so, an explosion could have been started by a drill creating a spark.

Another spark source is an electrical short circuit, which could come from a machine or a wheel cutting a wire. However, if voltage and current are kept low enough, sparks that start fires will not be produced. Although the Pittsburgh center is researching the design of such circuits and developing standards, applications are admittedly limited because most mining machines require high power.

Engineers in Pittsburgh are working to make an explosion quencher operational as soon as possible. It works by detecting the ultraviolet radiation in the first few milliseconds before the actual flame is seen and then explodes two metal troughs of potassium bicarbonate powder, which smothers the flame within 10 milliseconds. Moisture in the potassium carbonate and coal dust in the sensor are two potential trouble spots.

Research at the Pittsburgh center is also concerned with mine ventilation, one of the most critical safety areas. Wind tunnel experiments are conducted to determine the effects of curves and obstructions, as well as the functioning of regulators, in preventing gas build-up and bringing in fresh air. A crucial research question is aimed at draining methane off in advance of mining to prevent an explosion.

At the Explosive Research Center, also in Pittsburgh, work is being done to determine the fundamental nature of explosions in general. Research there on flame propagation through methane layers, for example, may uncover a way to minimize future explosions.

As to what caused the Mannington explosion, safety engineers may never know. By the time investigators get down into the mine, fire will probably have wiped out all evidence.

Although it is the Manningtons that get the headlines, most of the 200 mining deaths each year are caused by scattered cave-ins. So far they are responsible for 85 deaths this year. Haulage, or machine deaths, was second with 31 deaths. Before Mannington, nine deaths had been caused by explosions. Since 1952, over 5,500 miners have been killed on the job and 250,000 seriously disabled. Latest figures show 109,709 underground coal miners in the country.

Research can provide some answers to the problem, but research depends on how much money Congress is willing to allot. Much will also depend on new legislation and its adequate application and enforcement. Unless action is immediate, the Mannington disaster—if it follows the usual pattern of previous mine disasters—will be buried and forgotten in the hills of West Virginia.

COSMIC RAYS

New mysteries, not answers

Cosmic rays have been studied for fifty-odd years in the hope that they would reveal where in the universe they come from and what happens to them on the way. So far there is little certain information. And as new instruments, mainly on satellites, open up more areas to study, the result seems to be new mysteries instead of answers.

One new area, described at last week's American Physical Society meeting in Miami Beach by Prof. William L. Kraushaar of the University of Wisconsin, is that of high-energy gamma rays, in which each particle has an energy greater than 100 million electron volts.

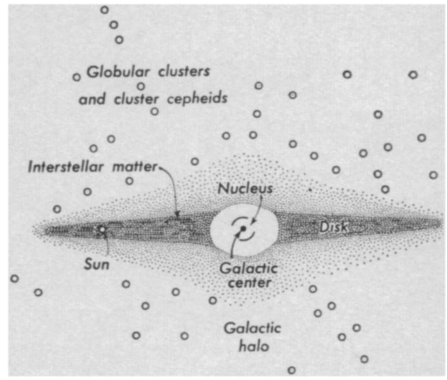
These rays, as observations by a detector mounted on an orbiting solar observatory satellite show, are particularly bright in directions parallel to the plane of the galaxy, not only toward the center of the galaxy, but also in the opposite direction, the so-called anticenter. The question, according to Prof. Kraushaar, is why the galactic plane should be so hot in the production of these high-energy gammas. Tentative solutions try to explain this by finding something that could give rise to them and is already known to be heavily concentrated in the galactic plane.

One possibility is that the rays could be produced by collisions of other kinds of cosmic rays with the interstellar gas, known to be concentrated in clouds along the central plane of the galaxy. But the distribution of the gamma rays does not correlate very well with that of the gas. The discrepancy is about 10 percent.

Another possible source is interactions of electrons, also known to be there, either with light from the stars or the cosmic blackbody radio background. In either case collisions with electrons could raise these comparatively low energy photons to the high-energy gamma ray region. But there aren't enough electrons of the requisite energies—10 times too few for the blackbody radio, 100 times too few for the starlight.

Dr. Kraushaar's final suggestion, and one he rather favors, is that the gamma rays are produced by Bremsstrahlung, radiation emitted by the same electrons when they happen to be decelerated by the influence of other particles. But, objects Dr. Reuven Ramaty of the Goddard Space Flight Center, the Bremsstrahlung explanation requires many more electrons both toward the center of the galaxy and toward the anticenter than are known to be there.

Dr. Ramaty's concern is where the



Krogdahl/Macmillan

electrons come from, and this too is a puzzle. He has studied them at all energies from one million electron volts to 300 billion electron volts. One can tell fairly well that they come from somewhere within the galaxy, he says. If they didn't—that is, if the whole universe were as full of electrons as we know the space near the earth is—then we would get far more cosmic X-rays.

Furthermore, the high-energy electrons must come from even closer, he says. The flux that should be arriving if the earth were seeing high-energy electrons from the whole galaxy does not appear, no matter which of the currently plausible models of the galaxy one uses. Dr. Ramaty concludes that the high-energy electrons cannot be produced all over the galactic disk. They must be local: less than half a million years old and from less than 1,500 light years away.

Nearer sources than had previously been supposed are also suggested for another cosmic ray component, atomic nuclei of low energy. These nuclei, with energy less than 200 million electron volts per particle, could not be studied until about two years ago, says Dr. John A. Simpson of the University of Chicago. In those two years, however, they have been looked at by satellites and probes going as far away as Mars.

The problem here is that the energies of these nuclei should fall off as one goes more and more toward elements whose neutrons greatly outnumber their protons. This decline had been calculated theoretically according to the amount of interstellar matter they should have passed through and other things that should have happened along the way. But observation does not show the energy falling off.

One way to get to what the observation shows, says Dr. Simpson, is to postulate two separate populations of cosmic ray nuclei—some that come from

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far reaches of the galaxy and others that have their origin nearby. There should be a "substantial number of sources only a few hundred parsecs (less than 1,000 light years) from us," he says.

Dr. Simpson suggests these sources may be flare stars, of which there are a good number nearby, but not enough is known about flare stars to be sure. "Flare star observation is now one of the things that's in the backwaters of astronomy," says Dr. Simpson. ◇

TRANSPLANTS

So well for so long

On Nov. 21, Dr. Norman E. Shumway transplanted a heart into Darrell Hammarley, a 56-year-old retired airline pilot. Six hours later, it became apparent that the heart was not working well. Dr. Shumway sewed in a second heart replacement, in the first such operation in history. At midweek, the patient was in good condition at Stanford University Medical Center, Palo Alto, Calif.

Following Dr. Shumway's double transplant by only a few hours, Dr. Denton Cooley of St. Luke's Hospital, Houston, gave another heart to Everett Thomas, a 47-year-old accountant who received his first new heart last May 3. Thomas, who lived longer with a borrowed heart than any other person in the United States, was rejecting that heart and failing to respond to anti-rejection drugs when Dr. Cooley made his second attempt to save him. But Thomas died less than two days after the operation.

"Denton was really shaken by Thomas' death," a colleague said. "Thomas had done so well for so long."

In some cases, a second transplant may have less chance of surviving than the first, if a patient develops new anti-heart antibodies. This phenomenon, known as myocardiopathy, afflicts about five percent of persons with heart disease and is itself an incurable disease in which the patient rejects even his own heart. When this condition is not present, surgeons believe that a second transplant could work as well as a first. This has proved true with kidney patients who have had two, and even three, new kidneys. These individuals stand a good chance of living at least two years with their new organs. Some are alive after eight years. At this time, however, the prognosis for heart patients is not as hopeful.

"I'm pleased but surprised that our patients are doing as well as they are," says Dr. Christiaan Barnard. "We subject very sick people to a major, and new, operation and have had very encouraging results, all considered."

THE MOON RACE

Apollo, Zond and LM

Charting and timing a space flight like the coming Apollo 8 moon-orbiting mission is a mathematician's nightmare.

Besides judging the moon's swing around the earth, flight planners must plan the launch at an angle that will not carry it over heavily populated areas. The launch must be timed so that several hours of daylight remain in the abort area, so that recovery teams will be able to pick up the crew if it is necessary to abandon the mission in its early minutes. The length of the mission must also be considered, so that there will be adequate lighting in the recovery area.

Apollo 8 also poses certain special problems. A major goal of the flight is for the astronauts to check out landing sites, although they will not touch down. Thus the launch must be timed so that the sun will shine on the landing sites at the same angle as it would for an actual landing attempt, so that surface features—boulders, crevasses and slopes—will appear as they would then.

Apollo landing requirements at present are that the sun must be at an angle of between 7 and 21 degrees above the horizon. Because the sun crosses the lunar sky at some 12.5 degrees per day, it is at a permissible angle for little more than a day over each landing site. There are five possible landing sites, however, stretched out across almost the entire width of the moon, so Apollo 8 will have a launch window of almost six days, from Dec. 21 to 26. The future landing mission will have the same leeway.

The Soviet Union could conceivably beat the U.S. to the punch. Four of Russia's six unmanned Luna craft, however (including both successes), touched down in the same area—the Ocean of Storms near the moon's western edge—which may mean that Russia is banking on a single site selection for its first manned landing.

This in turn would mean that Russia has only a day or two during any of the moon's 28-day trips around the earth to launch preliminary flights that will see the moon under the same lighting conditions. Zond 5 and Zond 6, launched Sept. 14 and Nov. 10 respectively, were spaced 57 days apart, just one day more than two exact lunar months. The next likely day is Dec. 8, the following one Jan. 6.

Whether the Soviet Union will take advantage of one of these opportunities for a manned moon flight is an open question.

Two facts argue against a cosmonaut going to the moon this month or next. One is the rugged winter weather in the Soviet Union, which could expose a returning spaceman to hours of sub-zero blizzard; no cosmonaut has ever flown later than October or earlier than March. Also, only one Russian has been in space since the massive space-craft redesign believed to have taken place since Cosmonaut Vladimir Komarov was killed in the crash of Soyuz 1 on April 24, 1967.

On the other hand, the prestige value of, at least, flying a man around the moon before Apollo 8 could be a strong inducement to try. Soviet scientists could be planning to get around the weather problem by landing in the comfortable Indian Ocean. Zond 5 did that.

In the U.S., moon plans have taken another step with the selection of the Apollo 10 crew, which could conceivably land on the moon. Command pilot will be veteran Thomas P. Stafford, who has logged almost 100 hours in space. Second in command will be John W. Young, who filled the same role on the first manned Gemini mission and later commanded Gemini 10. Perhaps the trickiest job, however, will be that of former Gemini 9 commander Eugene A. Cernan, who will pilot the spidery lunar module—which may be the item that will keep Apollo 10 from landing on the moon.

In the first place, Apollo 10 will be only the second manned flight of the lunar module, which has the job of ferrying the astronauts down from a lunar orbit to the moon's surface and back.

Another difficulty is weight. The LM has grown some five tons from its original design weight of 22,000 pounds. Increases in booster strength have enabled a new weight ceiling of 32,000 pounds, but engineers at the Grumman Aircraft Engineering Corp. in Bethpage, N.Y., have still had to struggle to save every possible ounce. The first Apollo mission now scheduled to get a LM with the full weight-saving treatment—"the first one that could be landed on the moon," says a space agency official—is Apollo 11.

The other obstacle between Apollo 10's LM and the moon is electronics—the black boxes that are custom-tailored for each mission. "Some of the electronic components aboard the LM 4 vehicle (the one now assigned to Apollo 10) were not designed and installed with a lunar landing in mind," says a Grumman official. The appropriate boxes could be transferred from Apollo 11's LM, but the change would probably cause another delay in the Apollo lunar timetable.