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NUCLEAR PROPULSION OF MERCHANT SHIPS

AN ENGINEERING SUMMARY

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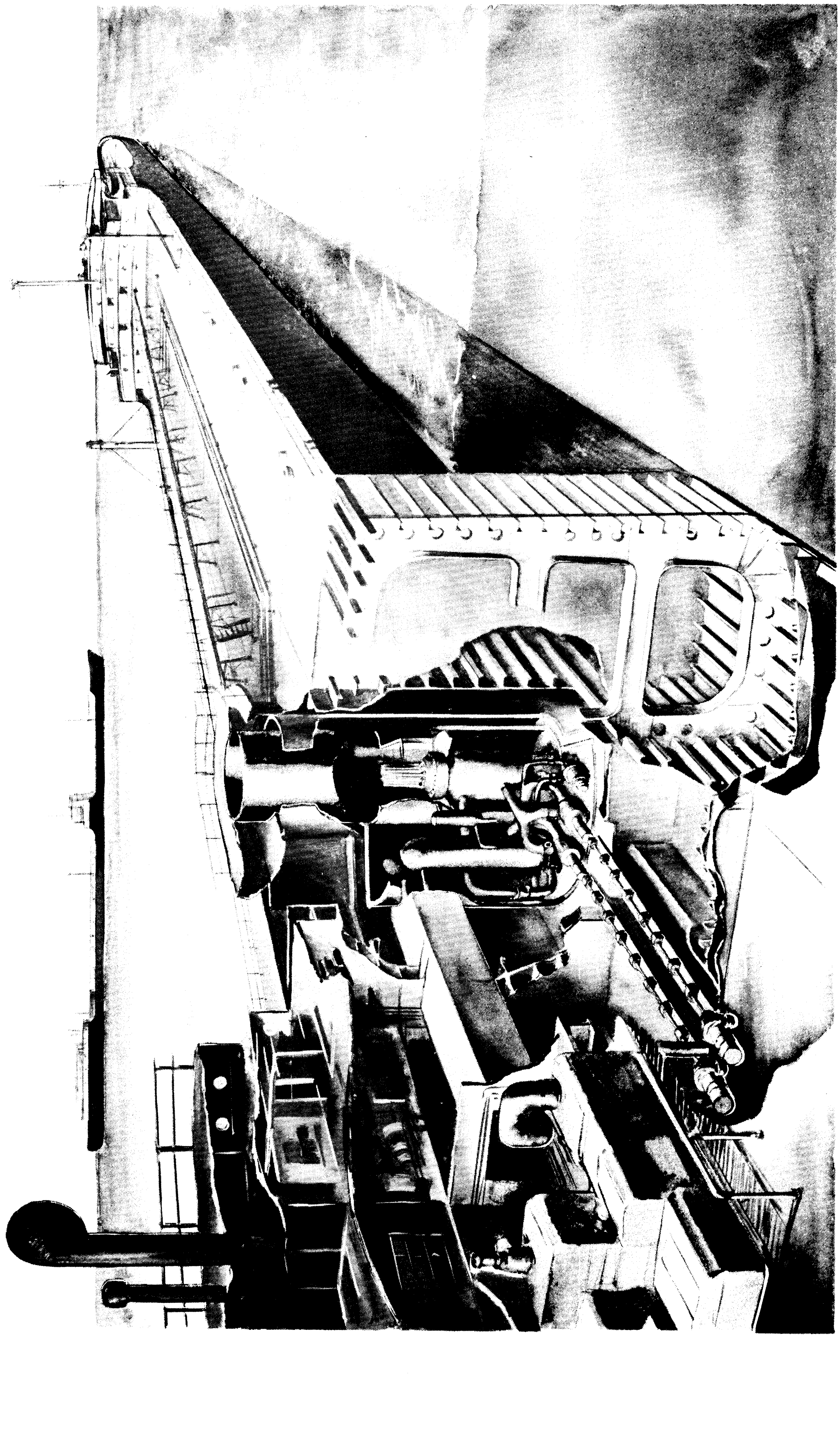

SUMMARY REPORT

The results of an independent evaluation of nuclear energy to marine applications by a special study group at The University of Michigan demonstrate that it is technically feasible and safe to construct and operate merchant ships powered by nuclear reactors. The economic considerations for such a ship are made but due to their complexity they can be determined and evaluated with accuracy only after construction and operation of one or more ships. Analyses point to the desirability for the immediate construction of a nuclear powered merchant ship.

The investigations include studies of operating nuclear equipment as well as new nuclear equipment and processes in various stages of development. The final engineering studies are limited to presently available nuclear equipment and processes requiring no or only minor modifications, thus placing the work on a sound and conservative basis.

The health and safety requirements for a nuclear powered merchant ship can be met to provide protection of personnel, cargo, and ships at sea and in port. The procedures adopted by the United States Atomic Energy Commission in achieving their outstanding safety record serve as a pattern for regulations necessary to attain adequate health and safety aboard ship.

The economics of construction and operation of conventionally-powered ships is well established. At this time it is not possible to predict costs for nuclear powered ships with the same reliability. Although it is not possible to compare approximate economic advantages at the present time for a nuclear powered merchant ship, the construction and operation of such a ship is the only means by which reliable competitive economic and performance data can be obtained.

The study of existing engineering achievements reveals that many American manufacturers have capabilities for supplying nuclear power equipment. This capacity has been made possible by a license agreement between the companies and the United States Atomic Energy Commission. The nuclear power equipment is developed to the degree of perfection that a nuclear power plant can be installed in a merchant ship without serious risk of excessive rapid obsolescence. Further effective progress in making applications of nuclear power to the propulsion of merchant ships will be made when one or more ships are constructed and placed in operation. These ships should be constructed now so that, in the words of the Merchant Marine Act of 1936, Declaration of Policy, the United States Merchant Marine may be

> "composed of the best-equipped, safest, and most suitable types of vessels, constructed in the United States and manned with a trained and efficient citizen personnel."

APPENDIX I

CRITERIA FOR A NUCLEAR POWERED SHIP

Experts in the field of nuclear engineering, marine engineering, and naval architecture have given consideration to a nuclear powered ship for merchant marine service. It is obvious that the ship which best fulfills the optimum conditions for nuclear propulsion is a type which has the greatest percentage of under-way time and is of large size and power. A large tanker will best meet these economic and technical requirements. Accordingly, approximate general criteria which have been established to guide the project are:

TABLE I

EXAMPLE OF MARINE TANKERS OPERATING CONDITIONS

Type of Ship	Tanker	
	Dead Weight 32,000 Ton Tanker	Dead Weight 38,000 Ton Tanker
Speed	16 to 18 knots	17.5 knots
Shaft Horsepower*	22,000 maximum	22,000 maximum
Length Between Perpendiculars	630 feet	677 feet
Beam	90 feet	93 feet
Depth	45 feet	48 feet 6 inches
Draft	32 feet 6 inches	36 feet 6 inches

The nuclear power plant for the range of conditions specified above will follow so far as practicable conventional tanker power plant design. Thus, the chief difference will lie in having the reactor with its auxiliaries rather than an oil-fired, steam generating unit to produce steam for the turbine. With this approach, it is possible to compare steam generated by nuclear energy with steam generated by a conventional boiler fired with oil as fuel.

Basic decisions of technical philosophy are essential to expedite economic designs, construction, and operation of nuclear powered ships. Some of these considerations essential to early achievement of an operating ship are as follows:

1. Selection of Type of Reactor

If a nuclear reactor, which requires no fundamental development other than component testing, is to be selected now for a merchant ship, the present "state of art" indicates that the selection is limited to one reactor. This type is a heterogeneous, high pressure, circulating water type comparable to the submarine thermal reactor.

2. Reliability of Reactor Operation

An important consideration is the reliability of a nuclear power plant over the ranges of a ship's operation. This necessitates a decision as to the number of nuclear reactors needed in a given ship. A properly selected single nuclear reactor can be designed, constructed, inspected, and operated with reliability comparable to that experienced in two boiler steam ships. The design studies indicate the feasibility of a single reactor, two steam-generating heat exchangers, and single dual-stage turbine equipment.

3. Auxiliary Power Generation

The ranges of flexibility in a nuclear reactor are such that coupled with its reliability it can sustain ship operation at port and at sea over a wide range of speeds, and no auxiliary sources of power are necessary.

4. Comparison of Reactor Controls with Steam Controls

Certain controls are inherent to reactor design and others are essential for power level and speed. The advances made in reactor control technology have proven that such reactor controls are complex in design but simple in operation.

5. Crew Requirements

Analyses have given careful consideration to the differences which might be necessary in terms of ship's crew for a nuclear powered ship and a conventionally-fired ship. The number of crew required should ultimately be no more than crew requirements employed in conventional oil-fired ships.

6. Advancements Achieved through Building and Operating a Nuclear Powered Ship Now

The keystone of merchant marine nuclear power advancement lies in building and operating a nuclear powered merchant ship. By adapting the type reactor used in the "Nautilus" to merchant shipping, measurable progress can be achieved. Such progress lies in technical advancements, economics, reliability, safety, personnel training, and leadership. Merchant shipping with nuclear power can establish a pattern for improvement of reactor fuels, simplification of reactors and propulsion machinery, improvements in marine equipment, and demonstration to the world of peacetime efforts in atomic energy.

7. Limit and Power Ranges of Nuclear Reactor Power in a Ship

Present technology and "state of art" limit the range of practical power operations in merchant ships. The best economics can be obtained in merchant ships employing nuclear power plants in the higher horsepower ranges.

APPENDIX II

HEALTH AND SAFETY

The results of investigations of nuclear power have shown that all required safety measures of merchant shipping can be met. These requirements can be established by proper selection of the type reactor, its controls, and neutron and radiation shielding material. Considerations are given to the safety requirements for all conditions of ship operation and maintenance such as:

Cargo loading and unloading

Reactor fuel loading and unloading

Operations at sea

Dry-dock operations

Emergency maintenance

Preventative maintenance programs

With the outstanding record of health and safety achieved by the U. S. Atomic Energy Commission, the technology of health-physics and health-safety has progressed so that health problems associated with nuclear interactions and radio-activity are well under control. Further safeguards practices will be applied through the Reactor Safeguards Committee of the Atomic Energy Commission.

APPENDIX III

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APPENDIX IV

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