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THE FUEL ASSEMBLIES AND ELEMENTS RESEARCH LABORATORY

The Research Institute of Atomic Reactors

THE FUEL ASSEMBLIES AND ELEMENTS RESEARCH LABORATORY

Dimitrovgrad - 1993

In this booklet we want to retell about purposes, tasks and possibilities of the Fuel assemblies and elements Research Laboratory (FRL). You will find here an description about building structure, equipment and arrangement of hot cells for irradiated objects investigation. The in-cell equipment and its technical characteristics, measuring automatization means, experimental data acqusition and processing are described here in details.

The typical program of the VVER and RBMK reactors fuel assemblies and elements investigation are presented. In doing so the emphasis lays on ecologicaly clean non-destructive research technique, including methods of testing objects under extreme conditions.

The main leads of the FRL equipment and methods development are considered.

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1. Purposes and Tasks of the Fuel Assemblies and Elements Research Laboratory

RIAR

The Research Institute of Atomic Reactors (RIAR) was established in 1956. It is situated in Dimitrovgrad not far from Uljanovsk. RIAR is one of the most important nuclear centers in the Russia. RIAR deals with the problems of:

- *reactor materials science;*
- fast reactor fuel cycle;
- power reactor physics and engineering;
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RIAR has unique powerful research and prototype power reactors, hot material science and radiochemical laboratories, technological buildings for production of experimental products and irradiation facilities, computer center and many other facilities which are being developed, improved and held on a level with the modern world standarts.

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1. Purposes and tasks of the fuel assemblies and elements research laboratory (FRL).

FRL combines a universal complex of facilities to investigate irradiated objects. The laboratory eguipment allows to perform full studies of power and research reactors fuel assemblies (FAs) and fuel elements (FEs). Particular emphasis is placed upon the post-irradiation studies of FAs following types: PWR (VVER-440,VVER-1000), BWR channel type (RBMK) and FBR (BN-600,BN-350,BOR-60) and upon the development of measuring procedures and equipment for such studies. The laboratory carries out the work both according to the governmental orders and to the agreements with different enterprices including the commercial ones.

The main lines of the laboratory activities are:

- *investigations of spent FAs, FEs and their fragments, delivery of possible recomendations to perfect their designs, manufacturing technology and operating modes, directed to improve their perfomance;*
- *studies of FEs and their fragments behaviour under high temperatures at conditions simulating transient and emergency operations of the reactor;*
- *pre-reactor quality testing of the FEs and their fragment;*
- *the development of experimental facilities, equipment and methods of studing FAs, FEs and their fragments in hot cells, boxes, cooling pools including methods and technical means for irradiated fuel testing in emergency and transient operations.*

From the point of view of organizing investigations the main conception of the FRL consists in combination of large-scale testing of objects with definite aims of the solvent problem. This conception is provided in its turn for using simple and express as well as precise methods.

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2. The Laboratory Equipment

2. The laboratory equipment.

Hot cells, boxes, technological equipment of the FRL are intended mainly for operation with full-scale FAs and FEs of any types of power reactors (Fig.1). The overall dimensions of the service area are oriented on the VVER-1000, RBMK-1500 FAs. The minimal dimensions are limited only by physical principals of the used method.

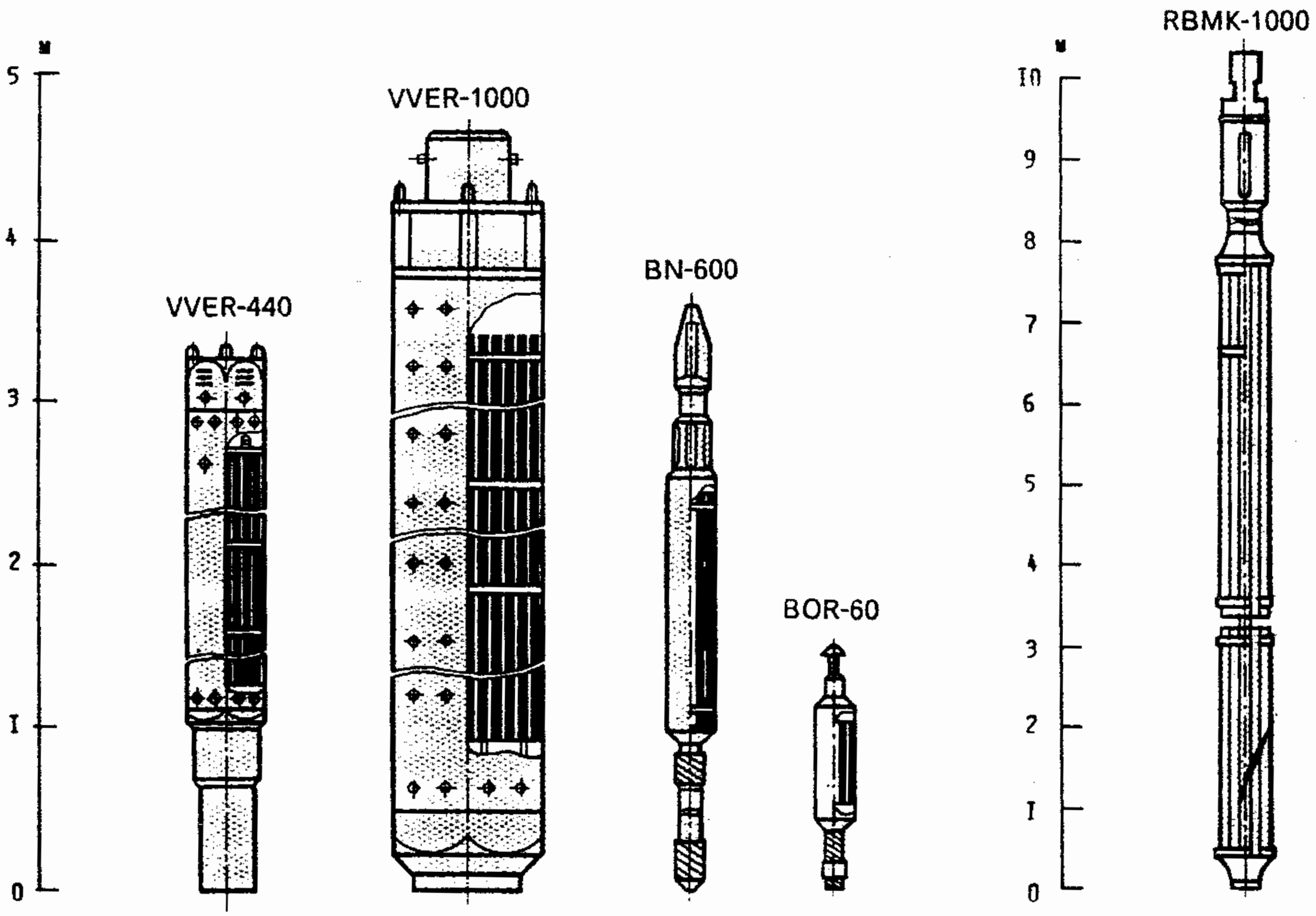


Fig.1 Types of FAs under investigation.

2.1. Hot cells and storages.

FRL is located in a specialized building the main part of which form the transport hall and a set of hot cells (Fig.2). The extreme large cells are of two-storeyed design with the inner dimensions: length 7.5 m, depth 4.0 m and height 7.2 m. Cells are equipped with the travelling-bridge cranes with load carrying capacity up to 1000 kg. Small hot cells are one-storeyed with two inspection windows and in-cell space with length 5.0 m, depth 1.8 m and height 2.6 m. Loading mechanisms of these cells are also of bridge type and with load carrying capacity up to 100 kg. In hot cells there is effected the FAs and FEs vertical transportation and studies technology. That is why all cells are fitted out with pits where the receiving wells are placed. Over the wells there are mounted research facilities or technological units for transportation of FAs or crates with FEs. Cells are equipped with power, water and compressed air supply, ventilation and decontamination systems.

In the ceiling of each cell there are two hatches for FA and FE transportation, normally closed with slabs.

The transport hall is equipped with the travelling-bridge crane up to 50,000 kg load capacity and a cooling pool with seats to store FAs or FEs (Fig.3). To transport them between the cooling pool and hot cells several types of containers are used.

The FAs and their fragments are stored during the study process in vertical storages, placed in hot cells pits.

Besides the devices for FAs and their fragments transportation and storage there are machines for FAs and FEs cutting in K-2 and K-7 cells. In K-7 cell the dismantling of the FA with the length up to 4600 mm and the diameter up to 290 mm is carried out, and in K-2 cell – the FA with the length up to 2000 mm and the diameter up to 100 mm.

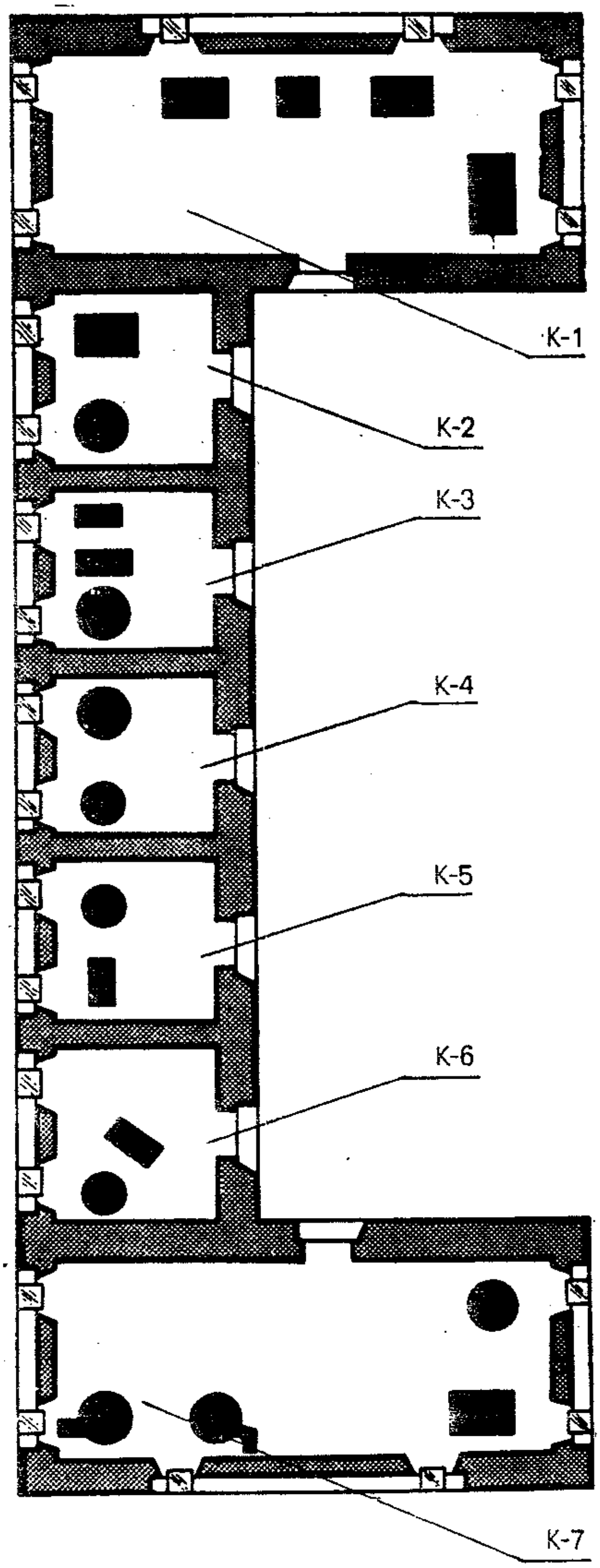


Fig.2. Hot cells arrangement diagram.

K-1 hot cell

(facilitics for measuring the fuel elements outer diameter and eddy-current defectoscopy; fuel elements gamma-scanning facility; facility to measure the shroud shape)

K-2 hot cell

(milling machine; set of equipment for fuel elements refabrication)

K-3 hot cell

(radiography facilities; automatic facility for short fuel elements gamma-scanning; facilities to measure long fuel elements general activity and defectoscopy)

K-4 hot cell

(automatic facilities to measure fuel elements outer diameter and pulse eddy-current defectoscopy; facilities for FEs visual inspection and eddy-current defectoscopy)

K-5 hot cell

(facilities for cladding laser punching and for the gas fission products analysis; emergency tests facility)

K-6 hot cell

(facility for deposits taking off and for fuel elements surface clearing (up to 4000 mm); cassette facility for fuel elements clearing)

K-7 hot cell

(facilities for fuel elements tightness testing; milling machine; facilities for fuel elements gamma-scanning and eddy-current defectoscopy; device for FA and FE visual inspection)

After finishing primary studies the fragments of fuel and construction items are taken for the further more detailed studies. The remained part of the FA is transported for storage and future reprocessing.

To repair and manufacture technological and testing equipment there are mechanical shops in FRL.

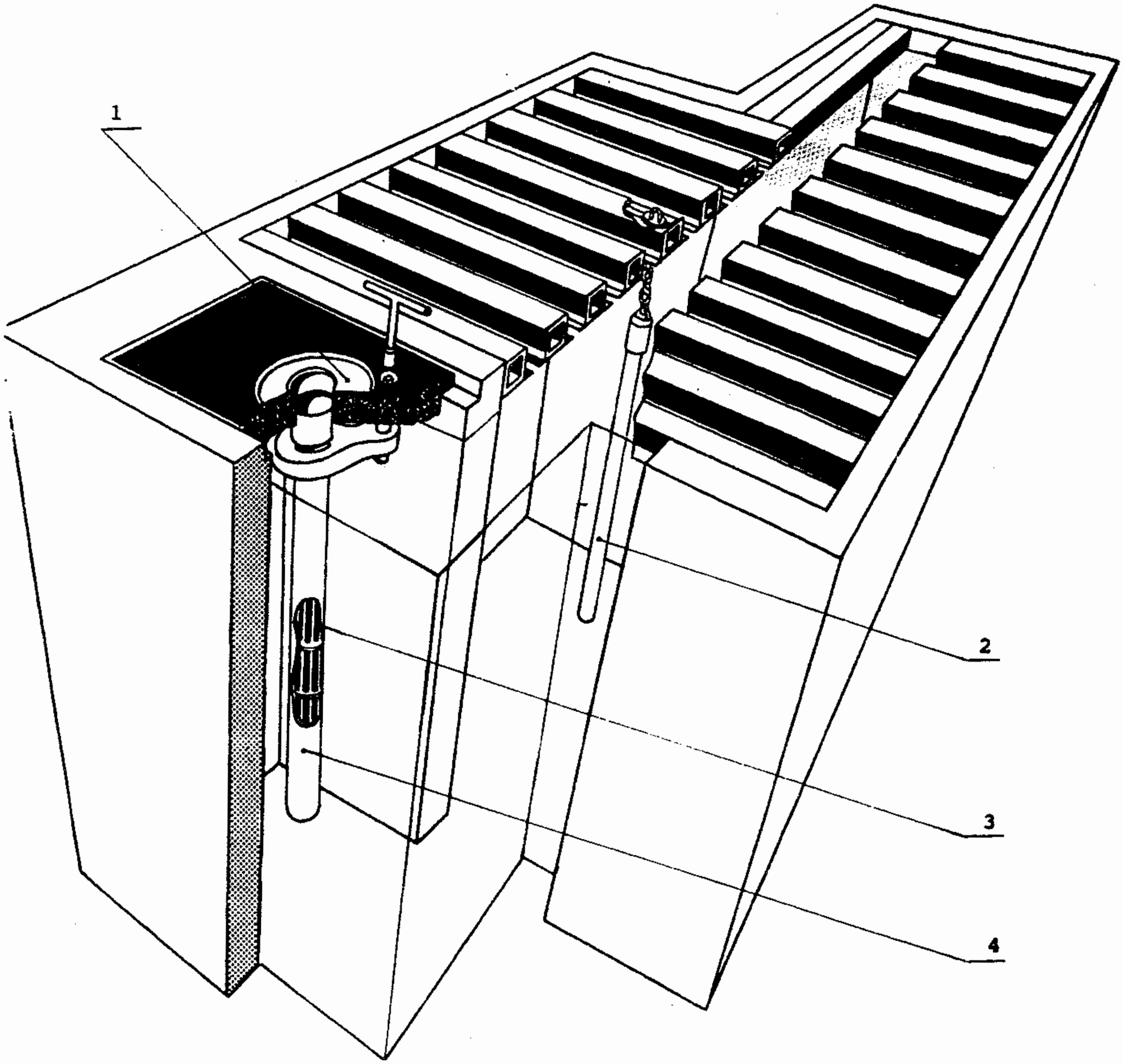


Fig.3. Fuel assamblies and elements cooling pool.

2.2. The testing equipment

2.2.1. K-1 hot cell

The gamma-scanning facility for FEs up to 4000 mm length and with the diameter frcm 4 to 15 mm (Fig.4) is located in this hot cell. The facility posseses high positional accuracy (the step equals 0.1 mm). It is achieved by using ball-screwed couple as a scanning system and stepping motors controled by programmed controliers. A collimator with the regulated slit width from 0.1 to 10 mm is used in the facility.

Two profilometry and eddy-current FEs defectscopy faciities (Fig.5) are in this very cell.

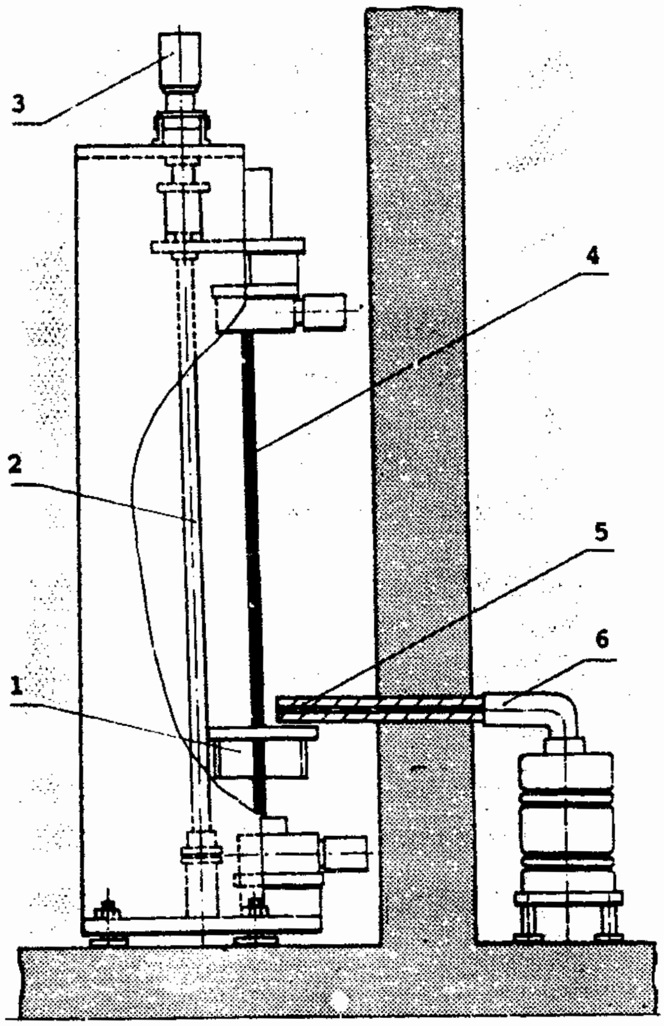


Fig.4 Full-scale fuel elements gamma-scanning facility: 1 - locating surface unit; 2 - driving screw with magnetic ruler; 3 - FE movement motor; 4 - fuel rod under test; 5 - collimator unit; 6 - detector

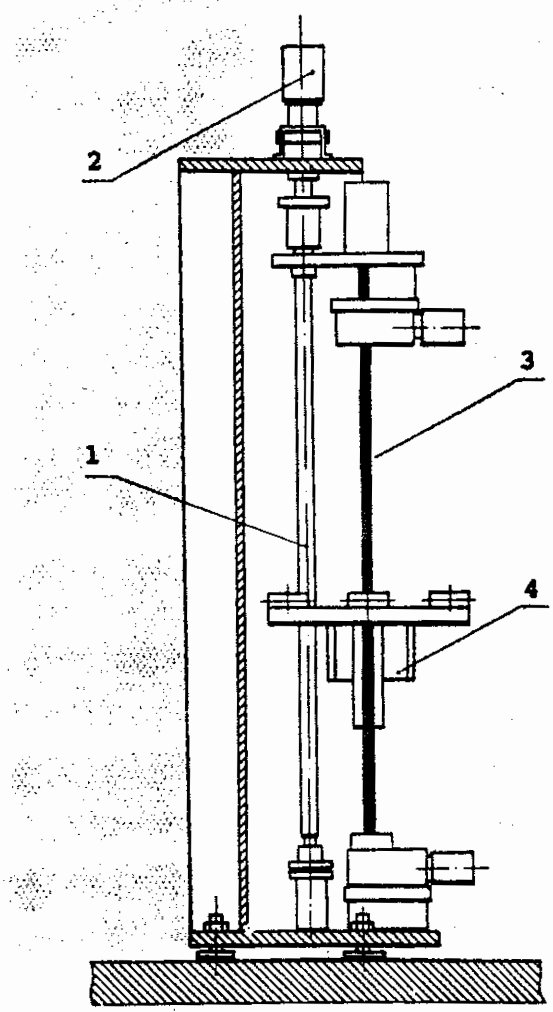
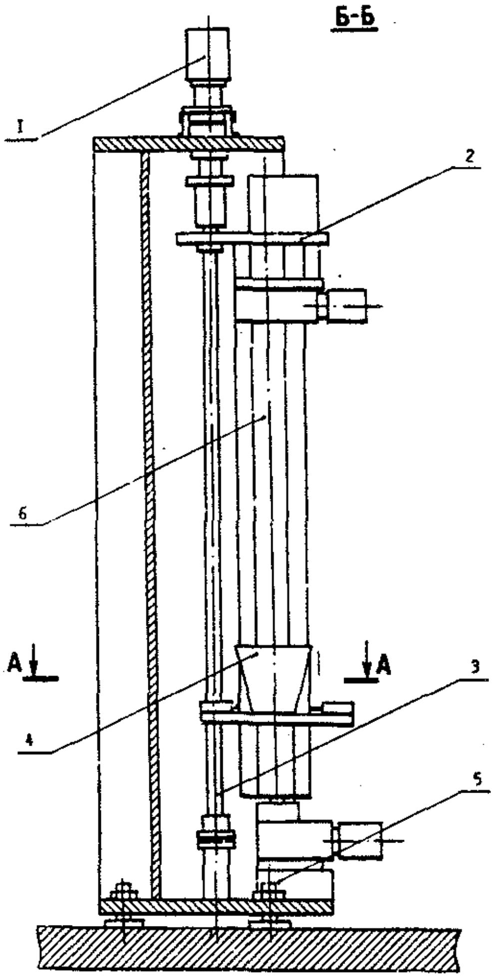


Fig.5 Facility to measure fuel elements outer diameter and defectoscopy: 1 - driving screw with magnetic ruler; 2 - measuring carriage movement motor; 3 - fuel rod under test; 4 - transducer

A facility to determine the shroud shape change (Fig.6) measures the distance from basic axis to the surfaces and ribs of the FA by the contact method. The measured data processing permits to obtain information about the distribution of distancies between opposite hexagonal shroud faces, its bowing and twisting, and also the deviation of the face surface shape from the flat one.



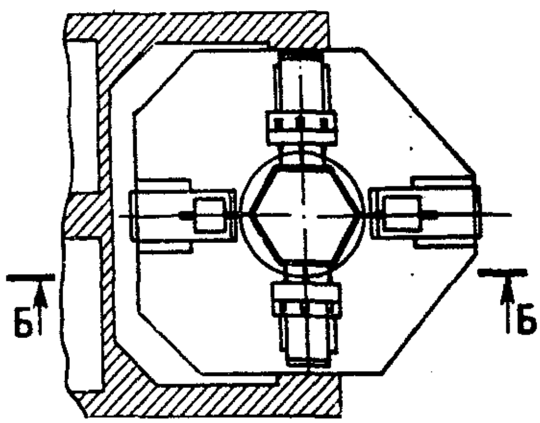


Fig.6 Facility for measuring FA shroud dimensions and shape: 1 - guiding unit; 2 - fuel assembly; 3 - measuring carriage movement motor; 4 - clamp carriage; 5 - measuring carriage; 6 - driving screw; 7 - low locating surface unit

2.2.2. K-2 hot cell

K-2 hot cell facilities are designed to manufacture experimental FEs from irradiated FEs of power and test reactors (Fig.7). The complex consists of a machine for cutting FEs, a facility for fuel removal from the ends of spent FE; a facility for circumferential welding; a cell to provide the FE cladding tightness under excessive pressure; a facility to test tightness by gelium method. The listed equipment permits to manufacture irradiated FE with Zr or stainless steel alloys cladding. The greatest diameter of the experimental FEs is up to 14 mm, length - 1100 mm, the fuel inside the FE is uranium dioxide. The inert gases inner pressure is up to 5.0 MPa. The technological process is presented as a scheme on fig.8.

The facilities for selecting fuel samples along the FE radius and the facilities for manufacturing the air-tight irradiated FE imitator are also located here.

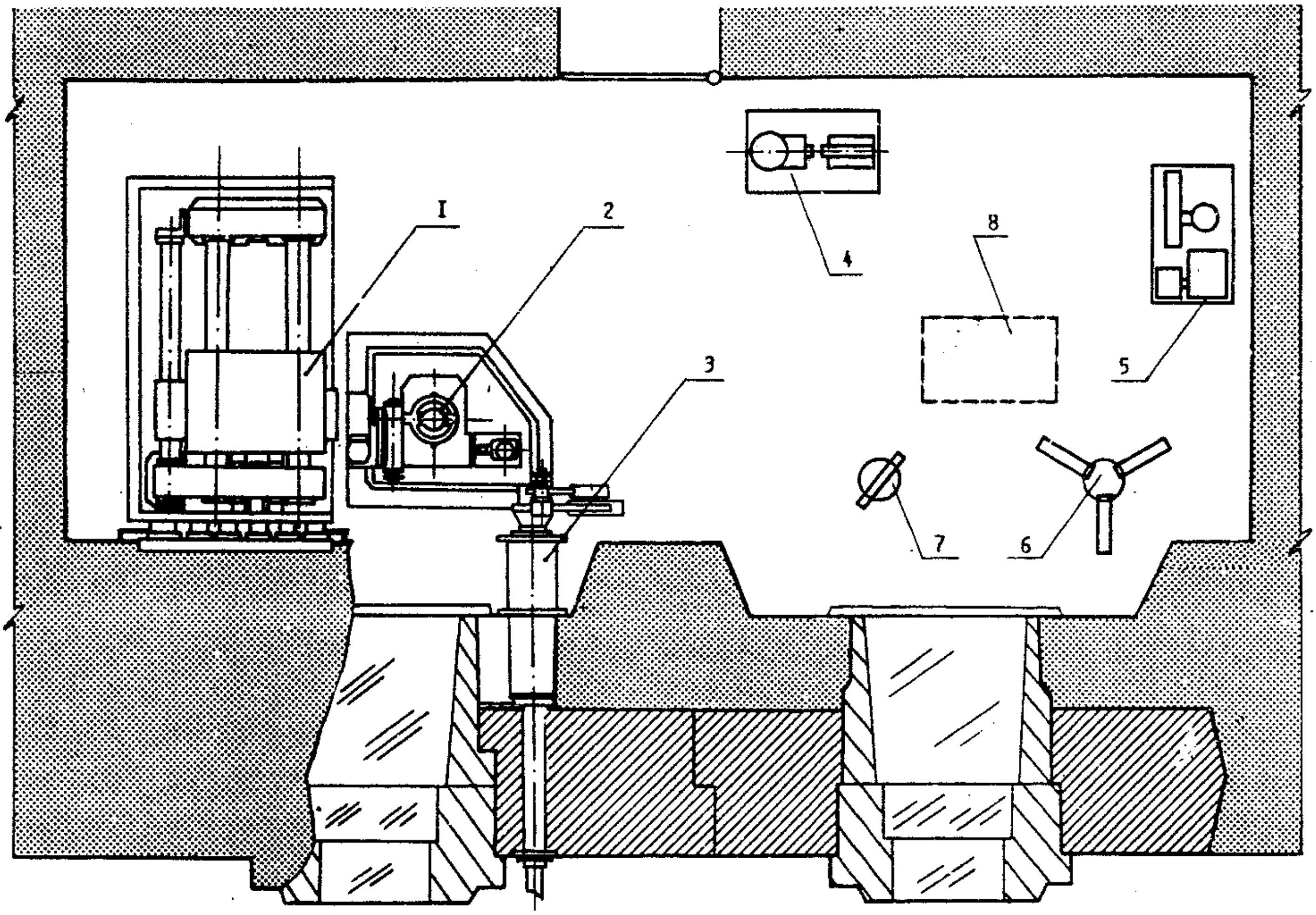


Fig.7 Complex of facilities for fuel elements refabrication: 1- FE cutting machine; 2 - clamping unit; 3 - screwdriver; 4 - fuel removal unit ; 5 - facility for circumferential welding ; 6- facility for welding under pressure; 7 - tightness testing apparatus; 8 - the working position for mobile units

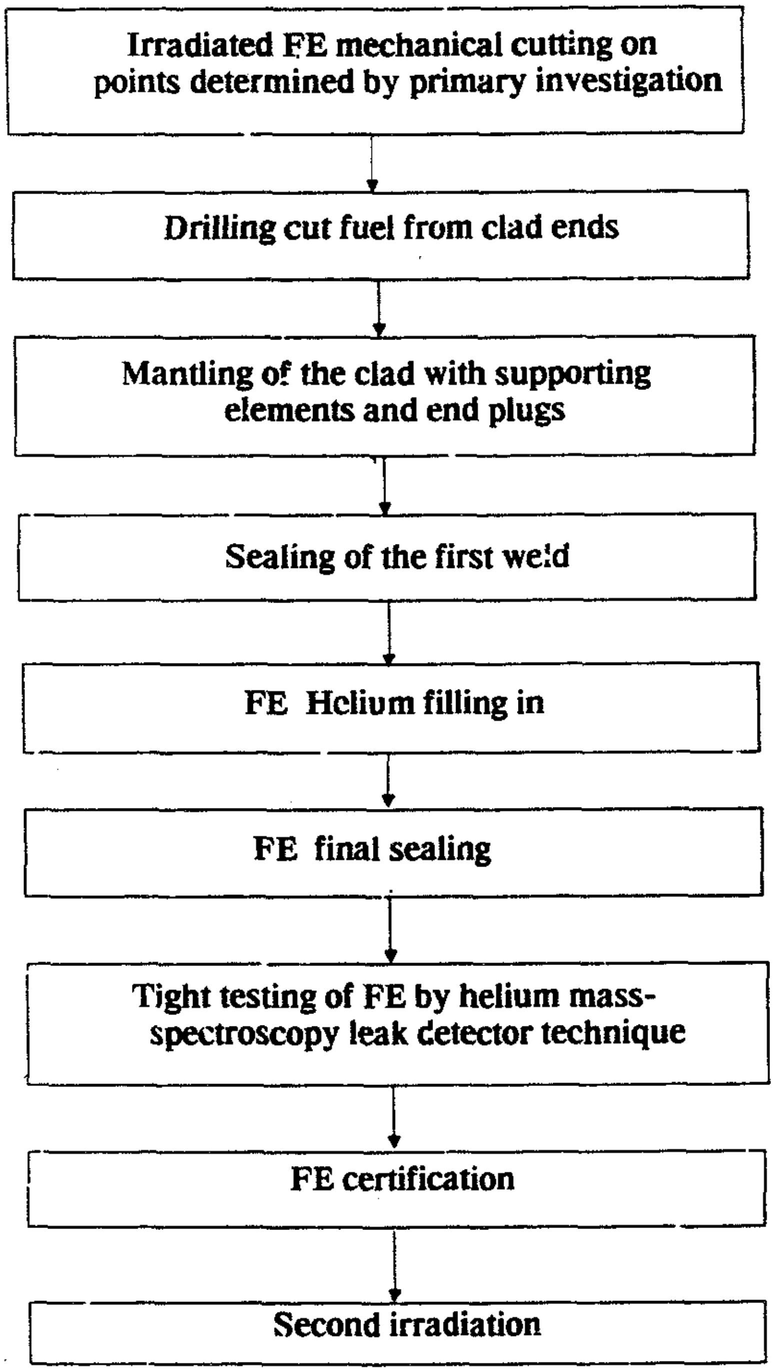


Fig.8 Technological scieme of experimental fuel elements manufacturing from irradiated FEs of power reactors

2.2.3. K-3 hot cell

In K-3 hot cell there is an automatic gamma-scanning facility (Fig.9) with a drum-store for nine FEs. The diameter of tested FEs may change from 1 to 15 mm, the length - up to 1100 mm. The facility is fitted with a set of collimators. Their slits width is changing from 0.1 to 10 mm. The emission and transmission tomography of the FE is performed at this facility.

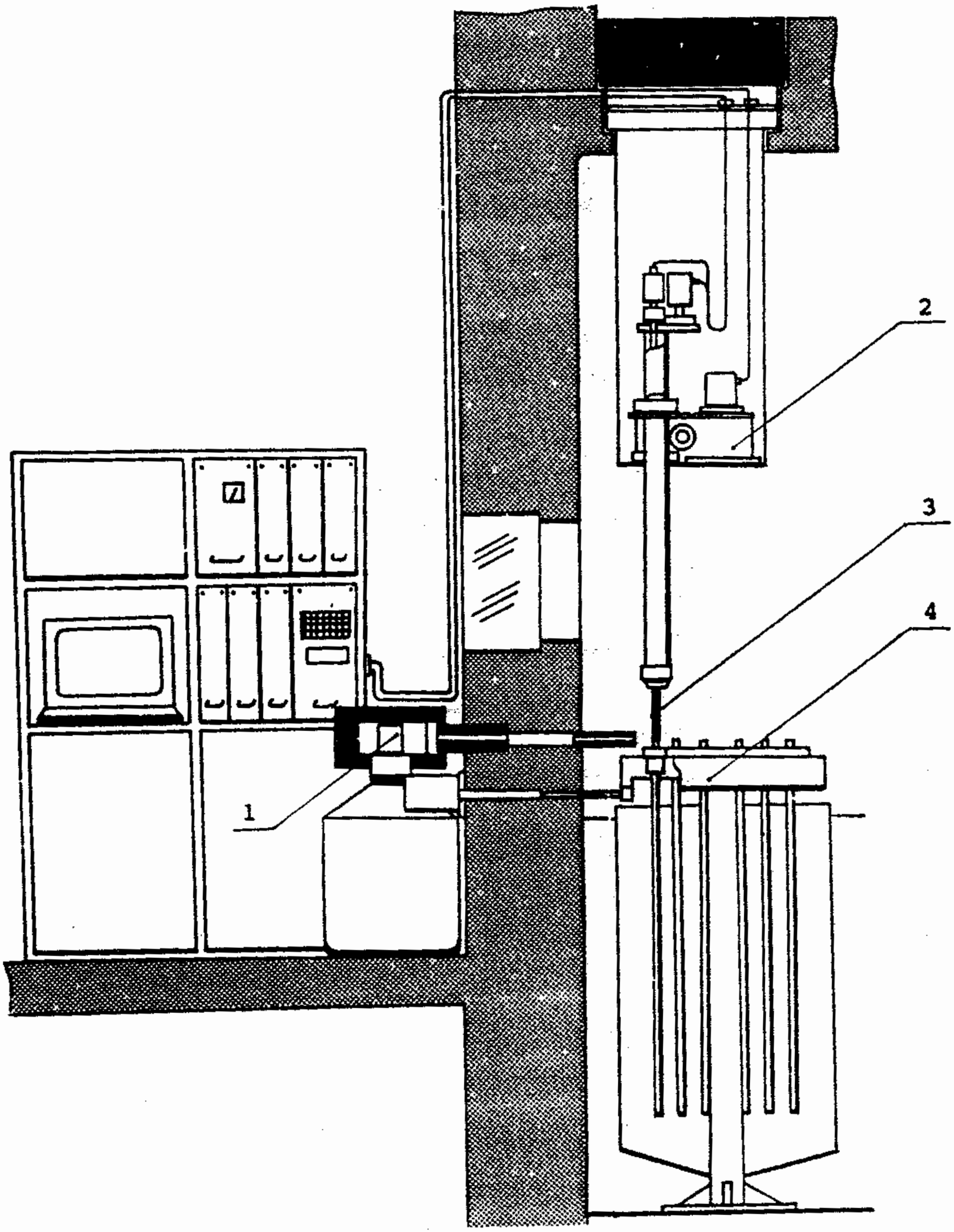


Fig.9. Gamma-scanning facility for FEs up to 1200 mm: 1 - detector and collimator unit; 2 - FE movement unit; 3 - fuel rod under test; 4 - FEs store drum

In the room under the hot cell there is X-radiography facility (Fig.10). The X-ray apparatus supplies the current in the tube up to 0.6 A and the voltage up to 125 Kv. The use of such tube allows to decrease the photographic-materials exposure near the FE to several seconds and to reduce *significantly* the background gamma-radiation effect of the FE fission products to the X-ray picture.

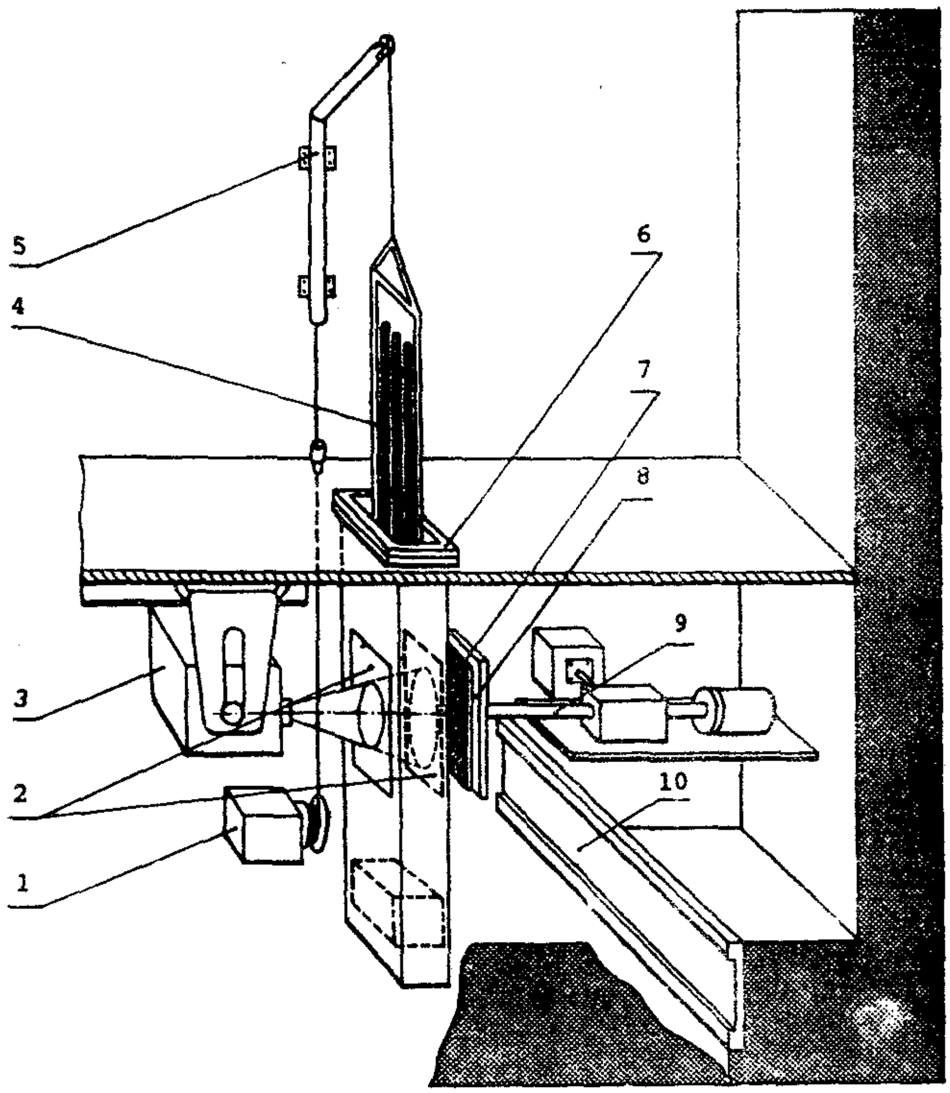


Fig.10. X-radiography facilities: 1 - winch reducer; 2 - windows; 3 - X-ray apparatus; 4 - crate for FEs; 5 - elevator; 6-pit; 7 - unit for film protection from X-ray; 8 - tape cassette; 9- tape transporter; 10 - cassette guide

In the centre of the hot cell there is gamma-scanning facility for FEs up to 4 m length. Methods of eddy-current defectoscopy and registration of the liquified krypton-85 gamma-radiation in the FE plenum are implemented in this facility.

The irradiated FEs transmission and emission tomography facility is also located in this hot cell. The facility is equipped with collimators with slits width from 0.1 to 0.5 mm and a set of different energy gamma-radiation radionuclides.

All but automatic one of the cell facilities are used to test any types of the FEs including the one from VVER-1000.

2.2.4. K-4 hot cell

All the units and facilities of the K-4 hot cell are destined to study FEs up to 1300 mm length and the diameter up to 15 mm.

The profilometry and eddy-current defectoscopy automatic facility is located in this hot cell. As the base of this facility was used a unit to move FEs and a store-drum for 18 FEs (Fig.11). All the movements are carried out with step motors. The original pulse eddy-current flow detector developed in FRL is used in the facility. The diameter distribution along the FE length is determined by means of the contact method with the help of inductive transducers with the accuracy not worth + 0.010 mm.

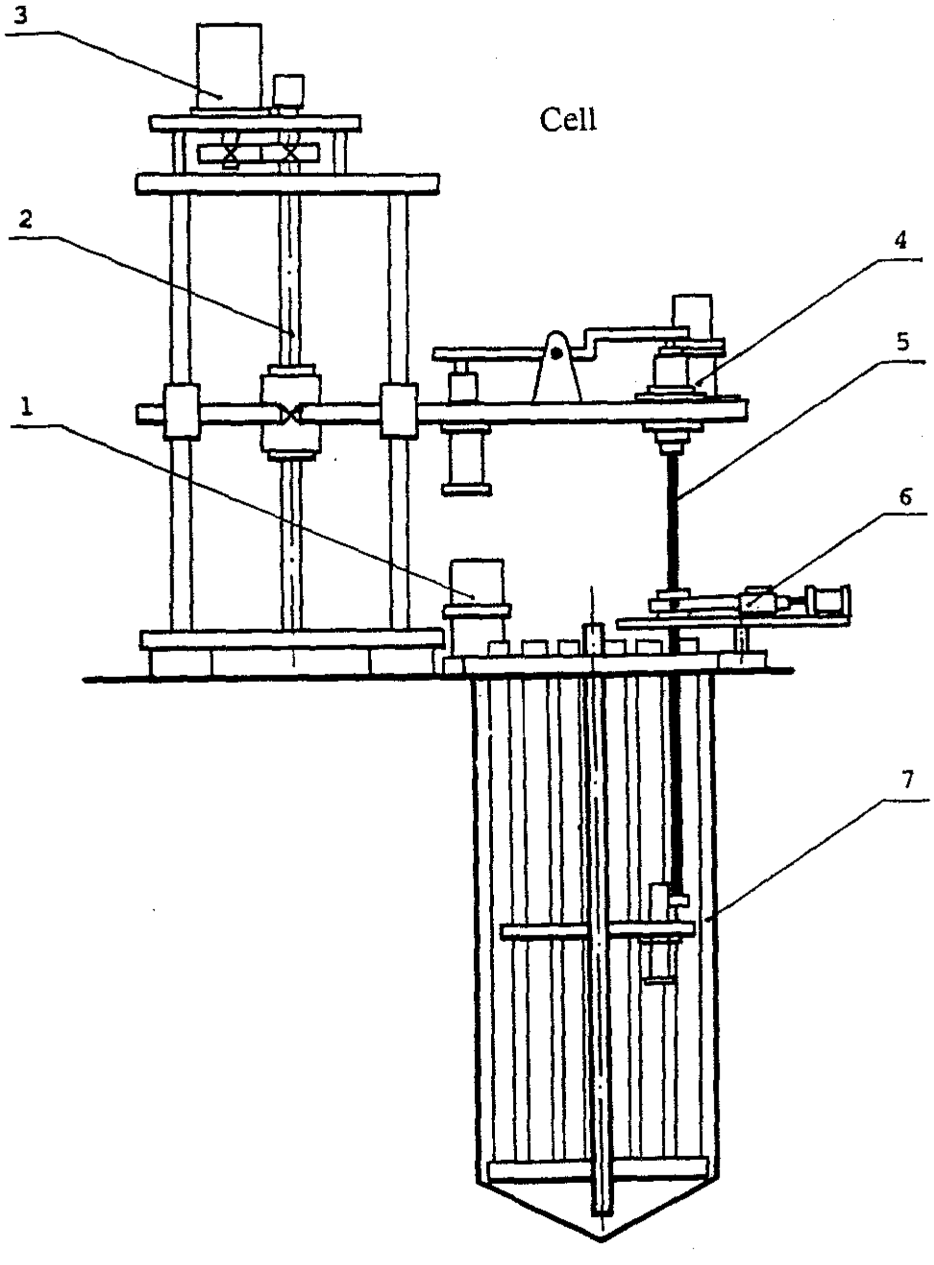


Fig.11. Automatic facilities to measure the FEs outer diameter and eddy-current defectoscopy: 1 - drum rotating motor; 2 - driving screw; 3 - FE movement motor; 4 - FE rotating motor; 5 - fuel rod under test; 6 - transducer unit; 7 - FE store drum

In the second part of the hot cell there is an optical inspection unit and pulse eddy-current digital flow detector for precise studies of the FEs cladding defects. The unit for measuring FEs volume, based on the liquid level increase (Fig.12) is just here. The level height is determined by the ultrasonic method, the measuring error is + 50 mm. In the middle of the hot cell there is a facility for the complex geometry FEs profilometry.

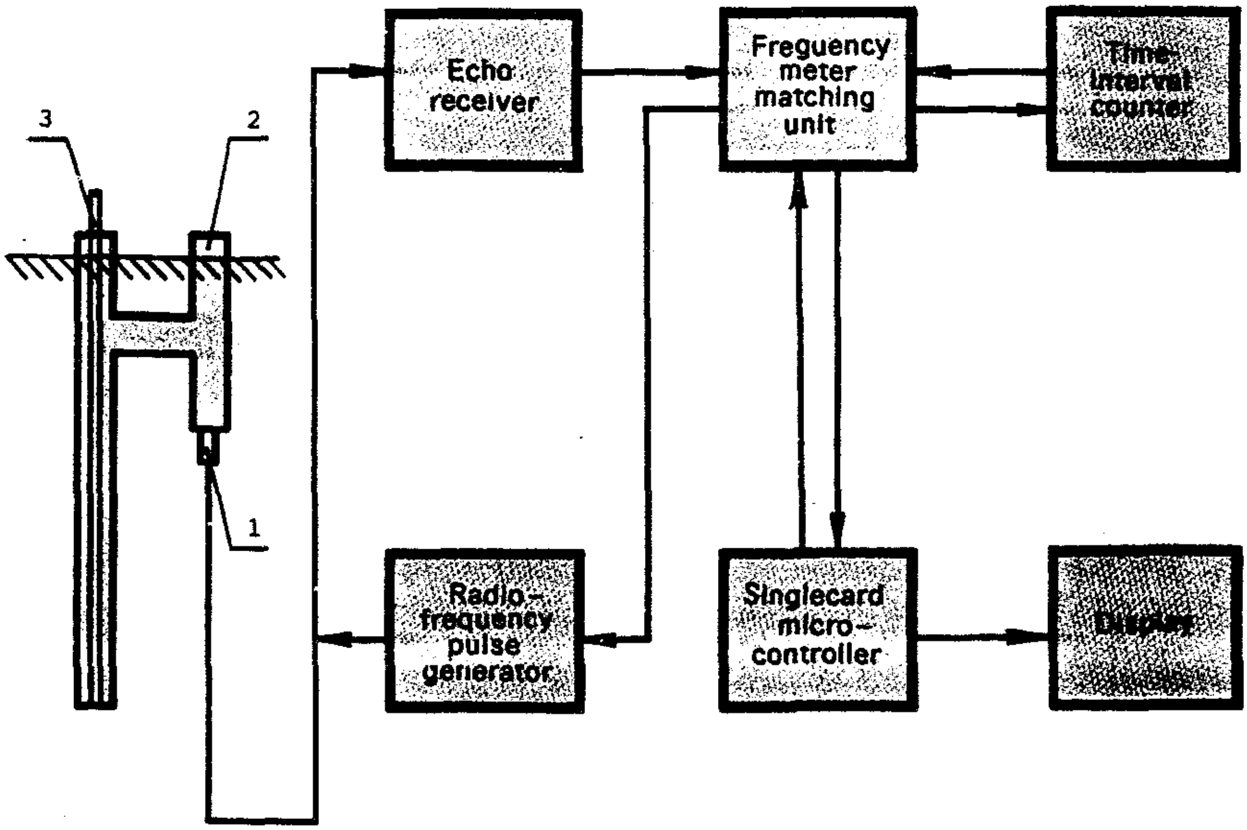


Fig.12. FEs volume measuring facility: 1 - ultrasonic emitter; 2 - volume meter; 3 - fuel rod under test

2.2.5. K-5 hot cell

In this hot cell there are located facilities for determining pressure, volume and for gas composition analysis in the fuel rod free volume (Fig.13). The FE cladding is burned-through by a laser ray and the pressure of the gas passed to the calibrated vessels of different volume is measured at one of the facilities. On the basis of analysis rezults the pressure and gas volume in a rod are determined. A part of the gas is selected to another device to determine its composition with the chromotography and mass-spectrometry methods.

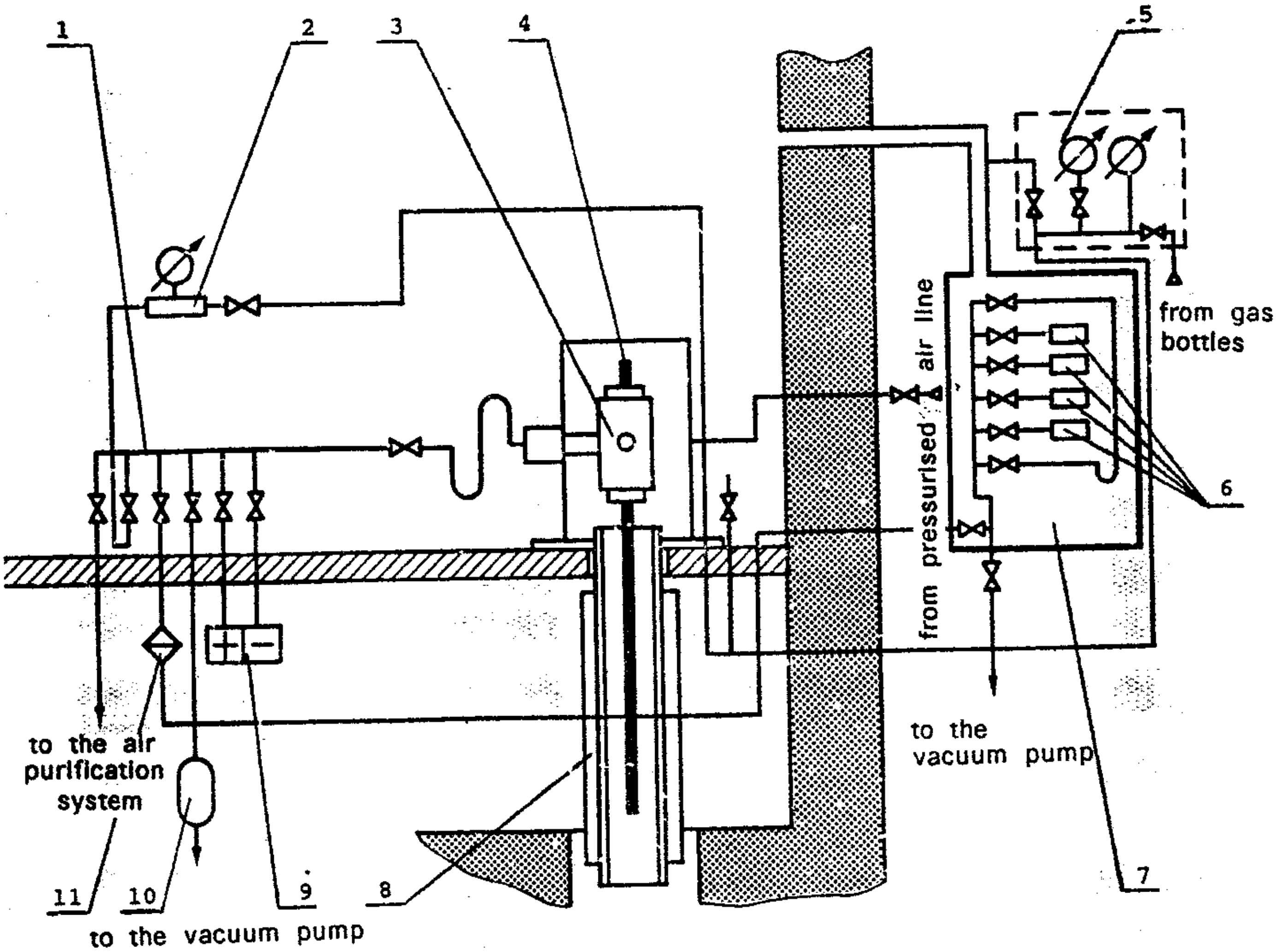


Fig.13. Facilities to measure pressure, volume and gas composition under FE cladding:
1 - measuring unit; 2 - compensation vessel; 3 - the FE sealing unit; 4 - fuel rod under test; 5 - samples testing unit; 6 - ampoules for samples selection; 7 - box for samples selection; 8 - furnace; 9 - manometer; 10 - vacuum vessel; 11 - filter

As needed other facilities can be mounted to determine the gas pressure and volume by non-destructive methods with the help of deep cooling and registration of the liquified krypton-85 gamma-radiation, and by means of the cladding temperature changes registration in time after pulse cooling or heating of the fuel rod.

Two high-temperature test rigs for FE fragments tests in operations simulating emergency situations of the VVERs cores are also located here (Fig. 14).

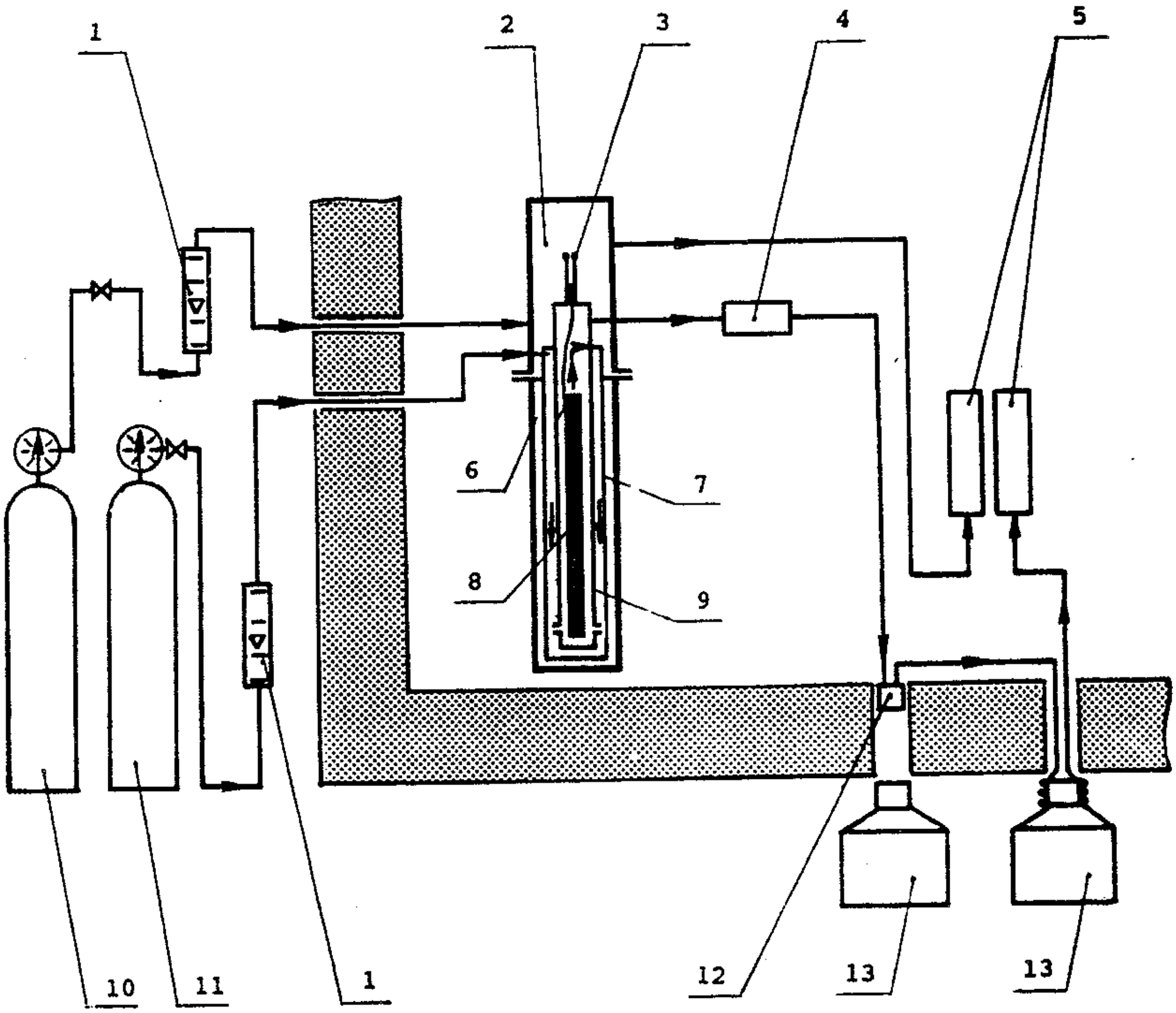


Fig.14. In-cell high-temperature facility for FEs testing: 1 - rotameters; 2 - protective cap; 3 - thermo-couple; 4 - small filter; 5 - main filters; 6 - outer cover; 7 - heater; 8 - fuel rod under test; 9 - ampoule; 10 - bulb with argon; 11 - bulb with helium; 12 - measuring device; 13 - gamma-ray detectors

2.2.6. K-6 hot cell

In this hot cell there are located the intermediate storage and facilities for the clearing of FEs and deposites removal from them.

2.2.7. K-7 hot cell

K-7 hot cell used to FAs getting technological operations, outer visual viewing of shroud tube and FEs both together and alone. Special machines are used to cutting and taking the shroud tube out FEs bunch, FEs cutting, FEs taking out FEs bunch with synchronous registration of power taking, FEs arranging on crates. FEs crates are keeping in deep wells of the hot cell or are moving to other cells or cooling pool.

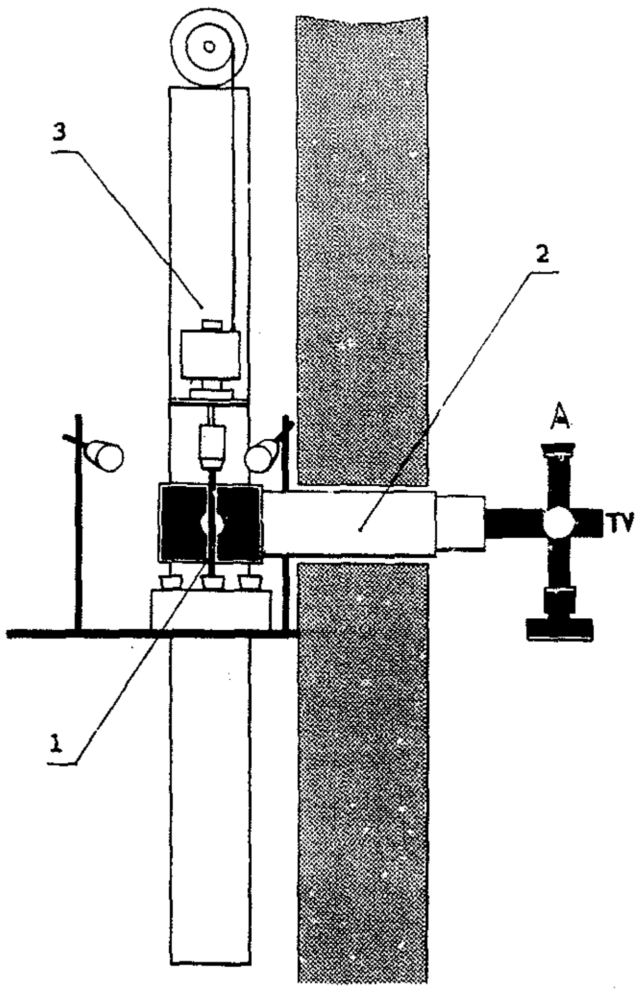


Fig.15. Facility for FEs and FAs visual inspection: 1 - fuel rod under test; 2 -periscope; 3 - FE moving and rotating unit

Facilities for FAs and FEs visual inspection (Fig.15) are disposed in this hot cell and are equipped with an original vision device. The device maintains from 0.8x to 30x magnification, the visual inspection, photography and recording on a video-taperecorder is possible. Facilities to measure the FE and shroud length are in the hot cell too (Fig.16). Measurements are carried out by means of comparison with sample length with the help of indicating heads and cathetometers . The measurement accurancy is +0.3 mm in 4 m length. To account corrections for thermal elongation the distribution of temperature along the shroud and fuel rod is measured. There are facility for FEs tightness checking by siping method.

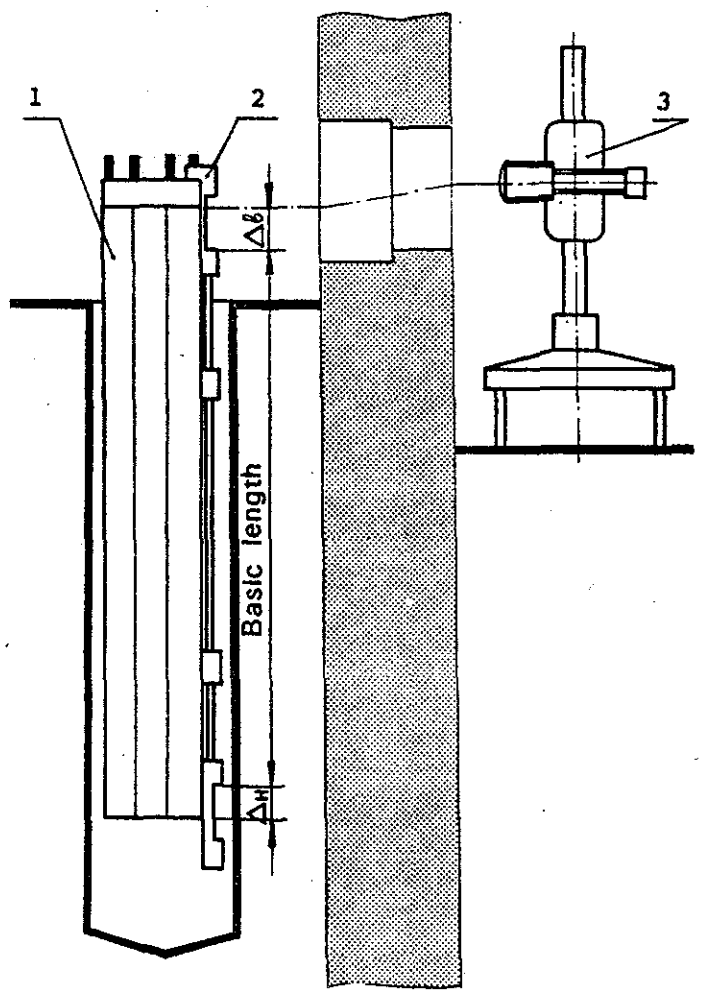


Fig.16. FE length measurement facility: 1 - fuel rod under test; 2-measuring bar; 3- cathetometer

2.3 Heavy boxes.

In parallel with the hot cells complex there is a line of heavy boxes connected with it (Fig.17). In these boxes the devices designed for the detailed studies of fuel rods fragments are located. A set of heavy boxes facilities permits to make the microsection preparation with subsequent metal-and-ceramography method studies. The microanalizer and facilities for fuel rods microsection gamma-scanning are meant to determine the fuel, fission products and transuranium elements distribution along the fuel rods radius. In boxes there are also installed a facility to measure the fuel oxygen factor and a metallographic microscope with magnification from 1x to 1000x.

In special rooms of FRL there are facilities with light boxes meant for the work with non-radiated fuel rods or low-active materials.

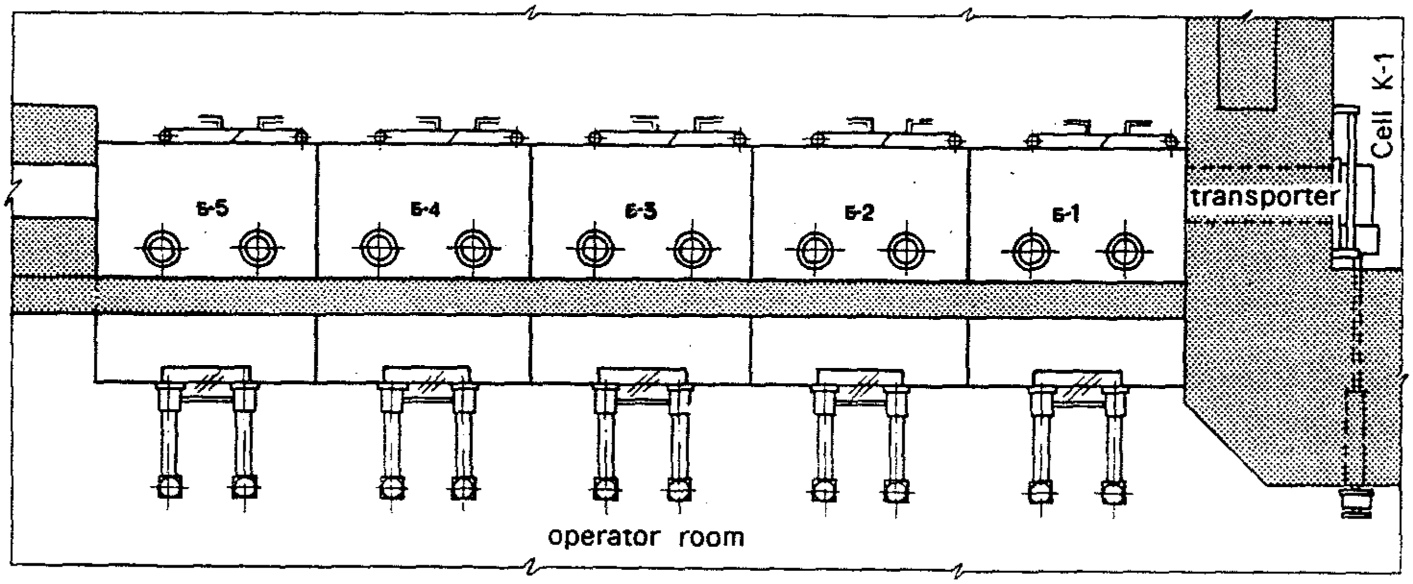


Fig.17. Heavy boxes

2.4. Data acquisition and processing hardware and software.

As a rule a computer controls all the main facilities which make data acquisition, storage, vizualization and primary processing. All the peripheral computers are joined in a complete system with the main one. The primary experimental data comes to the main computer by communication lines or by means of magnetic tapes or floppy disks. This computer makes complex data processing, graphical representation and storage (Fig.18). Any data from the main computer can be sent as needed to a personal computers to process data of the whole set of FAs by data base.

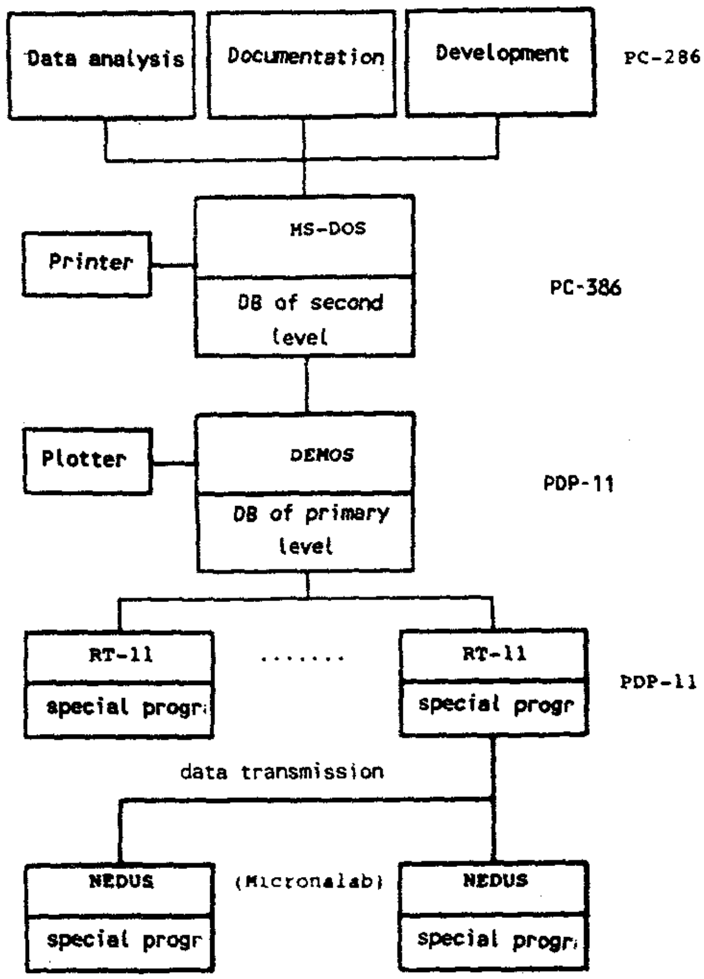


Fig.18. Hardware and software structure of the measuring and information system

2.5. Materials quality testing equipment.

In special rooms of FRL are:

- facilities to determine the diameter, wall thickness, the inner and outer coating of a small section tubes (Fig.19). The tubes diameter can bechanged from 1 to 50 mm . Contact and ultrasonic dimensions measuring techniques and the harmonic multi-frequency eddy-current flow detector are implemented here too;
- the automatic microdensitometer to work out the radiogrammes;
- the X-radiography equipment; .

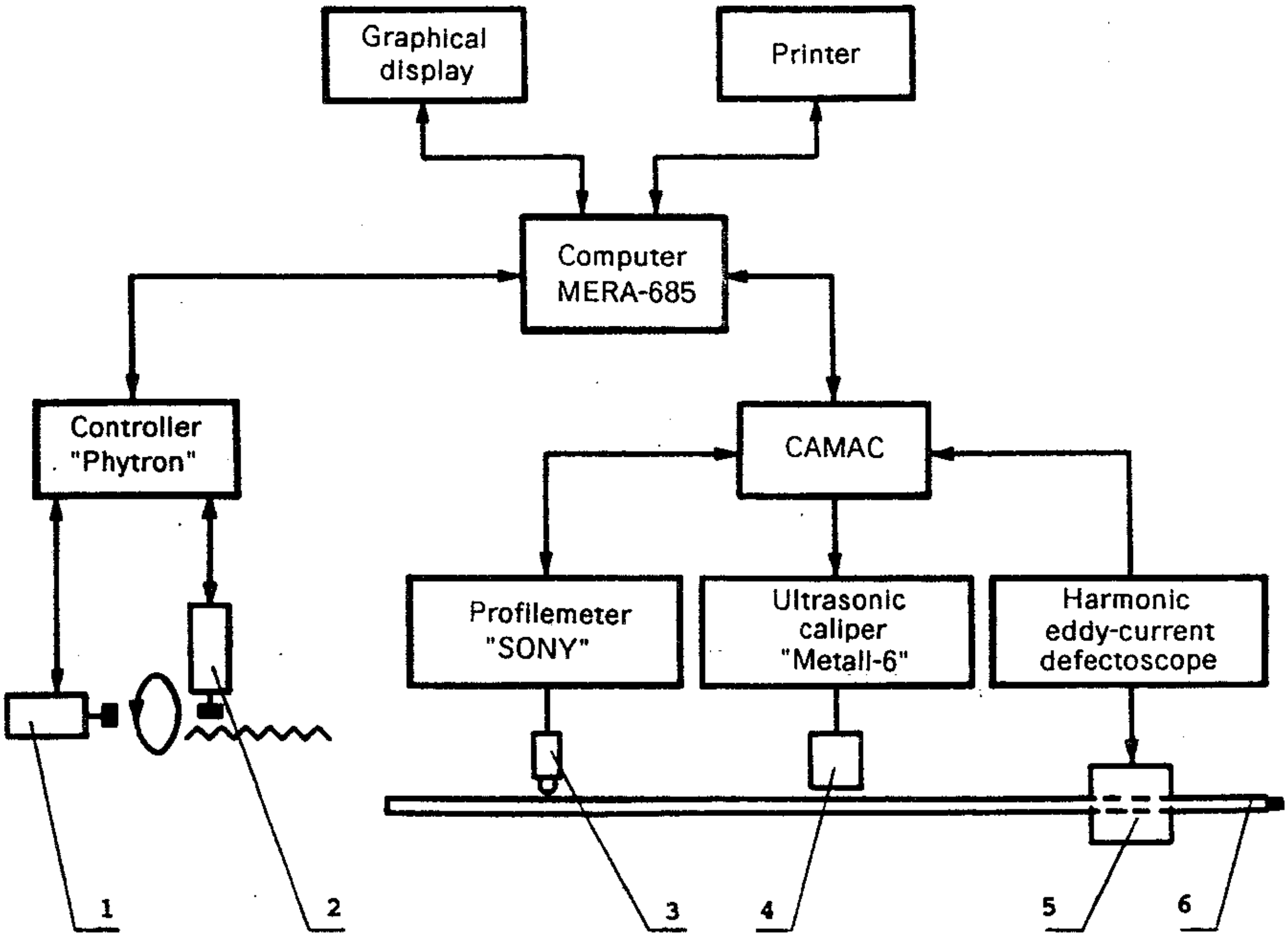
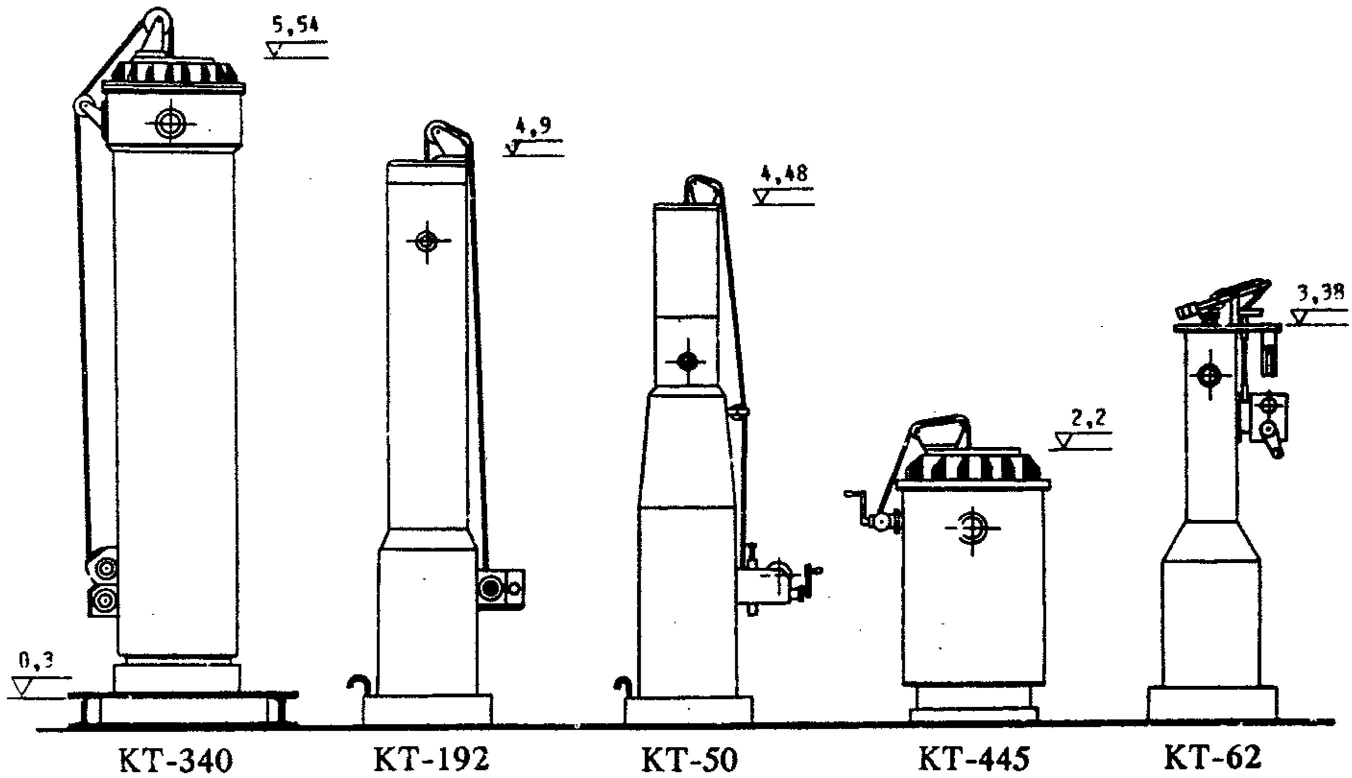


Fig.19. FEs cladding primary inspection facilities: 1 - sample rotating unit; 2 - sample transporting unit; 3 - outer diameter transducer; 4 - ultrasonic sensor; 5 - eddy-current transducer; 6 - fuel rod under test

- test rigs for the high-temperature studies with the heating temperature up to 2700 C;
- the transmission tomograph for nonirradiated FEs.

2.6. Transport technology.

Fig.20. FRL container stock



The transport of the FEs and FAs to the FRL from NPPs, other research nuclear centers, fuel reprocessing plants is performed by railway or trucks in a special transport-packing containers of TK-6, TK-10, TK-11 types and others. Transport operations inside the FRL building are carried out by two ways. FEs and objects up to 1.5 m length are displaced from cell to cell by a horisontal transporter. Objects and fuel rods of a larger length are tranfered between the cells and also from the cooling pool to study cells and back in specially developed containers (Fig.20). Transport and study technology of FAs and FEs of all power reactors provides for a vertical location of the investigated object in FRL.

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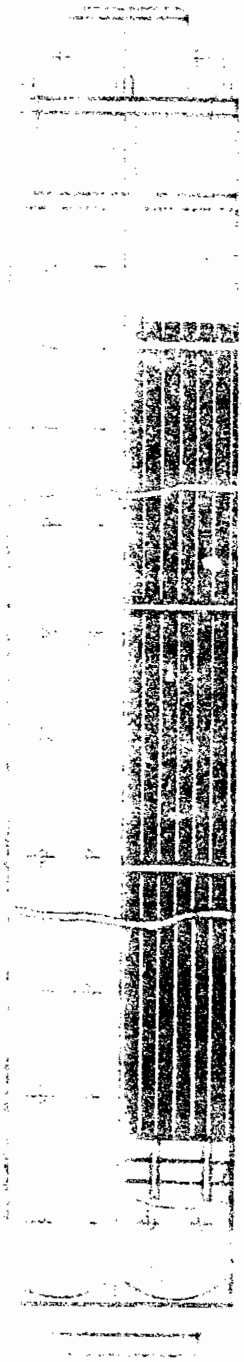
3. Fuel assemblies and elements investigations.

FAs and FEs studies are made according to programs, agreed with the customer.The sequence of the most typical studies:

- Fuel assembly and fuel rods bundle visual inspection.
- The bowing,twisting, the distancies between opposite hexagonal faces, shroud elongation measurement.
- Fuel assemblies dismantling,fuel rods removel efforts measurement.
- The visual inspection of fuel rods, space grids, FAs construction units.
- The measurement of fuel rods elongation, space grids holes diameter, FA head and spring compression efforts .
- Profilometry and eddy-current defectoscopy of fuel rods.
- The determination of fuel rods tightness,pressure and gas composition in the fuel rods free volume.
- The gamma-scanning and neutro-scanning of fuel rods.
- The X- radiography of fuel rods.
- The measurement of the gap between fuel and clad.
- Fuel rods cutting and samples preparation.
- Metallo- and ceramographic studies.
- Sampling for analysis and radial distribution analysis of the fuel nuclide composition.
- Fuel rods microsection gamma-scanning.
- Studies of the fuel and cladding structure, determination of clad thickness and transitional lay fuel-clad thickness and composition. The measurement of the fuel pellet central channel diameter.
- The processing,interpretation and presentation of results.

The result [illegible] visual inspection is the description of the [illegible] the photographies of typical cladding surface [illegible] to the axial and azimuthal coordinates (Fig.21) [illegible] about the fuel rods state in a beam permits to emerge [illegible] parameters influence degree (Fig.22).



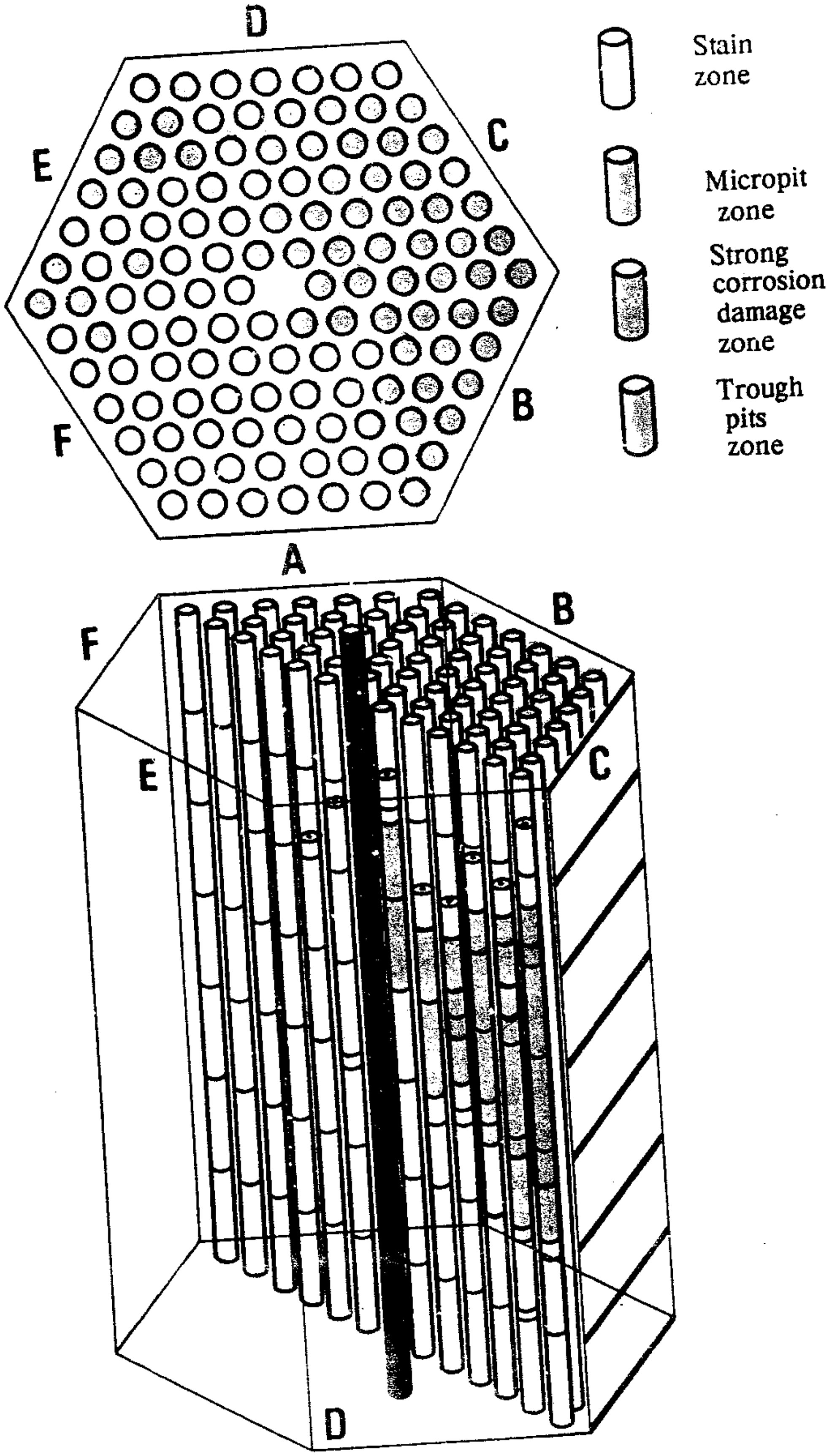


Fig.22. The information presentation according to the visual inspection results.

The FA form changing is presented as the distribution of distancies between opposite hexagonal faces, FA axe bowing, FA face twisting, and face curvature (Fig.23).

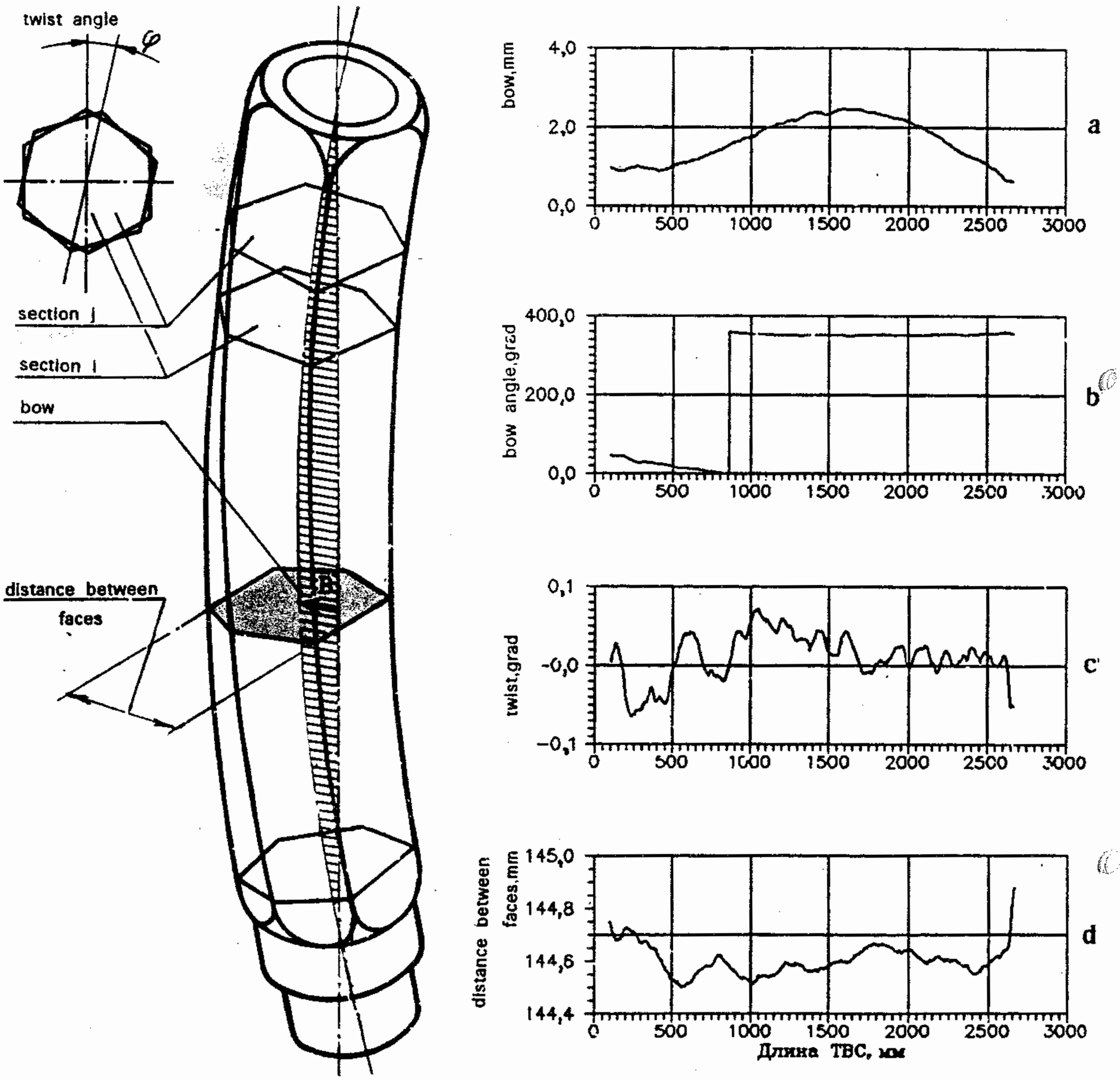


Fig.23. The data presentation form according to the study results of FA shroud deformation: a) bowing, b) bowing angle, c) twisting, d) distancies between opposite hexagonal faces

Fuel rod geometric parameters change, the cladding outer diameter in particular, eddy-current defectoscopy results and radio-nuclides information are presented as corresponding parameters distribution plots (Fig.24).

By gamma-scanning results the fuel burn-up and fission product migration are determined, when operating in reactor, and the burnup for the fuel rod different cross-sections along the FA is compared.

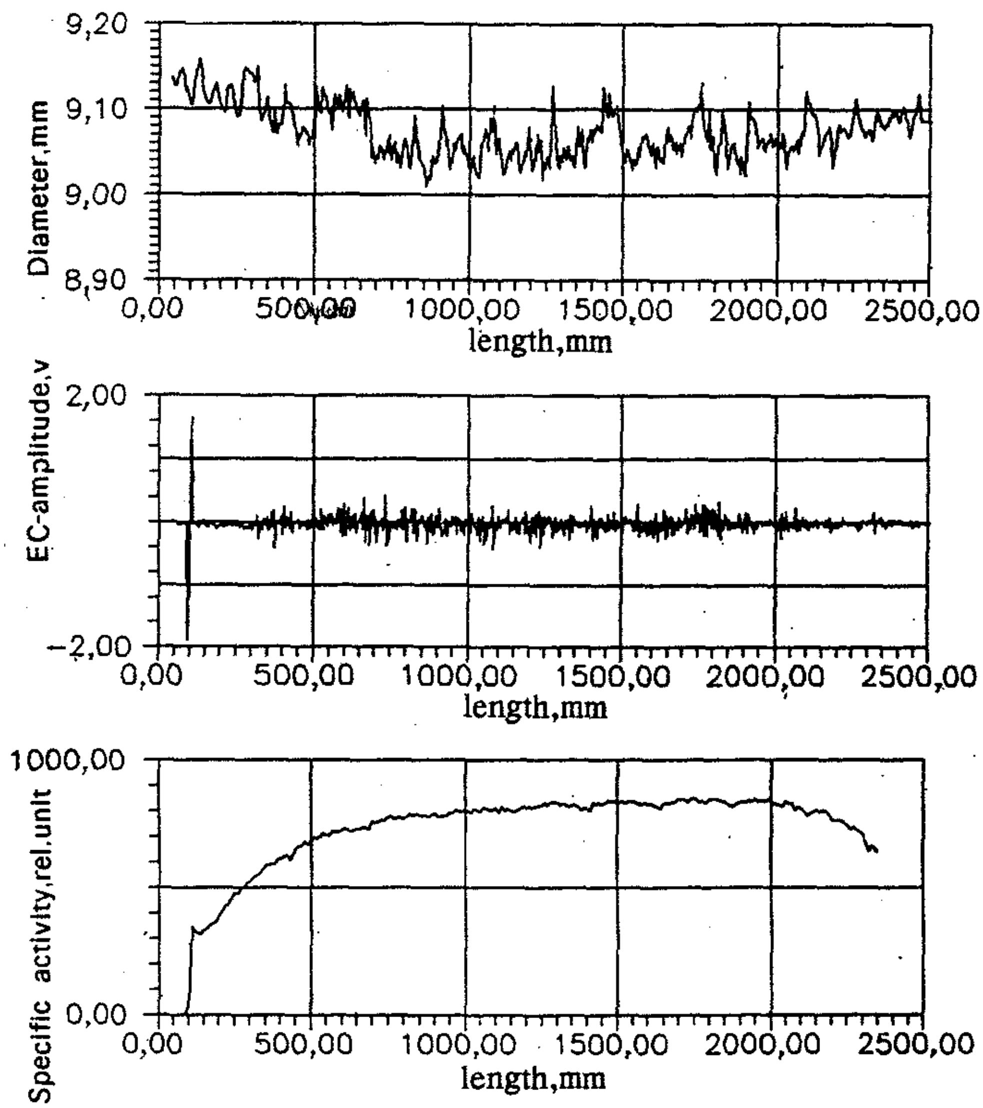


Fig.24. The data presentation form according to the FEs non-destructive studies results: a) outer diameter distribution along the FE, b) eddy-current signal distribution, c) fission products FE gamma-radiation intensity distribution

The X-radiography gives the information about the FE inner macrostructure. By the results obtained with this technique they estimate the fuel pellet diameter, fuel density along the FE height, fuel-clad gap availability, fuel pellet cracking, welds and other items of the FE construction state.

The FEs tightness is determined by puncture technique. The isotop composition of gases, released from fuel is determined by means of mass-spectrometry. Correlations between the quantity of gases released to the free volume and values of other FE parameters and the FE position in FA are analysed.

According to the radionuclides distribution by the FE radius are carried out the estimation of the temperature radial distribution in a fuel rod, the nature of fuel and clad interaction and other parameters with the aim of codes verification for the neutron-physical calculation.

Fuel-clad gap size is determined by reduction and is refined by measuring with the help of metallographic samples.

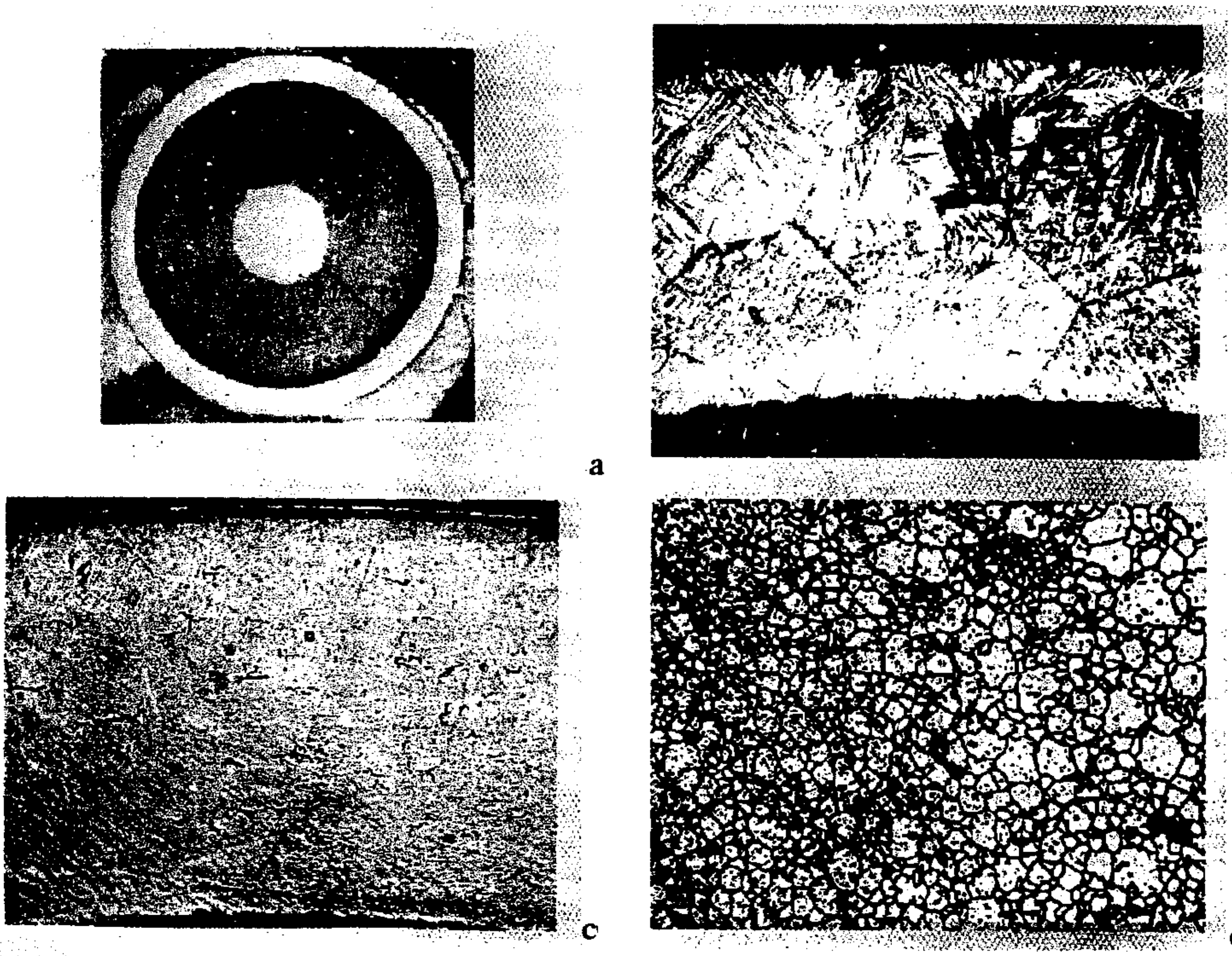
The eddy-current defectoscopy informs about the cladding local geometrical parameters changes, about changes of its conductivity and the presence of defects and the cladding hydrogenation and corrosion too.

The fuel density is determined by hydrostatic weighing. The measurement accuracy is + 0.01 g/cm.

The metallography, ceramography and quantitative microscopy are used to study the active materials structure (Fig.25). The sample is prepared from the FE fragment. To harden the sample is impregnated with epoxy resin or Wood alloy. After preparation metallographic sections are studied under the microscopes. The information is stored on videotape recorder or in computer memory where the data processing is performed. The same samples can be used if required in autoradiography, cross-section gamma-scanning methods or after special treating for microanalysis and mass-spectrometry that is carried out by sampling technique.

The FE clad is polished and etched. Microphotographes illustrate the materials structure, the outside and inside oxide film thickness of the clad, as well as the quantity, the form and orintation of hydride inclusions and corrosion.

To describe the fuel state are determined the grains size, the pores and chemical elements distribution, including fission products. There is a possibility to test FE fragments with the help of electron microscopy and microanalysers.



a b c d

Fig.25. Macrostructure of the fuel rod cross-section (a), cladding microstructure (b,c), fuel microstructure (d)

RIAR

The Research Institute of Atomic Reactors (RIAR) was established in 1956. It is situated in Dimitrovgrad not far from Uljanovsk. RIAR is one of the most important nuclear centers in the Russia. RIAR deals with the problems of:

- reactor materials science;
- fast reactor fuel cycle;
- power reactor physics and engineering;
- radiochemistry.

RIAR has unique powerful research and prototype power reactors, hot material science and radiochemical laboratories, technological buildings for production of experimental products and irradiation facilities, computer center and many other facilities which are being developed, improved and held on a level with the modern world standarts.

4. Emergency Operation Simulation

4. Emergency operation simulation.

To study the fuel elements behaviour in emergency operating modes there are test rigs, simulating different emergency parameters. As a rule these test rigs are based on reactor loops or in-cell heating modules.The both ways of emergency simulations are designed to work with highly irradiated spent fuel.

In FRL the high-temperature test rigs are supplied with units to prepare working mediums (steam,air,inert gas), visual inspection units, systems for measuring dimensions and fission products registrations with the help of gamma, mass- spectrometers and chromatographers.The emergency processes with the temperature increase up to the fuel melting are simulated in high-temperatured modules. For FEs models manufacturing there was developed a technique that permits to cut fragments on needed length from spent fuel elements to tight them by welding setting up a specified medium in the fuel rod.As an example on the Fig.26 there is shown the temperature dependence of the release rate of Cesium-134, Krypton-85 from the fuel of VVER-1000.

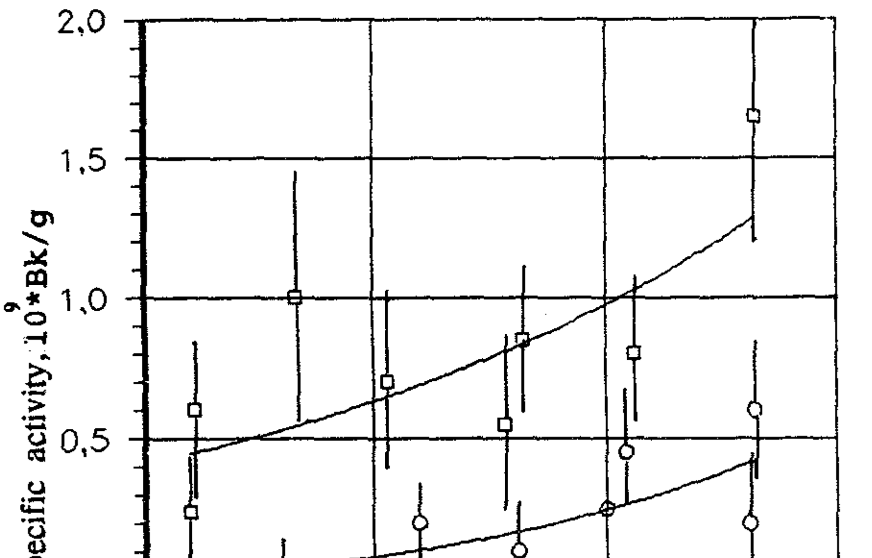


Fig.26. Cs-134 and Kr-85 (released from VVER-1000 fuel when FE is heated) specific activity vs temperature

5. Techniques Development

5. Techniques development.

Practically all the techniques used in the FRL are its own elaborations. Moreover, the FRL is engaged in work on means and procedures development of FEs studies for research enterprises of Russia. By convention all elaborations is possible to devide into three groups:

- equipment for hot cells;
- inspection rigs for the cooling pool;
- high-temperature electric heating test rigs.

The approach taken to develop equipment and methods provides modularity and interchangeability of units in experimental facilities. This permits in its turn to satisfy varying tasks and purposes of studies.

To simplify the manufacture of hot cells research equipment, establishing unified means for measuring the unified scanning systems are designed in the FRL. Work is now underway towards the construction and improvement of methods of the eddy-current defectscopy, neutron and X-radiography, the technique of determining pressure and gas composition in FEs without their destruction. Moreover are now improved non-contact dimensionmetry, visual-optical systems and nuclear-physical methods of studying the nuclides distribution by the FEs and FAs volume.

Nowadays a pool type inspection rig for FA of RBMK-1000 at "Ignalina" NPP designed and produced in the FRL together with other enterprises of the Nuclear Branch is put into operation (Fig.27).

In FRL there are developed techniques to establish the safety of the reactors operation in emergency and transient conditions and are performed investigations of FE and their fragments behavior under temperature changes up to 2000-2500 C in different mediums.

The elaborated equipment and methods permite to provide for:

- the adequacy of the test conditions reconstruction of natural emergency (medium, temperature and the rate temperature change);
- the recording of fission products release kinetics dependence during the heating process;
- post-thermal studies of the fuel structure-phase changes

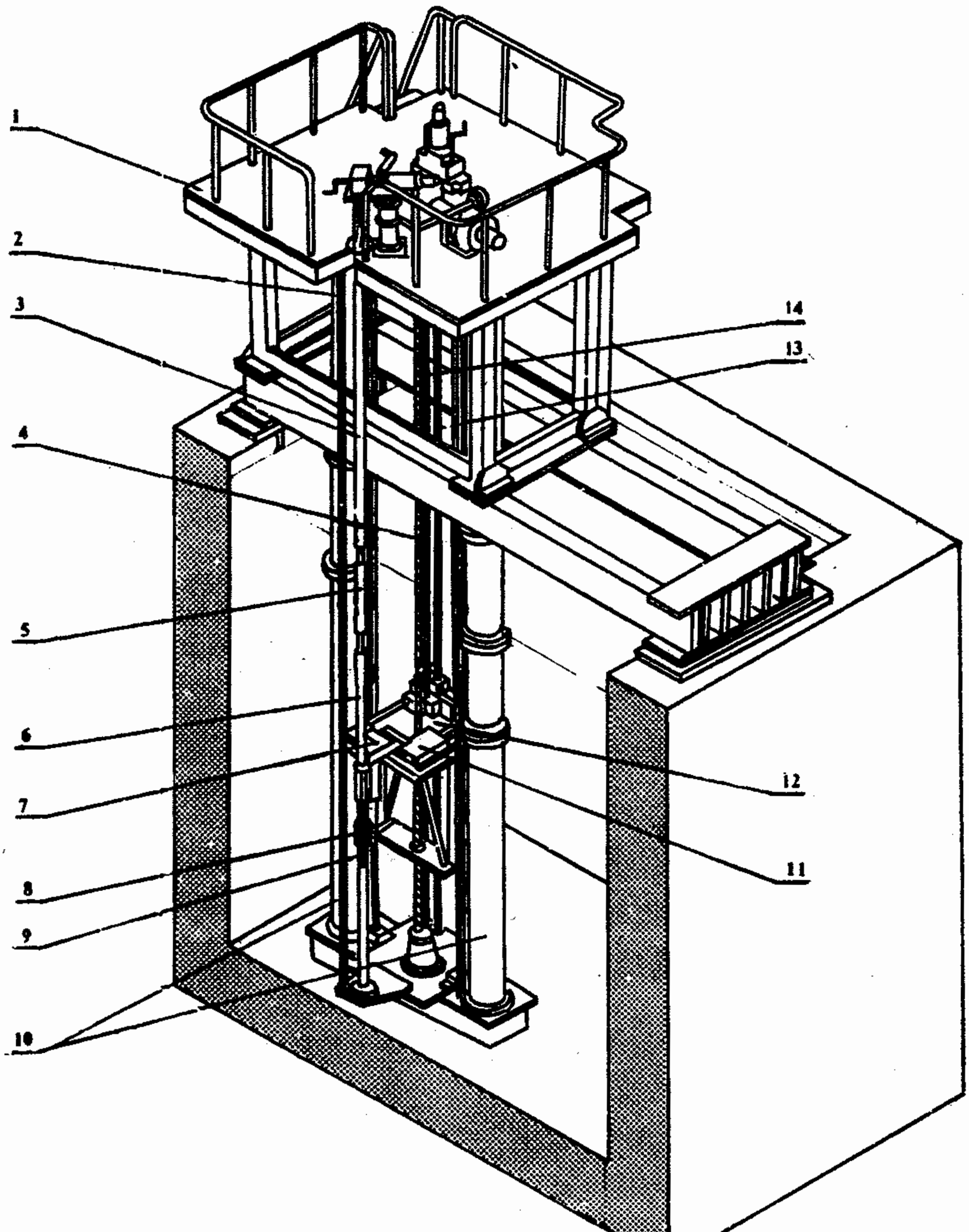


Fig.27. FA inspection pool iest rig for RBMK-1500 of Ignalina NPP: 1 - operating platform; 2 - ruler; 3 - FA suspension; 4 - screw; 5,6 - FAs; 7 - movable measuring snap gauge; 8 - FA locating unit; 9 - support unit; 10 - columns; 11 - mechanism of measuring carriage movement; 12 - carriage; 13,14 - pins for snap moving in the carriage plane

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6. Non-nuclear Problems

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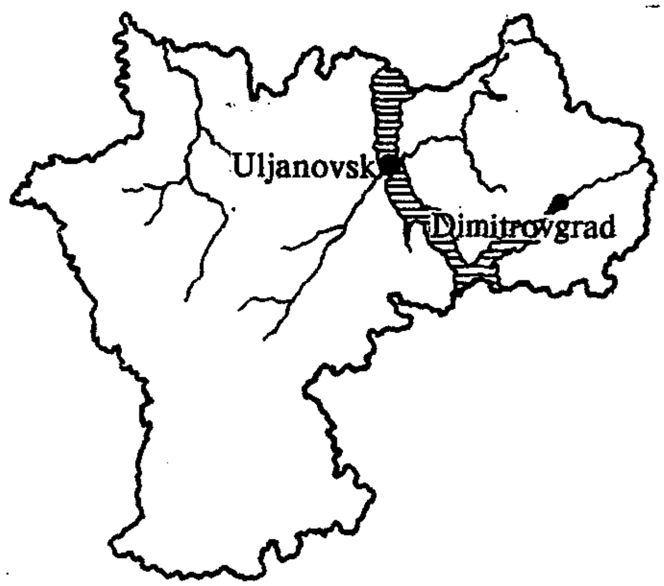
6. Non-nuclear problems.

The FRL carries out some works developing methods and means of materials testing in automobile and air-space industry. In general it is the development and manufacture of facilities for the quality and dimensions control of metal bars,bimetallic plates, protective coating for engines, neutron-radiographic studies of materials macrostructure, especially hidrogenous.



FRL is an advancing system with constantly improved technological base and study and development techniques, able to a quick on new research and technology achievements.

We invite everybody who works in the field of new technologies: nuclear power plants, design and research enterprises for mutually beneficial cooperation.

Contents

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