank Sullivan, for many years the nig engineer at the 40-inch telescope of Yerk Observatory, passed away on Novemb 10, 1956, after a short illness. He was bo in 1873. His interest in astronomy w stimulated by J. A. Parkhurst.

More than two generations of astror mers, working at the world's largest refr tor during the first half of this centu have had the assistance of indefatigat Mr. Sullivan. The observers would chan shifts during the night, but their help would remain from sundown to sunup his unselfish devotion to observatio astronomy.

LETTERS

Sir:

At the recent Western Amateur Astronomers convention in Flagstaff, I heard a paper by Eugene Lahr, "Micrometeorites in Your Own Back Yard." But the subject of the paper was meteoritic dust and not micrometeorites. The latter term has been definitely defined by Fred L. Whipple as designating "an extraterrestrial body that is sufficiently small to enter the earth's atmosphere without being damaged by encounter with the atmosphere."

In 1950, John D. Buddhue published an extensive monograph on meteoritic dust, with a bibliography of 108 papers. I have myself been interested in the problem for more than 30 years. I collected meteoritic dust during the 1930's, by a number of methods, but the best one was to trap the magnetic dust ...

tile roofs by placing magnets, wrapped plastic bags, at the exits from downspou This work was reported in a short pap in *Scientific Monthly* in 1940.

At that time I proposed establishing collecting station on a coral island, mote from exposures of igneous roc where regular collections could be ma and studied for a year or longer. T plan was to erect a noncorrosive roof fro which all drainage would pass throu traps. Thus, magnetic and nonmagnet solids alike could be removed and studie Rain washings would be supplemented b spraying the roof, to make the catch mo regular and to provide special washin for meteor showers. It was also sugges stations be set up at different latitudes Such a program would be ideal for th International Geophysical Year.

H. H. NININGE
American Meteorite Museu

News of Science

rth Satellite

'lans for the construction of a small, nanned, earth-circling satellite vehicle be used for basic scientific observa- ns during the forthcoming Interna- al Geophysical Year (IGY) were an- nced at the White House on 29 July Detlev W. Bronk, president of the tional Academy of Sciences, and Alan Waterman, director of the National ence Foundation. Scientists expect to nplete the satellite developmental rk in time for a successful launching one or more vehicles during the IGY, eriod selected during 1957 and 1958 world-wide observations in the fields he earth sciences by some 40 nations. The satellite program was initiated in npliance with a resolution passed by Special Committee for the Interna- al Geophysical Year (the "CSAGI") ts Rome meeting in Oct. 1954. The lution reads: "In view of the great portance of observations during ex- ded periods of time of extraterrestrial iations and geophysical phenomena he upper atmosphere, and in view of advanced state of present rocket tech- ues, CSAGI recommends that ught be given to the launching of ll satellite vehicles, to their scientific rumentation, and to the new prob- ls associated with satellite experi- nts, such as power supply, telemeter- . and orientation of the vehicle." nilar resolutions were adopted in Sept. 4 at meetings of the International ion of Geodesy and Geophysics and International Scientific Radio Union. he satellite, intended specifically and rely for scientific uses, is being devel- d with the technical advice and as- nce of scientists who have long been aged in research on the upper atmos- re. The White House announcement l that the Department of Defense will vide the required equipment and lities for launching.

'ormal notification of the inclusion he satellite project in this country's r program was communicated to Syd- Chapman, president of CSAGI, by eph Kaplan, chairman of the U.S. ional Committee for the IGY. Kap- wrote: "The participation of other ions engaged in the International physical Year program is invited, and his end we shall provide full scientific information on the orbiting vehicle so that other nations may monitor the de- vice and make appropriate observations."

Once established in its orbit, the satel- lite will be able to telemeter informa- tion to earth about conditions in the outer edge of the atmosphere. It can also report on extraterrestrial radiations and particles that are shielded by the earth's atmosphere—ultraviolet radiation, cos- mic rays, meteors, and so forth—that have a strong influence on the upper at- mosphere and indirectly affect the lower atmosphere.

In the past, vertical rocket flights to extreme altitudes have provided consid- erable information about the upper at- mosphere, but such flights are limited to very short periods of time. Only by use of a satellite can sustained observations in both space and time be achieved. Plans are being made for a basketball- sized vehicle that will orbit around the earth for a period of days at a height of 200 to 300 mi and at a velocity of 18,000 mi/hr, gradually circling back into the upper atmosphere where it will eventually disintegrate harmlessly.

The satellite project is one important part of the United States plans for scien- tific work during the IGY, when scien- tists will conduct the most comprehensive study of the earth ever undertaken. In- tensive investigations throughout the world will be carried out in meteorology, latitude and longitude determinations, geomagnetism, gravity measurements, ionospheric physics, aurora and airglow, solar activity, cosmic rays, glaciology, oceanography, seismology, and rocket exploration of the upper atmosphere.

Each of the fields in the program is characterized by its global nature, and many are related to solar-energy fluctua- tions and disturbances. There will be spe- cial emphasis on observations from loca- tions that are usually inaccessible, such as Antarctica—and now from satellites. Measurements must be made simultane- ously so that the relationships between fields can be determined on the basis of world-wide coverage.

The list of nations that will participate in the IGY program includes: Argentina, Australia, Austria, Belgium, Brazil, Burma, Canada, Chile, Czechoslovakia, Denmark, Finland, France, East Ger- many, West Germany, Great Britain, Greece, Hungary, Iceland, India, Ire- land, Israel, Italy, Japan, Mexico, Mo- rocco, Netherlands, New Zealand, Nor- way, Pakistan, Peru, Philippines, Spain, Sweden, Switzerland, Thailand, Tunisia, Union of South Africa, U.S.S.R., United States, and Yugoslavia. Each country will plan and execute its own program, un- der a general plan developed and coor- dinated by the Special Committee for the International Geophysical Year.

The U.S National Committee for IGY, established by the National Acad- emy of Sciences, is in charge of plan- ning, directing, and executing this coun- try's program. The committee and its technical panels, which include many of the nation's leading geophysicists, have developed the program in cooperation with a number of universities, institu- tions, and agencies. Federal sponsorship and support has been obtained by the committee through the National Science Foundation.

Secrecy in the Sky

The following excerpts are drawn from an editorial entitled "Secrecy in the Sky" that appeared in the 4 Aug. issue of the *New York Times*.

"A few Senatorial voices have been raised to protest against the President's intention to tell the world . . . what in- formation may be telemetered to ground stations by the artificial satellites that are to be sent up in 1957 or 1958. . . . For years we clung to secrets that were no secrets at all. If we paid any attention to the protesting Senators, our physicists and engineers would have nothing to say at the atoms-for-peace conference in Geneva . . .

"If the Soviet Union plants a satel- lite in the sky . . . it will find out as much as we can about the frontier of outer space. . . .

"It would be a mistake not to publish all that we may discover about the con- ditions that prevail 250 miles away from the earth, even though something of in- direct military use may be important. More important is the preservation of the spirit that the President infused in the recent "summit" conference at Geneva. His willingness to pool our knowledge of the atom with that of other nations for mankind's benefit, the emphasis that he has laid on the peaceful uses of the atom and now his proposal to make the knowledge to be gained by an artificial satellite common property, is all in the high tradition of science.

"Too long have scientists been muzzled by following a policy of secrecy necessary only as far as strictly military matters are concerned. The President has taken an immense forward step by restoring free- dom of scientific discussion to its old state."

Krebiozen

On 2 A vice presid nois, filed State Supr George D. of the Uni based on s cluded in *Krebiozen:* The cor studying K shows pron and that a ings Ivy h and medi their meet grams to v invited in and his pr subjects [h journals." The Kr 4 years ag announced disclose th suspension Medical S can Medi al Resear orably on mission o pointed u Stoddard the mater a leave of Several Stoddard dency as fidence" of trustee joined to action of dard for h and inte Septemb as head science, v professor work wit auspices Stodda controver over Kr ready to Judge Jo Superior straining book by means th out heari addition were St Krebioze Krebioze nois corp Comm the Chic "Restrain

Wilbert Smith on

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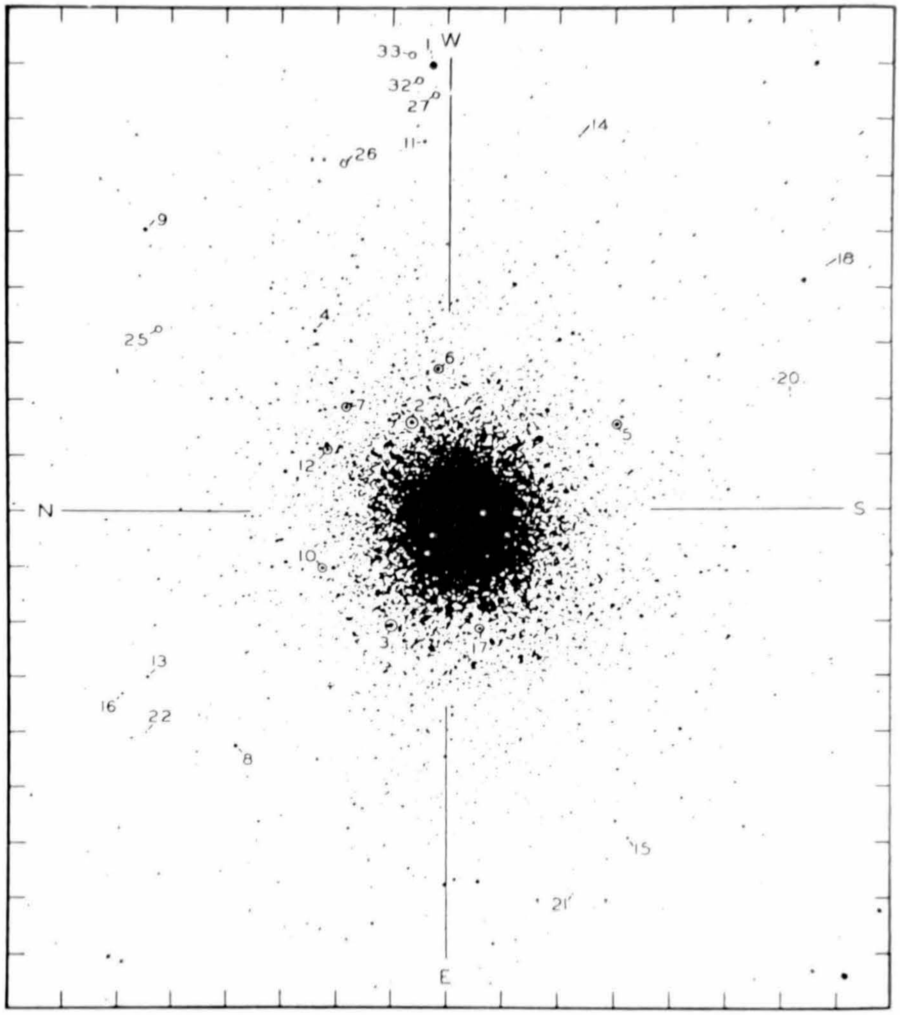
·d. The extensive photometry of ›ance indicators, such as Cepheids novae, belonging to these nearby :ems can be handled fairly well by tographic methods if the data are perly calibrated on a correct scale of ;nitudes. For this purpose, very faint ıdard sequences have been established h the photon counter in three of the ›teyn selected areas. W. Baade has ·ady used these sequences, along with evised Cepheid zero point, to estimate ıew modulus for the Andromeda gal- · of 24.2 magnitudes, corresponding to distance of about two million light- ırs. This result has been tentatively ıfirmed by direct photoelectric obser- ·ions of red giants in the southeast lo of that galaxy, including the star which counts are given in Fig. 10.

The counter has also yielded an im- rtant result bearing on stellar popula- ›ns. It has shown that the main se- ences of globular clusters are comprised subdwarfs. This was discovered from e photometry of faint stars in Messier · (featured in the center of this issue), and it has now been confirmed in Messier 3. Further work on other clusters is in progress. The result apparently means that the familiar main sequence for stars in the solar neighborhood is only a particular case lying near one edge of a main-sequence band embracing dwarfs and subdwarfs together.



This chart of M13 is from a 200-inch photograph, and can be used as a key to the feature picture on the following pages. Numbers identify stars measured photoelectrically by Dr. Baum. The yellow magnitudes for the numbers included on the chart are: 1, 10.74; 2, 12.03; 3, 12.04; 4, 12.14; 5, 12.15; 6, 12.43; 7, 12.64; 8, 12.81; 9, 12.85; 10, 13.14; 11, 13.28; 12, 13.46; 13, 13.49; 14, 14.50; 15, 14.84; 16, 15.01; 17, 15.07; 18, 15.47; 20, 16.05; 21, 16.10; 22, 17.03; 25, 17.86; 26, 17.99; 27, 18.33; 32, 21.14; 33, 21.40. The marks at the edges represent minutes of arc. Adapted from the "Astronomical Journal."

ASTRONOMICAL SCRAPBOOK

Other Satellites of the Earth

ONE of the most famous meteoric phenomena on record happened on February 9, 1913. This was long believed to have been a procession of about 40 fireballs, moving very slowly from horizon to horizon in nearly the same path, seen from western Canada, across Minnesota, Ohio, New Jersey, and Bermuda to the equator—a distance of over 5,000 miles.

It was, however, established by C. C. Wylie in 1939 that these widely spaced observers had not viewed the same meteors, so what really occurred was an intense but ordinary meteor shower rather than a true meteoric procession.

Even so, there are some interesting consequences of the original idea of a procession of meteors. For if the course and velocity with which such bodies approach the earth were favorable, they could be captured as satellites, circling far enough above the earth's surface to avoid destruction by the atmosphere—the fate of all ordinary meteors. They would then be the type of body looked for in C. W. Tombaugh's intensive photographic search now under way at the Lowell Observatory. His is the first sustained effort, with modern optics and careful programming, to discover additional satellites of the earth.

How a hypothetical satellite would appear to an observer was discussed in detail by W. H. Pickering in 1923. He showed that a meteorite one foot in diameter, revolving in an orbit 200 miles above the earth's surface, could be as bright as 10th magnitude at times, shining by reflected sunlight. It would resemble an unusually slow-moving telescopic meteor. Objects of this sort may well be picked up in Tombaugh's search.

Controversy about earth satellites dates back at least to 1821. The British meteorologist, John Farey, held that many meteors were small terrestrial satellites traveling in eccentric orbits, dipping deep into the earth's atmosphere at every perigee passage. This view was rebutted by Dr. William Burney, of Gosport, England. Nevertheless, the idea lingered, and in 1867 the British amateur, W. E. Hickson, argues for their existence. You can find a meteoric satellite in science fiction as early as Jules Verne's *From the Earth to the Moon* (1865).

Is it possible that a meteoric satellite has already been observed? The unfounded report of last August is explained in last December's *Sky and Telescope*, page 51. There was rather more justification for the momentary suspicion that one had been found in 1938, but the rapidly moving object discovered on Koenigstuhl Observatory photographs turned out to be a new asteroid, Hermes, passing within 440,000 miles of the earth.

There is, nevertheless, a classic case where the discovery was reported by a

(Continued on page 354)

(Continued from page 334)

prominent professional astronomer in a leading scientific journal, together with full details and a complete orbit computation. The man was F. Petit (1810-1865), director of the Toulouse Observatory, whose communication to the French Academy of Sciences was printed in its *Comptes Rendus* of October 12, 1846.

Three observers saw the body, Lebon and Dassier at Toulouse, and Larivière at Artenac, 26 miles away, on March 21st of that year, at 6:45 p.m. When Larivière first noted this luminous object, it was low in the south, near Sirius; it moved slowly past Orion and into the northwestern sky, where it vanished behind a low cloud bank. It stayed in sight for 10 seconds, and its apparent diameter was half that of the moon.

First supposing this object to be a meteor, Petit calculated its track, and found to his surprise that the observations indicated an elliptical orbit around the earth with a period of revolution of 2 hours 44 minutes and 59 seconds. The mean distance from the center of the earth came out 6,180.1 miles, and the orbital eccentricity 0.36007. Therefore, at perigee—the time of observation—the body would have missed the earth's surface by only 7.1 miles. Why this conspicuous object was not earlier recognized was easily explained by Petit: At less favorable apparitions its much greater distance from earth would make it correspondingly fainter.

In the audience at the French Academy when this paper was read sat the great Leverrier, codiscoverer of Neptune. He commented that the orbit calculation should be revised to take air resistance into account.

Hindsight is easy, when an additional century of experience by meteor astronomers is available to us. In 1846 the calculation of meteor heights and paths was still a novelty, and Petit had not realized that the observations were too rough to support such an elaborate superstructure of computation. His orbit depends very critically upon the uncertain estimates of the duration of visibility. The 10-second duration reported by Larivière leads to an elliptic orbit that intersects the earth's surface twice; the six seconds of the Toulouse observers makes the orbit around the earth a hyperbola. Petit had arbitrarily averaged these durations for his calculations with seven-place logarithms!

Petit's similar discovery of a second supposed earth satellite on July 23, 1846, also appears invalid, from uncertainty in the all-important estimates of duration. There can now be hardly any doubt that both these objects were merely ordinary fireballs. Clyde Tombaugh need not fear having been anticipated 109 years ago, if he finds a satellite of the earth.

J. A.

By-Products of the Search for Natural Satellites of the Earth

CHARLES F. CAPEN, JR., *New Mexico College of Agriculture and Mechanic Arts*

IN DECEMBER, 1953, a systematic photographic search for small *natural* satellites or moonlets of the earth was begun at Lowell Observatory in Flagstaff, Arizona. It was conducted by Clyde W. Tombaugh for the Office of Ordnance Research, Ordnance Corps, U. S. Army.

The first phase of the search came to a close in June, 1956, when certain survey zones of the sky accessible from the Lowell Observatory's latitude of 35° 12'.5 north had been covered. Mr. Tombaugh, who normally works as an astronomer at White Sands Proving Ground, is at present a research professor at New Mexico College of Agriculture and Mechanic Arts, from which he is directing a continuation of the search at an observing station in Ecuador.

As recently described by Mr. Tombaugh in *Jet Propulsion*,* the regions of space nearest the earth are virgin fields for such exploration. The angular velocity of a close satellite would be very great, so it could not be recorded on normal astronomical photographs. At the distance of the moon, an object of low reflectivity and less than 100 feet in diameter would be about 13th magnitude, probably detectable only by a fast camera driven at the proper angular rate. The accompanying chart (Fig. 1) shows stellar magnitude as a function of size and distance, assuming that a natural satellite would probably have a rough surface and, like the moon, would reflect only about seven per cent of the incident sunlight.

Therefore, our basic method of search is to drive a fast, wide-field camera at a rate expected to conform with the angular speed of a satellite across the sky. While this produces a long streak for each star in the field, the image of an actual satellite would appear on the film as a point or a very short trail. But since the angular speed of such a body would not be known in advance, the program calls for repeated surveys of each sky area with the camera driven at many different tracking rates.

The hunt was begun with an 8½-inch f/1.6 Schmidt camera, made many years ago by the amateurs Charles and Harold Lower, mounted on the Lowell 13-inch photographic refractor. (The latter instrument had been used by Mr. Tombaugh for the discovery of the planet Pluto in 1930.) The telescopes were fitted with a Graham variable-speed transmission drive, allowing the tracking of satellites at any angular velocity and, therefore, at any desired distance from the earth.

During the next two years of the search, two K-24 aerial cameras of 2.8-inch aperture with Ektar f/2.5 lenses were added, in order to obtain continuous orbital coverage for the close-in zones having higher angular drive rates than the Schmidt could achieve. But at such high rates of motion, the slit of the 13-inch dome could not be moved fast enough to keep in front of the cameras, so all three were remounted under a roll-off roof, as shown in Fig. 2.

Many unusual phenomena were observed visually or recorded on film during the long, cold nights of the satellite patrol at Flagstaff. One evening a 3rd-magnitude

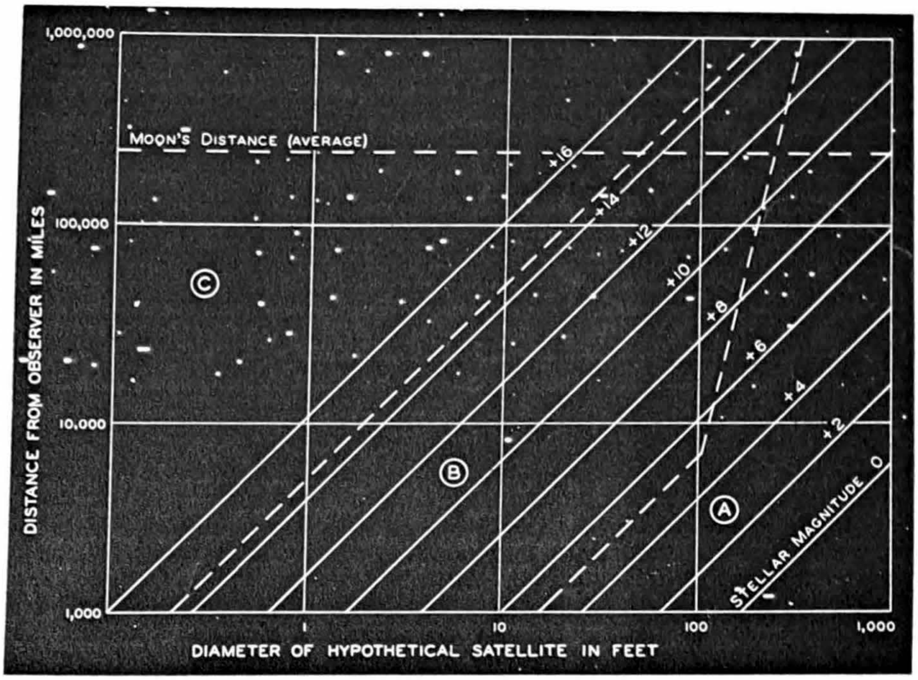


Fig. 1. In this diagram, Clyde Tombaugh has assumed that a hypothetical satellite is seen at full phase (opposite the sun in the sky) and that it reflects seven per cent of the sunlight falling on it. A satellite in area "A" could be found by existing telescopes with standard drives; in "B" it should be detectable with the f/1.6 Schmidt and special drive used in the Ordnance Corps satellite search; in "C" a natural satellite would be even more difficult to discover.

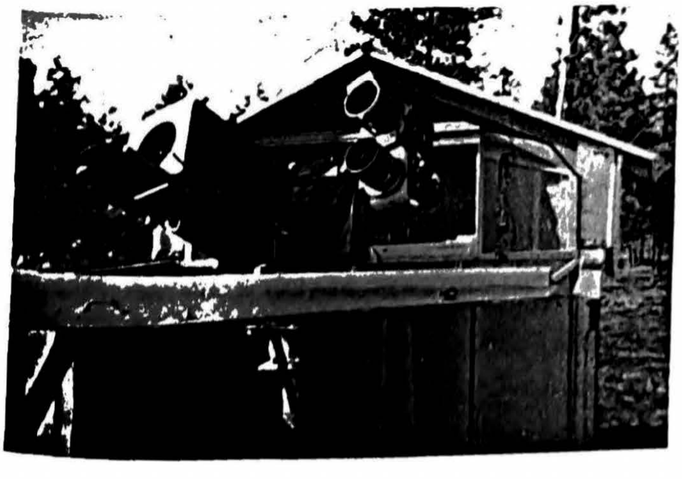


Fig. 2. The 8½-inch Schmidt camera is on the left side of the mounting, the K-24 cameras on the right, with the roof of the shelter rolled back.

* "Proposed Geodetic Triangulation From an Unmanned Orbital Vehicle by Means of Satellite Search Technique," Clyde W. Tombaugh, *Journal of the American Rocket Society*, 25, 232, May, 1955.

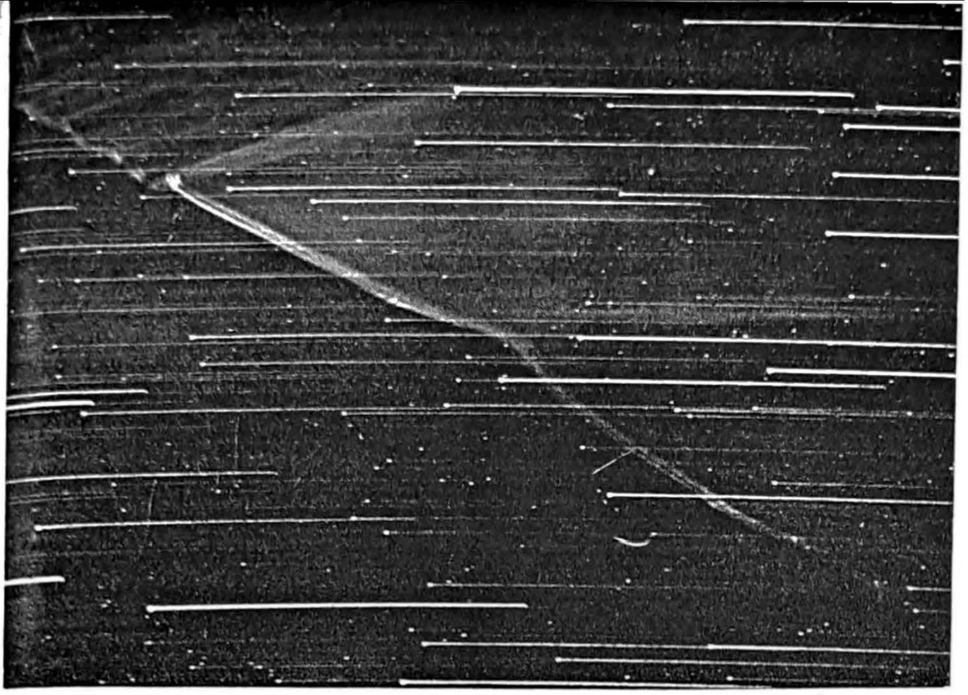


Fig. 6. The luminous train of the fireball of April 26, 1956, from a one-minute Schmidt exposure that began 15 seconds after the fireball passed. For the first five seconds the camera was stationary, recording the train as the diagonal streak in this picture. Then the camera was driven at a rate of 186 degrees per hour, trailing the images toward the right. Parts of the fireball train show an upward displacement, due to winds aloft. Compare this with Fig. 7, showing the appearance of the train soon afterward.

train caused by wind shear, probably at a height roughly 50 miles above the surface of the earth.

Another Schmidt exposure (Fig. 7) was made 2 minutes 15 seconds after the fireball's final flash occurred. The luminous train had now become much dispersed and distorted by the upper winds into a fanlike structure. The upper end of the train was blown northeast, the center slightly to the north, while the lower end was blown westward. This effect could have been caused by differences among the winds at various altitudes.

With observations made at only one site, there was no way of measuring the height of this sporadic meteor. It is hoped that some observer in another part of Arizona may have seen and recorded this object; other reports would be welcome in order to calculate the absolute heights and wind velocities.

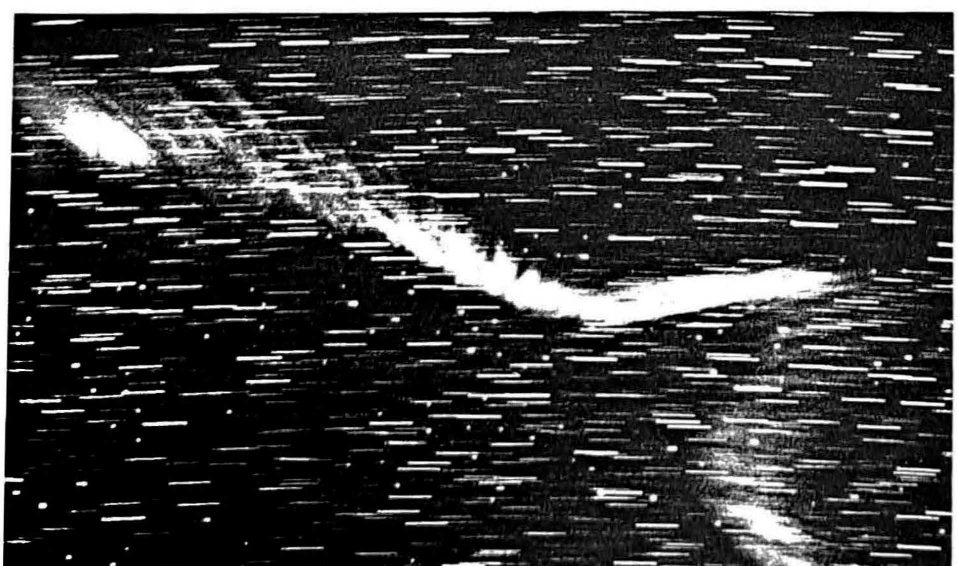


Fig. 7. The Schmidt camera was used without drive for this one-minute exposure of the train of the same fireball, 2¼ minutes after the meteor disappeared. The inconspicuous kink of Fig. 6 is now very noticeable at the right.

One of the unusual asteroids found with the 48-inch Schmidt telescope during the National Geographic-Palomar Observatory sky survey (page 107, January issue) has been named *Geographos* by its discoverers, R. Minkowski and A. G. Wilson. It is also known as minor planet 1620, although after its discovery on August 31, 1951, it was temporarily designated 1951 RA; the permanent number was not assigned until later, when its orbit became well-enough known to insure its recovery in future years.

Requiring only 17 months to complete one revolution around the sun, Geographos moves in a path whose perihelion point lies near the orbit of Venus. When farthest from the sun, the minor planet is a little outside of the orbit of Mars. Probably not much over a mile in diameter, this faint asteroid can be observed only when it passes near the earth.

According to computations by S. Herrick, Jr., and C. Hilton of the University of California at Los Angeles, Geographos will approach within four million miles of the earth in 1969, closer than any other minor planet of known orbit. Observations of the asteroid at that time can be used to determine the distance scale of the solar system. Our presently accepted value of the distance from the earth to the sun is based on similar observations of another asteroid, Eros, which approached within 16,200,000 miles in 1931.

GLASS LIGHT FUNNELS

The usefulness of large telescopes would be much increased if the great wastage of light in stellar spectrographs could be avoided. When the 100-inch reflector is used in poor seeing, the disk of a star's image is so large and unsteady that only about four per cent of the light actually passes through the narrow slit of the spectrograph. To overcome this defect, many years ago an "image slicer" was invented by I. S. Bowen, who is now director of Mount Wilson and Palomar Observatories, but practical difficulties hindered its use at the telescope.

N. S. Kapany, University of Rochester, has proposed a light funnel made of a bundle of glass fibers. These are clamped in circular form at one end to receive the star's light; at the other end they are clamped in the shape of the spectrograph slit. Light is "piped" through each fiber by total internal reflection. Absorption and other light losses are theoretically about five per cent in a funnel three inches long, so an increase in the efficiency of a spectrograph seems possible by this method.

Extensive laboratory tests have been made of this principle at the University of Rochester's Institute of Optics. Even though the same difficulties that hampered the image slicer may preclude use of the light funnel in stellar spectrographs, there are many other possible applications in science and technology.

ange light moved noiselessly from north south, appearing to be slowly falling; it oved to be the jet flame of a high-flying craft without apparent navigation hts. Some films recorded strange zigzag es of light; these were meteorological lloons being released at night for see- ; studies by the Naval Observatory's agstaff station (see page 4, November, 956, *Sky and Telescope*).

One morning in May last year, strange ghts were noticed that hovered in forma- on just above the treetops, and then oved on silently; personnel at the Naval bservatory station also noted the phe- omenon, which fitted the description of e so-called Lubbock lights. They appeared the next morning at nearly the same time, but seemed to move faster, as if closer to us. This time they recalled a past experience of mine—they looked and acted like a squadron of helicopters! This explanation was later confirmed.

Other night phenomena very frequently recorded on the satellite-search films were meteors. A typical trail is shown in Fig. 3, recorded by the Schmidt camera, but the most spectacular meteor was that of April 9, 1956, caught with one of the Ektar lenses during a regular five-minute exposure at a driving rate of 186 degrees per hour. (This driving rate would be expected to match the angular velocity of a satellite at a geocentric distance of about 7,000 miles, assuming a circular orbit.)

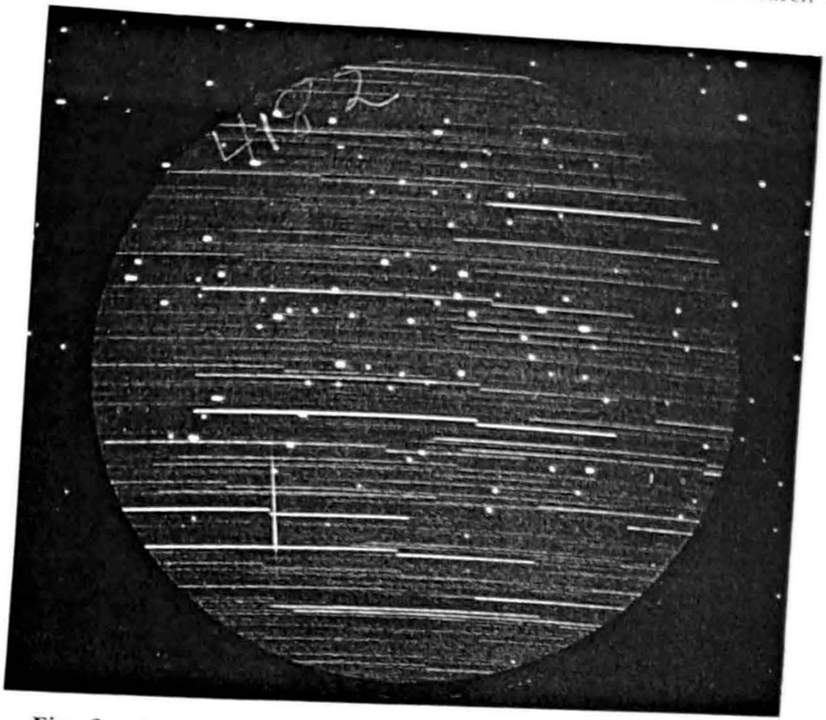


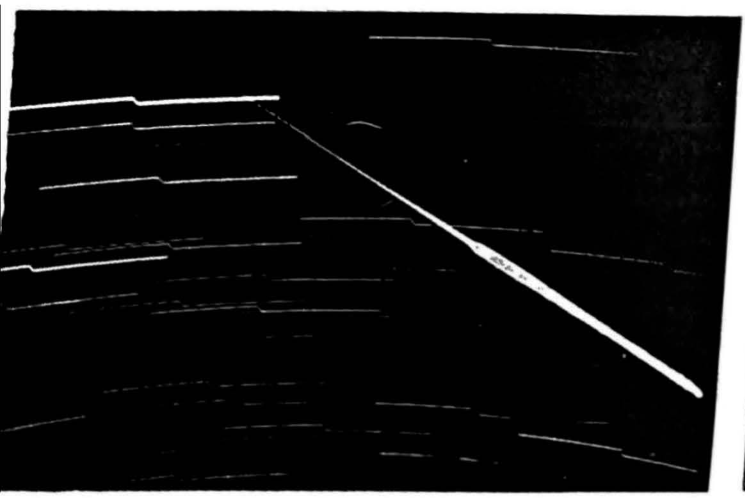
Fig. 3. A contact print of a typical three-minute search exposure with the Schmidt camera, on April 19, 1955. The driving rate of the camera was 190 degrees per hour. Note the declination offset, which divides each star trail into two parts. During the exposure, a bright meteor crossed the field (lower left); thickenings of its trail indicate bursts of light.

The offset between the first and second parts of the star trails in Figs. 3 and 4 is in declination only, made mechanically during the exposure without closing the shutter. The main purpose of the shift is to facilitate identification of images of a satellite. If the camera were to track at the exact apparent motion, the satellite images would be two dots, one above another, separated by the amount of the offset; such pairs of images would not be expected from film defects and other spurious effects. In the more likely event that the satellite images are themselves short trails, their relative lengths would give a measure of the object's distance from the earth.

The fireball of April 9th was of apparent magnitude −3.5 or −4, as bright as the planet Venus, and it left a luminous train visible for 14 minutes in the southern sky. This meteor appeared just above Phi Ophiuchi, and passed between Saturn and Beta Scorpii into Libra. After occulting the star 42 Librae, it began to flash intermittently, and finally burned out in a brilliant burst of light past Theta Centauri. The path is drawn in Fig. 5.

Fifteen seconds after the terminal burst, the Schmidt camera was turned on the luminous train and a picture (Fig. 6) was made in two parts: without drive for five seconds, then with a drive rate of 186 degrees per hour for one minute. It is evident that the train was quickly distorted by winds at different altitudes in the upper atmosphere. Its interpretation requires visualizing the effect of the rapid sweeping of the camera on the shape of the train, but with the aid of the star trails I found that the upper part of the train was moving northeastward at a rate of 1.1 degrees per minute of time.

The lower, west end of the meteor train is 3.7 degrees long, and appears to have had a westward drift of 0.8 degree per minute of time. As a whole, the luminous train seemed to have a counterclockwise rotation. Notice the start of a kink in the



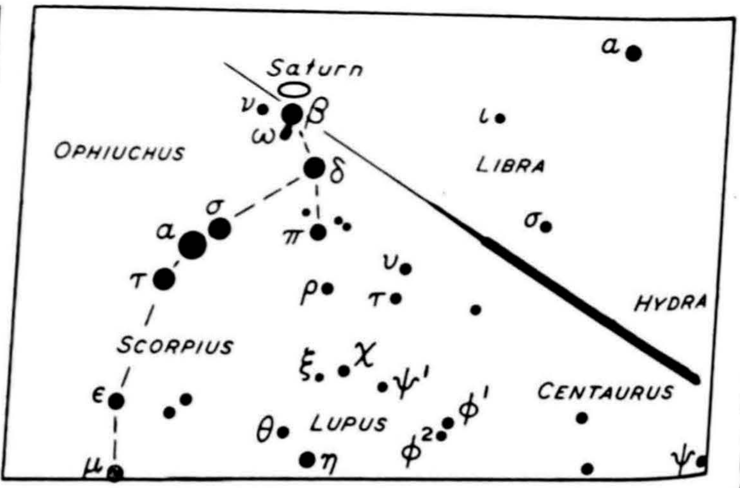
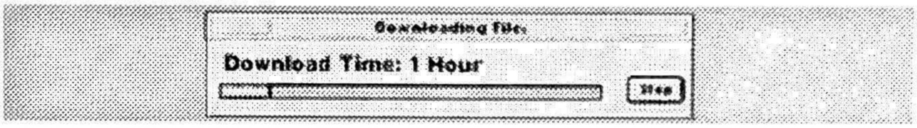


Fig. 4 (left). This is the K-24 film that recorded the bright fireball of April 26, 1956, which appeared at 2:34:45 a.m., Mountain standard time. Note how the meteor suddenly became much brighter near the midpoint of its path. The stars whose trails appear in the photograph may be identified with the aid of Fig. 5 (right), which is a plot of the path of the fireball among the stars of the southern sky.



Mystery Satellite

In February 1960 a station of the North American Air Defense System picked up a radar echo from an enormous space station orbiting the Earth. This intercept caused panic and alarm throughout America's and the Soviet Union's Defense Departments. It was the wrong kind of orbit for a Soviet launch. The space station was in a polar orbit, whereas the orbits of Soviet satellites were invariably inclined at 65 degrees to the equator, which took the satellites over South America and North Africa. Apart from that, there was no booster on either side of the Atlantic capable of putting such an object into space. American scientists had calculated that the weight of the orbiting station was around 15 tons. For three weeks the Americans kept track of the space station, then it vanished as suddenly as it had appeared.

The February intercept was just the first in a series of strange space phenomena which have baffled scientists worldwide for over three decades. On September 3, 1960, seven months after the first intercept, it was revealed that an unidentified object had been photographed in the sky over New York by a tracking camera at Grumman Aircraft Corporation's Long Island factory. The object, which appeared to emanate a red glow, had been seen several times during the preceding two weeks, apparently following an east-to-west orbit, whereas most satellites were launched in the opposite direction, and its speed appeared to be about three times that of America's Echo 1 "metal balloon" satellite.

The Americans attached so much importance to these mystery sightings that they organized a special committee to gather as much information as possible about them. But the committee's findings, if there were any, were kept secret and the sightings were forgotten.

Then, on May 15th, 1963, a Mercury capsule carrying Gordon Cooper blasted into space from Cape Canaveral on a 22-orbit mission around the world. During the final orbit, Cooper informed the Muchea, Australia tracking station that he could see a glowing, greenish object rapidly approaching his capsule from directly ahead.

Whatever Cooper saw was solid and large enough to be picked up travelling east to west by Muchea's radar. Cooper's sighting was reported by NBC, which was broadcasting live coverage of Cooper's flight, but when Cooper landed, reporters were not allowed to ask him about the sighting. The "official" statement was that Cooper had been hallucinating due to release of poisonous carbon dioxide from an electrical short in the capsule.

But Cooper, who is a firm believer in UFOs and later made the UN speech in which he had referred to aliens, UFOs and interstellar travel, had 10 years earlier seen a UFO while piloting his F-86 Sabrejet over western Germany.

In June 1965, astronauts Ed White_the first American to walk in space and who was later to die with Gus Grissom and Roger Chaffee in a launch-pad fire during a test of an Apollo capsule_and James McDivitt were passing over Hawaii in a Gemini capsule when they observed a strange metallic object some distance away. It appeared to have arms or projections. McDivitt took pictures of it with a motion picture camera. Those films have never been released.

The "official" Air Force explanation was that the two astronauts had seen a Pegasus satellite, which was equipped with broad protruding "arms" to register hits from micro-meteorites. But the Air Force forgot to mention that while the astronauts were over Hawaii, the Pegasus was over 1,000 miles away and could not have been observed.

In December 1965, Gemini astronauts Jim Lovell and Frank Borman also saw something strange in space during the second orbit of their record-breaking 14-day flight around Earth. Borman reported that he was observing an unidentified spacecraft some distance away from their capsule. Gemini Control at Kennedy suggested that he might be seeing the final stage of the huge Titan booster which had lifted him and Lovell into orbit earlier that day.

Borman confirmed the sighting of the booster shining brilliantly in the sunlight. But what he was observing was something different; something he could not explain. Later NASA claimed that Borman had seen the wreckage of a U.S. Air Force rocket that had been blown up during a launch several days earlier. But the Air Force rebuked the claim when they insisted that no wreckage was in that particular orbit. They were placing a series of military recon satellites into orbit, however, and those launches were cloaked in secrecy.

There may be rational explanations for all the NASA sightings and for many of the sighting which occur in America almost daily. For years flying saucer scares were carefully fostered by the Soviet Union to draw attention from sensitive areas and secret experiments. Anything unusual seen in the skies above Sverdlovsk, a town barred to all foreign visitors because it is an important center of Soviet missile production, was attributed to UFO activity.

We suspect every other industrialized nation does the same to protect their "black" projects and secret weapons.

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