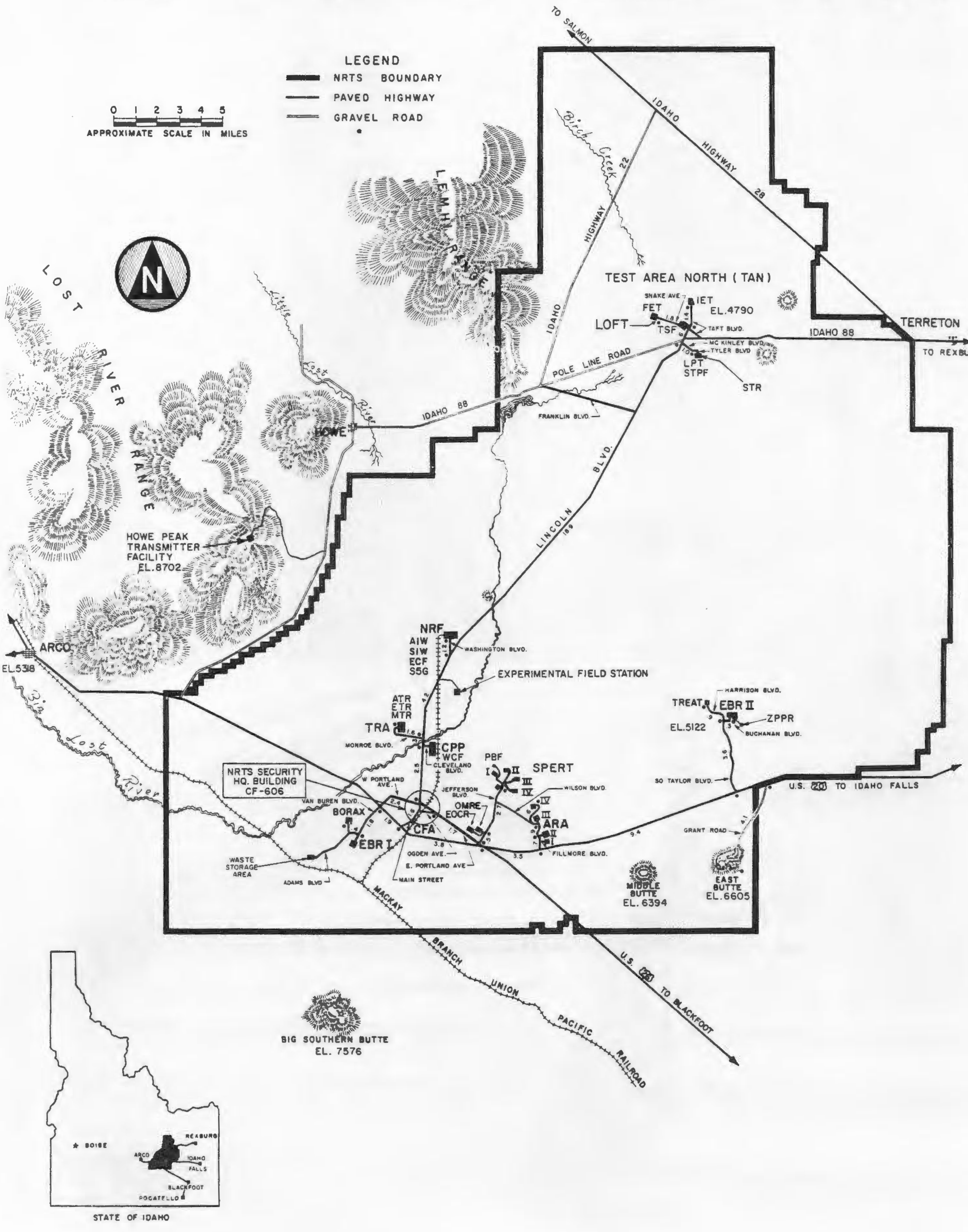
1973

NATIONAL REACTOR TESTING STATION



TABULATION OF FACILITIES AT THE NATIONAL REACTOR TESTING STATION

Reactors Operating or Operable
(As of July 1973)

	Name	Page	Abbreviation	Operating Contractor
1.	Engineering Test Reactor	9	ETR	ANC
2.	Experimental Breeder Reactor No. 2	21	EBR-II	ANL
3.	Large Ship Reactor "A"	32	A1W-(A)	WEC
4.	Large Ship Reactor "B"	32	A1W-(B)	WEC
5.	Submarine Thermal Reactor	31	S1W(STR)	WEC
6.	Transient Reactor Test Facility	23	TREAT	ANL
7.	Argonne Fast Source Reactor	24	AFSR	ANL
8.	Engineering Test Reactor Critical	9	ETRC	ANC
9.	Advanced Reactivity Measurement Facility No. 1*	12	ARMF-I	ANC
10.	Advanced Test Reactor Critical	10	ATRC	ANC
11.	Natural Circulation Reactor	33	S5G	WEC
12.	Advanced Test Reactor	10	ATR	ANC
13.	Split Table Reactor	35	STR	ANC
14.	Coupled Fast Reactivity Measurement Facility*	13	CFRMF	ANC
15.	Zero Power Plutonium Reactor*	23	ZPPR	ANL
16.	Power Burst Facility	27	PBF	ANC

Reactors Dismantled, Transferred, or in Standby Status

	Name	Page	Abbreviation	Operating Contractor
1.	Boiling Water Reactor No. 1	18	BORAX-I	ANL
2.	Boiling Water Reactor No. 2	18	BORAX-II	ANL
3.	Boiling Water Reactor No. 3	18	BORAX-III	ANL
4.	Boiling Water Reactor No. 4	19	BORAX-IV	ANL
5.	Heat Transfer Reactor Experiment No. 1	33	HTRE-I	GE
6.	Heat Transfer Reactor Experiment No. 2	33	HTRE-II	GE
7.	Heat Transfer Reactor Experiment No. 3	33	HTRE-III	GE
8.	Shield Test Pool Facility Reactor*	34	SUSIE	GE
9.	Critical Experiment Tank*	34	CET	GE
10.	Hot Critical Experiment*	34	HOTCE	GE
11.	Stationary Low Power Reactor No. 1**		SL-1	CE
12.	Reactivity Measurement Facility*	12	RMF	PPCo.
13.	Gas Cooled Reactor Experiment	37	GCRE	AGC
14.	Organic Moderated Reactor Experiment	38	OMRE	AI
15.	Experimental Organic Cooled Reactor (mothballed before startup)		EOCR	PPCo.
16.	Experimental Breeder Reactor No. 1	19	EBR-I	ANL
17.	SNAP 10A Transient No. 3	35	SNAPTRAN-3	AI/PPCo.
18.	Special Power Excursion Reactor Test No. 1	29	SPERT-I	PPCo.
19.	Boiling Water Reactor No. 5	19	BORAX-V	ANL
20.	High Temperature Marine Propulsion Reactor*	36	630-A	GE
21.	SNAP 10A Transient No. 1	35	SNAPTRAN-I	AI/PPCo.
22.	Mobile Low Power Reactor No. 1 (Army)	37	ML-I	AGC
23.	SNAP 10A Transient No. 2	35	SNAPTRAN-2	AI/PPCo.
24.	Experimental Beryllium Oxide Reactor	36	EBOR	GA
25.	Fast Spectrum Refractory Metals Reactor	35	710	GE
26.	Advanced Reactivity Measurement Facility No. 2	13	ARMF-II	PPCo. & INC
27.	Materials Test Reactor	8	MTR	PPCo. & INC
28.	Special Power Excursion Reactor Test No. 2	30	SPERT-II	PPCo. & INC
29.	Special Power Excursion Reactor Test No. 3	30	SPERT-III	PPCo. & INC
30.	Special Power Excursion Reactor Test No. 4	30	SPERT-IV	PPCo. & INC
31.	Zero Power Reactor No. 3*	21	ZPR-III	ANL
32.	Cavity Reactor Critical Experiment*	35	CRCE	GE & INC
33.	Nuclear Effects Reactor*	37	FRAN	INC
34.	Spherical Cavity Reactor Critical Experiment	35	SCRCE	ANC

* Zero or Low Power Reactor

** Accidentally destroyed during shutdown, January 3, 1961, following 931.5 megawatt days of successful operation

Other Facilities In Use

	Name	Page	Abbreviation	Operating Contractor
1.	Auxiliary Reactor Area	36	ARA	ANC
2.	Idaho Chemical Processing Plant	13	ICPP	ACC
3.	Expended Core Facility	32	ECF	WEC
4.	Fuel Element Storage Facility	17	FESF	ACC
5.	Health Services Laboratory	6	HSL	AEC-ID
6.	Chemical Engineering Laboratory		CEL	ACC
7.	Waste Calcining Facility	16	WCF	ACC
8.	Field Engineering (formerly Flight Engine Test Facility)	34	FET	ANC
9.	Low Power Test Facility	35	LPTF	ANC
10.	Test Area North	33	TAN	ANC
11.	Technical Services Center (CF-688, -689)	5	TSC	ANC
12.	Central Facilities Area	5	CFA	ANC
13.	Naval Reactors Facility	31	NRF	WEC/GE
14.	Test Reactor Area	7	TRA	ANC
15.	Technical Services Facility	34	TSF	ANC
16.	Experimental Field Station	--	EFS	AEC-ID
17.	Hot Pilot Plant	--	HPP	ACC
18.	Shield Test Pool Facility	36	STPF	ANC
19.	Reactor Training Facility	6	RTF	ANC
20.	Computer Science Center (in Idaho Falls)	44	CSC	ANC
21.	Fuels and Examination Facility	22	FEF	ANL
22.	Waste Storage Area	39	WS4	ANC
23.	Standards Calibration Laboratory (CF-698)	7	---	ANC

Facilities Not Presently In Use

	Name	Page	Abbreviation	Operating Contractor
1.	Initial Engineering Test Facility	34	IET	ANC
2.	Radioactive Lanthanum Facility	--	RALA	ACC
3.	Gamma Irradiation Facility	--	GIF	ANC

Facilities Under Construction

	Name	Page	Abbreviation	Operating Contractor
1.	Hot Fuel Examination Facility	22	HFEF	ANL
2.	Irradiated Fuel Storage Facility	17	IFSF	ACC

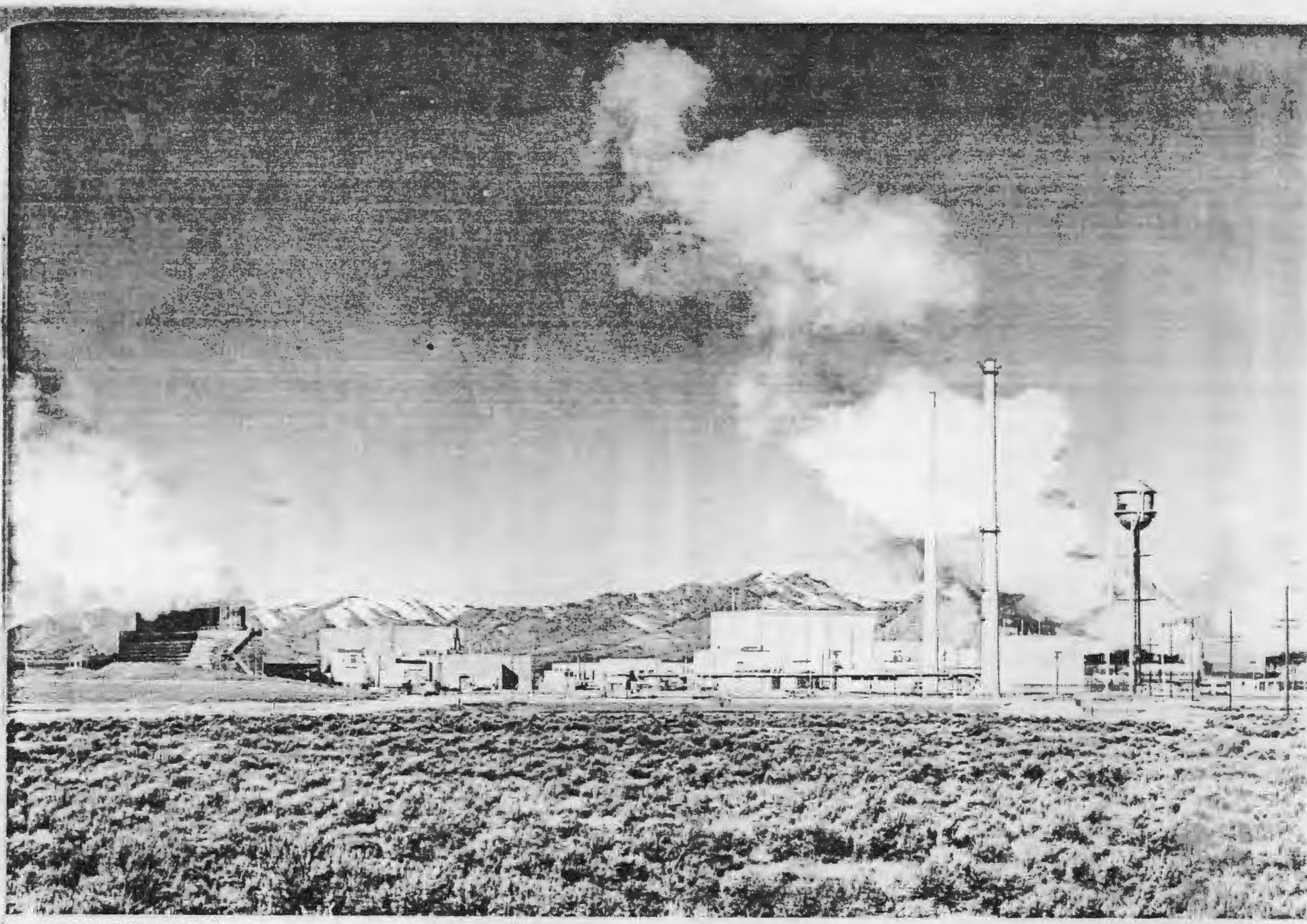
Reactors Under Construction

	Name	Page	Abbreviation	Operating Contractor
1.	Loss of Fluid Test Facility	34	LOFT	ANC

Major Nuclear Programs at NRTS

	Name	Page	Abbreviation	Operating Contractor
1.	Reactor Materials Testing Program	7		ANC
2.	Naval Propulsion Reactors Program	31		WEC
3.	Liquid Metal Fast Breeder Reactor Program	18		ANL
4.	Chemical Processing/Waste Management Program	13		ACC
5.	Water Reactor Safety Program	24		ACC

Operating Contractor Acronyms: ACC, Allied Chemical Corporation; AGC, Aerojet General Corporation; ANC, Aerojet Nuclear Company; ANL, Argonne National Laboratory; AI, Atomics International; CE, Combustion Engineering; GA, General Atomic; GE, General Electric; INC, Idaho Nuclear Corporation; PPCo., Phillips Petroleum Company; WEC, Westinghouse Electric Corporation.



WATER VAPOR RISES FROM COOLING TOWERS AT TEST REACTOR AR

National Reactor Testing Station

The vast sagebrush desert of southeastern Idaho is home for more nuclear reactors than have been built at any other one location in the world.

The Atomic Energy Commission established the National Reactor Testing Station in 1949, primarily to help prove that the atom could safely be harnessed for generating electric power and other peaceful uses. Situated on a mile-high area of the upper Snake River Plains, the NRTS covers a tract of nearly 572,000 acres or 893 square miles, more than three-quarters the size of Rhode Island. The land is a sweeping plain of lava outcroppings and sagebrush flats, bordered on the north and west by snow-topped mountains and on the south by three towering buttes.

Though NRTS planning in 1949 anticipated possibly 10 reactors by 1964, nearly 40 had actually been built by that time. As of June 1973, the number of NRTS reactors built had reached 50, of which 16 were operating or operable.

The Station is centered on a former Naval Proving Grounds which served the Navy's Pocatello (Idaho) Ordinance Depot in southeastern Idaho. Most of this large withdrawal of predominantly public domain land lies in Butte County, although it extends into Bingham, Bonneville, Jefferson, and Clark Counties.

No one resides at the NRTS. The permanent employees live in more than 30 communities adjacent to the testing Station, the largest percentage in Idaho Falls. All housing has been provided by private enterprise through normal financing. Project-operated bus service is provided from the major communities. The nearest NRTS boundaries are 29 miles west of Idaho Falls, 32 miles northwest of Blackfoot, 50 miles northwest of Pocatello, and 7 miles southeast of Arco.

NRTS Mission, Administration

The Station's broad mission is to develop economic nuclear power by furthering the Commission's reactor development program. To that end, more than 50 reactor facilities have been built, or are under construction or design.

The NRTS is administered by the Idaho Operations Office of the U. S. Atomic Energy Commission from offices at 550 Second Street, Idaho Falls, Idaho. The Idaho Operations Office has a twofold primary mission: (1) administration of such basic Commission programs as test irradiation services, reactor safety, and the chemical processing of highly enriched fuels and associated research and development; and (2) providing various technical and common services in support of other Commission field offices having projects at the NRTS, including major contributions to the AEC's Liquid Metal Fast Breeder Reactor development program and naval propulsion reactors.

Manager of the Idaho Operations Office is R. G. Bradley. Deputy Manager is C. R. Malmstrom. The office reports to the General Manager, U. S. Atomic Energy Commission, Washington, D.C.

Four major operating contractors are engaged in the Station's program activities: Aerojet Nuclear Company, Allied Chemical Corporation, Argonne National Laboratory, and Westinghouse Electric Corporation.

Significant Accomplishments

The National Reactor Testing Station has contributed substantially to the beneficial use of atomic energy. Some important NRTS "firsts" are: producing the first usable quantities of electricity from nuclear sources; proof testing the feasibility of nuclear propulsion for both submarine and surface ships; demonstrating the principle of breeding nuclear fuel; powering of a turbojet engine exclusively from nuclear heat; demonstrating the advantages of organic substances (hydrocarbons) as a reactor moderator or coolant; operating a large reactor using a full core loading of the artificial fuel, plutonium; operating a high-flux reactor with 20-percent enriched uranium as fuel; the direct coupling of a reactor to a closed-cycle, gas-driven turbine-compressor set; plant-scale conversion of highly radioactive liquid wastes to solid form for safer storage in 90 percent less space; and operating a gas-fueled reactor core.

Many contributions to the advancement of reactor technology have been made by the Station's three large materials test reactors.

Other significant contributions are being made at the NRTS in the field of reactor safety, chemical processing and waste management.

The first production of useful amounts of electricity from nuclear heat occurred at Experimental Breeder Reactor No. 1, December 20 and 21, 1951. Four years later, another reactor, BORAX-III, supplied all the electricity needed to meet the demand load of the city of Arco, Idaho (July 17, 1955).

Four significant developments in the field of nuclear propulsion have taken place at the NRTS. On March 31, 1953, the prototype of the nuclear submarine Nautilus was placed in operation, launching the era of nuclear propulsion. The feasibility of powering a turbojet engine by nuclear heat was first demonstrated in January 1956. The first of two large ship reactors sustained criticality in October 1958, heralding the feasibility of using nuclear power for surface ships. And a first-in-the-world criticality was achieved May 17, 1967 on a gas core (uranium hexafluoride) reactor concept with promise as a more efficient rocket engine for deep space travel.

Physical Characteristics

The NRTS is situated on a desert plain at an average elevation of 4,865 feet. Considerable gravel deposits exist and much of the station is underlain with beds of lava rock. Depth to the lava rock varies considerably. In general, construction of roads, railroads, etc., requires only removal of the overburden and brush, grading the gravel, and adding the required depth from nearby gravel borrow areas. The plain is a major geographic, geologic, and economic segment of Southern Idaho. The Station itself comprises nearly 572,000 acres of sagebrush and basalt fields. It is nearly 39 miles long from north to south, and about 36 miles wide in its broader southern part.

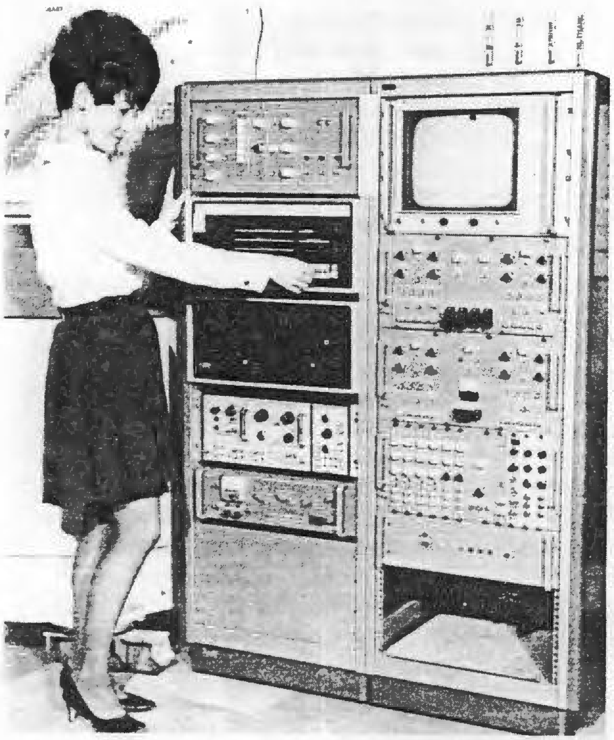
Although annual precipitation in the NRTS area has averaged only 8.5 inches over the last 15 years, underlying it is a huge natural underground reservoir of water in the basaltic lava rock. The lateral flow of this water is about one billion gallons per day. It is supplied principally from the North Fork of the Snake River. Additional water comes from the Big and Little Lost Rivers and Birch Creek, which start in the mountains to the north and sink into the porous soils of the NRTS area. Hydrologic research indicates that the underground water seeps very slowly (10-20 feet per day) to the south and west, emerging in numerous springs along the Snake River between Milner and Bliss, Idaho.

Average annual temperature at the Station is 42°F, with extremes of 102 and -43°F. The prevailing dry, sunny, and breezy weather has proven excellent for operations.

Central Facilities Area

To minimize duplication of buildings, equipment, and personnel, the common needs of the various technical installations at the NRTS are met largely by a Central Facilities Area which has been developed at the site of the former Naval Proving Grounds headquarters. CFA facilities include: a medical dispensary, a central security headquarters, the Health Services Laboratory, the No. 1 Fire Station -- all operated by AEC personnel -- the U. S. Geological Survey, and the Air Resources Laboratory of the National Oceanic and Atmospheric Association (Weather Bureau). Other centralized operations include the Technical Services Center (offices and a technical library), Standards Calibration Laboratory, cafeteria, craft shops, warehouses, and a transportation system, all operated for the AEC by Aerojet Nuclear Company.

• *Health Services Laboratory*



HSL EMPLOYEE OPERATES COMPUTERIZED GAMMA SPECTROMETER

The AEC's Health Services Laboratory (HSL) at the NRTS is world-renowned for its pioneering work in the fields of radiation monitoring devices, radiochemical analyses, and radiation safety research and development.

The HSL's specialized individual health protection functions include (1) providing industrial medical services, including operation of dispensaries in both the Central Facilities Area at the site and the NRTS' headquarters building in Idaho Falls; and (2) personnel radiation dosimetry (for detecting external radiation) and wholebody counting and radiochemical analyses (for measuring possible internal deposition of radionuclides in workers).

AEC Laboratory scientists carry on a year-round program for studying and monitoring (both on- and off-site) the underground water supply, air, and soil, and area farm produce. Data obtained from this work substantiate the safety of NRTS operations for site employees and the public.

Working in conjunction with, but independent of, the AEC employees are some 14 highly trained atmospheric, geological, and hydrological experts employed by the U. S. Geological Survey and the Air Resources Laboratory of the National Oceanic and Atmospheric Administration at the NRTS.

Current HSL programs include studies of the dispersion characteristics of radionuclides in the air, water, and soil; mechanisms of radionuclide interaction with both vegetation and animals; and chemical methods affording greater sensitivity in detecting and identifying radionuclides. The laboratory expends 15 man years of effort per year to assist the Regulatory side of the AEC in evaluating the environmental impact of licensed operations throughout the country.

This work supports not only NRTS programs but also contributes to reactor siting, emergency planning, and regulatory standards throughout the world. In addition, HSL technologists are performing special environmental studies and independent radiation measurements for the AEC at many other nuclear installations throughout the United States.

• *Reactor Training Facility*

A 1968 addition to the Central Facilities Area was the Reactor Training Facility (RTF) for instructing reactor engineers in the fundamentals of operating nuclear test reactors and giving them practical experience in the operation of reactors under both normal and abnormal conditions. It is a reactor simulator system with consoles duplicating the MTR, ETR, and ATR. All newly hired reactor engineers are required to complete a one-year course of instruction before being qualified as reactor engineers.

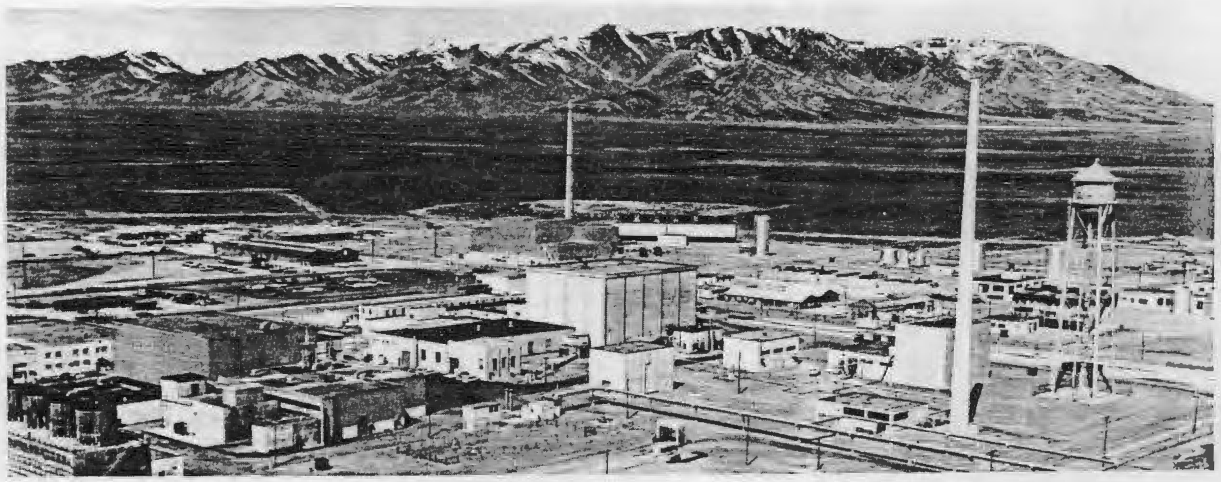
- *Standards Calibration Laboratory*

Completed in 1969 was a new Standards Laboratory in which super-accurate instruments permit utmost precision in dimensional, physical, and electrical-electronic calibrations. The laboratory provides traceability of all measurements to the U.S. National Bureau of Standards through a primary calibration laboratory.

- *NRTS Technical Library*

Located in the Technical Services Center and operated by Aerojet Nuclear Company, the Technical Library serves all personnel of the NRTS. The library's resources are primarily in the fields of physics, chemistry, mathematics, biology, metallurgy, and engineering. Non-NRTS people may visit the library by prior arrangement with the Idaho Operations Office's Security Division or they may obtain material on interlibrary loan through the Idaho Falls Public Library or other area libraries, such as Idaho State University.

Test Reactor Area



The Test Reactor Area at NRTS (the world's largest and most advanced nuclear materials-testing complex) provides extensive facilities for studying the performance of reactor materials and equipment components in environments of high neutron flux, thereby enabling scientists to obtain essential data for improved reactor designs. Two large test facilities can find out in weeks or months what might take years to discover in reactors designed for purposes other than testing.

All of the facilites in the TRA were operated for the AEC by Phillips Petroleum Company until 1966, when the operating responsibility was assigned to Idaho Nuclear Corporation. In July 1971, the operating contract was reassigned to Aeroject Nuclear Company.

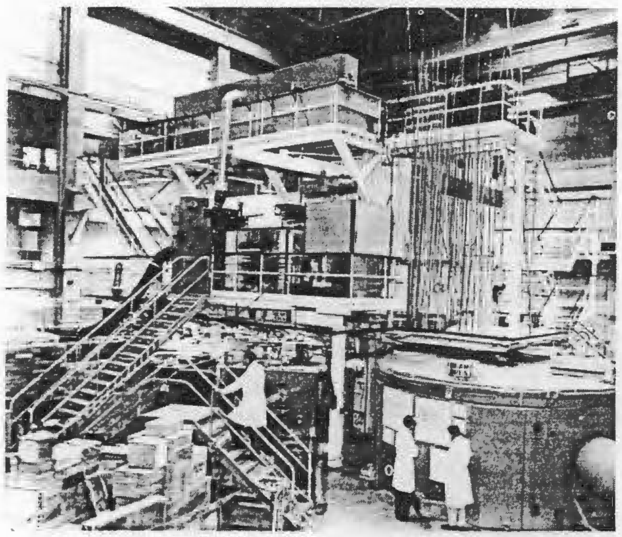
While intended primarily for furthering the AEC's reactor development programs, the test irradiation facilities on occasion have been made available to educational, research, industrial, and commercial installations, as well as other federal agencies.

The great bulk of experiments can be classified into three groups: (1) the capsule or static specimen type; (2) the dynamic, small specimen type; and (3) the dynamic full-scale component type.

The NRTS testing reactors operate on established schedules calling for periodic shutdown to insert or remove experiments and related equipment, and to replenish or rearrange fuel loading.

The principal objective is to meet as closely as possible the needs of each experimenter while, at the same time, maintaining the maximum onstream efficiency consistent with those practices necessary to protect the safety of the operating personnel, the reactor, the experiments, and the environment.

• *Materials Testing Reactor*



The MTR first achieved nuclear startup on March 31, 1952 (11:19 p.m.), the second reactor to be operated at the NRTS. The historic reactor went into retirement April 23, 1970, its materials testing workload having been taken over by the new and larger Advanced Test Reactor.

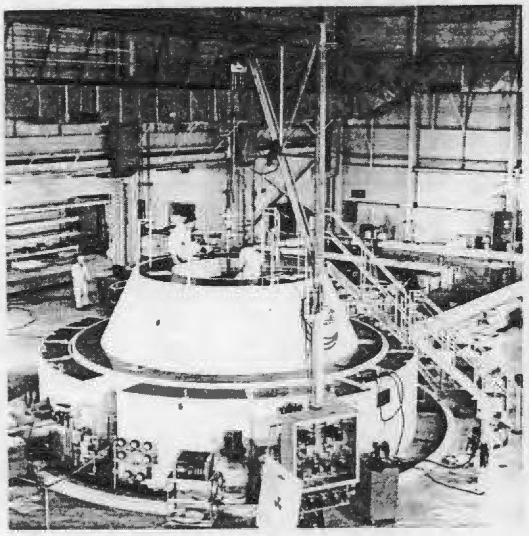
The choice of core structural materials and fuel elements for every reactor designed in the country since 1952 has been influenced by information obtained from tests in the MTR. High flux radiation fields available in this reactor made possible greatly accelerated screening tests which were of immediate benefet to reactor design. Successful operation of the MTR was in itself a great experiment that resulted in a whole family of plate-type reactors, including the ETR. The MTR is known, therefore, as the "granddaddy" of all plate-type reactors. In its earliest stages, it contributed vitally to work on pressurized water reactors and later to the Yankee and Dresden power stations, organic reactors, liquid metal fueled reactors, and even homogeneous reactors. In the military reactor field, the MTR has accommodated major experiments for the Army, the Navy, and also for the former Aircraft Nuclear Propulsion Program.

The reactor was operated at 30 megawatts (thermal) until September 1955 when the thermal output was increased to 40 megatts. The increases made more high flux space available and shortened irradiation periods in some cases. Almost every conceivable material has been irradiated in the MTR, either statically in capsules or dynamically in loops. The individual experiments have ranged in complexity from the simple irradiation of cobalt-59 wafers (to form radioactive cobalt-60) in aluminum capsules to beam hole loop installations using high temperature fused salt fluids as their circulating medium. The reactor could provide neutron fluxes averaging 2.5×10^{14} and maximum fluxes of 5×10^{14}.

The MTR logged in excess of 125,000 operating hours and more than 19,000 neutron irradiations. It has been loaded with as many as 600 separate irradiation samples at one time. More than 194,000 separate gamma irradiations were conducted using spent fuel elements from the MTR.

During August 1958, the MTR became the first reactor to be operated using plutonium-239 as fuel at power levels up to 30 megawatts, the original design power of the reactor. A total of 262 megawatt-days of operation was achieved, with a normal complement of radiation experiments in the reactor, before depletion of the core shut down the reactor. The demonstration proved the feasibility of fabricating a plutonium-fuel core capable of withstanding high-power, high-flux conditions. The test also demonstrated that a reactor fueled with plutonium can be satisfactorily controlled.

• *Engineering Test Reactor*



Placed in operation in 1957, the ETR was at that time the AEC's largest and most advanced test research facility, with an operating level of 175 megawatts (thermal). Achieving full power in 1958, the ETR grew out of the urgent need, largely within the Commission's activities, for more high-flux testing space, more stable flux, a greater variety of fluxes than the MTR, and, also, "through the core" facilities. The bulk of this need was for evaluation of fuel, coolant, and moderator characteristics and compatibilities under environments similar to those which exist in many types of potential reactors.

In 1972 the ETR began preparations for a new role as a key test vehicle in support of the AEC's high priority Liquid Metal Fast Breeder Reactor (LMFBR) safety program. Conversion of the reactor for this purpose started May 1, 1973 upon completion of its last planned operating cycle in support of light water reactor fuels and materials development.

The new assignment will utilize the reactor's high neutron flux for conducting safety programs relating to LMFBR fuel core design and operation. These will be performed in a sodium-cooled irradiation test facility which is being developed for the AEC. Modification to the reactor will include the addition of a new top closure which has been especially designed to accommodate the new irradiation loop. Other modifications include the addition of a helium coolant system and the sodium handling system in support of the test facility.

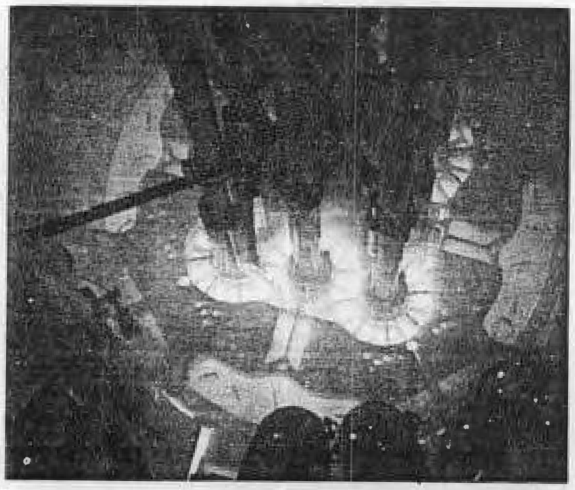
The facility and loop are being prepared by Aerojet Nuclear to support the AEC's high priority LMFBR program. Testing in this new facility, which will be conducted by Argonne National Laboratory, is scheduled to begin in mid-1974 and will contribute significantly toward verification of the safety characteristics of the LMFBR fuel and core design.

• *ETR Critical Facility*

The ETRC, which achieved criticality on May 20, 1957, is a full-scale, low-power nuclear facsimile of the Engineering Test Reactor (ETR). Primarily the ETRC has been used to determine in advance the nuclear characteristics of experiments programmed for irradiation in the ETR, and the power distribution effects for a given ETR fuel and experiment loading.

Since no two ETR loadings are identical, it is difficult to predict the ETR nuclear environment whenever completed experiments are removed or new ones are added to those already underway. Yet, it is necessary to know these effects for calculating the irradiation to be received by the experiments for determining core life, control rod withdrawal programs, and reactivity worths, and that core safety assurance requirements are satisfied. The ETRC is relatively inexpensive to operate and manipulation of core components is very simple. Therefore, proposed ETR fuel and experiment loadings can be mocked-up in the ETRC and then the fuel loading can be manipulated until a desired power distribution throughout the core is attained which satisfies the pertinent safety requirements. In this manner, the ETRC saves a great deal of time and money by performing necessary low-power testing without interrupting full-power operation of the ETR. Additionally, the ETRC provides an inexpensive tool for testing new experimental concepts, fuel loadings, rod programs, and reflector configurations. These tests would be virtually impossible in the ETR reactor.

• *Advanced Test Reactor*



CERENKOV EFFECT ILLUMINATES ATR CORE

Construction began in November 1961 on the Advanced Test Reactor (ATR), the world's largest test reactor, with an operating thermal power level of 250,000 kilowatts. The first nuclear startup of ATR, at zero power, was achieved July 2, 1967 and full power was achieved on August 16, 1969. First operation with in-pile experiments began December 25, 1969.

The ATR is designed for use in developing advanced naval reactor cores and advanced fuel systems and materials for space and commercial power programs. It provides an extremely high flux (1 x 10^{15} thermal) environment for a multiplicity of high-pressure loops. The cylindrical symmetry of the experimental loops, their diameter (averaging about 3 inches), and the large number of samples to be irradiated at one time strongly influenced the choice of the reactor type.

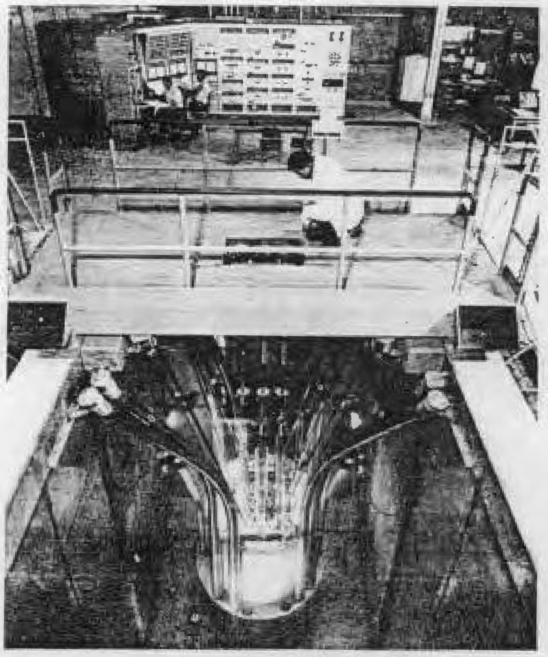
The ATR is a light-water-moderated and -cooled reactor. It employs a neutron flux concentration principle (flux traps) to achieve very high flux levels in its test spaces without excessive power densities in its fuel elements. The geometry of the ATR core is similar to that of a four-leaf clover with four flux traps in the leaves, one where the leaves join, and four in the spaces between the leaves. The ATR contains a unique control rod configuration which allows the flux to be increased or decreased in individual flux traps during reactor operation while maintaining the fluxes constant in the other positions. This flexibility not only allows the tailoring of the fluxes to meet exactly the needs of each experiment but it also provides for the most efficient use of the reactor power.

The advanced design concept used in the ATR is expected to contribute substantially to reactor technology and development. It is designed to produce approximately 30,000 watts of power per gram of uranium-235 from test fuel specimens as compared to about 10,000 watts per gram from test fuel specimens in the ETR. Other design features have provided significant improvements in the uniformity and stability of the neutron flux and in the operation and servicing of the reactor and its experiments.

• *Advanced Test Reactor Critical Facility*

The ATRC first achieved startup on May 19, 1964. It performs the same functions for the Advanced Test Reactor that the ETRC does for the ETR. The ATRC proved to be a valuable auxiliary tool long before ATR startup in verifying the effectiveness of design control mechanisms and physicists' predictions of power distributions in the big test reactor core.

Though designed to permit continous operation by 5,000 watts, the ATRC is routinely operated at about 500 watts.



By using the ATRC, necessary low-power testing does not have to be performed in the 250-million-watt ATR, thus conserving valuable time in the big reactor for actual irradiation experiments at full power. The ATRC is used also to verify the safety of the proposed experiments before placing them in the high-power reactor.

- *MTR-ETR Hot Cell Building*

As support for the ETR-ATR irradiation programs, Aerojet Nuclear operates a hot cell facility capable of handling up to 20,000 curies of one to three million electron volts (MeV) gamma radiation. There are three hot cells in the facility, all equipped with remotely operated machine tools, measuring instruments, and master-slave manipulators to permit metallurgical testing of samples irradiated in the test reactors.

- *Nuclear Physics Research Programs*

Aerojet Nuclear Company conducts research programs for the AEC at the Test Reactor Area where several unique facilities are available to the scientists. These facilities include the two high-power test reactors (ATR and ETR) the critical facilities for each test reactor (ATRC and ETRC), two special low-power reactors to measure reactor physics parameters (ARMF-I and CFRMF), a beta-ray spectrometer, a mass separator, hot cells, and a host of special electronic equipment.

These special research programs are currently focused on the physics and material parameters required for the Commission's Fast Flux Test Reactor development, being built at the AEC's Hanford (Washington) Works. They include programs to measure integral cross sections in a fast flux zone; to produce radioactive samples and support for the integral cross section measurement; to study radioactivity and decay properties of significant radioactive nuclides; to deduce and catalog best values of cross sections of interest; to determine the influence of irradiation and temperature on the fatigue behavior of reactor structural materials; to identify characteristics of neutron-deficient nuclides; and to develop special uses for radioisotopes.

Knowledge of these physics and material characteristics is basic to safe and efficient reactor design. For instance, the scientists working on the fatigue program are examining candidate materials to be used as cladding for fuel and reactor structural material for the fast reactors of the future. Specimens of several select materials are placed in a reactor and irradiated to high fluences at typical fast reactor energies and under various reactor temperatures. Both irradiated and control specimens are then tested to determine the effect on lifetime of these materials under the metal fatigue conditions they would experience in a reactor. This information will be used to select the reactor material which will provide the most economical components within the required safety limitations and lifetime characteristics.

The nuclear physics tasks at the

NRTS are now centered around the need to know the spectrum-averaged cross sections for certain isotopes which are important in fast reactor systems. The major effort is concentrating on fission product isotopes and mixed oxide fuels with secondary emphasis on structural and fissile materials. This program utilizes the unique reactor facility identified as the CFRMF (which is becoming a flux standard for fast reactor programs) in addition to an improved hot alpha facility and a recently installed mass separator.

In support of the nuclear physics tasks, the scientists at the NRTS have continued to compile precise data on the decay schemes of radioactive nuclides. Over the past several years, the scientists around the world have used a Gamma-Ray Spectrum Catalogue published at the NRTS as the source of base data for studying gamma-ray decay nuclides. This year, the scientists at the NRTS will publish a new catalog with over 200 nuclides described in a significantly improved format.

• *Metallurgical Research Facilities*

Extensive metallurgical and remote handling facilities and personnel are available for development, research, and analysis on nuclear materials. Capability is particularly strong in nuclear fuels development and testing and in determining irradiation effects on materials.

Equipment includes wrought and powder fabrication, arc, induction, and EB welding, tensile, creep and fatigue testers, optical and electron microscopy and electron microprobes. Hot Cells for post-irradiation examination of materials and components are located convenient to TRA, TAN, and ARA.

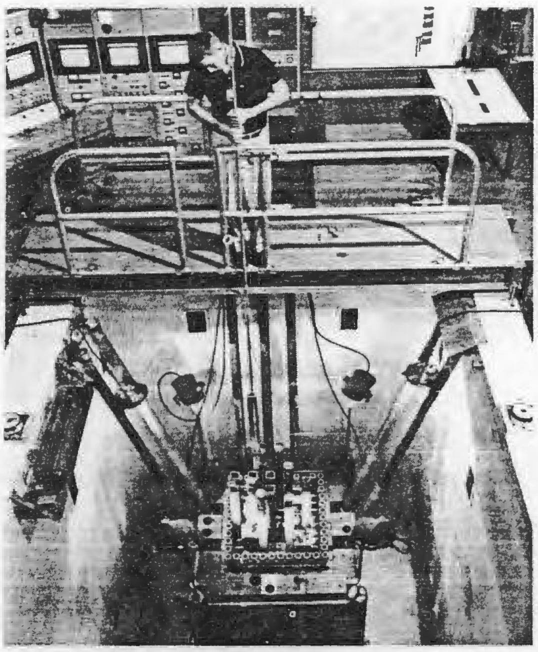
• *Reactor Services Building*

This facility in the Test Reactor Area provides space for assembling and pretesting experiment apparatus to be inserted in the test reactors.

• *Reactivity Measurement Facility*

The RMF, a detector-reactor which measured reactivity changes in materials irradiated in the MTR-ETR, was operated for more than eight years, following startup on February 11, 1954. It was used to assay new and spent fuel elements and to assist in experiment scheduling by evaluating reactivity losses and flux depression caused by in-pile apparatus. The RMF was retired April 10, 1962.

• *The Advanced Reactivity Measurement Facilities*



The ARMF-I, which went critical on October 10, 1960 in a specially constructed building east of the MTR, augmented the Station's capabilities for precise determination of nuclear characteristics of reactor fuels and materials. It is part of the Commission's program to achieve more efficient reactor fuel utilization and to improve the quality of reactor core components. The facilities afforded were considered to be the most sensitive devices for reactivity determinations in existence until ARMF-II, which was constructed in the opposite end of the same tank occupied by

ARMF-I, achieved criticality on December 14, 1962. A major improvement in the ARMF-II was its "readout" system which automatically records measurements on IBM cards for direct processing in electronic data machines. This refinement was developed from experience with the RMF and ARMF-I. ARMF-I incorporated many of the features of the RMF and, in addition, had greater mechanical stability, specially designed fuel elements to obtain better nuclear characteristics, and improved instrumentation.

- *CFRMF*

The ARMF-II reactor was modified late in 1968 to provide fast reactor physics information. Known as the Coupled Fast Reactivity Measurement Facility (CFRMF), the new tool is being used to study differential cross sections and to test calculational methods. A section of the core has been modified to produce a region of high energy neutron flux used in comparing calculated and observed results as a check against the adequacy of existing cross section data and codes used in fast reactor design.

Chemical Processing Area

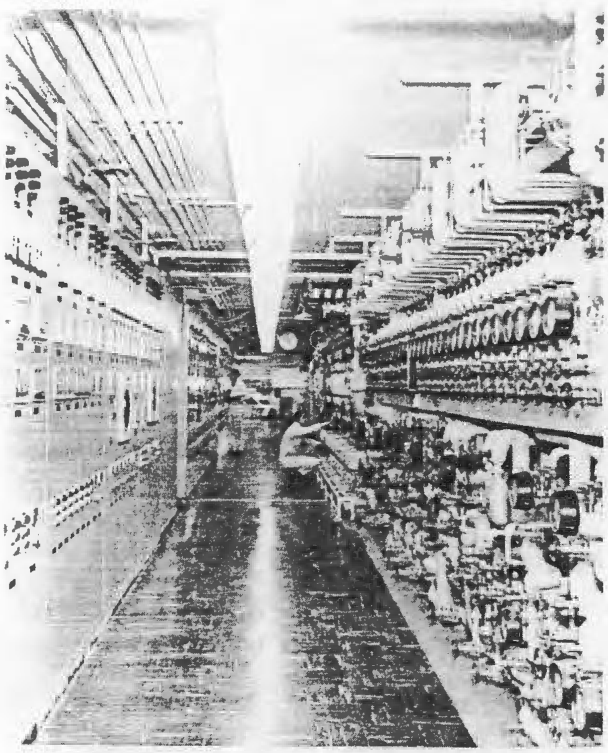
The AEC's Idaho Chemical Processing Plant is a multipurpose facility capable of recovering unburned uranium-235, worth $300 an ounce, from enriched uranium fuel elements discharged from research, test, propulsion, and power reactors. Recovery efficiencies of 99.5% are routinely achieved.

The ICPP's operating contractor during construction and preoperational plant testing was American Cyanimid Company. The operating contract was assigned to Phillips Petroleum Company just before first "hot" operations were begun in February 1953. Idaho Nuclear Corporation became the ICPP operating contractor in 1966, succeeded by Allied Chemical Corporation in July 1971. Construction of the basic plant facilities, by Bechtel Corporation, began in 1950.

Most of the ICPP design, with its maximum process flexibility, would be readily adaptable to commercial processing plants. It has been used both as a production facility and as an engineering-scale process demonstration facility. Although its main processing load has been aluminum-uranium alloy fuels (such as those of the ETR), the first successful processing of significant quantities of zirconium and stainless steel-clad fuels took place here. Spent fuels of these types which have been processed in the ICPP include the first cores from the "Nautilus" and "Sea Wolf" submarines and the first Organic Moderated Reactor Experiment. Processing of Zirconium and stainless steel alloyed fuels subsequently has become the principal production responsibility for the ICPP.

Continuing studies are being made to optimize the use of existing and new facilities for meeting the challenges of the multiple fuels processing program plan. This plan involves economic recovery of uranium from many "one-of-a kind" reactor fuels that cannot be reprocessed anywhere else.

• *Idaho Chemical Processing Plant*



ICPP OPERATING CORRIDOR

The ICPP employs both batch and continuous dissolver systems, including the first production-scale use of soluble nuclear poison, followed by three cycles of liquid-liquid solvent extraction to separate uranium-235 from fission products and from structural and alloying material contaminants. Two different solvent extraction systems usually are used in sequence -- a tributyl phosphate "head-end" extraction, followed by two cycles of methyl isobutyl ketone extraction which yield an essentially pure solution of uranyl nitrate product, which is then processed into uranium trioxide granules for shipment to Oak Ridge National Laboratory. Process and material accounting requirements dictate rigorous statistical and analytical control of the process. Extensive laboratories and instrumentation are available for performing analyses on highly radioactive as well as cold samples. Significant contributions to the field of radioactive analysis have been made during the many years of ICPP operation.

Zirconium-Alloyed Fuel Reprocessing. The first method for reprocessing highly enriched zirconium-uranium alloyed fuels was developed at the Idaho Chemical Processing Plant. The first plant-scale processing campaign began in February 1965 and was completed in February 1966, and this process is now used routinely. For separate processing, zirconium-alloyed fuels are dissolved in hydrofluoric acid solutions in a Monel dissolver. Operation of this dissolver with large masses of fissionable uranium is possible at ICPP because boron, a soluble neutron poison, is used for criticality control. A semi-continuous mode of operation is employed involving periodic dissolution of large batches of fuel in a continuously flowing aqueous hydrofluoric acid stream, followed by continuous tributyl-phosphate and methyl isobutyl ketone extraction of the resultant dissolver product.

Co-processing of Zirconium and Aluminum Fuels. During co-processing of aluminum and zirconium fuels, the dissolver product solution from the aluminum fuel, after accountability measurement, is used to complex the dissolver product from the zirconium fuel in lieu of stock aluminum nitrate solution. Thereafter, the process continues as already described. Co-processing will be practiced as much as possible (depending on the availability of proper amounts of zirconium and aluminum fuels during a processing campaign) since it eliminates the need to purchase significant quantities of aluminum nitrate solution which ultimately ends up in radioactive waste storage, and higher overall processing rates result. Co-processing is more economical, resulting in lower chemical costs, lower waste volumes, and higher through-put rates.

The main process building, which houses the bulk of equipment and controls, is a 240-by 100-foot structure, largely below ground. It is 90 feet high from subfloor level to pitch of the roof. In one section, the building is approximately 60 feet below the gound level. The main building encloses a usable floor area of 63,174 square feet. Structurally, the building consists of two levels. One level is reinforced concrete, the other is transite and structural steel. Most process equipment containing radioactive materials is located within concrete walls. Chemical makeup tanks and auxiliaries are located in the transite-steel section. The concrete section is divided into two rows of cells with operating, service, and access corridors between the two.

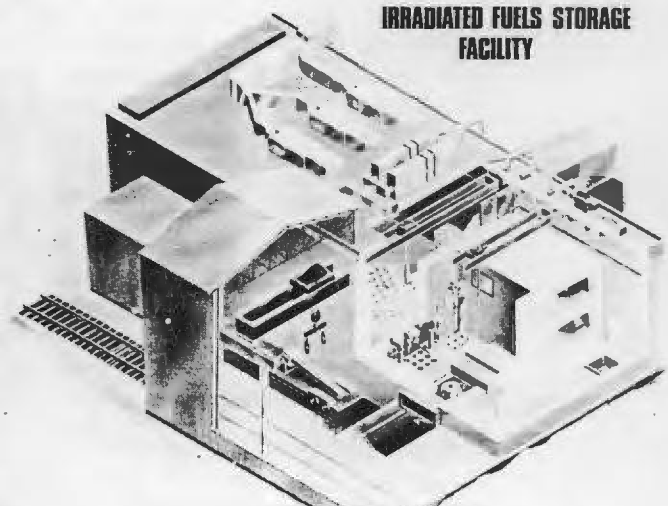
CAN OF URANIUM TRIOXIDE, READY TO SHIP

Plant modifications made in 1972 have added processing capability for EBR-II type stainless steel fuel elements using an electrolytic dissolution process. Also, design was started during this same year to add a "head-end" process for processing Rover type graphite fuels using a high temperature combustion process which would burn the graphite to the gaseous carbon dioxide leaving the uranium in a form that can be subsequently dissolved and purified in the existing solvent extraction systems.

Interim storage of the highly radioactive liquid wastes from fuel reprocessing is provided by eleven 300,000-gallon undergound tanks. After an adequate cooling period, liquid wastes from those tanks are pumped through an underground piping system to the Waste Calcining Facility where they are solidified and reduced in volume for safer, more economical, interim or long-range storage.

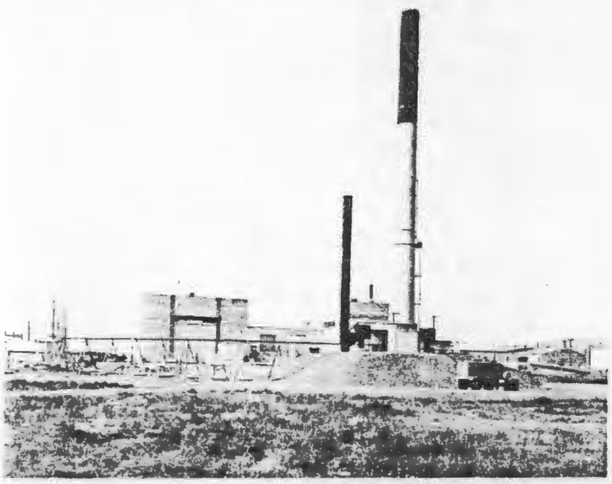
The various processing steps are performed in separate concrete-walled cells lined with stainless steel and containing various vessels, piping, and other chemical equipment. This plant differs from the large separation plants at Hanford and Savannah River in that it was designed for direct maintenance by technicians rather than by remote control

IRRADIATED FUELS STORAGE FACILITY



using "slave" cranes, manipulators, and special connectors. Facilities are also provided in support of the main process building for receipt and storage of irradiated reactor fuels preparatory to processing. In addition to the normal under water storage basin facility, dry storage facilities were constructed in 1971 to receive spent fuel from the Peach Bottom, Pennsylvania, gas-cooled reactor. Also, construction was started in 1972 for a $3 million dry storage concrete building to receive and store irradiated fuels from the HTGR Fort Saint Vrain reactor.

• *Waste Calcining Facility*



The Waste Calcining Facility is the first plant-scale facility to use successfully the fluidized bed principle for reducing highly radioactive waste solutions to a safer (noncorrosive and leakproof) solid form, requiring one-seventh as much storage space. This facility also permits full-scale studies of fixation of radioactive materials aimed at minimizing storage and surveillance costs, measuring radioactive decay heat generation, and developing methods of heat removal from stored solid wastes. Other developmental work is attesting the feasibility of applying the fluidized bed calcining principle to wastes from fuels with stainless steel, zirconium, and other claddings. Calcination of both aluminum and zirconium wastes has been conducted on a routine production basis using

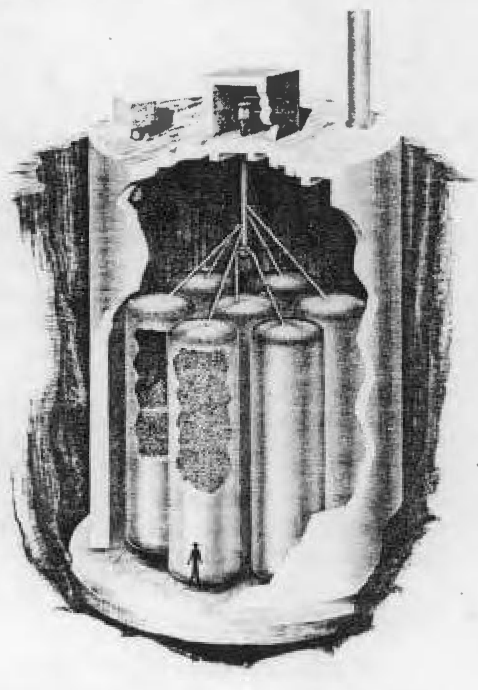
WCF PRODUCT LOOKS LIKE THIS

calcium additions to minimize free fluoride ion corrosion. By 1973, two and one-half million gallons had been processed to preclude further construction of liquid storage tankage.

Successful innovation of an improved heating system, involving combustion of kerosene with oxygen inside the calciner instead of the original liquid-metal heat transfer system provided a 25 to 50% increase in capacity beginning late in 1970.

In the fluidized-bed process, waste solution is sprayed into a chamber containing heated, nearly spherical granules about the size of coarse sand. A controlled airflow has the effect of "fluidizing" and circulating the granular material within the chamber, permitting even distribution on the granules of the liquid waste which is sprayed as a fine mist into the chamber. Heat evaporates the water and converts the dissolved aluminum and fission product nitrates into oxide coatings on the granules. As the size of the particles increases, the violent agitation continuously chips small fragments off some of the granules. Some of these fragments are carried as fine dust into the calciner's off-gas cleanup system, and the rest either remain in the chamber to form seed for new granules or go with the solid product (nonfragmented granules) by air stream through shielded undergound tubes to buried storage bins.

Construction of the third calcine storage facility was completed in 1972 and filling begun immediately. New facilities are needed every five years to meet production requirements. All calcine is retrievable should reprocessing or off-site shipment ever be desired. R&D continues to evaluate various process alternates that might be feasible to render the calcine less soluble either through the use of process additives or by compaction and encapsulation.



WCF STORAGE BINS AND VAULT

• *Fuel Element Storage Facility*

Irradiated fuel can be stored here for months or years until enough of a particular type has accumulated to make a processing run in the ICPP economical. Lead-shielded fuel transfer casks weighing up to 75 tons can be received from either truck or rail shipments. Straddle carrier trucks are used for transporting smaller casks within the ICPP facility.

Certain fuel types such as the Rover and the HTGR graphite fuel that would react with water must be stored in a dry storage area. The fuel element storage area includes two such facilities: The Peach Bottom facility consists of 47 underground 3-foot-diameter x 20-foot-deep steel lined vaults equipped with heavy concrete shielding covers and was designed to receive the first expended core from the Peach Bottom gas-cooled reactor in Pennsylvania. The HTGR irradiated fuel storage facility is a concrete building, 125 x 50 x 34, equipped with manipulators and storage racks for storing irradiated fuel elements from the first two cores of the Fort Saint Vrain reactor. Core two of the Peach Bottom will also be stored there. Design of this facility was started in 1972.

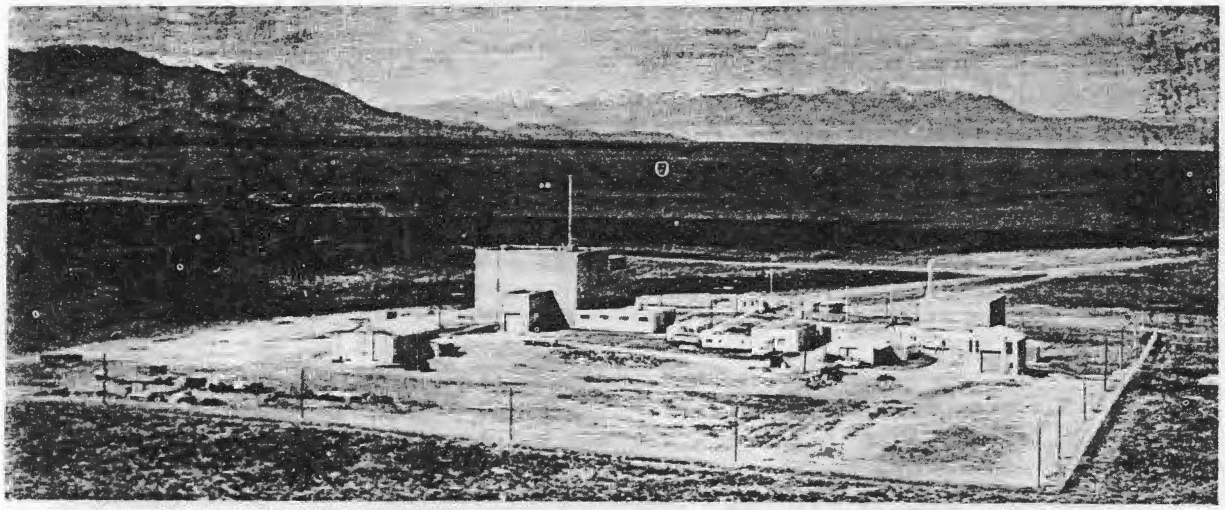
• *Waste Disposal Building*

Gaseous and low-level liquid wastes are treated at the Waste Disposal Building. Gaseous process effluents are washed and filtered before release to the stack. Facilities are provided for storage of certain gases to permit decay of the radioactive components before release to the atmosphere. There are also facilities for recovering krypton and xenon from the gaseous effluences. Construction began in CY-1973 on a $2.3 million Atmospheric Protection System that will provide complete filtering of all process ventilation air and backup treatment of the process off-gas air to preclude the release of airborne activity due to accident conditions which would breach the primary filtering systems.

All low-level radioactive liquid wastes are decontaminated by processing via evaporation. The radioactive concentrates are sent to underground liquid storage and eventual calcination. The overheads are decontaminated further by ion exchange before release to the Snake Plain Aquifer. All liquid wastes meet drinking water quality in regards to radioactive content prior to discharge.

Construction was completed in 1972 of facilities that monitor all plant service waste water and provide for automatic impoundment should they become accidentally radioactive by contamination. Provisions were also made for the decontamination of such diverted service wastes.

Experimental Breeder Reactor No. 1 (West) Area



The EBR-I Area, lying in the southwest part of the Station, has been the locale of eight different reactors that have provided test data since 1952. All eight, including BORAX's I-IV, Experimental Breeder Reactor No. 1, the Argonne Fast Source Reactor, BORAX-V, and Zero Power Reactor No.3, were designed for the AEC by Argonne National Laboratory. First construction work by the Commission at the NRTS commenced in this area in May 1949 with the drilling of the EBR-I well. Thus, the EBR-I, completed in April 1951, was the first major facility to be constructed at the National Reactor Testing Station.

• *BORAX-I*

BORAX-I was the first in a series of five NRTS reactors which pioneered intensive work on boiling water reactors. In these reactors, the coolant moderator boils in the core and passes saturated steam direct to the turbine for power generation. This system makes possible a relatively simple design with advantages of good performance and low costs. For most boiling water reactors no intermediate heat exchanger is used to transfer heat from the coolant to another medium, as is the case with indirect-cycle systems. There is a decided advantage in the efficiency of power production in a direct-cycle system in which the temperature at the turbine throttle is essentially the same as the reactor outlet temperature.

BORAX-I was constructed in 1953 to demonstrate the feasibility of this type of reactor concept. The facility was deliberately destroyed in July 1954 to determine its inherent safety under extreme conditions.

• *BORAX-II*

BORAX-II was constructed in late 1954 for further tests and new core combinations were tried using varying enrichments of uranium-235 in the metal fuel plates. The power level was six megawatts (thermal).

• *BORAX-III*

BORAX-III, operated in 1955, was designed for 15 megawatts (thermal), compared with 1.4 megawatts (thermal) in BORAX-I and with a 2,000-electrical-kilowatt turbine generator to investigate use of boiling water reactors for genera-

ting electric power. On July 17, 1955, it produced sufficient power experimentally to power and light the city of Arco, Idaho -- an American first. The reactor generated approximately 2,000 kWe (kilowatts electrical) over a period of about two hours, distributed as follows: 500 kWe to light Arco, 500 to power the BORAX facility, and 1,000 to power the Central Facilities Area at NRTS.

• *BORAX-IV*

BORAX-IV was operated from December 1956 until June 1958. This reactor, 20 megawatts (thermal), was used principally to test high-thermal-capacity fuel elements made from mixed oxides (ceramics) of uranium and thorium.

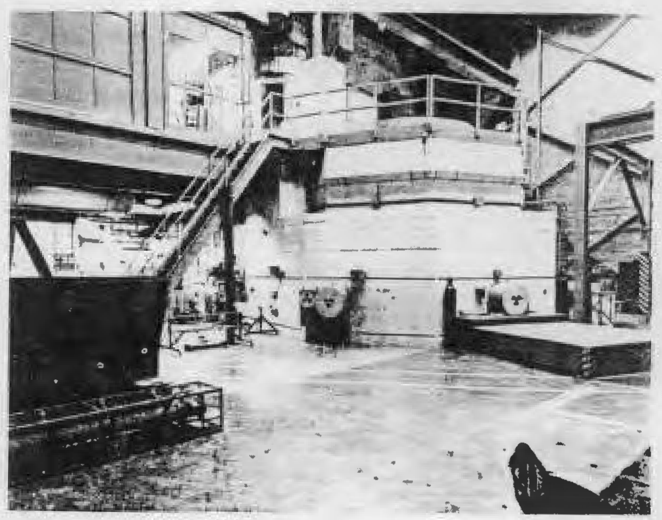
The ceramic core of uranium-thorium oxide fuel elements demonstrated the feasibility of stable operation with this fuel. It can be operated at higher temperatures, is less reactive with water coolant in case of cladding rupture, is cheaper to manufacture, and has higher burnup possibilities. It also produced measurable quantities of the artificial, thorium-derived fuel, uranium-233. BORAX-IV was operated satisfactorily with several experimentally defective fuel elements in the core. Relatively minor contamination of auxiliary equipment resulted.

• *BORAX-V*

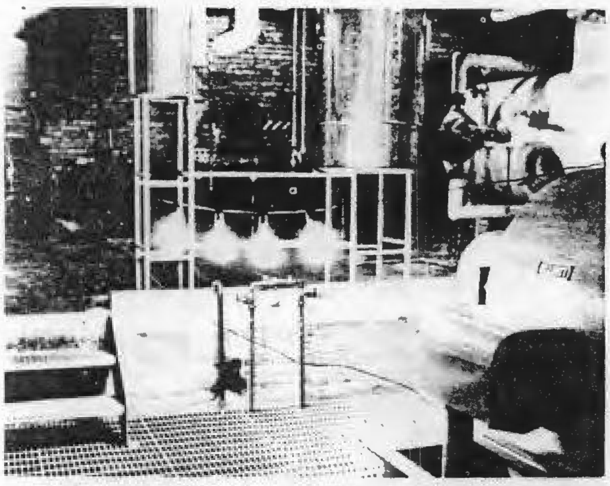
BORAX-V, with a design power of 40 megawatts (thermal), provided an extremely flexible facility for determining the safety aspects and feasibility of an integral nuclear superheat system. BORAX-V achieved criticality on February 9, 1962, and on October 10, 1963, produced superheated (dry) steam wholly by nuclear means for the first time. The reactor demonstrated that improved efficiency from manufactured steam is obtainable by incorporating as a design feature a number of superheat fuel assemblies in the reactor core lattice. This raised the temperature of the saturated steam from489°F in the core to 850°F dry steam (600 psig) in the superheat portion of the reactor. The increased cycle efficiency holds promise of reducing nuclear power costs.

A final experiment in BORAX-V demonstrated that negligible contamination to turbo-generator equipment resulted from operating with an experimentally defective fuel element in the superheat core. The reactor was placed on standby status in September 1964, and has since been decommissioned.

• *Experimental Breeder Reactor No. 1*



EBR-I sustained initial criticality in 1951 and was decommissioned early in 1964 for lack of further assignments. It had demonstrated that a nuclear reactor, designed to operate in the high-energy neutron range, is capable of breeding (creating more fuel than its operation consumes) and also of achieving competitive nuclear power. The reactor was unmoderated and used sodium-potassium alloy (NaK) as coolant and enriched uranium (largely U-235) as fuel. A blanket of natural uranium (largely U-238) around the core provided the "fertile" material in which breeding took place. The liquid metal coolant permitted the neutron energies to be kept high to promote the breeding of fissionable material. In addition, the coolant enabled high-temperature and low-pressure operation, both conducive to efficient power production.



FIRST ELECTRICITY FROM A NUCLEAR REACTOR

FIRST PLUTONIUM FROM A BREEDER REACTOR

EBR-I was brought to full power with the Mark I core on December 21, 1951, with an operational loading of 52 kilograms of uranium-235, and subsequently operated with three different core loadings. Experiments performed with the Mark I and II cores achieved a breeding ratio of at least one; that is, as much fissionable material was produced as was consumed. Projections indicated the possibility of 1.2 and 1.5 breeding rations for uranium-235 and plutonium-fueled power plants, respectively.

The Mark III core was installed late in 1957 with a more rigid configuration to rule out mechanical movement as a source of feedback. Extensive operation under varying conditions of flow and power demonstrated that careful design had eliminated instabilities which had caused a partial meltdown of the previous core in November 1955. Plutonium fuel elements were fabricated for the Mark IV core and loaded with 28.7 kg of plutonium in November 1962. The technology and feasibility of plutonium as a reactor fuel was advanced greatly by the successful operation of this core from first criticality on November 27, 1962, until the EBR-I was decommissioned in April 1964.

On August 26, 1966, President Lyndon B. Johnson participated, together with AEC Chairman Glenn T. Seaborg and other officials from government and industry, in ceremonies at the NRTS officially designating EBR-I as a registered national historic landmark.

EBR-I took into retirement a record of these notable firsts:

(1) Production of the first usable electricity from nuclear heat (in 1951).

(2) Demonstration of the feasibility of breeding (in 1953).

(3) Production, in July 1963, of usable electricity with plutonium as the major com-

ponent in the fuel.

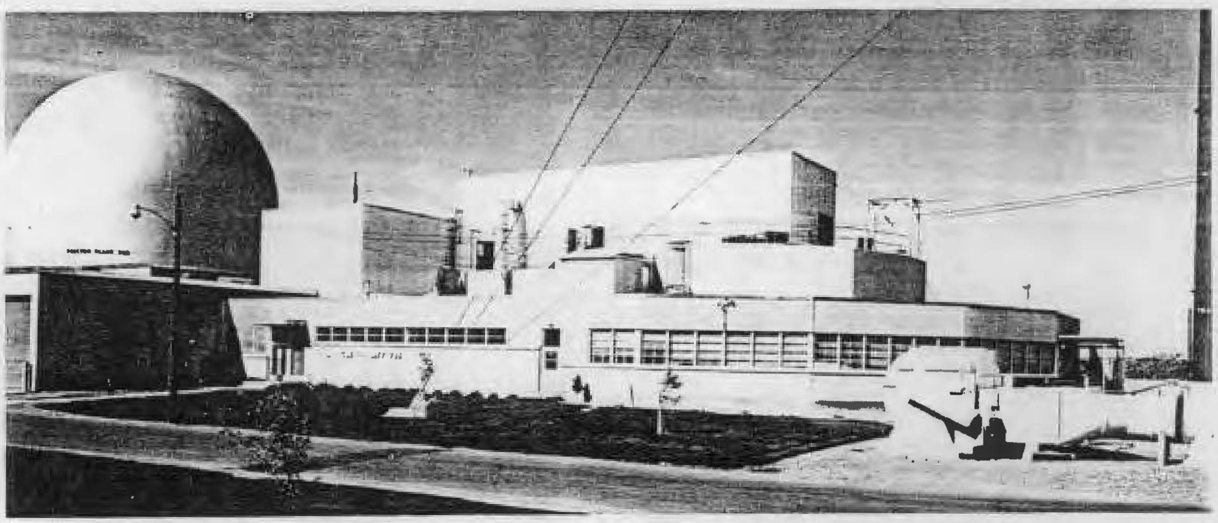
(4) Demonstrating the feasibility of using liquid metal (sodium-potassium) at high temperatures as a reactor coolant.

• *Zero Power Reactor No. 3*

A split-table machine in which criticality was achieved by bringing two halves of a fuel configuration together, ZPR-III was used for determining the accuracy of predicted critical mass geometries and to determine critical measurements in connection with various loadings for makeup of fast reactor core designs. The cores of EBR-II, Fermi, Rapsodie, and SEFOR reactors were originally mocked-up in this facility. Theoretical predictions of the performance of such systems took into account neutron reactions of importance to the neutron chain occurring over a wide range of energies, say from 50 kilovolts to a few million volts. Experimental critical assembly results in this field were almost completely lacking before advent of the ZPR-III facility in October 1955.

Trays with fissionable material and other metals were used to simulate cores of various reactor types and configurations. Core designs for plutonium-fueled fast power reactors also were improved by ZPR-III. ZPR-III was placed in standby in November 1970.

Experimental Breeder Reactor No. 2 (East) Area



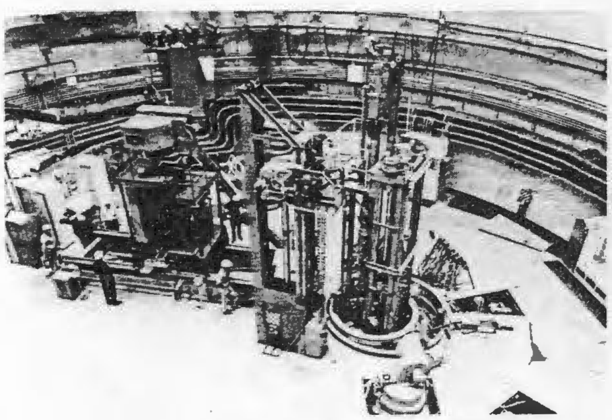
The EBR-II Area is situated at the extreme southeastern edge of the Station, 20 miles from EBR-I. It currently consists of three principal reactor facilities, EBR-II, the Transient Reactor Test Facility (TREAT), and the Zero Power Plutonium Reactor (ZPPR), all of which are operated for the AEC by Argonne National Laboratory. Argonne Fast Source Reactor (AFSR) also is in this area.

• *Experimental Breeder Reactor No. 2*

EBR-II, which achieved initial criticality on September 30, 1961, is an unmoderated, heterogeneous, sodium-cooled reactor and power plant incorporating lessons learned from EBR-I. The reactor, originally designed as an engineering demonstration plant, is currently the Commission's prime facility for irradiating samples of reactor fuels and structural materials for the Liquid Metal Fast Breeder Reactor development program. During 1972, several hundred such samples were irradiated with emphasis on improving the capability to perform fast reactor fuel testing in EBR-II. Designed for a thermal output of 62,500 kilowatts and a gross electrical capacity of 20,000 kilowatts, EBR-II employs full-size components in its sodium system, such as pumps and heat exchangers, under pressure and temperature conditions comparable to those required for high-performance, full-scale reactors.

Incidental to its operation as a fast reactor fuels testing facility, EBR-II had generated 396,383 kilowatt hours of electricity from the nuclear heat of its fissioning atoms (as of December 10, 1972). This output was fed into the NRTS network which -- augmented by firm power from private utilities -- serves all facilities at the Station, including those in the EBR-II area.

EBR-II achieved "wet" criticality (that is, with the core submerged in liquid sodium coolant) on November 11, 1963, and went to power on August 13, 1964. Reactor power has been increased over the years to its design capacity of 62,500 kilowatts to speed up the testing of fuels and materials for the LMFBR program.



EBR-2 OPERATING FLOOR

• *Hot Fuel Examination Facility/South*

(formerly Fuel Cycle Facility)

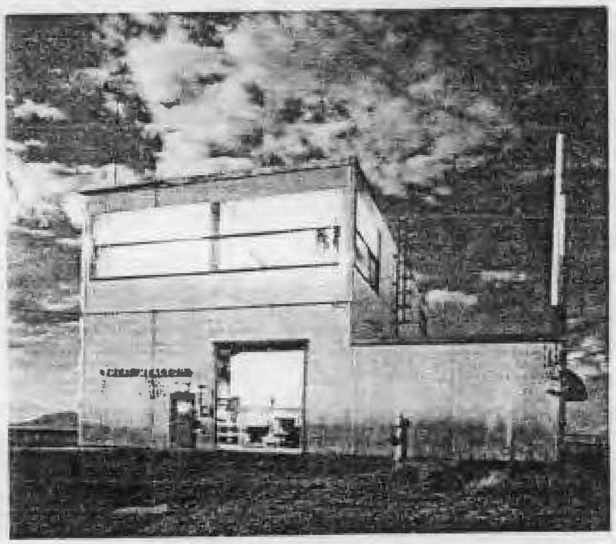
A major objective of EBR-II was furthered until 1968 in its integrated Fuel Cycle Facility (FCF), namely, developing new concepts for reprocessing and refabricating fuels for breeder reactors. Spent EBR-II fuel was reprocessed in the FCF's unique pyrometallurgical plant only two weeks after discharge from the reactor, as compared to "cooling" times of up to six months required for conventional chemical dissolution techniques. The FCF process involved: melt-refining spent fuel pins to release fission product gases from the fuel; replenishing, recasting, testing, recanning the thin fuel-alloy rods; and reassembling components into fuel assemblies for return to the reactor. The process was accomplished entirely by remote control inside a large, dough-nut-shaped, argon-atmosphere hot cell. As HFEF/S, it is now devoted entirely to examination of materials and fuels irradiated in EBR-II for the LMFBR program. Since 1968, the facility has been adapted to interim and final examination of fast reactor fuel and structural specimens irradiated in EBR-II.

• *Hot Fuel Examination Facility/North*

HFEF/N OPERATING CORRIDOR

The work being done in HFEF/S is now being expanded to a new $10.2 million hot-cell complex called Hot Fuel Examination Facility/North. HFEF/N has an argon-atmosphere main cell measuring 30 x 70 feet and 25 feet high. Its 15 work stations are being equipped with such devices as remotely operated stereomicroscopes, gamma scanners, and metallographic work boxes. Two of the work stations have 30-foot-deep pits in the floor for vertical positioning of closed "loop" experiments, which will have been irradiated in test reactors at NRTS. Construction of HFEF/N began in 1970 and was completed in 1972. In addition to EBR-II, the HFEF complex will provide support to FFTF, TREAT, and PBF.

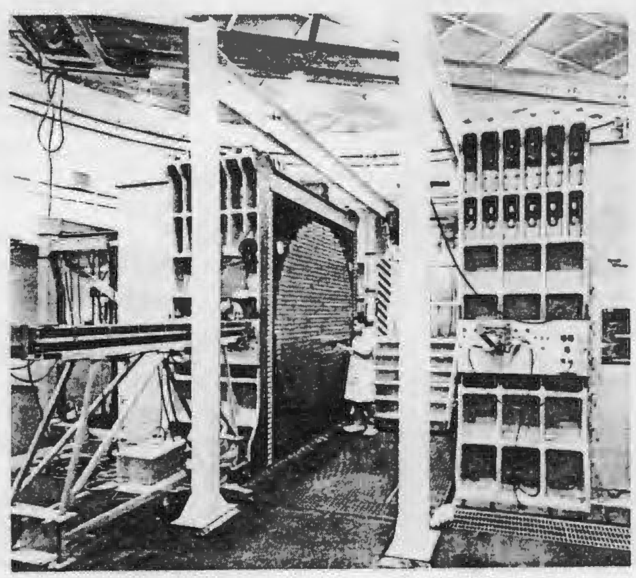
• *Transient Reactor Test Facility*



TREAT is a reactor designed to produce short, extreme pulses of nuclear energy with resultant temperatures high enough to permit meltdown studies of samples of fuel elements and components intended for use in fast reactors. The reactor became operative in February 1959. Early studies with this uranium-oxide-fueled, graphite-moderated, air-cooled reactor were aimed at determining the effect of extreme pulses of energy on prototype fuel pins for EBR-II. A program of metal-water reactor studies was also carried out. A unique design feature of TREAT consists of shielded viewing slots on two of the reactor faces. Both optical and gamma camera systems have been developed for use with these two slots so that reactive mechanisms taking place in samples can be recorded on film for detailed study. The short-term energy bursts attainable in this reactor are of greater intensity than those obtainable in the large testing reactors. The surges result when large numbers of atoms are fissioned in a short time. This causes intense heat to be generated in the sample being tested. The surges are useful in simulating abnormal reactor operating conditions and permit reactor designers to observe, on a small scale, the effect of such conditions on prototype fuel elements intended for use in fast reactors. An innovation at TREAT in 1968 was the making of high-resolution neutron radiographs of irradiated fuel and other irradiated specimens from various NRTS facilities. Current work includes studies of fuel failure in packaged loops containing flowing sodium.

• *Zero Power Plutonium Reactor*

ZPPR is a critical facility similar to, but larger than, ZPR-II. Situated about 1000 feet southeast of EBR-II, the new reactor is a major facility in the AEC's high priority Liquid Metal Fast Breeder Reactor program. Experiments conducted in ZPPR provide reactor physics information to support designing and developing large plutonium-fueled fast breeder reactors for future commercial nuclear power plants generating up to 1,000,000 kilowatts of



electricity. The new reactor essentially consists of a framework in two halves for constructing fuel core mock-ups of large (up to 14 feet in diameter) fast-breeder reactors. In operation, drawers loaded with mock-up fuels and other materials are inserted into honeycomb lattices in each of the separated halves. To initiate a chain reaction, the two halves are brought together. Construction of ZPPR started in August 1966 and was completed in September 1968. First nuclear operation was on April 18, 1969. The total estimated construction cost was $3.7 million, exclusive of more than $100 million of plutonium and other materials needed for fabricating the reactor's fuel.

• *Argonne Fast Source Reactor*

The AFSR, operated by the Commission's Argonne National Laboratory, is an experimental reactor used as a tool in studying the physics of fast breeder reactors. It was placed in operation at the EBR-I (West) area during October 1959 with a design power of one kilowatt. The reactor serves essentially as a source of neutrons used in developing improved instruments and techniques for making measurements in the neutron energy range characteristic of fast reactors. It was designed to augment studies of fast reactor physics carried out in ZPR-III (Zero Power Critical Facility No. 3). It is currently being used in conjunction with ZPRR.

Water Reactor Safety Program

The bulk of the AEC's longtime program for investigating the safety of water-cooled reactors has been centered at the NRTS since 1955, when Phillips Petroleum Company began reactor safety studies in the SPERT-1 reactor. Operating responsibility for the safety program was transferred to Idaho Nuclear Corporation in 1969 and reassigned to Aerojet Nuclear Company in 1971.

Early developmental research by Phillips centered chiefly around the behavior and consequences of the so-called runaway power (or reactivity) accident. Ultimately, testing in four SPERT reactors led to an understanding of several natural mechanisms which resist power increases and terminate the runaway power conditions. SPERT tests also contributed to the development and better understanding of engineered reactor-safety control systems.

Currently, the Water Reactor Safety Program (WRSP) is directed toward studying fuel behavior and the behavior of a nuclear power plant and its safety systems during a hypothetical loss-of-coolant accident (LOCA). Such an accident--though one has never occurred during some 25 years' experience in operating dozens of water-cooled reactors--is being studied as the worst possible accident conceivable for large power plants. This is in accordance with the Commission's policy of continuing to seek information that can be used to resolve safety issues related to reactor design, licensing, and operation.

The WRSP consists of four fully coordinated efforts aimed at in-depth understanding of the thermal-hydraulic and mechanical phenomena resulting from primary coolant system decompression following a LOCA, and of the effects of quickly reflooding the core as safety systems are actuated to mitigate the consequences of such an accident. This understanding can only be obtained through calculational results derived from sophisticated analytical models (mathematical equations) supported by experimental data. Accordingly, the WRSP is being furthered at NRTS by the Accident Analysis Program, Separate Effects Testing, Power Burst Facility Testing, and Loss of Fluid Test Facility Integral Test Program.

• *Accident Analysis Program*

These studies involve developing and verifying mathematical equations (analytical models) and corresponding computer programs capable of predicting the step-by-step sequence and behavior of a hypothetical LOCA.

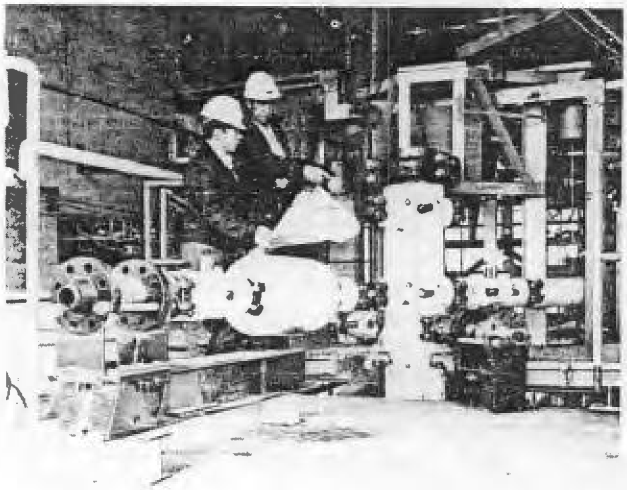
Scientists, engineers, mathematicians, and computer experts are working at the NRTS to devise equations describing the dozens of interacting subevents in a LOCA. Then, computer programs are developed to "solve" the equations for the conditions of interest (temperature, pressure, and others) that would occur throughout the course of such an accident.

For example, the NRTS program has in the past or is currently developing such equations and computer models for (1) fuel rod thermal and mechanical response during the coolant blowdown, core heatup, and core cooldown, from either top spraying or vessel flooding; (2) reactor structural response to seismic excitation, primary coolant decompression, and emergency core cooling injection; (3) thermal-hydraulic processes which occur during the subcooled blowdown, saturated blowdown, and emergency cooling injection stages; (4) containment structure response; and (5) fission product migration.

The accident analysis work is directly applicable to informational needs of the AEC's Director of Regulation (for licensing large power reactors and establishing codes and standards for licensing) and of Aerojet Nuclear (for developing the LOFT Integral Test Program). Successful conduct of the Accident Analysis Program depends on data from many test programs to establish the validity and precision of the various predictive techniques being developed.

COMPUTER SCIENCE CENTER

• *Separate Effects Testing*



SEMISCALE TESTING EQUIPMENT

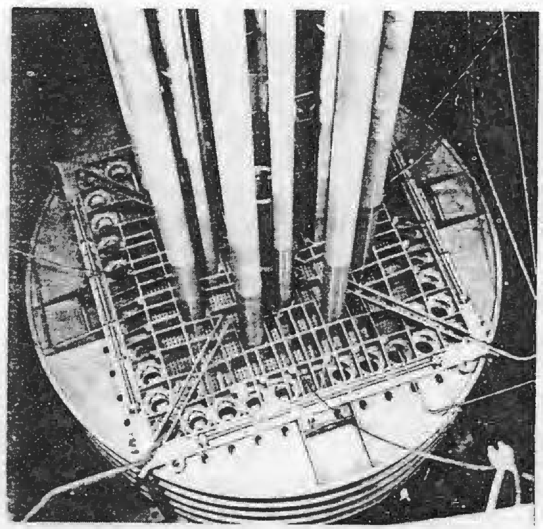
This nonnuclear test program is designed to provide an experimental basis for developing and verifying the calculational techniques required to predict all phases of a LOCA as well as provide preliminary information for supporting the LOFT design effort and for developing the LOFT experimental program. The tests include:

Semiscale Blowdown and ECC Project. Investigations beginning in 1965 involved expelling coolant from a small simulated reactor vessel by means of a blowdown nozzle. The next phase tested a simple system consisting of a small reactor vessel (22-inch diameter, 74-inch height), and electrically heated 9-inch core, and a single, circulating coolant loop. Tests scheduled to begin early in 1974 will use a 1-1/2 loop system scaled to the present LOFT design. Future plans contemplate testing a two-loop system, designed to model a typical pressurized water power reactor and its emergency core cooling systems.

FLECHT (Full-Length Emergency Core Heating Tests). This effort involves heat transfer testing of electrically heated, full-length (12-foot) nonnuclear rod bundles to determine the effectiveness of emergency core cooling systems for both boiling water reactors and pressurized water reactors. Both zircaloy and stainless steel claddings were used in the tests conducted under subcontracts with General Electric Company (for BWR tests) and Westinghouse Electric Corporation (for PWR tests).

Fission Product Behavior Experiments. This series of small scale tests was to help assess the adequacy of analytical models developed to describe the release of fission products and their behavior subsequent to a LOCA. The testing was performed at ICPP and at Oak Ridge National Laboratory.

• *Power Burst Facility Testing*



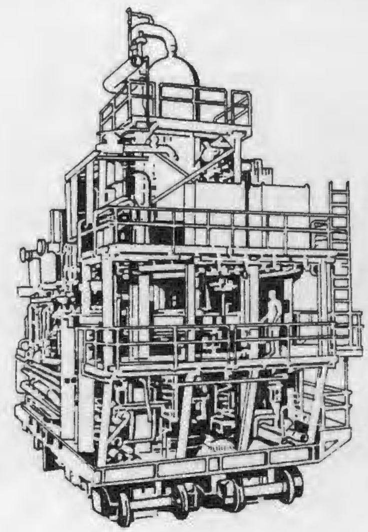
PBF CORE

The basic objective of the PBF program is to provide information which can be used to better resolve fuel behavior issues related to power reactor operation. Specifically, all testing to be performed in PBF is concerned with defining the response of a fuel-clad system to abnormal reactor conditions which result in a mismatch between the heat generated in the rod and the ability of the coolant to remove the heat. The purpose of this testing is to provide data for use in developing or improving analytical models which may be used to analyze the response of power reactor fuel to abnormal and postulated accident conditions. All of the data will be obtained from reactor fuel in a controlled reactor environment. The test plant includes experiments directed toward resolution of significant safety issues for the three classes of accidents postulated for light-water cooled reactors: power/cooling mismatch, LOCA, and excess reactivity insertion.

- *LOFT Integral Test Program*

After the individual parts of the WRSP accident analysis models have been verified in nonnuclear Separate Effects Testing and PBF testing, confirmatory information on the adequacy of all previous steps for an integrated nuclear pressurized water plant will be sought by performing the entire LOCA sequence in a reactor facility called LOFT, for Loss of Fluid Test.

The LOFT program mission is threefold: (1) provide experimental data for evaluating the adequacy of analytical methods for predicting the accident response of large power reactors, the performance of engineered safety systems, and the margins of safety inherent in that performance; (2) identify any unexpected events not now accounted for in the analysis of plant and nuclear response or in the design of engineered safety systems; and (3) provide experience in developing standards and applying AEC and other standards and codes applicable to pressurized water reactor construction.



LOFT MOBILE TEST ASSEMBLY

Power Burst Facility

The Power Burst Facility (PBF) achieved first criticality September 22, 1972. It is designed to provide experimental data on the response of fuel rods to postulated accident conditions. The PBF consists of an open-tank reactor vessel, a driver core region with an active length of three feet, a central flux trap region containing an in-pile tube in which the test fuel is located, and a loop coolant system for providing the required system conditions in the test space. The loop coolant system was designed to provide typical PWR system conditions of temperature pressure and flow, and will be capable of providing BWR system conditions and system conditions characteristics of an LWR during a postulated loss-of-coolant accident.

The PBF reactor can be operated at a steady state power up to 40 MW, or with either shaped or natural power transients to provide representative power and energy densities in test fuel clusters containing as many as 45 fuel rods.

A major objective of the in-pile subassembly testing program in PBF is to provide the necessary experimental data for evaluating, verifying, and, if necessary, modifying analytical models for application to the understanding of large power reactor core behavior under postulated accident conditions.

Construction of PBF was started near the old SPERT-I (Special Power Excursion Reactor Test-I) site in October 1965 and completed in October 1970. Additional modifications for 48-hour operation, environmental consideration, and loss-of-coolant capability are in various stages of completion. Total cost of the facility is estimated to be $17.9 million.

SPERT Reactors

The Special Power Excursion Reactor Tests were operated for the AEC by Phillips Petroleum Company until 1969, then by Idaho Nuclear Corporation, and, since July 1970, by Aerojet Nuclear Company. The four SPERT reactors were designed and operated for studying a wide range of variables such as plate design; core configuration; coolant flow; and reflector, moderator, void and temperature coefficients.

The SPERT reactor experiments fell into four major classifications: static experiments to determine such core characteristics as void and temperature coefficients; step tests in which the system is suddenly made supercritical; ramp tests in which reactivity is added to the reactor at a constant rate; and stability tests which may involve either spontaneous or externally induced oscillations. These tests were performed under various conditions of temperature, pressure, and coolant flow on cores of differing designs. All operations were conducted from a central control building, one half mile from the reactors. The vast majority of the experiments conducted in the SPERT reactors were safely below the threshold of core damage. Fuel damage was sustained in only a few tests.

• *SPERT-I*

SPERT-I URANIUM OXIDE FUEL CORE

SPERT-I was placed in operation June 11, 1955 and decommissioned in the fall of 1964. It was an open-tank, light-water-moderated and -reflected reactor, originally using 92 percent-enriched uranium fuel. The reactor tank, about four feet in diameter and 14 feet high, was filled with water to a level about two feet above the core. For most of the hundreds of excursions conducted in SPERT-I, five cadmium-blade-type control rods (four for reactor operation and one for the initiation of power excursions) were operated by drive mechanisms supported on a bridge across the shield tank, with two instrumentation systems, one for controlling the reactor and one for studying transients. A closed-circuit television camera mounted above the tank made it possible to view the reactor in operation on a TV screen in the control room.

In general, the SPERT-I tests were characterized by sudden power rises, arrested by inherent shutdown, or self-limiting tendencies of the reactor itself. In a typical excursion, reactor power would attain a peak in a fraction of a second and, without manipulation of control rods, drop to much lower, though generally steady, levels.

In 10 years of operation, approximately 1300 kinetics tests were performed with six different reactor cores in SPERT-I. After 1962, the primary emphasis was placed on extending the reactivity accident into the destructive region.

Before being phased out in the fall of 1964 to permit the construction of a new reactor (the Power Burst Facility) at the same site, SPERT-I had compiled a list of accomplishments that included:

A 2,300-megawatt deliberate power burst on November 5, 1962, which destroyed a highly enriched uranium (93% U-235) metal plate core of the type used in research and test reactors, providing valuable data for simplification of safety design features.

A 17,400-megawatt power burst on November 12, 1963, using a low-enrichment (4% U-235) core of uranium oxide fuel pins, which successfully withstood the test without causing expulsion of water from the tank or damage to the reactor, other than the bowing of 140 pins and the splitting of two of them.

A deliberate power burst of 35,000 megawatts on April 14, 1964 (using substantially the same uranium oxide core as in the November 1963 test), again demonstrating the damage-resistant capabilities of oxide fuel and also that the failure of a few pins will reduce the expected energy release, thereby protecting the rest of the core.

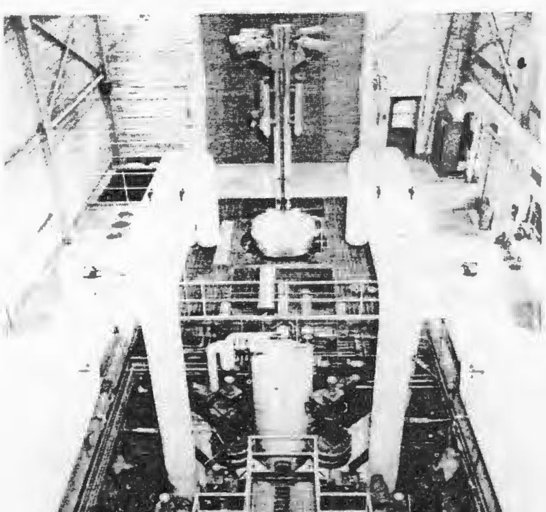
The success of both uranium oxide

fuel tests was of major safety significance to the nuclear power industry which is using low-enrichment, uranium oxide fuel in water-cooled reactors powering large central stations.

• *SPERT-II*

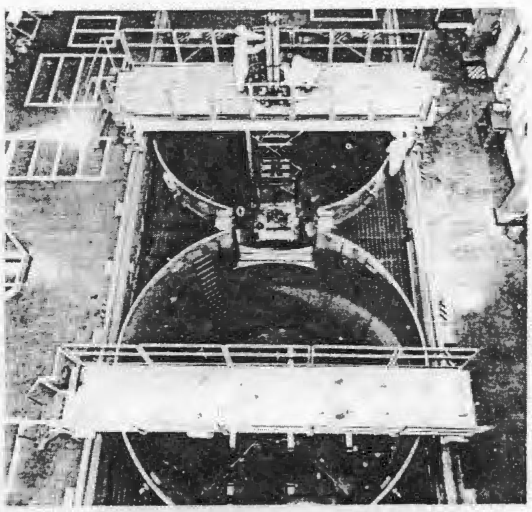
SPERT-II sustained initial criticality March 11, 1960. This facility consisted of a pressurized water reactor with coolant flow systems designed for operation with either light or heavy water at pressures up to 375 pounds per square inch, temperatures up to 400°F, and flow rates up to 20,000 gpm. Coolant flow could be directed either upward or downward through the reactor core at velocities up to about 25 feet per second to establish the desired initial conditions prior to transient testing of the reactor. SPERT-II was placed in standby in October 1964 after completion of programmed operations in August of 1964.

• *SPERT-III*



SPERT-III became operative on December 19, 1958. It was considered to be the most versatile facility yet developed for studying the inherent safety characteristics of nuclear reactors. It provided the widest practical range of control over three variables: temperature, pressure, and coolant flow. Pressures from atmospheric to 2,500 psi, water temperatures from 68° to 668°F, and coolant flow rates ranging from zero to 20,000 gpm with heat removal capacities up to 60,000 kilowatts for durations of 30 minutes were attainable in the flexible SPERT-III. SPERT-III was placed in standby upon completion of its programmed operations in June 1968.

• *SPERT-IV*



SPERT-IV construction was completed in October 1961, and criticality was achieved on July 24, 1962. This was an open-tank, twin-pool facility which permitted detailed studies of reactor stability as affected by varying conditions including forced coolant flow, variable height of water above the core, hydrostatic head, and other hydrodynamic effects. More specifically, the SPERT-IV reactor made detailed studies on phenomena of instability first demonstrated in some of the more than 1,000 excursions conducted in SPERT-I. The small size of the SPERT-I tank necessitated construction of the larger SPERT-IV facility in order to pursue further investigations of instability phenomena. The Capsule Driver Core was operated for several years in the SPERT-IV reactor to gain information on fuel destructive mechanisms pending completion of the new Power Burst Facility. The CDC program in SPERT-IV ended in August 1970.

Naval Reactors Facility

Four major installations comprise the NRF. These are the Submarine Prototype (S1W), the Large Ship Reactor (A1W), the Expended Core Facility (ECF), and the Natural Circulation Reactor (S5G).

It was in the S1W, formerly the Submarine Thermal Reactor or STR, that the United States' nuclear navy was born. The project, aimed at freeing our naval vessels from their need for refueling at sea or frequent returns to port, achieved success with an initial power run in the "Nautilus" prototype on May 31, 1953. Then followed attainment of full design power on July 25, 1953, and, shortly thereafter, accomplishment of a simulated voyage nonstop from Newfoundland to Ireland, "submerged" and at full power, lasting more than 66 hours. This proved that atomic propulsion of ships was feasible and that the "Nautilus", long before it set out to sea, could do the remarkable things it has since accomplished, including subnavigation of the polar ice cap from the Pacific to the Atlantic in the summer of 1958.

The logical next step was to develop a prototype for surface ships. However, other problems, including the necessity of proving that reactors can be teamed up, remained to be solved. In October 1958, the first reactor of the Large Ship Reactor Facility sustained criticality, followed by the second reactor in July 1959, and full power operation by both reactors on September 15, 1959. The aircraft carrier "Enterprise" and the missile cruiser "Long Beach" are powered by A1W-type plants.

• *S1W*

The S1W is popularly called the atomic submarine plant. It is operated for the Commission and the U. S. Navy by Westinghouse Electric Corporation under jurisdiction of the AEC's

Pittsburgh Naval Reactors Operations Office. The S1W facility still houses the prototype of the Nautilus although the testing program has changed from one of simulating the Nautilus power plant to one of testing advance design equipment, prototyping new systems for current nuclear projects, and obtaining data for future naval vessel power plants. In addition, the S1W Site continues to be a training center for Navy personnel who will man present and future underseas atomic craft.

The nuclear power plant and the associated propulsion equipment are installed inside two hull sections of a submarine originally built to duplicate the corresponding sections of the atomic submarine "Nautilus". In this submarine hull, the research and development took place in a maze of pipes, wires, motors, valves, and instruments which, on March 30, 1953, resulted in a successful reactor. It was brought to power on May 31 and several weeks afterward made the equivalent of the aforementioned Atlantic crossing, submerged at top speed.

Since then, the submarine prototype continued to establish an outstanding performance record. It operated over two and one-half years on its original uranium fuel charge. In 1956, the plant completed the longest full-power run ever attempted by a propulsion plant, land, sea, or air. During the test, it operated continuously for 66 days and nights. When it was routinely shut down at the end of the run, there still remained sufficient uranium fuel for hundreds of additional hours of full-power operation. This unprecedented test gave engineers and scientists an opportunity to check instruments and equipment under conditions more demanding than would be expected in the actual submarine. While the test was underway, Navy atomic crew trainees manned watch stations, just as if they were on an actual cruise.

• *The Large Ship Reactor (A1W)*

The A1W is a prototype facility that consists basically of a dual pressurized water reactor plant within a portion of a steel hull of a large surface ship. All components are of a type that will withstand seagoing use. The first of the prototype's two pressurized water reactors sustained criticality in October 1958 and achieved full power operation in January 1959. Reactor No. 2 went critical in July 1959, and on September 15 of that year both reactor plants operated at full power for the first time. This is the first nuclear plant to have two reactors powering one ship propeller shaft. The prototype powers the plant's propeller shaft through a geared turbine propulsion unit. The shaft is loaded by a special power absorbing generator which will simulate loads placed on an aircraft carrier propeller during actual ship-at-sea conditions.

From continuing tests are coming new and advanced reactors and cores for naval surface ships. The A1W reactors are designed for interchangeable use between cruiser and carrier type ships. The aircraft carrier "Enterprise" is powered by eight A1W-type reactors and the cruiser "Long Beach" utilizes two. The A1W is operated for the Commission and the U. S. Navy by Westinghouse Electric Corporation.

• *Expended Core Facility*

The Expended Core Facility, also operated for the Commission and the U. S. Navy by Westinghouse, handles the dismantling and analysis of expended cores received from the U. S. nuclear navy in preparation for shipment to the Idaho Chemical Processing Plant for recovery of enriched uranium in the spent fuel. Part of the building contains deep, water-filled pits for safe underwater disassembly and preparation for analysis of the radioactive fuel. Sections of the disassembled elements are sent to hot cells within the building for research and testing. The hot cell windows are six feet thick.

- *Natural Circulation Reactor (S5G)*

The land prototype S5G plant is immediately south of the large ship reactor (A1W). The natural circulation concept -- becuase of its inherent safety, plant simplicity, increased reliability and reduction of noise -- promises advantages over pressurized water reactors requiring pumps and other auxiliary equipment. One of the most difficult problems in the development of this more advanced nuclear propulsion plant for submarines using natural convection to circulate the reactor cooling water is to ensure that the plant will operate satisfactorily under conditions of ship motion.

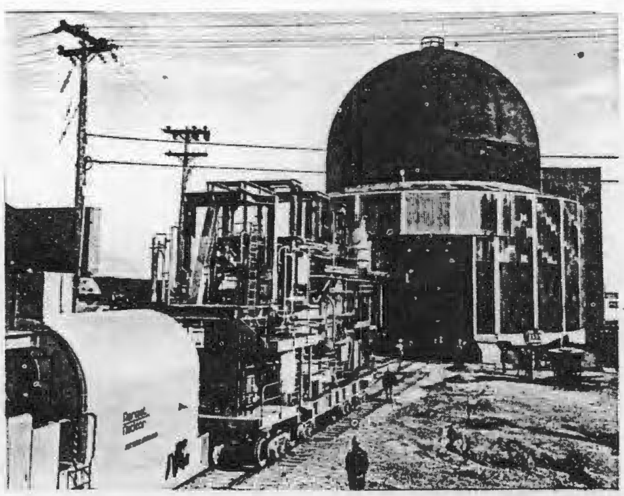
Consequently, the NRTS prototype was designed to simulate the pitching motions that the reactor would experience at sea. Design and development work for the S5G was performed at the Commission's Knolls Atomic Power Laboratory, Schenectady, N. Y. The S5G facility is now operated for the AEC by Westinghouse Electric Corporation.

Test Area North (TAN)

TAN was originally the site of the Aircraft Nuclear Propulsion (ANP) project where significant progress was made by General Electric Company for the AEC in the 1950's toward development of a nuclear airplane. The program involved building and testing three Heat Transfer Reactor Experiments (HTRE-1, HTRE-2, and HTRE-3, which developed 20, 14, and 32 megawatts of heat energy, respectively). Among other things, these air-cooled reactors proved the feasibility of operating an aircraft turbojet engine with nuclear heat. Three low-power reactors also were operated at TAN to support the ANP program -- Shield Test Pool Facility Reactor (SUSIE), Critical Experiment Tank (CET), and Hot Critical Experiment (HOTCE). Since the ANP project was discontinued (by order of the President) on March 28, 1961, several other programs have been assigned to the area.

The hub of current activities at TAN -- now operated for the AEC by Aerojet Nuclear Company -- is the Technical Services Facility, or TSF. Here are several large shops, including a high bay area which has unique capabilities for remote handling of intensively radioactive materials involving either delicate and precise work or massive industrial-sized operations. These service shops, and other existing facilities in which testing is done, have been shared to great advantage by the newly assigned programs with testing facilities located in a fan-shaped pattern around the services area.

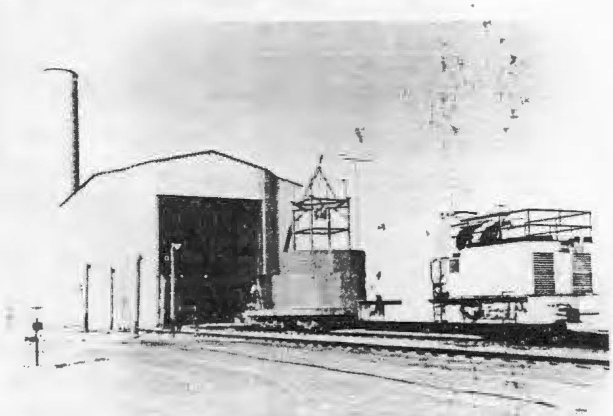
• *Loss-of-Fluid Test*



The Field Engineering Test Facility (FET) at TAN is a large hangar-like structure that is being adapted for the Loss-of-Fluid Test, called LOFT. This safety experiment is being designed to study the efficacy of engineered safeguards in water-cooled power reactors by deliberately initiating a major coolant pipe rupture, a highly improbable but worst conceivable accident for such reactors. LOFT will involve a scaled-down model (55,000 thermal kilowatts) of a commercial power reactor placed inside a containment building similar to present-day containment structures. The experiment is designed for mounting on a double-width railway flatcar, or dolly, which can be pulled by shielded locomotive over quadruple rails to the TAN Hot Shop for post-test analysis. LOFT is part of the Commission's Water Reactor Safety Program. The program was conducted for the AEC by Phillips Petroleum Company until 1969 when it was assigned to Idaho Nuclear Corporation. In July 1971, the program responsibility was reassigned to Aerojet Nuclear Company. LOFT construction was started in the fall of 1964. Completion of the basic facility is expected in 1973. Estimated construction costs total $35 million.

• *Initial Engineering Test Facility (IET)*

A four-track railroad connects IET with the service shops, permitting reactor experiments to be shuttled back and forth by a shielded locomotive on double-width flatcars for test and post-test analysis. This unique capability, which includes a complete reactor control system into which reactor assemblies can be plugged for experimental purposes, has made the IET especially valuable for safety testing, and more particularly as part of an extension of the



SPERT program known as the Safety Test Engineering Program, or STEP. Conducted for the AEC by Phillips Petroleum Company, STEP involved engineering-scale field testing to demonstrate the safety of aerospace as well as land-based reactors systems. The successful testing of a SNAP-10A (Systems for Nuclear Auxiliary Power No. 10-A) auxiliary power space reactor April 1, 1964, was one of the early STEP undertakings. Designated SNAPTRAN-3 (Snap Transient No. 3), the test showed that such a device would immediately destroy itself instead of building up a high inventory of radioactive fission products should it fall into water. Successful follow-on tests of the SNAP-10A system were SNAPTRAN-1 and SNAPTRAN-2.

• *Spherical Cavity Reactor Critical Experiment (SCRCE)*

LPTF, IN BACKGROUND, AND STPF

The SCRCE was an outgrowth of a program begun by General Electric Company in the 1960's to investigate the feasibility of a promising space propulsion reactor concept for the National Aeronautics and Space Administration. In 1969, the program was transferred by the joint AEC-NASA Space Nuclear Propulsion office to Idaho Nuclear Corporation, and in July 1971 to Aerojet Nuclear Company.

The purpose of the Spherical Cavity Reactor Critical Experiment was to test the nuclear feasibility of a nuclear propulsion concept: heating hydrogen propellant to approximately 10,000°F by a ball or core of low density gaseous uranium hexafluoride (UF_6), the ball of gas held in place by the hydrogen flowing around it, something like a ping-pong ball suspended in a stream of air. Uranium core temperatures as high as 100,000°F were considered possible.

The employees at the LPTF made a "first in the world" experiment on May 17, 1967, by successfully bringing a gas core (uranium hexafluoride) reactor to a "critical" stage.

• *Split-Table Reactor (STR)*

Like the Cavity Reactor program (which was operated first by General Electric, then by Idaho Nuclear, and now by Aerojet Nuclear), another critical-experiment facility performing research work at the LPTF is the Split Table Reactor. This experiment is assembled in a split-table structure with an alumium-honeycomb matrix. It is housed in the second cell of the LPTF. The cell formerly housed the 710 Fast Spectrum Refractory Metals Reactor.

The STR serves as a matrix for mocking up reactor design concepts and it can test both thermal and fast neutron systems. The reactor can be either reflector or poison-controlled for the principal purpose of obtaining basic physics and design data. It can also be used as a measurement tool for developing sub-critical test devices that accurately control reactor core component quality or fissile materials safeguards.

• *Fast Spectrum Refractory Metals Reactor*

This low-power critical facility was operated in the LPTF from March 1962 to 1968 to collect data on a proposed fast-spectrum refractory metal reactor concept called the 710 reactor. The concept involved using metals such as tungsten and tantalum in developing a compact, very high temperature reactor for generating power in space. Work has been discontinued pending further developments in space requirements planning. Existing nonnuclear technology (solar cells coupled with solid state instrumentation) can provide for present power needs in space. General Electric Company was the operating contractor for the program which was administered by the AEC's Oak Ridge Operations Office.

- *High Temperature Marine Propulsion Reactor*

Also at LPTF, the 630-A Reactor Critical Experiment was operated for the Commission by the General Electric Company (under the AEC's Oak Ridge Operations Office) to explore the feasibility of an air-cooled, water-moderated system for nuclear-powered merchant ships. Further development was discontinued in December 1964 when decisions were made to lower the priority of the entire nuclear-powered merchant ship program.

- *Experimental Beryllium Oxide Reactor*

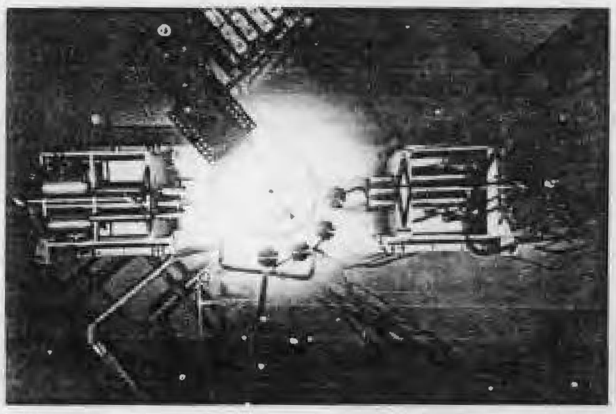
Modifications to another former ANP building, the Shield Test Pool Facility, were begun in May 1963 to house the Experimental Beryllium Oxide Reactor (EBOR). The Commission terminated work in December 1966 prior to completion of construction. The project's objective was to develop technology for using beryllium oxide as a neutron moderator in high-temperature, gas-cooled reactors. Among the reasons for the cancellation was the encouraging progress achieved, concurrently with EBOR construction, in developing graphite as a moderator, which lessened the importance of developing the alternate moderator. The action was consistent with continuing efforts of the AEC to assign available resources, including funds and personnel, on a priority basis to those reactor concepts with the best promise of economic power production and efficient use of nuclear materials. EBOR was subsequently modified to enable using the facility for evaluating various nondestructive test methods that employ acoustics to detect existing or potential flaws in reactor vessels and piping. Southwest Research Institute conducted the program, sponsored by the Edison Electric Institute in association with the Tennessee Valley Authority. STPF has been modified to house the semiscale 1-1/2 loop system for the reactor safety program.

Auxiliary Reactor Area

Since January 1966, work in the Auxiliary Reactor Area has involved a variety of technical support services for the station's developmental research programs.

From 1957 through 1965, a nine-year, military-oriented program in this area (then known as the Army Reactor Area) saw near fruition of the Army's quest for a compact, light-weight, mobile power reactor that could be transported by air or tractor-trailer with minimal intervals between shutdown and restartup in a new location.

• *GCRE and ML-1*



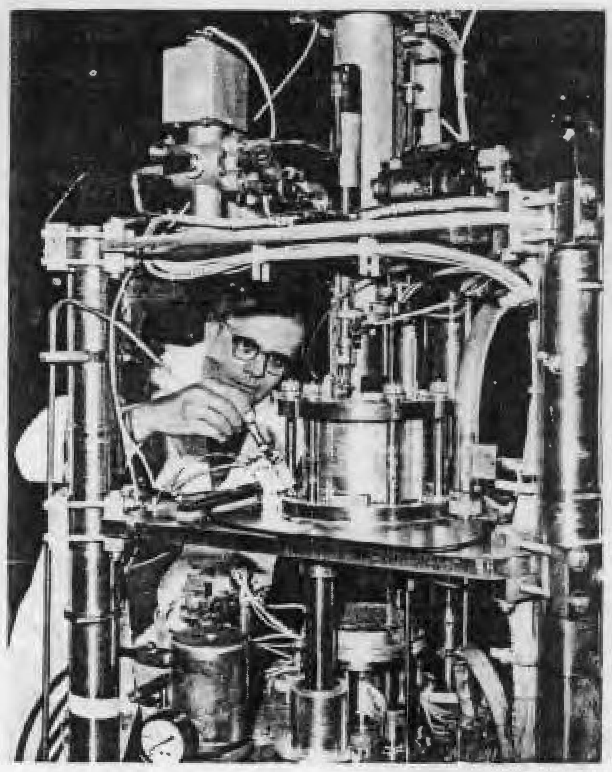
GCRE CORE AT POWER

The most successful portion of the Army program involved the Gas Cooled Reactor Experiment, or GCRE, and the Mobile Low Power Plant No. 1, or ML-1, both operated for the AEC by Aerojet General Corporation. GCRE was a water-moderated, nitrogen-cooled, direct and closed-cycle reactor generating 2200 kilowatts of heat, but no electricity. It achieved criticality February 23, 1960. After accomplishing its mission (the proof of principle phase of a mobile nuclear power plant followed by three-months testing of a prototype reactor package for ML-1), it was placed in standby on April 6, 1961. The actual ML-1 reactor operation occurred in a separate facility, beginning with criticality on March 30, 1961 and ending on May 29, 1964 after a series of power runs climaxed by 664 consecutive hours of operation. A late-1965 determination by the Army resulted in phasing out of the ML-1 program because of inability to identify a specific current mission and questions of cost effectiveness.

• *Instrument Development*

The Gas Cooled Reactor Facility (formerly GCRE) has been augmented by two new laboratory buildings to provide space and equipment for Aerojet Nuclear Company's Instrumentation and Control Branch which provides research and development and physical support for LOFT, PBF, the Station's test reactors, and the Company's nuclear technology division. Instrumentation that can obtain nuclear and dynamic data, otherwise not available, is being researched and developed.

FRAN, a small pulsed reactor capable of supplying bursts of high-intensity fast neutrons and gamma radiation, was transferred to the NRTS in mid-1967 from the Nevada Test Site, where it had been op-



FRAN RESEARCH REACTOR

erated by Lawrence Radiation Laboratory. Beginning with first criticality August 28, 1968 in the former ML-1 reactor building, FRAN was employed for a short time to test the performance of new detection instruments being developed for reactor control purposes. The reactor was moved to the AEC's Lawrence Radiation Laboratory at Livermore, California in June 1970.

Organic Reactor Area

• *Organic Moderated Reactor Experiment*

A reactor concept conceived and partially financed by Atomics International, OMRE was constructed and operated at NRTS for several years to demonstrate the technical and economic feasibility of using a liquid hydrocarbon as both the coolant and moderator. The primary purpose of the reactor was to study the radiation and thermal stability of the organic materials used and the associated physical property changes under actual reactor operating conditions. OMRE was phased out in April 1963 after accomplishing this purpose. First OMRE criticality was achieved September 17, 1957.

APPENDIX

Facts and Sidelights

The NRTS is served by a branch line (freight only) of the Union Pacific Railroad, the official siding being Scoville. Highways traversing the Station include U. S. 20, connecting Idaho Falls and Arco; U. S. 26, connecting Blackfoot and Arco; Idaho 88, connecting Terreton and Howe; Idaho 22, connecting Dubois and Idaho 88 near Test Area North; and Idaho 28, connecting Salmon and Idaho 22.

Visits to the NRTS are limited to those persons having official-business passes issued by the Security force. Members of the Security force have been deputized as state police. An air space restriction prohibits unauthorized air travel over the area below 10,000 feet, mean sea level.

Nuclear research and development programs of three military service branches -- the Air Force, Army, and Navy -- have been conducted at the NRTS. Private industrial firms have carried out the work under joint contract to the Services and to the Commission.

A waste storage area for low-level radioactive solid and semisolid wastes lies in the south central part of the Station. Contaminated materials, such as laboratory glass, wipe rags, and some semisolid chemical wastes are buried there in alluvial sediment trenches. Interim storage is also provided for barrels of transuranic solid wastes, both in pits and in an asphalt-floored earth-mounded facility.

A centralized security plan with spot emphasis on specific areas was devised when the Station was established. This obviated construction of more than 125 miles of costly fencing, lighting, and patrol roads. More than a million dollars of the allocation for administration and services was saved by consolidating facilities, designing for the most economical construction, and utilizing surplus from other Commission offices.

While the Station itself is isolated, there are more than 30 surrounding communities where workers live. The housing and service capabilities of these communities made it unnecessary to establish a Federal community. Most of the communities have experienced a steady growth pattern, particularly Idaho Falls, where nearly 70 percent of the permanent force resides and where the Commission has its Idaho Operations Office headquarters. Records of the Idaho Falls building inspector show that since 1949 when the Station was established, 6,671 dwelling units had been constructed as of December 31, 1970, an annual average of 318 units. This compared with 151 units built per year for the four-year period, 1945-48.

Specific examples of population growth are the following 1970 census populations for key cities adjacent to NRTS (1950 census figures are in parentheses): Arco, 1,173 (961); Blackfoot, 8,558 (5,180); Idaho Falls, 35,318 (19,218); Pocatello, 38,826 (30,825); Rexburg, 8,265 (4,253); and Shelley, 2,614 (1,856).

The Station and its technological program have afforded new opportunities for the young people of Idaho, particularly college graduates, to find challenging opportunities for work without having to leave their home state.

In addition, the appeal of working in the field of atomic energy has been responsible for a considerable influx of new residents to the area from every state in the Union and many parts of the world.

The Station's permanent operating force, consisting mostly of employees of firms under contract to the government, has fluctuated between 4000 and 5500 since June 1958. AEC employees on the permanent payroll have numbered around 400. In addition, the construction, or temporary, work force has ranged from approximately 300 to 900 annually for the past 10 years.

The annual permanent force payroll has varied from $25 million to $60 million since 1958. In addition to permanent force payroll, construction workers wages and contractor procurement and purchase orders for equipment, supplies, materials, and services required to operate, maintain, and expand the Station have averaged from $30 to $40 million annually for the past 15 years. Thus, the total monetary impact of NRTS activities on the economy of the area and the Nation has ranged from $55 to $100 million each year since the Station was established.

Total NRTS payroll for the fiscal year ending June 30, 1973 was $76.3 million. The NRTS budget that year was $103.9 million, including $95 million for operations and equipment and $8.9 million for construction.

Capital Investment in facilities, built and under construction as of June 30, 1970, totaled $450.7 million. The estimated completion cost of additional authorized projects, including those started and not started, was $48.3 million. The combined figures total $499 million, including construction administered by the Pittsburgh, Chicago, and Schenectady field offices, as well as Idaho. Estimated replacement value of NRTS facilities was $1.061 billion as of December 31, 1972.

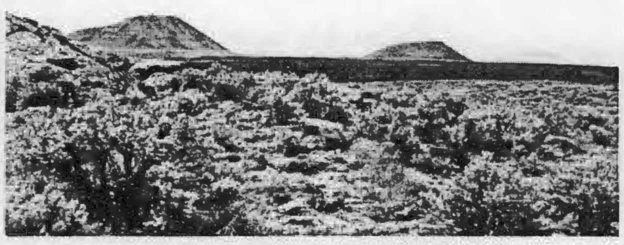
The NRTS is the largest single employer of engineers in Idaho and adjoining states. Engineering degrees are held by more than 700 employees at the Station. At least 160 of these engineers are in administrative positions. Nearly 1,500 college graduates, including more than 300 physicists and chemists, are employed at the NRTS. Advanced degrees are held by more than 450 of these graduates, including more than 100 doctorates.

History Of The Site

The Snake River Plain is classified with the Pleistocene epoch, which began one million years ago and is the most recent geologic time category. Fossils of prehistoric mammals have been found in excavations at the NRTS. It is postulated that they are from camels and mastodons which inhabited the region during the latter part of the Pleistocene epoch about 35,000 years ago. A fossil taken from carboniferous strata encountered during well drilling at approximately 100 feet below land surface has been determined to be over 40,000 years old.

Recent archaeological investigations disclosed evidence that man has been in the region of Eastern Idaho for perhaps 10 to 12,000 years[a]. Fur trappers were the first white men to enter the area now occupied by the NRTS. Thyery Godin, a

French-Canadian trapper, representing the English Northwest Company, discovered what was then known as the Godin River in 1820. Later it became known as the Big Lost River because of the phenomenon of the river's "disappearance" in the area now circumscribed by the NRTS boundaries. Alexander Ross, representing the Hudson Bay Company, visited the Godin River in 1824 and mentioned the "Three Pilot Knobs," which could have been the Three Buttes on the NRTS or the Teton Mountains which also were referred to by this name. The Lost River Sinks and the Three Buttes were shown on map sketches made by Captain Bonneville, U.S. Army, in 1832-33-34. In the winter of 1832-33, he referred to the Snake River Plain as the great plain of the Three Buttes.



In the late 1870's, the NRTS area was crossed by a trail used for large cattle herds which were moved eastward from Oregon to eastern markets and ranges made available in Wyoming by treaties with the Indians. Two stage coach lines also crossed the plain near the Twin Buttes, which long served as a landmark for early gold seekers. A branch of the Oregon Short Line railroad was constructed in 1910. Cerro Grande, now only a location name at the southern boundary of the NRTS, was the end of the O.S.L. line until the rails were extended to Arco and to the mining town of Mackay.

An area within the NRTS boundary was once a part of the Big Lost River Irrigation Project, one of the historically colorful reclamation projects in the West. It was authorized under the Carey Act of 1894 which provided that each state could be given land suitable for irrigation if the states did the reclaiming. Idaho accepted the application on the basis that private capital could be induced to construct the works and that the state would provide supervision.

A dam on the Lost River was started in 1909 to provide storage to irrigate some 100,000 acres, 30,000 of which were known as the Powell Tract lying within what are now the boundaries of the NRTS. During 1910, canals, ditches, and channel structures were constructed. The project was plagued with grave errors of engineering, financial difficulties, and legal and political controversies. Construction on the Powell Tract was discontinued in the spring of 1911. The old canals and structures are still prominent landmarks.

A similar project on the Little Lost River involved a small tract of land on the northwest side of the Station. The Mud Lake Project in the northeast also included land within the NRTS boundary. Both projects were the result of overly optimistic estimates. The dry canal systems are all that remain.

During World War II, the U. S. Navy utilized about 270 square miles of the plain for a gunnery range. An area southwest of the Naval area was once used by the U. S. Army Air Corps as an aerial gunnery range. The present Station includes all of the former military area and a large adjacent area withdrawn from the public domain for use by the Commission. The former Navy administration, shop, warehouse, and housing area is today the Central Facilities Area of the NRTS.

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[a] E. H. Swanson, Jr., "Before Recorded History," in Captain Bonneville's County, E. H. Lovell (ed.), Eastern Idaho Farmers Press, Idaho Falls, Idaho (1963) pp. 11-12.

Operations

The operations responsibilities of the Atomic Energy Commission's Idaho Operations Office (ID) embrace three broad categories of reactor development: power, research, and testing.

ID administers the following operations:

> The Commission's principal program for test irradiation services, utilizing two large high-flux test reactors at the NRTS and one private industrial reactor elsewhere.
>
> A large chemical processing plant for recovery of uranium from highly enriched fuels that can be consumed only partially in reactor operation.
>
> A major part of the Commission's program in light-water-cooled safety testing and research.

ID also oversees the furnishing of common services which support all programs at the National Reactor Testing Station, including those of the AEC's Chicago, and Pittsburgh field offices. Such services include transportation, waste disposal, utilities, environmental safety, security protection, general maintenance, library and technical information service, standards calibration service, cafeteria and food service, medical service, and motor vehicle service.

• *Engineering and Construction*

In addition to responsibilities for directing operation of the National Reactor Testing Station, the Idaho Operations Office directs a site building program that has grown to a property valuation of more than $1 billion [a] since 1949. This responsibility not only includes engineering and construction in support of its own program but a substantial part of the engineering and construction necessary to carry out the programs of other operations offices which have facilities at the NRTS.

Engineering and construction programs at the NRTS averaged 38 contracts for 112 projects, costing $15 million annually, from 1950 through 1955 and increased steadily to a 1958 program that consisted of 80 contracts for 264 projects totaling $24.8 million. The 1959-70 programs have cost more but there have been fewer contracts and projects.

[a] Estimated cost of replacement.

• *Health and Safety Requirements*

The Idaho Operations Office is responsible for the protection of property and for the health and safety of people, plants, and animals in and near the National Reactor Testing Station area. Elaborate safeguards are constantly in effect to minimize any possible hazard from routine or experimental activities at the NRTS.

Health and safety interests encompass all phases of occupational safety. The program includes development and enforcement of traffic and industrial safety policies; administration of an environmental program to determine the effects of various radioactive materials on plant and animal life; maintenance and development of instrumentation to detect radiation hazards; maintenance of a complete program, as required by ID or its contractors, to provide chemical or radiochemical analysis for any substance which is a potential health hazard; establishment of a comprehensive radiation monitoring program, including wholebody counting and personnel monitoring, a telemetered air monitoring network, and various subsurface water and geological investigations; administration of an active medical program to provide "human maintenance"; treatment of injuries and diseases sustained by NRTS personnel; responsibility for the safe management of radioactive material; and organization and training of radiological assistance teams for responding on call to off-Site incidents within a five-state area (see "Radiological Assistance Program" below).

The Idaho Operations Office also coordinates cooperative operational and research programs with other Government agencies such as the National Oceanic and Atmospheric Administration (formerly the U. S. Weather Bureau) for diffusion and climatological research, and the U. S. Geological Survey for hydrological studies.

- *Support to Compliance Division*

The Idaho Operations Office provides dosimetry, analytical, and public information services for the Commission's Division of Compliance, Region IV, which inspects licensed users and refiners of radioactive materials for compliance with Government regulations concerning the health and safety of individuals engaged in such programs. Headquarters for Compliance Region IV is in Denver, Colorado.

- *Radiological Assistance Program*

The Radiological Assistance Program at the National Reactor Testing Station provides assistance in the form of specially selected teams which can be dispatched to points in Colorado, Idaho, Montana, Utah, and Wyoming in case of incidents involving radioactive materials. Teams, under the direction of the Idaho Operations Office, consist of trained medical and monitoring personnel who are prepared to act in response to radiation accident calls. The AEC selects the teams to fit the emergency, calling on personnel from the AEC, its contractors, and other agencies, as needed. Part of a nationwide network, the teams are capable of evaluating situations and recommending measures to control radiation hazards in the interest of public safety. Team physicians, trained in the biological effects of radiation, may be called upon by local physicians for consultation in the event of radiation exposures and related problems.

- *Security*

Overall security responsibilities for the NRTS are vested in the Security Division of the Idaho Operations Office. This division is staffed and equipped to provide physical protection, as well as to safeguard classified and/or strategically important material. The Division processes and grants the necessary clearances for Site employees and provides a centralized physical security inspection and planning function. It operates a communications center involving an elaborate system of radio networks. It also maintains a professional fire department and trains plant fire brigades.

Common Services

AEC-Idaho furnishes contractors at NRTS numerous services, including those provided by: security headquarters, three fire stations, two medical dispensaries, the Health Services Laboratory, and weather reporting and forecasting performed under an arrangement with the Air Resources Laboratory of the National Oceanic and Atmospheric Administration, U. S. Department of Commerce.

In addition to direct support furnished by the AEC, utility and many other common services for the entire Station are centered in the Central Facilities Area, operated for the Idaho Operations Office by Aerojet Nuclear Company.

Aerojet Nuclear staffs and maintains: a Site-wide communications system, including telephone and teletype service, radio communications, and fire and security alarm systems; the Station's high-voltage power-distribution system for the entire Site, including dispatching facilities, high-voltage switching operations, and system maintenance and billing service; a complete network of roads and streets; on-Site railroad facilities serving several areas and connecting with a branch line of the Union Pacific Railroad at the Site boundary; a system for disposal of slightly radioactive liquid wastes; a trash and garbage removal collection service; a sewage system; and a water distribution system supplied by deep wells.

In addition, the Commission's fleet of more than 90 large passenger buses is operated by Aerojet Nuclear to transport NRTS operating personnel between their homes in surrounding communities and their work areas at the NRTS. The trips range from approximately 20 to 75 miles. The company also operates shuttle buses between Headquarters in Idaho Falls and the Station on a regular schedule. Passenger car and "taxi" service is furnished on call and is available not only for NRTS official visits, but for special pickup and charter service in the area as official business requires.

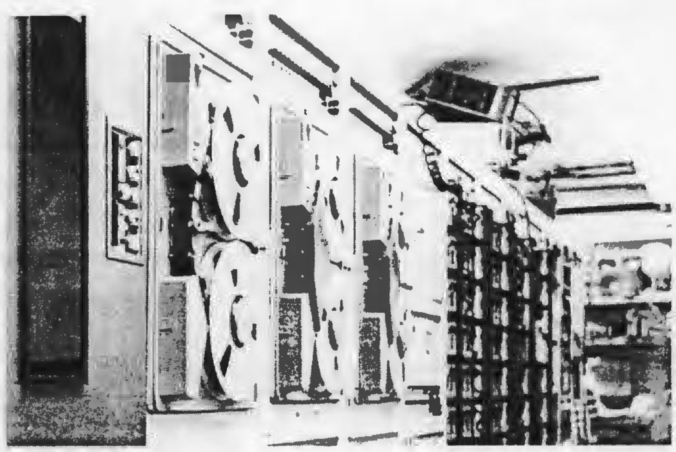
Services not classed as utilities provided for the AEC by Aerojet Nuclear, and optionally available to the entire NRTS, include: a technical information library; standards calibration service; warehousing; procurement of supplies and materials; photography and photo processing; reproduction and printing; cafeterias; equipment operators and labor pool; equipment and vehicle pool; craft and maintenance shops (sheet metal and welding, radio, plumbing and steam fitting, paint, machine work, equipment repair, lead, electric, carpentry); laundering of radioactively contaminated apparel and articles; material storage yards; and mail, parcel post, express, and freight handling services that utilize a fleet of AEC trucks as well as common carriers to accommodate the bulk of all materials shipped to and from the NRTS.

Several contractor offices and the suboffices of some AEC-Idaho Headquarters functions also are situated in the CFA, as well as a materials testing laboratory and an aggregate yard and concrete batching plant operated for the Commission by Aerojet Nuclear Company.

• *Computer Science Center*

Aerojet Nuclear provides computer services utilizing the AEC's Computer Science Center (CSC) in Idaho Falls. The $6 million, third generation IBM-360/75 computer in the CSC, supported by approximately 100 operating and programming personnel, serves the entire NRTS by means of four remote input/output terminals (RIOT) at TRA, CFA, EBR-II, and AEC Headquarters in Idaho Falls. In addition, a RIOT in Richland, Wash. serves the AEC's Richland Operations Office and its Hanford Works contractors. Several Federal Agencies in Idaho, such as the Departments of Interior and Agriculture, are also served on an as-required basis.

COMPUTER SCIENCE CENTER



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NATIONAL REACTOR TESTING STATION VICINITY MAP