

UNCLASSIFIED

AD 295 989

*Reproduced
by the*

**ARMED SERVICES TECHNICAL INFORMATION AGENCY
ARLINGTON HALL STATION
ARLINGTON 12, VIRGINIA**



UNCLASSIFIED

NOTICE: When government or other drawings, specifications or other data are used for any purpose other than in connection with a definitely related government procurement operation, the U. S. Government thereby incurs no responsibility, nor any obligation whatsoever; and the fact that the Government may have formulated, furnished, or in any way supplied the said drawings, specifications, or other data is not to be regarded by implication or otherwise as in any manner licensing the holder or any other person or corporation, or conveying any rights or permission to manufacture, use or sell any patented invention that may in any way be related thereto.

295 989

63-2-3

AID Report P-63-14

21 January 1963

CATALOGED BY ASTIA
AD No. 295989

SOVIET NUCLEAR RESEARCH REACTORS
VVR-S (MOSCOW) AND VVR-S (TASHKENT)
Review of Soviet Literature

AID Work Assignment No. 31

ASTIA
RECEIVED
FEB 13 1963
ASTIA 8

Aerospace Information Division
Library of Congress

SOVIET NUCLEAR RESEARCH REACTORS
VVR-S (MOSCOW) AND VVR-S (TASHKENT)
Review of Soviet Literature

AID Work Assignment No. 31

The publication of this report does not constitute approval by any U. S. Government organization of the inferences, findings, and conclusions contained herein. It is published solely for the exchange and stimulation of ideas.

Aerospace Information Division
Library of Congress

FOREWORD

This is the fifth in a series of reports on Soviet reactors. The first three reports in this series (AID Reports 62-43, 62-127, and 62-172) were prepared in response to AID Work Assignment No. 16. The fourth report (AID Report 62-197) and the present report have been prepared in conformance with AID Work Assignment No. 31.

This report provides a description of the two Soviet water-moderated water-cooled reactors (VVR-S), one of which is located in Moscow and the other in Tashkent, Uzbekskaya SSR. The VVR-S reactors, intended for experimental and research purposes, were developed from the experimental enriched-uranium VVR reactor [see AID Report No. 62-43]. Background information, general construction details, features of the control and safety systems, and information on the experimental facilities afforded by the reactor are presented. The report is based on Soviet open literature available at the Aerospace Information Division and the Library of Congress. Any further information concerning these reactors will be published in the form of supplements to this report, as soon as it becomes available.

A list of references cited accompanies the text. Library of Congress call numbers are given at the end of the source entry when the source is available at the Library of Congress.

TABLE OF CONTENTS

Foreword	11
The VVR-S Reactors: Background	1
I. THE MOSCOW VVR-S REACTOR	2
1. General Construction	2
2. Flow Diagram of Primary Loop	6
3. Basic Reactor Parameters	7
4. Control and Safety Systems	7
5. Experimental Facilities	10
II. THE TASHKENT VVR-S REACTOR	11
References	12

THE MOSCOW AND TASHKENT VVR-S REACTORS:

BACKGROUND

The design of the water-moderated, water-cooled VVR-S reactor was developed from the light-water, enriched-uranium VVR research reactor of the Atomic Energy Institute, Academy of Sciences USSR, in Moscow. [1]

The VVR-S type 2000-kw research reactors are lot-produced and are used by various Soviet and non-Soviet scientific research institutes [2]. Six such reactors were put into operation between 1957 and 1959 [3]. The following Soviet scientists received the Lenin Prize in recognition of their contribution to the development of this reactor: S. M. Feynberg, V. V. Goncharov, G. A. Stolyarov, T. N. Zubarev, P. I. Khristenko, V. F. Kozlov, and O. I. Lyubimtsev [2].

The VVR-S reactor in Moscow was built under the general supervision of O. I. Lyubimtsev and I. V. Koptev. T. N. Zubarev calculated the physical and neutron parameters. During development of the VVR-S reactor, the basic design parameters and the performance of various systems of the reactor were investigated at zero power level using a specially designed test stand. In addition, all experimental results and experience obtained with the original VVR reactor were utilized. [4]

Since the Moscow and Tashkent VVR-S reactors appear to be identical in design, only one of them, the Moscow reactor, will be described in detail. A general view of the Tashkent VVR-S reactor, and some additional information concerning this reactor, are given separately following the detailed discussion of the Moscow VVR-S reactor.

I. THE MOSCOW VVR-S REACTOR

1. General Construction

A general view of the Moscow VVR-S reactor is given in Fig. 1. Construction details are shown in Figs. 2, 3, and 4 (next three pages), to which reference will be made as appropriate in the text.

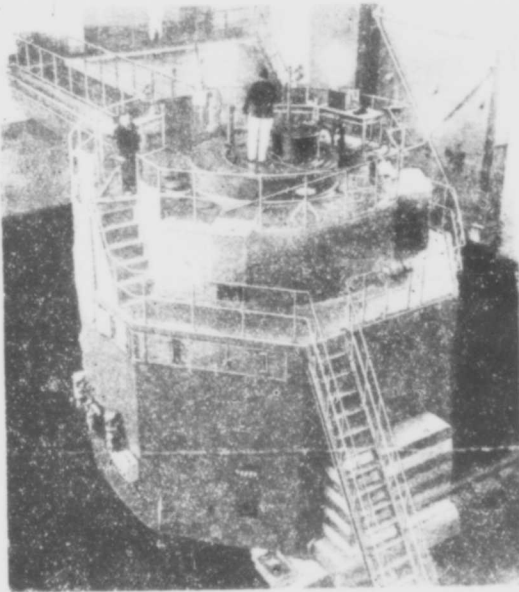


Fig. 1. General view of the Moscow VVR-S reactor from the thermal column side [1]

The reactor core is housed in an aluminum-alloy tank 2.3 m in diameter and 5.9 m high. This tank also contains experimental channels, fuel transfer chutes, and control rods. [3]

The tank consists of three cylindrical shells welded to a spherical bottom, and two removable covers. Welded into the tank are nine horizontal channels, seven vertical channels passing through the tank from top to bottom (for experimental purposes, e.g., transferring irradiated specimens to hot cells or housing experimental loops), a fuel transfer chute with an inside diameter of 200 mm, and a recess to accommodate the forward disks of the thermal column (see Figs. 2, 3, and 4). The overflow, drain, and circulation tubes, and the tubes housing the measuring instruments, are welded into the bottom of the tank. The upper part of the tank contains nine vertical control rod channels, channels for irradiating samples, and seven ionization chamber channels. [3]

The reactor is shielded laterally by 800 mm of water, a 200-mm cast-iron supporting structure surrounding the tank, and a 1600-mm concrete shield (density 3.2 g/cm³). The water shielding extends 3.5 m above and 1.15 m below the core. In addition, upper shielding is provided in the form of cast-iron disks 800 mm thick (see Figs. 2 and 3). [3]

The supporting structure of the reactor (mentioned above) consists of a lower series of cast-iron rings, an outer shell, and an upper series of cast-iron rings (see Fig. 3). The basic purpose of the cast-iron rings is to reduce radiative heating of the concrete shielding. Atop the cast-iron structure is mounted a large revolving cover, either electrically or manually operated, which provides additional radiation shielding for working personnel. A smaller cover,

[Text resumes on p. 6.]

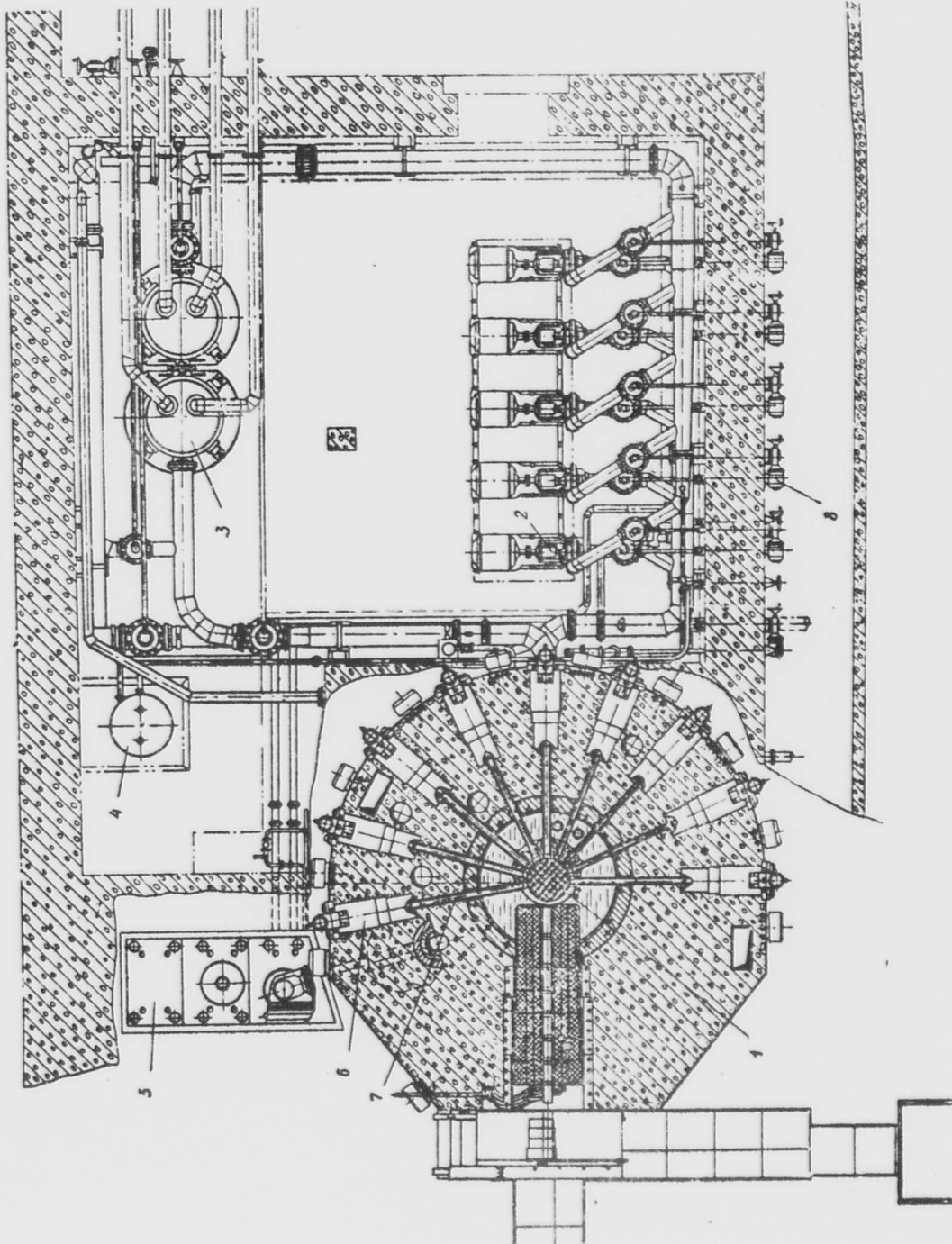


Fig. 2. Horizontal cross-section of the reactor and pump house [3]

1 - reactor; 2 - pumps; 3 - heat exchangers; 4 - filters; 5 - fuel storage area;
 6 - horizontal channel beam plugs; 7 - horizontal channels; 8 - valve servodrives.

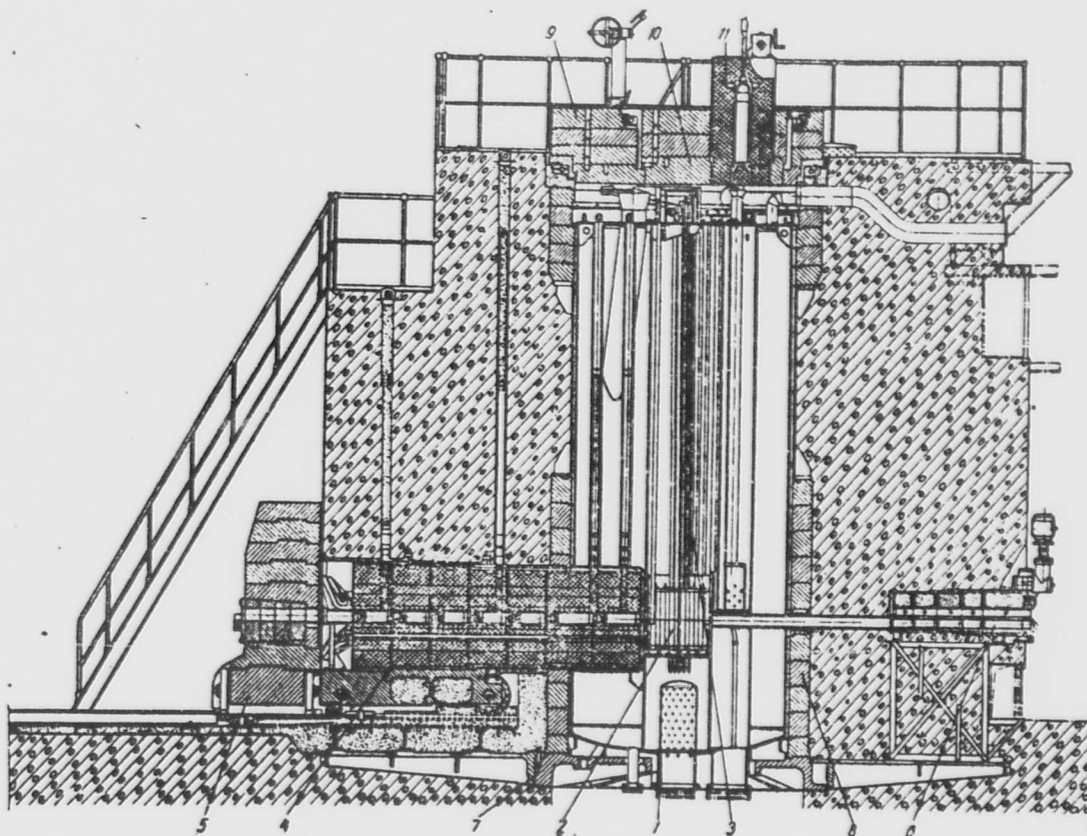


Fig. 3. Vertical cross-section of the reactor through the thermal column [3]

1 - reactor vessel; 2 - core; 3 - control rod channels; 4 - thermal column;
 5 - thermal column shielding; 6 - horizontal channel plug; 7 - base plate;
 8 - supporting structure; 9 - upper revolving cover; 10 - small revolving
 cover; 11 - container for removal of spent fuel.

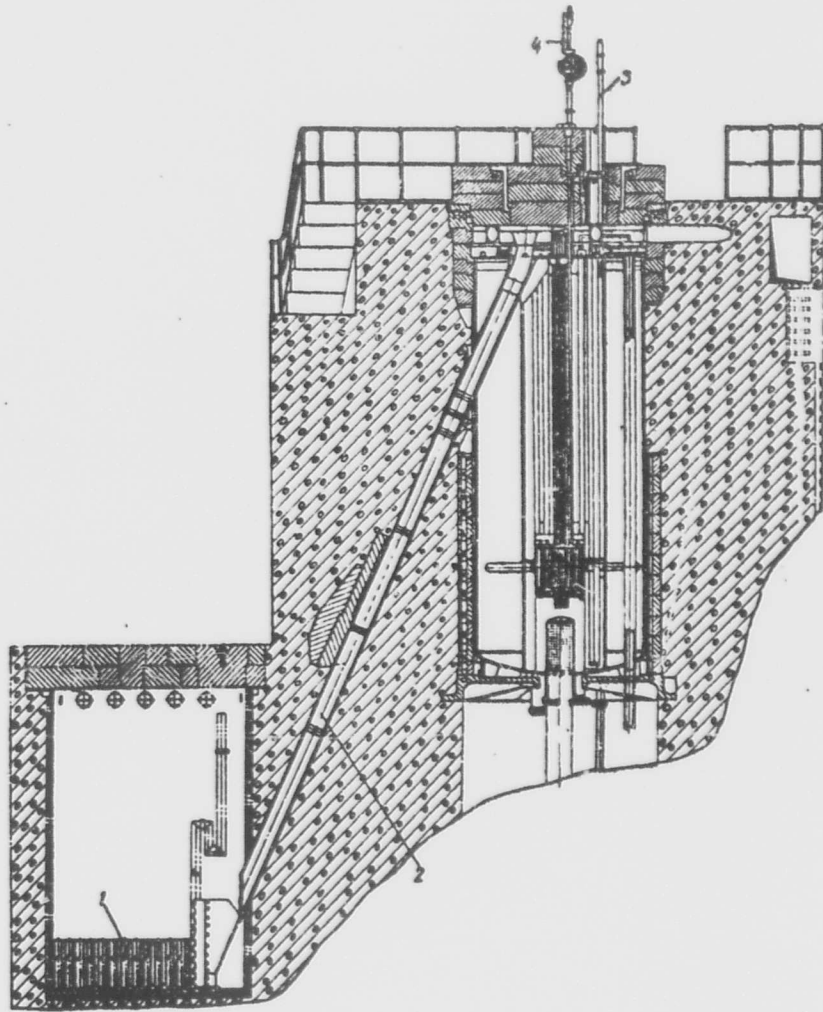


Fig. 4. Vertical cross-section of the reactor through the fuel transfer chute [3]

1 - spent fuel storage area; 2 - chute for transferring spent fuel elements; 3 - optical unit; 4 - manipulator unit.

manually rotated, is mounted eccentrically in the large movable cover (Fig. 3). Installed in this smaller revolving cover are a manipulator and an optical unit, and a container for transporting fuel assemblies during manual unloading of the reactor (see Fig. 3). [3]

The concrete shielding contains an inclined fuel transfer chute (Fig. 4), biological channels, a manipulator storage channel, seven channels for ionization chambers and control and safety rods, the channel for the experimental thermal column, and channels for storage of plugs and the optical unit and other accessories. [3]

Radioactive air and vapors from the areas above and below the reactor and over the stored fuel are removed by ventilation. [3]

Unloading and reloading of fuel assemblies and transfer of irradiation samples is accomplished through the large and small revolving covers by means of a power-driven manipulator unit, an optical unit, and the fuel transfer chute, which may be used both for fuel assemblies and samples. The two revolving covers permit positioning of the manipulator unit over any part of the serviced area by using the angular coordinates of all points in the core which are given in tables attached to the covers. The manipulator is used to transfer fuel assemblies from core to storage and to transfer irradiated samples to hot cells. The covers, which serve as top shielding, are left in place during these operations, so that radioactive contamination of the top of the reactor and irradiation of personnel is avoided. [3]

The manipulator unit consists of an arm with tongs, a tong control servo, and a drive for raising and lowering the arm. [3]

The optical unit for visual observation of the central zone of the reactor consists of shielding plugs and an optical instrument. [3]

The reactor is loaded to insure an excess reactivity of $\Delta k = 0.05$. Compensation of excess reactivity and reactor control are accomplished by control and safety rods. [3]

The design of the VVR-S reactor takes into account the possibility of power excursions in the reactor by providing reinforced biological shielding (density 940 g/cm³) against neutron- and gamma-radiation, and considerable redundancy in the provision and arrangement of other equipment. In addition, the cast-iron rings composing the reactor's supporting shell are provided with 14 vertical cooling ports to counteract heating of the shielding. All these features allow for power excursions of up to 10,000 to 20,000 kw under conditions when the area of heat-release surface and the heat-transfer coefficient α are increased. [3]

2. Flow Diagram of Primary Loop

The primary loop flow diagram is given in Fig. 5. The distillate in the core is heated from 34° to 36°C. The heat is transferred to running water in the secondary loop by means of two heat exchangers

having a surface area of $\sim 95 \text{ m}^2$ each. The heat exchangers are mounted vertically and serve as traps for mechanical impurities in the primary loop. These impurities are eliminated by draining them into the waste tank. Fission fragments are removed from the distillate by filters containing anion and cation exchangers and activated carbon.

Up to 10% of the total distillate is continuously pumped through the deaerator to remove explosive gas mixtures formed during operation of the reactor. The pump units (see Figs. 2, 5, and 6) are located well below the level of the reactor in order to insure a suction head and to eliminate the occurrence of cavitation during pumping, which produces reactor power surges. A remote-controlled throttle valve regulates the rate of flow of the distillate and prevents water hammer. A photo of the reactor pump house is shown in Fig. 6. [3]

The level of the distillate in the reactor vessel drops when the deaerator is turned on. Therefore, the level of the distillate attains the prescribed mark only when the circulation in the loop is arrested. The cross-sections of the auxiliary loop and overflow pipes are chosen such that no overflow can occur when the loop circulation is stopped. [3]

3. Basic Reactor Parameters

The following are the basic parameters of the VVR-S reactor as given in reference [3]:

Heat power	2000 kw
Maximum heat flux	$0.44 \cdot 10^6 \text{ kcal/m}^2 \cdot \text{hr}$
Number of fuel assemblies:	
at start of run	31
at end of run	51
Distillate flow rate in primary loop	$650 \text{ m}^3/\text{hr}$
Water flow rate in secondary loop	250 to $300 \text{ m}^3/\text{hr}$
Fuel load (U^{235})	
at start of run	4 kg
at end of run	5.6 kg

4. Control and Safety Systems

Cross-sections of the control and safety systems are shown in Fig. 7. Excess reactivity is compensated manually by five control rods. The scram system consists of three rods. The power level is automatically maintained by one rod. All the rods are made of boron carbide except for the power-level control rod, which is made of boron steel. The rods are arranged in the core in the form of a cross. The

[text resumes on p. 9.]

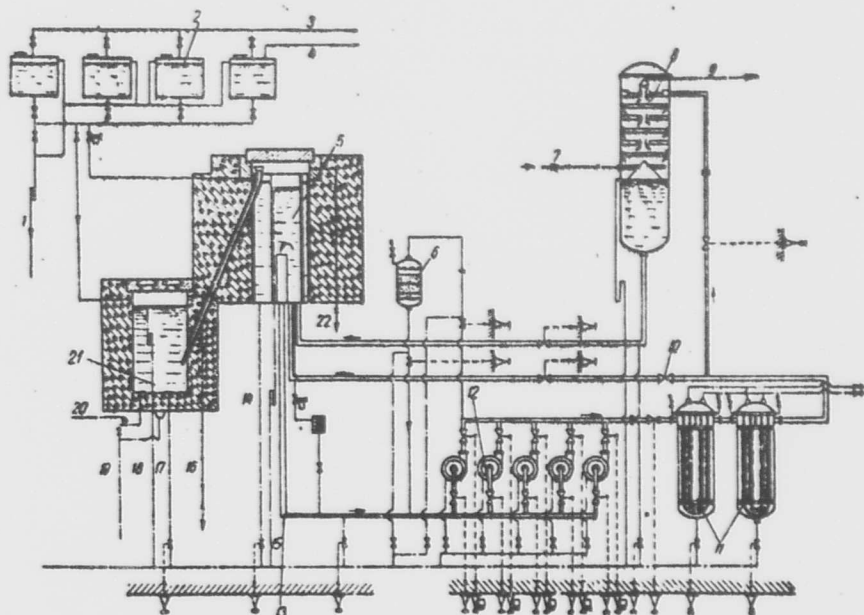


Fig. 5. Flow diagram of the reactor system [3]

1 - discharge to drainage system; 2 - distillate tanks; 3 - distillate supply; 4 - process water; 5 - reactor; 6 - filter; 7 - air from main room; 8 - deaerator; 9, 16, 22 - ventilating ducts; 10 - throttle valve; 11 - heat exchangers; 12 - pumps; 13 - pump headers; 14, 17 - drainage tubes; 15, 18 - overflow pipes; 19 - to drainage system; 20 - to tank level gauge; 21 - spent fuel element storage.

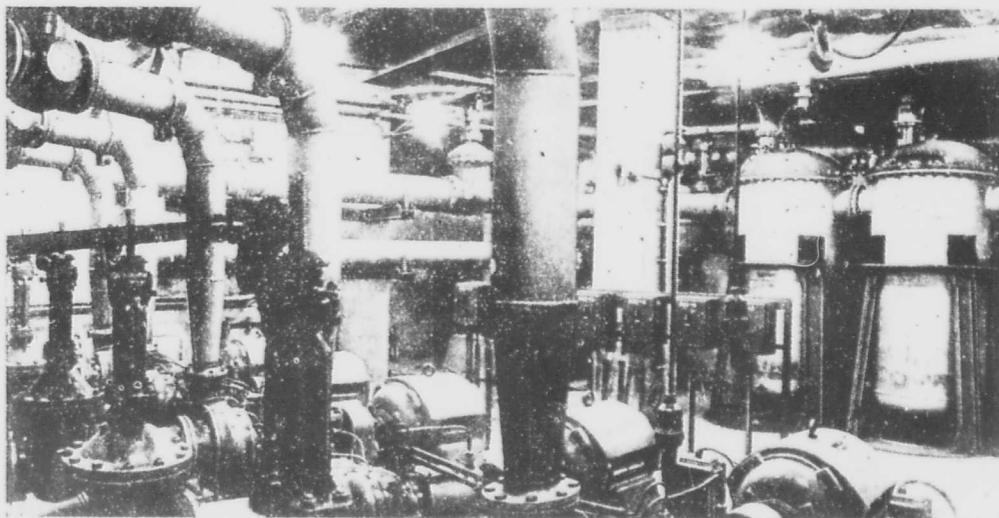


Fig. 6. View of reactor pump house [3]

position of the rods is monitored by position sensors. [3].

Reactor power during startups and steady-state operation is monitored by seven KNT-52-type ionization chambers located in the reactor tank. Three of these ionization chambers, for use during startups, are vertically movable; the remaining four, for use during steady-state operation, are stationary (see Fig. 7). [3]

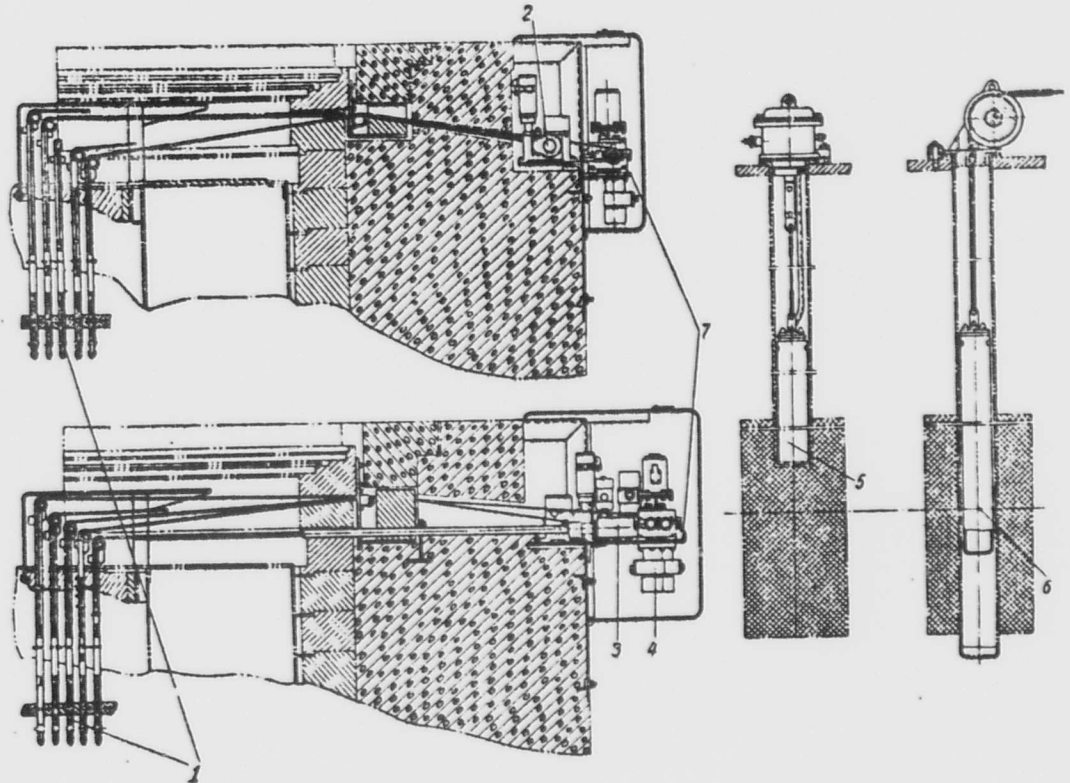


Fig. 7. Longitudinal cross-sections of control and safety systems [3]

1 - control rods; 2 - scram rod servodrive; 3 - precision servodrive;
4 - automatic-control servodrive; 5 - stationary (steady-state operation)
ionization chamber; 6 - movable (startup) ionization chamber; 7 - support
bracket.

A precision shim rod equipped with electric servodrive is used for the accurate measurement of changes in reactivity during the introduction of various materials into the core. The linear displacement velocity of the shim rod is 2 mm/sec. [3]

The manual-control servodrive is capable of driving the rod at a control velocity of 6 mm/sec and a scram velocity of 37 mm/sec. The automatic-control servodrive can drive the rod at a speed of 6 mm/sec when manually operated and at speeds up to 35 mm/sec when operated automatically. [3]

The scram rods are driven by a compressed spring and their own weight, and are capable of dropping into their bottom position within 0.2 to 0.3 sec after receipt of the emergency signal. The servodrive contains a friction brake which is applied near the end of the drop to reduce the impact of the rod. [3]

5. Experimental Facilities

The VVR-S reactor is designed to produce a neutron flux of $\sim 2 \cdot 10^{13}$ n/cm².sec. Its excess reactivity is sufficient for research and for the production of radioactive isotopes. Available for these purposes are eight channels 40 mm in diameter and one dry channel 60 mm in diameter in the core, and 20 additional channels, 60 mm in diameter, in the displacement rods which are installed in the core at the beginning of a run. In addition, the lateral shielding is pierced to the perimeter of the core by nine horizontal channels 60 and 100 mm in diameter, and by a thermal column having four vertical channels 80 mm in diameter. There are three biological channels 350 mm in diameter and four monitoring channels 80 mm in diameter in the reactor's concrete shielding. The construction of the reactor also provides for the installation of two experimental loops in the core. [3]

The thermal column (see Figs. 2 and 3), which is mounted on a trolley-borne cradle, consists of five removable graphite disks encased in aluminum drums. It is water-cooled by an assembly consisting of eight Field tubes and a water coolant supply and removal system. The graphite disks contain a central (axial) channel and four vertical channels for physical experiments (Fig. 3). The channels are closed with graphite plugs. The outer end of the thermal column is equipped with a cast-iron biological shield, in which the manually operated central channel plug is mounted (Fig. 3). The thermal column shield is mounted on rails and is moved with a winch and cable arrangement. This cast-iron shield serves to close the recess into which the thermal column fits when the latter has been withdrawn. The thermal column and the shield, which can be moved into their respective positions with an accuracy as great as 0.1 mm, are remote-controlled from two consoles in the reactor room. This accuracy of control is necessary to insure the alignment of the vertical channels of the thermal column with the vertical channels in the reactor shielding and the alignment of the horizontal central channel with the channel in the cast-iron shield. [3]

II. THE TASHKENT VVR-S REACTOR

A general view of the VVR-S reactor belonging to the Nuclear Physics Institute of the Academy of Sciences Uzbekskaya SSR, is shown in Fig. 8. The reactor, which is located in Kibray, a suburb of Tashkent [5], was placed in operation in 1959 [6]. The reactor is intended for physical research and for the production of isotopes (including short-lived isotopes) for the use of the scientific community of [Soviet] Central Asia [6].

Many of the research results obtained with this reactor have already found practical applications. One example is the development of automatic control systems for industrial rubber production machinery, which was made possible by the use of isotopes manufactured in the Tashkent reactor [6].

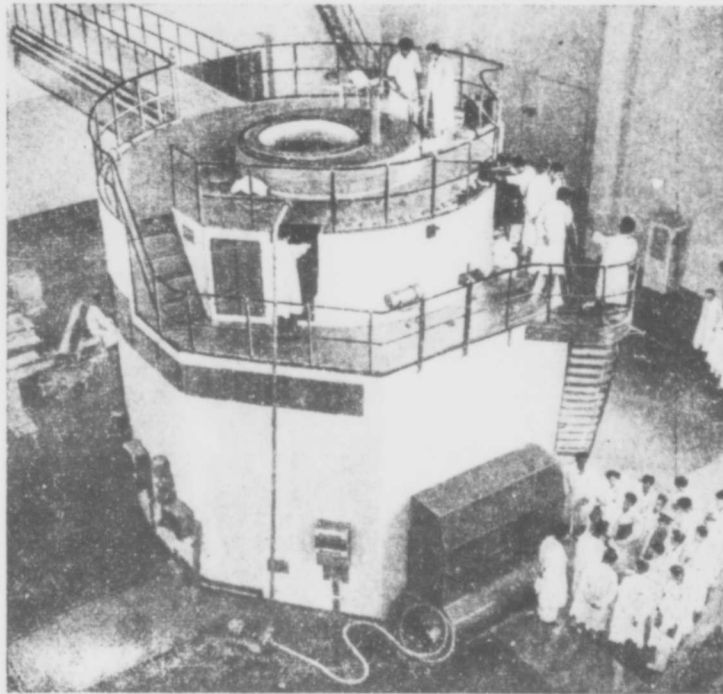


Fig. 8. General view of the Tashkent VVR-S reactor [6]

REFERENCES

1. Library of Congress. Aerospace Information Division. Soviet nuclear reactors VVR and IR: review of Soviet literature (AID work assignment no. 16). 17 Apr 1962. 42 p. (AID Report 62-43)
2. Lenin Prize winners. Atomnaya energiya, v. 8, no. 5, May 1960, 407-408. QC770.A83, v. 8
3. Kozlov, V. F., and M. G. Zemlyanskiy. Design of the VVR-S nuclear research reactor. Atomnaya energiya, v. 8, no. 4, Apr 1960, 305-315. QC770.A83, v. 8
4. Lazukov, N. A., I. Ye. Chelnokov, and V. P. Ivanov. Test-stand investigation of the VVR-S experimental nuclear reactor. Atomnaya energiya, v. 5, no. 1, Jul 1958, 44-51. QC770.A83, v. 5
5. News briefs [2d item]. Atomnaya energiya, v. 5, no. 1, Jul 1958, 92. QC770.A83, v. 5
6. News briefs. Construction of atomic reactors [unsigned article]. IN: Akademiya nauk SSSR. Vestnik, no. 11, 1959, 67-69. AS262.A627 1959

UNCLASSIFIED

UNCLASSIFIED