AUG 1975

# SCIENCE BULLETIN

*National Science Council*
*2 Canton Street*
*Taipei, Republic of China*

# Tsing Hua Builds Mobile Reactor

The National Tsing Hua University has completed building a Mobile Educational Reactor (MER) with the financial support of the National Science Council. The reactor is expected to be critical within a few months.

The object of the MER project is to construct a nuclear reactor on a vehicle so that it can move to other universities as a teaching aid. The major work is contained in the reactor trailer and the instrument trailer. The former houses a low power reactor and its control equipment, and the latter carries all instruments for reactor experiments and for radiation laboratory experiments. The two trailers work together as a set. The following is a brief description of the MER project.

### Reactor Trailer

The reactor trailer has a gross weight of about 30 tons. The overall dimension is 4 meters in height, 3 meters in width and 11.5 meters in length. This is the maximum size with which a trailer can be permitted to run on the highways in Taiwan. This trailer contains mainly the reactor, the control center, the overhead crane, the air conditioner, the emergency ventilation unit, and the electric power supply system.

The reactor, which is cylindrical in form, occupies the central part of the trailer. It is 210 cm in diameter and 208 cm in height. Its weight is about 13 tons.

The reactor operation is performed in the conrtol center, which consists of an instrument column and a control console. The instrument column functions to supply the reactor kinetic information to the operator. This column contains the high voltage supply for detectors, the control power supplies, the neutron monitoring systems, the temperature recorder and area radiation monitoring instruments. The control console contains the blade-control-switch, the blade position indicator, the scaler and timer, a general purpose strip chart recorder, the trip and alarm system and the safety interlock system. A fission product monitor is installed at the right-hand side of the console.

An air conditioner, which has a capacity of 50,000 BTU per hour, is designed to maintain the trailer temperature at 25°C. An emergency ventilation unit consists of a 1 hp blower with an absolute filter for removing radioactive particulates larger than 0.3 microns in the air of the trailer in case of emergency.

Normally, the trailer uses the city electric power. Two-rolls of power cables, each of 100 meters in length, are provided for connecting the trailer to the city power supply unit. In case of failure of city electricity supply, the trailer power is maintained by two gasoling-operated electric generators. These generators are installed in the front section of the trailer. One of them is a 6 KVA, single-phase unit, supplying power to the control center and the lighting. The other generator is a 10 KVA, three-phase unit, which supplies power to the crane, the ventilation system and the air conditioner. The electricity distribution is controlled by a main power panel fixed on the front wall of the trailer. The total power demand is 15 KVA, at three-phase, 220 volts and 60 Hz.

The trailer is provided with four independently adjustable legs in addition to its eight wheels. Each leg can be smoothly extended to 34 cm by cranking a handle. With these legs, trailer can be parked at a sloping land.

### Instrument Trailer

The instrument trailer has the same size as that of the reactor trailer but with a lighter load. The gross weight is about 18 tons. The space of the trailer is designed for accommodating 16 to 24 students and conducting eight to ten experiments at a time inside the trailer. Instruments housed in this trailer include: scintillation detectors, GM detectors., semiconductor detectors, proportional counters, neutron counters, fission chambers, high-voltage supplies, power bins, preamplifiers, linear amplifiers, scaler and timers, radio-active sources, coincidence unit, rate meters, single channel analyzers, multichannel analyzer, survey meters, strip chart recorder, oscilloscopes, precision pulse generator, and other accessories. The trailer also carries with it tools and equipment for maintenance purpose.

### The Reactor

The reactor can be divided into five parts—the core, the reflector, the

(*To continue on Page* 2)

## ROC Committed To Atom for Peace Policy

The Republic of China is not developing nuclear weapons and has no plans to do so in the future because the country is committed to the peaceful use of nuclear energy.

Dr. S.S. Shu, chairman of the National Science Council, made the statement last month in commenting on a *Time* magazine report that free China is developing the nuclear bomb with the target date set at 1980.

Denying the *Time* report, Dr. Shu recalled that the Republic of China was among the first nations to sign the Nuclear Nonproliferation Treaty. He also pointed out that both President C.K. Yen and Premier Chiang Ching-kuo had reaffirmed the government policy to harness nuclear energy for peaceful use only.

## Tsing Hua Builds Mobile Reactor

(*Continued from Page* 1)

control blades, the shield, and experimental facilities.

*The Core* The reactor core uses 20% enriched uranium in the form of $U_3O_8$ homogeneously mixed with high density polyethylene as the fuel and moderator. The mixture, containing 61 mg $^{235}U$ per cubic centimeter is molded into disks, which have a density of 1.25 g $cm^{-3}$. These disks have a diameter of 24 cm, and various thicknesses from 1 to 4 cm. The core is formed by piling the disks up to a height of about 28 cm. The critical mass is 700 g of $^{235}U$. The maximum loading of $^{235}U$ is limited to about 710 g, corresponding to an excess reactivity of 0.3%. No coolant is required for this reactor because the operating power is limited to 0.1 watt.

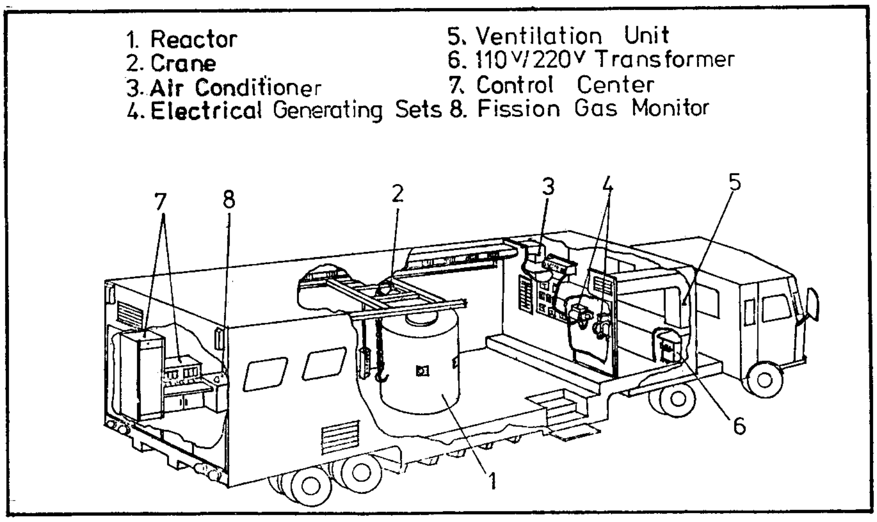
*The reflector and control blades* The core is surrounded by a graphite reflector of 20 cm thick on all directions. The reflector is divided into two parts, the inner reflector, and the outer reflector. The former, which has a thickness of 5.5 cm, is housed in an air tight aluminum tank together with the reactor core to protect against the leakage of fission products; the latter is in a hollow cylindrical form which has a thickness of 14.5 cm and surrounds the aluminum tank. The reflector works to reduce the neutron leakage and hence save the critical mass of the fissile material. Two cadmium control blades are positioned in slots between the inner and outer reflectors, diametrically tangent to the aluminum tank. Each blade has a worth of 0.5%, is diven by a clutch-gear-motor assembly beneath the reactor, and can be moved up and down to control the operation of the reactor.

A 10 mCi Ra/Be neutron source is mounted inside the lower part of the inner reflector. On reactor starting, this neutron source can move upwards to the bottom of the core by means of a flexible cable drive assembly.

*The Shields* External to the graphite reflector is the lead shield, which is 10 cm in thickness and functions as a gamma shield. The lead shield which weighs 3.2 tons, also works as a rigid enclosure and supporter for the core-reflector assembly. The body of the lead shield is again surrounded by an annular water tank, i.e. the reactor tank, 60 cm wide times 200 cm high, which contains 5.3 tons of boral water as the neutron shield. The boron concentration is 8 mg $cm^{-3}$. The reactor tank has a cylindrical shape. The external dimension is 210 cm in diameter and 208 cm in height. Four neutron detectors are distributed at the interface between the lead shield and the reactor tank to monitor the neutron density during reactor operation.

*The Experimental Facilities* To supply thermalized neutrons for experiments, a thermal column dimensioned 86 cm diameter times 55 cm height is put on top of the lead shield. This column is normally filled with grapite blocks. The graphite column is removable and can be replaced by a water column if necessary. A vertical central beamport of 9 cm diameter passes through the center of the thermal column and ends up at the top surface of the core. An auxiliary vertical beam port of 5 cm diameter passes through the themal column laterally and ends up to the horizontal central plane of the core. Both of these beam ports are normally plugged up with graphite cylinders. There are, in addition, two horizontal beam ports for neutron irradiations. One, passing through the core center, has a diameter of 2.5 cm; and the other, passing through the outer reflector, a diameter of 9 cm. Both through ports have their openings on the outside wall of the reactor tank. These opening are normally closed up with plugs and are interlocked for reactor operation.

All the reactor parts, including the core, the reflector and the experimental facilities can be disassembled and reassembled to meet the teaching needs.




*The reactor trailer isometric showing the arrangement of the reactor with associated equipment inside the trailer.*

### Reactor Safety

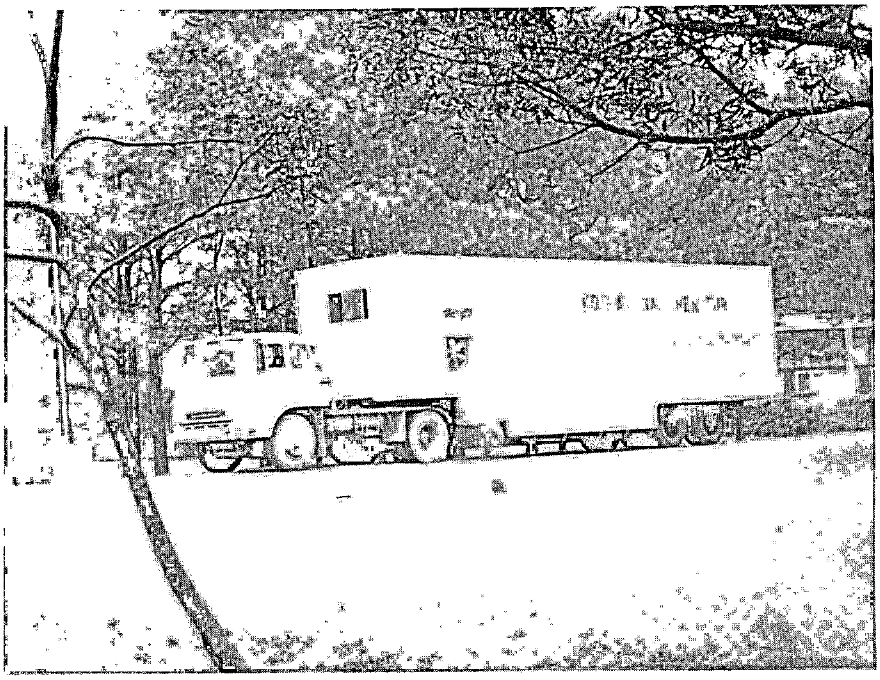
Safety has been the first consideration when the MER is designed.

The reactor is designed according to the Siemens SUR-100 type. This reactor is inherently safe in the sense that it has small fuel inventory, low operational power level, low neutron flux, low radiation level (only few R/Hr at core center), negligible fission products produced under continuous operation, and large negative temperature coefficient.

The maximum fuel loading is limited to 710 g of $^{235}U$ which corresponds to an excess reactivity of 0.3%, and the power level is limited to 0.1 watt. Basing on the calculation and experience with the SUR-100, the saturation activity of fission products in the core will be no more than 400 microcuries and the maximum dose rates due to gamma-rays and neutrons will be less than 8.5 mrem/hr in the axial direction, and 2.7 mrem/hr on the reactor surface in the radial direction if the reactor is steadily operated at the power level of 0.1 watt.

The reactor is normally controlled by two cadmium blades. The worth of one blade is enough to shut down the reactor. The reactor can also be shut down by separating the reactor core. Any trip signal will introduce a scarm action. When this occurs, the lower half of the core will drop down automatically by 5 cm, which is equivalent to an addition of a negative reactivity of 6% to the reactor.

The fission products produced in the core is continuously checked by a fission-product monitor built in the reactor trailer. In case any radioactive



*MER trailer leaving Tsing Hua campus for its 564-km journey of highway test.*

particulates leak out into the trailer, the emergency ventilation system can be turned on. The absolute filter in the ventilation unit can filter out particulates larger than 0.3 micron size from the air, thus preventing contaminating the environment.

The possibility of supercriticality during reactor operation is limited by the maximum excess r eactivity of 0.3% loaded in the reactor in cooperation with the large negative temperature coefficient ($-3\times10^{-4}$ deg $C^{-1}$) both of which confine the reactor temperature rise to a maximum of 10°C. Hence, if the core temperature should rise 10°C above the room temperature, the reactor would automatically become subcritical. The positive period introduced by a large excee reactivity will also trip the reactor by through the electronic system.

To eliminate the possibility of super-criticality happening in a traffic accident during highway travelling, all the fuel disks in the upper core are removed out of the reactor and stored in a container installed in the instrument trailer as mentioned before. The instrument trailer is transported by a different tractor. The quantity of $^{235}U$ contained in these (nine) fuel disks are 400 grams of equivalent to approximately the half amount of the reactor critical mass. This measure restricts the maximum nuclear hazard to the source level.

Typhone and flood will not affect the MER operation. Clearances between adjacent reactor components have been minimized to avoide the disposition due to vibrations. Shock absorbers are uesd for supporting radiation detectors. The trailer leveling is important to the reactor safety because the drop down action of the lower half core initiated by reactor scram signal makes use of the gravitational force. A big inclination of the trailer might jeopardize the core falling acceleration. To eliminate this possibility, four adjustable legs have been installed under the reactor trailer. The leveling of the trailer is monitored at the console and is interlocked with the reactor start-up system.

# Taipei to Host Workshop on Industrial Innovation and Product Development

A week-long Workshop on Industrial Innovation & Product Development will be held in Taipei on August 11-18 under the joint sponsorship of Academia Sinica and the U.S. Academy of Sciences. Dr. David B. Langmuir, research consultant and former director of Research Planning, TRW Systems Corporation at Santa Monica, Calif., and Dr. S.S. Shu, chairman of the National Science Council, will jointly preside over the meeting as co-chairmen. President C. K. Yen will deliver a keynote speech at the opening ceremony.

The purpose of the workshop is to identify problems and goals relating to industrial innovation and product development in the Republic of China during the next four years and to possible courses of action.

*Basic assumptions* are:

1. The technological level of industry in Taiwan must rise progressively during the coming decade in order to protect the economic gains made during recent years and to promote continued economic and social development.

2. Growth in the technological level will require coordinated action not only in research and development but also in other areas essential to management of innovation and product development, including production and marketing.

3. In view of ROC's current status in economic development and unusual reliance on international trade, emphasis of the workshop is to be placed on industry needs.

4. The issues to be discussed at the workshop require the participation of industry, government, and universities.

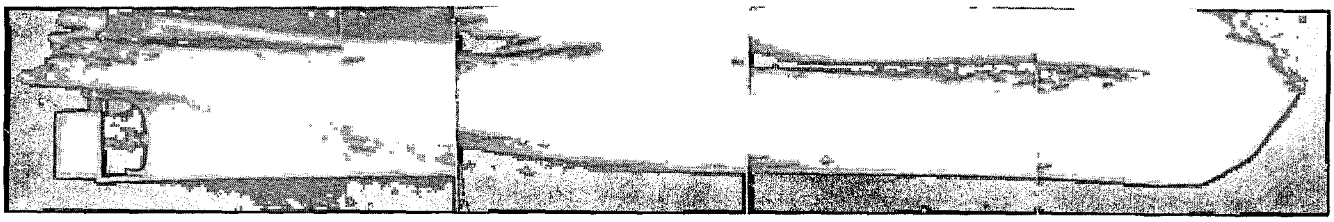
*The general approach* is as follows:

1. Concentrate on three industries: electronics, petrochemicals, and machine tools, as suggested by the Chinese participants.

2. Gain as clear a view of the problems as possible by advance communications, and by briefings and personal contacts during the first days of the workshop.

(*To continue on Page* 4)

# Know-how for Shipbuilding Industry



*Flow pattern along a 300-GI trawler*

Naval architecture is one of the new fields being given attention in the Republic of China's growing research activities in the applicable aspects of science development. The study on ship design is being emphasized to meet the know-how requirement for the country's expanding shipbuilding industry.

The Institute of Naval Architecture, National Taiwan University, which is Taiwan's leading research organ in ship design, acquired a new ship model basin in the fall of 1972 with the financial assistance of the National Science Council. Since then the institute has stepped up its research activities in cooperation with a number of interested organizations including the Chinese Navy, Taiwan Shipbuilding Corporation, China Shipbuilding Corporation, Joint Commission on Rural Reconstruction, etc.

The following is a brief account of the research activities carried out at the Institute in the last three years:

**Ship Hydrodynamics:**

* A series of fishing boat design researches have been made. They include 150GT, 300GT, 415GT, and 1000GT hull forms. Also studied via photo technique and flow line theory is a 300 GT. straight hull form, whose performance is found to be as good as its parent round hull form but is easier and cheaper to be built.
* Still water resistance of a 36-foot planning hull form has been studied by the instruments designed and manufactured by the institute. Resistance characteristics of the planing hull form as separation ratio, LCG position, loading factor etc. have been investigated to give the general design guide lines.
* For given engine and hull form, suitable propeller design procedures are studied. Along this line, a medium loading propeller for a 150 GT barge is studied via standard design methods and lifting line theory.
* Wake survey and wave survey instruments are designed and manufactured by the institute, test runs are made on a 26,700 dwt builk carrier.
* Other studies include: model scale effect study, ship added mass study, super-cavitatoin propeller design study, straight line motion stability study, yawing of a steered ship study, thrust deduction calculation, ship launching study, etc.

**Ship Structures:**

* Analysis has been made to predict the possibility of cracks due to stress concentration and buckling in the transverse web frame of a super tanker.
* Transverse strength analysis of super tanker has been studied by using Grillage method.
* Optimum design of minimum weight scantling of the transverse structurn has been made to reduce the weight and cost of a ship.
* Studies have been made to calculate the center deck effectiveness for various loading conditions, to calculate the relability and stress distribution of a cargo ship with deck pillers replaced by a hatch side box type overhang beam, etc. Other activities:
* Performance characteristics of a 17,900 DWT drilling ship with drill hole open or close have been test studied, and later confirmed by sea trial results.
* Performance characteristics of a 26,700 DWT and 27,800 DWT bulk carriers are studied to investigate the bulbous bow design features.
* Stability experiments with a sailing boat and a 48 GT cement boat has been made to determine its stability characteristics.
* The inclining experiment, turning test, and speed trial of a 25 GT cement fishing boat have been field tested to define its general characteristics.

## Taipei to Host Workorshop on Industrial Innovation and Product Development

(*Continued from Page* 3)

3. Explore ways in which industrial research experience in the U.S. may be applicable to the situation in Taiwan.

4. Present, to the extent possible, options available for achieving the desired progress in innovation and new product development in the above industries.

*The agenda* is based upon the following strategy:

1. Plan large attendance at the first session and final session. Keep all other meetings small; they will be working groups with specific jobs to do.

2. Devote about three-fourths of the working sessions to three meetings in parallel, one for each industry. Assign each of these groups the task of producing, according to its experience and judgment, a first-draft development plan for its industry, with estimates of approximate costs and identification of critical difficulties.

3. Combine these plans in the remaining time so that the whole workshop can develop a picture of the overall program and problems.

4. Develop a statement of the various ways in which the hypothetical program might be accomplished (how financed, where performed, how managed, how integrated with production and marketing). Develop recommendations, if warranted.

5. Present the findings and options to a larger invited group at the final session.



印刷廠：中新印刷股份有限公司
台北市信義路二段二七七號
中華郵政登記認爲第一類新聞紙
台灣郵政管理局登記執照台字第二七六五號