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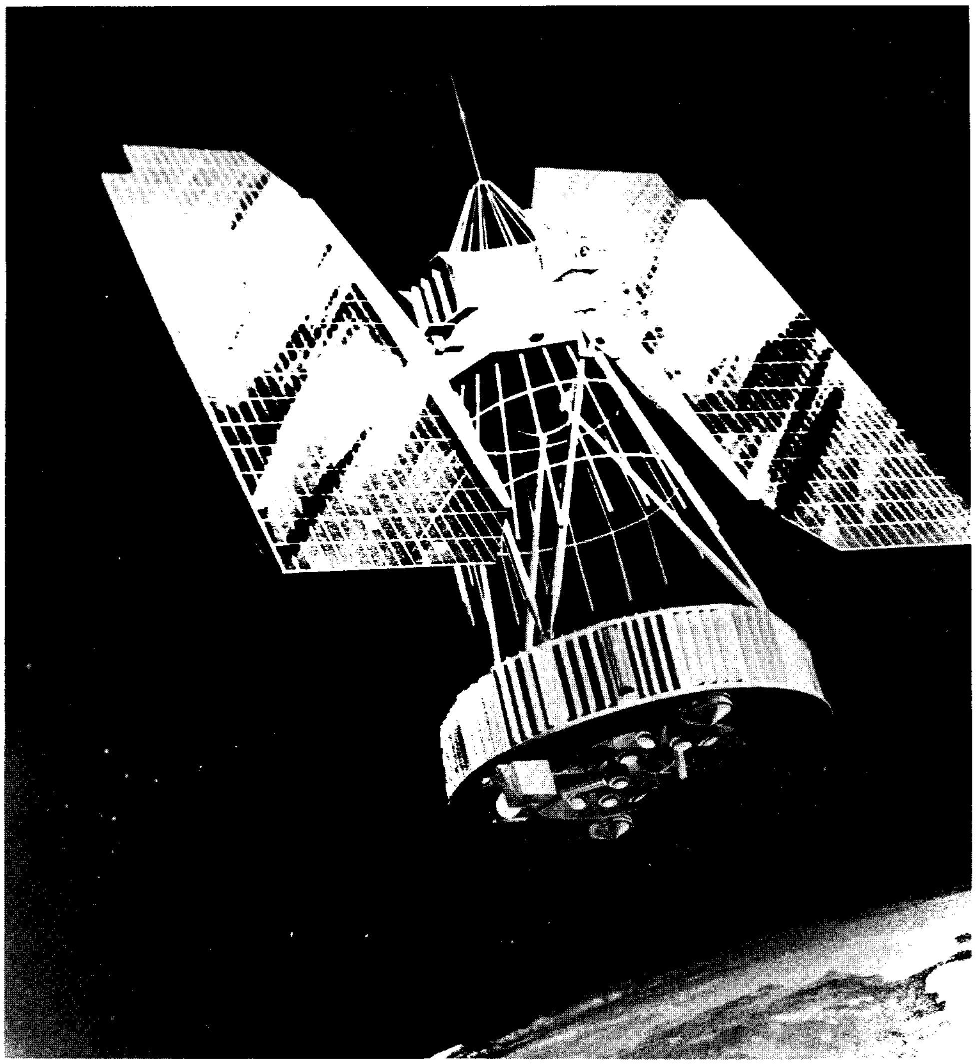
NIMBUS



Nimbus in orbit (artist's conception).

Advanced equipment designed and proposed for use in future weather satellite systems is being tested in NASA's Project Nimbus. The first Nimbus satellite, designated Nimbus I, was launched August 28, 1964.

Nimbus is a second generation meteorological satellite program. It was preceded by the successful TIROS project which, by making possible increased observations of the earth's atmosphere, contributes to accuracy of weather forecasts and to the extension of meteorological knowledge. (See *NASA Facts—TIROS*, No. B–2–64.)

NIMBUS I SENDS FIRST NIGHT-TIME CLOUD PICTURES

Nimbus I provided the first pictures of the earth's surface and of cloud patterns ever taken by a weather satellite at night. TIROS satellites are limited in their observations to the earth's sunlit side. The Nimbus I achievement points the way to around-the-clock weather coverage by satellite.

Midnight infrared photograph by Nimbus I shows heavy clouds over Alps and Central Europe and scattered clouds over Mediterranean Sea and North Africa. (Foot of Italy "boot" at right.)

The excellent quality pictures taken by Nimbus at night were achieved by means of its High-Resolution Infrared Radiometer (HRIR) system. The system detects minute differences in the relatively faint invisible infrared radiation (heat) emitted by clouds and the earth's surface. It converts the data to electrical signals that are stored on magnetic tape for transmission on command to earth.

When the signals are received on earth, they are fed to facsimile recorders that turn them into a strip of pictures. The shades (lightness or darkness) of images in the pictures are directly related to the infrared radiation emitted by the pictured objects. For example, water areas (such as seas, oceans, lakes, and rivers) appear dark because water rapidly gives off heat. Cold

Hurricane Ethel in an infrared photograph by Nimbus I.

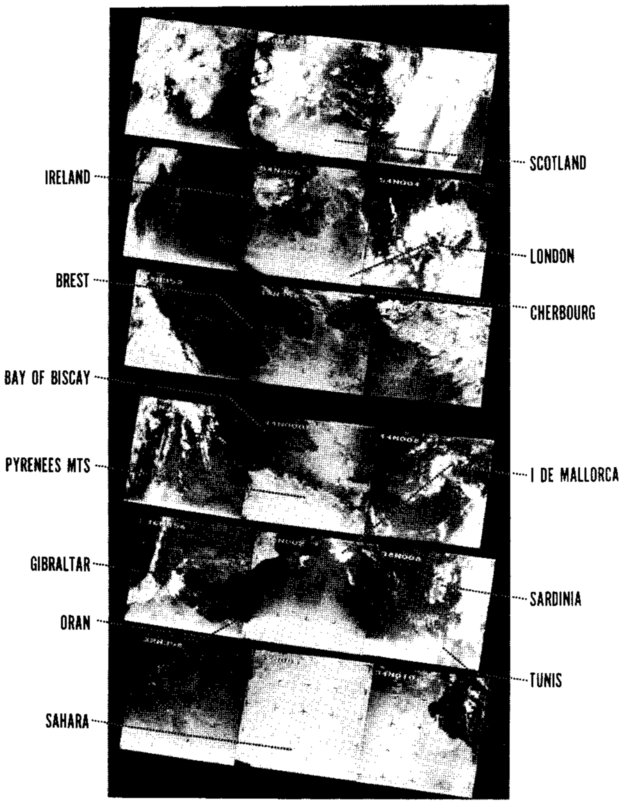
mountain tops that emit virtually no heat are bright. Land is in various shades of gray, becoming lighter with elevation.

Similarly, intensity of infrared radiation emitted by clouds decreases as altitude increases. In effect, the HRIR system provides three-dimensional information—not only length and width but also temperature data from which cloud heights may be derived.

THREE-CAMERA SYSTEM

Nimbus is also equipped with an Advanced Vidicon Camera System (AVCS) consisting of three vidicon cameras (small television cameras) and related equipment. The three cameras, which operate simultaneously, produce an oblong three-panel photograph covering weather conditions over about 750,000 square miles of earth. As many as 33 three-panel views can be provided per orbit.

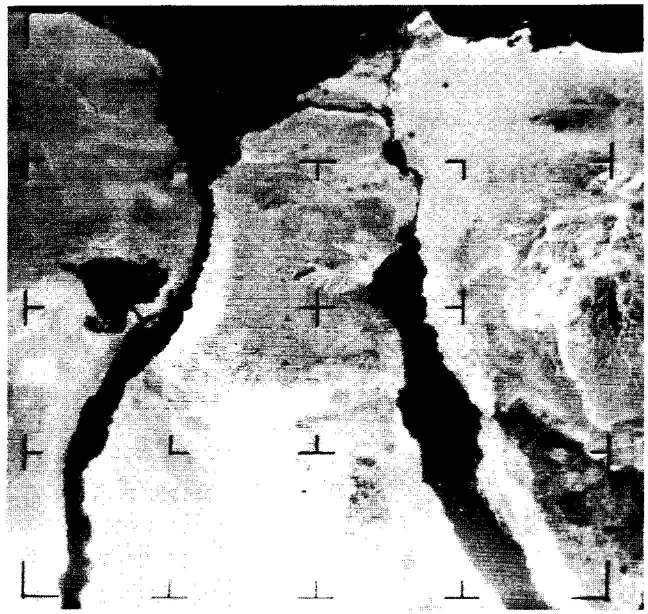
NIMBUS
AVCS PICTURES



Nimbus I triple-camera coverage from the North Atlantic Ocean to Sahara Desert on August 30, 1964.

From the design altitude of 575 miles, Nimbus cameras provide a resolution of approximately one-half mile. This means that cloud and terrain features as small as a half mile are detectable in the photographs. Photographs taken at a lower altitude show more detail. The AVCS system operates only in daylight and turns off automatically when Nimbus reaches the earth's night side. It turns on again when the satellite reaches the earth's sunlit side. AVCS pictures are stored on magnetic tape for transmission on command to ground stations.

Plans call fo the AVCS cameras to be installed in the TIROS Operational Satellites (TOS). In TOS, however, a single camera is used for taking pictures instead of three cameras operating together.



Nimbus photograph of Nile River (at left) during flood. Sinai Peninsula is at extreme right.

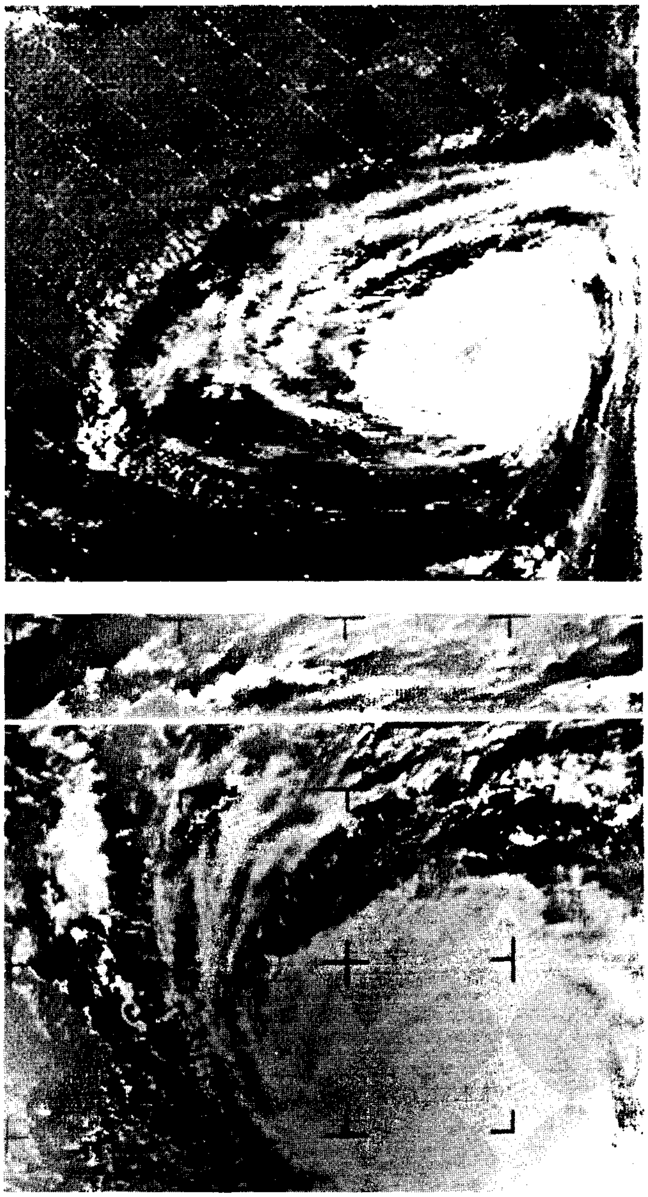
ADDITIONAL EXPERIENCE PROVIDED APT USERS

Nimbus provides valuable additional experience to ground weather services that use the Automatic Picture Transmission (APT) system. APT was first flown on TIROS VIII, launched December 21, 1963.

APT telecasts can be picked up by relatively simple ground equipment costing about $30,000. As flown on Nimbus, the APT system can provide local meteorologists with pictures of the weather over an area of more than 750,000 square miles, extending more than 825 miles in every direction from their stations. It can send each local station as many as 15 pictures daily.

Like the AVCS, the APT system operates only in daylight. The APT system does not store pictures for later transmission but starts sending them within 8 seconds after taking them. It takes 200 seconds to transmit a single picture (see below).

The APT camera resembles that of the AVCS except that a polystyrene plastic layer is provided to extend the time that its vidicon tube can retain the image. This image is scanned by an electron beam in the compartively slow time of about 200 seconds as compared to 6½ seconds in the AVCS.

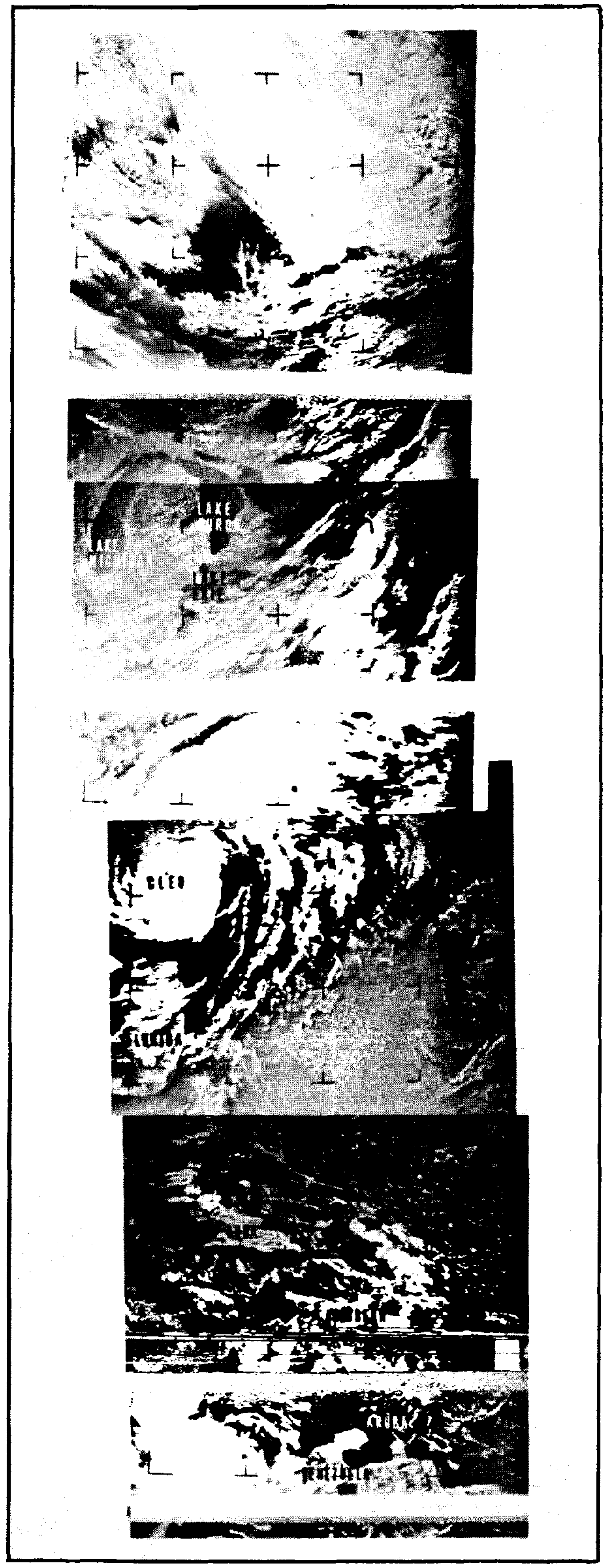


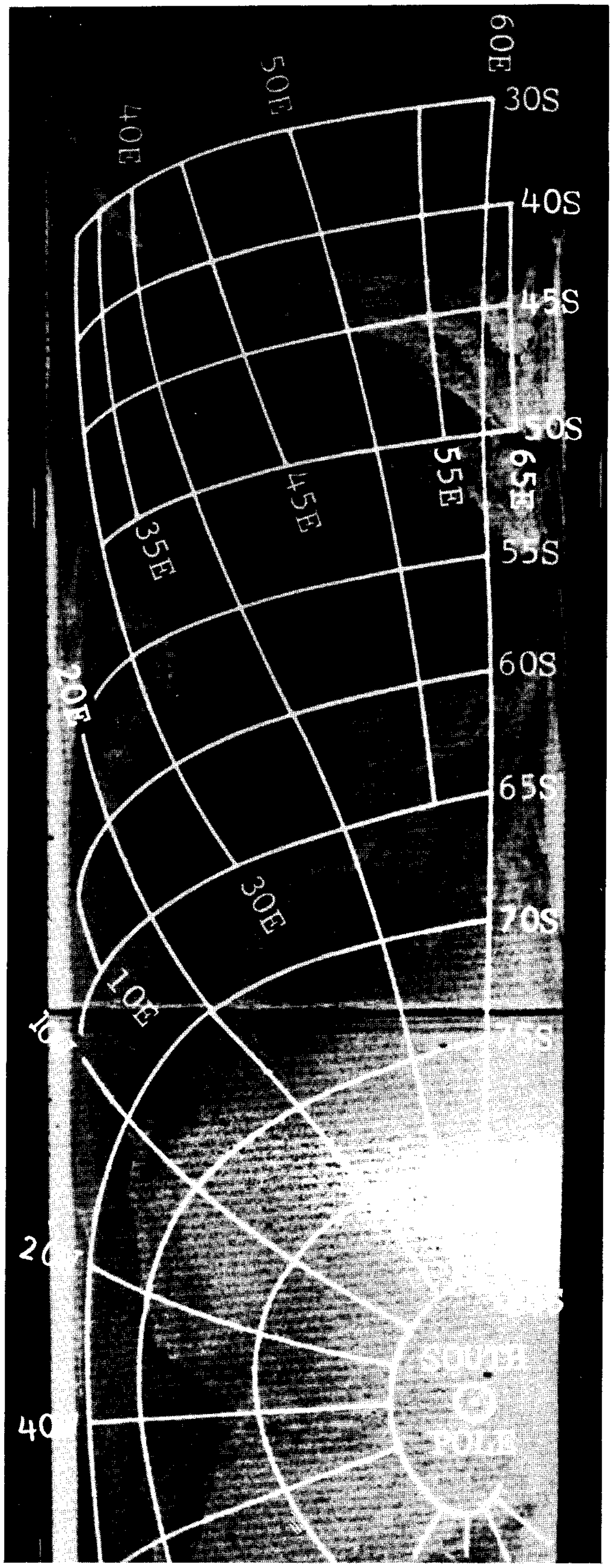
Hurricane Dora, which devastated Florida and Georgia in 1964, is pictured by infrared at night (top) and in daytime picture by Automatic Picture Transmission (bottom). Nimbus pictures have made significant contributions to studying and tracking hurricanes such as Dora.

The electron beam converts the image into an electrical signal that is radioed to earth.

This slow-scan feature permits the use of the relatively simple and low-cost equipment in the APT ground station. Since data are being transmitted at a slower rate, they can be sent on radio beams of narrower bandwidth. The bandwidth on which the APT system transmits is much narrower even than that of signals sent to home television sets.

Composite of four photographs transmitted by the Nimbus I Automatic Picture Transmission (APT) system on August 29, 1964, covers an area from Canada to South America.





Strip of pictures made from Nimbus infrared data shows clouds (gray) over the South Indian Ocean (black) and the icy Antarctic continent (bright mass at bottom). Locational markings were overprinted at ground station.

MAPPING THE WEATHER

One of the most significant advances in meteorology was the development of the weather map pioneered by Heinrich Wilhelm Brandes in 1820. Brandes compiled observations made in Europe on March 6, 1783.

This map and further study showed that local storms were frequently parts of great systems covering large areas. They also indicated that storms usually followed the same paths. Thus, knowledge of the existence of a storm, and the paths storms generally took, could contribute to weather forecasting.

In time, meteorologists realized that weather is global in nature and world-wide data are needed to make accurate local forecasts. Toward this end, a vast network of weather observation stations was set up around the globe, and arrangements were made for rapid exchange of information.

Until relatively recent years, weather forecasters were hampered by serious blind spots in their observation system. For example, many severe storms originate over areas of ocean, desert, polar, and equatorial regions where there are no regular reporting stations.

The launch of TIROS I on April 1, 1960, marked a major breakthrough in weather surveillance. Since that date, the global observations made by TIROS satellites have been incorporated in operational weather forecasts.

The Nimbus I satellite, a research vehicle, represents another significant advance in the technology of weather observation by satellite. Among its other achievements, Nimbus I demonstrated the feasibility of a 24-hour-a-day global weather watch by satellite.

SPACECRAFT DESCRIPTION

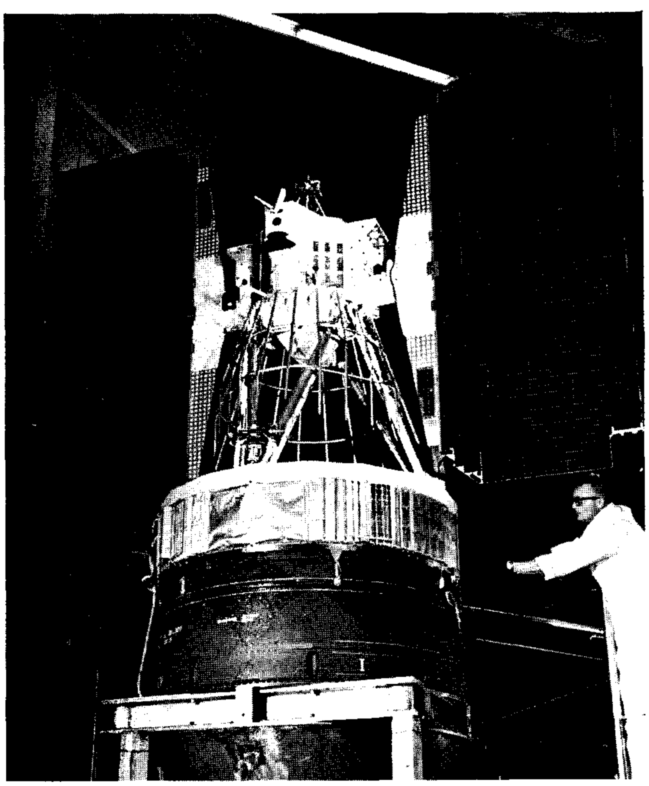
The Nimbus I satellite, which weighs 830 pounds, extends 12 feet from its circular base to the tip of its command antenna. It has a span of 11⅙ feet across its two solar paddles. The main spacecraft body measures 4¾ feet in diameter at the base and 10 feet tall.

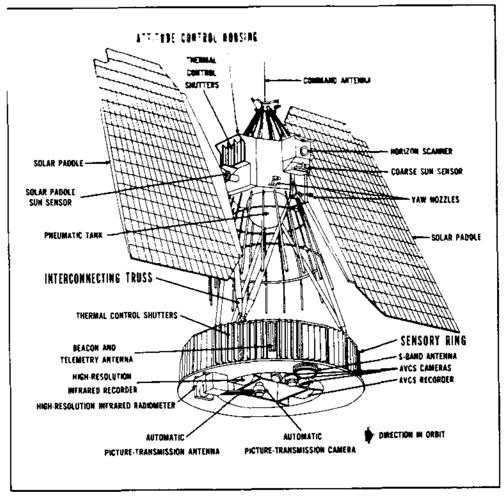
The command antenna receives orders from ground stations for the satellite to transmit data. The solar paddles hold 10,500 solar cells which are photoelectric devices that convert sunlight to electricity. The paddles provide 450 watts of power for spacecraft operation and recharge seven storage batteries which furnish electricity when the satellite is not in sunlight. The batteries also power Nimbus from launch until the solar paddles unfold in orbit and begin to function.

Nimbus is made up of three main sections. One is a sensory ring containing the AVC, HRIR, and APT Systems described earlier, also the storage batteries, tracking beacons, and the telemetry equipment which reports on the spacecraft's condition. A connecting structure, called an "interconnecting truss," joins the sensory ring to a hexagonal "attitude control housing." The housing contains the equipment that orients and stabilizes the satellite so that its cameras and infrared radiometer point constantly at earth and swivels the solar paddles so that they always face the sun. The system, called one of the most complex ever built, consists of some 5600 electronic and 150 mechanical parts.

Because space has no atmosphere to diffuse and retain heat, spacecraft are subject to sharp temperature changes. Temperatures on a spacecraft's outside surface may reach 260 degrees Fahrenheit in the sun and drop to 240 degrees below zero Fahrenheit in the shade. The interior temperature of the sensory and attitude control sections is kept within a range of 10 degrees above or below 25 degrees Centigrade (77 degrees Fahrenheit).

Technicians work on Nimbus.





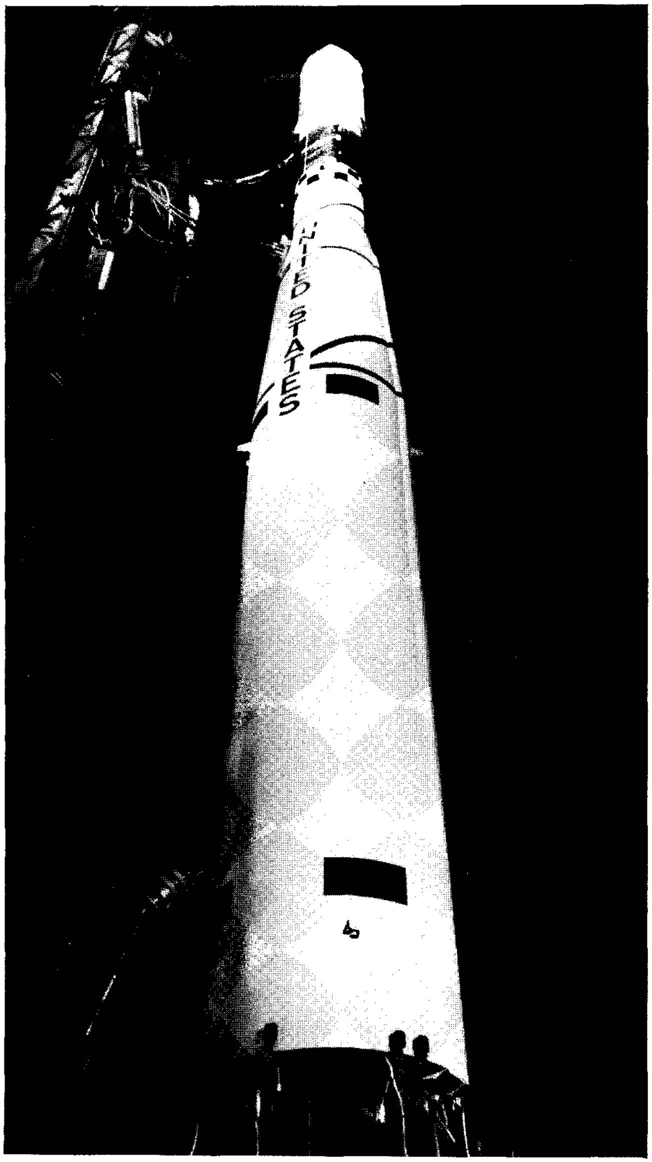
Principal equipment of Nimbus.

ORBITAL INFORMATION

Nimbus satellites are designed to be launched into nearly circular polar (traveling north and south) orbits about 575 miles above earth. A polar-orbiting satellite provides north to south, or latitudinal, coverage by its flight path. It provides east-west, or longitudinal, coverage because of the earth's rotation.

Nimbus I, launched from the Western Test Range, Point Arguello, Calif., attained an initial orbit ranging from 252 to 578 miles above earth. Its period was 98.3 minutes; i.e., it completed an orbit every 98.3 minutes. Its elliptical, instead of a planned circular orbit, was caused when the second stage of its Thor-Agena launch vehicle ceased firing prematurely. Despite the unplanned orbit, the satellite's camera and radiometer systems sent thousands of high quality pictures of the earth and cloud patterns.

Nimbus I stopped operating on September 23, 1964, when its solar paddles locked into one position. Unable to swivel and follow the sun, the solar paddles could not provide the electrical power needed to keep the spacecraft functioning.



Thor-Agena launch vehicle with Nimbus payload awaits launch.

GROUND FACILITIES

Several kinds of ground stations constitute the surface facilities taking part in the Nimbus experiment. The Nimbus Technical Control Center, located at NASA's Goddard Space Flight Center in Greenbelt, Md., evaluates the spacecraft's performance and determines commands to be sent it.

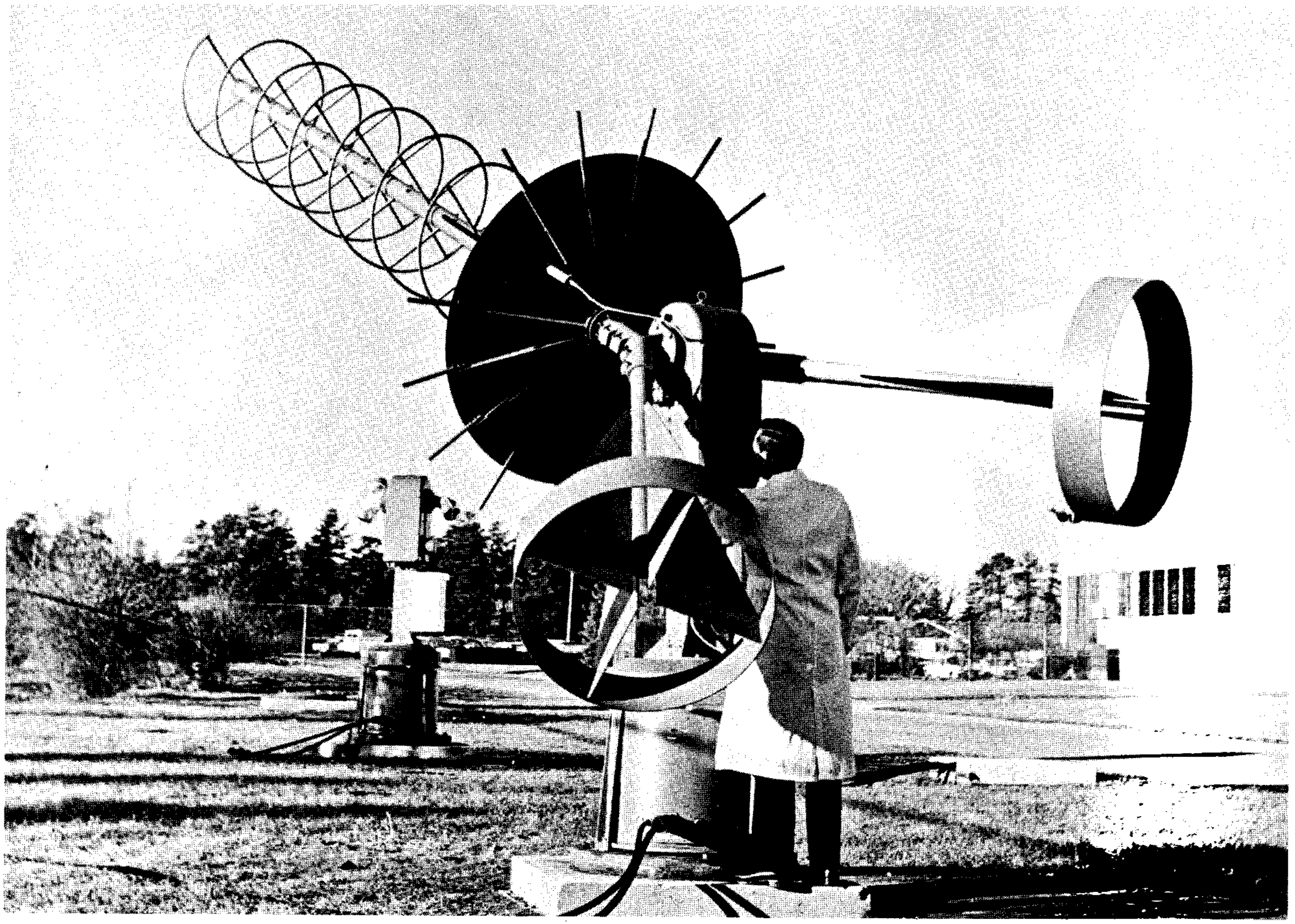
The commands are radioed to Nimbus by either of two Command and Data Acquisition Stations located at Rosman, N.C., and Gilmore Creek (near Fairbanks), Alaska. The 85-foot diameter antennas of these stations also pick up data radioed from the camera and radiometer systems of Nimbus. The information is fed to and processed by Nimbus Data Handling Facilities at Gilmore Creek and Goddard.

The Data Handling Facilities record the camera and infrared data on magnetic tape similar to that used to record live television shows for presentation at later dates. The camera data are also fed to kinescopes (small television sets) which turn them into pictures that are photographed on 70 mm. film. The infrared data are channeled to facsimile recorders that convert them into strips of pictures.

NASA's global Satellite Tracking and Data Acquisition Network tracks Nimbus and provides orbital predictions. This information is funneled to the Nimbus Technical Control Center and processed by the Nimbus Data Handling Facilities at Goddard.

About 60 Automatic Picture Transmission (APT) stations set up by government and commercial organizations in this country and abroad participated in the Nimbus I experiment. The principal equipment of an APT station is a manually-operated radio receiving antenna, a com-

85-foot diameter antenna at Gilmore Creek, Alaska.



APT antenna.

mercially available radio receiver, and a facsimile recorder comparable to those that make the wirephotos appearing in daily newspapers.

Goddard supplies each APT station with information about Nimbus' orbit and when and where to aim its antenna to receive the APT picture. As an additional aid, Nimbus transmits a radio signal to alert the stations to its approach.

The National Weather Satellite Center, U.S. Weather Bureau, receives Nimbus data from the Nimbus Technical Control Center. The Weather Satellite Center analyzes the data and disseminates information derived from it to weather services in the United States and abroad. The Weather Satellite Center also archives the data used in meteorological operations.

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