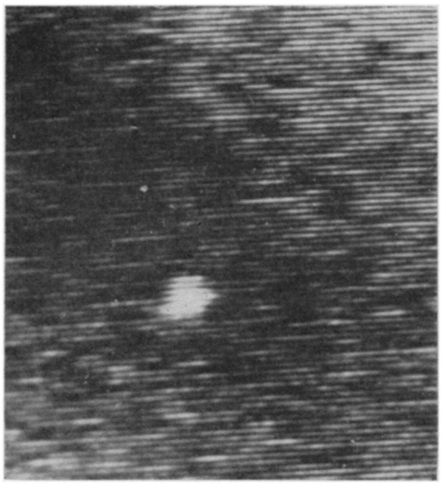
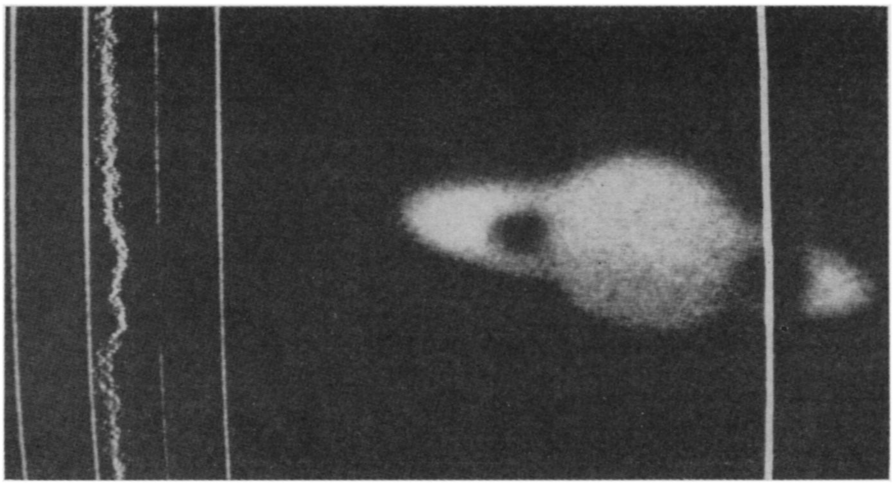


Apollo 8, seen heading moonward.



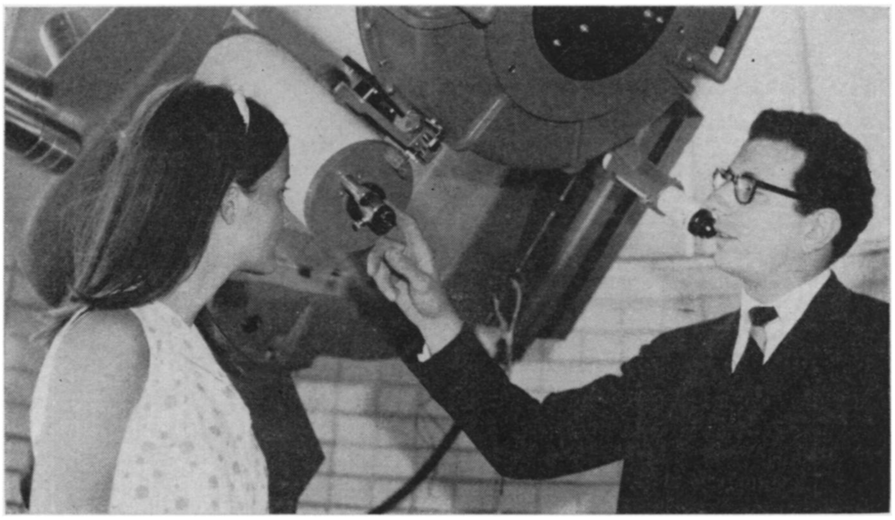
Ringed Saturn, together with reference lines used to measure luminosity.

ASTRONOMY

Replaying the stars

Borrowed from television sports broadcasting, a new tool scans the skies.

by Jonathan Eberhart



Photos: Denver Museum of Natural History

Lunetta at business end of his system. Cable from image tube is at rear.

Astronomers are constantly in search of fainter and fainter objects, and have long been investigating celestial objects whose light is far too dim even to excite the human optic nerve. Galileo and a dozen generations of his successors had only their naked eyes with which to peer through their telescopes.

The science improved with the addition of photography, and increasingly sensitive films, which enabled time exposures to capture the stars' faint light.

It was not until the middle of this century, however, that electronics were finally brought into play with the development of image tubes or amplifiers (SN: 1/14/67, p. 37). Starlight falling on a photocathode at one end of an image tube produces a proportional cascade of electrons which is accelerated down the tube to form an intensified image on a screen at the other. This gave telescopes the light-gathering efficiency of instruments as much as three times their diameter; the astronomer would simply photograph the screen.

Still greater efficiency came from another kind of amplifying tube, the image orthicon, developed by the Radio Corporation of America in the mid-1940's. In the orthicon, as in the image tube, a cathode produces a stream of electrons, but instead of forming an image on a screen they strike a target which is then read off by another beam, producing an electronic video signal like the output of a television camera.

For an astronomer, an ordinary, off-the-shelf television camera would be of little or no use; it requires a substantial amount of light. To make the image orthicon into an amplifier, enabling it to detect very tiny amounts of light, it was modified so that the read-out beam could be turned off, allowing the intensity of the image to build up, or integrate, on the target. Then, when the beam was turned back on, the much brighter image would produce a signal that would shoot out of the tube in a thirtieth of a second.

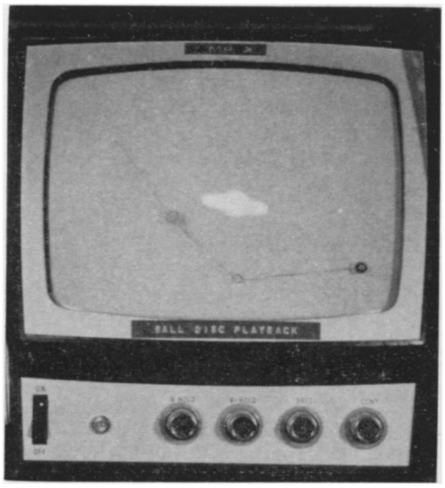
The resulting signal appears as a brief, bright flash on a television monitor, where it can again be photographed. This technique is saving hours for an increasing number of astronomers by enabling images to be captured hundreds of times faster than could be done by film alone.

Now the system has been improved again, and not even by a research astronomer.

Many astronomers have long been frustrated by what Donald M. Lunetta, curator of the Charles C. Gates Planetarium at the Denver Museum of Natural History, calls Lunetta's postulate: "The time required to get your turn at the eyepiece is proportional to the time required for a cloud to cover the subject."

Image orthicons have gone a long way toward remedying the situation by enabling images to be recorded even when there are only a few seconds of clear seeing available at a time. This was not enough for Lunetta, however. The photographs of the image orthicon monitor still had to be developed in the usual fashion before it was possible to evaluate the quality of the image.

So, together with two Denver firms, TeleMation and Elsco, Lunetta spent almost three years devising a system



Control panel is astro-replay's heart.

that borrows one of the latest gadgets from television sportscasting, the video disk recorder, or instant replay. The result is one of the most living, in-touch-with-the-space-age planetariums in the country.

On the planetarium roof is a 22-inch Schmidt-Cassegrain telescope, with an image orthicon television camera mounted to work through it. The telescope is guided, and the camera operated, both by remote control from within the planetarium's 50-foot-diameter dome. The operator aims the telescope, using a TV monitor as a viewfinder, then pushes a button if some integration is necessary in the image orthicon to bring out a faint object.

While the integration is going on, the image on the monitor disappears, then shows up as a sudden flash. The flash is also stored on the disk recorder, which then provides a lasting image of the subject, just like the stopped-motion effect used in covering football games.

Unlike a video tape recorder, in which the tape must be kept moving across the playback head, making stopped images impossible, the disk recorder preserves a moving image as a series of still pictures, each one recorded on a successively smaller concentric ring of the disk. This differs from a phonograph record, in which the grooves are not separate, but one continuous spiral. The video disk keeps moving at a constant speed, while the speed of the image's motion is varied by adjusting the speed at which the recorder's playback head moves in from ring to ring. In Lunetta's system, the head simply stays locked to the ring containing the flash from the discharging image orthicon.

If the image is a good one, the operator can easily transfer it to video tape for a permanent record. He could just as easily photograph the monitor screen, but besides having to put up with film processing time, he would then be adding whatever distortion is present in the monitor system. The video tape can record the unblemished signal just as it leaves the image orthicon.

If the image is poor, which can happen for example because the integration process builds up the internal electronic noise of the image orthicon while it builds the incoming image, the operator need only push a button to wipe out the image and integrate a new one.

The best-known use of Lunetta's system came in December, when network television viewers saw it pick out the Apollo 8 spacecraft some 150,000 miles out in space. Because of the brightly reflected sunlight, that test required only one second of integration. A single second of integration in the image orthicon in Lunetta's system produces a light-gathering sensitivity equivalent to an American Standard Association film rating of one million. By contrast, most high-speed photographic film runs no higher than 400 ASA and a few special films reach up to about 8,000 ASA. A densitometer can be used to push film as high as 32,000.

For Lunetta's purposes, the main advantage of the instant replay system is that he can project space events, almost as they are happening, onto the planetarium dome. Visitors arriving for an evening show are often greeted by the sight of the lunar surface in stark close-up, as the operator pans the telescope across the moon's face.

Lunetta is also planning to make video tapes available to schools for study of significant events in the heavens. Compared to many of the aged films and filmstrips available today on astronomy, the reality and currency of the almost-live images could make them an unusually vital teaching aid.

Besides such obvious planetarium fare as the moons and rings of Saturn, audiences at the mile-high city's planetarium have been able to see such elusive subjects as the gas clouds in the constellation Orion's belt, and even the comet Honda streaking across the sky. At present, Lunetta is using the system in a hunt for supernovas, which some lucky visitors to his planetarium might catch, though he can't announce them ahead of time.

Such a system has far greater potential than merely impressing audiences, however. On the large telescopes, the amplifier and disk recorder could serve as an aiming device in astronomical research on faint targets. Instead of having to develop film from time exposures or even photos of the image orthicon's output flash, the operator can check his results instantly, saving valuable hours of telescope time.

In such research, says Lunetta, photography would probably be used for the final recording, once the target had been found. The high resolution of film can preserve fine detail much better than can any kind of television image.

Interest in instant replay astronomy is beginning to appear outside the Gates Planetarium. At the Lick Observatory in California, a somewhat different kind of image enhancement device, consisting of an image amplifier coupled to a Westinghouse development called a secondary electron conduction TV camera, was recently connected to a video tape recorder to make possible direct television views of Apollo 8 returning to earth. This summer, the observatory plans to add a disk recorder, to enable instant replay of integrated images.

In England, astronomers at the Royal Observatory are reportedly experimenting with a technique that enables even relatively faint images to be integrated and viewed without the need for the disk. By modifying the circuitry, they are able to produce a series of integrations without completely erasing the image in between. This minimizes the flicker that would otherwise appear between integrations, so that they can observe the image right on the TV monitor without the need for recording it at all.

At Princeton University, researchers have been using light-amplifying image tubes as viewfinders for balloon-borne telescopes in Project Stratoscope for almost 10 years. Since they have only been for aiming, the images were not recorded, and the scientists have put up with the slight flicker. In about a year, however, they plan to fly such a system to make the actual observations, using a video tape recorder to record the images.

In addition, says Princeton researcher John Lowrance, they are working with image tubes modified to provide integration times of as much as two hours, compared to a few seconds in most cases. The National Aeronautics and Space Administration is also interested in such systems for use in future astronomical satellites.

Even in planetariums, however, instant replay could transform the entire notion of popular astronomy, by making the unusual events in the heavens available and visible as they happen. The potential is great, and already shows up in diverse ways. "Hippies keep coming to me and asking if they can have pot parties in the dome," Lunetta says. "It's a real freak-out."