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Consolidated Fuel Reprocessing Program

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Status of the Breeder Fuel Cycle in the United States *

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Introduction

This paper reviews the status and plans for the fast reactor fuel cycle in the United States. The United States is undertaking a complete reexamination of its entire breeder program strategy, and the direction of the new program is not yet clear. In this paper, I will describe studies in progress to examine the associated fuel cycle strategies as they relate to the overall emerging breeder strategy. The present status of and recent developments in the fuel cycle R&D programs will also be summarized.

Status of Reprocessing Program

Over the past decade the United States has carried out an extensive program to develop advanced technology for breeder reprocessing while examining a range of project options to close the fuel cycle. During the mid-1970s, when a large number of breeders were envisioned on-line by the end of this century, a Hot Experimental Facility was conceptually designed to recycle fuel from the

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first four to six breeders. With the slowdown of the programs, options for closing the fuel cycle on a smaller scale (consistent with the perceived needs of the planned reactors) were examined. About three years ago, we began examining a project called the Breeder Reprocessing Engineering Test, or BRET. This project would utilize the major hot-cell space in the Fuels and Materials Examination Facility (FMEF), which also houses the Secure Automated Fabrication (SAF) line. The FMEF, now completed at the Hanford Engineering Development Laboratory (HEDL), is operated by the Westinghouse Hanford Company. In the originally planned first phase of the BRET project, fuel from the Fast Flux Test Facility (FFTF) would be recycled. With overall funding constraints on civilian nuclear power development in the United States, BRET has been deferred and is being reexamined in the context of the overall emerging U.S. breeder strategy. A primary objective of BRET, final development and testing of the concepts under development in a real, "hot" environment, could still be accomplished using only FFTF fuel. Decisions to continue with BRET to accomplish this role must await the completion of the entire breeder strategy review process.

Elements of Fuel Cycle Strategic Planning

Options for closing the breeder fuel cycle are being reexamined bringing together the planning activities of all organizations directly or indirectly involved: (1) The U.S. Department of Energy's (DOE's) Consolidated Fuel Reprocessing Program, which I represent; (2) the fabrication program interests at HEDL; (3) the General Electric Company and Rockwell International, the two reactor vendors chosen by the DOE to carry out the innovative concept studies over a three-year period; and (4) the breeder Consolidated Management Office (CoMO).

Potential Reactor Scenarios

In order to define the fuel cycle study, it was necessary to project reactor scenarios which would help define fuel recycle requirements. As the reactor strategies evolve, the fuel cycle plans will be made compatible with the reactor projects. For this purpose only, the following were initially assumed:

1. The FFTF will continue operating.
2. A small, prototype advanced liquid metal reactor comes on-line at Hanford in 1995.
3. One or more reactor vendors provide a commercial breeder at a utility site by the year 2000.

It must be emphasized that these assumptions in no way reflect any judgments or decisions as to the direction of the reactor strategies.

The purpose of this strategy planning thus becomes to develop options for dealing with one or more of the above-assumed reactor scenarios, recognizing that all of them may not come about but providing a sufficiently flexible approach to accommodate those that do.

Fuel Cycle Options

Three potential fuel cycle options that are focused only on near-term needs have been defined to date:

1. providing a co-located fuel cycle facility for reactor scenario 3;
2. utilization of BRET/SAF in an expanded mode as needed; and
3. delayed (five to ten years) closure, initially relying on presumed available supplies of plutonium, until the fuel cycle could be closed later for more than one reactor.

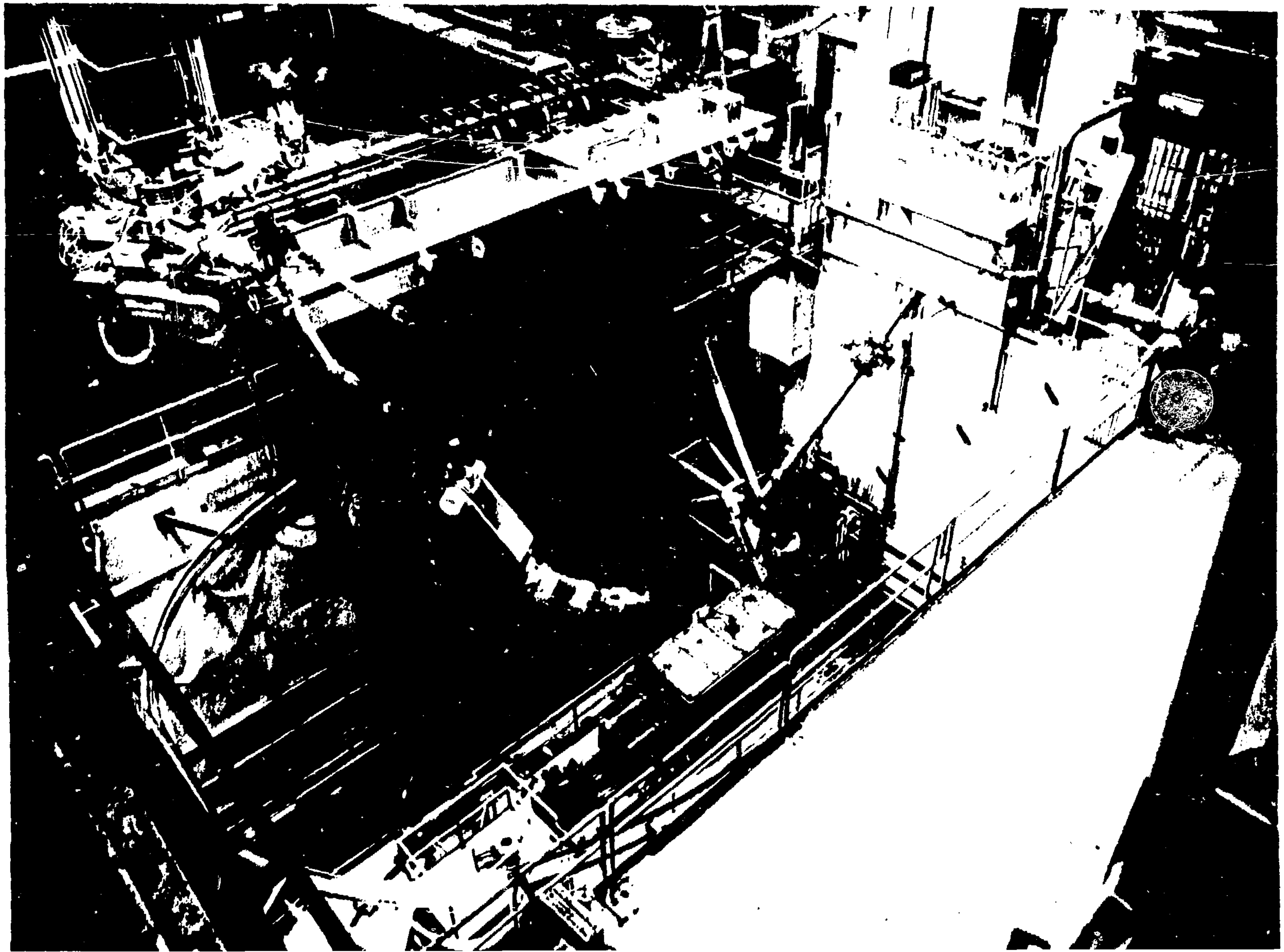
For the second option we have examined the expansion capability of BRET and the requirements for transportion of spent breeder fuel for an off-site reactor. Although the study is only partially completed at the time of the written paper, at least some of the results should be available at the time of the symposium. Early conceptual work shows that BRET could likely be expanded to accommodate up to 2000-MW(e) breeder capacity.

Working with the reactor vendors, scoping concepts are being developed for small, co-located facilities to close the fuel cycle at a utility reactor site. The primary benefits from such an option stem from the simplicity of managing the entire reactor–fuel cycle complex within a single organization and the perception that eliminating all transportation of plutonium will reduce costs and minimize safeguards concerns. During this year we are exploring this proposal in depth, developing a sounder basis for costs, determining the sensitivity of capacity of costs, and the overall feasibility. The reactor vendors are utilizing the data provided in these fuel cycle studies to develop an on-site fuel cycle strategy for their entire innovative study. These studies will compare the co-located option with the BRET expansion mode. We expect to examine a limited range of capacity for the co-located facilities since it might be necessary to address stations with outputs from single 400-MW(e) reactors to multiple units that might eventually total 2000 to 3000 MW(e). Since a great deal of engineering and cost information has been developed from the work done on BRET and SAF and since the co-located facilities are in the same range of size, a reasonable picture of costs for a range of capacities should be obtained..

Plans developed within CoMO for an initial reactor project have envisioned that cost savings could be realized by delaying closure of the fuel cycle as long as supplies of plutonium could be obtained relatively inexpensively. This might prove to be only five to ten years, but even that period might be long enough for the costs to be spread over more than one reactor rather than loaded on the initial project. This concept will be explored further, although it will undoubtedly prove quite difficult to estimate how much plutonium will be available and at what price. This study is also briefly addressing the future coupling of an LWR reprocessing industry for plutonium supply to breeder recycle.

In evaluating and comparing these options, efforts will be focused primarily in two areas: (1) costs and (2) the practicality of closing the fuel cycle by such an option.

REMOTE OPERATIONS AND MAINTENANCE DEVELOPMENT OF THE IET



extraction and scrub, is used to develop the contactors and to recover the uranium from the dissolver product. Remote maintenance tests have been performed on much of this equipment, and such tests will continue.

Over the past few years the breeder reprocessing program was refocused on smaller-scale equipment as needed for BRET. The remote maintenance concepts are largely independent of the scale of the process equipment, and the development activities remain largely unchanged. On the other hand, the process equipment had to be scaled down from the earlier work. Two prototype banks of smaller centrifugal contactors have now been operated successfully, and we are embarking on a longer-term reliability test of those prototypes.

To depict more clearly the concepts for BRET, a cross section of the entire facility is given in Fig. 2, and a plan and cross section of the Main Process Cell (MPC) are shown in Figs. 3 and 4. The cell plan view (Fig. 3) shows that

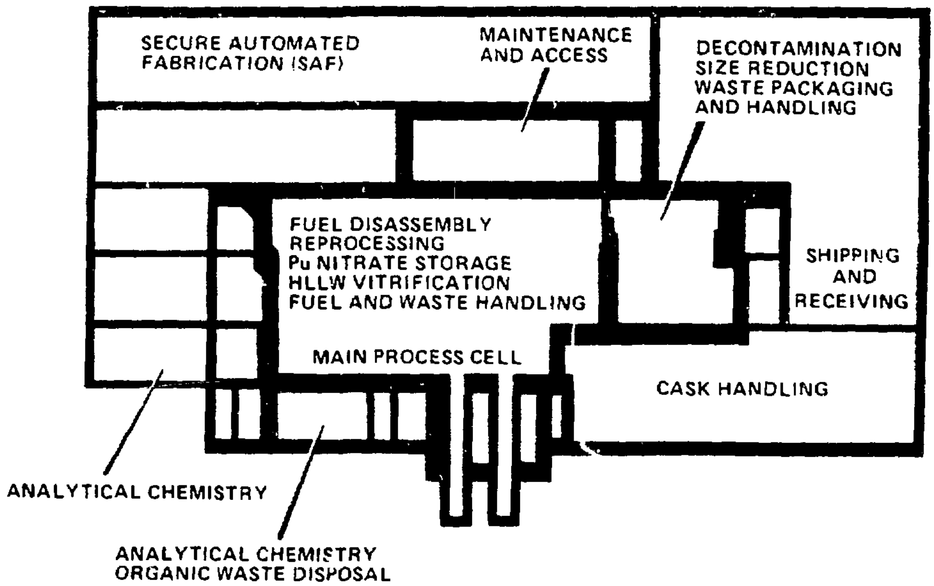


Fig. 2. Cross section of the proposed BRET facility.
From Oak Ridge National Laboratory

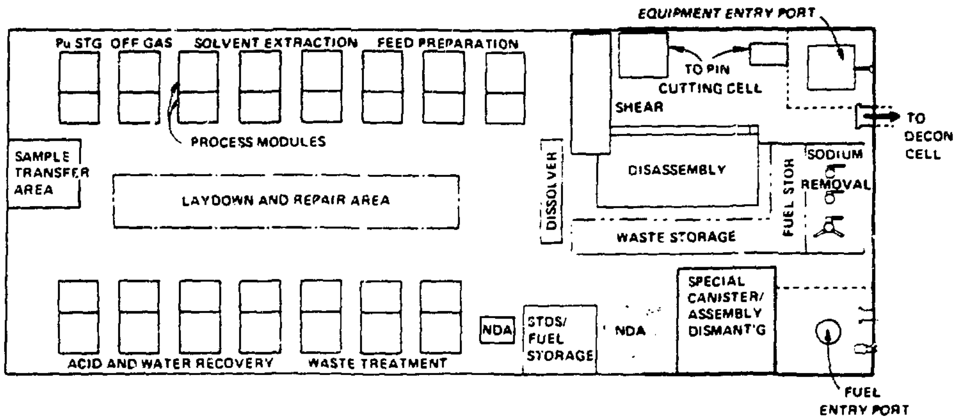


Fig. 3. Plan of main process cell of BRET.
From Oak Ridge National Laboratory

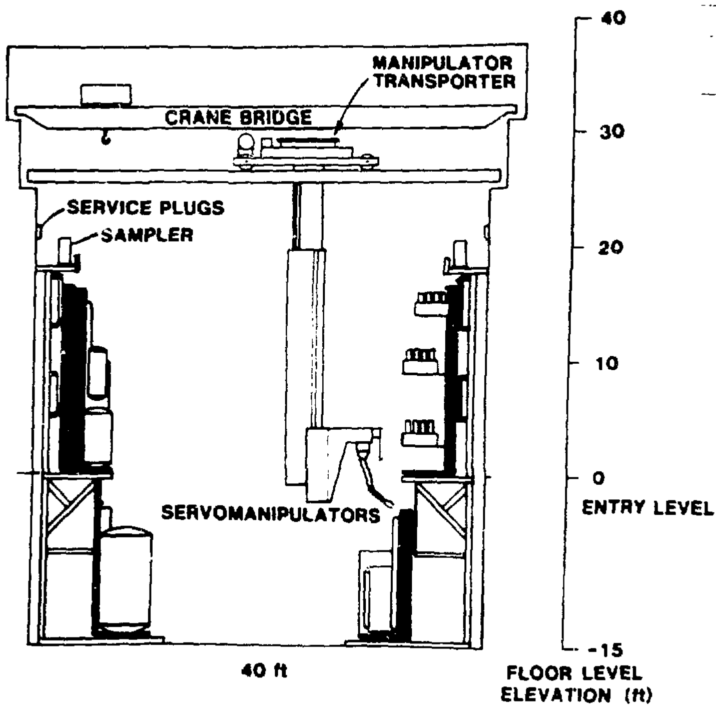
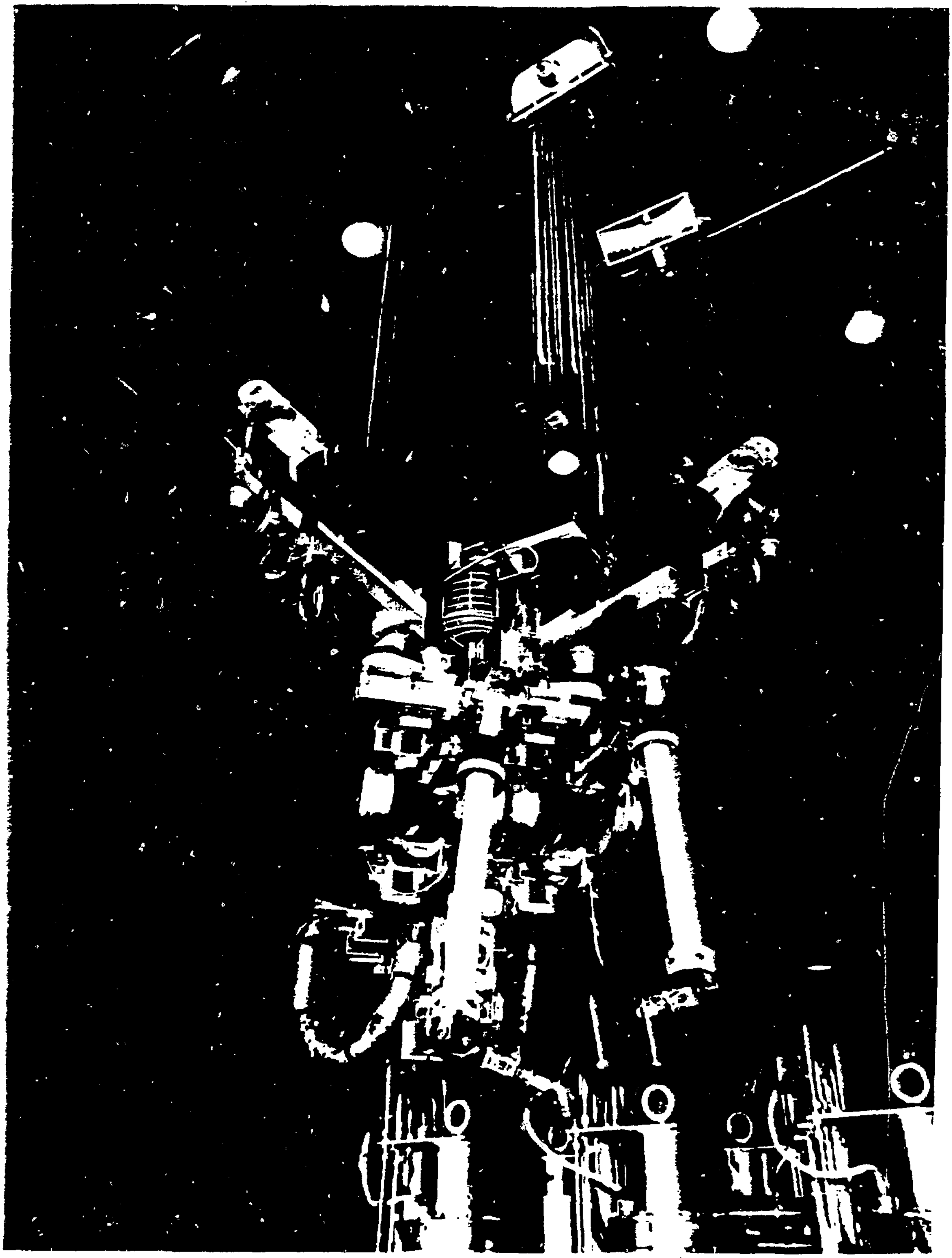


Fig. 4. Cross section of main process cell of BRET.
From Oak Ridge National Laboratory

almost all of the reprocessing and waste management functions are integrated into a single large cell, which has entirely adequate space for the 100-kg/d throughput capacity plant. Only the product conversion and some of the peripheral waste handling would be done in adjacent areas. The Upper Process Cell immediately above the MPC will be used for transfer and special maintenance operations. The cross-section view shows the equipment modules on which all process equipment is installed. In the center aisle is space for movement of the bridge-mounted servomanipulator, which provides great versatility in replacing failed components on equipment racks or in disconnecting complete racks on rare occasions when major changes or repairs must be made. A maintenance test on a centrifugal contactor bank is shown in Fig. 5, and the remote control room from where the work was performed is shown in Fig. 6. (A motor was replaced in two hours.)

Fig. 5. CRL model M-2 servomanipulator performing maintenance test on a centrifugal contactor unit.
From Oak Ridge National Laboratory

CRL MODEL M-2 SERVOMANIPULATOR
PERFORMING MAINTENANCE TEST
ON A CENTRIFUGAL CONTACTOR UNIT



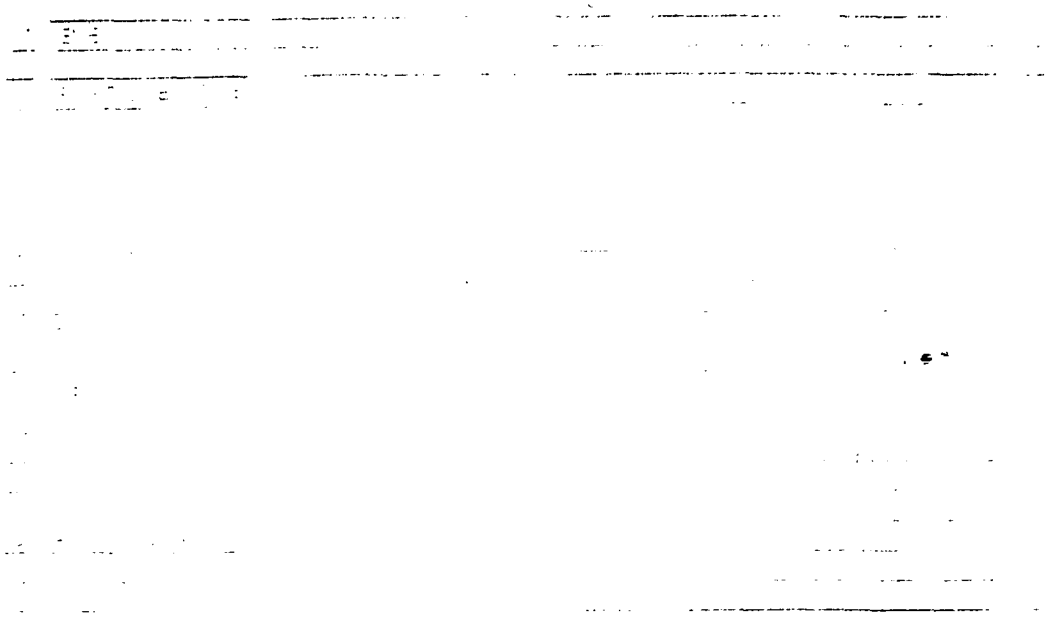


Fig. 6. Remote maintenance control room.
From Oak Ridge National Laboratory

The reliability and maintainability of the servomanipulator will be improved significantly with the Advanced Servomanipulator (ASM) that is now being installed in an area adjacent to the IET facility. The new manipulator, shown in Fig. 7, has undergone testing in a laboratory environment, using one of the arms as a pseudo-master in the early tests. The units have about a 1-lb sensitivity in the force feedback feature and a handling capacity of 50 lb. By using torque tubes and gear drives instead of the conventional tapes and cables, much higher reliability can be achieved, and the modular design permits replacement of failed modules with another manipulator.

While the long-range goals and missions of the breeder program are still unresolved, the ongoing development activities are reaching an advanced stage, bringing the new technology one step closer to reality. We expect to complete these development programs over the next few years.

REMOTE MAINTENANCE CONTROL ROOM

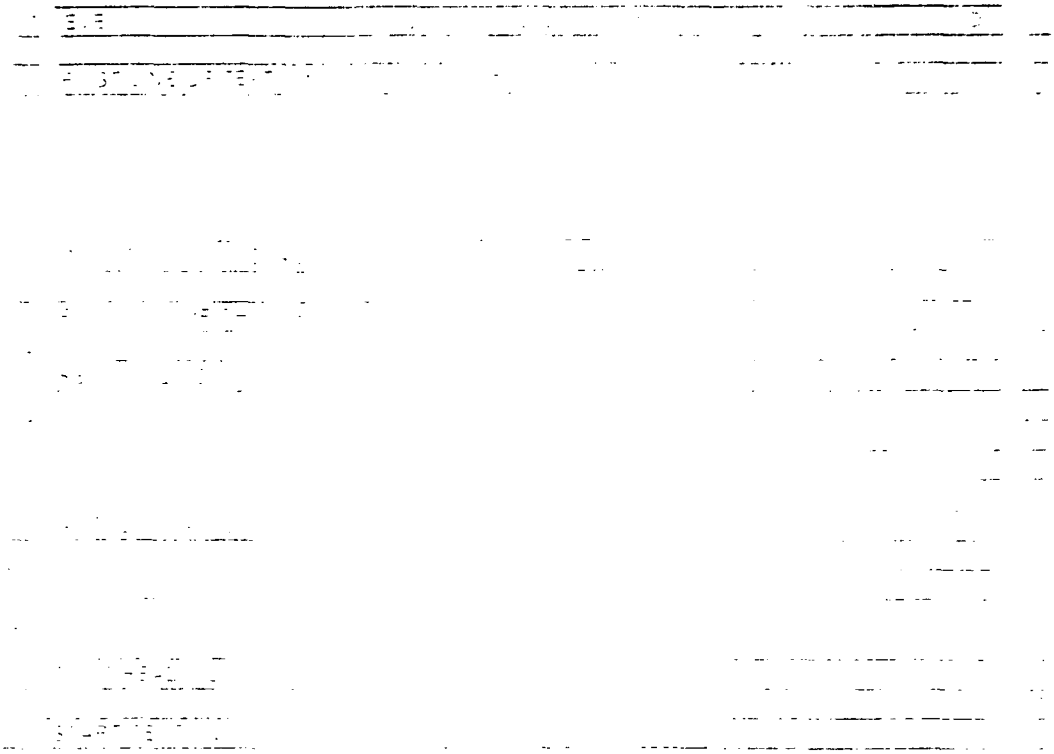


Fig. 7. Advanced servomanipulator on test stand.
From Oak Ridge National Laboratory

ADVANCED SERVOMANIPULATOR ON TEST STAND.