Superconductivity in the powerhouse

Superconductivity, the property of certain substances to pass electric currents without resistance at temperatures near absolute zero, promises large power savings if and when it can be applied to large-scale electrical equipment. One that is likely soon to be a benefit to many nonscientists is superconducting generators for power stations.

According to a review paper delivered at the meeting of the American Physical Society in New Orleans last week by J. H. Parker Jr. of the Westinghouse R&D Center in Pittsburgh, such devices are very nearly ready to be connected into utility systems. Their present state results from a worldwide research and development effort that began in the late 1960s. Small test models have been completed in several countries, including the United States, France and the USSR. Now, designs of a practical size for utilities are on the way.

Details of design vary from research group to research group. Parker concentrated on the one most familiar to him, a 300 megavolt-ampere machine being built by Westinghouse in collaboration with the Electric Power Research Institute. This machine is expected to be ready for delivery to a utility by 1985. The utility that will most likely receive it is the Tennessee Valley Authority's Gallatin plant in Tennessee.

Actually it is only the rotor, or revolving part of the generator, that is superconducting. It was not found practical to use superconductivity in the high magnetic field conditions of the armature or stationary part. The conventional copper coil windings of the rotor are replaced with niobium-tin alloy supported by nonmagnetic material and cooled to a temperature of 4 kelvins by a constant flow of liquid helium from a nearby refrigerator. Although the armature is not superconducting, it had to be redesigned as well. The conventional teeth around which the coil windings are usually laid were removed, and the coils are wound in a flat "pancake" stack that makes a high-voltage armature.

As the superconducting magnet, which is the rotor, turns, it induces an alternating current in the armature. There is a possible back reaction: The current in the armature generates time-varying magnetic fields, and these fields may penetrate the windings of the rotor, inducing time-varying currents there. A superconductor will pass direct current without resistance, but if a time-varying current, especially an alternating current, is applied, there is a so-called a.c. power loss, which is analogous to resistance, and which can heat the coils, conceivably even to the point where superconductivity is suppressed. The rotor must therefore be protected from these time-varying fields, and shielding had to be designed for it.

All these major conceptual changes entailed many alterations in other systems that go to make up the whole generator. Much of the research and development effort went to make first computer models and then physical models, component by component and system by system, and test them thoroughly before beginning construction of a whole machine.

Superconductivity should make power loss in the field coils of the rotor go to zero, and that in turn predicts a total apparatus with about one-third the power loss of a conventional one. Other benefits include the high-voltage armature, improved system performance, smaller size and weight and lower initial cost. By some time after the turn of the century superconducting generators may surpass conventional ones in maximum power rating. For conventional generators that is 2,250 to 2,500 megavolt-amperes; superconducting ones may be able to go to 3,500. Superconducting generators should respond better after a "fault" on the line. A fault can be a lightning stroke, an arc between two transmission lines or the grounding of a line. In these cases the generator sees a zero load but continues to deliver power. After a short time under this condition it will go out of synchrony with the rest of the grid. The higher reactance of the superconducting machine gives it a longer time margin than conventional machines. This can mean a significant economy: fewer redundant transmission lines. The faulted line does not have to be switched off as quickly so the system has longer to find alternate pathways.

— D.E. Thomsen

Chiron: A comet to be?

"Slow-moving Object Kowal" seemed a rather cumbersome name for a natural body orbiting the sun, but four years ago it was the least-committal term astronomers could think of as a temporary label for the strange discovery by the Hale Observatories' Charles Kowal. It was just a short streak on some photographic plates taken in October of 1977 (SN: 11/12/77, p. 311), and even though it was soon located on plates from as long ago as 1895, its nature remained a mystery. Following an elongated path that carried it from just inside Saturn's orbit out nearly to that of Uranus, it was far from the domain of accepted asteroids; on the other hand, the photographic streak, caused by the object's motion, revealed none of the fuzziness that might have identified it as a comet (though such fuzziness would be unlikely so far from the sun). Soon after the discovery, Kowal named the object Chiron, after one of the Centaurs of Greek mythology, but it still remained poorly understood.

Now a group of astronomers has added a bit to the scanty Chiron data bank.

Heretofore, it has not been possible even to make a reliable estimate of Chiron's size, since its brightness on the plates could represent a small shiny (i.e., ice-covered) object, a large dark one, or something in between. A clue, however, comes from William Hartmann of the Planetary Science Institute in Arizona, Dale Cruikshank and R. W. Capps of the University of Hawaii and Johan Degewij of Jet Propulsion Laboratory in California, writing in the forthcoming Icarus (47:333). Most objects in the outer solar system, they note, fall roughly into either the bright or dark category, and produce about the same groupings when separated by their colors in the J, H and K bands of the near-infrared spectrum. Since neither the albedo nor diameter of Chiron is known, the researchers took the only available avenue, using the NASA three-meter infrared telescope on Hawaii's Mauna Kea to measure its JHK colors.

Early estimates of Chiron's diameter ranged from 100 to as much as 400 kilometers. The JHK colorimetry, however, according to Hartmann's group, seems to be consistent with that of objects having extremely dark surfaces, which suggests Chiron to be from 310 to 400 km across. This could make it larger than all but four of the thousands of known asteroids, as well as many planetary satellites.

It does not mean, however, that Chiron is necessarily a rocky body. Recent studies have indicated that as little as one percent by weight of dark material such as that of carbonaceous-chondrite meteorites can radically darken the surface of an otherwise icy object. So not even the JHK colors can rule out the possibility that Chiron is the sort of "dirty snowball" or "dirty iceberg" believed by many researchers to characterize the nuclei of comets.

Yet comet nuclei are thought to be far smaller; even comet Halley may have a solid core no more than one or two kilometers across. The answer may lie in the fact that, even at perihelion, Chiron does not get close enough to the sun to have lost any of its ices. But if that is true, can it indeed be considered a comet? Orbital analyses by other scientists (E. Everhart, H. Scholl) have suggested that gravitational perturbations from the stars and outer planets could have brought Chiron in from the "Oort cloud" (far beyond the orbit of Pluto) where comets are believed to be concentrated. On the other hand, Chiron's present orbit, though its period is believed to vary from about 47 to 51 years, seems stable enough to indicate that perhaps subsequent gravitational effects have brought its inward wandering to at least a temporary halt. In effect, Chiron could be an ice-rich ball, like many of Saturn's moons, waylaid on the road to comethood.

—J. Eberhart