FABRICATION OF FUEL ELEMENTS ON THE BASIS OF INCREASED CONCENTRATION FUEL COMPOSITION

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ABSTRACT

As a part of Russian Program RERTR Reduced Enrichment for Research and Test Reactors), at NCCP, Inc. jointly with the State Scientific Centre VNIINM , the mastering in industrial environment of design and fabrication process of fuel elements (FE) with increased concentration fuel compositions is performed. Fuel elements with fuel composition on the basis of dioxide uranium with nearly 4 g/cm^3 fuel concentration have been produced thus confirming the principal possibility of fuel enrichment reduction down to 20% for research reactors which were built up according to the projects of the former USSR, by increasing the oxide fuel concentration in fuel assemblies (FAs). The form and geometrical dimensions of FEs and FAs shall remain unchanged, only uranium mass in FA shall be increased.

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Conversion of research reactors to low enriched fuel raises a number of problems before all taking part in research reactors conversion. To solve these problems both the theoretical and experimental studies shall be required.

It shall be possible to solve the problem of fuel enrichment reduction using the following two ways:

- development of the new FE and FA design for existing reactors;
- increase of fuel mass in FEs for FAs of the available designs.

From the economical point of view, the first way shall be not efficient and not advisable. The refore the concept of the Russian Program RERTR shall be based on application of high-density (uranium intensive) fuel compositions, such as uranium silicide, uranium-zirconium-niobium alloy, uranium dioxide etc.

Organization and research activities in the field of production of such type of fuel or fuel elements on its basis as well as development of waste reprocessing technology are in progress at the NCCP together with the State Scientific Centre (VNIINM). 1986 in laboratory conditions pilot fuel elements for IRT-3M and MR FAs using fuel in the form of uranium silicide grains with fuel concentration 5 g/cm^3 were manufactured FEs of MR type have passed in-reactor tests with no defects identified and these FEs have reached burnup 45,3 - 49 %. Moreover in the in the same 1986 year pilot FEs of MR type with fuel composition consisting of triple uranium-zirconium-niobium alloy and having fuel concentration 7 g/cm^3 were fabricated. These works are being fulfilled in close cooperation with Russian Institutes NIKIET and RNC KI (Kurchatov Institute).

We consider the increasing of dioxide fuel concentration using new technological decisions to be feasible and more attractive way from the economic point of view.

In the 80th at our plant the conversion of FAs produced at the plant for domestic and foreign research reactor from U-Al to dioxide fuel was accomplished.

Dioxide fuel has proven itself to be an excellent fuel for both research and commercial reactors.

After mastering the process of fabrication of FAs with FEs on the basis of uranium dioxide and their setting into operation at NCCP there were identified no failed FAs among those used in twenty different swimming-pool and channel reactors.

At the same time there was performed the smooth conversion of FAs on the basis of uranium dioxide (see fig. 1-4), such as IRT-2M, IRT-3M, MR, VV-M5 (can be used in reactors instead of VVR-M FAs) to reduced 36 % enrichment.

Nowadays at the NCCP the process of mass production of FAs on the basis of uranium dioxide with fuel concentration 2,5 g/cm^3 has been mastered. These technology was also used during development of isotope targets production for Mo-99.

Dummy models of such targets have been already fabricated at NCCP (fig. 6). It should be noted that during the development of fuel compositions, the oxide fuel obtained using different technologies and fuel of different grain compositions and with different fuel particles form were tested, for example, fuel in the form of spherical particles, obtained using the sole gel production process, fuel in the form of pellets etc.Besed on the results of theological property studies , the oxide fuel produced by recovery process was chosen.

We are sure and this can be confirmed by the results of experimental works that the possibilities of this fuel composition are far not exhausted during FAs conversion to 19,75% enrichment with fuel concentration 4 g/cm^3. The earlier manufactured FEs for IRT-2M and MR FAs with fuel concentration 3.56 g/cm^3, which passed successfully in-reactor tests in research reactors of RNC KI and MIFI (Moscow Institute of Engineering and Physics) and reached correspondingly the burnups 36.4 % and 43.3 % shall be the indicative of the said above.

In the period 1994/95 the activity to obtain dioxide fuel composition in order to make possible the conversion of the research reactor fuel assemblies to 19,75 % enriched fuel is being conducted.

Fuel compositions with fuel concentrations up to 4 g/cm^3 have been obtained. Studies of fuel compositions and materials used during FE fabrication as well as original technical decisions made possible to develop the unique process of production of FEs for research reactors on the basis of oxide fuel with U-235 19,75 % enrichment.

But the abovesaid does not mean that all problems with the given fuel composition have been solved. In 1995 experimental FEs for two types of FAs such as 2M and MR with fuel concentration 3,85 g/cm^3 have been manufactured. Having tested different variants of design and technological decisions during manufacturing , we were a success to solve a number of main tasks: there have been selected the necessary tools, materials, grain composition etc.

However many problems related to ensuring FEs stable quality have been yet not solved. It is necessary to solve the problems of improvement of FEs with new compositions non-destructive control, because our principal objective is not only to produce FEs with the required technical characteristics but also to ensure their stable quality for the customer to be sure that the acquired produce (items) shall be reliable in operation and of good quality.

By the end of this year we are planning to manufacture pilot MR, VVR-M2, IRT-3M fuel elements with 19,75 % enriched fuel based on uranium dioxide with fuel concentration up to 3,85 g/cm^3 and to start their reactor tests.

At present NCCP together with VNIINM proceeds with investigations, mastering the fuel element fabrication process and preparation of fuel compositions for reactor tests. At present the following works have been completed:

- Analysis of technological characteristics of materials used for fuel element production has been performed.
- The problem of end defects in FEs has been solved.
- Analytical and technological studies of plasto-elastic characteristics of fuel compositions 2,5 and 3,85 g/cm^3 have been conducted.
- Radiometric and metallographic studies of fabricated fuel elements have been accomplished.
- According to the results of inspection and studies of pilot samples of fuel elements, mastering and updating of fabrication processes has been performedExperimental FEs for IRT-2M and MR FAs with fuel concentration 3,85 g/cm3 have been manufactured and as a part FA have been delivered to reactor tests.

To conclude the review of works being accomplished at the NCCP in the scope of Russian Program RERTR, it shall be noted:

- NCCP together with VNIINM proceed with the development of uranium-intensive fuel for research reactors, development of fuel elements fabrication process and wastes recycling technology.
- Technical problems of manufacturing fuel elements with increased concentration and 19,75 % enriched fuel for some Russian research reactors and foreign reactors using fuel assemblies produced in Russia have been principally solved.
- Unique technology of manufacturing fuel elements with oxide fuel concentration up to 4 g/cm^3 can be used during development of targets for Mo-99 production.

NCCP together with the leading Russian Research Centres shall be ready to cooperate with all Participants taking part in research reactors conversion, in order to convert, as soon as possible, all research reactors to low enriched fuel and reduce the risk of spreading of high enriched uranium.

VVR-M2 ONE-SECTION FUEL ASSEMBLY

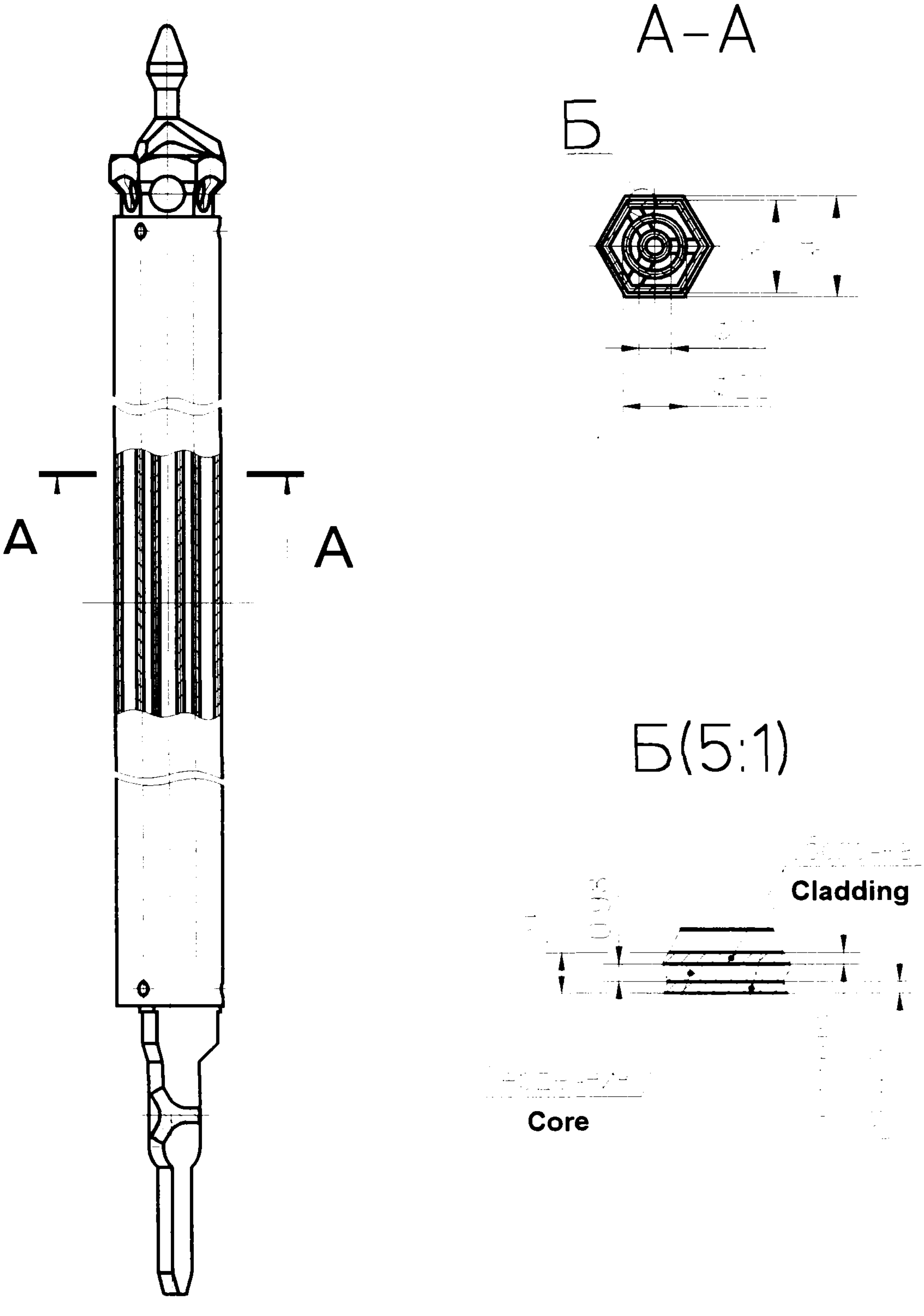

Fig. 1

IRT - 2M 4-TUBES FUEL ASSEMBLY

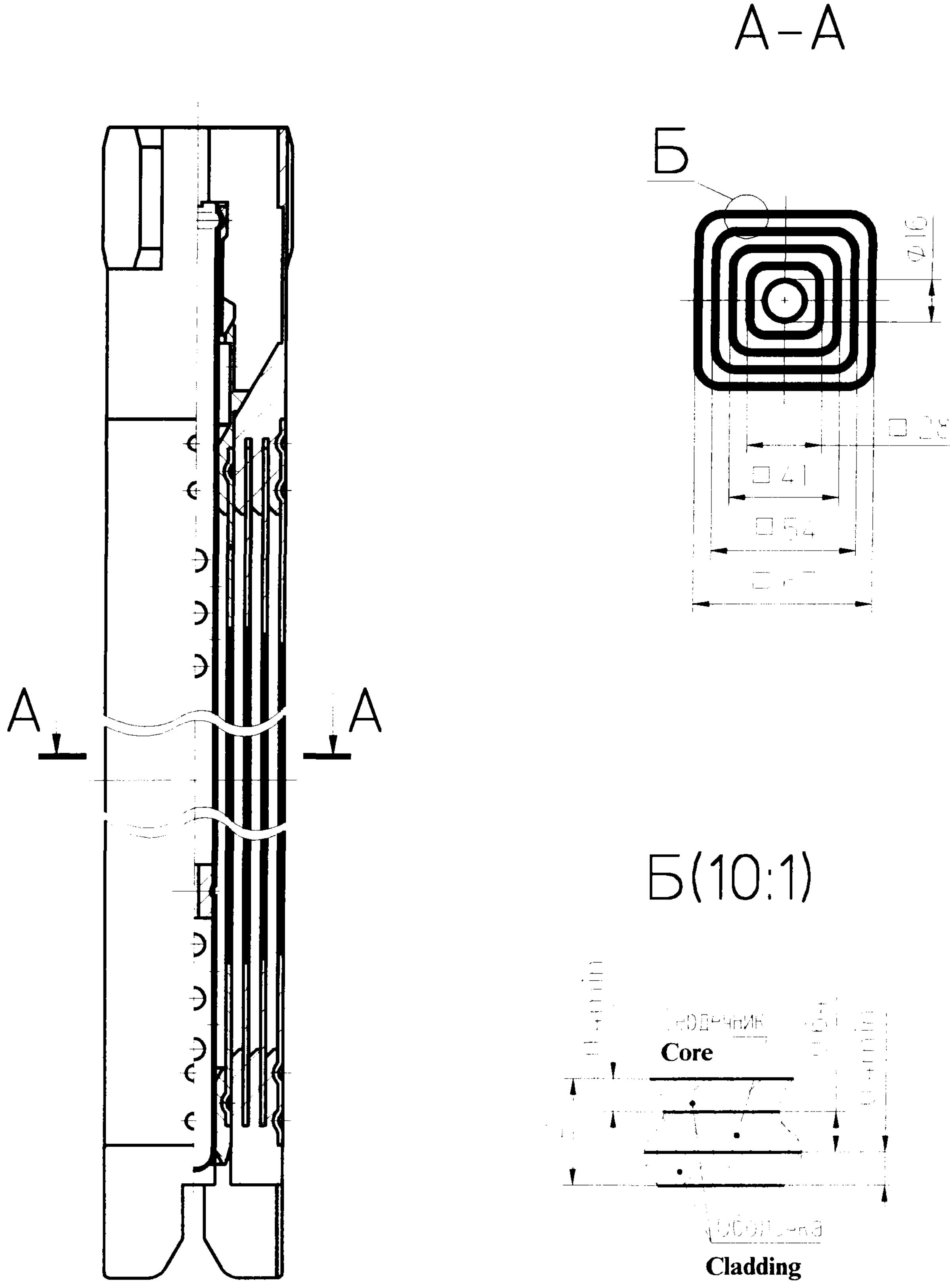

Fig. 2

IRT-3M 8-TUBES FUEL ASSEMBLY

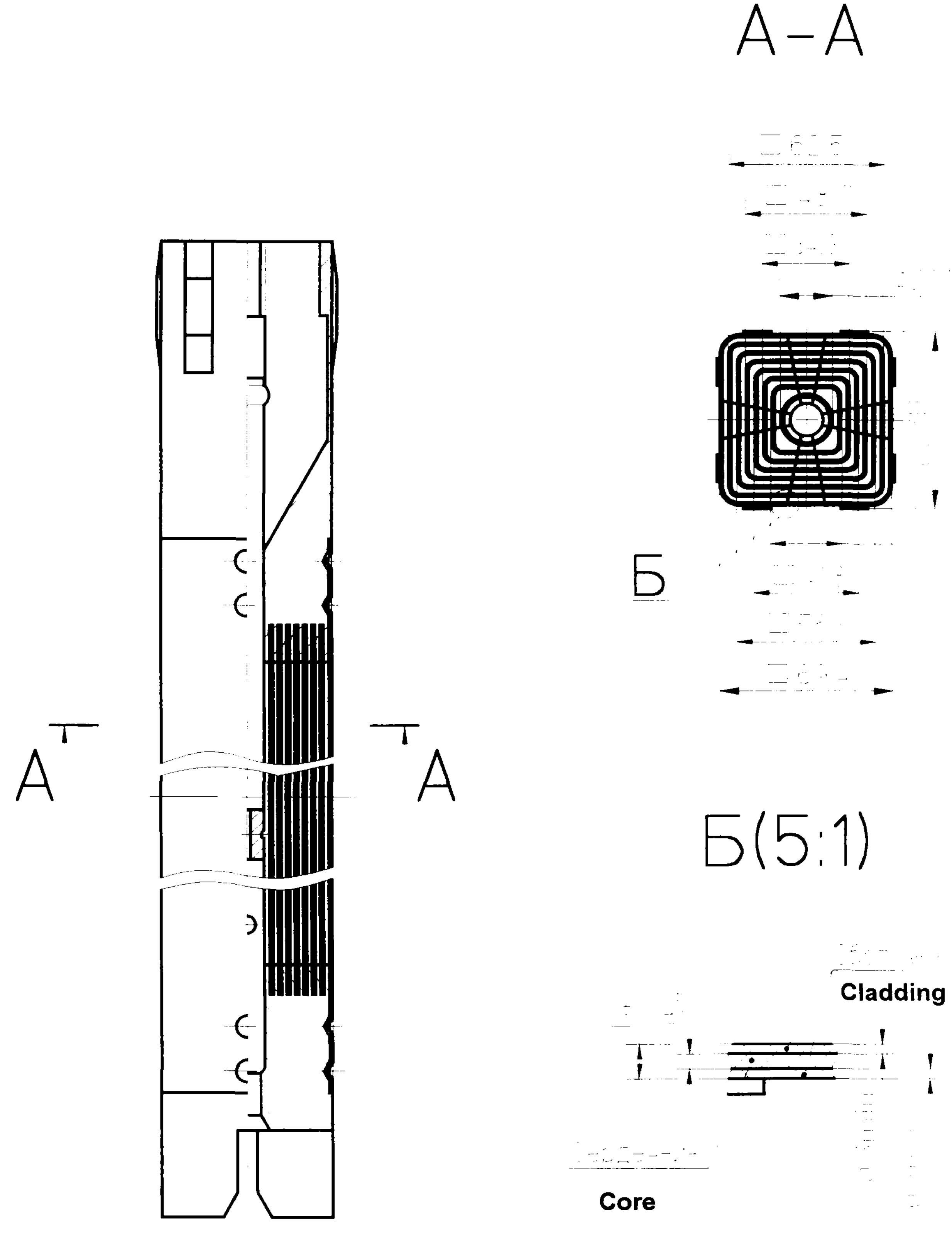

Fig. 3

MR 6-TUBES FUEL ASSEMBLY

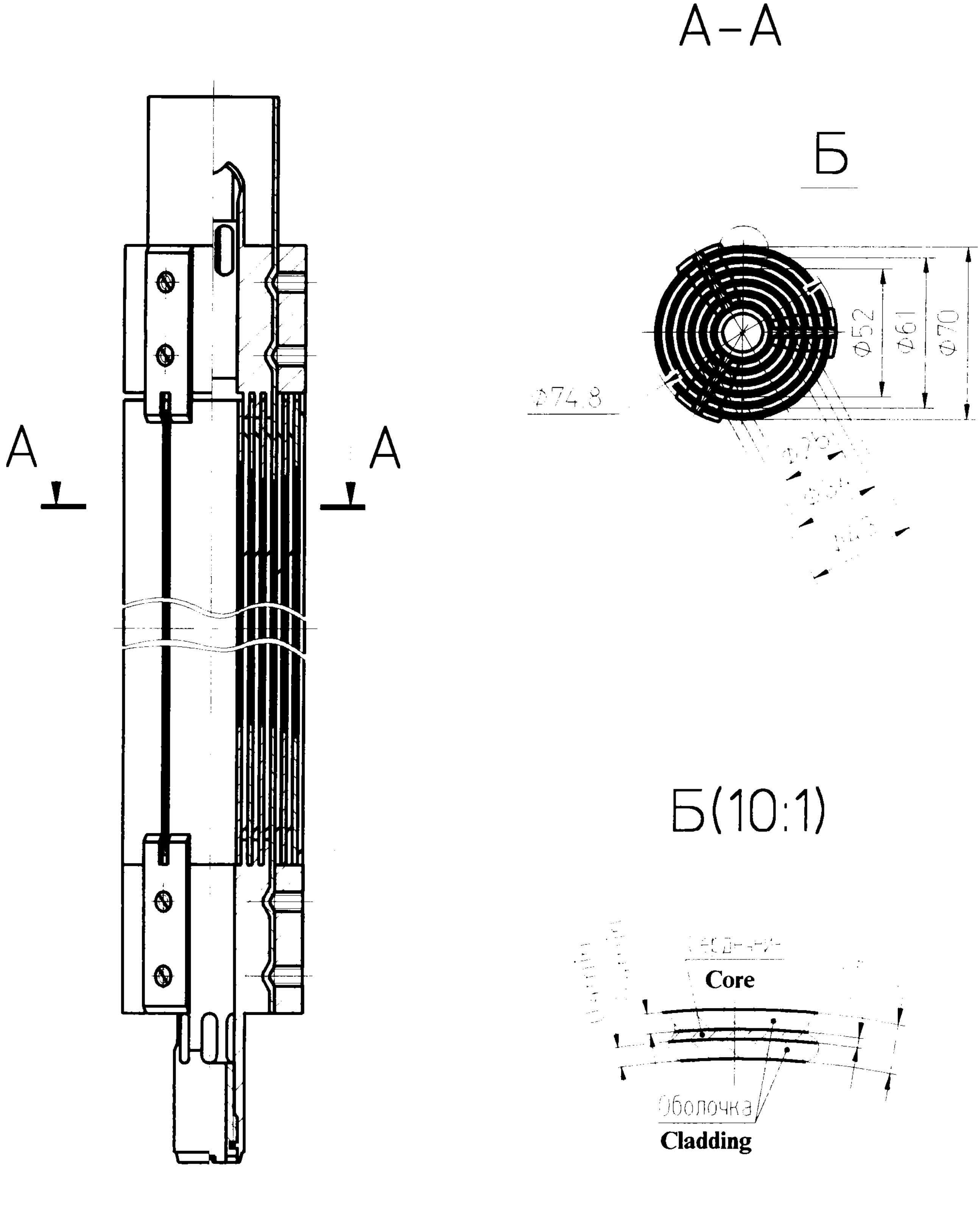

Fig. 4

VVR-M5 ONE-SECTION FUEL ASSEMBLY

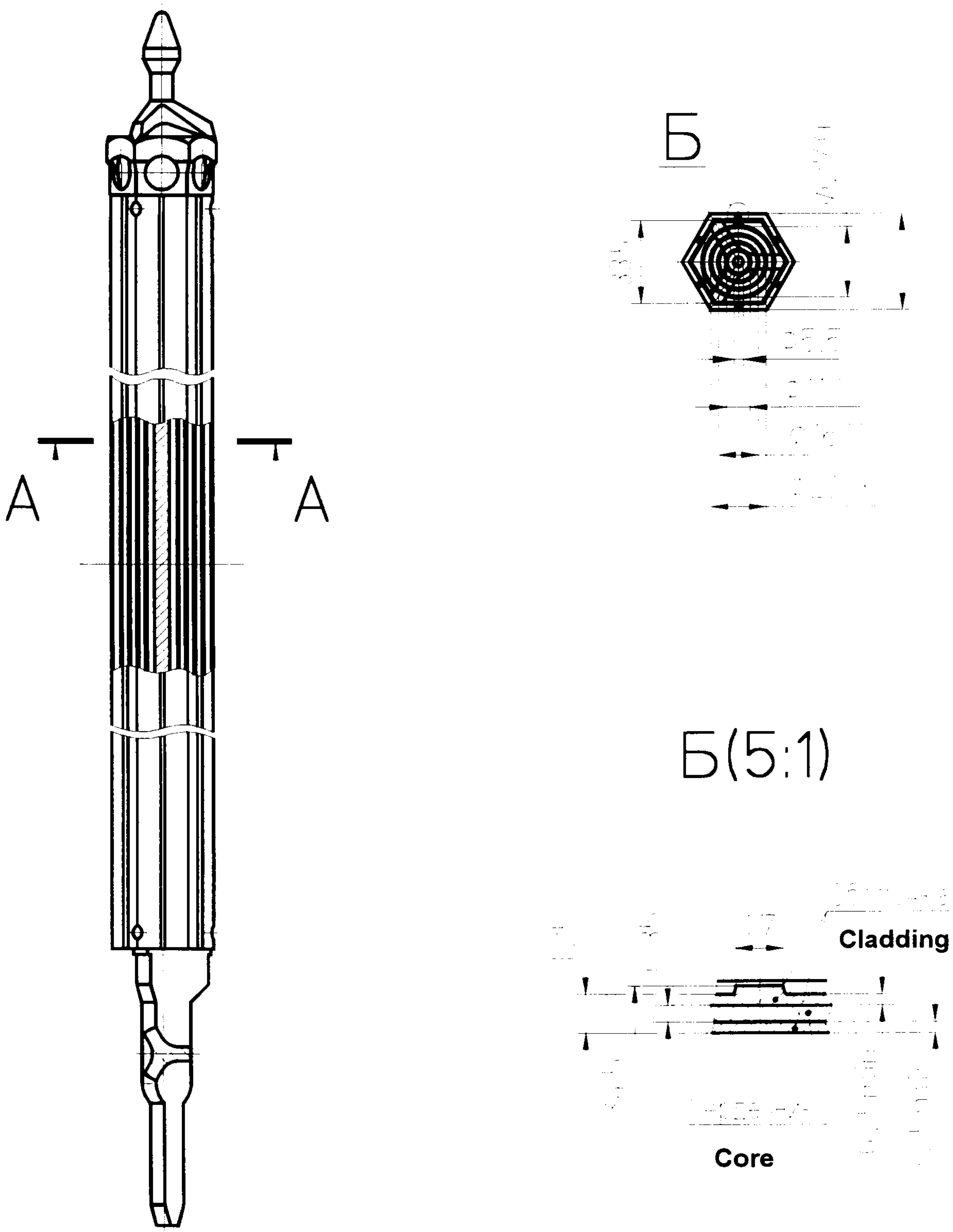

Fig. 5

"TARGET"

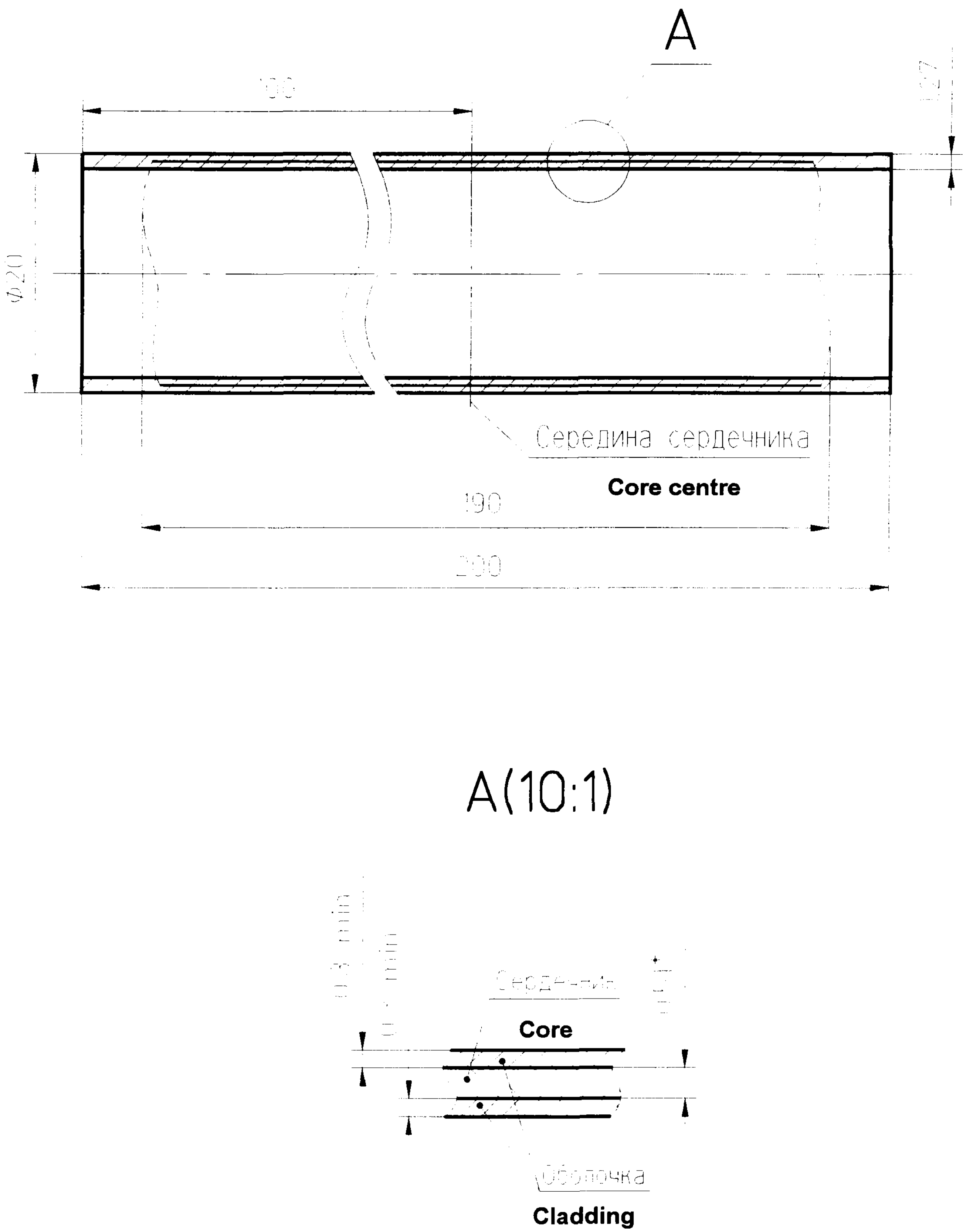
A
100
Φ20
Середина сердечника
Core centre
190
200
A(10:1)
Core
Оболочка
Cladding

Fig. 6

Fig.7 IRT-3M 8-TUBES FUEL ASSEMBLY CROSS-SECTION

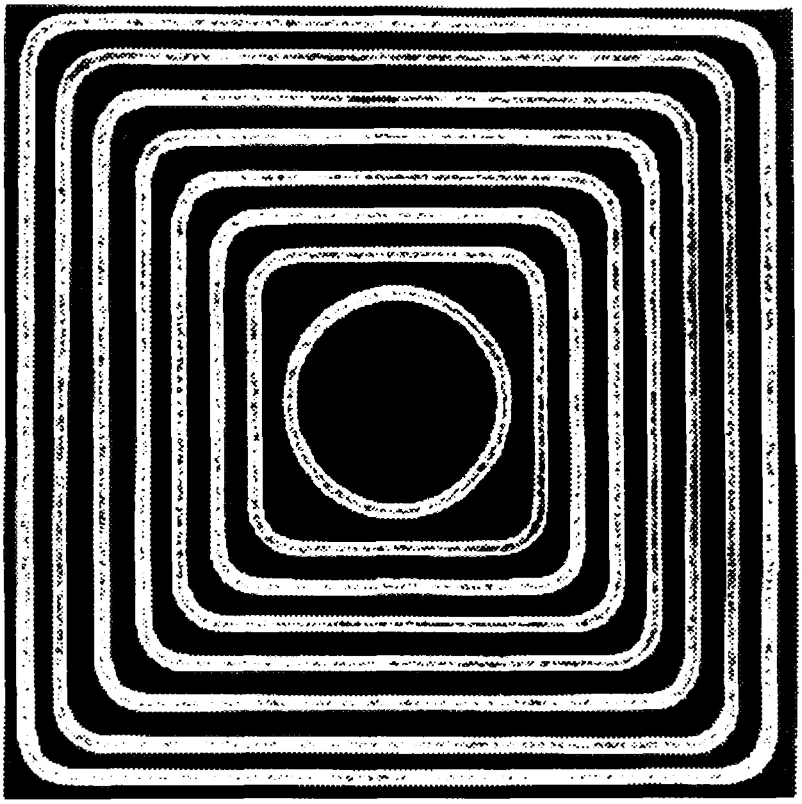

Fig.8 VVR-M5 5-TUBES FUEL ASSEMBLY CROSS-SECTION

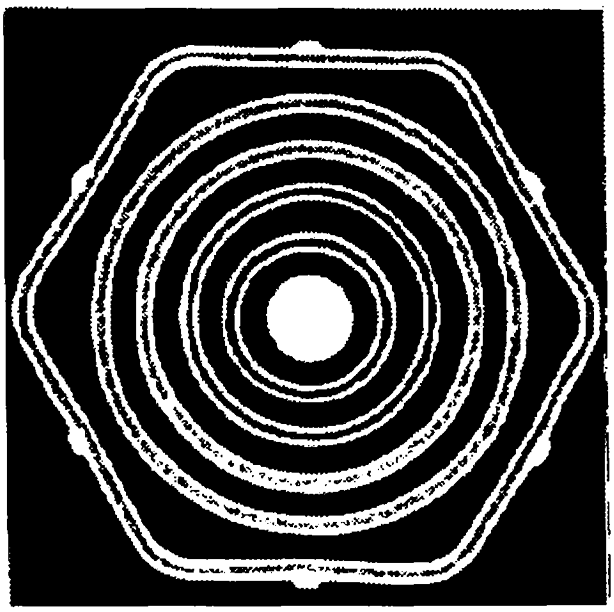

Fig.9 VVER-M2 FUEL ELEMENT (FE) CROSS-SECTION

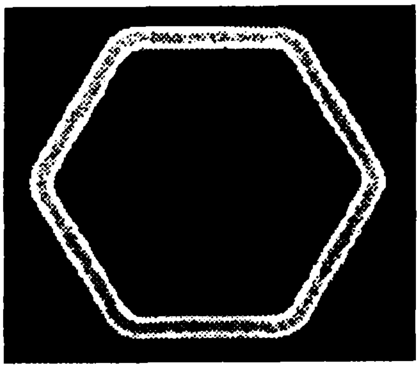

Fig.10 IRT-2M FUEL ELEMENT CROSS-SECTION

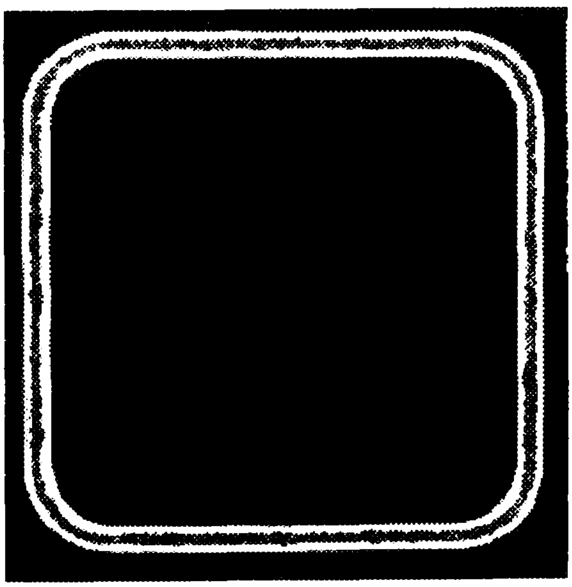

Fig.11 IRT-3M FUEL ELEMENT CROSS-SECTION

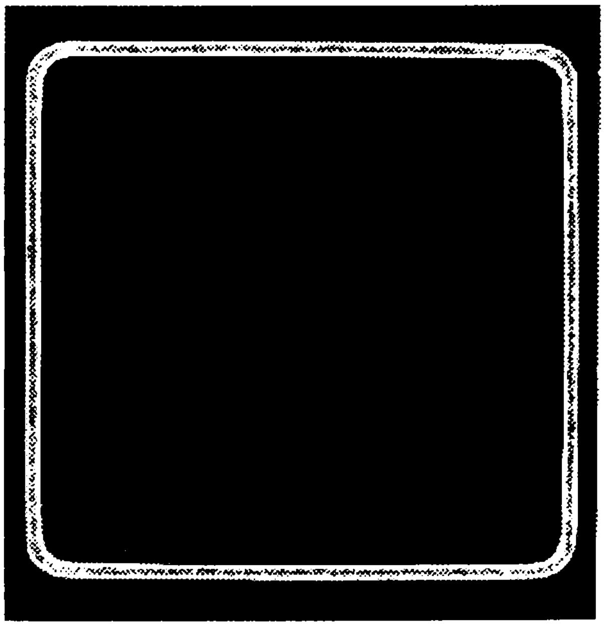

Fig.12 MR FUEL ELEMENT CROSS-SECTION