

to be replaced if its condition had been known. There were metal flakes in the grease, and several of its rollers had damaged surfaces. But the bearing's 17-inch-diameter shaft could still be turned by hand. Although worn, this bearing had not obviously seized up.

The investigating team is advising the observatory staff to be very careful in taking the debris apart during cleanup. "It's a very live set of wreckage," Matyas said. "I saw it from one month to the next and it was a different pile."

Looking backward

The 300-ft was designed in 1960 to serve as an interim radiotelescope while the more sophisticated, \$14 million, 140-ft was under construction nearby. Bids were called in February 1961, the steel support structure was put up by the end of 1961, the open aluminum-mesh surface was completed by August 1962, and in January 1963 routine observing began on the 300-ft. Its construction cost was a relatively low \$850 000 because it was made of standard structural steel

members. Total costs of \$3.5 million (or \$10 million in 1988 dollars) included buildings, instrumentation, and resurfacing and upgrading to a fine aluminum mesh to allow observing at wavelengths as small as 6 cm—far shorter than the 21-cm spectral line of neutral hydrogen.

The observing log records 178 830 hours of observing with the 300-ft from 1 January 1963 to 15 November 1988. This represents 80% of all night and daytime hours. Very little time (only 3%) was lost to weather and equipment failure. The remaining 17% was used for routine maintenance, resurfacing, painting and changes in equipment. In fact the 300-ft was about to be outfitted with a new spectrometer and timing analyzer for redshift surveys and pulsar searches. During its observing lifetime the radiotelescope had 1036 users, of whom about 25% were students; 53 of these students got at least some of their doctoral thesis data by observing with the 300-ft. Often participating in radio surveys undertaken by groups of radioastronomers, the NRAO staff used about 24% of the

observing time.

The 300-ft telescope discovered about 25% of known pulsars, including the pulsar in the Crab Nebula; mapped gaseous content in galaxies based on 21-cm neutral hydrogen; and compiled redshift surveys of galaxies and general radio-sky surveys. The Tully-Fisher relation between a galaxy's luminosity and the width of its 21-cm neutral hydrogen spectral line was based largely on NRAO 300-ft observations in 1977. That relation represented a significant step in improving distances compiled in large redshift surveys of galaxies, many of which were undertaken with the 300-ft.

"The telescope has detected more radio sources than all other radiotelescopes combined," George Seielstad, NRAO's assistant director, told us. When it collapsed, it was nearing completion of a repeat of a radio-sky survey of some 100 000 sources (at 5 σ -level detection) brighter than about $18 \times 10^{-29} \text{ W m}^{-2} \text{ Hz}^{-1} \text{ sr}^{-1}$ at a wavelength of about 6 cm.

—PER H. ANDERSEN,

WITH REPORTING BY WILLIAM SWEET

FAS AND BRAZILIAN PHYSICISTS DISCUSS IMPROVED NUCLEAR SAFEGUARDS

The Federation of American Scientists, a 5000-member organization that calls itself "the oldest organization in the world devoted to ending the nuclear arms race," has started to provide technical assistance to the Brazilian Physical Society in an effort to contain an incipient nuclear arms race between Brazil and Argentina. The immediate objective is to get Brazil's Congress to establish a more independent system of national nuclear safeguards such that civilians will gain greater control over the country's nuclear program. The broader objective is to get Argentina to follow suit, so that a vicious circle of military actions and reactions will be replaced by a virtuous circle of arms control.

In February, with foundation support from the Plowshares Fund, FAS brought Brazilian physicists Fernando de Souza Barros and Luiz Pingueli Rosa to Washington to gather information on how a national safeguards system can be designed and run. Both are professors at the Federal University of Rio de Janeiro, and both are members of the Brazilian Physical Society's Commission on Nuclear Questions; Souza Barros is a past president of the society. In

Washington, the two met with staff on Capitol Hill and at the Office of Technology Assessment, the Congressional Research Service, the General Accounting Office and the Nuclear Regulatory Commission. After acquainting themselves with the methods the NRC uses to safeguard and secure nuclear materials, they visited Brookhaven National Laboratory, where they were hosted by physicist William Higinbotham, a safeguards expert.

David Albright, the FAS staff member responsible for the safeguards project, hopes now to arrange for meetings with the Brazilians on a regular basis, and he would like to start involving the Argentine Physics Association. He also contemplates involving other Latin countries, with the ultimate objective of bringing the Treaty of Tlatelolco into force. The treaty, which establishes a Latin American nuclear-free zone, has been signed and ratified by most Latin countries, but several have attached reservations that prevent it from taking effect.

Albright's objectives are rather tall for a small technical assistance program, and nobody pretends that FAS alone will end the Argentina-Brazil

nuclear arms race. Just the same, the situation appears to be very delicately balanced, so that a few gentle nudges could make a surprisingly large difference. In the words of Leonard Spector, the Carnegie Endowment's resident expert on nuclear nonproliferation, "Both countries will have technologies to produce weapons-grade material in the next 12-18 months," and yet "both are on the verge of having some effective restraints in place."

A large and complex number of developments, many intrinsically ambiguous, have contributed to the evolving balance:

▷ The collapse of Argentina's pronuclear military regime in 1983 after the Falklands (or Malvinas) war, in which a British submarine running on highly enriched uranium played a decisive part

▷ The disclosure, immediately before the fall of the regime, that a secret gaseous-diffusion uranium enrichment plant was under construction at Pilcaniyeu

▷ Brazil's construction of an unsafe-guarded ultracentrifuge uranium enrichment plant in the state of São Paulo

▷ Exchanges of visits by Brazilian

President José Sarney and Argentine President Raul Alfonsín to nuclear facilities in each other's countries

▷ Upcoming Presidential elections in which an antinuclear left is expected to be strengthened in Brazil and a pronuclear right in Argentina

▷ Defeat in Argentina of an attempt by Alfonsín to put the National Atomic Energy Commission under stricter government control

▷ Establishment in Brazil of a Superior Council for Nuclear Energy to oversee the country's entire nuclear program.

For some years Brazil has had a dual program in which major energy facilities and technology purchased abroad have been under civilian safeguards while the military has controlled unsafeguarded facilities such as the São Paulo centrifuge plant. The formation of the Superior Council is a step toward providing unified control of the programs, and its members include physicist José Gol-

demberg, rector of São Paulo University, who is a prominent critic of Brazil's nuclear program. The military dominates the council, however.

In a loosely related development, the World Bank has been holding up a loan of \$500 million for Eletrobrás, Brazil's newly established electricity company, because the company refuses to reevaluate the wisdom of continuing with construction of the Angra-3 nuclear power plant. With inflation running near 1000% *per annum*, the World Bank takes the position that Brazil can ill afford excessively costly nuclear power.

Brazil's government recently proposed austerity measures involving abolition of the Ministry of Science and Technology and drastic cuts of junior-level university faculty and researchers. Horacio Macedo, rector of the Federal University of Rio de Janeiro, has said the new policy would be "catastrophic for research institutions." —WILLIAM SWEET

GERMANS TIGHTEN EXPORT RULES AMID SPREADING SCANDALS

Last year it was discovered that a West German company with the unfortunate name of Nukem had been systematically mislabeling international shipments of nuclear wastes containing traces of plutonium; the disclosure prompted a parliamentary investigation, which is still going on, and raised serious questions about Germany's commitment to the spirit as well as the letter of the Nonproliferation Treaty (see *PHYSICS TODAY*, August 1988, page 67). This March it was disclosed that Egypt is building a poison gas factory with assistance from a Swiss company with the unfortunate name of Krebs AG—"Cancer Incorporated." Roughly midway between these two incidents, relations between West Germany and the United States were badly bruised when *The New York Times* revealed that a German company with the wholly innocent name of Imhausen-Chemie was building a chemical weapons plant for Libya, and that the Reagan Administration had repeatedly asked the German government to investigate the situation, but without success.

The Libyan incident got an enormous amount of press and brought out the worst in a lot of people. Spokesmen for the German government issued denial after denial about the involvement of the German company, only to admit in the end that the *Times* and the Reagan Adminis-

tration were correct after all and that the Germans already had been aware of the allegations about the Libyan plant several years ago. Under sharp attack domestically, the leaders of Germany's conservative coalition government took refuge in the argument that they had no information that could be made the basis of a criminal prosecution. This did not deter the West German Chemical Industry Association from suspending Imhausen, and it did not deter Imhausen's second-in-command from a suicide attempt in mid-February. (The Nukem scandal has cost two suicides to date.)

The immediate effect of the Imhausen scandal has been to further strengthen forces in the Federal Republic that favor stricter regulation of sensitive exports, including nuclear exports. Already the German government has announced new controls on chemicals and nuclear materials, equipment and technology.

Writing this January in *Die Zeit*, Germany's most prestigious journal of opinion, Gary Milhollin said that "West German help for the Libyan chemical weapons factory . . . is only a footnote in the much more ominous story of West German nuclear exports. During the last ten years West German firms have been the main suppliers for secret nuclear programs all over the world." Milhollin, a law professor at the University of Wiscon-

sin, a nuclear licensing judge and an expert on nuclear proliferation, has himself been a principal figure in investigations that have disclosed German shipments to five of the six countries considered to be closest to having clandestine nuclear weapons capabilities: India, Pakistan, Argentina, South Africa and Israel. In India, and possibly Pakistan as well, the supplies have helped feed thermonuclear weapons projects. (In the sixth country, Brazil, Germany's provision of safeguarded enrichment technology is believed to have made it easier to develop an indigenous unsafeguarded enrichment capability.)

On 15 February, Germany's economics ministers announced four new measures to strengthen export regulation: establishment of a database at the customs administration, with compulsory registration of manufacturers and dealers in the nuclear, biological and chemical sectors; introduction of export permit requirements for certain countries of destination and certain goods, including 17 chemicals; toughening of administrative fines and punishments, and amendment of a weapons-control law to discourage direct or indirect participation by Germans in chemical or biological weapons projects overseas; and added staff for surveillance and investigative authorities.

In the estimation of Leonard Specter, the Carnegie Endowment's nuclear proliferation expert, the laws represent a considerable improvement but still leave a loophole for Germans to participate in weapons-related nuclear projects overseas. Milhollin argues that regulation of exports needs to be separated from the economics ministry, which is notoriously pro-export. Milhollin advocates setting up a separate regulatory agency or giving the foreign ministry a veto over sensitive exports.

In his piece in *Die Zeit*, Milhollin raises the question of why German governments, over a period of a decade, resolutely refused to take action on complaints from the United States and Norway about a series of very questionable nuclear transactions. Noting that the Nukem scandals exposed a morass of corruption in one segment of the business world, Milhollin wonders whether the corruption might even extend to the highest political level. Regrettably, this is not a completely implausible theory. The current Christian Democrat-Free Democrat coalition was formed in fall 1982, when the Free Democrats broke with the Social Democrats in the midst of mushrooming investigations into financial payoffs at the top levels