18. SPACE PHOTOGRAPHY

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Introduction

The 10 manned Gemini flights produced a series of color photographs which are both striking in beauty and of immense scientific and academic value. Over 2400 photographs were secured and have demonstrated the value of space photography in such fields as geology, geography, oceanography, agriculture, hydrology, urban planning, environmental pollution control, meteorology, land management, cartography, and aerospace engineering. A representative selection of photographs from the various missions, as well as a short description of the informational content, are presented in this paper.

Camera Equipment

Figure 18–1 shows a selection of camera equipment used during the Gemini Program. The majority of the photographs were obtained with the NASA-modified 70-mm Hasselblad Camera, Model 500–C; both the 80-mm Zeiss Planar and 250-mm Zeiss Sonnar lenses were used. The Super Wide-Angle 70-mm Hasselblad Camera, Model SWA, was used on the Gemini IX–A through XII missions. Although designed primarily as an extravehicular activity device, the Model SWA camera recorded some of the most spectacular terrain photography of the program. The 70-mm Maurer Space Camera was also carried on Gemini IX–A through XII and permitted a unique versatility resulting from rapid interchangeability of components. The gray 80-mm Xenotar lens and magazine (50-frame capacity) secured conventional color photographs. The red f/0.95 Canon lens and magazine permitted scientific photography of very low light-level phenomena such as horizon airglow and libration regions. The blue lens, prism, grating, and magazine system were designed to work in the ultraviolet regions, primarily to record stellar spectrographs. Motion-picture equipment manufactured by J. A. Maurer, Inc., is also pictured. The 70-mm magazine especially built by Cine Mechanics, Inc., allow the Hasselblad systems to secure 65 frames instead of the conventional 12. A second-generation Cine Mechanics magazine with a capacity of about 160 frames was used on Gemini XII.

Table 18–I indicates the various 70-mm films carried on Gemini flights. The thickness of the film varied from about 0.007 inch to 0.0025 inch. Most of the film had emulsion coatings and bases especially formulated to NASA specifications. Figure 18–2 shows the machine manufactured by Hi-Speed, Inc., to process the Ektachrome film. Great care was used in processing the Gemini flight film. Prior to processing the film, the machine was thoroughly cleaned and then checked for precise sensitivity control; this included checks of the various photographic processing chemicals, exact temperatures, cycle durations, and chemical replenishments. The flight films were sent through the processor singly; this required a considerable amount of time but allowed very close surveillance. No flight film was lost due to laboratory malfunctions.

Selected Photographs

The following representative photographs constitute about 2 percent of the total photographs secured during the Gemini Program, and contain information of value in

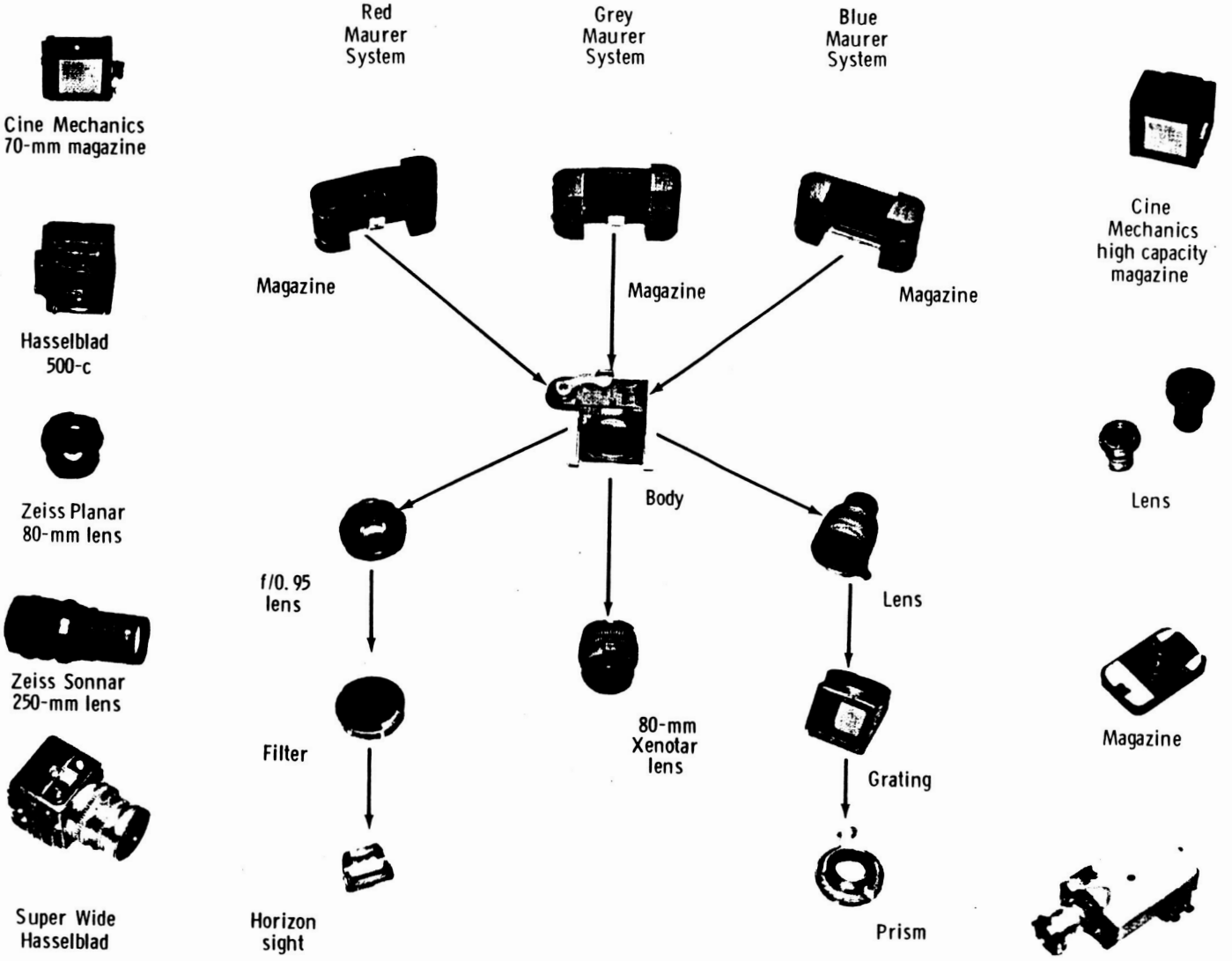

FIGURE 18–1.—Gemini camera equipment.

the various geoscientific or aerospace fields. The serious geoscientist would have to examine the entire collection in order to determine the total value to his field of interest.

TABLE 18–I.—*Gemini 70-mm Film*

Name	Type	Mission
S.O. 217	Ektachrome transparency	III, IV, V, VI–A, VII, VIII, IX–A, X
S.O. 368	Ektachrome transparency (improved)	XI, XII
D–50	Anscochrome transparency	V
8443	Ektachrome, infrared	VII
S.O. 166 (0–85)	Ultrahigh speed (ASA = 6000)	XI, XII
3400	Pan-Atomic X (ASA = 80)	VII
2475	High-speed (ASA = 1200)	VI–A, VII
103–D	Spectrographic (4500 Å–6100 Å)	IX–A, XI
I–0	Spectrographic (2500 Å–5000 Å)	X, XI, XII

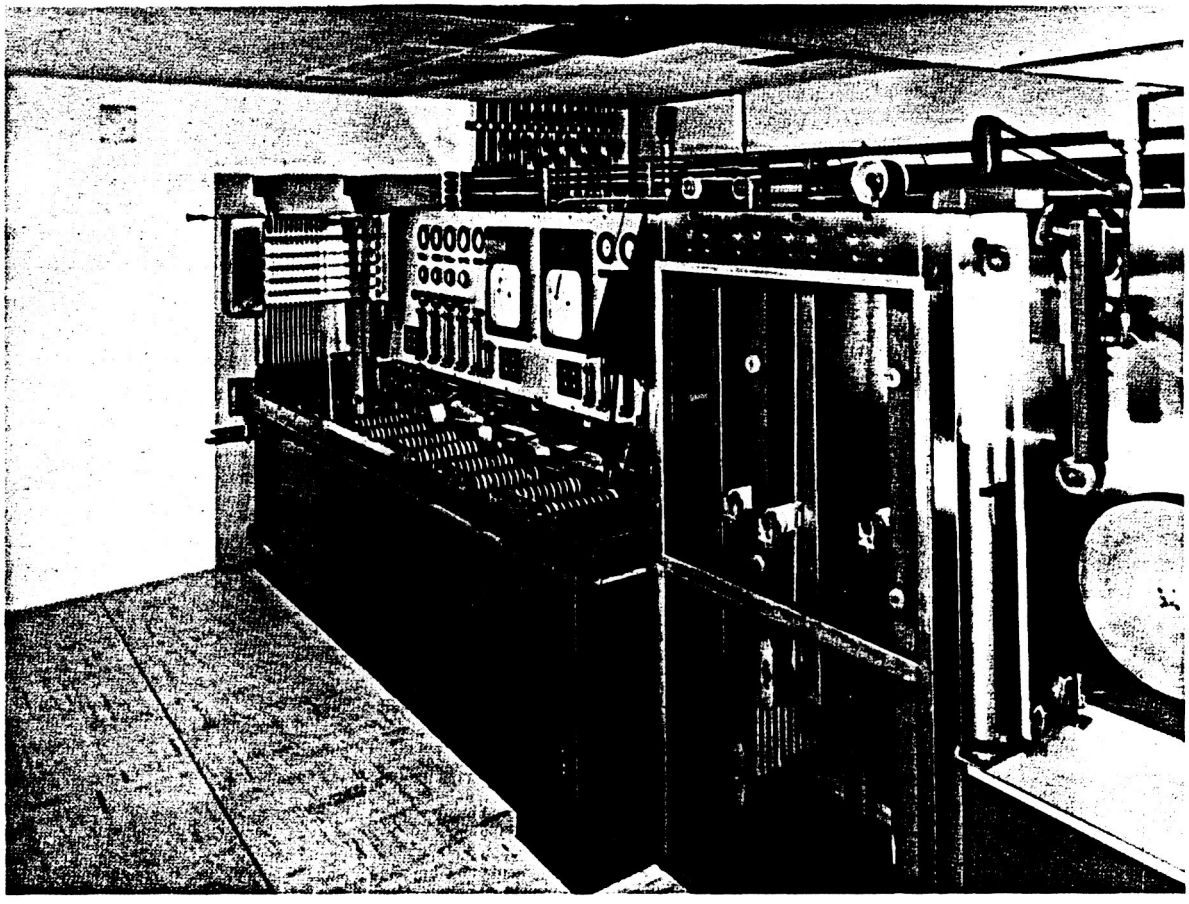

FIGURE 18–2.—Film processor.

Synoptic Terrain Photography

Figure 18–3 was taken from an altitude of 110 miles during the Gemini IV mission and has become a classic for obvious reasons. The Nile Delta is clearly visible, as well as the Sinai Peninsula, the Dead Sea, and the entire Suez Canal connecting the Red and Mediterranean Seas. The horizon is about 800 miles to the east, across Iraq and Saudi Arabia. The photograph shows both branches of the Nile River (Rosetta and Damietta) from Cairo, across the fertile and densely populated delta, to the Mediterranean Sea. Note the sharp contrast between the irrigated delta lands and the great deserts of Africa and Asia.

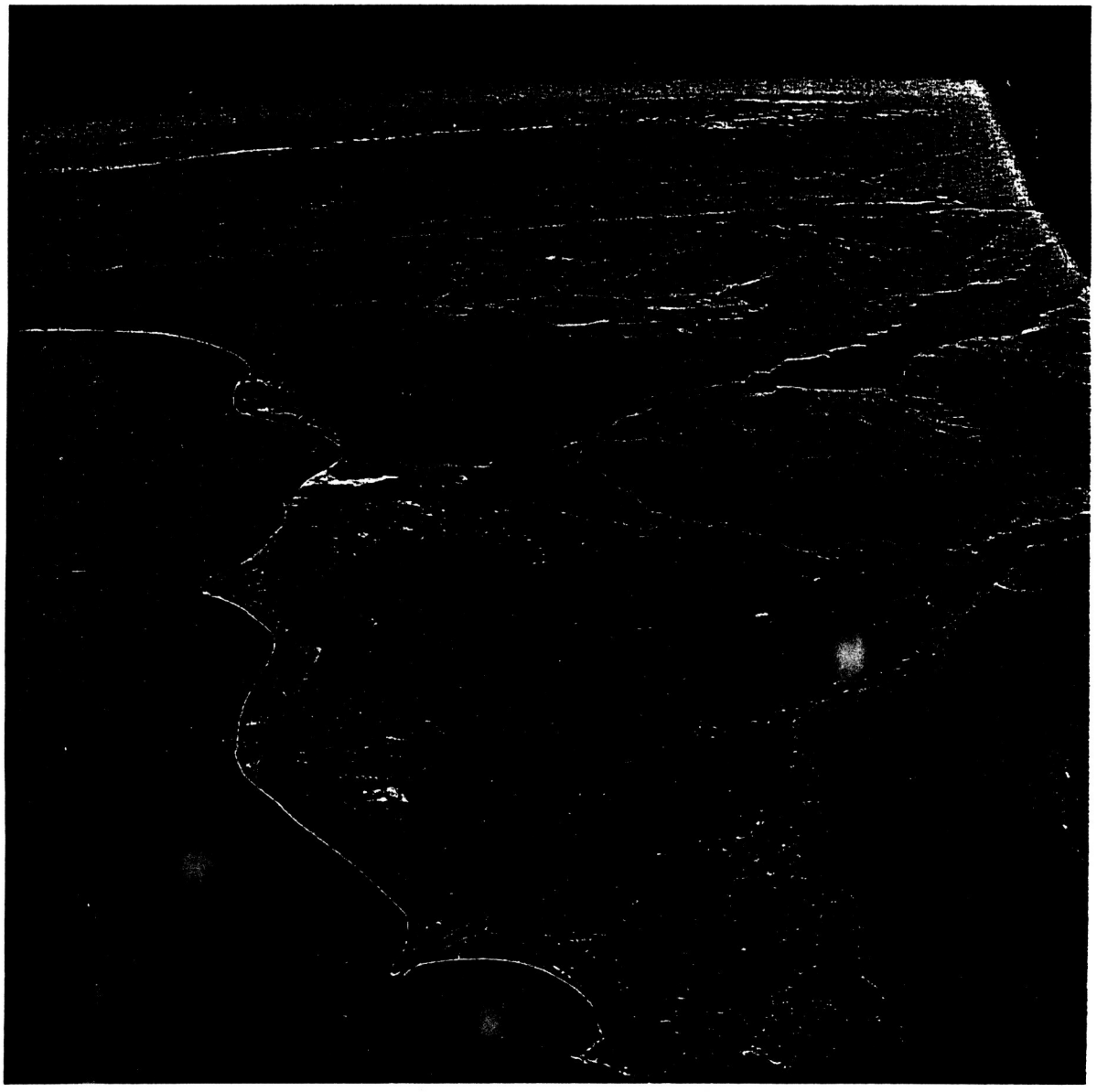

FIGURE 18–3.—Nile Delta.

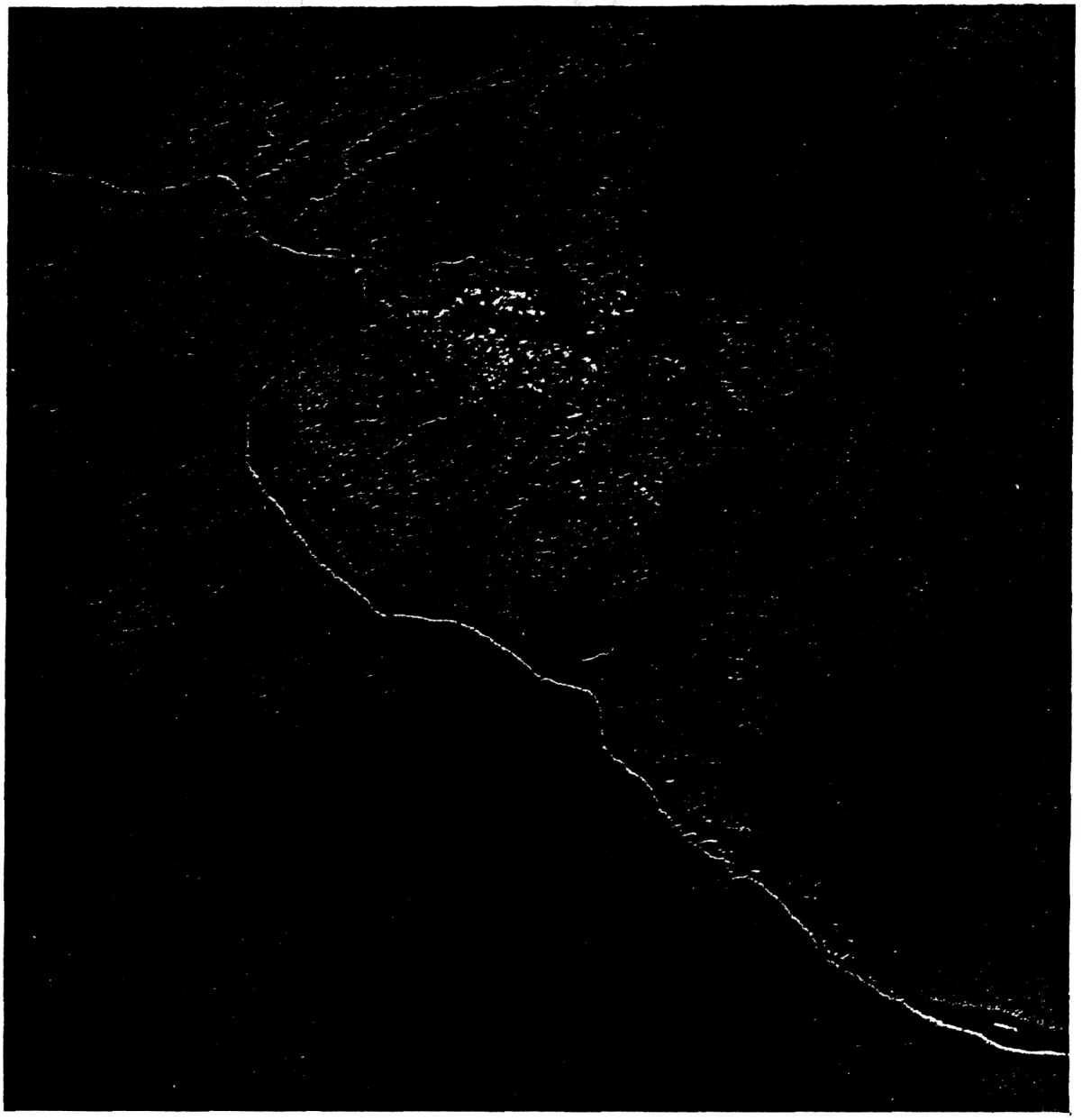

FIGURE 18–4.—Nile River.

Figure 18–4 shows how the geology controls the course of the Nile River for some 200 miles in Sudan and the United Arab Republic. The river hugs the contact zone between the black basaltic intrusives east of the river and the sedimentary rocks to the west. Much of the area visible in this Gemini IV photograph will be inundated when the Aswan Dam is completed and the 400-mile-long Lake Nasser is created in the Sahara.

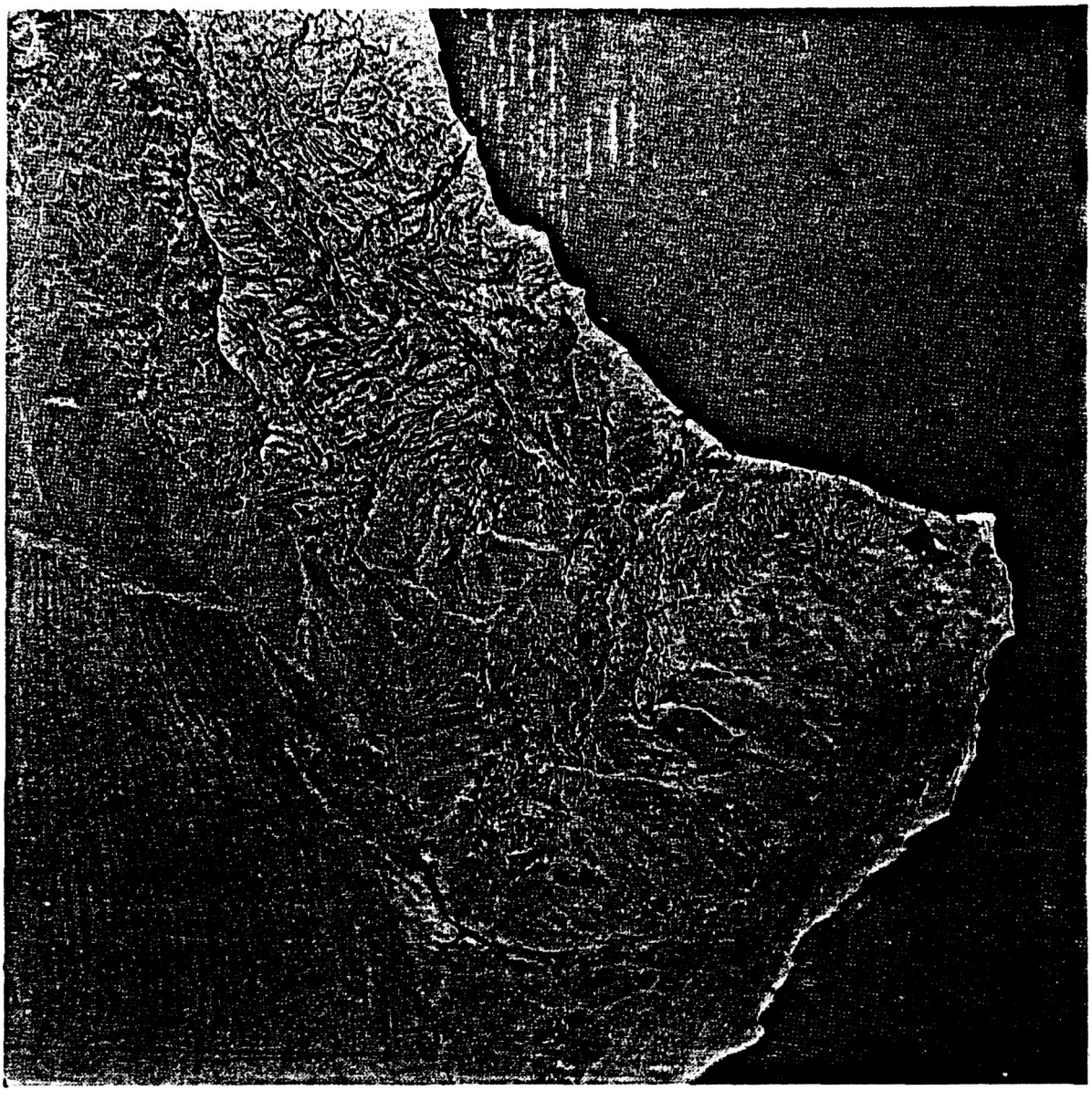

FIGURE 18–5.—Ras Al Hadd.

Figure 18–5 was taken during Gemini IV from an altitude of 120 miles. The Ras Al Hadd area of Muscat and Oman appears in fine detail; airport runways can also be seen at the point. Several oases are perceptible at the base of the pediment where ground water reaches the surface. Long seif dunes at the eastern extremities of the Rub Al Kahli (Empty Quarter) are visible and provide information of meteorologic value.

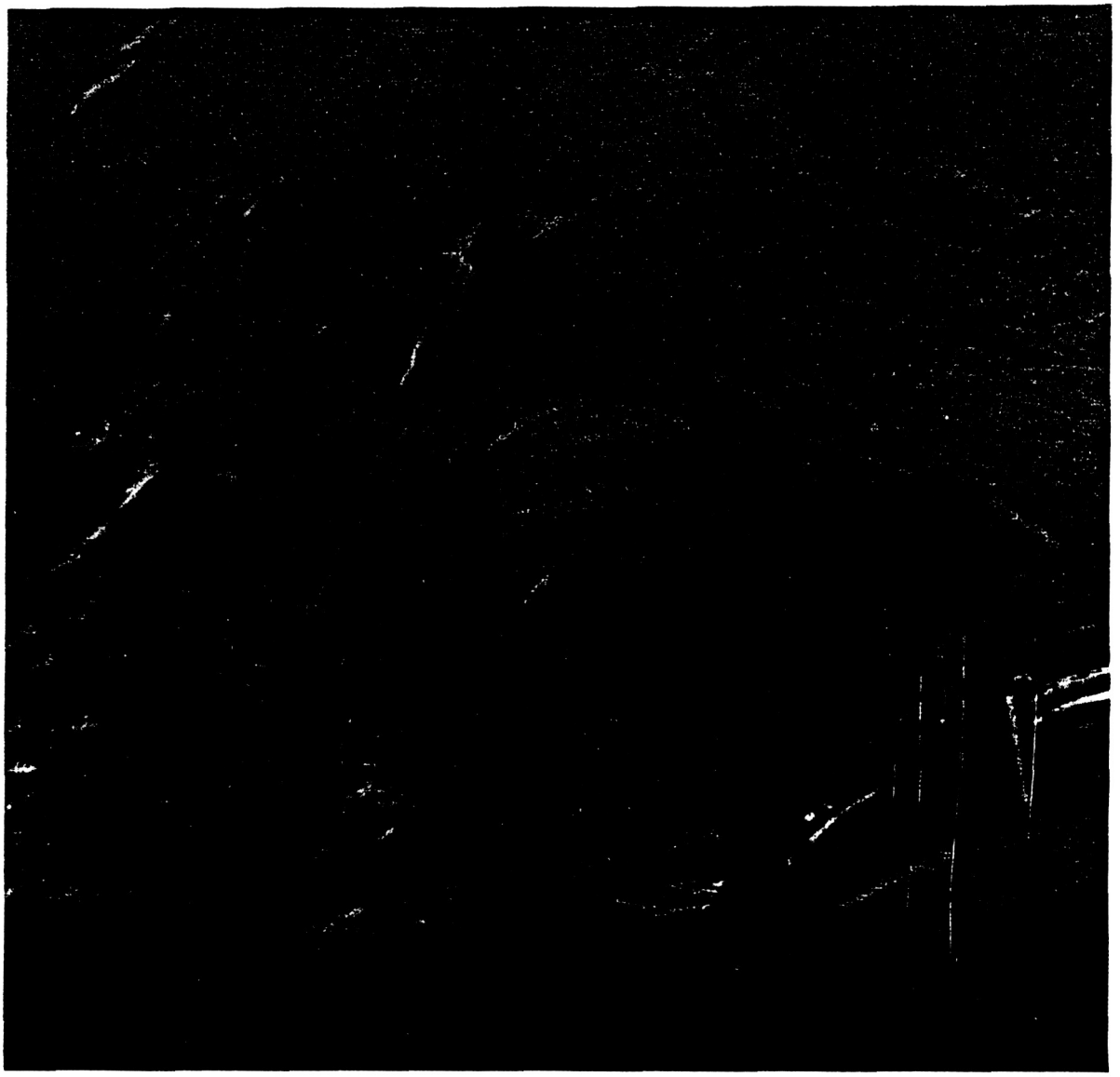

FIGURE 18–6.—Richat structure.

A view of large geologic structures can be captured in a single photograph such as figure 18–6 which shows Mauritania's Richat structure in excellent detail. The structure was possibly formed by a large meteorite-type impact, or possibly from the erosion of a volcanic plug or intrusion. This Gemini IV photograph has regenerated scientific interest in the structure in relation to the geology of the entire area.

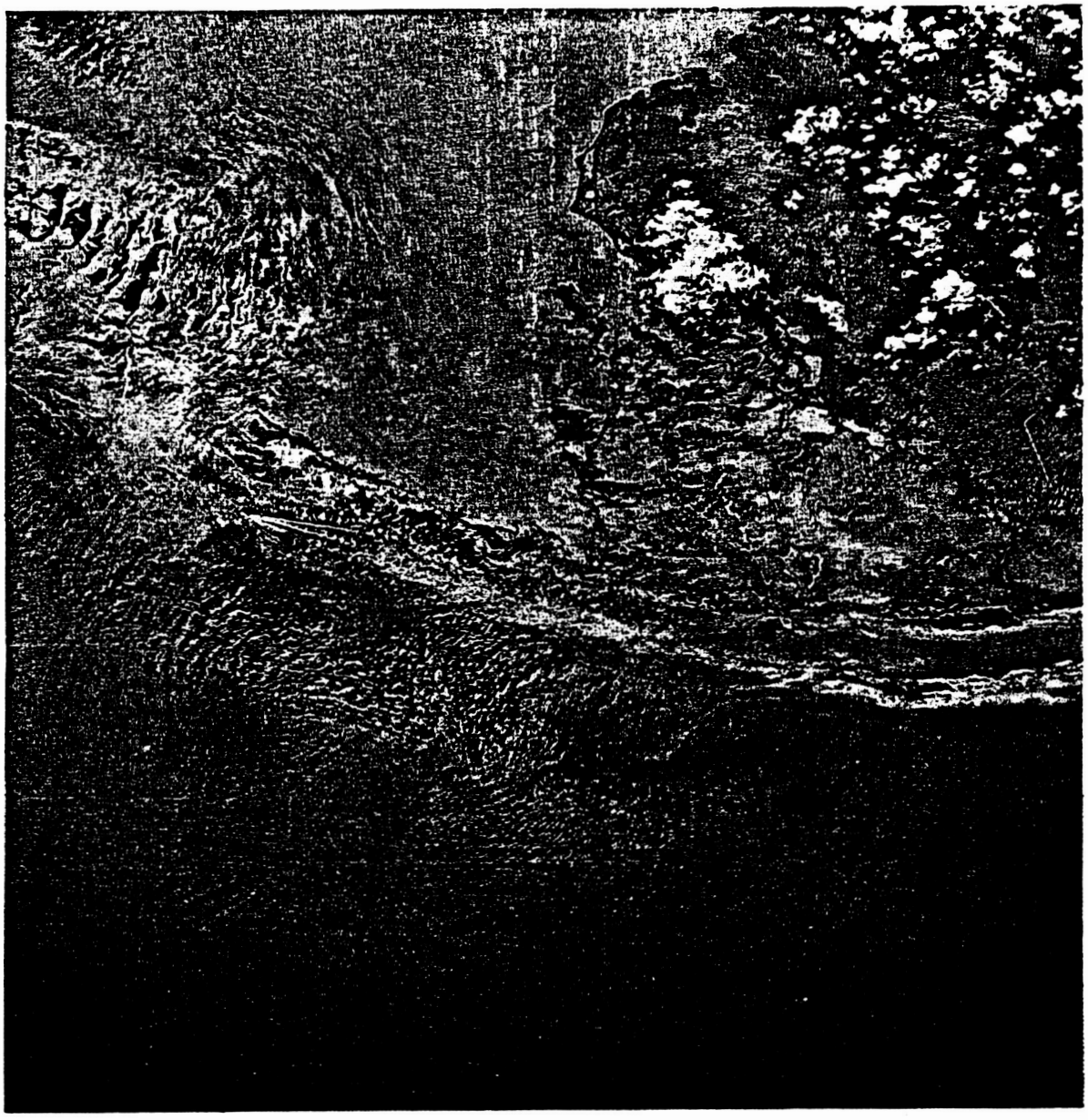

FIGURE 18-7.—Florida Keys.

In figure 18–7, the Florida Keys are dramatically visible from the Gemini IV spacecraft at an altitude of 115 miles. The entire chain from Key Largo to Boca Chica Key is visible, thereby providing a regional study from a single photograph. The Overseas Highway, which is never more than 30 feet wide, can be clearly seen. Many boat wakes in the Florida Strait are emphasized in the solar highlight. A large portion of the Everglades is visible in the upper right. On the underwater reefs visible at the right, Florida has established the John Pennekamp State Park to preserve the ecology of the area.

FIGURE 18–8.—Mouth of Colorado River.

Figure 18–8 was photographed during the Gemini IV mission, and shows quite clearly the mouth of the 1500-mile-long Colorado River and the related geology. The photograph, one of 39 made in a 4-minute rapid sequence between Baja California and central Texas, was taken from an altitude of 110 miles. The Mexican States of Baja California to the west and Sonora to the east, as well as the Gulfo de California, constitute the extent of the photograph. A white streak to the right of the river is the saltpan bed of the old river channel before upstream irrigation removed most of the water volume. A straight line just to the right (east) of the old channel is a portion of the San Andreas fault system. The distinct change in topography and in geologic structure is most evident, and was caused by the linear horizontal movement of the fault during the geologic past. To the right of the San Andreas fault are the sands of the Great Sonora Desert. The line of contact between the delta sediments brought down the river and the block-fault mountains and pediments of Baja California appears near the left (west) edge of the photograph. Suspended sediments carried down the river are clearly visible around the mouth.

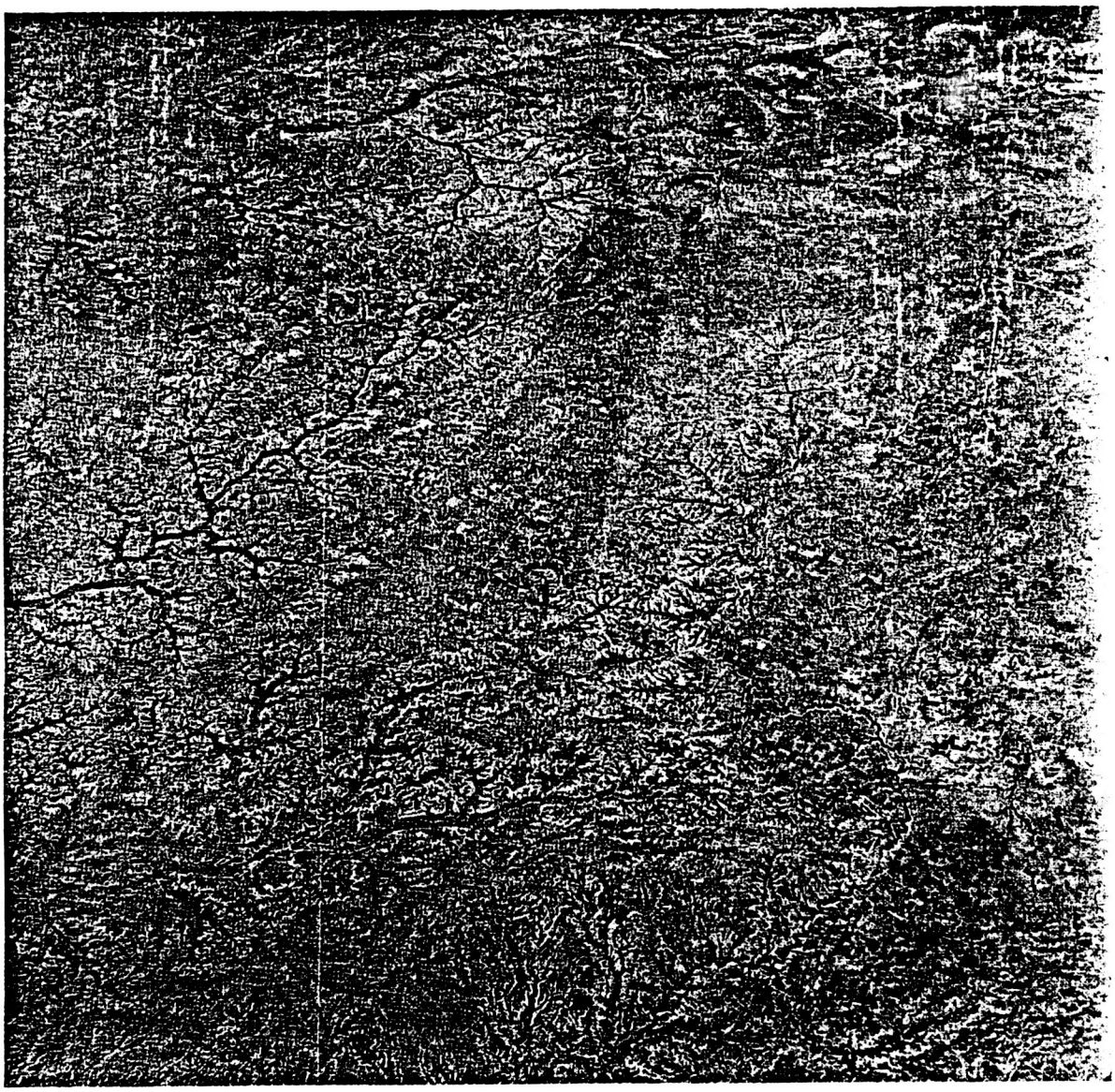

FIGURE 18–9.—West Texas.

Figure 18–9 is a portion of the Edwards Plateau area of Texas photographed during the Gemini IV mission. The view is to the west and shows the cities of Odessa, Midland, and Big Spring along the right edge. The unique darker areas in the left and lower left show the effect of a rain storm the previous evening, and how quickly vegetation demonstrates growth in a semiarid area. The dendritic drainage of the upper Concho system is quite evident due to the lush vegetation along these streams.

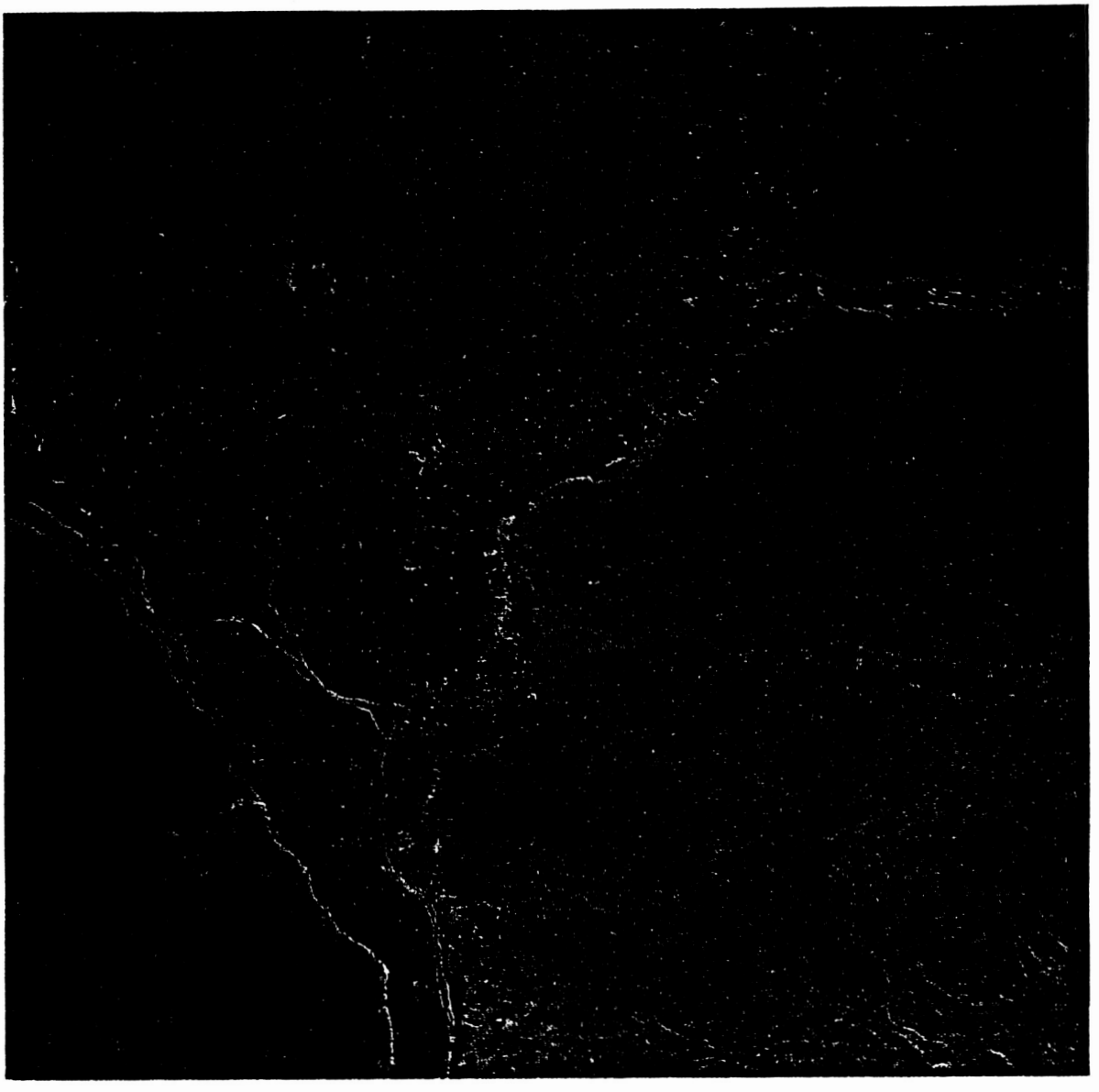

FIGURE 18–10.—Nile Delta.

Figure 18–10, showing a major portion of the Nile Delta, was taken during Gemini V from an altitude of 100 miles. With the 30 million people in the delta area and a high population growth rate, rapid regional information changes are most important. The photograph shows Cairo with a population of over 5 million; the distribution of cities and towns in the delta; and the networks of roads, railroads, and canals.

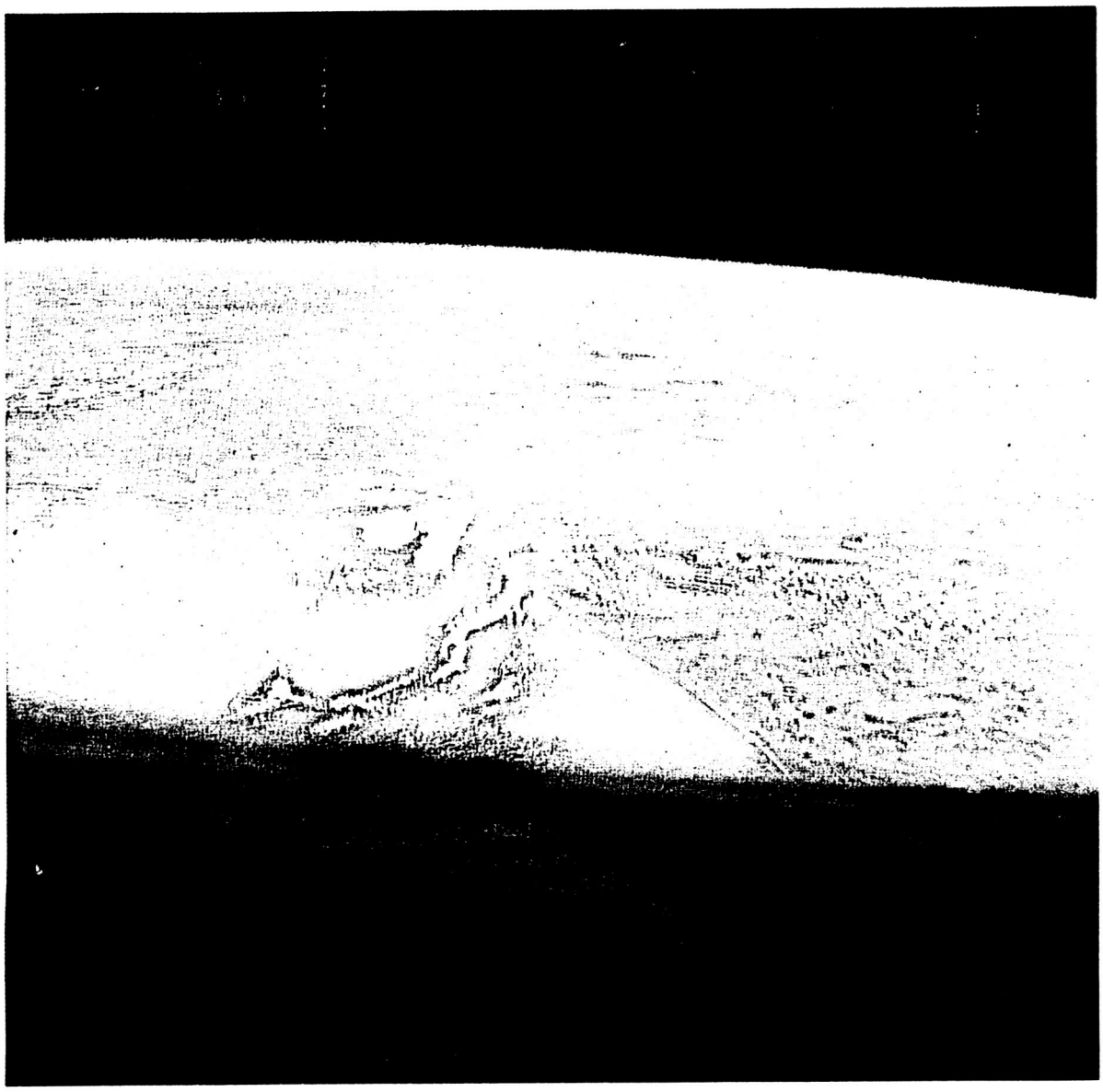

FIGURE 18–11.—Strait of Gibraltar.

Figure 18–11, photographed by the Gemini V crew, is a classic astronaut view of the Earth. The Strait of Gibraltar and the continents of Europe and Africa are pictured. The valley of the Guadalquivir River and the Sierra Morena in Spain, as well as Point Europa (Rock of Gibraltar), are clearly visible in the upper left. To the right are Morocco and Algeria. Unique cloud formations are visible on the Atlantic side of the strait.

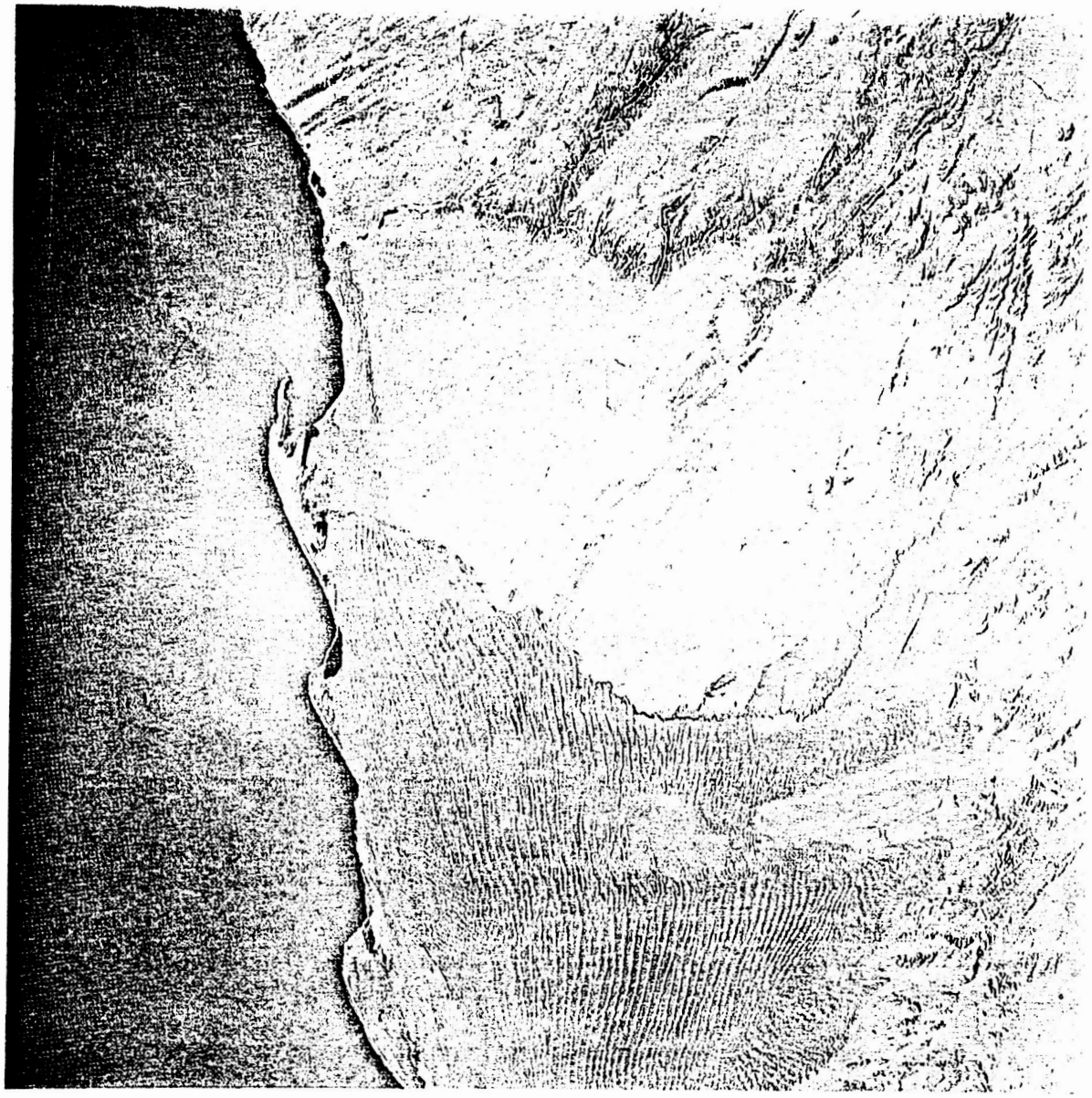

FIGURE 18–12.—Southwest Africa.

A Gemini V photograph (fig. 18–12), taken from an altitude of 200 miles, clearly demonstrates the forces of wind and sea in the Namib Desert of Southwest Africa. This is one of the driest areas of the world, and the sole productivity is diamonds buried in the sands. The seif-type dunes extend over 100 miles across the southern part of the area. As the prevailing winds carry the sand into the Atlantic Ocean, the strong Benguela Current causes the northward waterborne migration of the sands and the formation of the three very large sand hooks. The northernmost hook is 50 miles long, and the port of Walvis Bay is located on the lee side. The area is known as the Skeleton Coast, a name that goes back nearly 500 years when early navigators in galleons attempted to use this route from Western Europe to Asia. In order to reprovision, they had to fight strong northward currents and prevailing winds from the mouth of the Congo River to the Cape of Good Hope in ships which sailed poorly to windward. Failure to reach their destination was disastrous for ship and crew. Navigators such as Columbus believed that the riches of Asia could be obtained with less hardship by sailing westward across the Atlantic.

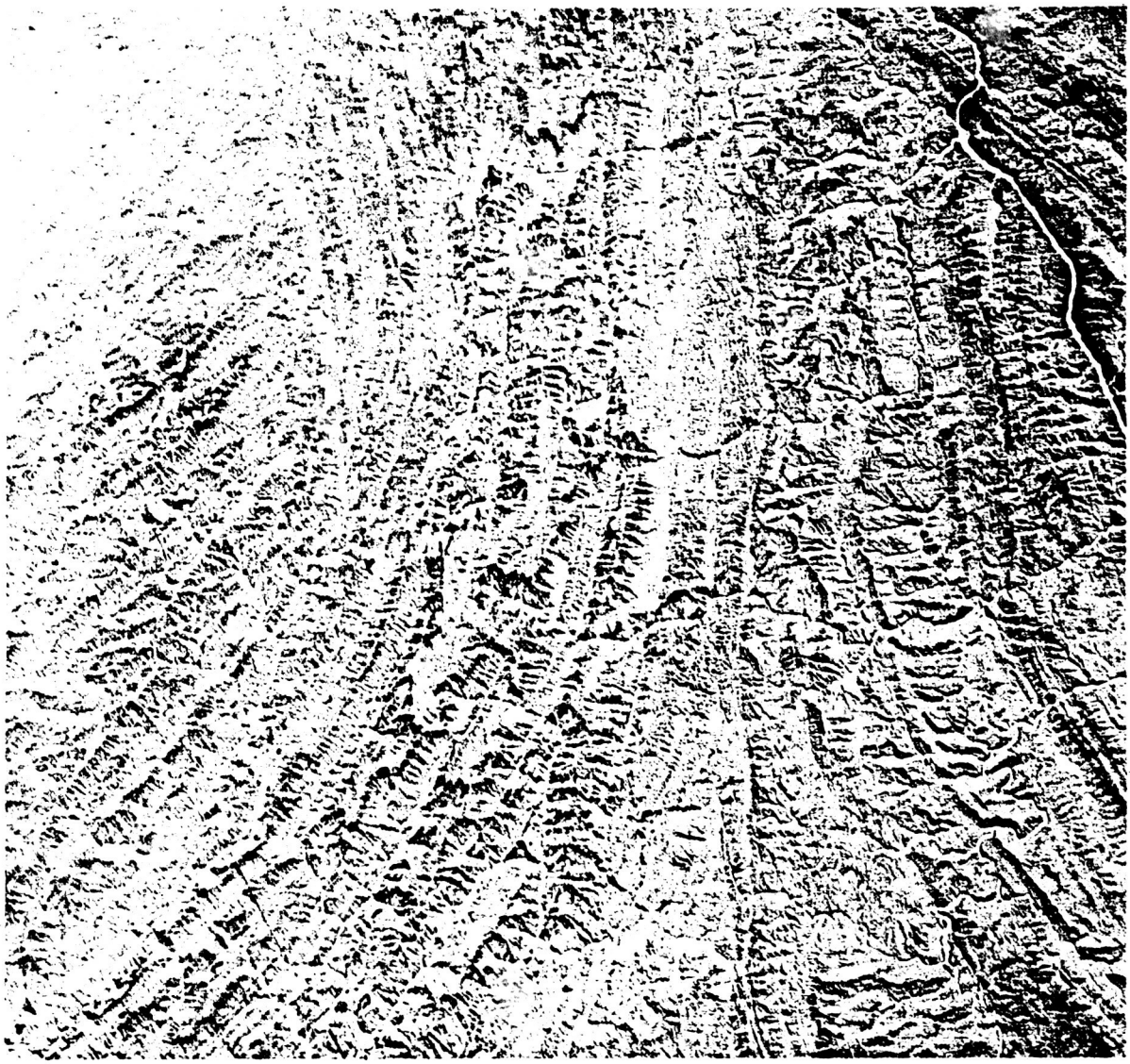

FIGURE 18–13.—China basins.

The line of intersection of two large basins located in Szechwan Province, China, is visible in figure 18–13. The photograph was taken during the Gemini V mission and shows the Yangtze River along the right edge. The long folded sedimentary ridges with intermediate softer beds control the drainage pattern of the area. The synoptic view from orbital altitudes reveals much information which cannot be discerned from the lower altitudes attained by airplanes.

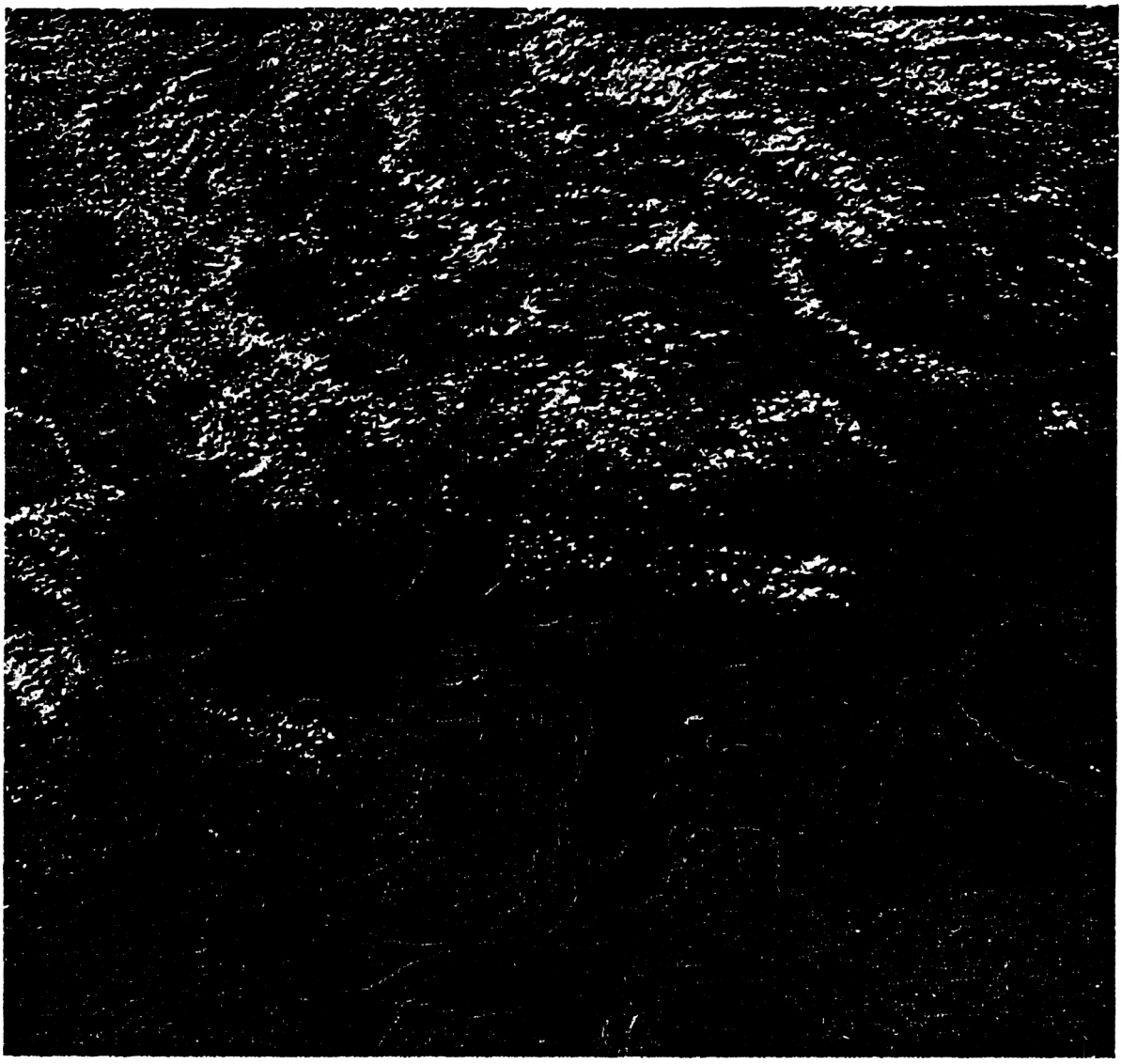

FIGURE 18–14.—Hunan Province, China.

Figure 18–14 was taken during the Gemini V mission, and shows a large natural floodway in Hunan Province, China, with the Yangtze River at left center. The open water of the floodway is Tung 'ting Hu, a lake about 100 miles long. The Hsiang River flows into the lake from the right and the photograph clearly shows the relationship of the floodway system to the surrounding topography.

FIGURE 18–15.—Mount Godwin-Austen (K–2).

The boundaries of China (Sinkiang), India, Pakistan (Kashmir), Afghanistan, and U.S.S.R. (Tadzhik) meet in the Karakoram Range of the Himalayas (fig. 18–15). The mountains are snow covered above 20,000 feet. The world's second highest peak, Mount Godwin-Austen (K–2) with an elevation of 28,250 feet, is near the upper edge of the photograph and the Indus River is located in the lower portion. The upper right shows the basin of the distant Takla Makan Desert. The Gemini V photograph was

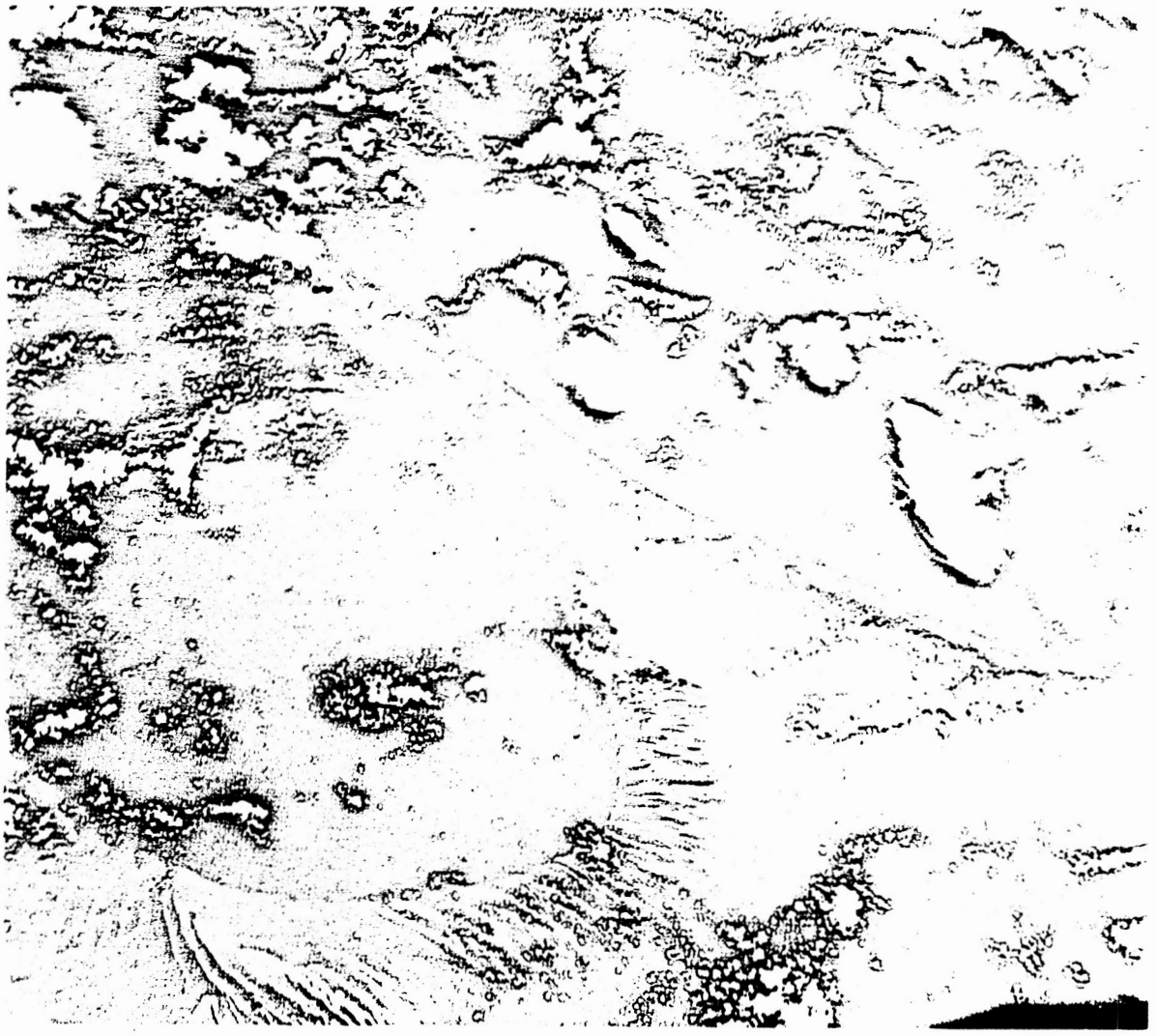

FIGURE 18–16.—Bahama Banks.

taken at the time of minimum snowcover, and indicates that space photography can provide data on the water runoff from snowfields of remote and poorly explored mountain ranges.

Oceanographers are interested in photographs such as figure 18–16, a view of the Great Bahama Bank taken from Gemini V. Except for the small land areas of Great Exuma Island, Cat Island, and Long Island, all the informational content concerns the floor of the ocean. Along the edge of the Tongue of Ocean, which is over a mile deep, the canyons cut in the coral banks are visible. Exuma Sound in the center drops abruptly from rocks awash to a depth of 8000 feet. Space photography for the first time affords an opportunity to photograph large areas of the world's oceans.

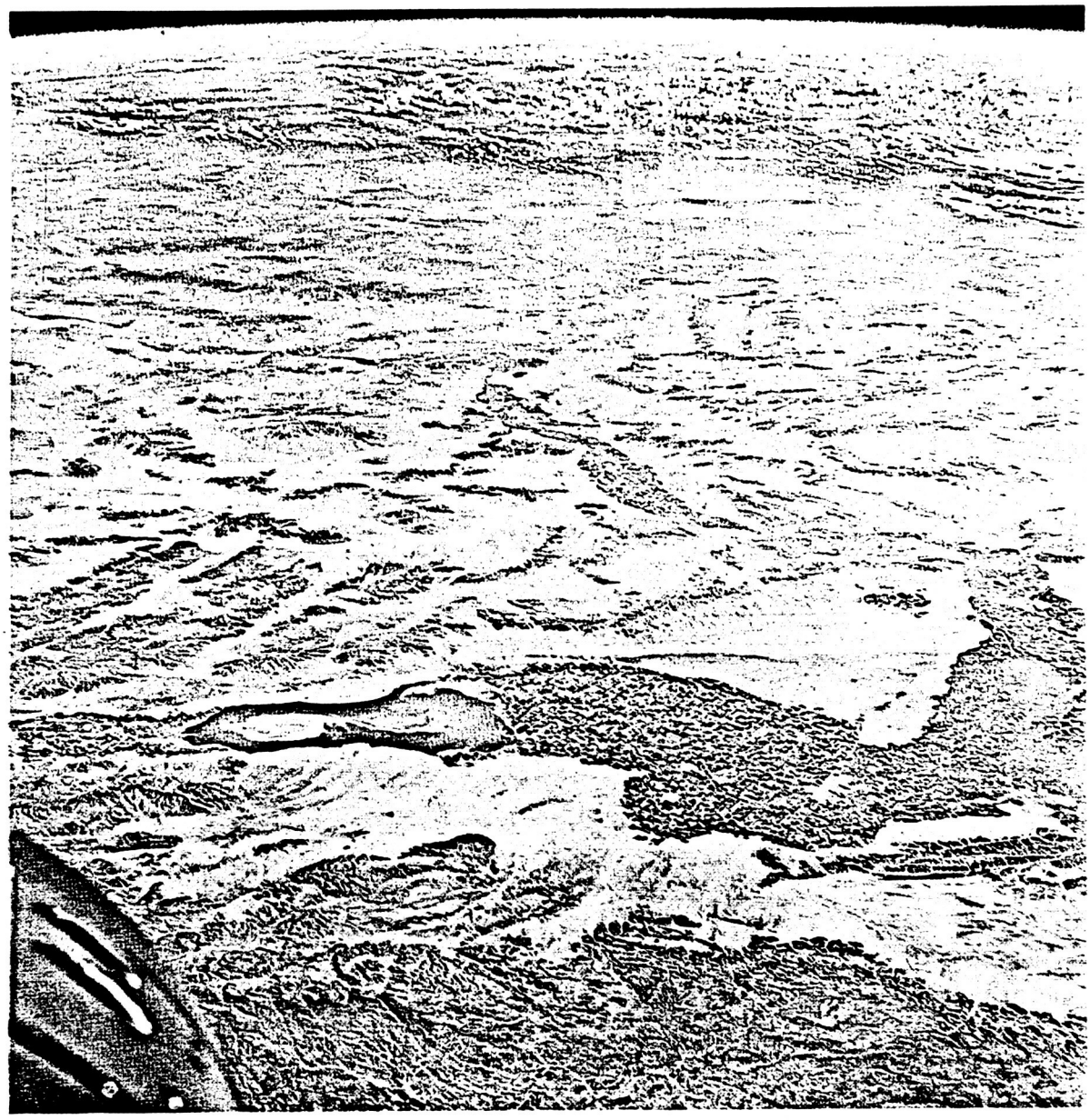

FIGURE 18–17.—Salton Sea.

Figure 18–17, taken by the Gemini V crew, shows the southwestern corner of the United States and portions of Baja California and Sonora in Mexico. The frontier cutting across the Imperial Valley is easily located due to the marked difference in the land division systems. The city of Mexicali on the border and the All-American Canal along the frontier are visible. A unique and unexplained gyre can be seen in the Salton Sea. The overall relationships of the many basins and ranges, which are the predominant geologic features of the area, can easily be studied. The Colorado River is visible from just above the mouth, through the entire Grand Canyon, to beyond Lake Powell in southeast Utah.

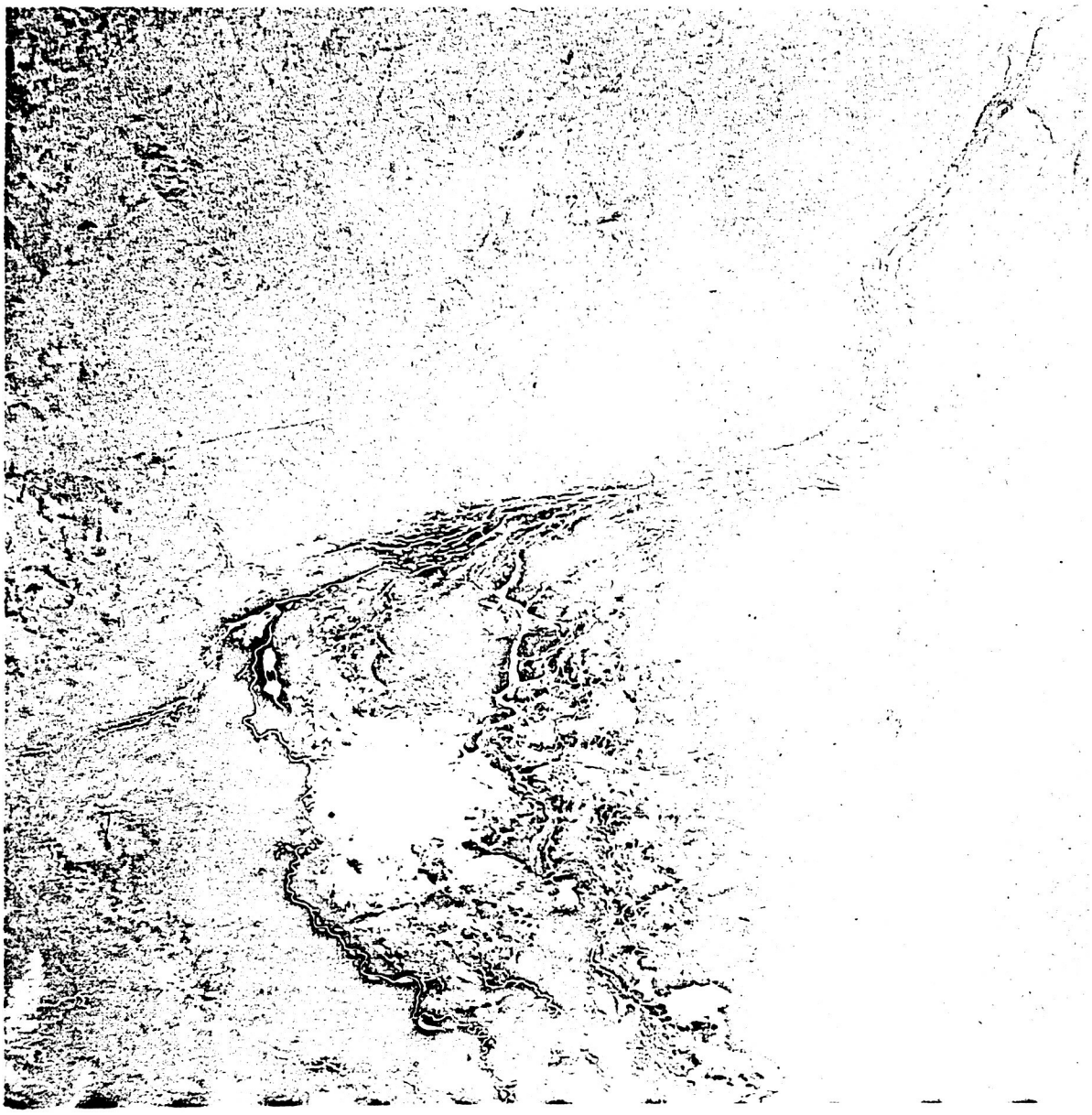

FIGURE 18-18.—The Sudd.

The area known as the Sudd, Arabic for the barrier or stopper, was dramatically photographed (fig. 18–18) from the Gemini VI–A spacecraft at an altitude of 185 miles. The main feature in the photograph is perhaps the world's largest swamp; the area is larger than the State of Pennsylvania. The White Nile flows out of the Great Rift Valleys of East Africa into Sudan and loses over 80 percent of its volume in a tangled mass of marsh, water hyacinth, and 15-foot papyrus grass. The river loses itself in many channels which open and close at random, as floating islands of papyrus block old and create new channels. Lightning often causes the grass to catch fire. The hostile terrain of this area has historically separated the cultures of Arab Africa from Negro Africa. Continued surveillance from manned spacecraft can provide much information on the river and the swamp vegetation, and may lead to an eventual triumph by man.

FIGURE 18–19.—Western Algeria.

The fine geologic details of the Sahara Desert in Western Algeria (fig. 18–19) were recorded by the Gemini VII flight crew. The dunes are long longitudinal ridges from 5 to 10 miles apart, 500 to 800 feet high, and up to several hundred miles long. A long ridge of upturned sedimentary beds is visible from the upper center to the lower right edge of the photograph. A wadi, a usually dry stream bed, follows the right edge of the ridge; just off the photograph, the wadi passes through a water gap and

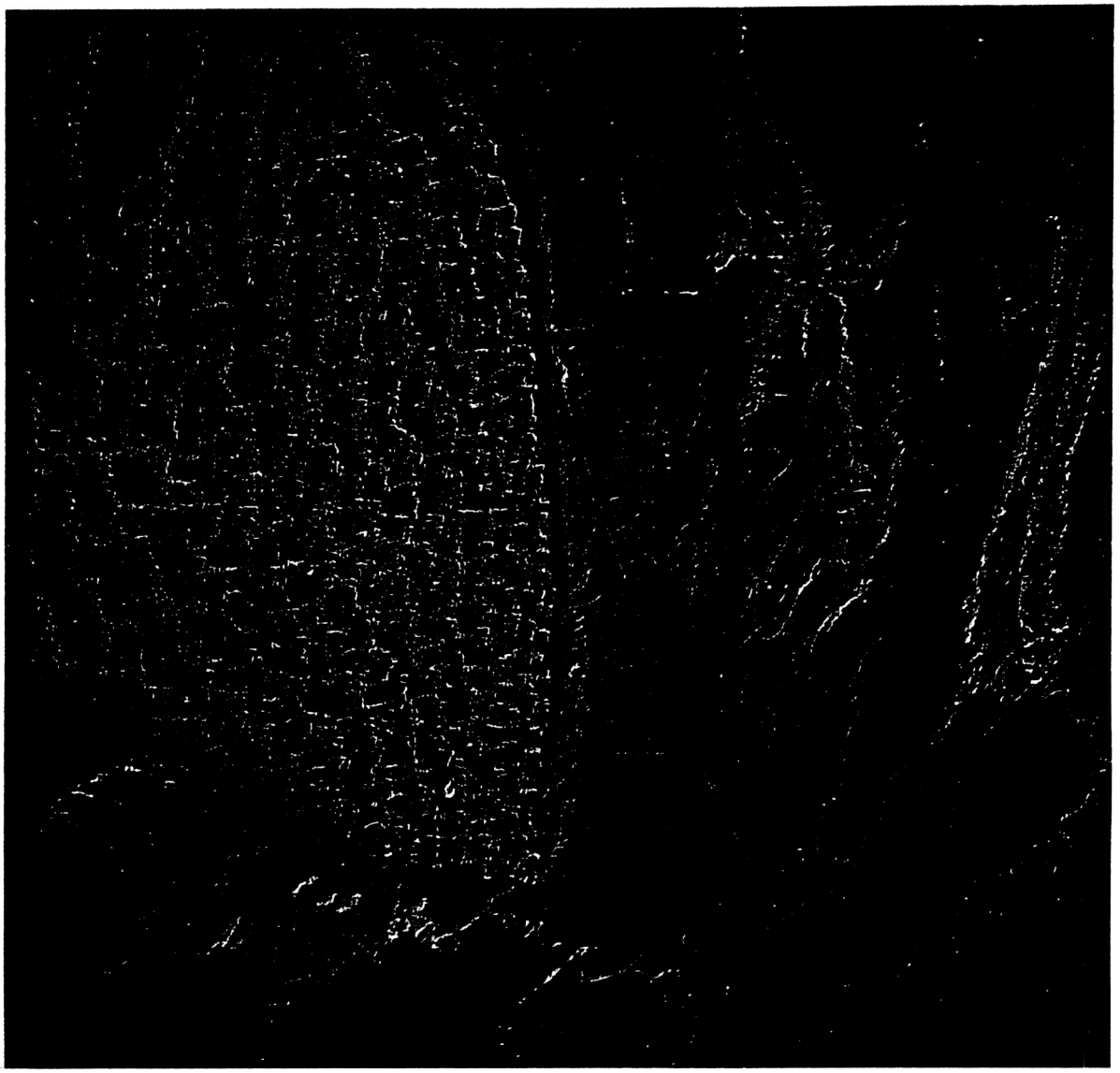

FIGURE 18–20.—Tifernine Dunes.

continues in the opposite direction down the other side of the ridge terminating in a large salt flat. The photographs of this usually dry country were made shortly after very heavy rains; the wadi is carrying surface water and the salt flat is inundated.

Figure 18–20 was obtained with a 250-mm Zeiss Sonnar lens, and shows the structure of a unique geologic feature, the Tifernine Dunes of Eastern Algeria. These dunes are probably the world's highest (1500 feet), and are trapped in a basin surrounded by mountains of basalt. The remote area had been poorly photographed prior to the Gemini VII mission.

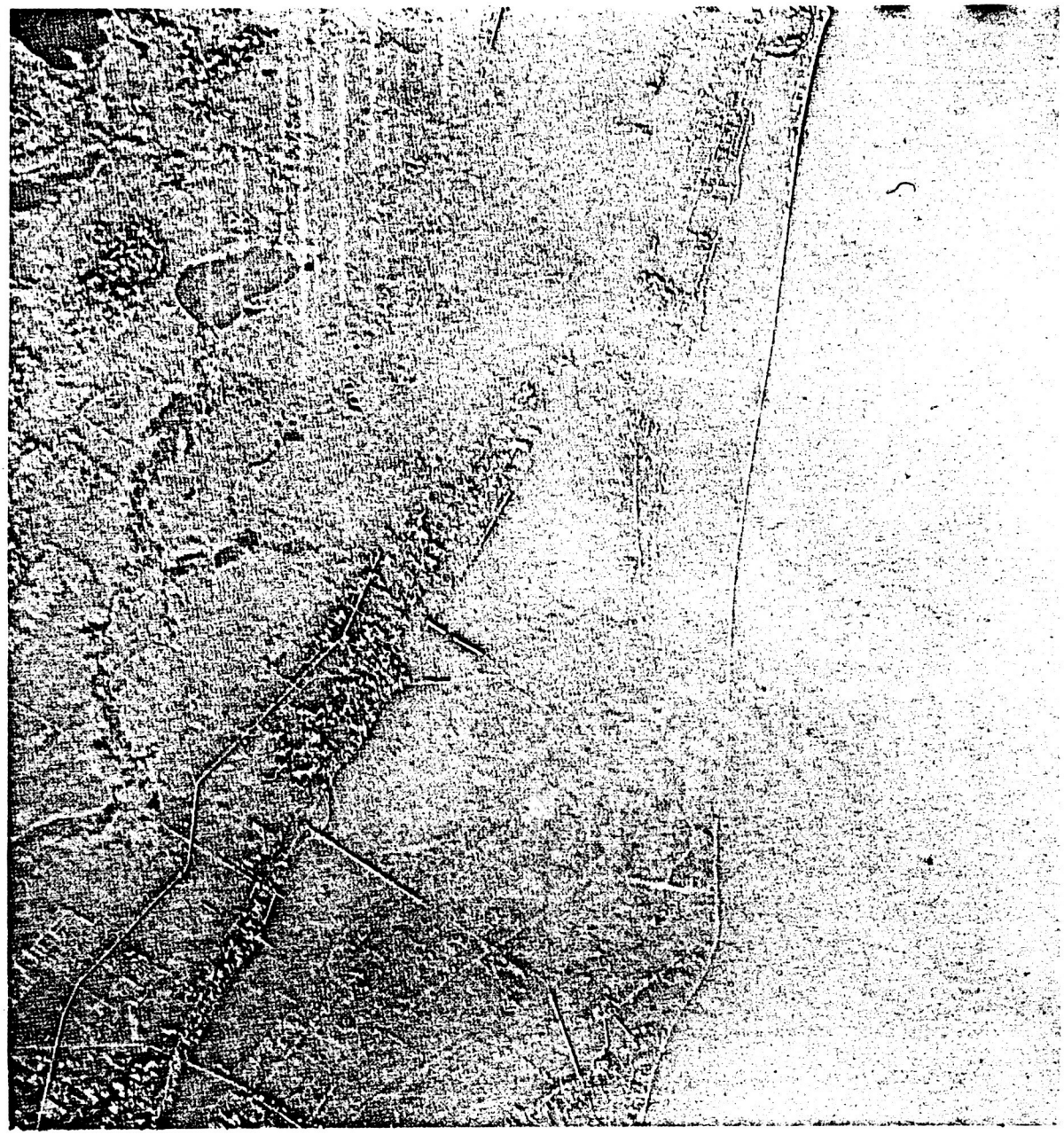

FIGURE 18–21.—Kennedy Space Center, Florida.

The potential value of space photography to the urban planner is represented by figure 18–21. The Gemini VII crew photographed the Kennedy Space Center, Fla., and vicinity while directly overhead at an altitude of 140 miles. Launch Complex 19, where the spacecraft was launched 2 days before, can be clearly seen as part of Missile Row. Launch Complex 39, which includes the Vertical Assembly Building, the crawlerways, and the two launch pads, is partially obscured by a cloud. Other manmade features which are clearly visible include freeways, city streets, buildings, causeways, railroads, bridges, piers, runways, and taxiways. The channel of the Intracoastal Waterway can be located beside the series of white dots in the Indian River; the white dots are small islands of spoil piles resulting from dredging. Space photography can be utilized by urban planners to study and make important decisions regarding the fierce competition for land among industrial, commercial, residential, agricultural, and recreational users. Government personnel can update planning documents, such as master plans, or tax and transportation maps, and quickly see what changes have taken place in land use.

FIGURE 18–22.—Lake Titicaca, Peru.

Lake Titicaca, located between Peru and Bolivia at an elevation of 12 506 feet, was photographed (fig. 18–22) by the Gemini IX–A crew. The photograph also shows portions of Chile and Argentina, and the Pacific Ocean in the background. The snow-covered peaks of the Cordillera Real (Royal Mountains) rise to over 21 000 feet and are visible in the lower left. The high Salars or salt flats, on the left margin, are higher than any point in the continental United States and are as large as the Bonneville Salt Flats. Drainage, from the lower left, is about 3700 miles down the Amazon to the Atlantic Ocean.

FIGURE 18–23.—Peru.

The Cordillera Blanca (White Mountains) of Peru were photographed (fig. 18–23) by the Gemini IX–A crew less than 1 minute prior to figure 18–22. Clearly visible is Huascaran Volcano (22 205 feet), the highest point in Peru; the snowline is at 18 000 feet. A thin white line down the west slope of the volcano marks the path of a destructive avalanche which killed several thousand people in the Santa River Valley in January 1962. Over 250 miles of the Pacific coast can be seen. The rivers in the upper right of the photograph flow down the Amazon system for over 3500 miles to the Atlantic. In areas which still require accurate and detailed mapping, space photography will be a valuable asset. Great effort is required to obtain accurate information on the amount of snow on these mountains and the predicted water runoff. Space photography can reduce the hardships encountered by topographic survey parties at altitudes in excess of 20 000 feet, and eliminate the frequent loss of life. In over 40 years of aerial photography, only a quarter of Peru has been photographed; the Gemini IX–A crew photographed over three-quarters in 3 minutes.

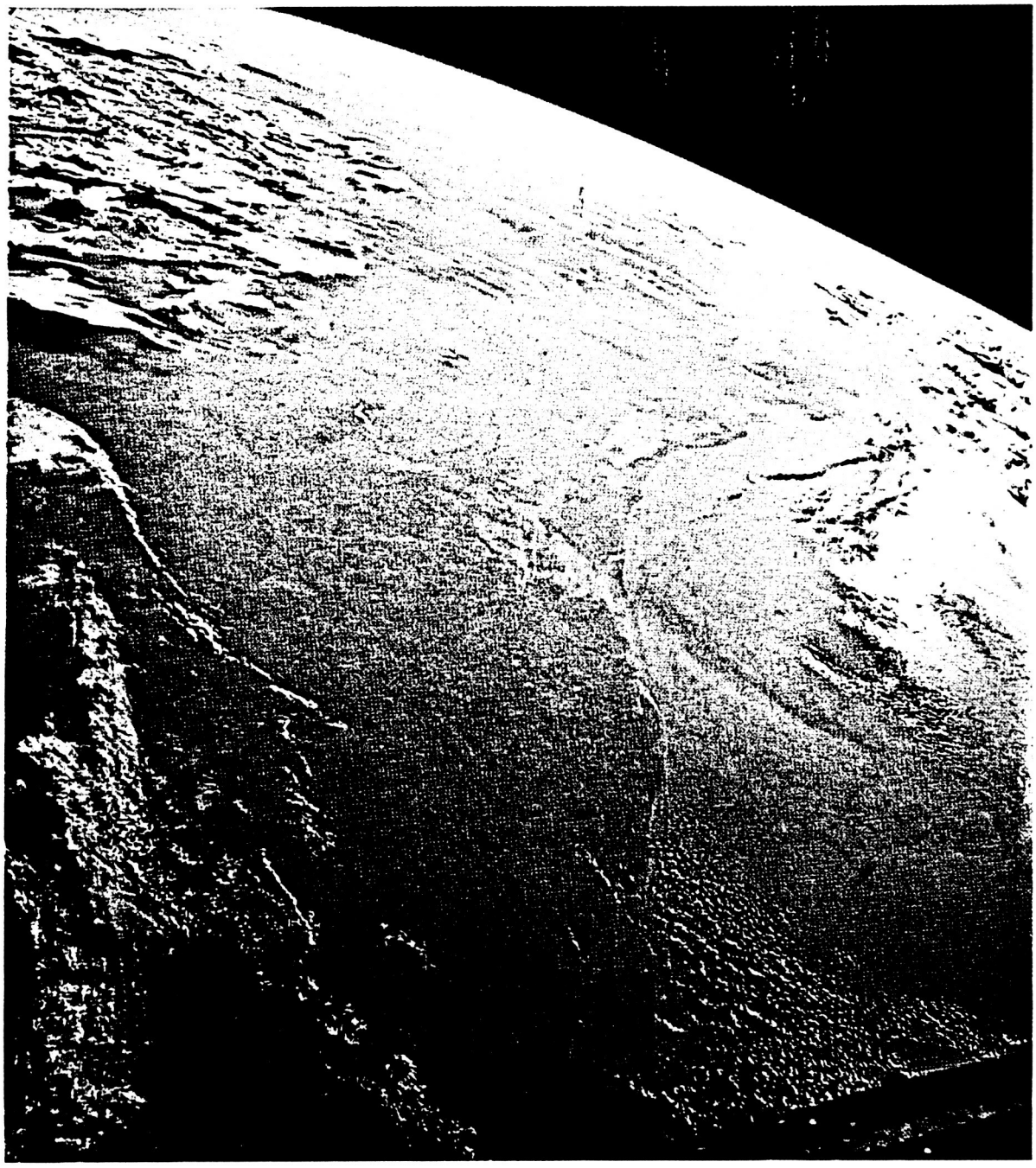

FIGURE 18–24.—Texas-Louisiana Gulf coast from Gemini XI.

Figure 18–24 is a very interesting study of the sources and distribution of air pollution along the Texas-Louisiana Gulf Coast. This photograph was taken through the open hatch of the Gemini XI spacecraft shortly after dawn. Large sources of air pollution can be seen originating from smokestacks in Houston, Texas City, Freeport, and Port Arthur, Tex., and in Lake Charles, Baton Rouge, and Bogalusa, La. As shown in the photograph, the air pollutants in the Houston area move northeastward at the lower levels until winds aloft carry the pollutants southward over the Gulf of Mexico. In the future, space photography will provide a worldwide aid in the detection of sources, and the collection and movement of airborne pollutants.

FIGURE 18–25.—Texas-Louisiana Gulf coast from Gemini XII.

Figure 18–25 was taken by the Gemini XII crew along the Texas-Louisiana Gulf Coast and shows Houston, the Manned Spacecraft Center, the Harris County Domed Stadium, the Houston Ship Channel, and many other features of the area. Of greater geoscientific importance, the distribution of very polluted water in Galveston Bay and other waterborne sediment in such passes as Bolivar Roads, Sabine, and Calcasieu can be clearly seen. The movement of currents in the Gulf of Mexico is also quite evident, and has afforded the oceanographer the opportunity to learn a great deal about the movement and distribution of larval commercial shrimp so important to area economy. The photograph also demonstrates the potential uses of space photography in the observation of causes and distribution of polluted water.

FIGURE 18–26.—Northern half of Mexico.

During the Gemini XII standup extravehicular activity, a striking panoramic series of photographs was obtained showing the entire length of Mexico from Guatemala to Arizona. Figure 18–26 shows the northern half of Mexico including the cities of Monterrey, Reynosa, Chihuahua, and Ciudad Juarez. Features visible in the United States include White Sands

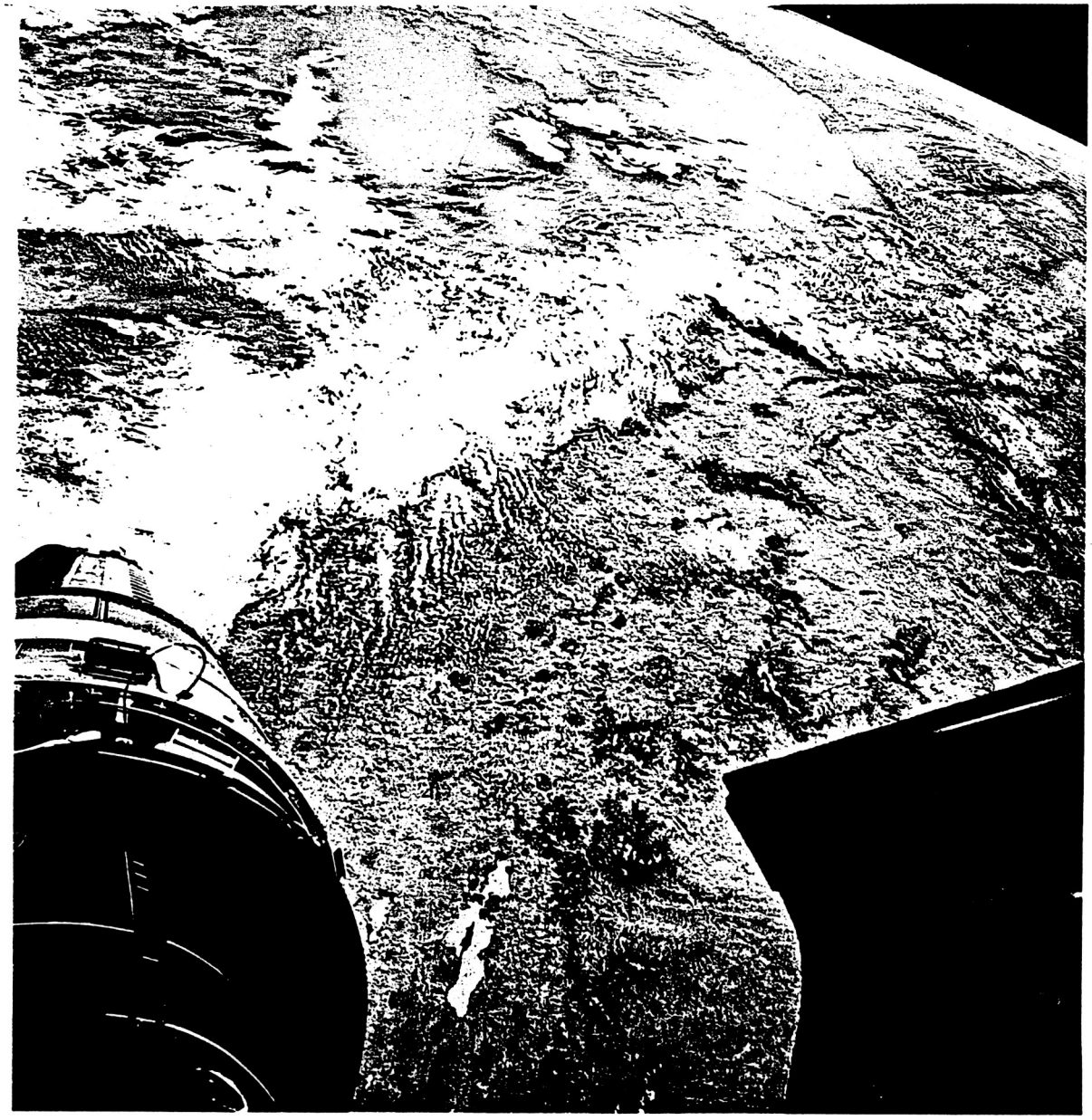

FIGURE 18–27.—Southern half of Mexico.

National Monument in New Mexico and Galveston Bay in Texas. Figure 18–27 taken a few seconds later shows the southeast half of the country including the Mexico City area (note the air pollution), the great snow-covered volcanoes such as Popocatepetl, the Isthmus of Tehuantepec, and the Yucatan Peninsula.

High-Apogee Photography

A series of superb photographs was taken by the Gemini XI flight crew while increasing the orbital altitude from 185 miles to a record 851 miles. Figure 18–28, taken approximately 200 miles above the Earth, shows a land area of almost 1 million square miles in the Sahara countries of Libya, United Arab Republic, Chad, Niger, Sudan, and Algeria. Clearly visible are the great sand deserts separated by mountains and escarpments of sedimentary or igneous origins. Two large volcanic areas, the Black Haruj and the Tibesti Mountains, are visible. The unique striations in rock and sand in the upper right demand more investigation by the geologist.

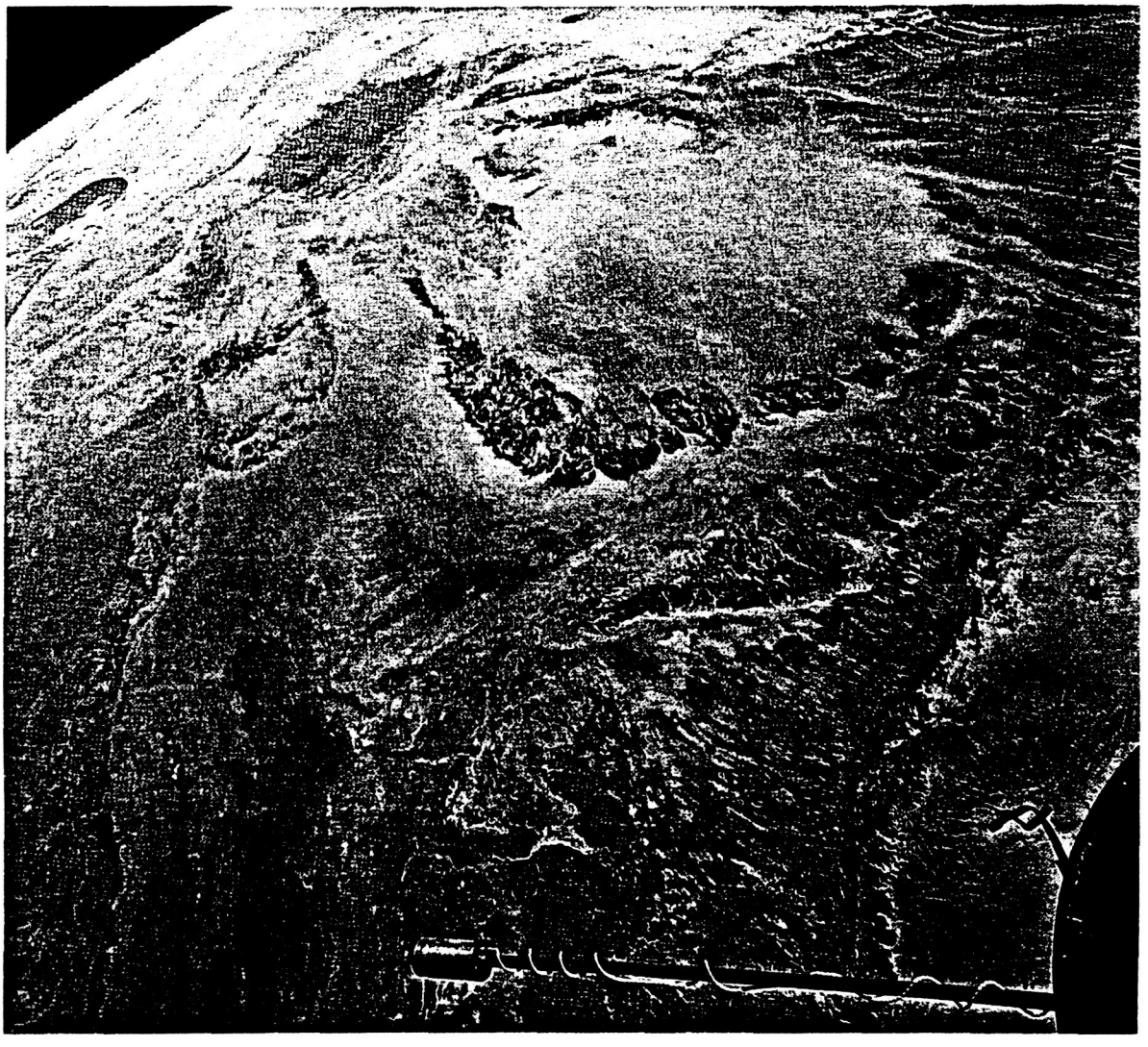

FIGURE 18–28.—Sahara area.

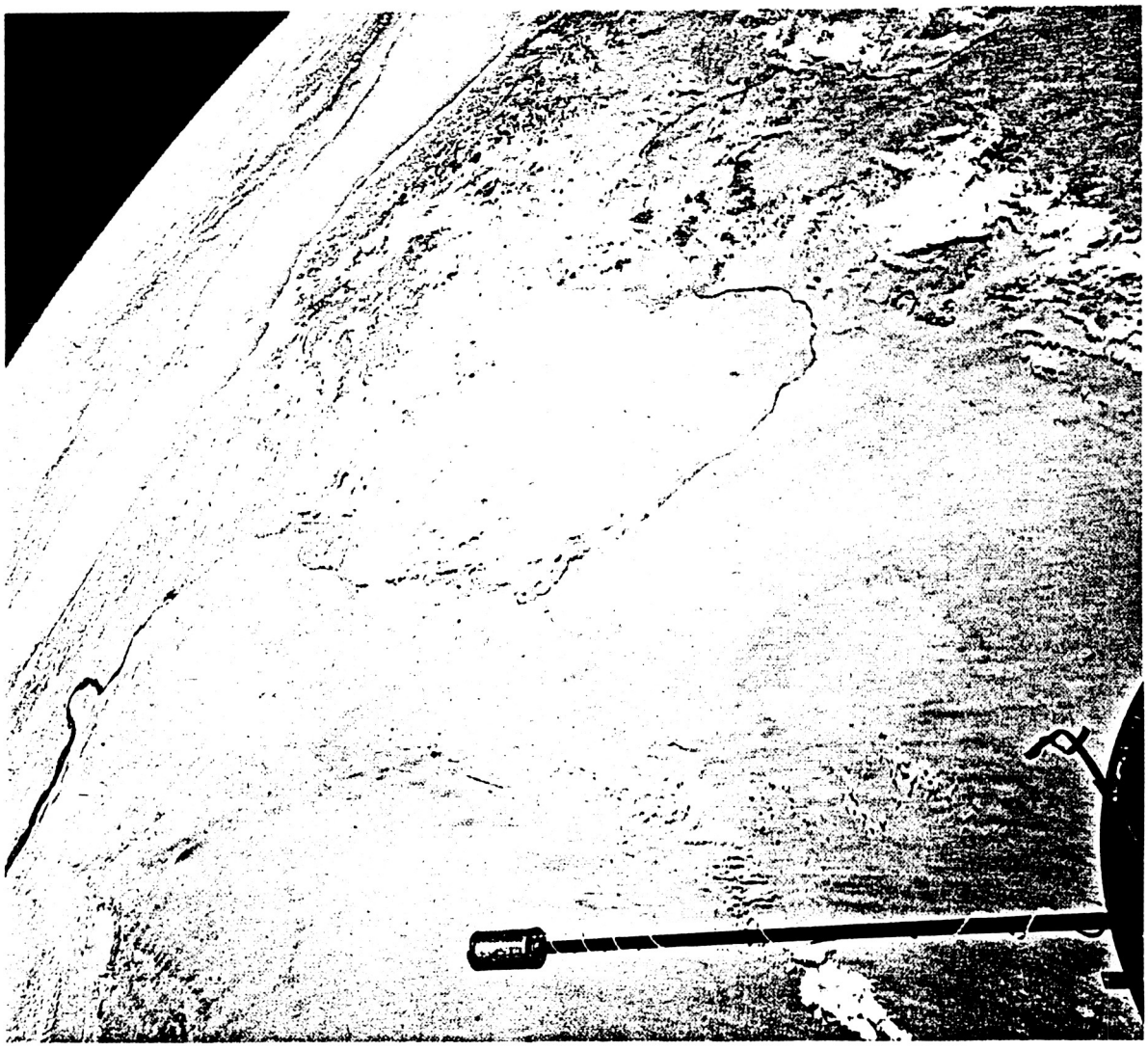

FIGURE 18–29.—Nile River.

Some 2 minutes later, the Gemini XI crew photographed approximately half of the 4200-mile-long Nile River (fig. 18–29). Taken from an altitude of about 220 miles, this synoptic view permits regional studies which cannot be accomplished by other means. The relationship of the world's longest river to the regional geology is clearly indicated from Bida (above Cairo) in the United Arab Republic southward to Kosti (above Khartoum) in the Sudan. The Red Sea and Arabia lie beyond.

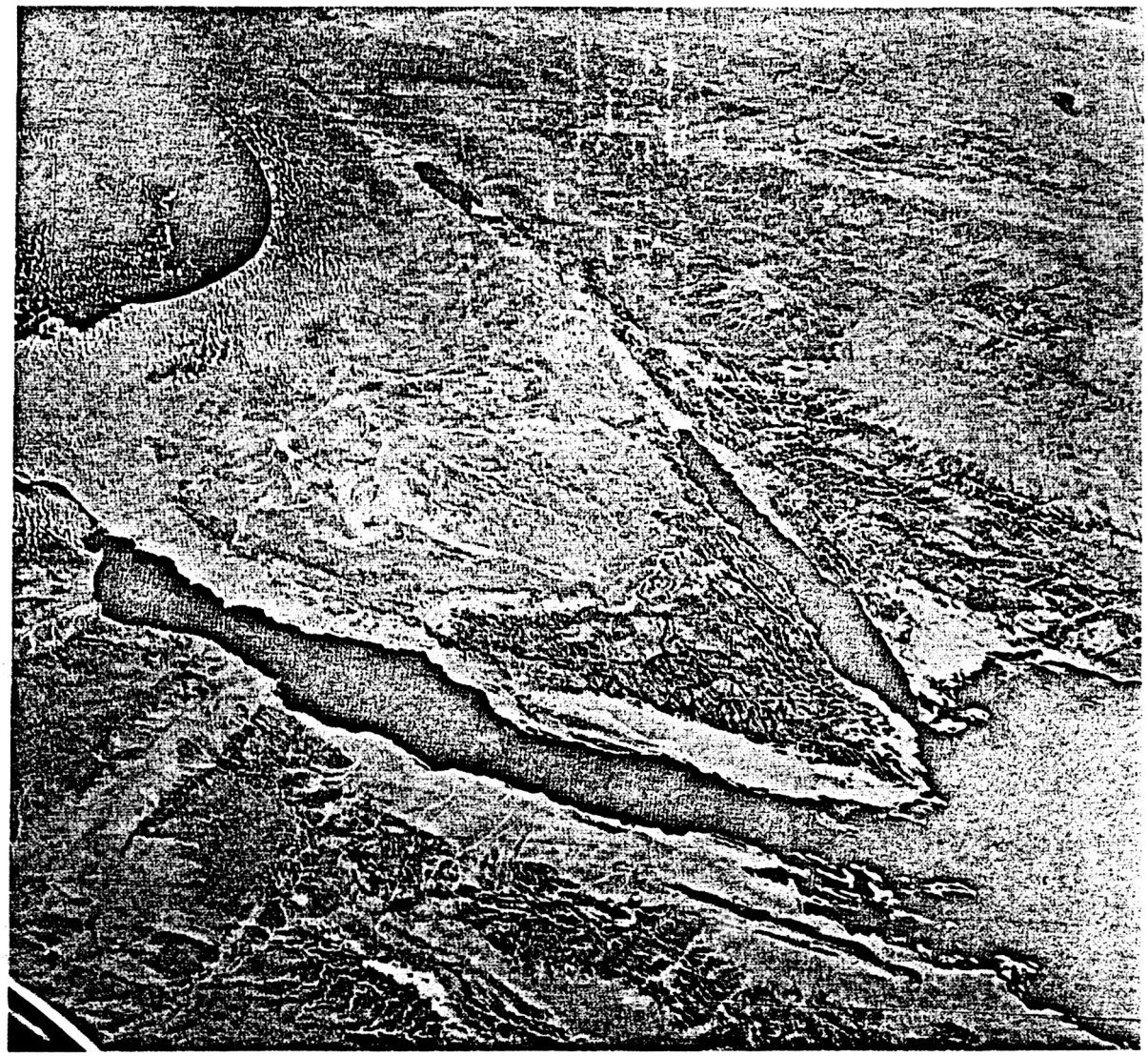

FIGURE 18–30.—Middle East.

Figure 18–30 was taken during Gemini XI from an altitude of about 200 miles, and shows all of Israel and Jordan and portions of Turkey, Lebanon, Syria, Iraq, Saudi Arabia, and the United Arab Republic. The capitals of Beirut, Damascus, Baghdad, Amman, and Jerusalem, as well as the Red Sea terminus of the Suez Canal, are visible. The entire Sinai Peninsula and such sub-sea-level lakes as the Dead Sea and Sea of Galilee are visible. A break in the Trans-Arabian pipeline occurred near Badanah, Saudi Arabia, shortly before the photograph was made, and the resulting fire, smoke, and shadow are recorded in the upper right.

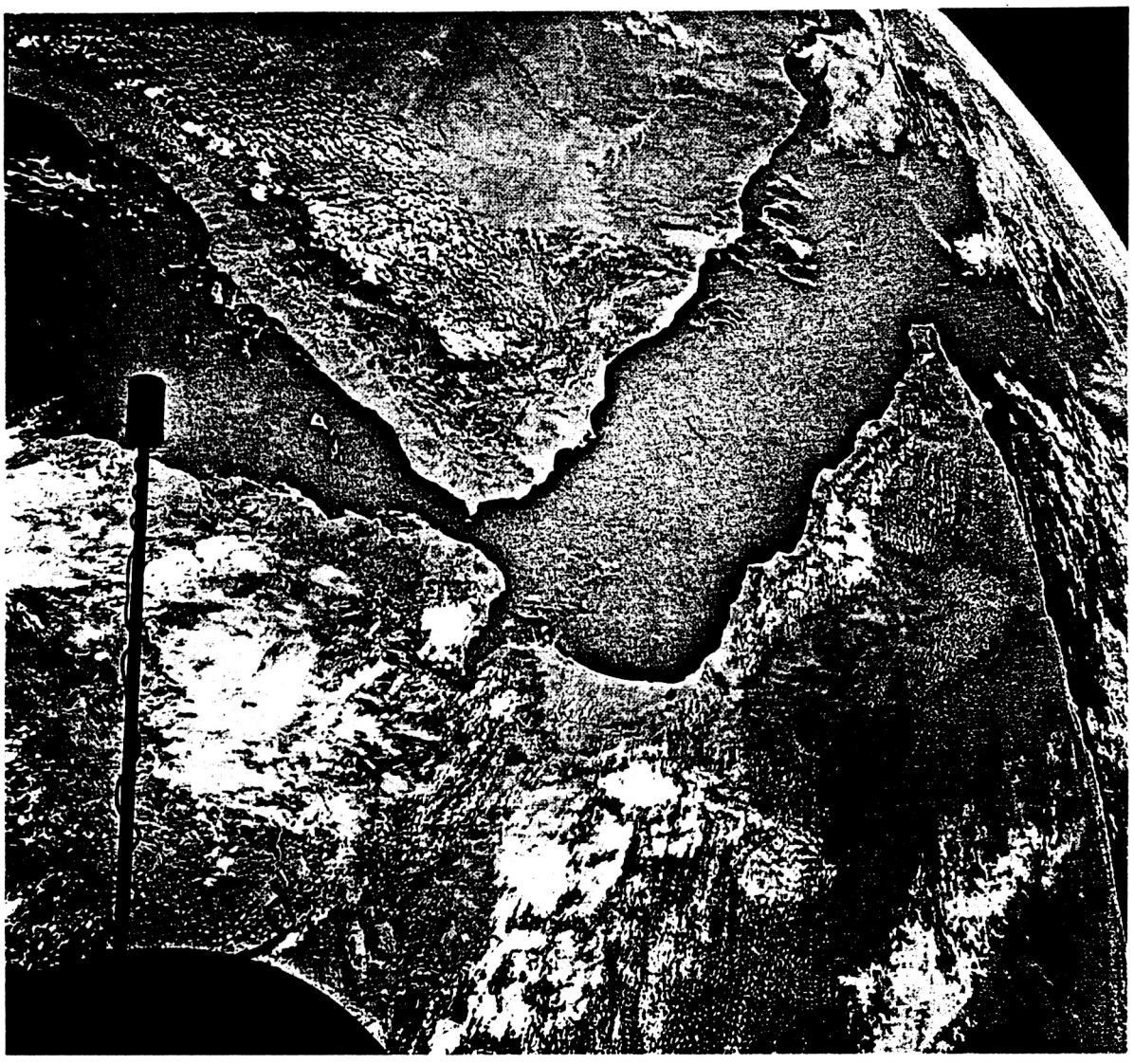

FIGURE 18–31.—Arabia-Somali.

From an altitude of about 410 miles, the Gemini XI crew photographed the junction of the Red Sea and the Gulf of Aden (fig. 18–31). Parts of Yemen, South Arabia Federation, Saudi Arabia, and the Muscat and Oman Sultanate are visible in the upper portions of the photograph, while parts of Somali, Ethiopia, and all of French Somaliland are in the foreground.

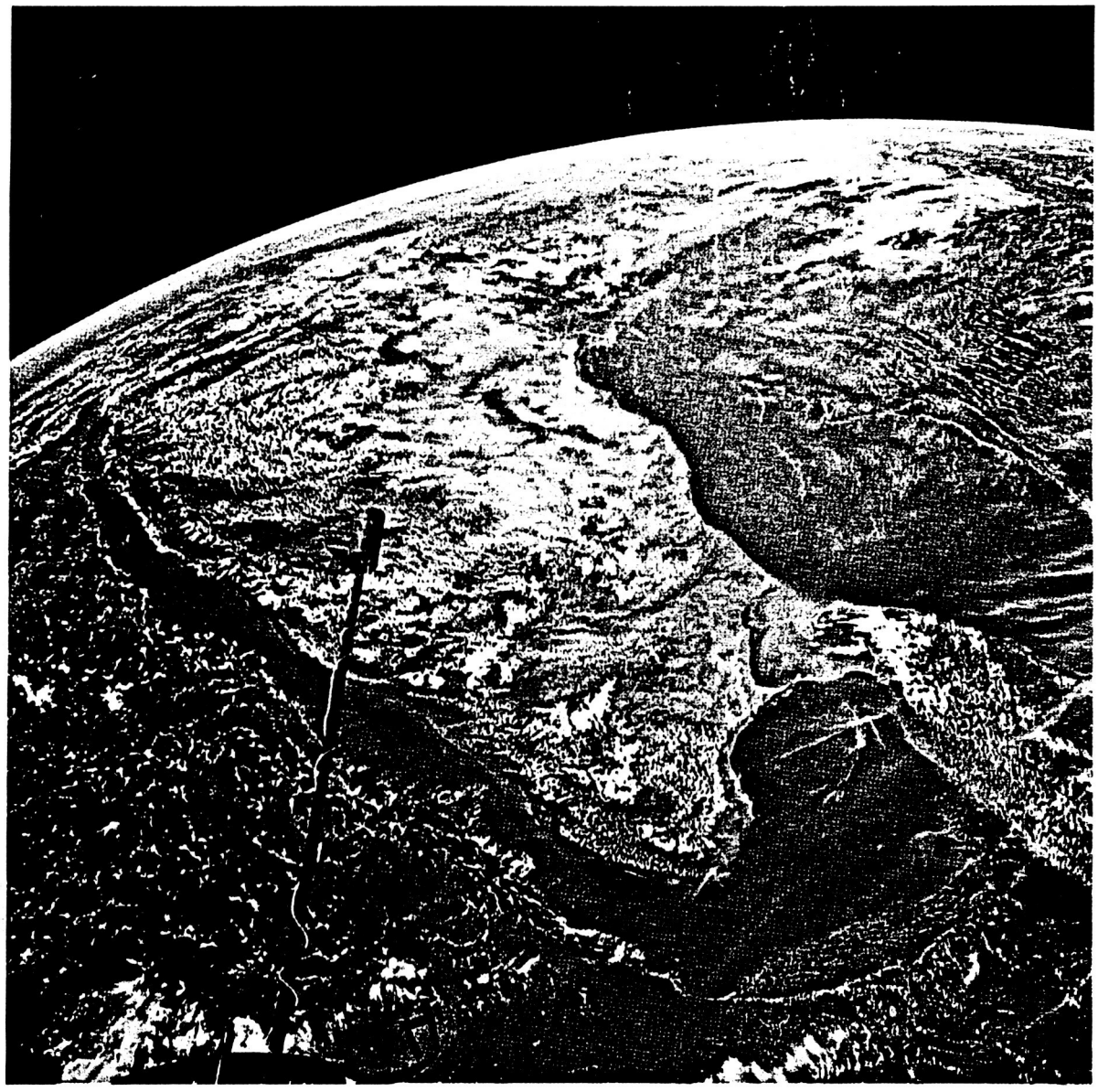

FIGURE 18–32.—India.

From an altitude of about 500 miles, the Gemini XI crew recorded a striking and beautiful view of the Indian subcontinent (fig. 18–32). The island of Ceylon is to the lower right. The climatic difference along the divide of the Western Ghats in India is clearly visible, with the lush jungle to the west and the semiarid regions to the east. Much valuable information is available concerning the meteorological conditions over such a vast area as the subcontinent and the adjacent Arabian Sea to the left and the Bay of Bengal to the right.

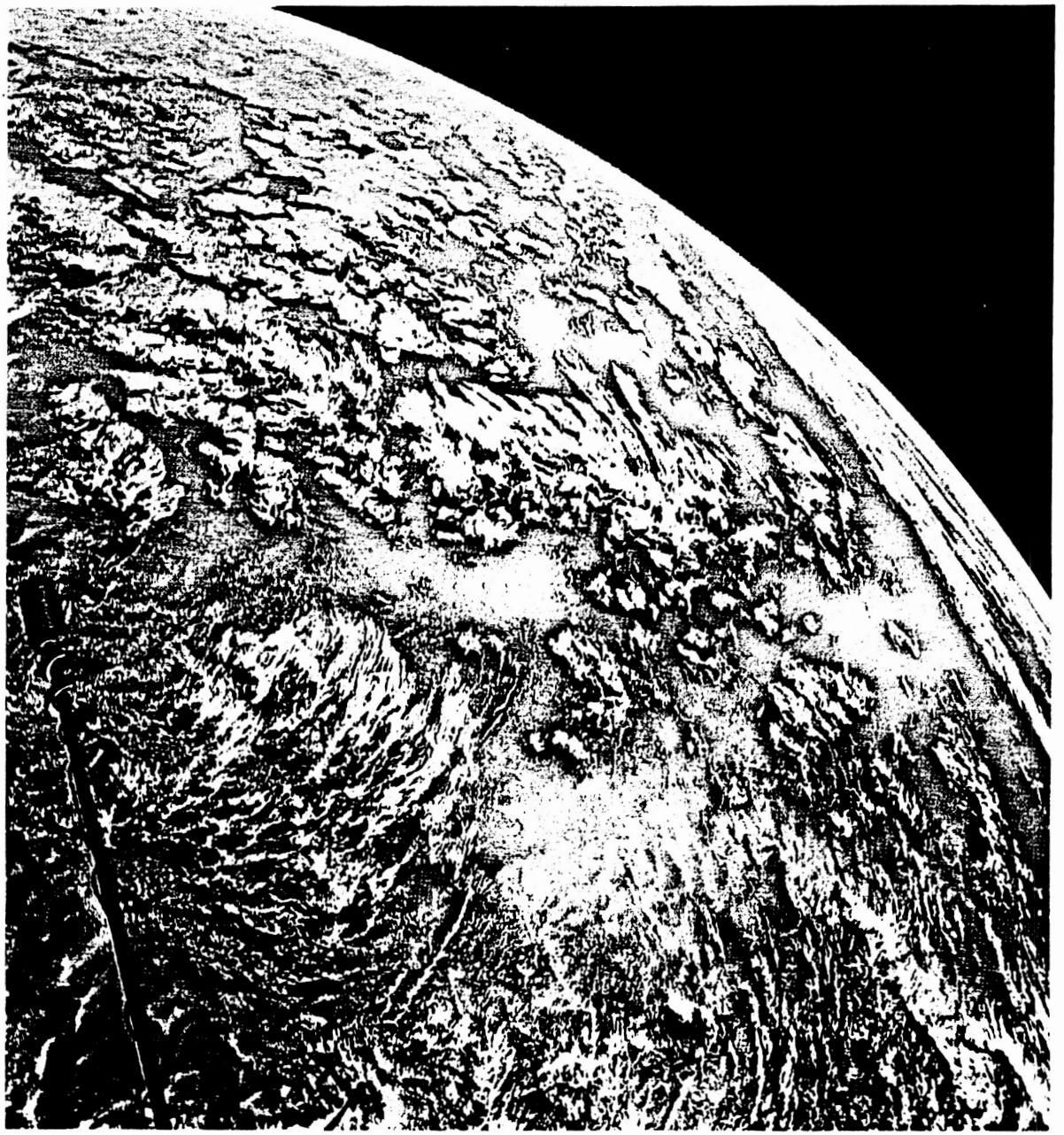

FIGURE 18–33.—Indonesia.

In figure 18–33, the cloud-covered Indonesian Islands were photographed during Gemini XI from about 740 miles above the Earth. The curved horizon is over 2000 miles to the east.

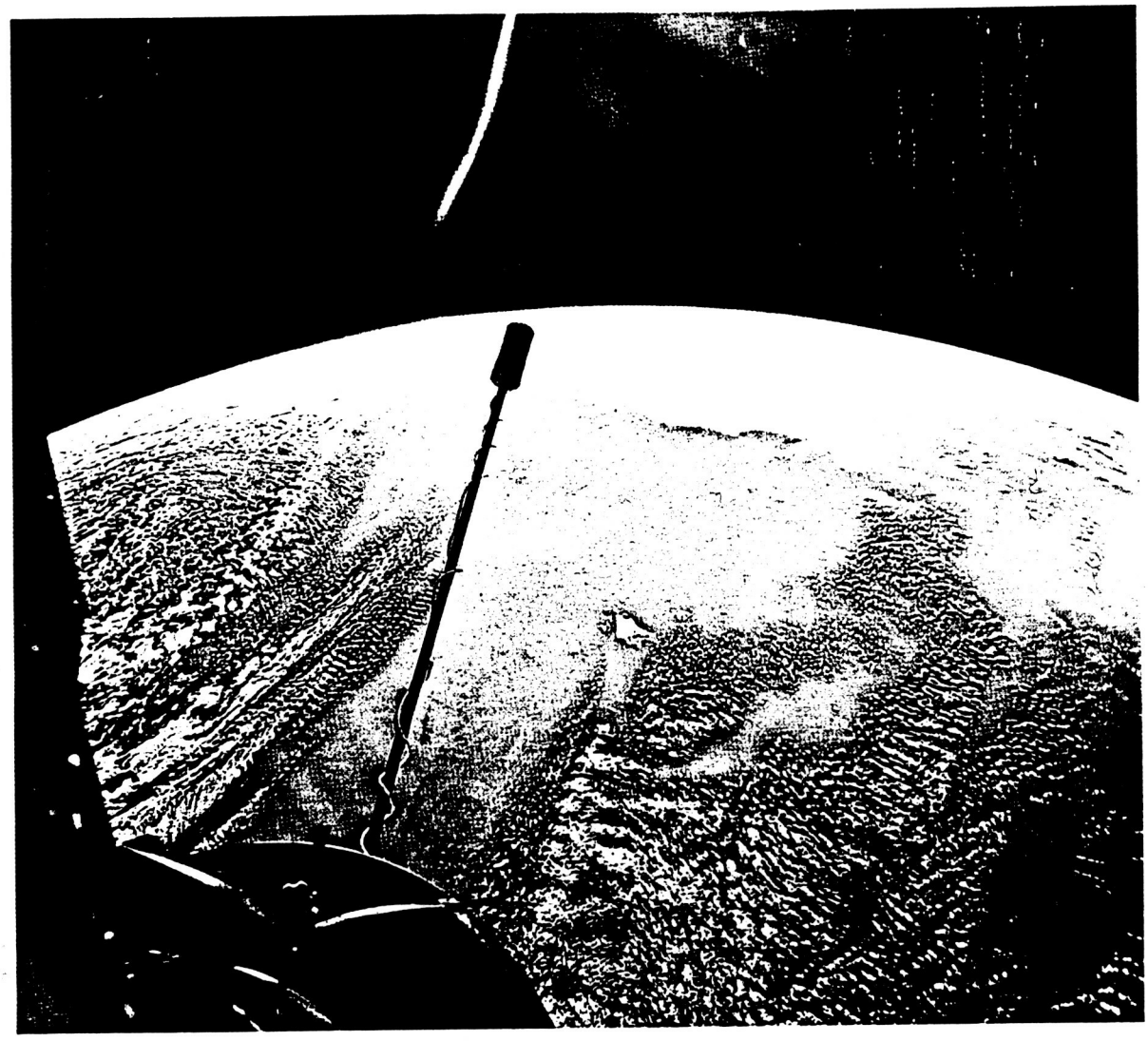

FIGURE 18–34.—Australia.

Figure 18–34 was taken while the Gemini XI spacecraft was 851 miles above the Earth, the highest altitude from which any photograph has been taken by man. The western half of Australia with the sunlit Indian Ocean beyond is visible. The horizon is nearly 3000 miles to the westward. The photograph was made near sunset, and ground detail is poor due to low light levels on the ground.

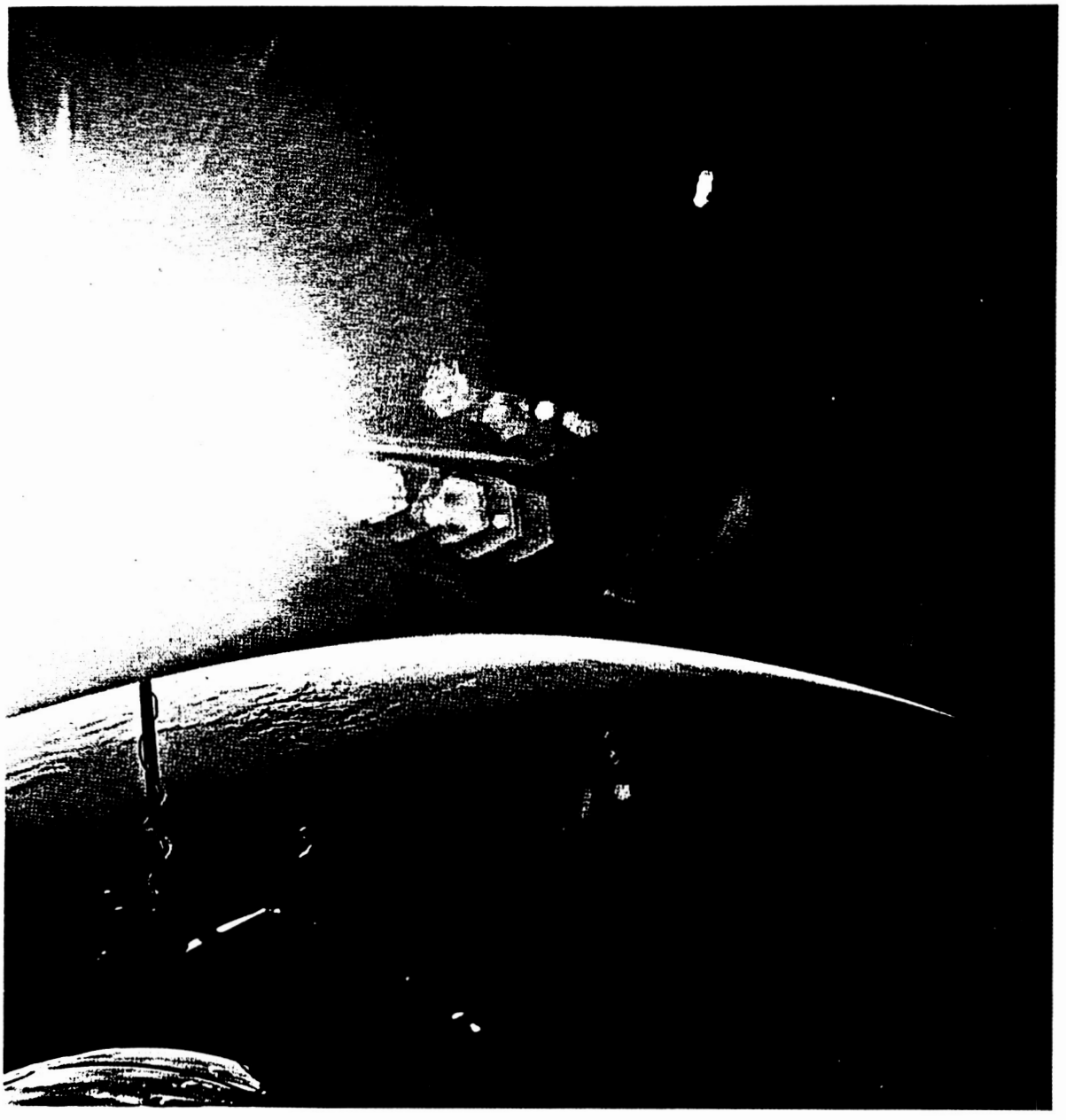

FIGURE 18–35.—Sunset.

The Gemini XI crew recorded the striking photograph of a sunset (fig. 18–35) from approximately 850 miles above the Earth. The sunset terminator is visible over 1000 miles to the west of the spacecraft and the Earth's limb about 3000 miles to the west. Due to the spacecraft altitude, however, the Sun is clearly visible well above the horizon.

Synoptic Weather Photography

The meteorologist has secured much valuable data from some 2000 Gemini photographs. The unmanned meteorological satellites are providing a great deal of valuable information and have been supplemented with the finer details and color of the photographs obtained from Gemini. The study of vortices is of particular importance in that the ultimate vortex may result in a destructive tornado, hurricane, or typhoon. Figure 18–36 was taken during the Gemini V mission, and shows the mile-high Mexican island of Guadalupe (200 miles off Baja California) interrupting the orderly flow of winds to create a bowed shockwave effect in the clouds to windward. Two vortices have developed to the lee of the island.

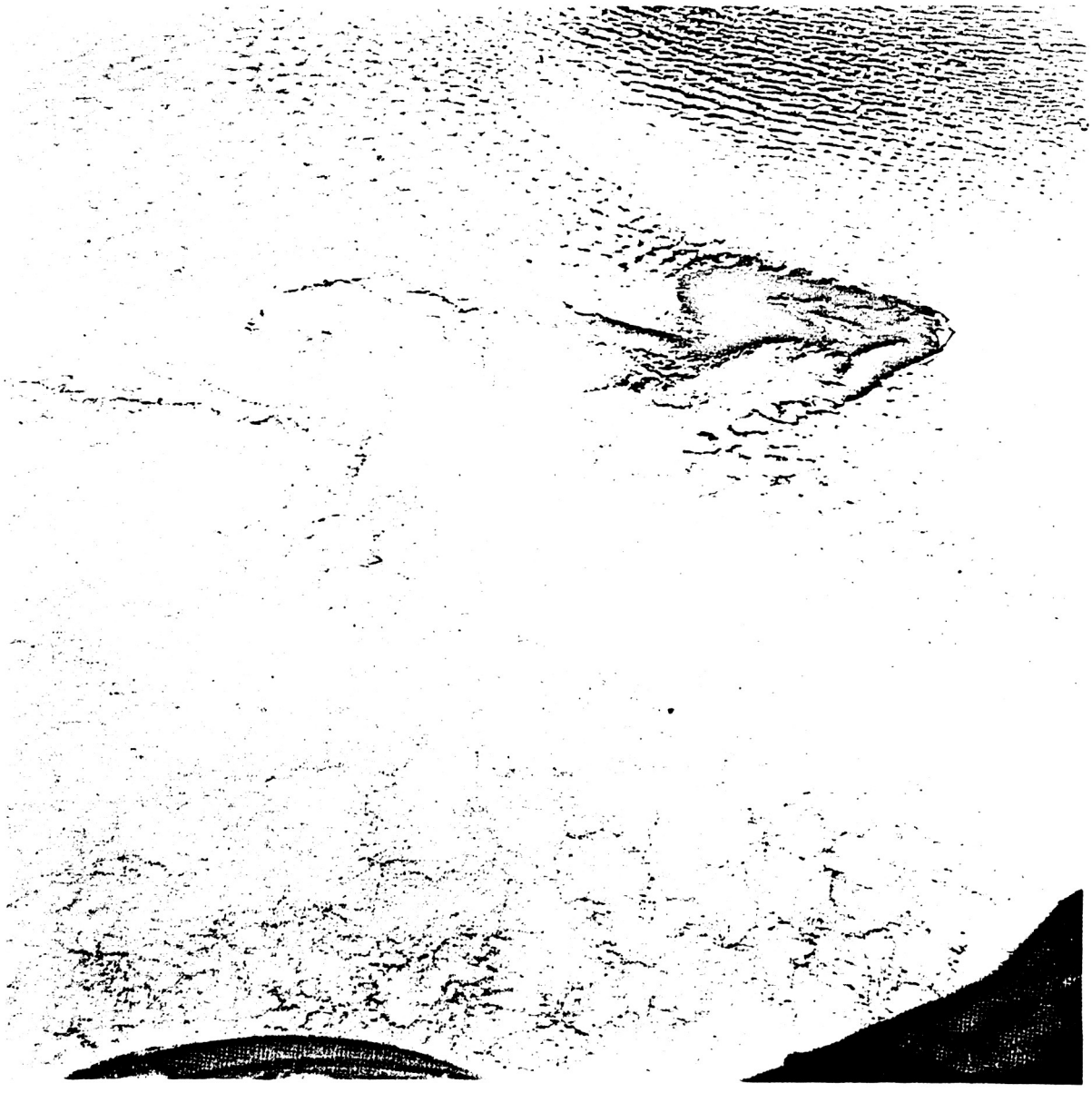

FIGURE 18–36.—Vortex off Mexico.

FIGURE 18–37.—Vortex off Morocco.

Figure 18–37 shows a very well developed vortex which has been caused by windshear at the coastal prominence of Ras Rhir in Morocco. The photograph clearly shows the eye of the vortex and the rotational effects on the periphery. This Gemini V photograph has become a classic example of the meteorological data which can be obtained from manned space-flight photography. It would be difficult to provide a machine with the ability to select and photograph phenomena of greatest value to the scientist.

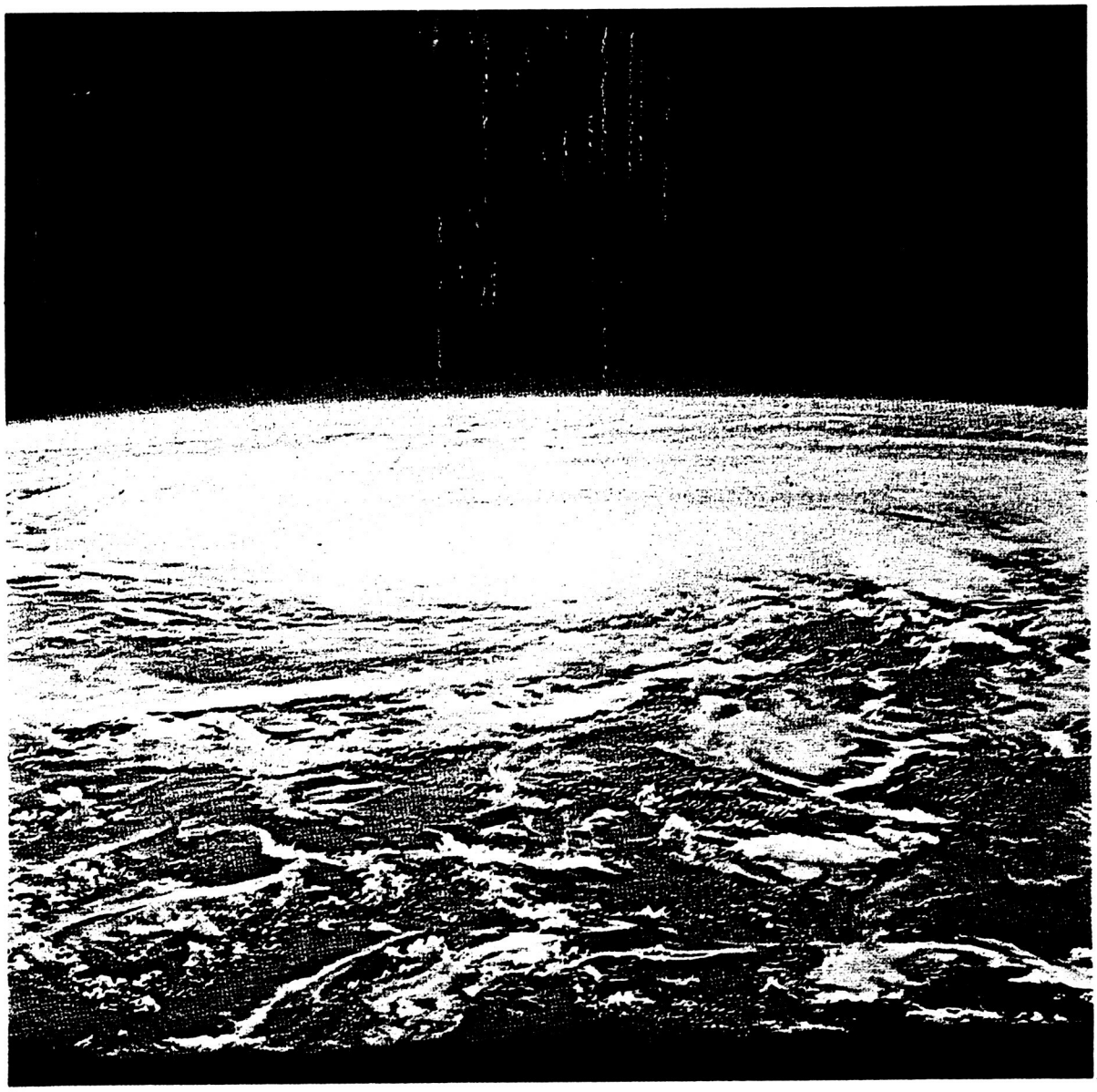

FIGURE 18–38.—Typhoon in Pacific Ocean.

A large mature typhoon moving across the central Pacific Ocean was photographed (fig. 18–38) by the Gemini V crew. The diameter of the system was approximately 400 miles and the circular motion can be distinguished in the photograph.

Near-Object Photography

Figure 18–39 is of great interest to the aerospace engineer, and shows the first Gemini extravehicular activity. The cloud background is over the Pacific Ocean between Hawaii and California. This is one of 16 photographs of the Gemini IV extravehicular activity, and is evidence that much can be learned not only of the pilot but also of the maneuvering unit, camera, space suit, and umbilical cord.

FIGURE 18–39.—First extravehicular activity.

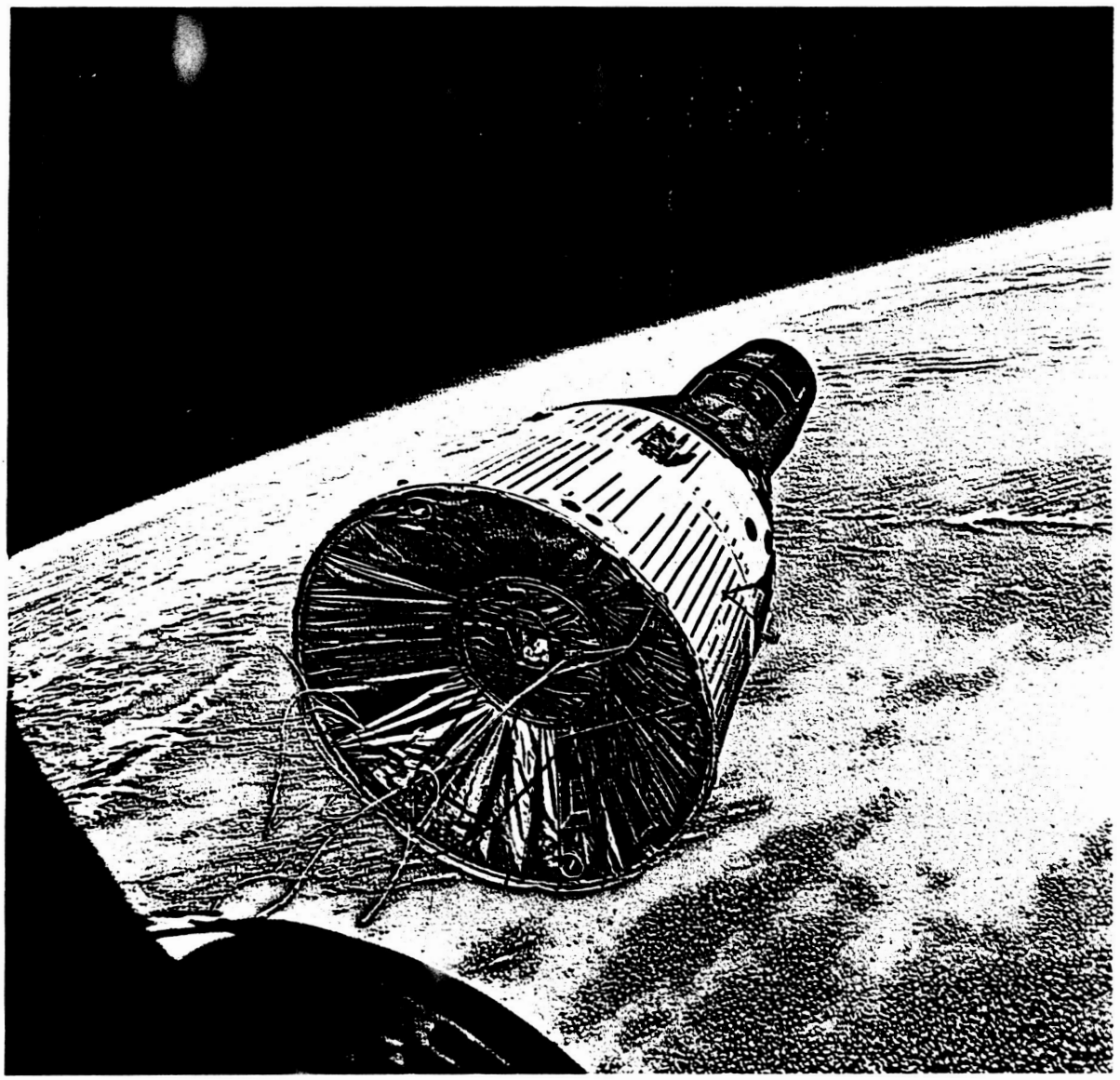

FIGURE 18–40.—Gemini VII from Gemini VI–A.

The historic first rendezvous of two manned space vehicles, Gemini VI–A and VII spacecraft, produced a series of 117 striking and informative still photographs and several hours of motion pictures. As the two vehicles moved through space some 185 miles above the Pacific Ocean, the Gemini VII spacecraft was photographed (fig. 18–40) from a distance of 20 feet by the Gemini VI–A flight crew.

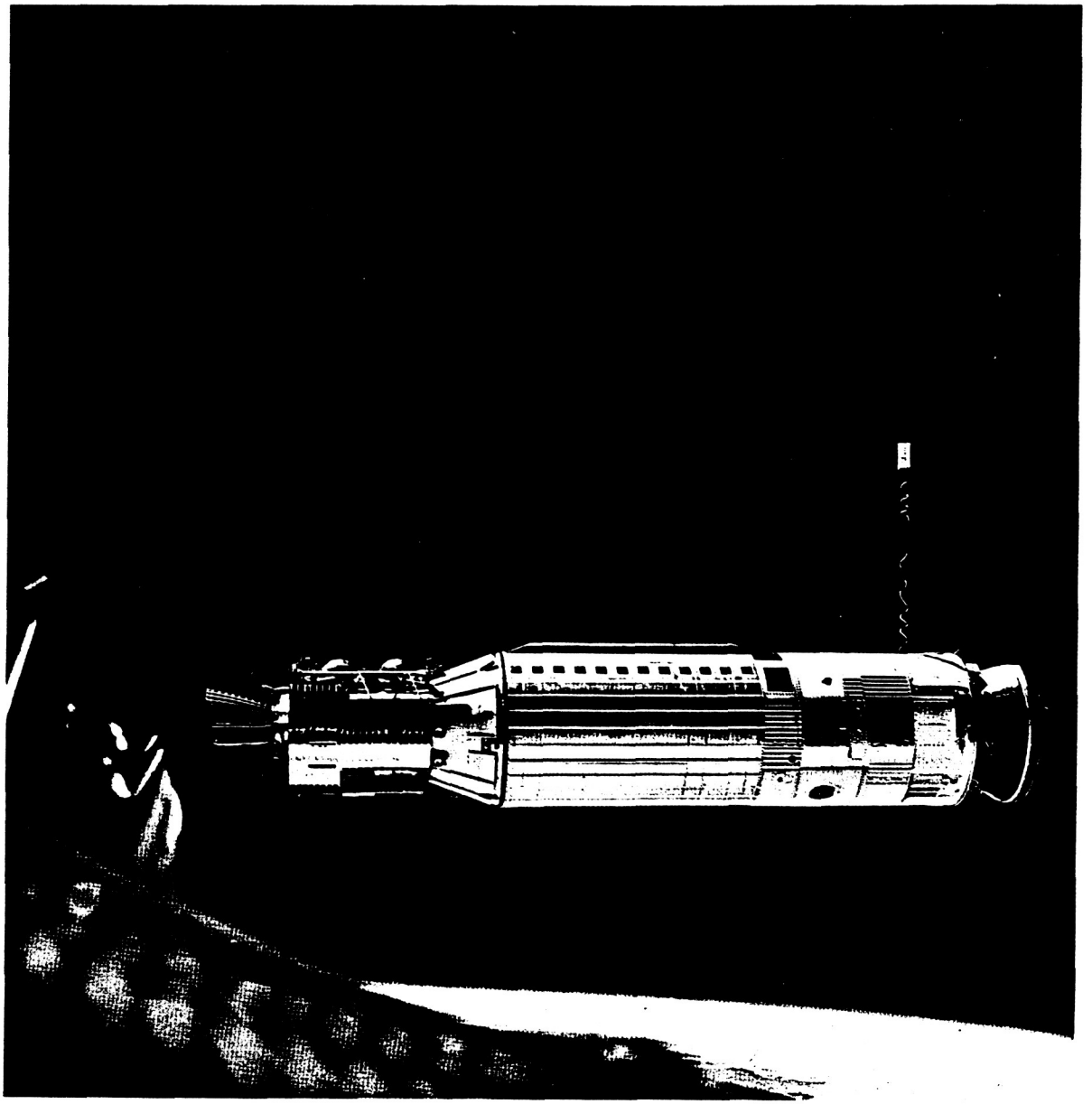

FIGURE 18–41.—Gemini VIII target vehicle.

Even though the Gemini VIII mission was terminated early due to a thruster malfunction, the aerospace engineering field has greatly benefited from the motion-picture and still photographic documentation of the first rendezvous and docking of a spacecraft with a target vehicle. In figure 18–41, the Gemini Agena Target Vehicle is approximately 50 feet from the spacecraft. This photograph was taken just prior to the docking maneuver and is one of a stereo pair which permits precise distance measurements. The motion-picture footage of the difficulties encountered at the time of undocking clearly illustrates the seriousness of the situation.

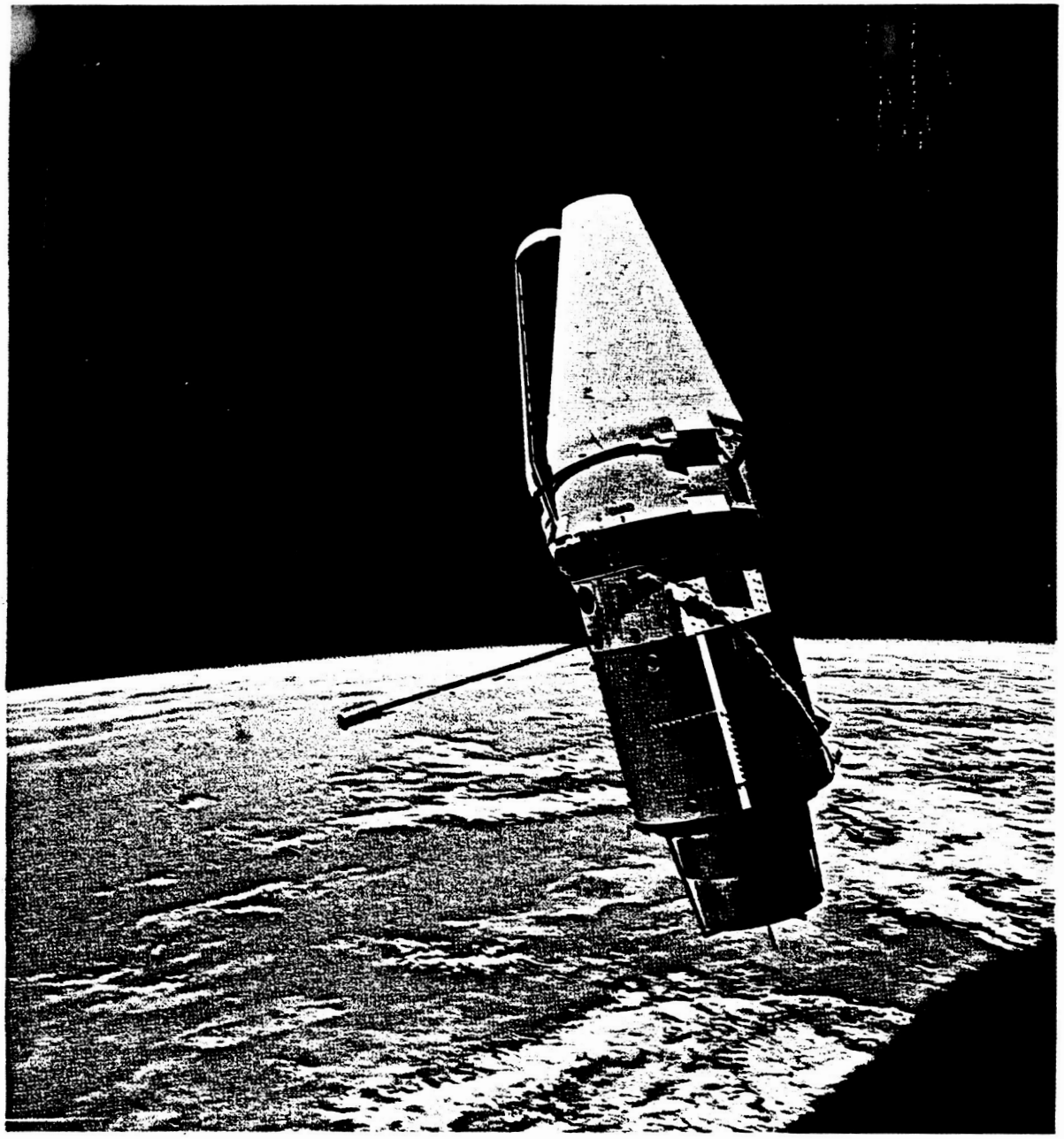

FIGURE 18–42.—Augmented Target Docking Adapter.

Figure 18–42 shows the Augmented Target Docking Adapter during one of three rendezvous accomplished by the Gemini IX–A crew. Docking could not be accomplished because the ascent shroud covering the docking adapter did not deploy after the vehicle was placed in orbit. The Gemini IX–A crew maneuvered the spacecraft to within inches of the Augmented Target Docking Adapter and secured 109 excellent photographs of the rendezvous and station-keeping activities. The ablative effect of launch heat on the shroud was photographed for the first time.

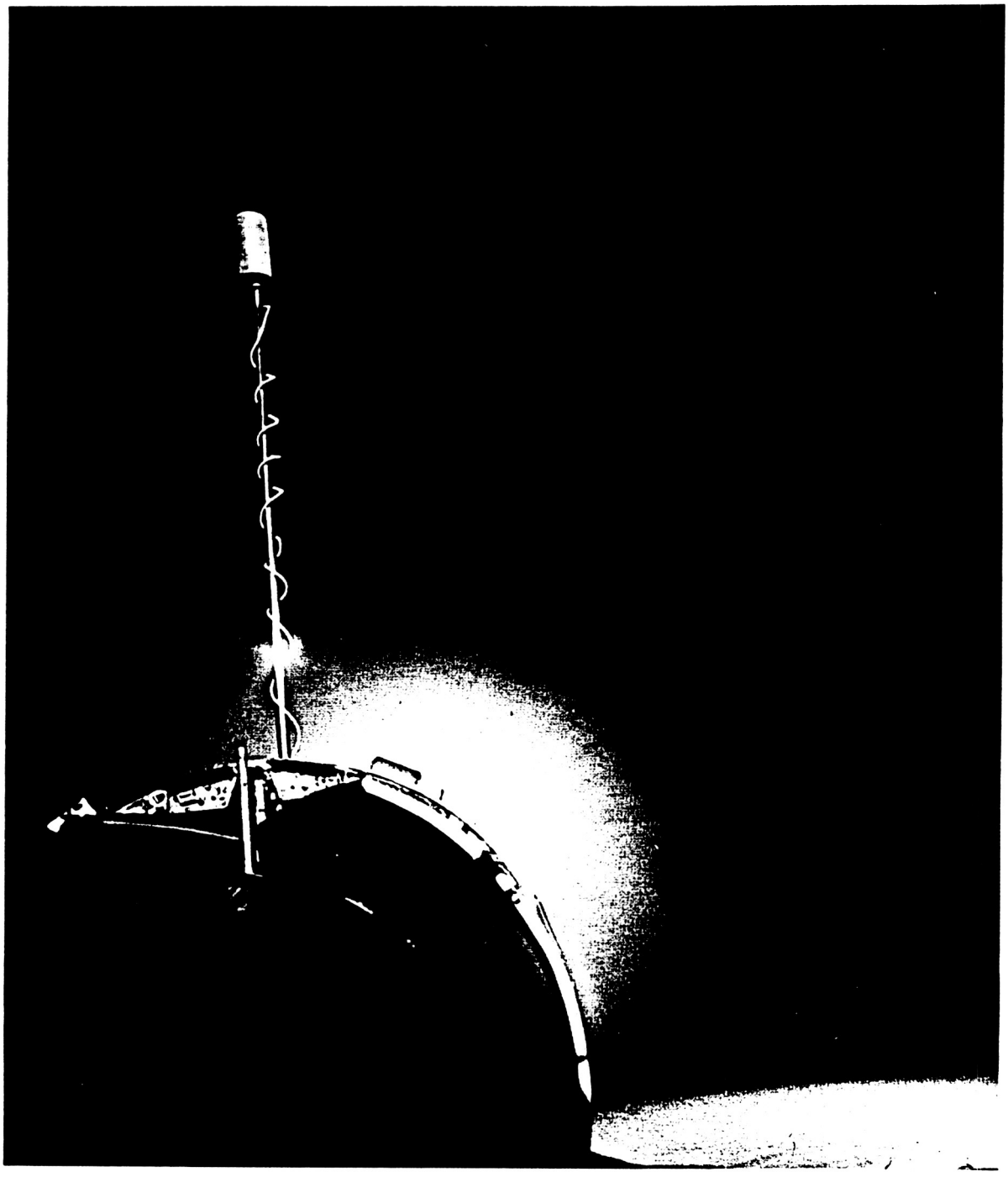

FIGURE 18–43.—Gemini X Primary Propulsion System firing.

Figure 18–43 is a photograph of the Gemini X spacecraft docked to the target vehicle with the target-vehicle status display panel and erected L-band antenna clearly visible. The glow around the target vehicle is caused by the firing operation of the Primary Propulsion System.

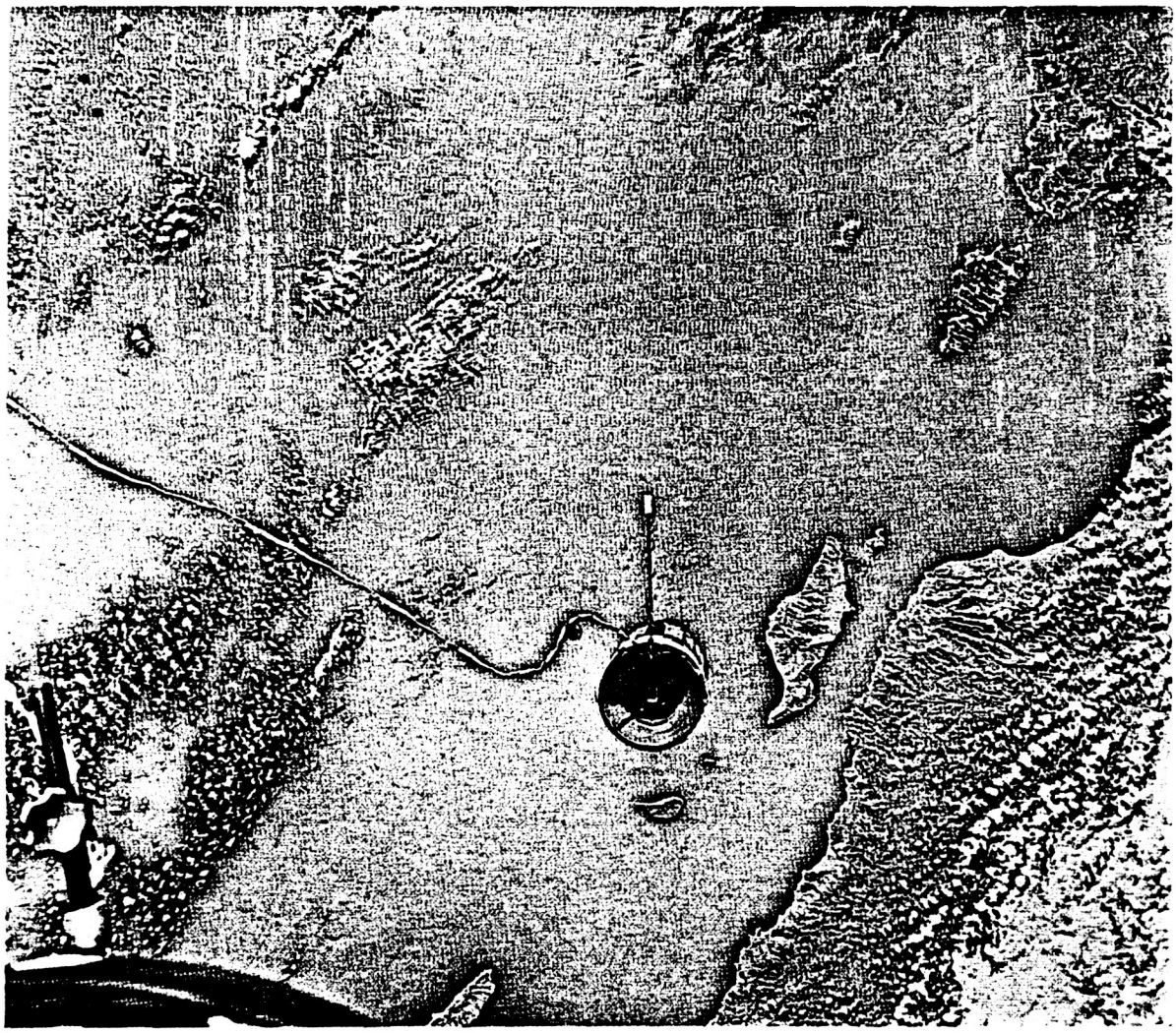

FIGURE 18–44.—Tethered target vehicle.

During the Gemini XI spacecraft/target-vehicle tether evaluation, a series of photographs was taken to show the exercise from the undocking and deployment of the tether until after the tether was jettisoned. Figure 18–44 was taken over Baja California at an altitude of about 185 miles and shows the target vehicle and the 100-foot Dacron tether.

FIGURE 18–45.—Extravehicular activity.

Figure 18–45 is one of a series of still and motion pictures taken of the Gemini XII extravehicular pilot working quite effectively while tethered to the target vehicle. This series of photographs demonstrates that man can do valuable and constructive work while extravehicular in space if the proper restraining devices are provided.

Concluding Remarks

The Gemini VII photograph of a distant full moon provides a fitting conclusion to a discussion of the photographic accomplishments of the Gemini Program (fig. 18–46). The 2400 exposures secured are all valuable, and a large number have provided information previously denied to the scientist. The two most important considerations furnished by this photographic record are found in the excellent historic documentation of the 10 manned missions, and in a clear demonstration of the feasibility of continuing with far more sophisticated photographic systems specifically designed to provide new and better information to the worldwide geoscientific community.

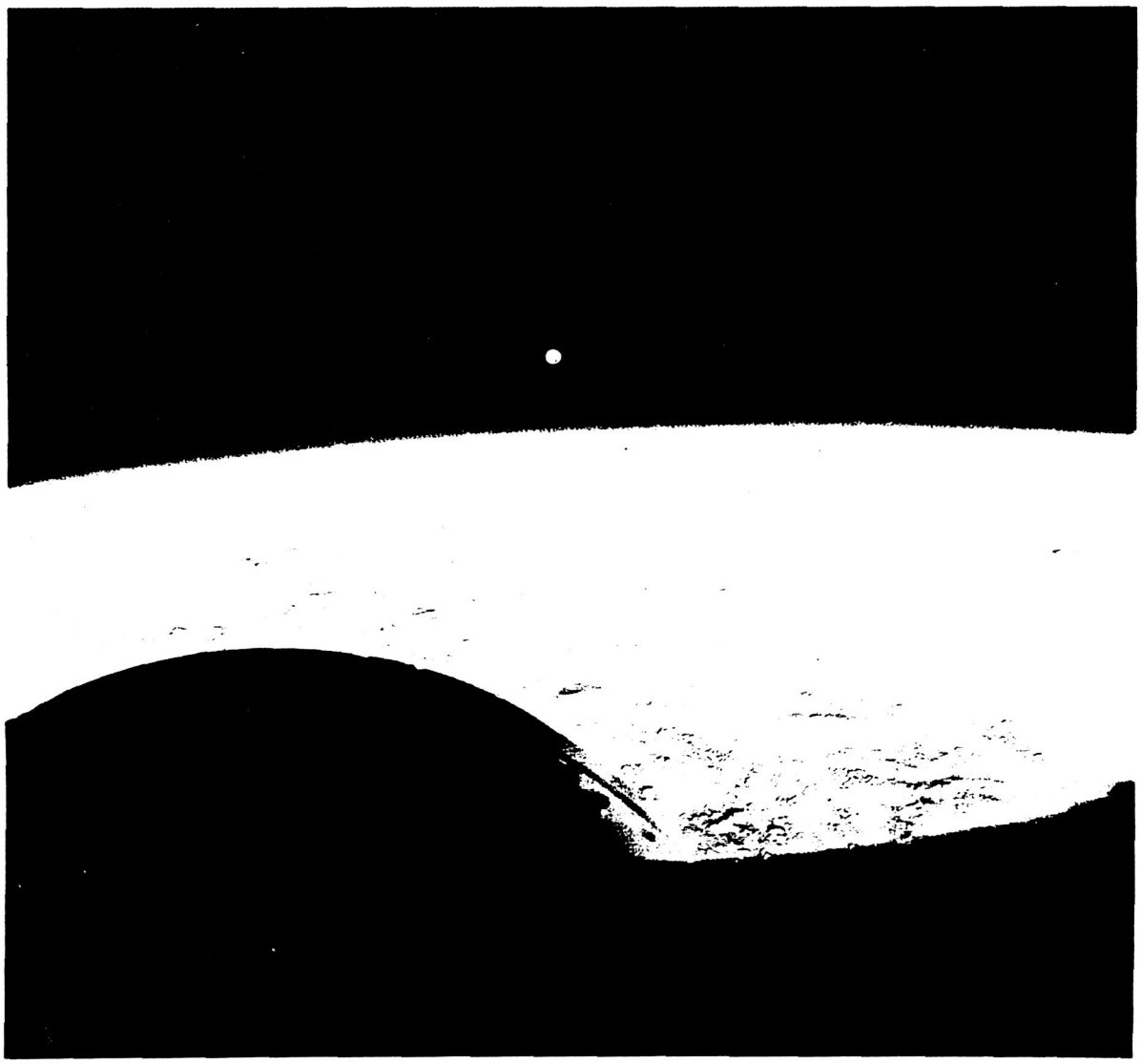

FIGURE 18–46.—Moon.