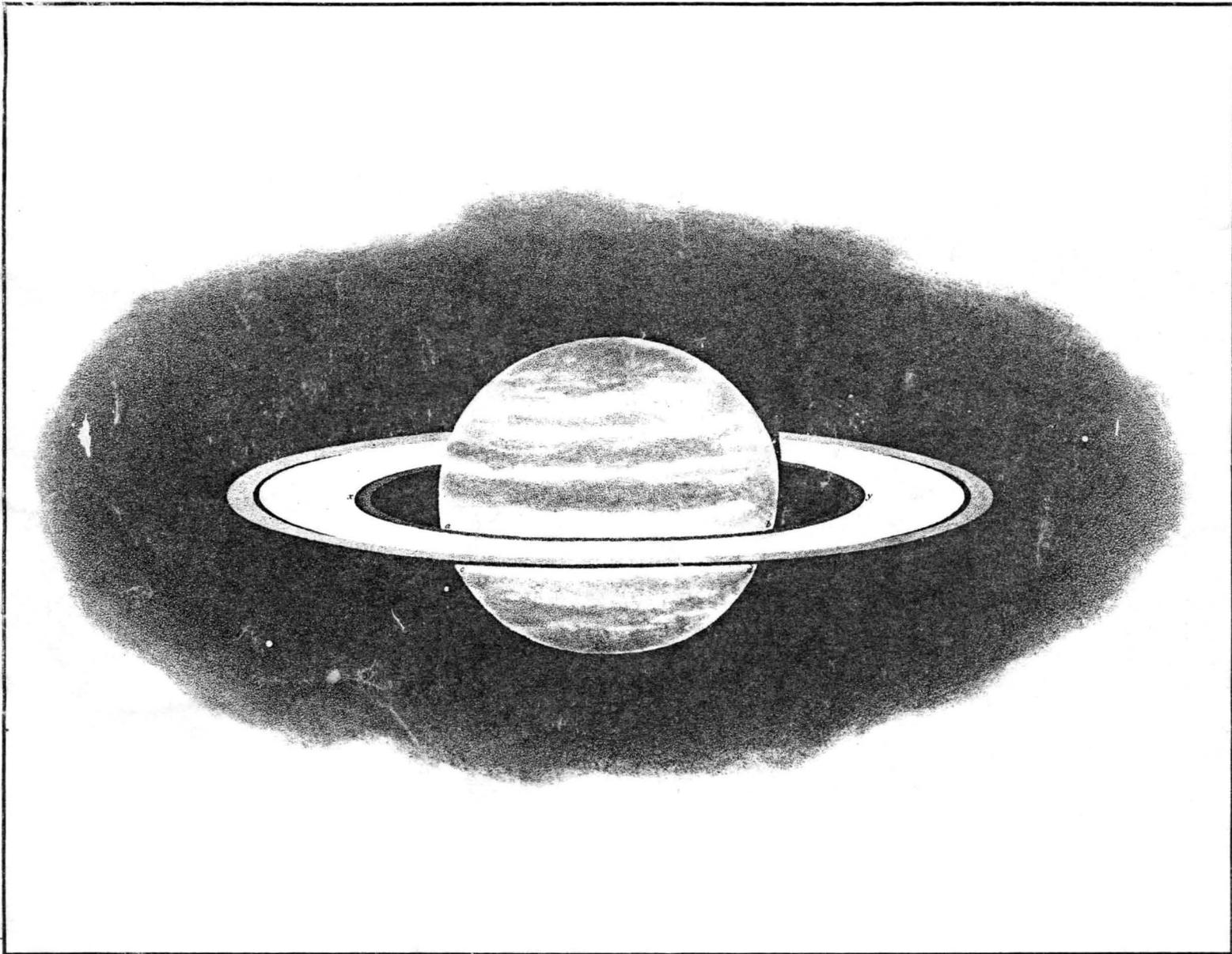


**PIONEER 11**  
**SATURN ENCOUNTER**  
**1979**



**DRAWN BY G. P. BOND**

**AQ. BY GEO. G. SMITH**

**SATURN, AS SEEN AT HARVARD OBSERVATORY, NOV. 15TH, 1850**

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Dear Colleague:

As promised, we are providing you a set of slides depicting the Pioneer 11 encounter with Saturn. We hope you will make good use of the slides and their descriptions in your courses, lectures, etc. (particularly in light of the upcoming Voyager I flyby of Saturn on November 12th).

We hope to be able to provide you with a similar slide set for the Voyager mission to Saturn soon after the encounter.

Sincerely,



John R. Sevier  
Associate Director

JRS:ck

The Pioneer Saturn Project was managed by NASA's Ames Research Center. Images were received at Ames after processing at the University of Arizona. Reproduction of descriptions and photos is courtesy of the Lunar and Planetary Institute.

AC77-1170-11

The relative sizes of Saturn and the Earth are shown.

AC79-9000

This color photograph of Saturn and its rings is one of the best ever taken by telescope. It was made by the 155 centimeter (61 inch) telescope of the University of Arizona's Mount Lemmon Observatory on March 11, 1974 at 0218 UT. The ring plane, which was seen close up for the first time by NASA's Pioneer Saturn spacecraft (formerly called Pioneer 11) on September 1, 1979, is tilted 26.9 degrees, nearly the maximum as seen from Earth. The phase angle was 6.3 degrees. Sixteen original color images, recorded on Ektachrome EF film, were combined to produce this image.

Pioneer Saturn's imaging photopolarimeter instrument yielded images with even better resolution during the historic first visit to Saturn. Pioneer Saturn, launched in April, 1973, traversed the Asteroid Belts, survived a close encounter with Jupiter's radiation belts, and arrived at Saturn with its array of scientific instruments in good working order even after 77 months in deep space. Saturn's "day" is 10 hours and 14 minutes long, the time for one rotation on its axis. Saturn is 887 million miles from the Sun, and its mass is 95 times that of the Earth.

AC79-9007.1

The first spacecraft to Saturn, Pioneer 11, is approaching the ringed planet, and will make its closest encounter September 1, 1979.

This artistic conception by Rick Guidice shows Pioneer Saturn emerging from Saturn's shadow after passing within 21,400 kilometers (13,300 miles) of Saturn's banded cloud tops.

Pioneer Saturn will send back 50 close up pictures of the planet, and some of its moon, Titan. Pioneer will determine if Saturn has a magnetic field and radiation belts, determine the nature of its interior and confirm its internal heat source. The spacecraft will study Saturn's atmosphere and make observations of a number of its ten moons.

AC79-9026

Saturn from 3,500,000 km (2,170,000 miles) on August 28, 1979.

AC79-9027

Saturn from 5,912,000 km (3,665,440 miles) on August 25, 1979.

AC79-9028

Saturn from 5,118,000 km (3,173,000 miles) on August 26, 1979.

AC79-9029

This color image of Saturn and its rings taken by the Pioneer 11 spacecraft at a range of 5,464,000 kilometers (3,395,170 miles) presents many new features of the planet. For example, the Encke Division of the rings is clearly resolved where previously it was blended with the Cassini Division. The belted structure of the planet is also beginning to emerge. A small dark spot at about 5 o'clock is due to a small bit of incorrect data which can be corrected on future reproductions. A small notch at the edge of the planet about 11 o'clock could either be a small bit of missing data or the shadow of a moon. The image was made on Monday, August 27.

AC79-9030

Saturn from 2,670,000 km (1,655,000 miles) on August 29, 1979.

AC79-9059

The moon Titan is seen for the first time by spacecraft as Pioneer completes its epic mission to Saturn on Sept. 2. In this view, made from raw data received from Pioneer at 11:30 a.m. PDT, Titan is about 370,150 kilometers (230,000 miles) from Pioneer, and Pioneer's speed relative to Saturn is about 40,400 kilometers per hour (25,100 miles per hour). When the image was made, Pioneer was 1,547,979,000 kilometers (963,000,000 miles) from Earth and 1,290,000 kilometers (800,000 miles) from Saturn. Pioneer made the first spacecraft close approach to Saturn on September 1, 1979 when it discovered a possible unknown Saturn moon and another division in the ring plane which has been dubbed "Pioneer Gap."

AC79-9101

This color photo shows for the first time the structure in Saturn's rings. The structure is shown by sunlight reflected upwards by the dust and snow particles in Saturn's rings. It is especially apparent in the outer ring where there is some structural detail. The images were made by Pioneer Saturn at 4:06 p.m., August 22, at a range of 8,360,000 kilometers.

AC79-9102

This Pioneer 11 image of Saturn and its rings was made when the spacecraft was 5,523,000 kilometers (3,425,000 miles) away from the planet on August 25. As Pioneer closes on Saturn for a September 1 encounter, scientists expect to discern the structure of the rings and see detail in the banded surface of Saturn. Two belts can now be seen above and below the ring shadow, and several spots are barely visible in the northern hemisphere.

AC79-9103

This color image of Saturn and its rings taken by the Pioneer 11 spacecraft at a range of 5,464,000 kilometers (3,395,170 miles) presents many new features of the planet. For example, the Encke Division in the outer ring of the rings is clearly resolved where previously it was blended with the Cassini Division between the two major rings. The belted structure of the planet is also beginning to emerge. A small dark spot at about 5 o'clock is due to a small bit of incorrect data which can be corrected on future reproductions. A small notch at the edge of the planet about 11 o'clock could either be a small bit of missing data or the shadow of a moon. The image was made on Monday, August 27.

AC79-9104

This blue light image of Saturn was made by Pioneer on Tuesday, August 28, at a range of 4,232,000 kilometers (2,626,000 miles). It shows some technical anomalies which cannot be immediately corrected by editing, although structure in the belts can be clearly seen. The satellite just off the planet edge at 2 o'clock is Tethys. On black and white prints it is very faint.

AC79-9105

One of the best images received yet from Pioneer as it approaches Saturn, this photo also shows Saturn's moon Titan at the upper right. In Saturn's ring plane, the Cassini Division is clearly resolved and distinct from the Encke Division. The A Ring has much higher optical depth near the Cassini Division due to more particulate matter. Polar and temperate belts are becoming more visible on the face of the planet and the photo shows no evidence of a D Ring.

The irregularities in ring silhouette and shadow are due to technical anomalies in the preliminary data which will later be corrected.

Looking at the rings from left to right, the ring area begins with the outer A Ring, the Encke Division, the inner A Ring, Cassini Division, the B Ring, C Ring, and the innermost area where the D Ring would be.

The image was made by Pioneer Saturn on Wednesday, August 29, and received on Earth at 3:19 p.m. PDT. Pioneer was at that time 2,846,000 kilometers (1,768,422 miles) from Saturn.

AC79-9107 and AC79-9107.1

A new vista of the Planet Saturn is shown in this image made by Pioneer as it closes on Saturn and its rings for a close encounter September 1. The banded structure of Saturn is apparent in this photo produced by the University of Arizona's imaging photopolarimeter instrument at 11:00 p.m. Wednesday, August 29, 58 hours before Pioneer flies by Saturn after a billion plus mile trip from Earth that started in 1973. Saturn's moon Rhea, seen as a speck of light below the planet, is the sixth moon out from Saturn. It is 1,600 kilometers (1,000 miles) in diameter, about half the size of Earth's moon.

Brightness of the rings on the right side of the planet is due to a higher gain setting on the instrument as it scanned that portion of Saturn's face. The somewhat distorted shape of the planet is due to uneven spacing of scan lines by the instrument and will be corrected by additional processing.

AC79-9107.2

### Best View of Saturn

Shown here is the best view yet available of Saturn and its rings, returned by the Pioneer spacecraft during its encounter with the ringed planet.

The picture has undergone extensive computer processing to bring out detail.

This view was taken by Pioneer Saturn from a distance of 2,500,000 km (1,500,000 mi) on August 29, 1979, 58 hours before closest approach). Resolution is better than Earth-based quality. The banded structure of the planet's cloud tops is quite evident. The silhouette of the rings can be seen against the lighted disk of the planet. Slightly above this silhouette is the shadow of the rings on the disk. Beyond the disk, structure can be seen in the rings. The rings have a distinctly different appearance in this and subsequent images than in Earth-based pictures because the rings are illuminated from below rather than from above as they are when we view them from Earth.

This means that incoming sunlight is reflected from ring particles and then through the rings. If particles in the rings are too dense, the sunlight cannot get through, and that ring is dark or black. With just the right amount of particles, the rings are very bright even from the unlit side. This unique view provided by Pioneer is allowing calculations of amounts of material making up the various rings.

The outer A ring and inner C ring are bright, and between them the B ring is dark. The Cassini Division at the inner edge of the A ring is clearly resolved and is bright. The A ring is dark just outside the Cassini Division because it has more particulate matter there. The satellite seen below the planet is Saturn's moon Rhea, which is 1,450 km in diameter, about one-half the size of Earth's moon.

AC79-9107.2 (continued)

Scientists believe that, from detailed study of this one, and other images, they can begin to see evidence of jet streams in Saturn's upper atmosphere. The slight blue edge is an artifact from the computer-enhancement procedure.

In this picture, a missing segment of the outer ring due to incomplete data has been "restored" by adding ring data from the outer portion of the complete ring from the opposite side.

The picture was made by the imaging photopolarimeter aboard Pioneer Saturn. The instrument separately measures the red and blue components of sunlight scattered from the clouds of Saturn and converts this information into numbers, radioed to Earth. The signals are then converted by computer into shades of gray on photographic film, and the two components plus a synthesized green image can be recombined into a color image very close to the planet's true color.

Pioneer-Saturn, launched in April 1973 traversed the asteroid belt, survived a close encounter with Jupiter's radiation belts, and arrived at Saturn on September 1, 1979, with its scientific instruments in good order even after a trip of over two billion miles and 77 months in deep space. The spacecraft returned an array of findings about Saturn's interior, rings, and magnetosphere, and is now headed out of the solar system.

AC79-9111

An image of Saturn's rings by Pioneer shows the structure of Saturn's ring system in detail never before seen. The spacecraft was 943,000 kilometers (585,950 miles) from Saturn. It is under these rings that Pioneer successfully traveled on the first exploration of Saturn on September 1, 1979. The image was made on Friday, August 31, at 4:00 p.m. PDT. The moon Tethys, seen at the top of the image, is 1,046 kilometers (650 miles) in diameter. The image, because of electronic reproduction, is a mirror image of the actual planetary scene.

AC79-9118

Saturn's ring system and its shadow are seen in this view from Pioneer when it was within 1,500,000 kilometers (971,200 miles) from first encounter with Saturn. Minor data anomalies appear as a dark band across the lower part of the planet. The image was made at 7:32 a.m. on Friday, August 31, twenty-four hours before Pioneer reaches Saturn. Saturn's north pole is at 2 o'clock.

AC79-9119

Pioneer, only 496,000 kilometers (309,200 miles) from Saturn, made this image of the planet's equatorial region at 3:15 a.m., September 1. Structural detail of the Saturn's cloud tops is clearly visible in this photo. The shadow of one of Saturn's moons appears as a dark speck at the lower right. Saturn's north pole is toward the upper right.

AC79-9120 and AC79-9120.1

PIONEER SATURN RING DISCOVERY

Saturn's rings now clearly have two major divisions -- the Cassini Division dividing the outer A ring from the middle B ring, already well known, and the so-called French Division dividing the Planet's middle B ring from the inner C ring.

Some French astronomers had proposed a wide gap between the B and C rings, but most astronomers had discounted this division. The upper wide black strip is the shadow of the rings seen on Saturn's surface. The shadow shows the two divisions as parallel pin stripes in the broad black band of the ring shadow. The lower pin strip is the new "French" division. The rings themselves, seen from the unlit side, are visible in the foreground.

This view was received from the Pioneer Saturn spacecraft on September 1, 1979 at 4:52 a.m. Pioneer was 395,000 km (244,900 mi) from Saturn.

Earlier, Pioneer had discovered a new ring, a thin outer band, called the F ring separated from the outer A ring by a wide gap named the Pioneer Division.

AC79-9129.1

This is an improved version of G-8 which was sent to Ames Research Center on September 6, 1979. The former image displayed the results of two IPP gain changes across the planet. These have been corrected and further rectification has produced an improved planet shape. The rings off the planet are difficult to see because of low albedo at a 90° phase angle. The saw tooth effect seen on portions of the edges of the planet and the rope-like appearance of the rings are due to data undersampling by the IPP (whereby only every other pixel element was recorded) which is a consequence of a low IPP sample rate. The low sample rate had to be employed to offset the effects of a low spacecraft transmission bit rate. Such a bit rate was necessary to compensate for radio interference from the sun whose direction almost coincided with the axis of the spacecraft and its earth-pointing antenna.

TRW-98978-73

TRW technicians at work on magnetometer boom on the Pioneer 11 spacecraft prior to its launch in April 1973. The instrument measures the interplanetary magnetic field from Earth's orbit to the limits of spacecraft communications. The 570-pound spacecraft carries 12 instruments and conducts 14 experiments. Pioneer 11 was originally designed to carry out a 22-month journey to Jupiter, which it encountered in December 1974. When it arrives at the planet Saturn on September 1, 1979, it will have flown more than 6 1/2 years and a distance of more than two billion miles. Its communication lifetime could well continue for another seven years.

S-1

Backlit image of Saturn's rings with rings and divisions identified.

S-2

Diagram showing major features of Saturn and its ring systems.

S-3

As Pioneer 10 and 11 leave the solar system, they carry this plaque with a message which shows when, where and by what kind of beings the spacecraft were launched. For complete description and history of the plaque see chapters three and four in Carl Sagan's book *The Cosmic Connection*.

S-4

Diagram of Pioneer 11 trajectory.

S-5

Diagram of Pioneer 11 ring plane crossing as viewed from earth.

S-6

Diagram comparing a proposed model of Saturn's structure to that of the Earth and Moon.

S-7

Diagram of a proposed Saturn atmospheric model.

S-8

Diagram illustrating distances to the rings and satellites.