RUSSIAN RESEARCH CENTRE **KURCHATOV INSTITUTE**
INSTITUTE OF REACTOR TECHNOLOGY AND MATERIALS
Kurchatov sq., 123182 Moscow, Russian Federation
Facsimile: 007 095 196 1701

THE ACTIVITIES OF THE RRC «KI» REACTOR MATERIALS DIVISION IN THE FIELD OF POST-IRRADIATION EXAMINATION OF FUEL RODS

V.Bespalov, Ja. Shtrombakh

MAIN ACTIVITIES OF DIVISION OF RADIATION MATERIAL SCIENCE IN THE FIELD OF EXAMINATION OF FUEL RODS

Investigation of the operating availability and reliability of fuel elements for various-purpose nuclear power installations

Manufacture of reinstrumentation fuel rods using fuel elements already irradiated in different type reactors. The additional irradiation of instrumented fuel rods and performing of its post-irradiation examinations.

Verification of codes modelling behaviour of fuel elements during its operation in reactors.

DIVISION OF RADIATION MATERIAL SCIENCE

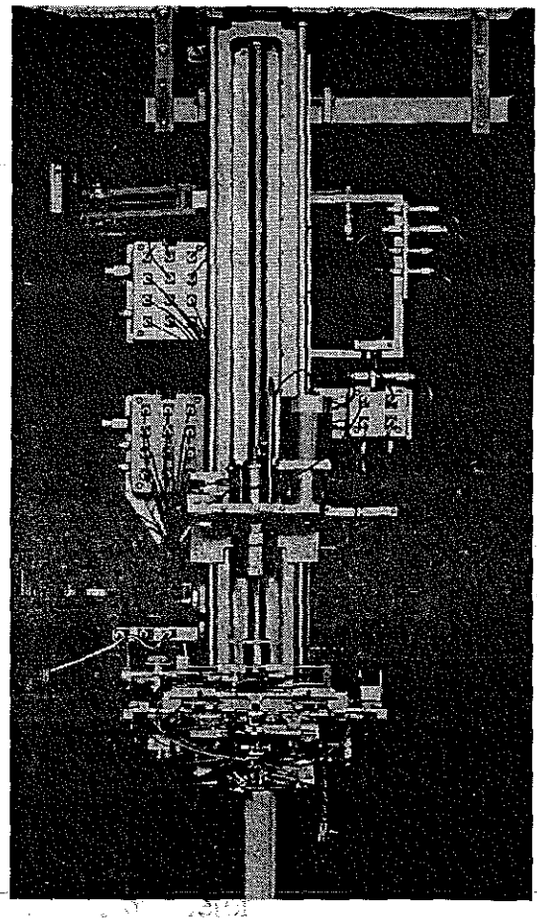
Division of Radiation Material Science of RRC «KI» involves series of "hot" cell chains of different capacities which permit irradiated fuel rods, fuel and structural materials to be tested using both non-destructive and destructive methods. The Division is provided with up-to-date equipment for performance of the tests.

Below basic techniques which are usually used in post-irradiation examinations are considered.

1. RESEARCH OF FUEL RODS BY NONDESTRUCTIVE METHODS.

There is an installation, on which the measurements of diameters of fuel rods, gamma-scanning and eddy current control of a condition of cladding of fuel rods (fig.1) are carried out. This installation was designed and manufactured by «SIEMENS»

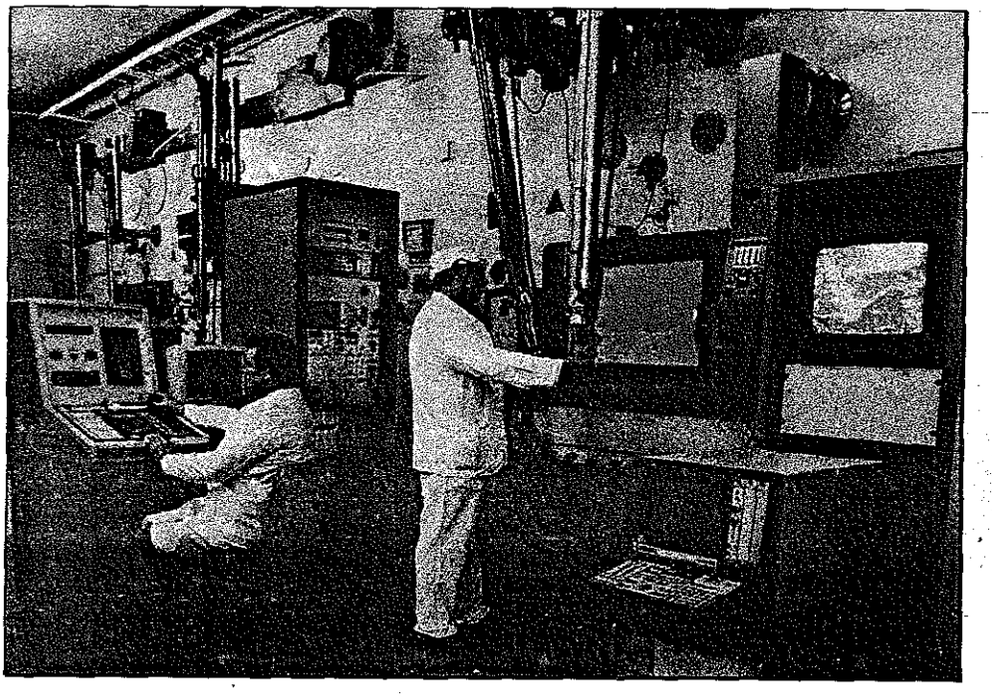
Fig.1.



In a fig. 1 it is possible to see the head for fastening fuel rod and gauges for measurement of a diameter, gamma-scanning and eddy-current control of cladding. The head together with the fuel rod is capable to move up and down and to rotate about the axis. Such moving of the head allows producing measurements of a diameter, gamma-scanning and eddy-current control of cladding along various forming lines of the fuel rod.

Fig.2.

The hot cell with equipment for non-destructive examinations of fuel rods



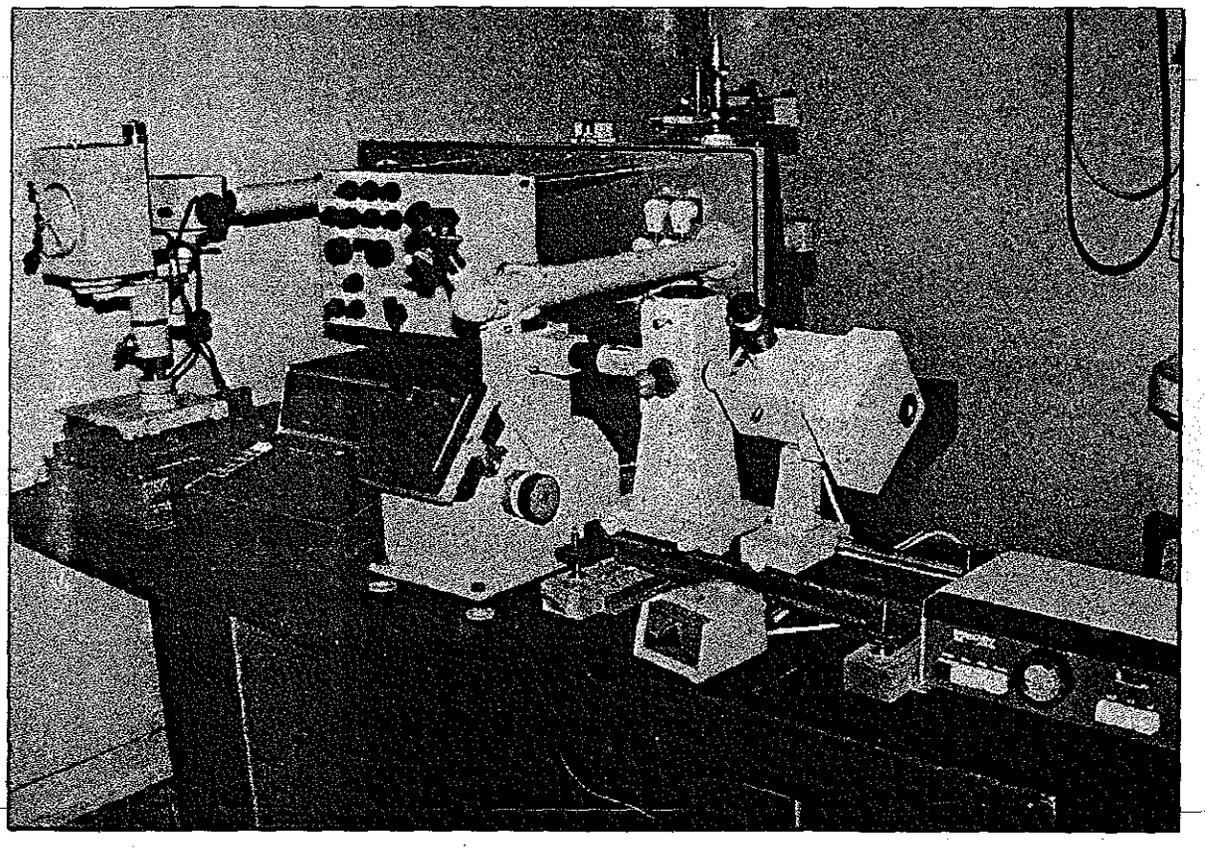
An error of measurement of a diameter is 1 micron. The fuel rods can be scanned both on total activity, and on activity of separate isotopes. The eddy current control reveals places of intensive oxidation of claddings, surface defects and cracks in cladding.

In fig.2 are shown control blocks in operator room. At the left you can see the control blocks of diameter measurement and eddy-current test of fuel rod. At the right the control block of gamma-scanning installation and periscope used for visual inspection of fuel rods are arranged. A range of periscope magnifications is from 1 up to 30 times.

2. RESEARCH OF FUEL RODS BY DESTRUCTIVE METHODS.

Here we shall consider only those techniques, which frequently are used at realization of post-irradiation examination of fuel rods.

Fig.3. Optical microscopy «TELATOM»



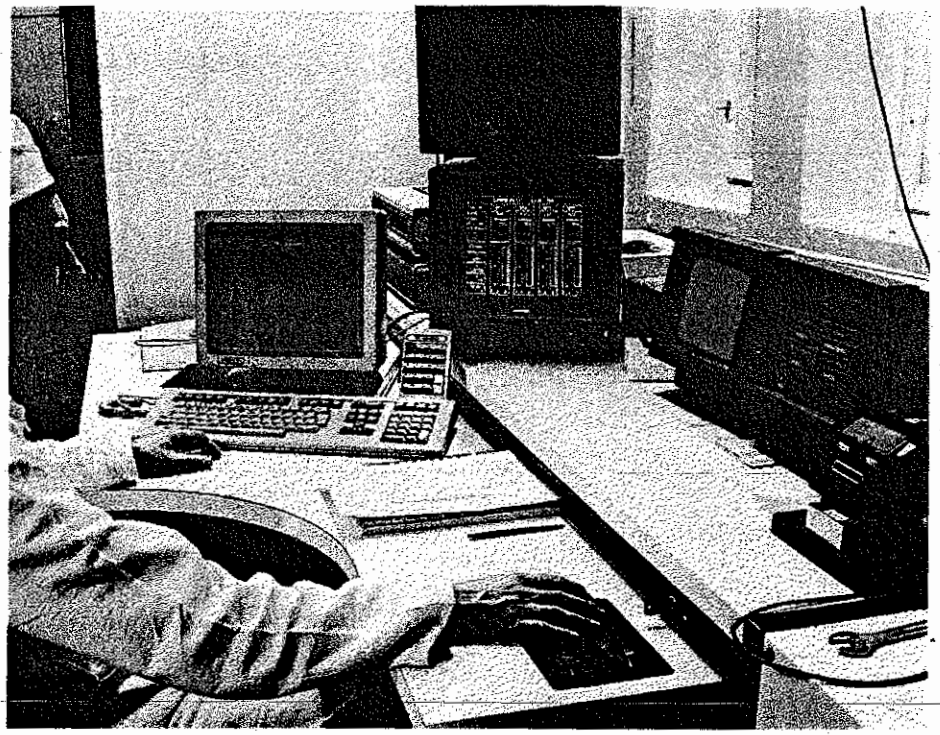
Optical metalography, fig.3.

The microstructure of fuel and cladding is studied on an optical microscope «TELATOM». This microscope is intended for performing of studies of the radioactive materials. It is equipped with radiation-proof optics. A range of these microscope magnifications is from 50 up to 1500 times.

X-ray spectrum analyzer "KAMEBAX", fig.4.

Here you can see only the control desk, the installation are placed inside of hot cell. The installation can work as well as an electron microscope in a scanning mode.

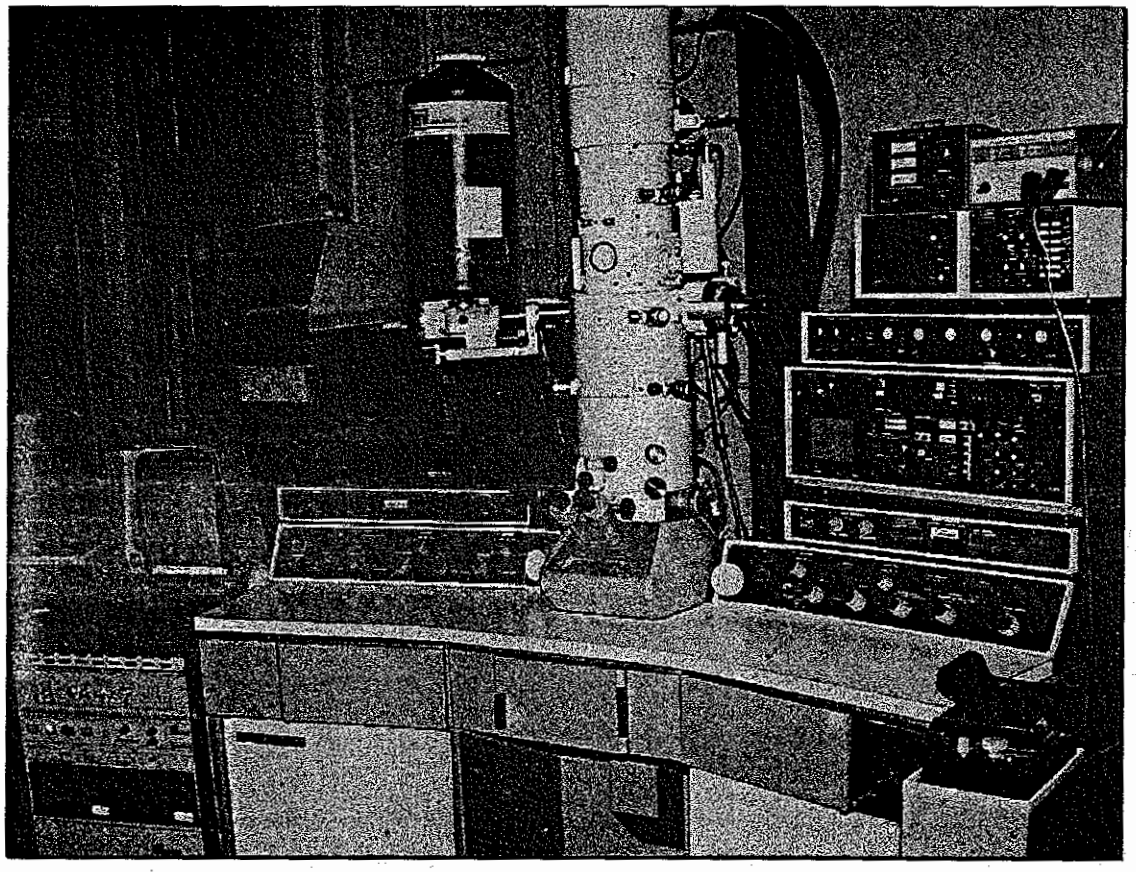
Fig.4. X-ray spectrum analyzer "KAMEBAX"



The analyzer gives possibility to study the distribution of various elements in materials. For example, it is possible to study distribution of fission products of on cross-section fuel rods. The considered technique allows receiving very valuable results that are usually used to analyze of behaviour of fuel rods.

Fig.5.

The electron microscope TEMSCAN-200CX



100 ÷ 200 kV

Electron microscopy, fig.5.

There are two microscopes TEMSCAN 200CX and 100CX, which work in a transmission and scanning mode. The microscopes have X-ray prefix for definition of element structure of studied materials. Electron microscopy is usually used for examination of cladding materials.

3. Reinstrumentation equipment

Refabrication and reinstrumentation of already irradiated fuel rods are necessary to study of the fuel thermal behaviour at high burn-up levels (40-60 MWd/kgU).

An unique reinstrumentation installation was developed and manufactured by specialists of AEA Technology. Windscale/

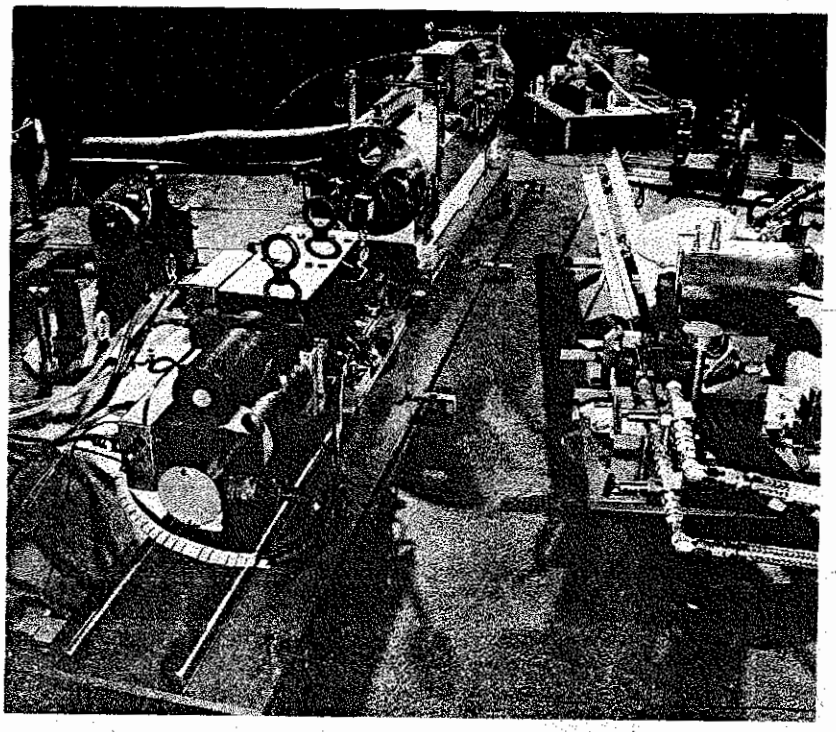
The installation is intended for equipment of the irradiated fuel rods by gauges of pressure and temperature, see fig.6.

In fig.6 you can see

- cryochamber for freezing CO_2,
- drill machine for drilling of central hole in fuel pellets,
- orbital argon-arc welding machine,
- fuel rod drying and inert gas filling equipment,
- crimp sealer and spotwelder.

Fig.6.

The reinstrumentation equipment



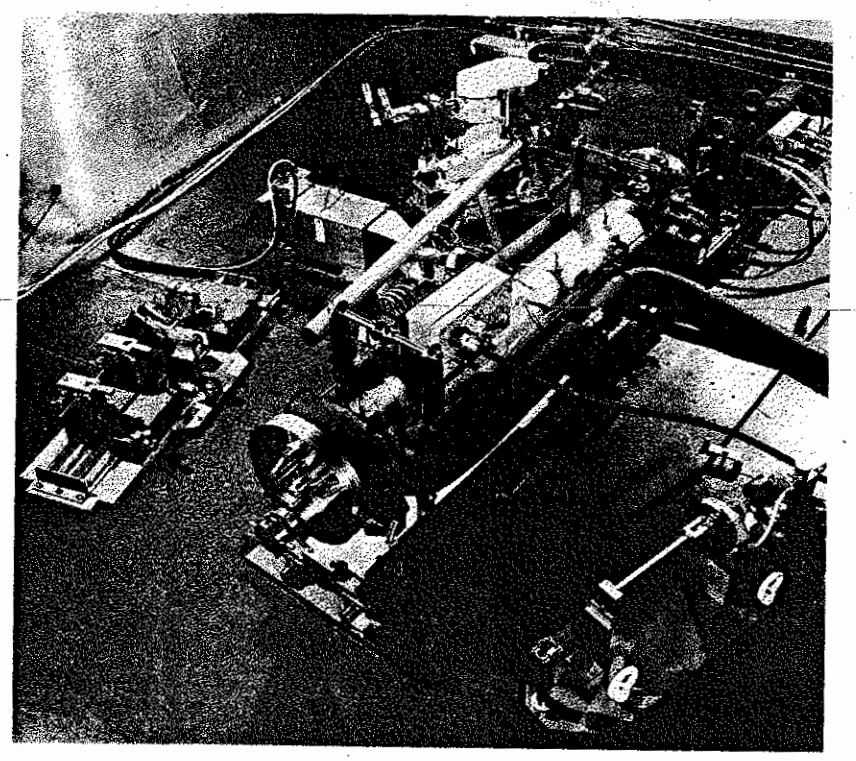
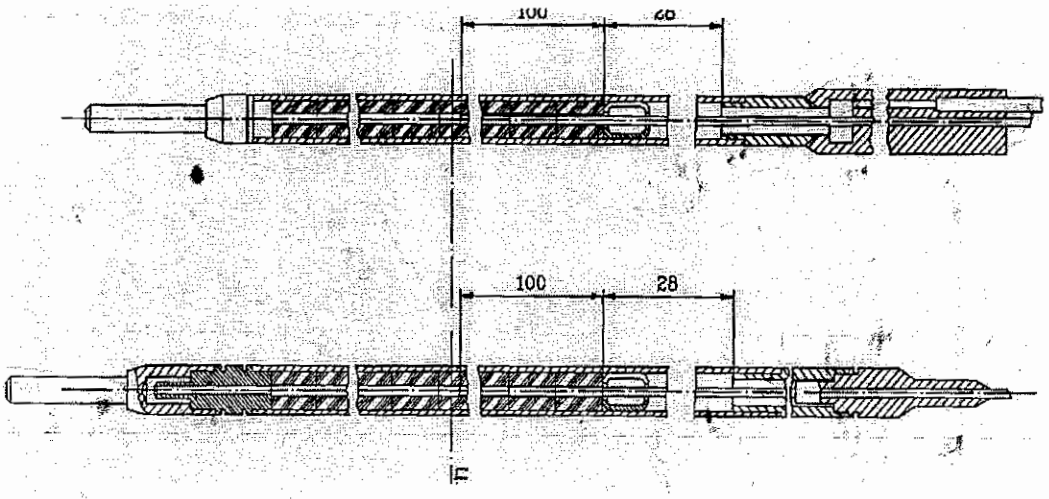


Fig.7. Reinstrumentated fuel rod.

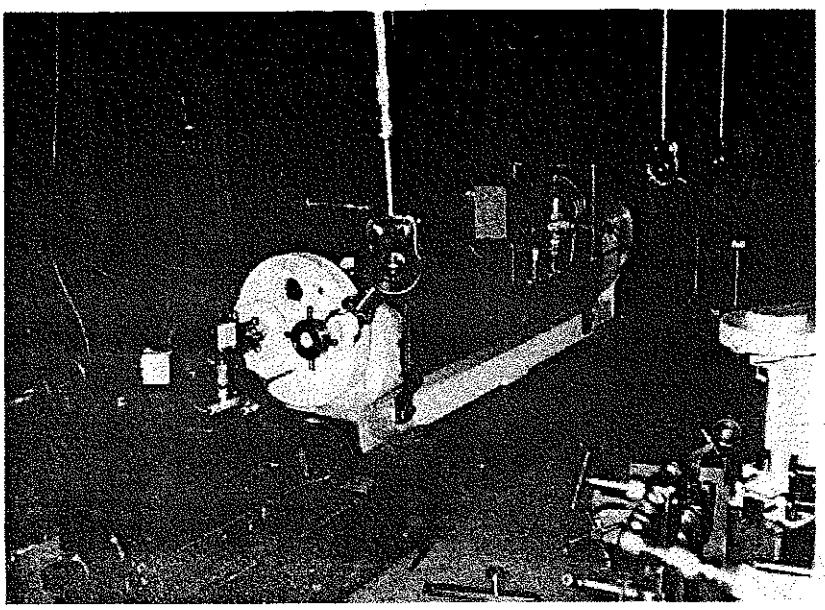


The following operations will be carried out (see fig.7):

- drilling of central hole in pellets by diameter of 2 mm on length up to 100 mm for accommodation of the thermocouple;
- insertion of the thermocouple;
- installation of plugs on ends of fuel rods and welding;
- filling up of fuel rods by helium or gas mix of helium with xenon;
- final hermetic sealing of fuel rods and check of fuel rods on tightness.

The operation related to drilling central hole in the fuel pellets is performed in the cryochamber. The fuel rod is placed inside of the cryochamber, which is filled with CO_2. CO_2 is frozen by liquid nitrogen. The freezing is used for fix of the fuel pellets inside of cladding. The process of the drilling is shown in Fig.8.

Fig.8. The process of the drilling of fuel pellets



On reinstrumentation installation we have made nonirradiated fuel rod equipped by two thermocouples. Now reinstrumentation installation is mounted in the hot cell. These works will be completed at the end of this year.

The presence of such equipment as reinstrumentation installation and installations for modern post-irradiation examinations allows us to choose the basic strategic line in the field of fuel rod development. This is: 1. manufacturing reinstrumented fuel rods; 2. irradiation of these fuel rods in the reactor in controllable conditions and 3. subsequent detailed post-irradiation examinations of these fuel rods. We consider that by such way it is possible to receive very valuable experimental results to be needed for a substantiation of behavior of fuel rods with a high burnup level under irradiation in the reactor. These data also are necessary for verification of existing computer codes.

And in the conclusion in fig.9 automobile installation for transportation of the irradiated fuel rods and fuel assemblies is shown.

Fig.9.

Special truck with set of containers and handling gadgets for transportation of irradiated fuel and construction materials