Recycling of solid wastes received a "major setback," the report concludes, and the "recycling boom of the early 1970s appeared to be over," as many volunteer recycling centers went out of business. Prospects for the long run remain promising, however, as the costs of new materials continue to rise.

Wildlife continues to bear the brunt of human expansion. Commercial ocean fishing continues to seriously reduce numbers of the most plentiful fish off U.S. coasts—populations of some stocks are only about half those of the early 1960s. On shore, approximately one out of every 10 animal and plant species native to the United States may now be endangered or threatened.

One of the most disturbing discoveries of recent research is that 60 to 90 percent of all cancer is related to environmental factors and that 15 to 40 years may pass between exposure and tumor development. The majority of known carcinogens are encountered in the workplace, but the sheer volume of new chemicals (some two million compounds are now known) has impeded full understanding of their possible hazards.

What does it all cost? Estimates by CEQ show that each American will spend (indirectly) some $98 in 1976 for environmental improvement and that costs will rise to 2.5 percent of gross family income by 1983. More jobs have been created than lost in the effort. □

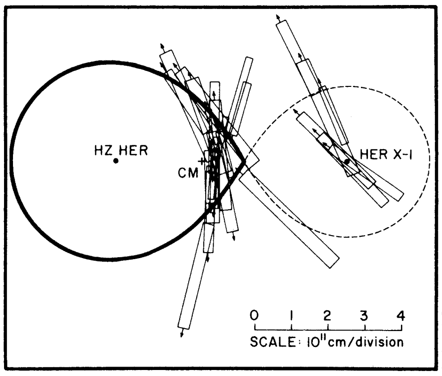
Her X-1: A middleweight neutron star

Several of the newly discovered pulsating X-ray sources or X-ray pulsars are members of binary star systems. This fortunate fact gives a hope of determining the mass of the body emitting the X-rays by studying the interactions of the two members of the binary. Determining the masses is important in deciding just what the X-ray sources are, because theory assigns different mass ranges to the possible candidates: white dwarfs, neutron stars or black holes.

Using the classical physics techniques by which astronomers have weighed stars for centuries, a group at the Massachusetts Institute of Technology determined a mass for the X-ray source Vela X-1 to an accuracy of about 30 percent (SN: 9/20/75, p. 182). Now two astronomers from the Lawrence Berkeley Laboratory, John Middleditch and Jerry Nelson, have determined the mass of Hercules X-1. The latest in sensitive optoelectronic observing equipment enabled them to make the determination, which they call "the first precise measurement of the mass of a pulsar, or neutron star." An accuracy figure of 10 percent is quoted.

Hercules X-1, as Middleditch and Nelson describe it, is a binary system consisting of an aged blue star and a dark companion that revolve around each other every 1.7 days. The gravitational interaction between the two bodies has distorted the outer atmosphere of the blue star into a teardrop shape with its pointed end toward the dark companion. Through the point of the teardrop, gas streams from the blue star onto the surface of the dark companion. This activity generates heat (to a temperature of more than 100 million degrees) that causes the surface of the dark companion to emit X-rays with an energy 10,000 times the energy of the sun's emissions.

The dark companion is a rotating body with a strong magnetic field. The magnetic field makes the X-ray emission directional like a lighthouse beam, and the rotation carries it around with a frequency of one



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Teardrop shape of HZ Herculis outlined by light flashes generated as X-ray pulses from Hercules X-1 strike its surface.

circuit every 1.24 seconds. During part of the sweep, the X-ray beam strikes the atmosphere of the blue star. The X-rays cause the matter they strike there to emit pulses of visible light.

What Middleditch and Nelson have succeeded in doing, believe it or not, is to detect these visible pulses as individual photons. To do so they used a sensitive photomultiplier tube mounted on the 61-centimeter telescope at the Lick Observatory on Mt. Hamilton near San Jose, Calif. The photon events were recorded on magnetic tape and analyzed for periodic patterns by a computer at LBL.

The results of that analysis allowed Middleditch and Nelson to determine the shape of the blue star's teardrop atmosphere, and that plus the duration of the eclipse as the dark companion passes behind the blue star (known in optical catalogs as HZ Herculis) permits calculation of the masses of the two stars. The dark companion's mass comes to 1.3 times the sun's mass, well in the range that theory predicts for neutron stars. Its diameter is about 20 kilometers.

Middleditch and Nelson hope to use the same method on other bodies, especially black holes, using the rapid light variations that should occur as gas from companion stars falls into them. □

Images of Venus by infrared

Astronomers have long studied Venus in the infrared in an effort to probe the secrets of its visually featureless atmosphere. The earliest attempts were simply full-disk measurements, basically nothing more than single, bulk temperature readings. In 1963, Bruce C. Murray, James A. Westphal and Robert L. Wildey made the first infrared "maps" of the planet, but the scan lines used to construct the maps were widely spaced, requiring the researchers to interpolate to produce their contour lines. The results thus were not true images.

Now David J. Diner, Westphal and F. Peter Schloerb of the California Institute of Technology have produced what they call the first true, high-resolution, infrared images of the Venusian atmosphere. As the 200-inch Hale telescope on Palomar Mountain scanned slowly across the planet's face in an east-west direction, the researchers used a moving secondary mirror to step quickly and automatically along measured, north-south intervals, producing a series of precise, vertical scan lines, each one arc-second wide and overlapping its predecessor by half its width.

Using a relatively large bandwidth of 8 to 14 microns, the Caltech team assumed the bright parts of the images represented a temperature of 230°K, based on the Mariner 10 spacecraft's non-imaging infrared detector. This, they report in ICARUS (27:191), implies that the features in the images are at about the 50-millibar pressure level in the atmosphere, which Diner says is about 80 kilometers above the Venusian surface.

The original, unenhanced version of the image shows what appears at a glance to be a bright spot at the south pole, bordered by a dark "collar." Actually, the scientists report, the south and north poles appear at about the same brightness; it is the dark collar, which also appears in the earlier "maps," that is the anomaly, making the south pole seem brighter.

With contrast enhanced by a computer, the image, in fact, confirms previous signs that the planet's polar limbs are darker than the equatorial limbs. The same technique also reveals a number of more subtle blotchy and band-like features, though they represent temperature differences of only 1° to 3°K. Even the difference between the planet's day and night sides (the dawn terminator is roughly along the inside edge of the bright spot at the left-hand edge of the enhanced image) is only about 2°K.

More important than the specific features in these first images, says Diner, is the potential of the precise, moving-mirror technique to show whether infrared features in the atmosphere correspond to ultraviolet ones, such as those photographed