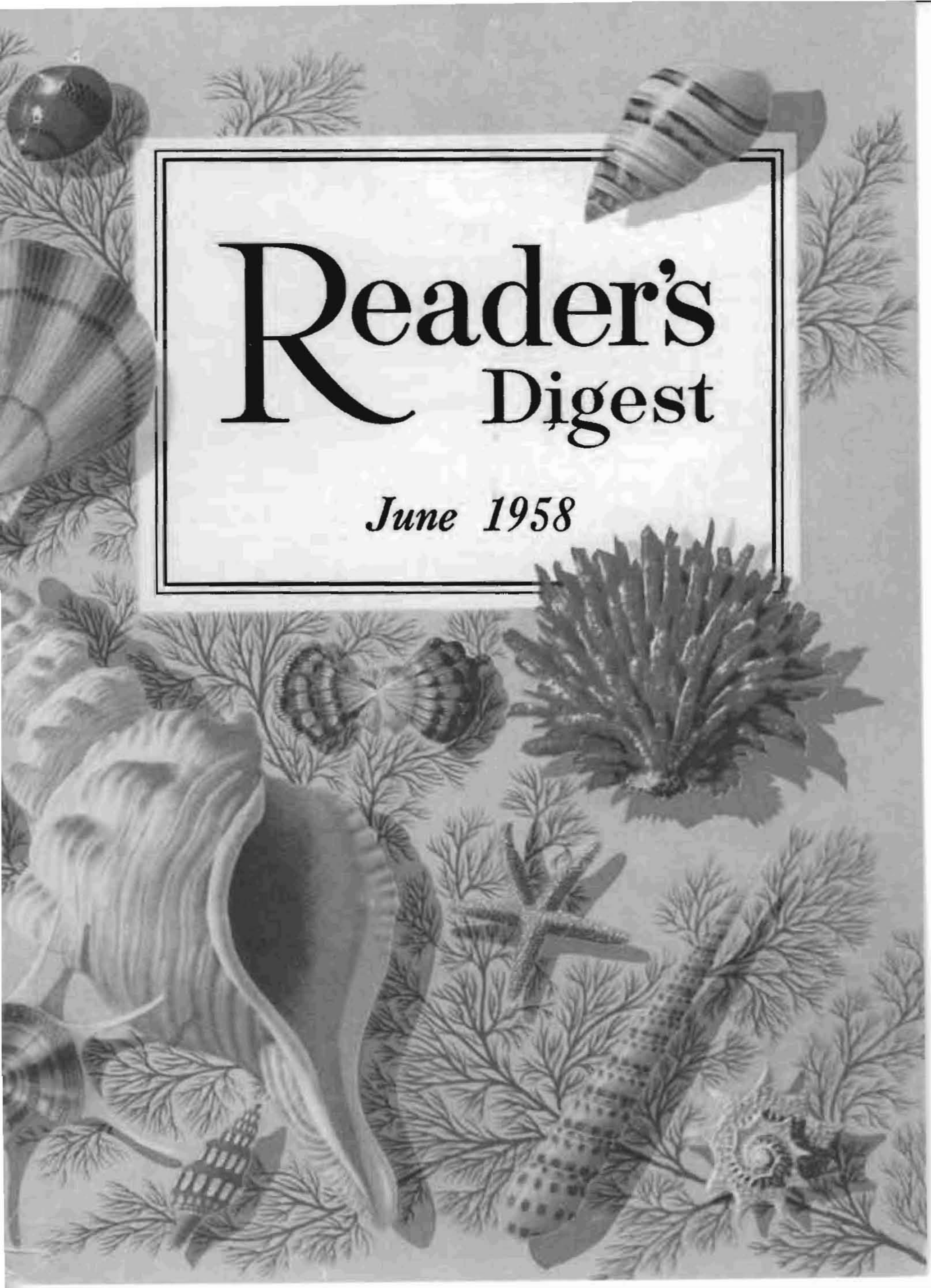

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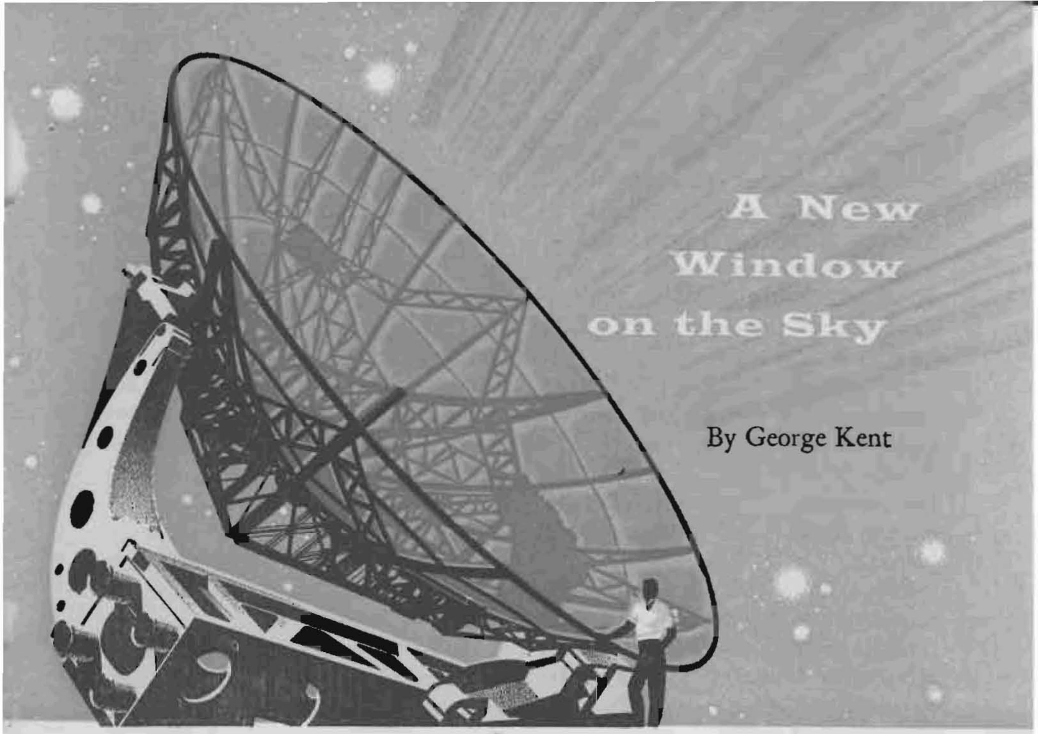

Radio astronomers are learning secrets of the universe by tuning in on broadcasts from outer space

Late one night in 1932, Karl Guthe Jansky was listening in on a radio receiver hooked up to a 100-foot antenna which he had built on an abandoned farm at Holmdel, N. J. A brilliant young research engineer, Jansky had been assigned by Bell Laboratories to make a study of radio static. Suddenly he picked up something he had never heard before—a mysterious hissing, like a long-drawn-out *whooshshsh*.

Next night the sound was there again and it puzzled him. Bell Labs had asked him to identify noises which were interfering with transatlantic radiotelephone conversations. Jansky had already found several sources of interference, such as man-made static and electrical storms. But this noise was different: it was like a loud, constant whisper coming always from the same direction. Nearby factories did not explain it, nor did broadcasting stations. A methodical worker, Jansky listened for it every night for several months, noting in his log the time when it appeared.

One quiet night, reviewing his records, he was astonished to find that the hiss had been coming in with clocklike regularity four minutes earlier each night than the night before. He checked a sudden hunch in an astronomy textbook and almost fell off his chair as the truth came bursting from the page. Because of the earth's revolution around the sun, stars rise and set each day four minutes earlier than the day before! The static came not from somebody's vacuum cleaner or electric razor . . . it came from the heavens.

Poets have talked about "the music of the spheres." Jansky was the first person to hear it. The result was radio astronomy, one of the most exciting discoveries of the 20th century.

Radio astronomy is not looking at, but *listening* to, the skies. Heavenly objects broadcast. Not only do they hiss—they rumble, they grind, they crackle. These impulses, picked up by radio telescopes with enormous antennas and powerful amplifiers, give scientists a fuller picture of the universe than they have ever had before.

With optical telescopes we've only been looking through a crack in the window. Such telescopes must work mostly at night and they can see only a small percent of the stars in the field. The rest are hidden by interstellar dust clouds which stop the light waves. But radio waves easily penetrate clouds, and come through day and night. With radio astronomy our window on the sky is always wide open.

Radio telescopes have already traced whole systems of stars that were previously undetected. Practical applications are coming, too. Ships crossing the ocean are beginning to steer by an offshoot of radio astronomy—the radio sextant. By means of a special antenna, the device tunes in on the sun and follows it like a sunflower whether it can be seen or not. In time, the same instrument will operate at night, guided by the stars. Intercontinental missiles also will be capable of being steered accurately and inexorably by emissions from the stars.

Radio telescopes may even reveal how the universe began (or whether, indeed, it *had* a "beginning"). The most powerful optical telescope in the world, that atop Palomar Mountain, can penetrate up to two billion light years into space—the distance that light, moving at 186,300 miles per *second*, would travel in two billion years. Radio telescopes could theoretically pick up signals from three to four times this unimaginable distance. This would permit astronomers to observe what might be called "the edge of our universe," where radiation emitted perhaps at the time of the universe's very beginnings could be detected.

The noises detected by radio telescopes are really light waves too long to be seen by the eye. Extremely hot objects like the sun and the stars radiate mainly short-wave *visible* light. Cooler objects, like the formations of gas that surround the stars, emit long waves that are identical with the waves used in broadcasting. The sky is literally crackling with this radio "noise."

Astronomers were slow to recognize Jansky's discovery. When he read a paper about it in 1933 to a meeting of radio engineers, few were impressed. His boss told him to stick to ordinary static, and reluctantly he did so. In 1950 he died at 44.*

But another young American had caught fire from Jansky's report, and for ten years he was the world's only radio astronomer. Grote Reber fixed radios during the day; nights he spent building a radio telescope in his back yard in Wheaton, Ill. It was a 31-foot-wide pie plate with an upright rod in the center. He did the work himself because he couldn't afford the $7000 a construction company asked.

Reber confirmed all of Jansky's findings and carried the work further. He was the first to give the rough locations of a number of radio "hot spots" in the sky: one in Cygnus, another in Aquila, another in Canis Major, and many others. He was the first to note that the familiar bright stars of our sky do not broadcast, that most of the emissions come from seemingly empty space. He made the first radio map of the heavens.

In 1940 he wrote a report on his findings, and, once again, nobody was impressed. But then the war came, bringing radar.

In February 1942 a series of blasting noises blacked out regular radar reception in England. It was feared that the Germans had succeeded in jamming the system. But physicist J. Stanley Hey investigated and found the true explanation: the interference was caused by radio signals from the stars. The Americans were right!

Other radar men were having the same experience—in America, in Australia, in Holland. The moment the war was over, these men rushed to enjoy a period of pure science. In a dozen countries they pointed their radar bowls at the sky in an effort to find out more about the elusive broadcasts. All they knew was that the radiation was there—a shapeless noise that could not be pinpointed. The problem was to figure out from which star or stars it came.

To trap the ultra-long waves they built better focusing devices by increasing the size of the radar bowls. Today's radio telescopes operate on the same principle. As the waves from space roll in, the bowls concentrate them as a telescope mirror focuses light, and send them through powerful amplifiers that can raise a faint signal to an audible sound. Astronomers don't actually listen to the sound, however. The impulses

*Although the importance of Jansky's discovery was not fully recognized during his lifetime, his name is ensured a permanent place in radio astronomy. Just as Watt, Ohm, Volta and Ampère were honored for their pioneer work in electricity by having units of electrical measurement named after them, so with Jansky. The strength of radio emissions is measured in janskys.

drive a pen which writes a scribbly line like a cardiograph and it is this visual graph which is studied.

Gradually astronomers learned to identify separate signals. When, for example, the scribble rises in an elongated loop or lurches sharply to left or right, the astronomer knows he has a signal from a single stellar object. He then tries to locate it by the direction of his beam and his general knowledge of the heavens. The aim is always to find some visible object in the sky that can account for the radio signal.

It was an observation made by Stanley Hey that established the course of the new science. In 1947 Hey distinguished a signal coming from an apparently empty space within the constellation Cygnus (the Swan). It came on his chart in narrow, wavering lines, as if the source were twinkling. Bit by bit radio astronomers around the world hemmed in the noise to an ever-smaller area.

Optical astronomers trained their instruments on the area, but could find no visible source for the signal. Then in 1951 Walter Baade and Rudolph Minkowski of the Mount Wilson and Palomar Observatories, armed with new radio telescope readings, turned the giant Palomar telescope on the spot. A curious smudge appeared on the photographic plate.

To Baade's trained eye the tiny smear of light could have only one meaning: it was a picture of two galaxies colliding in space, millions of stars rushing upon one another with a clash of vast clouds of gas. These worlds-in-collision lay an estimated 270 million light-years away, so far that even the Palomar telescope might have overlooked them. Here was dramatic confirmation of Hey's discovery.

In Australia, John Bolton tuned in on a strong signal which came from the exact spot where Chinese historians had reported seeing an exploding star back in 1054. The explosion was so bright that it had been seen in the daytime. A few months later Bolton had definitely identified the source as the Crab Nebula. He attributed the radio signal to agitated fragments of the star which exploded 900 years ago. Soon other radio signals were attributed to fragments of other exploded stars.

Up to now we have detected several thousand objects in the sky that transmit radio waves, but only about 60 of them have been matched with visible objects. In our own solar system we have heard faintly from most of the planets and have received strong signals from Jupiter and from the corona of the sun. The other signals come from objects that either are too far away to see or are by their nature invisible to optical telescopes: certain highly agitated gas clouds, remnants of exploded stars, colliding galaxies.

Scattered around the world today are some 100 radio telescopes. All are flowers of the seed sown by Karl Jansky, and a stranger collection of blooms no one can imagine. Some are tall, others slink along the ground. At Ohio State University, Prof. John D. Kraus operates one that looks like a gigantic rake with each 12-foot tooth wrapped in a steel coil.

Cambridge, England, has an apparatus as big as a football field that looks like a series of great iron clotheslines. The radio telescope at Nançay, France, is a huge cross, a mile long, on which are mounted mobile antennas that resemble squat searchlights. The biggest of all, described as "the world's largest scientific instrument," rises on 180-foot towers near Manchester, England, and consists of a 250-foot dish that can be spun and pointed in any direction. The dish is tilted by battleship gun turrets and is mounted on locomotive wheels riding a circular track.

Scientists predict that still bigger and better models are coming. Astronomy may even one day emerge from its towers and take actively to the upper regions with which it is most familiar. One good reason for going to the moon, it has been suggested, would be to build there a vast antenna system, hundreds of thousands of miles long winding in and out of the craters. There the radio astronomers would at last be in a position to listen clearly and sharply to the vast orchestra of stars.

Johnny Can Read!

FROM A review of children's science books by Robert McCary in the San Francisco *Chronicle:* "All three of these non-fiction books are written in clean, simple English that can be understood by any child and by many adults."

TOMMY H. Troland, a New London, Conn., nine-year-old with a passion for astronomy, was looking through a new textbook. "I noticed something kind of crazy about a picture of an eclipse," he says. "The caption said the picture showed an eclipse of the moon. But it looked more like an annular eclipse of the sun to me."

(An annular eclipse—for you grownups—occurs when the moon passes over the face of the sun and a thin ring of light shows around the edge of the moon.)

"I thought it had to be a solar eclipse," the nine-year-old continued, "because the earth's shadow is too big, when it's on the moon, to leave a ring."

Tommy showed the mistake to his father, who wrote the publishers. An astonished editor wrote back that the error, which had gone undetected for two years, will be corrected in the next edition. —AP