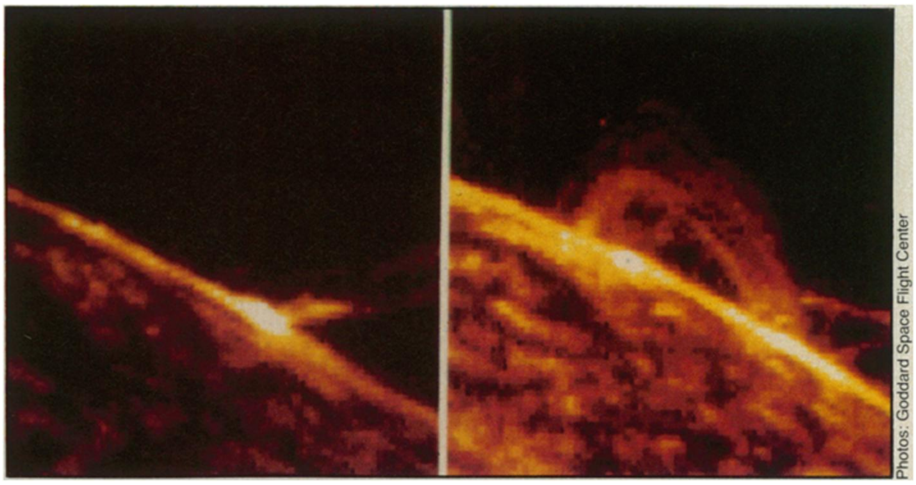
A FLAIR FOR THE SUN

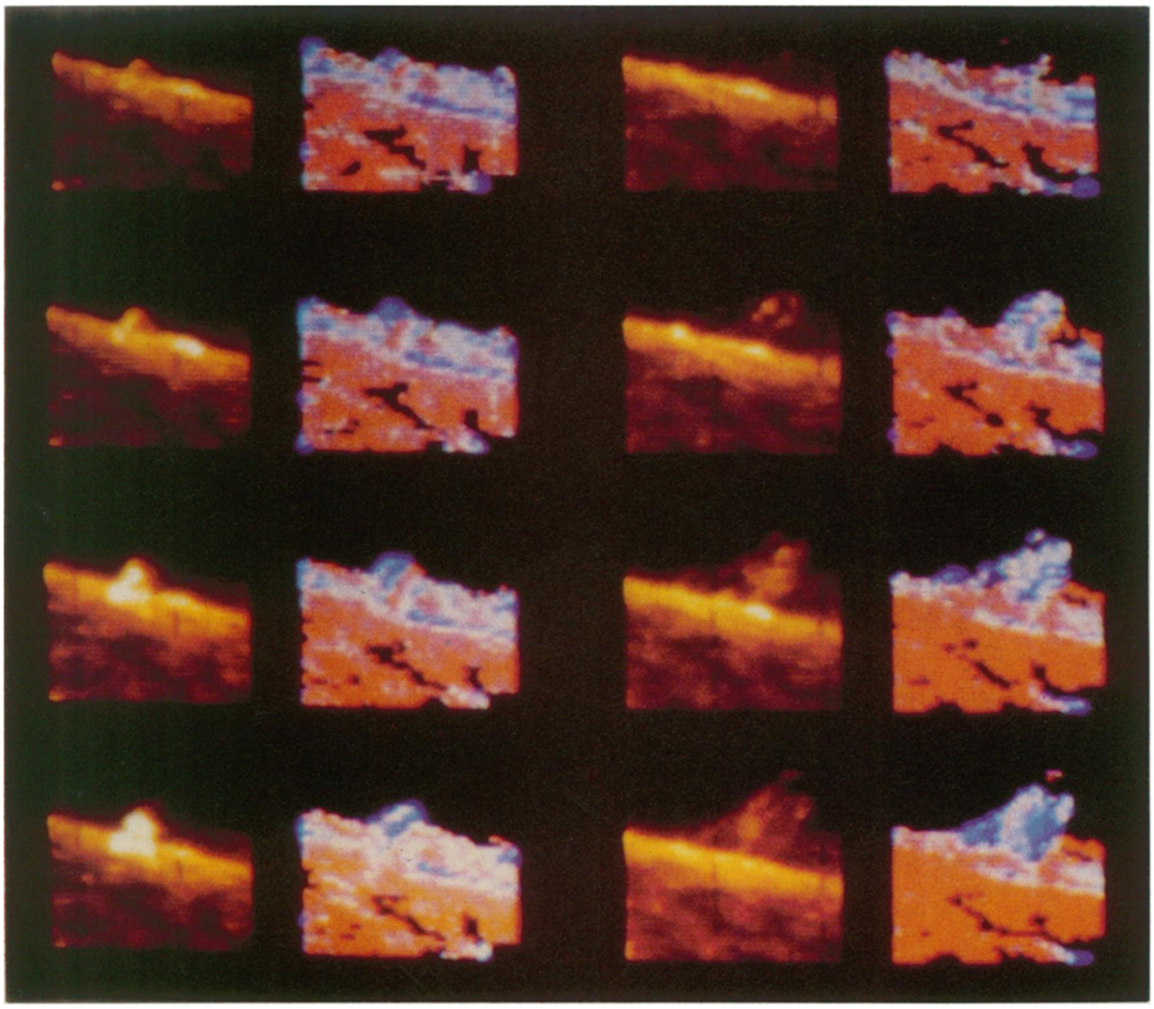
The Solar Max mission brings together seven orbiting experiments and a network of ground-based observatories to study disturbances on the surface of the sun

BY DIETRICK E. THOMSEN



Another kind of dopplergram, a close view of yet another solar prominence, also in the light of triply ionized carbon.

Below: development of a solar loop prominence recorded in the light of the spectral line of triply ionized carbon at 1,548 angstroms, emitted at temperatures around 100,000 K (orange color). The red and blue diagrams are dopplergrams showing motion of gas in the loop, blue moving toward the satellite, red away from it. Matter runs down both sides of the arch.



False colors dramatically illustrate zones of differing electron density in the sun's corona recorded by the Coronagraph/Polarimeter.

The ancients made a god out of the sun (and not only the ancients). To philosophers the sun was an orbic example of perfection. There was much consternation, therefore, back in the seventeenth century when Galileo demonstrated that the sun is a maculate conception. Since then interest in sunspots and related phenomena, loops, flares, coronal outbursts, etc., has been constant, passing gently from the consternation of philosophers to the fascination of astronomers and physicists.

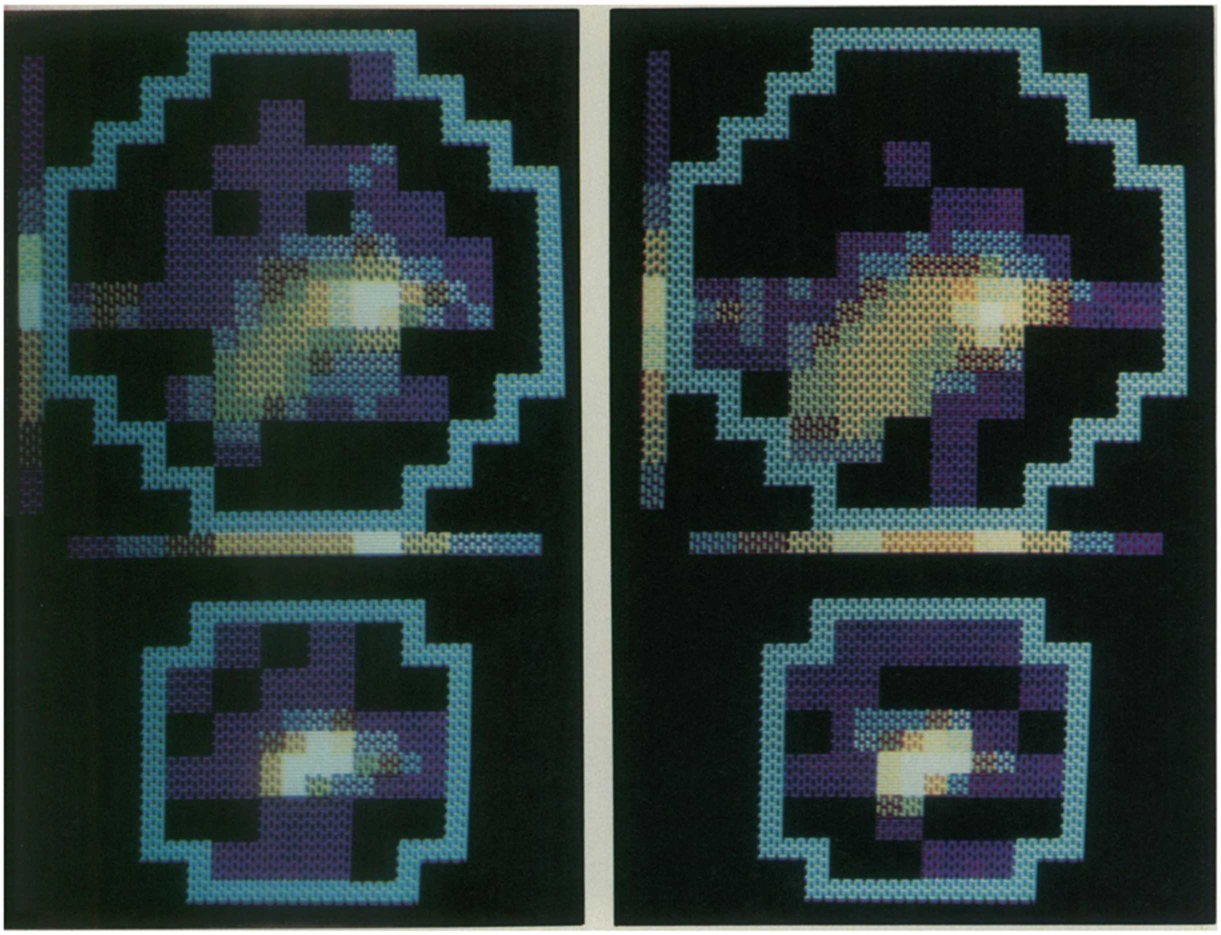
Nearly 400 years of sunspot watching notwithstanding, the scientists operating the instruments on NASA's Solar Maximum mission can still say, again and again, "for the first time." And they hope to be able to say it yet more often in the future. For the first time they have seen a theoretical mechanism for the production of a solar flare actually happen (SN:6/28/80, p. 404). For the first time they have seen solar flares that generate gamma ray line emission. For the first time they have a group of instruments on a single vehicle that can take a concerted look at a single spot or flare or active region in a broad range of wavelengths from gamma rays to red light. For the first time (necessarily) the work of such a vehicle is coordinated with the continuing observations of a worldwide network of solar observatories on the ground.

"Would you like to hear Big Bear's advice?" says David M. Rust, science coordinator for the Solar Maximum Year. He is speaking to a daily meeting of persons responsible for the management of the different instruments on Solar Max. The meeting is held at ground control headquarters at the Goddard Space Flight Center in Greenbelt, Md. Big Bear, the Big Bear Solar Observatory in California, advises that a possibly interesting active region is beginning on the western limb of the sun.

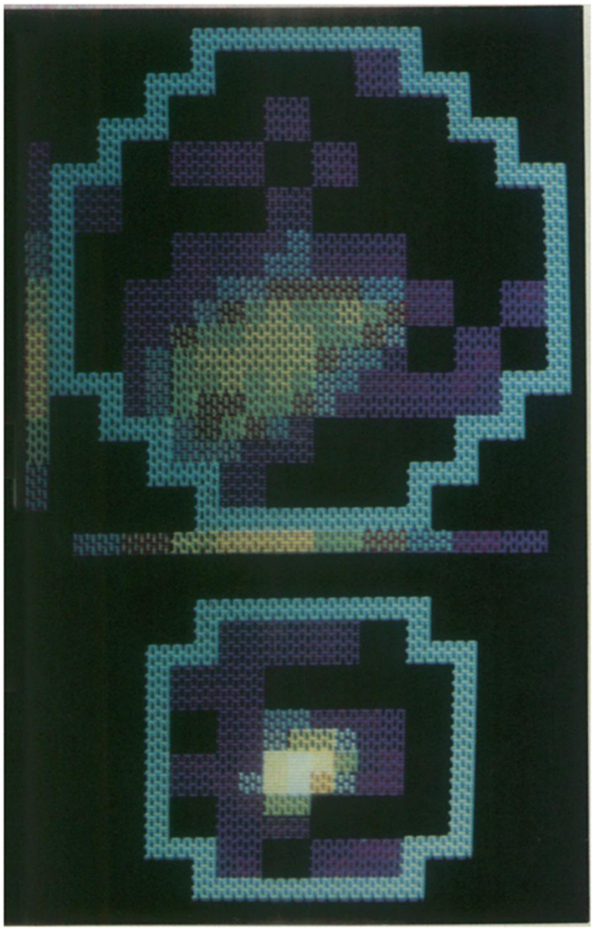
The teletype message is one of many that continually arrive in a small room just off the conference room, where David Speich, "the solar weather man," presides over a group that assembles and evaluates the messages and gives the "principal investigators" an up-to-the-minute report on the state of the solar atmosphere. In addition to the teletypes, Speich and his crew can dial up images of the sun as currently seen from several ground-based observatories. "Want to see what the sun looks like from Sacramento Peak [New Mexico]?" he says. He punches a code, and the image appears on a video screen. In the conference room itself a TV monitor bears a steady image of the sun. "Is that real time?" Rust asks. "Yes," someone replies. "There are no clouds there now." The image comes from a solar telescope in southern Maryland and is present in the conference room all day long. If clouds obscure the sun, the screen retains the last image until a new one is available.

This concern with real time is evoked by the transient and unpredictable nature of solar flares, which are the main target of investigation. "Flares are not terribly common," says Eric G. Chipman, a solar astronomer at NASA headquarters. "You're lucky if you get a good one." To see one as it happens the observer must be looking at the spot when it begins.

Picking spots is what the collaboration with the ground-based observatories is mostly about. Ground-based telescopes throw global images of the sun, on which all of the active regions can be followed. Solar Max's instruments are designed to study various mechanisms in the same solar flare. These include gamma ray emission in the hundreds of thousands to hundreds of millions of electron-volts (the Gamma Ray Experiment). X-ray emission is monitored in three ways: point by point (Hard X-Ray Imaging Spectrometer), by the amount of energy in different spectral ranges (Hard X-Ray Burst Spectrometer) and the emission at the beginning of the flare when gas is first being ionized (Soft X-Ray Polychromator). Ultraviolet emission is monitored by the Ultraviolet Spectrometer and Polarimeter. Visible light, particularly the Hydrogen alpha and Iron



Three close-ups and three longer views of the development of a solar flare as imaged by the Hard X-Ray Imaging Spectrometer. The lighter the false color in each pixel or picture element square, the more intense the X-rays recorded there. The sort of "tartan" patterned oblong represents a tongue of X-ray emitting material extending 40,000 kilometers out from the sun's edge. The sun's edge or limb crosses the picture horizontally. The sun's body is in the upper half.



XIV lines, are the province of the Coronagraph/Polarimeter. Finally, a specialized instrument, the Active Cavity Radiometer Irradiance Monitor, follows changes in the "solar constant," the amount of energy received by the earth from the sun.

All these instruments are designed to look at the same point at the same time. That has been achieved to a tolerance of about 80 seconds of arc, according to Peter T. Burr, Solar Maximum Mission Project Manager. To be concentrating on a single flare, they are designed for fairly small fields of view, characteristically a few minutes of arc square.

A minute of arc on the surface of the sun is equal to the distance between the earth and the moon, Loren W. Acton of the Lockheed Palo Alto Research Laboratory, one of the principal investigators for the Soft X-Ray Polychromator, reminds us for perspective's sake. A second of arc, the characteristic dimension of the loops of magnetized material that are precursors of flares, equals about the breadth of North America.

Even so, a square four or five minutes on a side is a small part of the sun's whole face. So the observatories on the ground watch for the appearance of new active regions, track the movements of old ones and advise about those they think likely to produce a flare. The solar weather-watchers bring this information to the daily meetings where the satellite's program is decided. It takes some trading among principal investigators and spacecraft managers, but eventually a budget of commands for the day is worked out. The satellite gets about 3,000 commands a day from the ground. It can store some until it is ready to invoke them, but it does not have long-term preprograming — that's real-time management. It can generate some commands itself. If the Hard X-Ray Imaging Spectrometer notices a sizeable explosion — most are very short-lived occurrences — it can override standing instructions and turn three other instruments onto the explosion.

Solar Max has been in orbit since Feb. 19 (SN: 2/23/80, p. 116). It is thus still at the beginning of its run, but it has shown that it can follow flares from inception to dissipation. For example, it can follow the acceleration of electrons in a flare with a resolution of one tenth of a second of time. (Electron acceleration is one of the principal things taking place.) It has found that there are flares energetic enough to energize the nuclei of heavy elements to the point where they radiate gamma rays. Theorists had expected this, but the gamma rays do not penetrate the earth's atmosphere. Now we know. Solar Max has also found small ultrahot spots on the sun, and it has noted changes in the solar constant of as much as 0.04 percent a day. It has all of 1980 and 1981 to keep looking. □