"Underwater Technology Developments in Ship Research Institute of Technical University of Gdansk”

Marek Narewski,

Lech A. Rowiñski

Ship Research Institute Technical University of Gdansk

Majakowskiego 11/12, 80-952, Gdansk-Wrzeszcz

During the last 20 years polish interest in underwater activity was limited to some selected areas, however some interesting achievements had been made. Manned submersibles like DELFIN and underwater habitats MEDUZA are the best known. Other projects which were completed in mid 70-ies include:

- towed, manned, wet submersible for underwater observation CZAPLA
- manned submersible LTS-7 GRZES for fishing gear observation
- decompression chambers for miliary and civil applications
- submarine rescue ships for Polish and other Navies

Decompression chambers were original polish design. Staff of the Ship Research Institute was engaged in design phase of those projects.[l] Four types of chambers were designed including foldable one, as well as one and two compartment chambers.

During 70-ties manned submersibles were considered as a major tool in underwater research. CZAPLA is an example of relatively simple tool for underwater observation in shallow depths. A diver was in a streamlined sledge. Control surfaces were used for steering in vertical and horizontal planes. However, the idea of aquaplane could not be widely used in practice because of limited diver endurance. Some prototypes were built and tested. Tow tests with a model of the vehicle were carried out in a towing tank. Sea trials of the CZAPLA vehicle with depth control system showed good performance of the vehicle. Because of financial and technological problems this project has not been continued.

The most original project on design and construction of 2-man submersible for fishing gear observation started in 1974. The use of GRP for pilots compartment placed this design among first in the world applications of reinforced plastics for manned submersibles. Spherical pressure vessel made of 12 pentagon modules had been built in our laboratory. Sandwich design was chosen for pressure vessel and appropriate testing program on spherical GRP 1:4 models completed. Creep performance and material properties had been evaluated. Original design algorithm had been worked out and tested in practice. Two real pressure vessels in 1:1 scale had been built in 1975 and tested to destruction in July in the next year. Due to non availability of a pressure test tank with diameter min.l.9m all tests had been performed on board of the small research vessel "Dr LUBECKI" (25m Lpp). The first prototype sphere (1.6m ID) collapsed on 270m depth. The construction of the pressure vessel had been changed into pure sandwich design. Testing to the depth up to 600m including repeated dives to 250m showed no sign of visible destruction. After those tests a new pilot compartment was built with a 1.4m ID. In the end of July 1977 a prototype of the submersible had been tested in Baltic waters. Basic technical data of the LTS-7 "Grze6" (Fig.l) are:

Crew	2 (pilot and passanger)
Endurance	normal 8 h
	emergency 32-48 h
Length	3 m
Height	2 m
Breadth	2 m
Weight in air	3000 daN
Payload	150 daN
Speed	max 2.5 kn
	under tow 5-6 kn

After making some improvements supplementary tests took place in Gdansk Bay during 1978-80. To extend work capabilities of the LTS-7 a simple, hydraulically activated manipulator with 4-degrees of freedom was built and installed on the submersible. However/ LTS-7 was built as an observation tool for fishing gear observation its application in this mode had not been realized. Practical application of the submersible for underwater observation tasks for PETROBALTIC drilling company showed some week points of the design. Lack of appropriate support vessel as well as limited need for exploitation of manned submersible caused that suggested modification of the submersible was postponed. Additionally/ Fishery Research Institute who was the owner of the vehicle had got into financial troubles and whole project canceled. Polish Navy which showed some interest in manned submersibles finally decided not to be involved in continuation of LTS-7 project. Times were changing and in the end of 1981 LTS-7 was transferred to The Central Maritime Museum in Gdartsk for refurbishment. Its use for exploration of Baltic bottom in search for old wrecks was planned by underwater archeology group. However, LTS-7 project was rather technological success than financial one, it was crucial for gathering valuable detailed experience about design and construction of submersible vehicle system.

The most important technologies developed during realization of this project include :

1. Design and manufacture of large diameter spherical pressure vessels.
2. Design and fabrication of underwater electrical connectors and cable systems.
3. Acrylic viewports design and manufacturing.

Underwater connectors for LTS-7 submersible were made using commercially available parts from military and scientific connectors. A new project on technology research and development of heavy duty electrical connectors for hyperbaric diving systems had been started in 1980. As a result a family of ZH series connectors had been developed (Fig.2). The resultant underwater electrical connector has a body made of 316 type stainless steel and gold plated pins sealed with compressed glass. This arrangement provides extremely gas tight and pressure resistant, reliable underwater electrical connector. ZH connector is helium proof and is suitable for the use in full ocean depths. The research phase of the project was completed in 1985. ZH type connectors fulfilled all the customer requirement and are approved for the use in hyperbaric systems by Morskoj Register of the USSR (MRS).

A ZHN connector series was developed some years later because of the need for light and cheaper connector for shallow depth applications. ZH and ZHN series are fully interchangeable. Substantially lower price of the ZHN type connectors is an interesting advantage for underwater equipment design. As an integral part of the cable-connector system electrical penetrators and cable terminations technology were developed. Four types of electro-mechanical cable terminations could be made incorporating single strength member as well as outer braiding. Electromechanical terminations were tested in real sea conditions on tow cables for towed side scan sonar system. Technology of cable and connector molding using polish made polyurethane and neoprene rubber is widely used in practice.

In 1985 a research project on design and construction of underwater towed vehicle for side scan looking sonar was started. A comprehensive hydrodynamic test program supported theoretical analysis. A special dynamometer for measuring hydrodynamic forces of immersed bodies had been built. The model tests gave valuable information for prototype tow-fish construction. After sea trials we decided to implement major changes in the prototype to improve service and maintenance of the vehicle. This model is in current production. In fact the tow-fish is simplest underwater vehicle. Mounting various types of instrumentation gives opportunity for different work configurations to be created to fulfil oceanographic and hydroacoustic mission requirements.

Basing on experience gained while working with SS tow-fish another type of towed vehicle was developed for oceanographic research. A well known idea of V-wing was employed. A very stable platform for low frequency hydrophones compiles minimum operational problems and a simple and compact design. Originally developed as an depressor for side scan sonar, RAY towed vehicle is used by Institute of Oceanography of Polish Academy of Science.

Another project was devoted to a design and construction of a new rescue system for heavy duty offshore requirements, A free fall life saving, diving capsule is a new rescue system which provides a short abandonment time and full protection against flames. The prototype Capsule accommodates 14 survivors and can stay immersed for 48 hours underwater.(Fig.3) Extensive drop tests with 1:5 and 1:1 models had been carried out. Decelerations during

entrance into the water were found well within existing limits for free fall lifeboats (less than lOg during 0.03s). Basic technological goals achieved during this project include:

- a design and construction of the large diameter pressure compartment made from GRP (3m ID, 50 m long term design depth);
- life support system with potassium hyperoxide as C02 absorber;

A study and preliminary design of the capsule for 34 survivors has also been made. Fig. 3B.

One of our present development programs is devoted to a new tools for underwater research and observation tasks. A prototype of a small remotely operated vehicle is now in trials. All basic components of the prototype CORAL ROV and its subsystems were manufactured in our laboratories.(Fig.4) However, it is not possible to built a competitive vehicle without sophisticated equipment from specialized manufacturers we decided to purchase some items to decrease total weight of the ROV and increase reliability of the system. General arrangement of the CORAL ROV is shown in Fig.4. Depth performance is 100m for CORAL 100 and 500 m for CORAL 500 with optional tether management system. Two different thruster configurations are currently available. Black and white or color TV camera is optional choice for observation system. Obstacle avoidance sonar HOMAR developed in the university hydroacoustic division could be supplied upon customer request.

Besides the above mentioned achievements some design and research projects had been completed in Dept. of Underwater Technology of the Ship Research Institute Gdañsk. The most important are:

- research and technology development of magnetic couplings for applications in hyperbaric systems;
- feasibility study of the fast, remotely operated, underwater intervention system;
- feasibility study of an autonomous free swimming ROV for deep sea minerals deposits investigation;
- feasibility study of a commercial manganese nodule mining system based on principle of large autonomous, shuttle vehicles;
- research and development of underwater paints and ship hull painting technology;

Research and teaching activity is also an important task which is carried out by the staff of the DUT.

Current research activity is directed on:

- new materials and technology of application GRP/CRP in underwater technology;
- development of the control algorithms for ROV applications;
- research and development of new intervention tools for underwater applications;
- computer aided design of underwater vehicles and design procedures using our databases and computer programs developed in DUT.

References:

1. J.Stalinski, Z.Nowicki, "Komory Dekompresyjne", Budownictwo Okrêtowe no 18 -Zeszyty Naukowe PG no 187/1970, pp 59-72

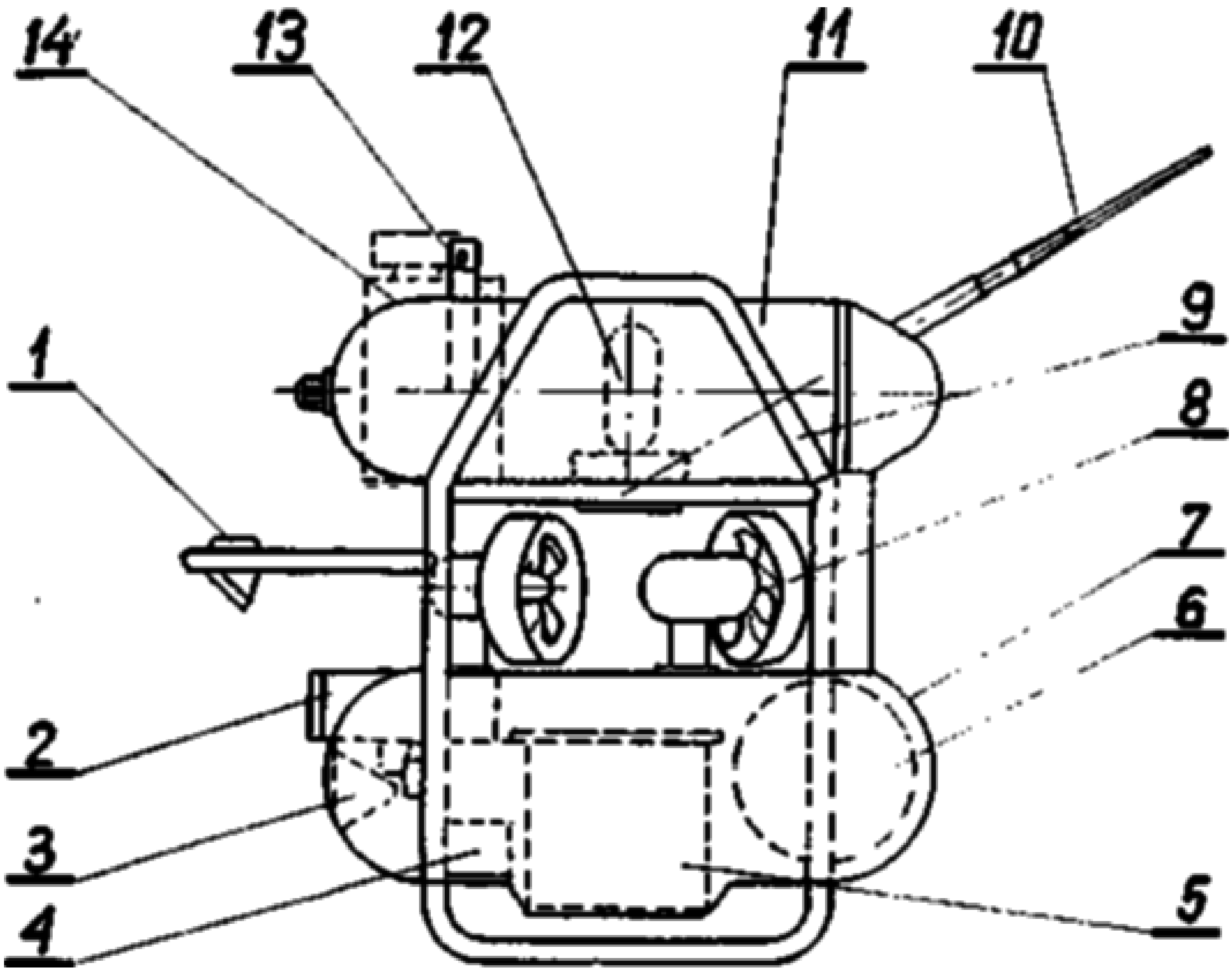
2. L.Rowiñski, "Jednostka z tworzyw sztucznych do obserwacji podwodnej". Bud. Okrêtowe no 3/1978, pp93-95

3. L.Rowiñski, "A Plastic Craft, for Underwater Observations". Polish Technical Review no 12/1978, ppl6-18

4.L.Rowiñski, G.Mizqier, M.Narewski, S.Gajda, A.Niepiek³o, "Badania, projektowanie i budowa zrzutowej kapsuly ratunkowej", Bud. Okrêtowe no 3/1988, pp 90-93

Fig.4 General arrangement of the prototype CORAL Remotely Operated Vehicle for underwater observation tasks (A) and tether deployment system (B).

A



1. Underwater light,
2. Photo camera,
3. Strobe lamp,
4. Camera tilt unit,
5. Power transformer,
6. Electric circuits container,
7. Covers
8. Lateral thrusters,
9. Mounting frame,
10. Neutrally buoyant umbilical,
11. Computer container,
12. Vertical thruster,
13. Xenon flashing light,
14. Obstacle avoidance sonar

1.

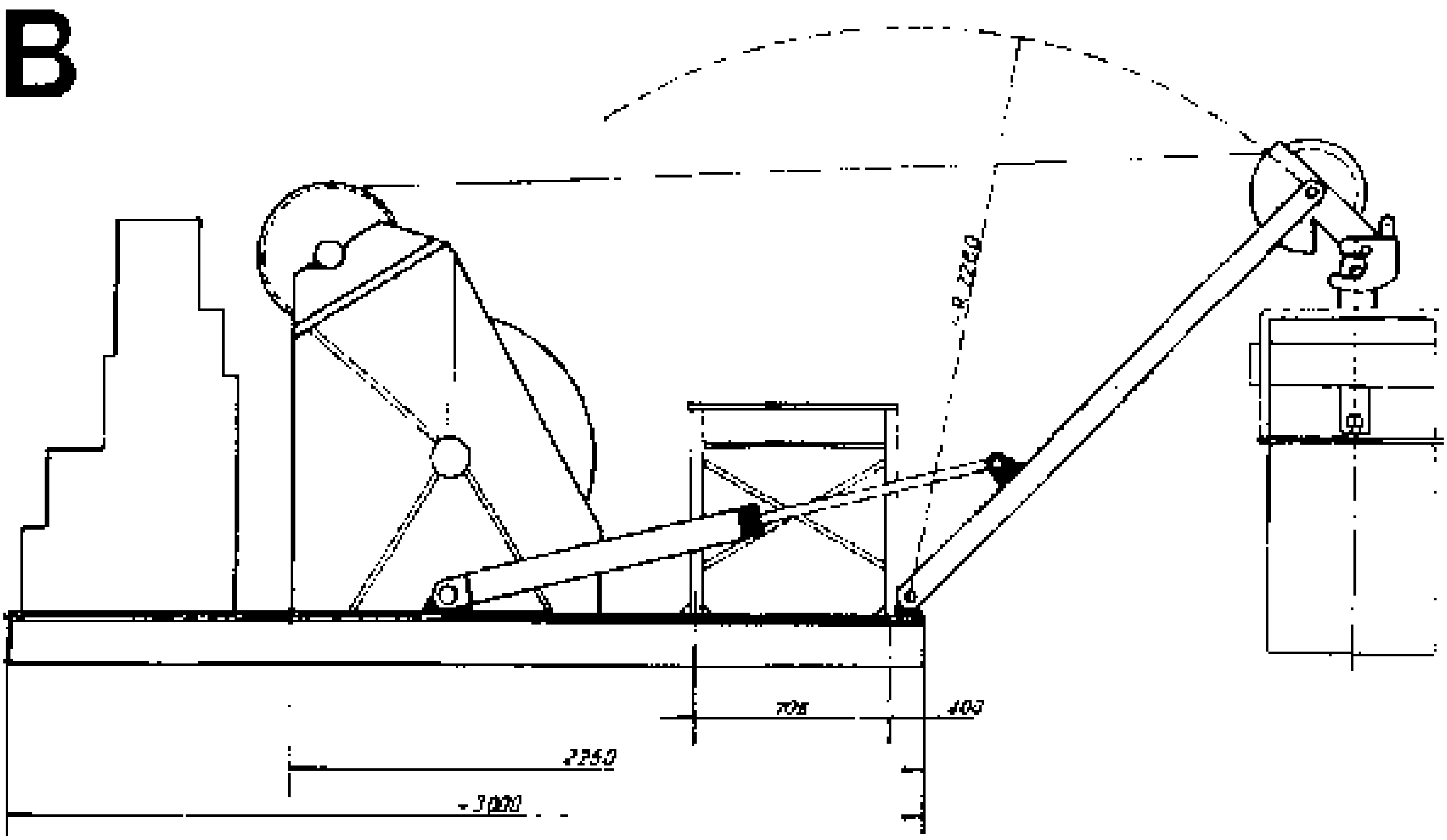
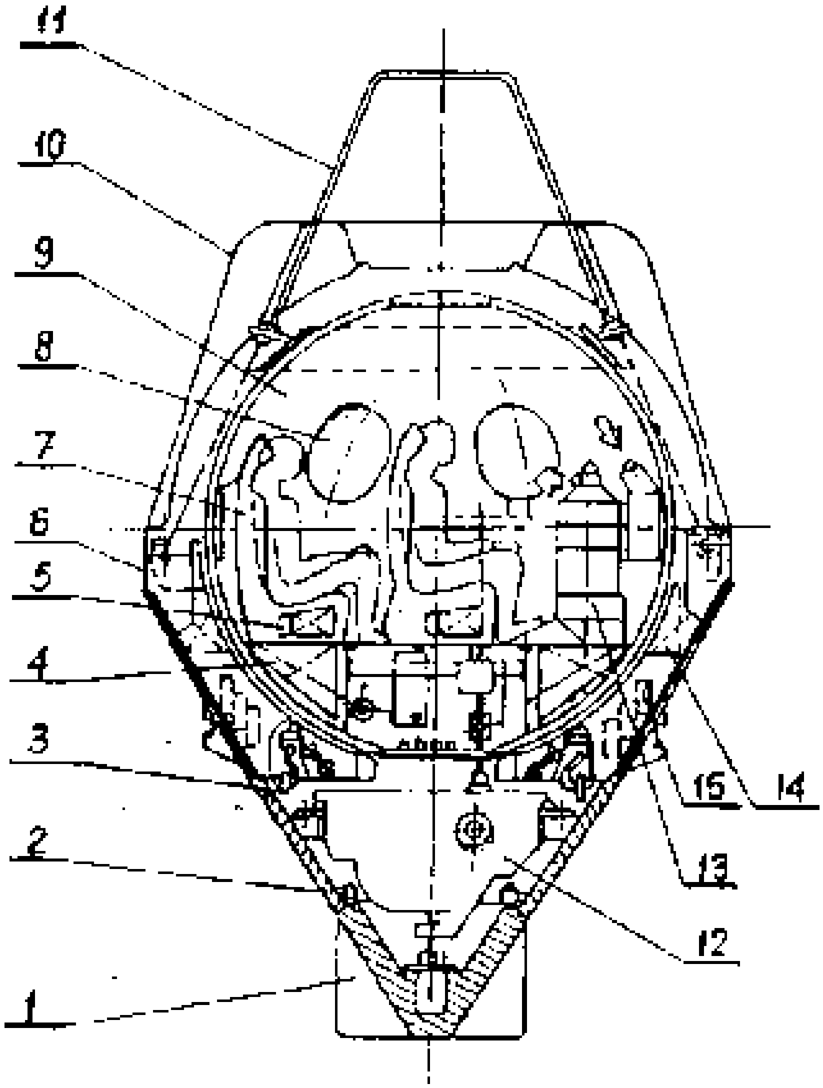


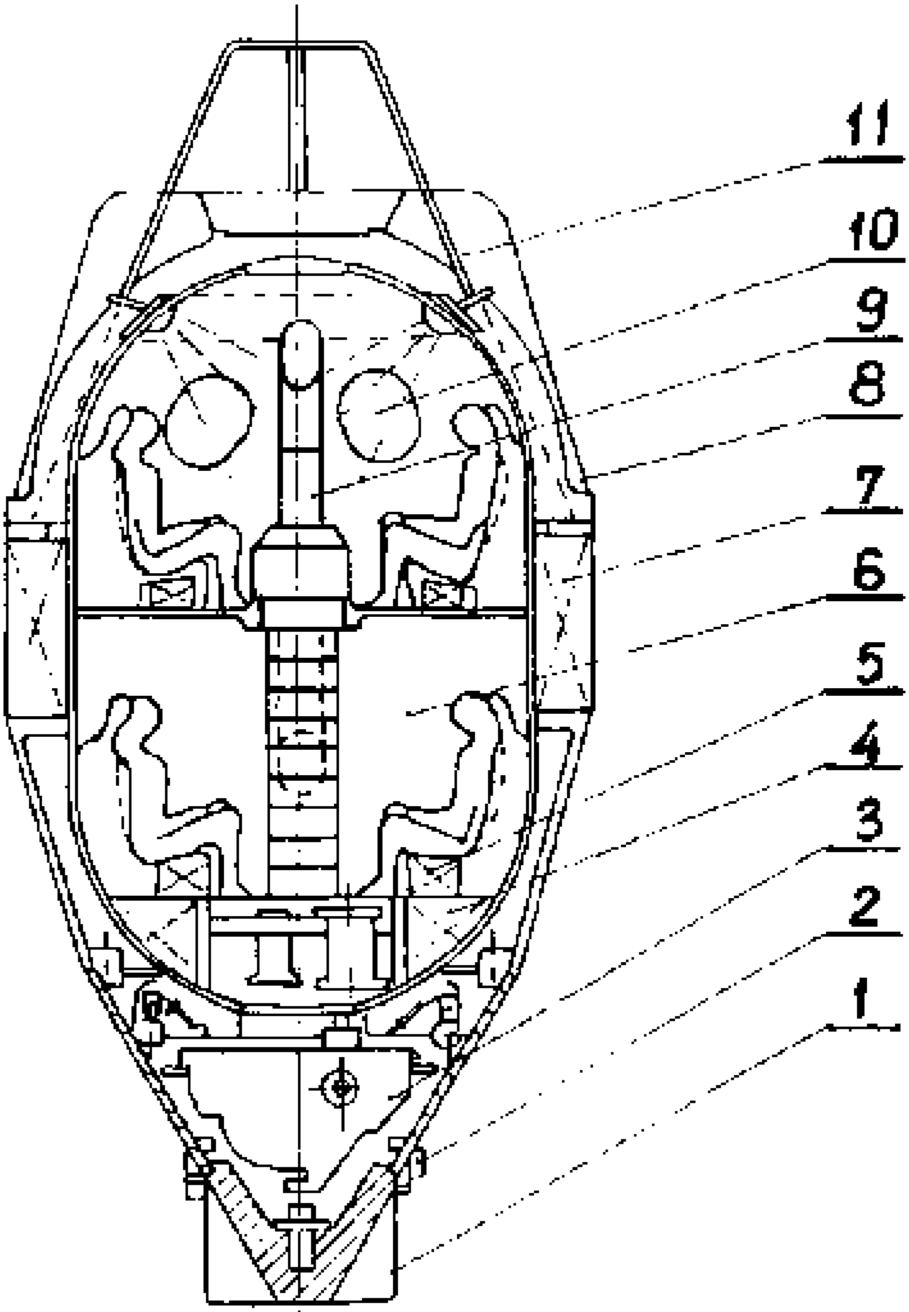
Fig.3 General arrangement of the free fall, diving, life saving capsule for 14 (A) and 34 survivors (B).



1. mushroom anchor
2. anchor release hook
3. ballst quick-release system
4. fresh water tank
5. food containers
6. side sheathing
7. seats for survivors
8. entrance hatch
9. containment sphere
10. top sheathing
11. lifting frame
12. windlass
13. air scrubbing system
14. extern.expand.buoyancy tanks
15. batteries

A

1. mushroom ballast anchor
2. anchor release hook
3. windlass
4. fresh water tanks
5. food containers
6. survivors compartment
7. addit. buoyancy tanks
8. outside sheathing
9. air scrubbing system
10. entrance hatch
11. transport frame



B