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V. V. Danilenko's Expertise in Explosive Chambers:

Translated Selections from the 2003 Book *Sintez i Spekanie Almaza Vzryvom*

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Below is a compilation of summarized and directly translated paragraphs from the chapter on explosive chambers in V. V. Danilenko's 2003 book, *Sintez i Spekanie Almaza Vzryvom* (Explosive Synthesis and Sintering of Diamonds).

Chapter 3 goes into great detail about the variety of capabilities, sizes, employed materials, design and construction of explosive chambers. The author's main focus is on the use of the chambers for diamond synthesis although other theoretical and experimental uses are also described.

The text demonstrates the author's expertise in the design, production, and employment of a multitude of explosive chambers capable of containing blasts from devices ranging from holding a few grams to hundreds of kilograms of high explosives.

Below, sections of text with quotation marks indicate a direct translation, while the text without quotation marks is a paraphrased and summarized translation of Danilenko's activities or parts of the chapter. These selections help elucidate any potentially relevant role Danilenko would have played in the development of the explosive chamber at the Parchin site in Iran that IAEA evidence suggests was used in the development of nuclear weapons components.

Chapter 3: Explosive chambers

Explosive chambers are used for:

- research and testing of new explosive materials and armor;
- explosive welding;
- synthesis of diamonds and ceramics;
- explosive separation of diamonds and ceramics;
- transport of explosive materials and devices; and
- removal and transport of explosive materials from populated locations (airports, train stations…)

Depending on their construction, explosive chambers can be:

- spherical or cylindrical with a vertical or horizontal axis
- with flat or elliptical bottoms
- hermetical or non-hermicatical
- made from steel, reinforced concrete or composite polymers
- constructed with an access hatch or composed of 2 separate parts
- filled with blast reducing materials or vacuum

(p. 87 of book)

The principal distinguishing characteristic of explosive chambers is their internal volume on which depends the maximum mass of the explosive device. As a general rough estimate, for every 1kg of explosive material there needs to be a 1-4m^3 volume. (p. 87)

Since 1963 Danilenko has designed, built, and tested various chamber constructions. One of these was used in the first synthesis of ultradispersive diamonds through detonation.

"In 1980 in Russia two spherical chambers were built with a diameter of 12m, wall thickness 100mm, mass 350 tonnes, and volume of 905m^3, designed for explosive devices of up to 1 tonne. For the construction of the chambers the unique, very strong and elastic steel AK-36 was used. In such a chamber were conducted explosions of devices of 250 kg mass, one of 500 kg and one more of 1 tonne of TNT. In addition to this, with the participation of this author, a unique experiment was conducted for the synthesis of ultradispersed diamonds through detonations in a water shell of a device from TG40 with mass 140kg." (p. 89)

In 1992 the author built and successfully tested for the company Alit a steel chamber of 2.5 x 17.5 m made of 3 parts connected with bolts with wall thicknesses of 300mm for the central section and 70mm for the two side sections. For the best cooling of the diamond and to lower the pressure on the chamber walls, before the blast, the entire length of the chamber is showered with water. The chamber was designed for explosions in an air filled environment of devices of up to 30kg (p. 90).

In 1999-2000 the author designed a cylindrical chamber of 4.6 x 19m with a volume of 315m^3 capable of withstanding multiple explosions of devices up to 70 kg. The chamber's air-water system is pictured in figure 3.3. The external part of the central section of a length of 9 m is strengthened with a reinforced concrete square of 7.6 x 7.6m with a mass of 700 tonnes. Before explosions the chamber can be showered with water and a vacuum created. (p. 90)

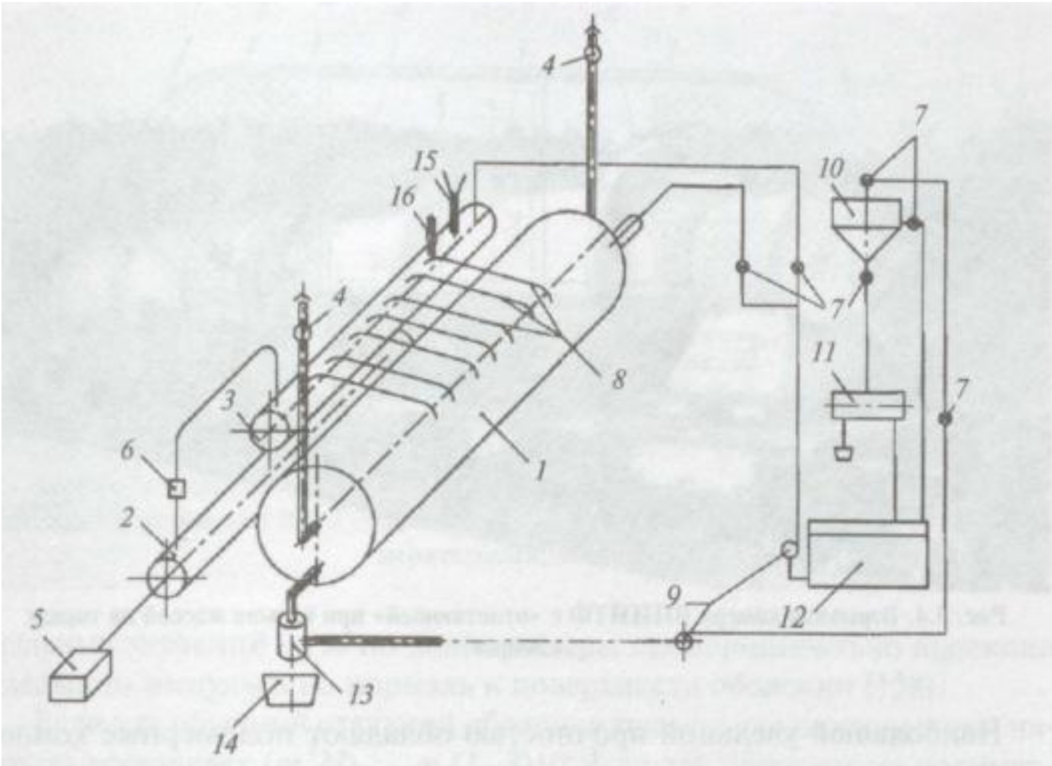

Image 3.3 - Blueprint for the air-water system of an explosive chamber [mentioned above] for diamond synthesis:

1 – explosive chamber; 2- air receiver; 3 – water tank; 4 – fan (ventilator for gas); 5 – compressor (10 atm); 6 – electric valve; 7 – valve; 8 – pipes; 9 – water pump; 10 – sedimentation/condensation suspension tank; 11 – horizontal collection centrifuge with automatic unloading; 12 – main water tank; 13 – filter net for the separation of sizable pieces; 14 - fragment/shrapnel container ; 15 – water level indicator; 16 – electric valve

For research purposes spherical chambers of 2-7m are the easiest to prepare although they are less resistant to failure compared to the cylindrical ones due to the pulse duration being reduced by 30% (thanks to the lateral dispersion of the load on the central section). (p. 89)

According to Danilenko, the thicker the walls of the explosive chamber, the higher the chance of defects. The effect of the blasts can be attenuated by using thin steel or fiberglass shells around the explosive device. Multi-layer shells increase several fold the resistance to movement cracks. (p. 91)

Employees at VNIITF designed, built (at the Uralkimash factory), and successfully tested a cylindrical chamber of 1.5m x 12.5m with 70mm with walls made of tension wound steel bands/plates with a capacity of up to 40 kg explosive devices. This chamber was used by the author for the synthesis of diamonds through the explosion of devices of up to 20 kg with and without a water shell. (p. 92)

It is important to note that the stresses on the explosive chamber are dependent not only on the size of the explosive device but also the configuration of the device itself (cylindrical, spherical, disc shaped…). (p. 94)

Single use cylindrical or spherical blast containers [different from blast chambers] built from fiber and polymer composites were developed at VNIIEF. The composite blast containers had the following characteristics:

- 0.5 x 1.8m, 200 kg mass chamber can contain the blast from a 2 kg device
- 2.55 x 9.5m, 25 tonnes chamber can contain the blast from a device of up to 200 kg. (p. 93)

In addition to the presence of a vacuum chamber, other methods to decrease the pressure of the blast wave on the explosive chamber's walls include surrounding the explosive device with foam, sand, and water – any gas state capable multiphase materials.

Results from experiments at VNIITF [Chelyabinsk-70] in 1986 [not specified whether Danilenko was involved] show that detonations of similar devices (20 kg) in a water shell compared to an oxygen (air) shell result in half the pressure on the bottom of the explosive chamber. (p. 98)

In 2001 was published theoretical work [presumably not by the author] which showed that the shockwave amplitude of a TNT device in a water shell equivalent to about 4 times the mass of the device is similar to that of a foam shell.[1]

It appears that a joint use of vacuum, a water shower, and a water shell yields the maximum attenuation of the pressure on the chamber walls.

The remaining issue of shrapnel (even from plastic materials) can be solved with the use of wood sheets, asbocement tubes, or steel screens. (p. 98-99)

A 2.5 x 17.5m explosive chamber by the company Alit is composed of a 2.5m long central section of 2 internal 100mm thick layers of AK-36 steel while the rest of the chamber is composed of 22k steel. Calculations of pressure and stresses on the internal walls of the chamber were made using the applied program DISK developed at VNIIEF. The stress on the chamber was due to the pressure resulting from the explosion of a TG40 composed explosive device.

From the physics side the program package DISK includes calculations based on equations of fluid dynamics with linear kinetic/kinematic and isotropic hardening. (p. 105)

Experiments conducted in the VNIITF chamber show that the use of a water shell of radius equal to that of the explosive device lowers the pressure on the bottom of the chamber by two times compared to a similar detonation without the water shell. (p. 106)

The load bearing capability of a reinforced concrete chambers indicates the maximum size of the explosive device which does not cause permanent deformations in the walls of the explosive chamber.

The load bearing capabilities of reinforced concrete chambers can be measured using tenzo-resistors and although calculations can be made with applied programs such as ADINA (USA), LUSAS (UK) and DISK (Russia), these do not suit reinforced concrete because it does not have elastic/retractile properties as shown by explosive tests on 3-layer chambers of steel-concrete-steel. (p. 109)

[1] Although spherical chambers are mentioned, most of the descriptions and calculations refer to cylindrical chambers which seem to be Danilenko's main area of focus.

In steel chambers the load bearing capability is dependent on the thickness of the walls and/or the radius of the chamber (i.e. the overall mass). One of the limitations of steel made explosive chambers is transportability. Once static, a chamber's capability can be augmented with reinforced concrete.
Hence these methods are more suitable for large explosive chambers of explosive capabilities higher than 40kg. (p. 109)

"In the future the development of high strength and reliable hermetic explosive chambers of very big volumes could allow us to solve humanities' energy problem by realizing the ideas of academic A.D. Sakharov of using explosive thermonuclear synthesis for the production of energy. The method suggests that in the detonation of thermonuclear devices in an explosive chamber the energy be transferred through a heat transfer agent onto the steam/heat electricity generators. In order to accomplish this grandiose task there is already a considerable amount of experience in the development and production of cheap thermonuclear devices close to the 10-20 kT TNT-equivalent. Hence the main and bigger issue is the creation of explosive chambers capable, in operational and malfunction situations, of containing the cyclical explosive stresses of such devices. Given the parameters of these goals the explosive chambers must have diameters of 130 m and a mass of close to 10^7 tonnes." (p. 93-94)