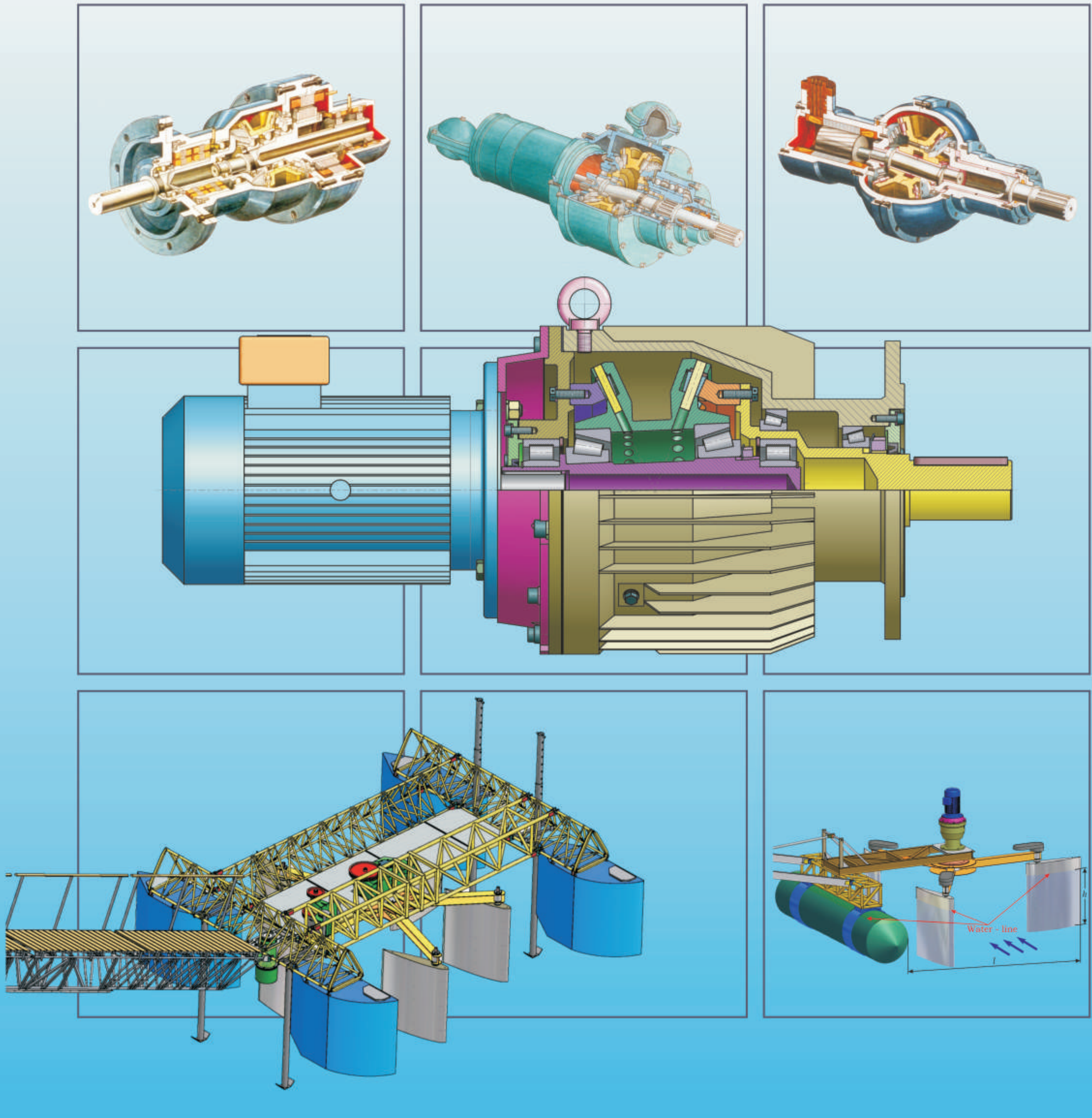
PLANETARY PRECESSIONAL GEARS

DRIVE MECHANISMS

SYSTEMS OF ENERGY CONVERSION

Principal investigator Prof., Dr. Sc. Ion Bostan



RESEARCH TEAM

Academician, Dr.Sc.Prof. Ion Bostan, principal investigator, Rector of the Technical University of Moldova

Dr.Sc.Prof. Valeriu Dulgheru, head of Department of Theory of Mechanisms and Machine Parts

Prof. Dr. Constantin Gluşco; Assoc. Prof. Dr. Anatol Oprea; Assoc. Prof. Sergiu Mazuru; Dr. Ion Babaian; Dr. Andrei Ţopa; Assoc. Prof. Dr. Mihai Ţopa; Assoc. Prof. Viorel Bostan; PhD student Maxim Vaculenco

From the left to the right
Line 1: Radu Ciupercă , PhD student, lecturer; Anatol Sochireanu, PhD student, lecturer.
Line 2: Oleg Ciobanu, PhD student; Ion Dicusară, PhD student, lecturer; Ion Bodnariuc, PhD student, lecturer; Radu Ciobanu, PhD student.
Line 3: Dumitru Vengher, PhD student, lecturer; Valeriu Odainâi, PhD student, researcher; Nicolae Trifan, PhD student, lecturer; Alexandru Olevschi, PhD student; Iulian Malcoci, PhD student.

THE ELABORATION OF MULTIPLE PRECESSIONAL GEAR THEORY AND MODERN MANUFACTURING TECHNOLOGY

New Scientific Direction in Machine Building – Planetary Precessional Transmissions

In 1979, a new type of mechanical transmission – planetary precessional transmission (PPT) was elaborated. This notion was proposed by the author and is used in international terminological circuit. The PPT novelty was protected with about 100 patents and author copyright.

The precessional transmissions differ from the classical ones by the kinematical structure, the principle of motion transforming and gear, by originality of the tooth gearing with spherical-spatial interaction. The conceptual novelty of PPT needed complex theoretical and experimental researches, on which basis there were elaborated methods of engineering calculation and control of the tensional state of the gear, were determined the projection norms and quality parameters of the transmissions, in general.

In order to realise the goal and scientific objectives oriented to the PPT implementation, starting with 1980, a community of young researchers was created, two scientific laboratories „New technologies for non-standard profiles generation" and „Research on parameters of mechanical transmission technical level" endowed with modern equipment were set up. In 1982 the Design Office, previously reequipped with modern stations of computerised designing, was established.

Elaboration of the fundamental theory of planetary precessional transmission gear

„The fundamental theory of the gearing" elaborated by F. Litvin is worldwide applied to classical transmission but cannot be applied to precessional transmission gear, because of:

- variability of the teeth profile depending on 5 variables (the number of teeth included);
- specific interaction determined by spherical-spatial motion of the meshed teeth;
- multi-couple gearing with low teeth difference ± 1.

Hence this, during 1979 – 1989, the scientific researches have been focused on the elaboration of the fundamental theory of the precessional gear correlated to the functional and structural specific of planetary precessional transmission. There have been elaborated mathematical models of the precessional gear taking into account the gearing multiplicity, up to 100% of simultaneously engaged teeth pairs, and provided the constant transfer function. As result, the precessional gear geometry was studied for a wide range of new non-standard convex-concave profiles.

There has been demonstrated that in planetary transmission with spherical-spatial motion of the satellite, the multiplicity of the gear (100%) can be assured only by using gears with non-standard variable convex-concave profile.

This condition-restriction assures distinct performances of planetary precessional transmissions, such as: high lifting capacity, extended kinematical possibilities, enhanced kinematical accuracy, reduced level of vibrations and noise emission, minimum overall dimensions and materials consumption. The researches in the field of PPT statics and dynamics permitted to increase the bearing capacity by reducing the distribution non-uniformity and load dynamics.

Engineering calculation methods and normative projection bases of PPT were elaborated.

The elaborated calculation methods and normative projection bases were included in the curriculum of former USSR both at the discipline „Machine Parts and Design Fundamentals" for the engineering specialties, and „Machine Parts" handbooks, edited in the Republic of Moldova and Romania during 1990-2006.

The fundamental theory of the precessional gear was published in the monograph - I. Bostan „Precessional transmissions with multi-pair gear", „Ştiinţa" Publishing House, Chisinau, 1991, 354 pages.

The conceptual novelty of the precessional multi-pair gear was protected by 8 patents and author copyright in the former USSR and in the Republic of Moldova, inclusively, the patent No 1563319 with the priority of 29.09.1987 patented at Rospatent, Russian Federation, with the registration date of 16.06.1995.

Over 30 structural schemes of PPT protected by patents and author copyright were elaborated. These can serve as structural base in the elaboration and designing of general and special destination actuator mechanisms.

Analytical description of the teeth profiles

The specific character of spherical-spatial motions of the satellite and observance of teeth gear multiplicity makes impossible the utilisation of teeth classical involute profiles. This fact requires the elaboration of new profiles adequate to the spherical-spatial motion of satellite which would ensure high performances to the precessional transmission.

In order to elaborate precessional gear which would insure simultaneously the transfer function invariability and teeth gear multiplicity, theoretical research was carried out concerning:

- the elaboration of the gear mathematical model with account of the peculiarities;
- the analytical description of teeth profiles by a system of parametrical equations on spherical surface and normal teeth section for inner and plane gear;

- the determination by CAD of geometrical and kinematic parameters influence of the gear upon the teeth profiles shape and the justification of their rational limits of variation;
- the elaboration of the theoretical basis evaluation of teeth gear multiplicity in precessional transmissions; the definition of area of gear multiplicity existence by 100% teeth couples.

In precessional transmission the gear wheel produces spherical-spatial motion round a fixed point. It is known, that the body which produces spherical motion has three degrees of freedom. As a rule, in theoretical mechanics, the position of the body, which produces precessional motion, is determined by Euler angles. In this case, the mobile system of coordinates $OX_1Y_1Z_1$ is bound rigidly with the gear wheel, as origins of the system of coordinates the immobile point O (centre of precession) being chosen (fig.1). This system of coordinates produces jointly with the gear wheel spherical motion related to the fixed system of coordinates OXYZ. Analytical relationship between the coordinates of gear wheel points, shown in the mobile $OX_1Y_1Z_1$ and fixed OXYZ systems of coordinates, was obtained due to the analysis of the two pinion positions - initial one, when the system of coordinates axis coincide, and final one, when the axis was removed.

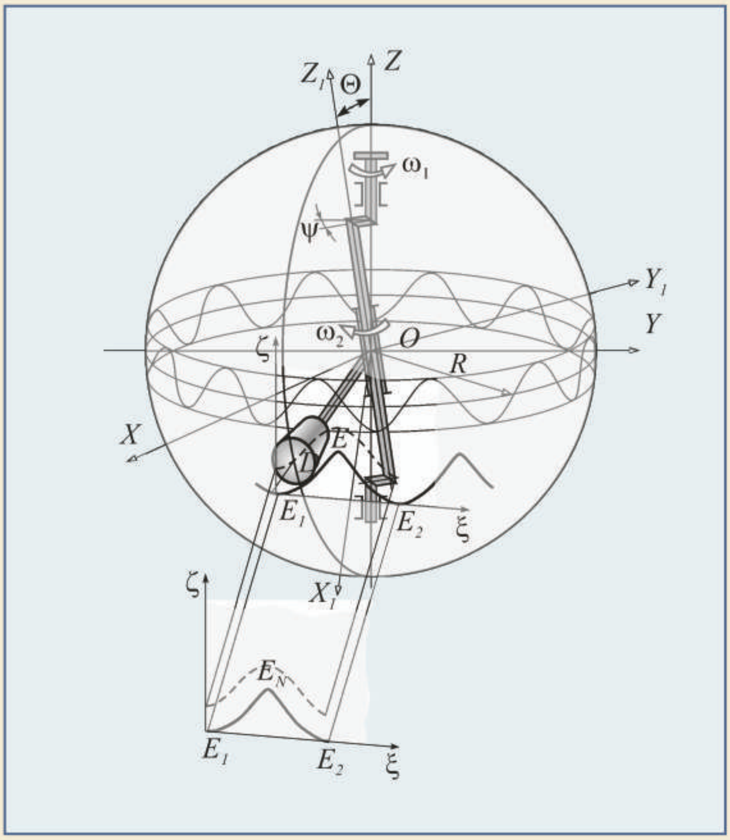


Fig.1. Teeth profile determination.

By expressing vectors $\overline{i}_1, \overline{j}_1, \overline{k}_1$ via basic vectors $\overline{i}, \overline{j}, \overline{k}$ of the fixed system of coordinates OXYZ we obtain:

$$\overline{i}_1' = \overline{i}\cos\psi + \overline{j}\sin\psi,$$
$$\overline{j}_1'' = -\overline{i}\sin\psi + \overline{j}\cos\psi, \quad \overline{k}_1' = \overline{k}. \qquad (1)$$

The second rotation is produced at angle θ (0≤θ≤π) round joint lines, after which the unit vector $\overline{i'}_1, \overline{j'}_1, \overline{k'}_1$ will move into directions $\overline{i''}_1, \overline{j''}_1, \overline{k''}_1$ (respectively, they coincide with the directions of axis OX", OY", OZ"), at the same time vector $\overline{k''}_1$, which coincides with vector, defines the position of axis OZ_1 in final position. By expressing vectors $\overline{i''}_1, \overline{j''}_1, \overline{k''}_1$ via $\overline{i'}_1, \overline{j'}_1, \overline{k'}_1$ we obtain

$$\overline{i}_1'' = \overline{i}_1';$$
$$\overline{j}_1'' = -\overline{j}_1'\cos\theta + \overline{k}_1'\sin\theta; \qquad (2)$$
$$\overline{k}_1'' = -j_1'\sin\theta + \overline{k}_1'\cos\theta.$$

By operating matrix theory, transition from gear wheel point coordinates is produced (for example, of the roller centre D), given in the mobile system of coordinates $OX_1Y_1Z_1$ to the coordinates of the same points in the fixed system OXYZ. After some modifications it was obtained

$$X_D = R\cos\delta\left[-\cos\psi\,\sin(Z_1\psi/Z_2) + \sin\psi\,\times\right.$$
$$\left.\times\cos(Z_1\psi/Z_2)\cos\theta\right] - R\sin\delta\,\sin\psi\,\sin\theta;$$
$$Y_D = -R\cos\delta\left[\sin\psi\,\sin(Z_1\psi/Z_2) + \cos\psi\,\times\right. \qquad (3)$$
$$\left.\times\cos(Z_1\psi/Z_2)\cos\theta\right] + R\sin\delta\,\cos\psi\,\sin\theta;$$
$$Z_D = -R\cos\delta\,\cos(Z_1\psi/Z_2)\sin\theta -$$
$$-R\sin\delta\cos\theta.$$

Point D moves on the spherical surface by radius R with its centre in the precessional centre O (fig.1). Being familiar with the trajectory of roller centre motion, the position of the contact point by central wheel tooth is determined, which family in a precessional cycle represents the shape of the wheel tooth.

In fig. 2 and 3 the profilograms of teeth, obtained for various gear geometrical parameters, are shown.

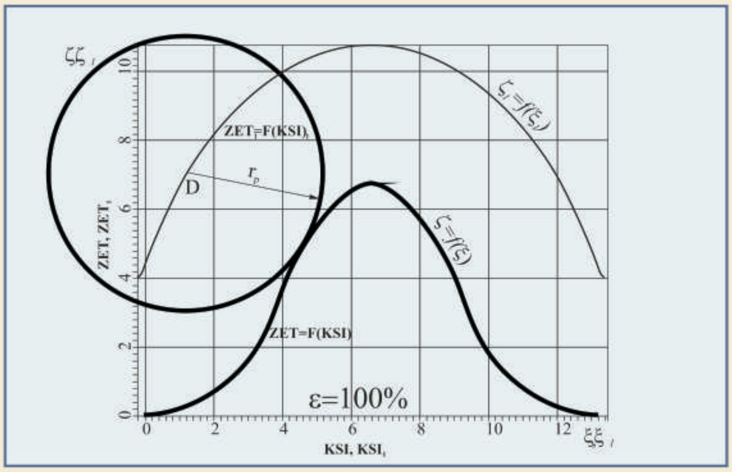


Fig.2. Profilograms of teeth for various gear geometrical parameters (Z1<Z2)

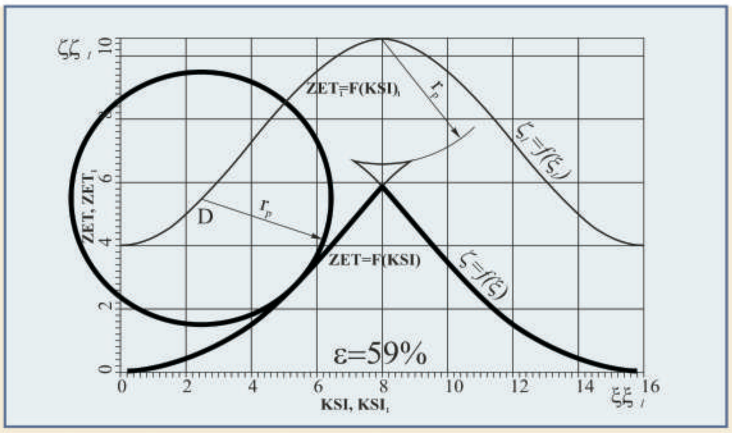


Fig.3. Profilograms of teeth for various gear geometrical parameters (Z1>Z2).

Variable profile gear generation technologies

The precessional gear geometry differs substantially from the classical gear geometry.

Therefore the classical methods of gearing generation used in machine building can not be applied for precessional gearing generation with teeth variable profile. During 1980-1983, the fundamental theory of a new generation process of precessional motion gear with generation contour was elaborated.

For this reason, the mathematical model of the generating process on the basis of Euler equations and a new generating method of precessional gear were elaborated. The new generating method helps to manufacture a tool by milling, knurling and grinding under precessional motion. The elaborated generating method of the generator precessional transmission permits to manufacture involute, cycloid, epicyclical, hypocycloidal, epihypocycloidal and octoidal profiles which have been used in world experience for classical conical transmissions, as for the precessional transmissions – the whole range of convex-concave non-standard profiles.

Concurrently with the evolution of the gear generation computerized systems, the suggested technology was readapted to the modern technique manufacture with 5 degrees of freedom.

High productive technologies for manufacturing toothed wheels through metal powder and plastic casting sintering were elaborated for the kinematical transmissions.

To increase the bearing capacity of PPT new technologies of longitudinal and profile modifications were suggested and realised. To perform the quality control of the precessional gear manufacturing, including those with longitudinal and profile modification, update control methods were elaborated.

The fundamental theory of the precessional gear generation process was published in the monograph - I. Bostan „Precessional transmissions with multi-pair gear", „Ştiinţa" Publishing House, Chisinau, 1991, 354 pages.

The elaborated technologies were tested technically and adjusted in the laboratory of „New generation technologies for non-standard profiles" and have been implemented in different domains.

The KNOW-HOW of these technologies and the elaborated control methods are protected by 15 patents and author copyright, inclusively, the patent No 1663857 of 05.01.1988 and patent No 1646818 of 27.06.1988, patented by Rospatent, Russian Federation, with the registration date of 16.06.1995.

Kinematics of the working mechanism for the teeth generating method

To realise the method of teeth processing he has elaborated the mechanism shown in fig.4. In the elaborated mechanism the node, which involves the tool into precessional motion, is fixed not to rotate round the common axis of the principal shaft - semiproduct shaft with a binding mechanism. The rotation of semiproduct 3 and of the principal shaft 1 are coordinated by the dividing mechanism of the tool.

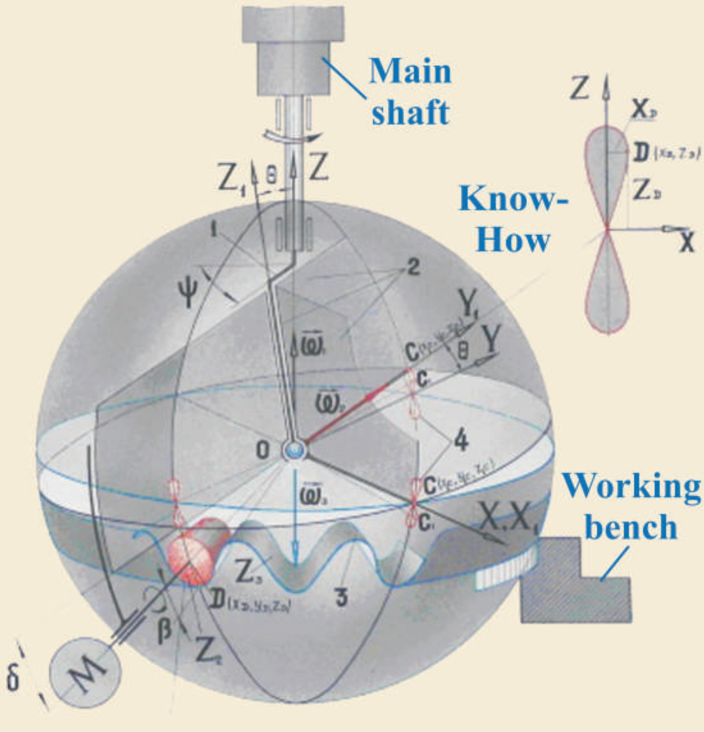


Fig.4. Spatial diagram for the teeth processing method by rolling, with the utilization of precessional tool.

The constructive execution of the tool binding mechanism with the shaft ensures the continuity of the transmission function ω_1/ω_2=const. and is determined by the motion trajectory of point C which belongs to the movable part. Setting up the position function of the binding mechanism and the motion equation of the generating wheel 2 and, using the matrix device for transferring from the movable system of coordinates $X_1Y_1Z_1$ to the fixed one OXYZ, we determined the coordinates of point C (the binding mechanism and the tool are inserted in diametrically opposite places)

$$X_C = R_C\,(1 - \cos\theta)\cos\psi\,\sin\psi\,;$$
$$Y_C = R_C\left(\sin^2\psi + \cos\theta\,\cos^2\psi\right); \qquad (4)$$
$$Z_C = R_C\,\sin\theta\,\sin\psi\,.$$

These equations (4) represent the parametrical equations of the supporting surface of the binding mechanisms, inserted in the device.

The shape of this device ensures the continuity of the transmission ratio of the kinematic chain to the spindle axis-semiproduct shaft.

Determination of the tool motion trajectory

For the angle of the conical axoid of the teeth wheel $\delta=0$ the equation of tool motion is identical to the equation (4), having only opposite values. This is explained by the fact that the tools are inserted in diametrically opposite places.

In the case of toothed wheels processing with an angle of the conical axoid $\delta>0$ the centre of the tool will have the coordinates in the movable system $OX_1Y_1Z_1$

$$X_{1D} = 0; Y_{1D} = -R\cos\delta\,; Z_{1D} = -R\sin\delta\,.$$

Then the equation of tool motion in the fixed system of coordinates OXYZ will be

$$X_D = -R\cos\delta(1 - \cos\theta)\times$$
$$\times\cos\psi\,\sin\psi - R\sin\delta\,\sin\theta\,\sin\psi\,;$$
$$Y_D = -R\cos\delta\left(\sin^2\psi + \cos\theta\,\cos^2\psi\right) + \qquad (5)$$
$$+R\sin\delta\cos\psi\sin\theta;$$
$$Z_D = -R\cos\delta\sin\theta\cos\psi - R\sin\delta\cos\theta.$$

The motion trajectory of point D (fig. 2) represents a symmetrically closed curve related to the big axis whose shape changes according to the angle value of conical axoid δ.

Determination of the family wrapping of tool surfaces

Tooth profile of the processed wheel represents the family wrapping of the generating contour profiles of the tool. The wrapping is determined by the equations of the working surface of the generating tool and by the relative motion parameters while wrapping.

To make easier the determination of wrapping we pass to the tool center coordinates in the movable system of co-ordinates (fig. 3), bound to the semiproduct 3.

$$X = X_D\cos\psi_3 + Y_D\sin\psi_3;$$
$$Y = -X_D\sin\psi_3 + Y_D\cos\psi_3\,; \qquad (6)$$
$$Z = Z_D\,,$$

where $\overline{X}_D, \overline{Y}_D, \overline{Z}_D$, are the coordinates of the tool centre in the movable system of coordinates; $\psi_3=\psi/i$ is the rotation angle of the semiproduct; i - is the transmission ratio of the kinematic chain "principal shaft - semiproduct".

The equations (6) define the motion trajectory of tool centre, evaluated on the sphere. Then we determined the equation of wrapping on the sphere (fig.5).

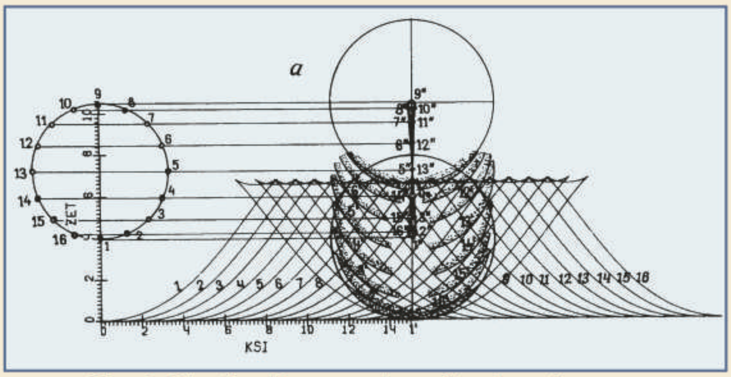


Fig. 5. The family wrapping of tool surfaces.

The analysis of profilograms demonstrate the level and direction of influence upon the angle of tool insertion by the rotation axis of the semiproduct, tool radius R and transmission ratio i of the kinematic chain "principal shaft - semiproduct" on processed tooth profile.

Manufacturing technology for teeth profile by utilising multipurpose equipment item with 5 movable axes

For the fulfillment of technology by utilising modern equipment, the equation for tool's point D trajectory were elaborated:

$$X_D = -R\left\{\cos\delta\left[-\cos\delta\sin\left(\frac{Z_1}{Z_2}\psi\right) + \cos\psi\cos\left(\frac{Z_1}{Z_2}\psi\right)\cos\theta\right] - \sin\delta\sin\theta\sin\psi\right\};$$
$$Y_D = -R\left\{\cos\delta\left[\sin\psi\sin\left(\frac{Z_1}{Z_2}\psi\right) + \cos\psi\cos\left(\frac{Z_1}{Z_2}\psi\right)\cos\theta\right] - \sin\delta\sin\theta\cos\psi\right\};$$
$$Z_D = -R\left\{\cos\delta\sin\theta\cos\left(\frac{Z_1}{Z_2}\psi\right) + \sin\delta\sin\theta\right\}.$$

Structure and kinematics of planetary precessional transmissions

The elaboration of working machines driving mechanisms is based on the diagram of precessional transmissions, presented in fig. 6.

The rotating motion of the crank shaft 1 is transformed into spherical-spatial motion of the block pinion 2 with two teethed crowns 6 and 7, which are rolling without sliding on the immovable and driven toothed wheels 3 and 4. Due to the minimum difference between the number of teeth $Z_3=Z_6-1$, $Z_4=Z_7-1$, $Z_6=Z_7+1,2,3...$, the transmission ratio is (Annex 1).

$$i = -\frac{Z_6\cdot Z_4}{Z_3\cdot Z_7 - Z_6\cdot Z_4}.$$

The teeth of crowns 6 and 7 are manufactured in the shape of conical rollers installed on axis having the possibility to rotate round them, and the teeth of central wheels 3 and 4 have non-standard convex-concave profile (fig. 2 and 3).

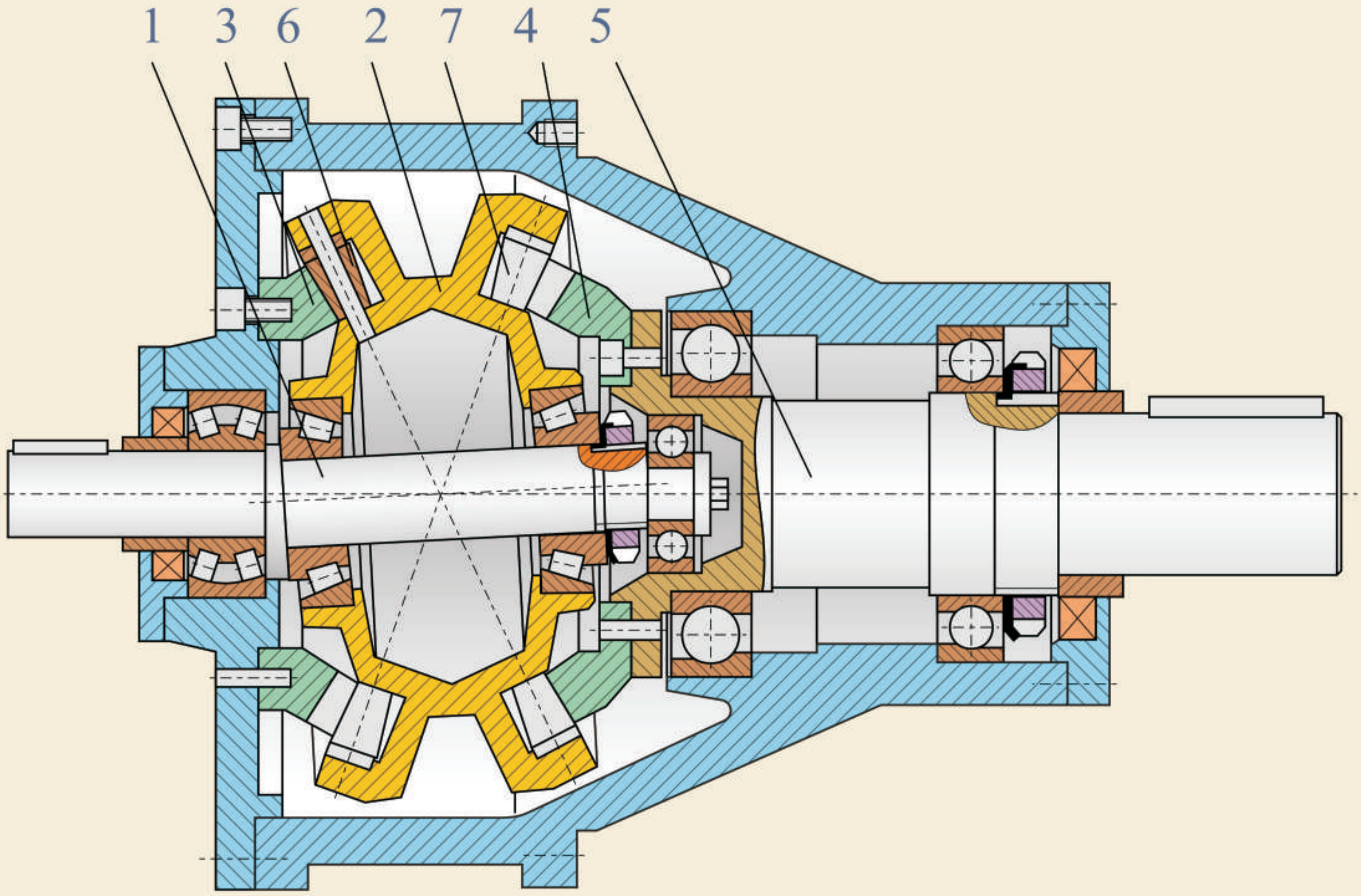


Fig. 6. 2K-H precessional transmission.

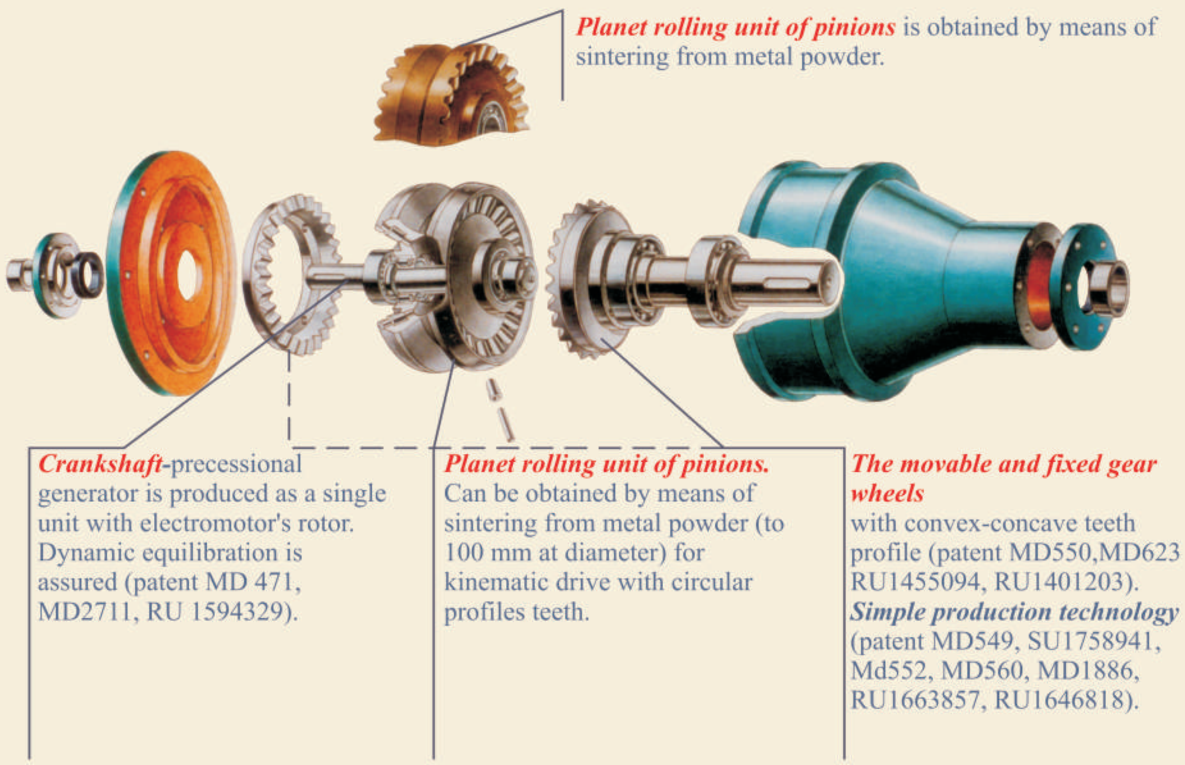


Fig. 7. Structure of the precessional gear transmission.

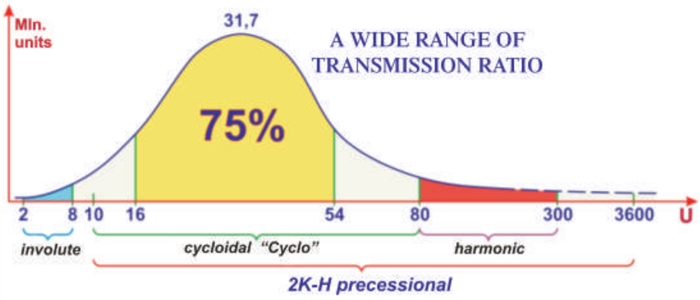
ADVANTAGES OF THE PLANETARY PRECESSIONAL TRANSMISSIONS

HIGH EFFICIENCY, rating 96%, is due to the use of a gear-rolling coupling with the convex-concave teeth profile and because there is no special mechanism connecting the planet pinion with the driven shaft.

A WIDE RANGE OF TRANSMISSION RATIO, from 8,5 to 3599, in the reduce with the only planet unit. In a solid reduce with two planet pinions, one enclosed into the other, it is possible to realize the ratio to 12960000.

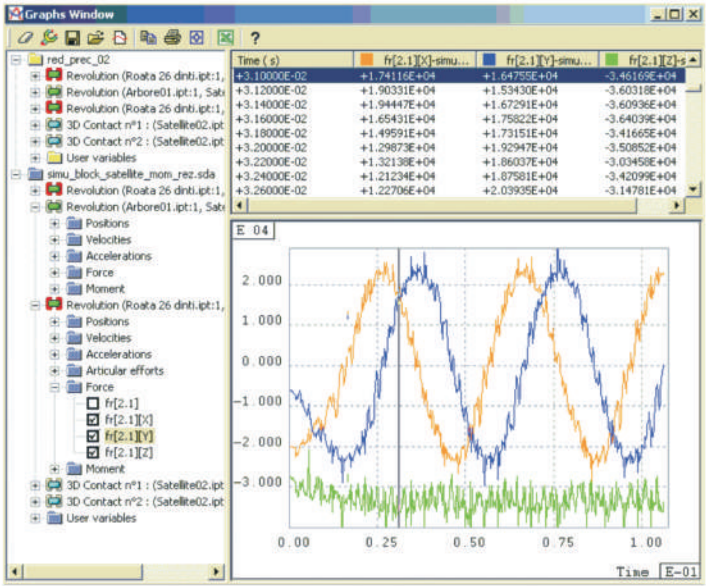
HIGH LIFTING CAPACITY is maintained by meshing when about 100% teeth couples are simultaneously mated resulting in load distribution among the teeth on the line of action.

COMPACTNESS AND SMALL WEIGHT have become possible because of the principle of operation and multicouple gearing. Specific material capacity of the reducers ranges from 0,022 to 0,05 kg/Nm.



HIGH KINEMATIC ACCURACY from 30 to 90 ang/sec. has been achieved due to the application of multicouple convex-concave engagement with the ground profile. The teeth form is shaped so as to compensate the irregularity of the driven shaft rotation connected with the spherical motion of the planet pinion. The meshing may be without clearance that makes it possible to set some controllable interference.

HIGH RATING LIFE is mainly provided by the good quality of engagement with the ground teeth profile and the possibility to mount the planet pinion on the bearing with great load rating without fitting the wheel diameter.



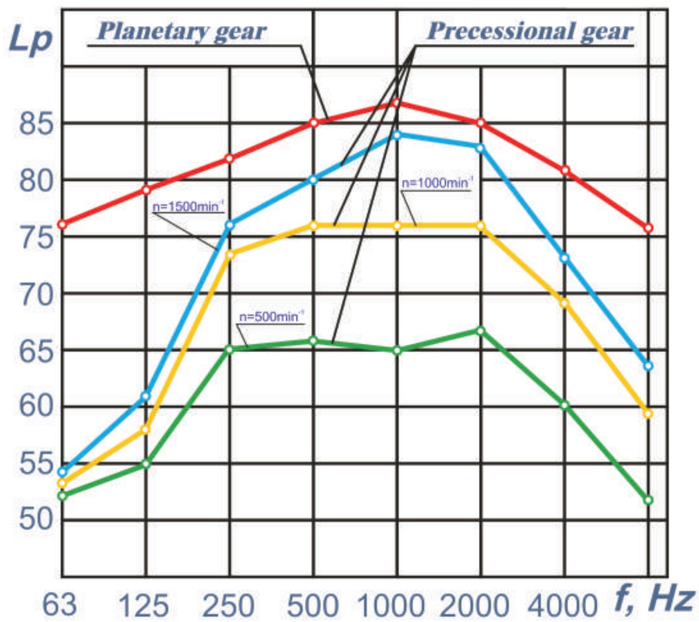
LOW LEVEL OF NOISE AND VIBRATION, from 50 to 60 dBa, has become possible due to the accuracy of the teeth profile, smoothlessnes of the driven shaft rotation, resting on shaping the teeth profile in accordance with the peculiarities of the spherical motion of the planet pinion.

LOW MOMENT OF INERTIA accounts for the peculiarities of the spherical motion of the planet pinion.

THE CONDITIONS TO OPERATE in the self-holding regime but in special designs - in the multiplication and differential systems.

Most of the advantages of precessional reducers are reasoned by the new type of toothed-rolling engagement with convex-concave teeth profile with all teeth simultaneously mating. To produce bevel gears with the presented engagement there has been developed a new method of teeth processing by grinding and milling.

The teeth are shaped by the universal gear-milling machine tools with the auxiliary devices and a grinding head. The device consists of five parts. Due to the method it is possible to mill and grind a wide range of different profiles, providing the reducers with the above mentioned advantages. The presented method guarantees the ideal accuracy of the profile and teeth pitch.

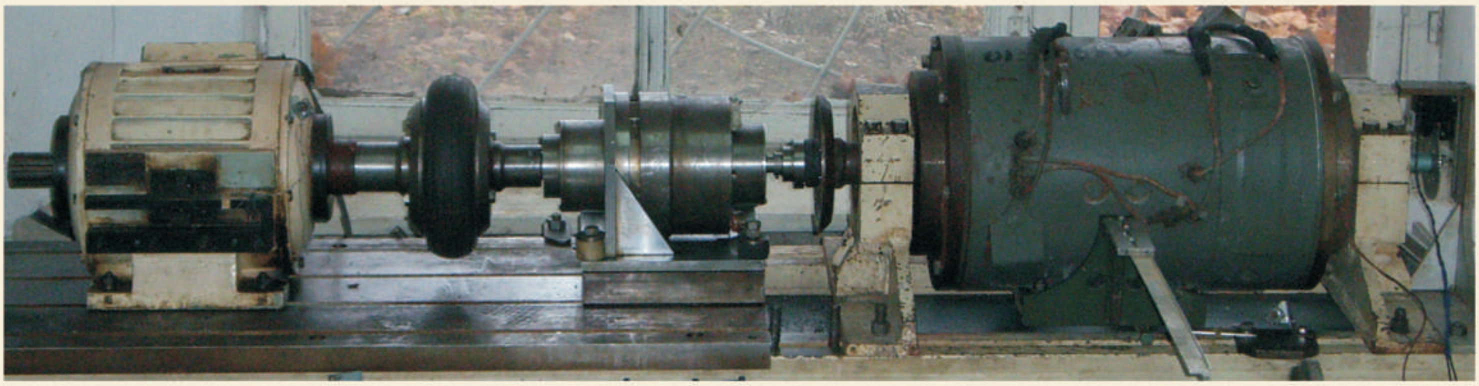


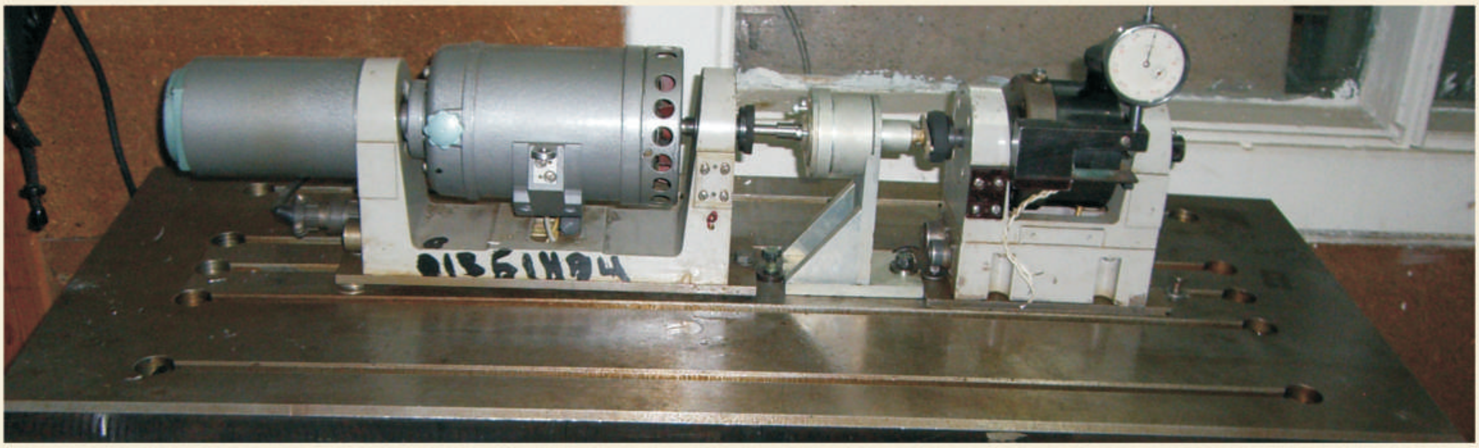
Reduction ratios, single reduction, Z=10 ... 50

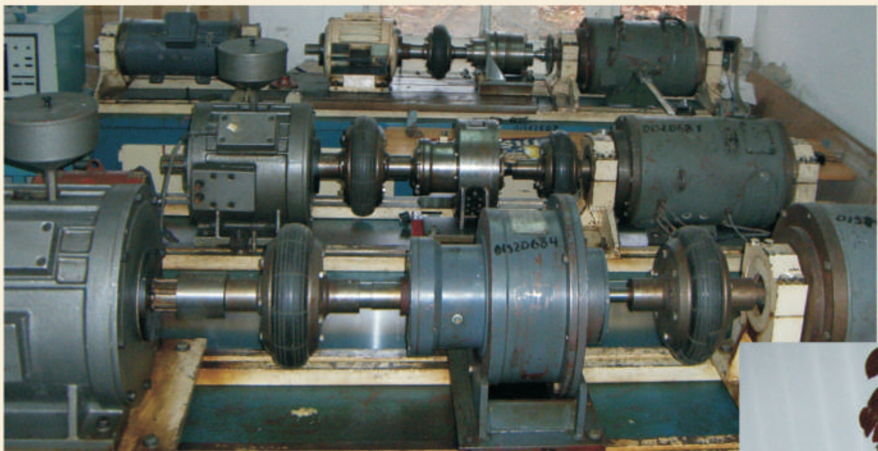
Z6>Z7								Z6<Z7							
i	i	i	i	i	i	i	i	i	i	i	i	i	i	i	i
-12.9	-23.0	-35.8	-52.6	-80.2	-130.2	-241.7	-735.0	13.8	23.5	35.8	51.1	74.7	115.0	194.2	408.0
-13.0	-23.1	-36.0	-53.3	-81.0	-131.9	-243.2	-740.0	13.9	23.6	36.0	51.6	75.0	115.5	194.3	409.5
-13.1	-23.3	-36.1	-53.6	-81.7	-132.0	-245.0	779.0	14.0	23.7	36.1	51.7	75.3	116.0	196.0	422.4
-13.2	-23.5	-36.2	-53.7	-82.1	-133.2	-246.5	-783.0	14.1	23.8	36.4	52.0	75.8	117.0	197.3	430.0
-13.3	-23.6	-36.3	-54.0	-83.4	-133.3	-249.7	-840.0	14.2	24.0	36.5	52.3	76.0	118.9	202.5	431.7
-13.4	-23.7	-36.8	-54.5	-84.0	-133.4	-252.0	-860.0	14.3	24.1	36.6	52.8	76.8	119.2	203.5	435.0
-13.5	-23.8	-36.9	-54.9	-84.1	-135.0	-255.0	-899.0	14.4	24.3	36.8	53.1	77.1	120.0	203.7	441.0
-13.7	-23.9	-37.0	-55.0	-84.3	-136.5	-257.4	-902.0	14.5	24.5	37.0	53.2	78.0	120.3	204.0	451.0
-13.8	-24.0	-37.1	-55.3	-84.5	-137.6	-258.0	-945.0	14.7	24.6	37.1	53.3	78.3	121.0	205.0	456.0
-13.9	-24.2	-37.3	-55.5	-84.7	-137.8	-260.0	-960.0	14.8	24.7	37.2	53.6	78.4	122.2	208.0	465.0
-14.1	-24.4	-37.4	-55.6	-85.2	-140.0	-262.5	-989.0	14.9	24.8	37.3	54.3	79.2	122.5	209.0	472.0
-14.2	-24.5	-37.5	-55.7	-85.3	-141.2	-271.3	-1023.0	15.1	24.9	37.7	54.5	79.5	124.0	210.0	481.0
-14.4	-24.6	-38.0	-56.0	-86.0	-142.2	-272.0	-1034.0	15.2	25.0	37.8	54.6	79.8	124.2	213.3	484.0
-14.6	-24.8	-38.1	-56.5	-86.4	-143.0	-274.3	-1080.0	15.4	25.2	37.9	54.7	79.9	125.0	213.8	494.5
-14.7	-25.0	-38.3	-57.3	-87.0	-144.0	-275.0	-1088.0	15.5	25.4	38.0	55.0	80.2	126.0	216.0	496.0
-14.8	-25.1	-38.7	-57.5	-88.1	-145.2	-279.0	-1127.0	15.6	25.5	38.1	55.5	81.0	126.5	217.0	506.7
-14.9	-25.4	-38.8	-57.9	-89.4	-146.3	-285.0	-1155.0	15.7	25.6	38.3	55.9	81.2	126.7	221.0	517.0
-15.0	-25.7	-38.9	-58.1	-89.8	-147.0	-287.0	-1224.0	15.8	25.8	38.4	56.0	82.0	127.3	223.2	528.0
-15.1	-25.9	-39.0	-58.2	-90.0	-148.5	-288.0	-1295.0	15.9	26.0	38.5	56.3	82.7	127.5	224.3	529.0
-15.2	-26.0	-39.1	-58.5	-90.5	-149.3	-296.0	-1368.0	16.0	26.1	39.0	56.5	83.1	129.0	225.0	533.0
-15.3	-26.1	-39.4	-59.2	-90.7	-149.5	-298.7	-1443.0	16.1	26.4	39.1	56.6	83.3	130.5	227.3	540.0
-15.4	-26.2	-39.5	-59.3	-91.1	-152.0	-299.0	-1520.0	16.2	26.7	39.3	56.7	84.4	131.2	230.4	560.0
-15.5	-26.4	-40.0	-59.4	-92.0	-153.0	-302.4	-1680.0	16.3	26.9	39.7	57.0	85.0	132.9	231.0	561.0
-15.6	-26.5	-40.1	-59.5	-92.1	-153.3	-313.3	-1763.0	16.4	27.0	39.8	57.5	85.1	133.0	232.0	563.5
-15.7	-26.9	-40.3	-59.8	-93.0	-155.0	-313.5	-1848.0	16.5	27.1	39.9	58.0	85.3	134.2	233.3	576.0
-15.8	-27.0	-40.5	-60.7	-93.5	-157.1	-318.2	-1935.0	16.6	27.2	40.0	58.3	85.5	134.3	235.0	587.7
-15.9	-27.1	-40.7	-60.8	-94.3	-157.7	-319.0	-2024.0	16.7	27.4	40.1	58.5	85.7	134.4	238.9	595.0
-16.1	-27.2	-40.8	-60.9	-95.0	-160.0	-323.0	-2115.0	16.8	27.5	40.4	58.9	86.2	136.0	242.7	616.0
-16.3	-27.3	-41.0	-61.1	-95.7	-161.0	-324.0	-2208.0	16.9	27.6	40.5	59.1	86.3	137.5	244.2	625.0
-16.5	-27.5	-41.1	-61.3	-95.9	-162.9	-328.0	-2303.0	17.1	27.9	41.0	59.2	87.0	138.6	246.0	630.0
-16.6	-27.6	-41.4	-61.5	-96.2	-163.3	-331.5		17.2	28.0	41.1	59.5	87.1	138.8	247.5	645.0
-16.7	-27.8	-41.5	-62.0	-96.4	-164.0	-334.4		17.3	28.1	41.3	60.2	87.4	139.5	250.7	666.0
-16.9	-27.9	-41.7	-62.4	-97.1	-164.8	-343.0		17.5	28.2	41.5	60.3	88.0	141.0	253.0	674.7
-17.0	-28.0	-42.0	-62.9	-97.2	-166.2	-350.0		17.6	28.3	41.7	60.4	89.1	142.2	256.0	676.0
-17.2	-28.2	-42.1	-63.0	-98.0	-166.4	-360.0		17.7	28.5	41.8	60.5	90.4	143.2	257.3	703.0
-17.3	-28.3	-42.2	-63.2	-99.0	-168.0	-361.7		17.9	28.6	42.0	60.8	90.8	144.0	258.4	705.0
-17.4	-28.4	-42.4	-64.0	-101.5	-169.2	-368.0		18.0	28.8	42.1	61.7	91.0	145.0	259.0	729.0
-17.6	-28.8	-42.5	-64.2	-101.8	-170.0	-369.0		18.2	28.9	42.4	61.8	91.5	146.2	261.0	736.0
-17.8	-29.0	-42.8	-64.8	-101.9	-172.7	-377.0		18.3	29.2	42.5	61.9	91.7	146.7	262.9	741.0
-17.9	-29.1	-43.0	-65.0	-102.4	-173.3	-384.0		18.4	29.3	42.7	62.1	92.1	147.3	263.5	767.7
-18.0	-29.2	-43.1	-65.6	-102.6	-174.0	-385.4		18.6	29.4	43.0	62.2	93.0	148.0	272.3	780.0
-18.2	-29.3	-43.2	-66.5	-103.5	-175.0	-388.5		18.8	29.8	43.1	62.3	94.0	149.5	273.0	784.0
-18.3	-29.4	-43.3	-66.7	-104.0	-177.6	-403.2		18.9	29.0	43.2	62.4	94.5	150.3	275.3	820.0
-18.4	-29.5	-44.0	-66.8	-106.3	-178.2	-405.0		19.0	30.0	43.4	62.5	95.1	150.5	276.0	841.0
-18.5	-29.6	-44.1	-66.9	-106.7	-182.8	-407.0		19.1	30.1	43.5	63.0	95.3	153.0	280.0	861.0
-18.7	-29.8	-44.3	-67.2	-107.3	-182.9	-408.5		19.2	30.2	43.8	63.4	96.0	154.0	286.0	900.0
-18.8	-29.9	-44.7	-67.3	-107.4	-184.0	-421.4		19.3	30.3	44.0	63.9	96.7	154.3	288.0	903.0
-18.9	-30.0	-44.8	-68.0	-107.5	-185.0	-430.7		19.4	30.4	44.1	64.0	96.9	155.2	289.0	946.0
-19.1	-30.2	-45.0	-68.3	-107.8	-186.2	-434.0		19.5	30.5	44.2	64.2	97.2	156.0	287.0	961.0
-19.2	-30.3	-45.1	-68.6	-108.1	-187.5	-440.0		19.7	30.6	44.3	65.0	97.4	158.1	299.7	990.0
-19.3	-30.7	-45.3	-69.0	-109.2	-189.0	-450.0		19.8	30.8	45.0	65.2	98.1	158.7	300.0	1024.0
-19.4	-30.9	-46.0	-69.9	-109.7	-190.4	-455.0		19.9	30.9	45.1	65.8	98.2	161.0	301.0	1035.0
-19.5	-31.0	-46.1	-70.2	-111.0	-190.7	-464.0		20.1	31.0	45.2	66.0	99.0	162.0	303.4	1081.0
-19.7	-31.1	-46.2	-70.4	-113.1	-192.5	-474.5		20.2	31.2	45.3	66.5	100.0	163.9	314.3	1089.0
-19.8	-31.2	-46.3	-70.7	-113.2	-193.2	-480.0		20.3	31.3	45.7	66.6	102.5	164.3	314.5	1128.0
-20.0	-31.5	-46.5	-71	-113.4	-193.3	-483.0		20.4	31.7	45.8	67.5	102.8	165.0	319.2	1156.0
-20.2	-31.6	-46.7	-71.5	-113.7	-195.0	-493.5		20.5	31.9	46.0	67.7	102.9	165.8	320.0	1176.0
-20.3	-31.7	-47.0	-72.3	-113.8	-196.3	-495.0		20.7	32.0	46.1	67.8	103.4	167.2	324.0	1225.0
-20.4	-32.0	-47.3	-72.5	-114.5	-201.5	-505.7		20.8	32.1	46.3	67.9	103.6	167.4	325.0	1296.0
-20.6	-32.1	-47.6	-72.6	-115.0	-202.5	-516.0		21.0	32.2	47.0	68.2	104.1	169.0	329.0	1369.0
-20.7	-32.3	-48.0	-72.8	-116.0	-202.7	-527.0		21.2	32.5	47.1	68.3	104.5	170.2	332.5	1444.0
-20.8	-32.6	-48.1	-73.1	-117.9	-203.0	-528.0		21.3	32.6	47.2	69.0	105.0	171.0	335.4	1521.0
-20.9	-32.9	-48.2	-73.2	-118.2	-204.0	-532.0		21.4	32.7	47.3	69.3	107.3	173.7	341.0	1600.0
-21.0	-33.0	-48.6	-73.7	-119.0	-207.0	-539.0		21.6	33.0	47.5	69.6	107.7	174.3	344.0	1681.0
-21.2	-33.1	-49.0	-74.0	-119.3	-208.0	-560.0		21.7	33.1	47.7	70.0	108.3	175.0	351.0	1764.0
-21.3	-33.2	-49.1	-74.3	-120.0	-212.8	-575.0		21.8	33.3	48.0	70.9	108.4	176.0	352.0	1849.0
-21.5	-33.5	-49.3	-74.4	-121.2	-215.0	-586.7		21.9	33.6	48.3	71.2	108.5	178.6	359.3	1936.0
-21.7	-33.6	-49.4	-74.8	-121.5	-216.0	-594.0		22.0	33.9	48.6	71.4	108.8	179.2	361.0	2025.0
-21.8	-34.0	-49.9	-75.0	-123.0	-220.0	-615.0		22.2	34.0	49.0	71.7	109.1	183.8	362.7	2116.0
-22.0	-34.1	-50.0	-75.8	-123.2	-223.0	-624.0		22.3	34.1	49.1	72.4	110.2	183.9	369.0	2209.0
-22.1	-34.2	-50.1	-76.1	-124.0	-224.0	-629.0		22.5	34.2	49.2	72.5	110.7	185.0	370.0	2304.0
-22.2	-34.3	-50.6	-77.0	-125.0	-226.3	-644.0		22.7	34.5	49.6	73.3	112.0	186.0	378.0	2401.0
-22.3	-34.8	-51.0	-77.3	-125.5	-229.4	-665.0		22.8	34.6	50.0	73.5	114.1	187.2	385.0	
-22.4	-35.0	-51.3	-78.2	-125.7	-230.0	-673.7		23.0	35.0	50.1	73.6	114.2	188.5	386.4	
-22.5	-35.1	-51.8	-78.5	-126.3	-231.0	-675.0		23.1	35.1	50.3	73.8	114.3	190.0	389.5	
-22.6	-35.4	-52.1	-78.8	-126.5	-232.3	-702.0		23.2	35.2	50.4	74.1	114.4	191.4	400.0	
-22.7	-35.5	-52.2	-79.2	-128.0	-237.9	-704.0		23.3	35.3	50.9	74.2	114.7	191.7	404.0	
-22.8	-35.6	-52.3	-80.0	-129.5	-340.0	-728.0		23.4	35.5	51.0	74.3	114.8	193.5	406.0	

Laboratory of Research on Mechanical Transmission Technical Level

Stands for experimental testing of technical level parameters of power and kinematic precessional planetary reducers





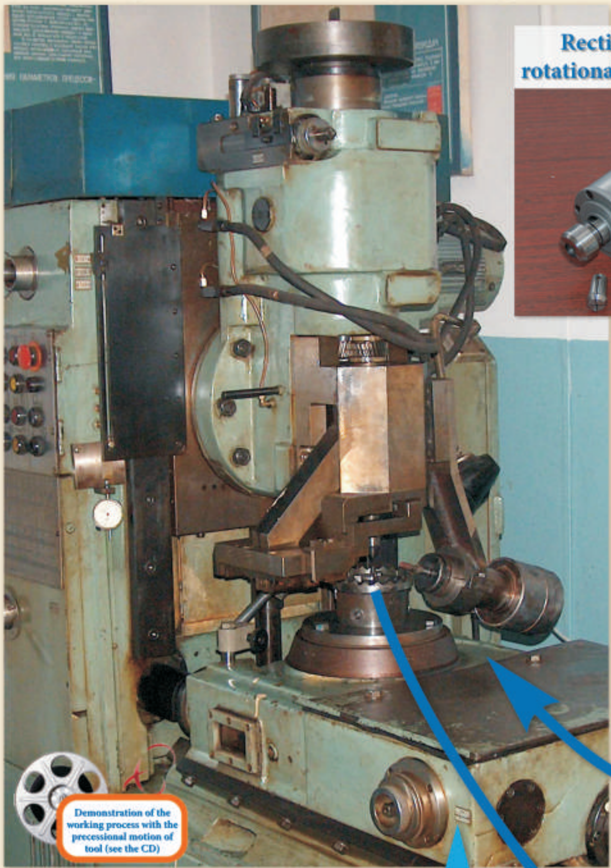


Stands for experimental testing of power precessional planetary reducers

Lecturer Ion Bodnariuc, PhD student, sitting at the testing stand, equipped with a measuring and data processing Labview computer system

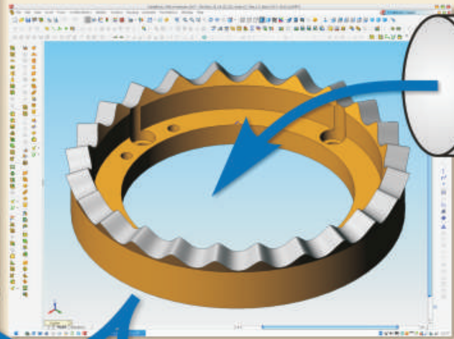
Laboratori of Manufacturing Technologies of Precesional Gears

Machine-tool for processing of wheels with spherical-spatial motion of the generating counter

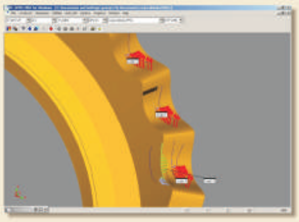


Rectifying head of high rotational motion (42000min^{-1})

***PhD student* Maxim Vaculenco**

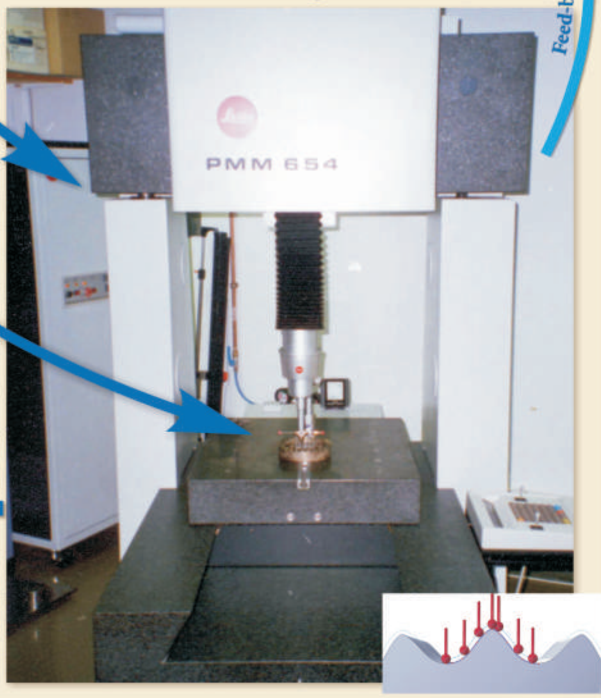


CAD/CAM/CAE/CAQ Progection



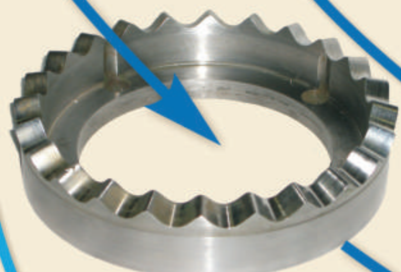
Feed-back to part design process

Coordinate Measuring Machine (CMM)



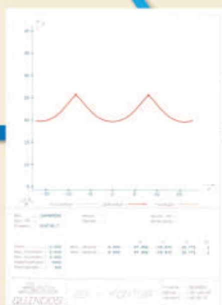
Profilometer

Feed-back to the manufacturing process



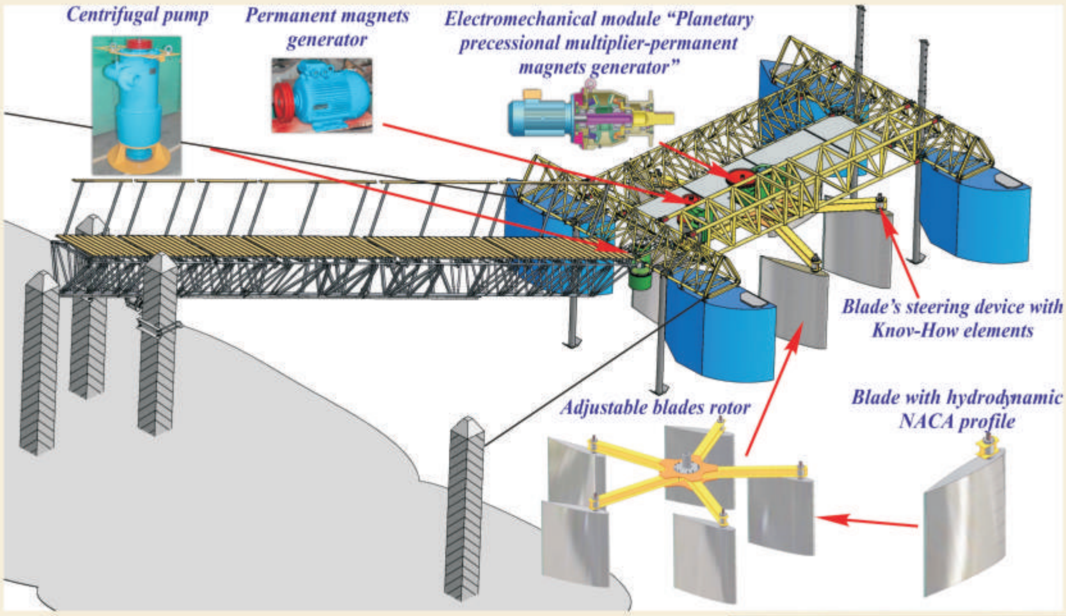
INSPECTION

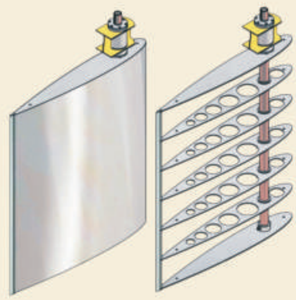
PROTOCOLS

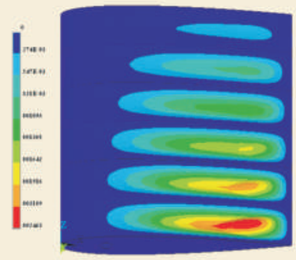


Samples of toothed wheels processed at the rectifying machine-tool with spherical-spacial motion of the profile generating counter

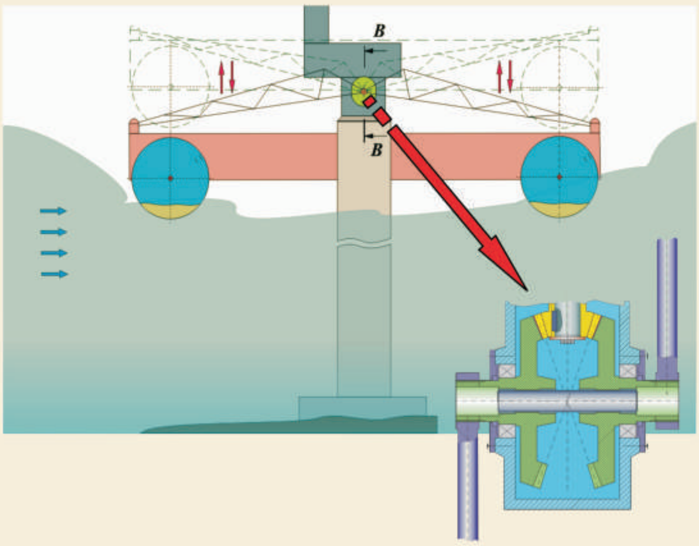
Centre for Elaboration of Renewable Energy Conversion Systems



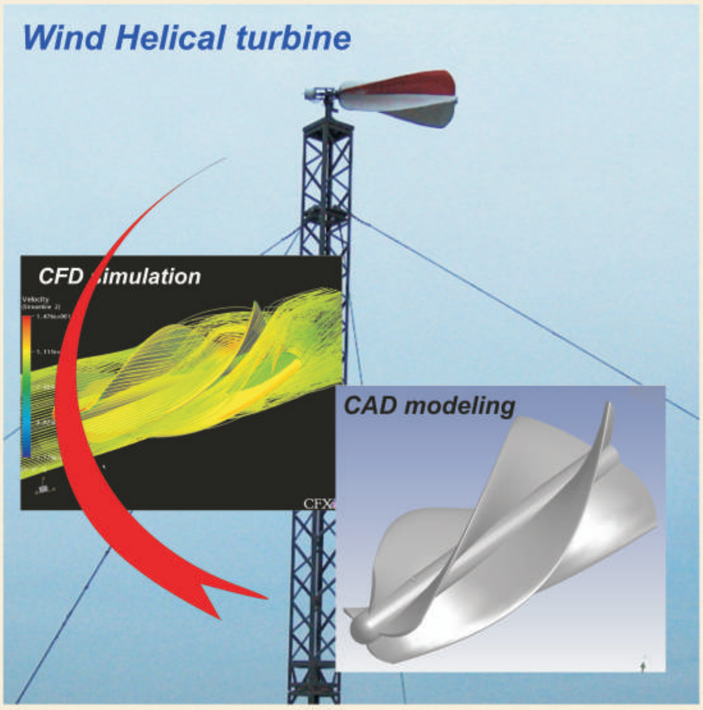




Unit for sea waves energy conversion into electrical energy



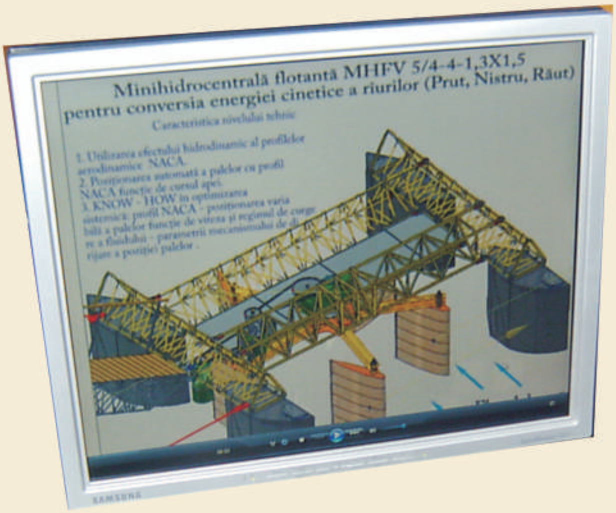
Dr. Assoc. Prof. Viorel Bostan, carries out computer simulation of the "liquid-blades with hydrodynamic profiles" interaction



Lecturer Rodion Ciuperca, PhD student, carries out 3-D modeeling and simulation of the "liquid-blades with hydrodynamic profiles" interaction

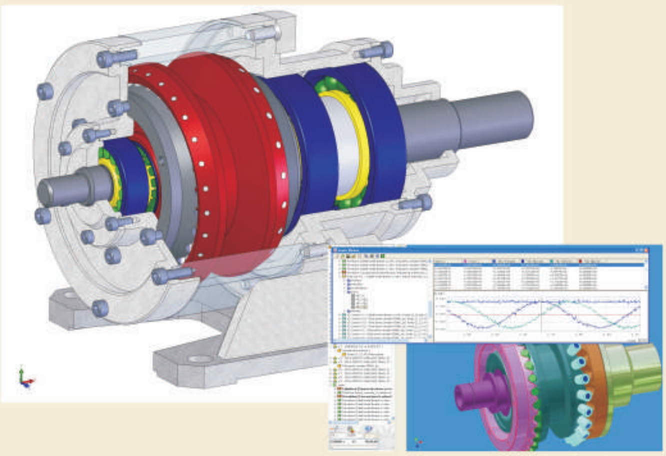
Centre for Mechanical Systems, Computer Simulation

PhD student Oleg Ciobanu
PhD student Radu Ciobanu
PhD student Odainai Valeriu
PhD student Cozma Tudor



CAD proiectation and CAE simulation of Micro-hydro-power-station

PhD student Nicolae Trifan
PhD student Dumitru Vengher



CAD proiectation and CAE simulation of Planetary Precessional Transmission

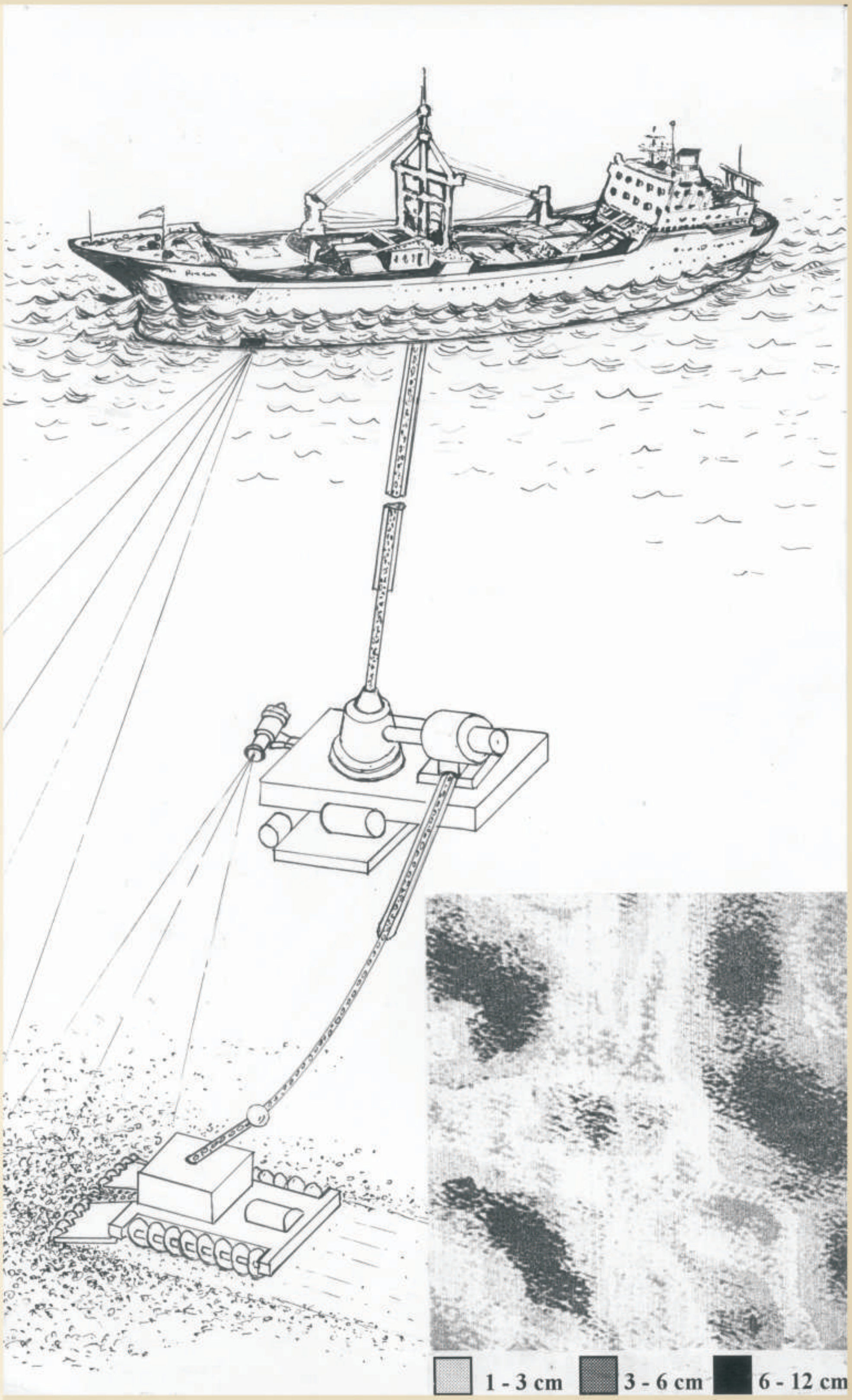
PhD student Anatolie Sochirean

THE ELABORATION OF SUBMERSIBLE ROBOT COMPLEX DRIVE MECHANISM FOR FERRO-MANGANESE CONCRETION EXTRACTION

A special interest presents the concretions of pure metals in the form of black tubers having a diameter 1-12 cm. The manganese concretions, typical for the World Ocean, contain in the average 27% Mn, 8% Fe, 1,4% Ni, 1,3% Cu, 0,2% Co. To be evident: the deposits of raw materials at a depth of about 5000m make 15-75kg/m^2.

From 1984 till the disintegration of the USSR a research team from the Technical University of Moldova (TUM) participated in the investigations within an all - union research program concerning the elaboration of the technological devices for Ferro-manganese concretion extraction. That program was set up by the Council of Ministers of the former USSR, decree of 29.08.87 "Concerning the measures of ensuring the elaboration of the technological devices for the extraction of Ferro-manganese concretions from the bottom of the sea sector belonging to the USSR" Nr. 1007. This problem can be solved by using new types of mechanical transmissions planetary precessional transmissions.

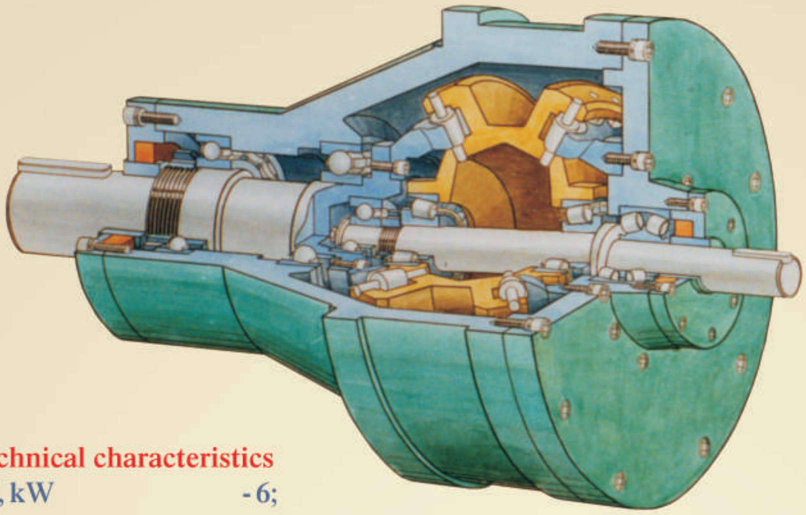
The high bearing capacity and reliability of the precessional transmissions provided by the multicouple gear favored the elaboration of a large range of precessional reducers for various drive mechanisms of the extracting robot complex. The transmission power being 0,37-74 kW and transmission ratio i=45...1700. From the elaborated range of precessional reducers we have implemented the "zero" series of 3 type-dimensions and performed the experimental research which showed high performances.

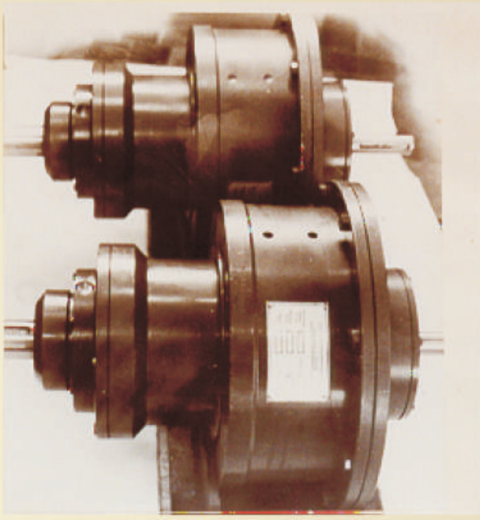


Robot complexes for extracting Ferro- manganese Concretions from the World Ocean bottom.

Reducer of the feeder-batcher drive mechanisms

THE ZERO SERIES OF THE PRECESSIONAL REDUCER WERE PRODUCED AT "AZOVMAS" FACTORY MARIUPOL, UKRAINE

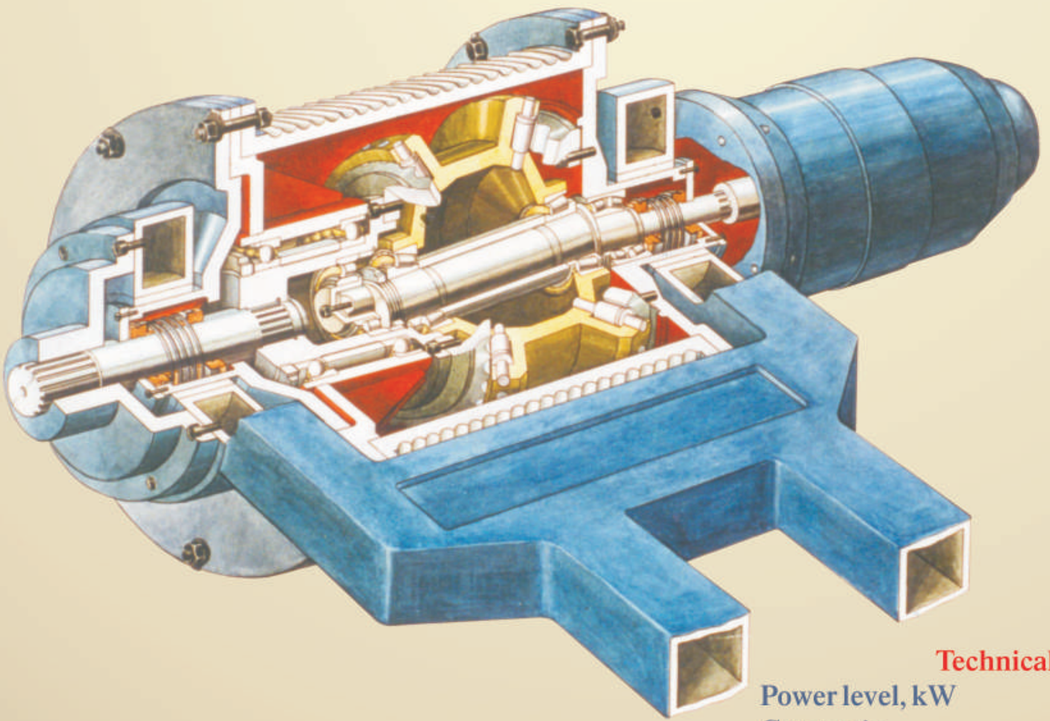




Technical characteristics

Power level, kW	- 6;
Gear ratio	- 144;
Efficiency	- 0,82;
Torque moment, Nm	- 2950;
Acoustic power level, dBa	- 60...75.

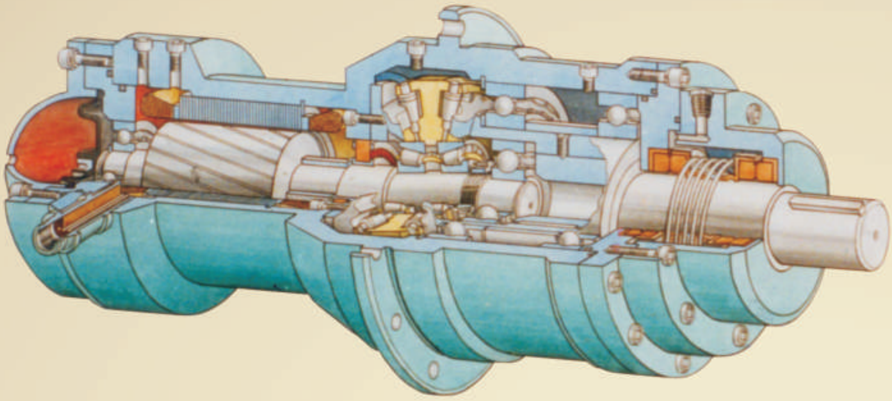
Precessional reducer of the mechanisms for the robot complex arm



Technical characteristics

Power level, kW	- 37;
Gear ratio	- 144;
Efficiency	- 0,82;
Torque moment, Nm	- 54312;
Specific material consumption, kg/Nm	- 0,049.

Precessional electromechanic al modulus of the hydrolocator drive mechanisms



THE ZERO SERIES OF THE PRECESSIONAL REDUCER WERE PRODUCED AT "AZOVMAS" FACTORY MARIUPOL, UKRAINE

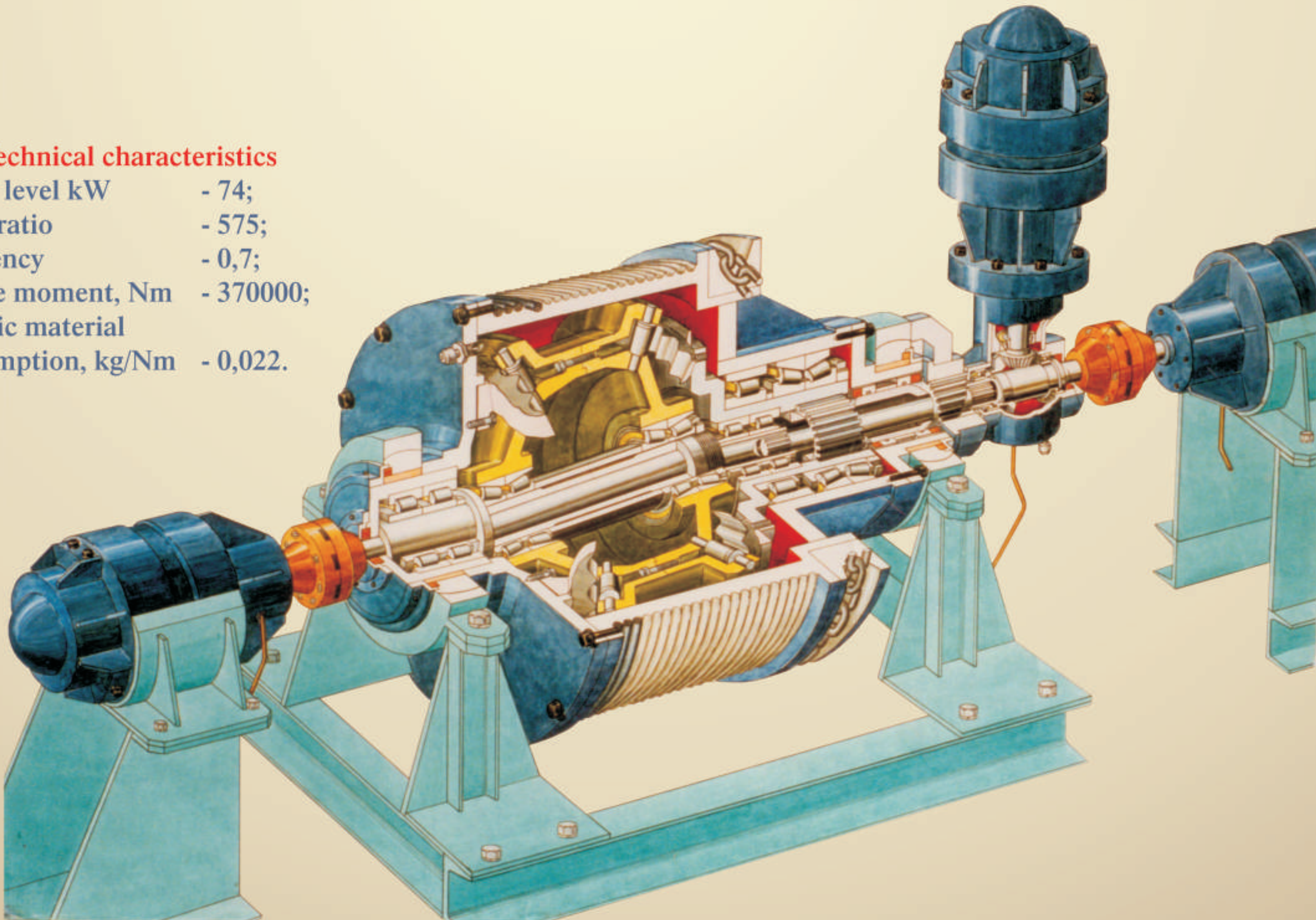
Technical characteristics

Power level, kW	- 0,37;
Gear ratio	- 323;
Efficiency	- 0,82;
Kinematic accuracy, ang/sec	- 60...90;
Acoustic power level, dBa	- 60...75.

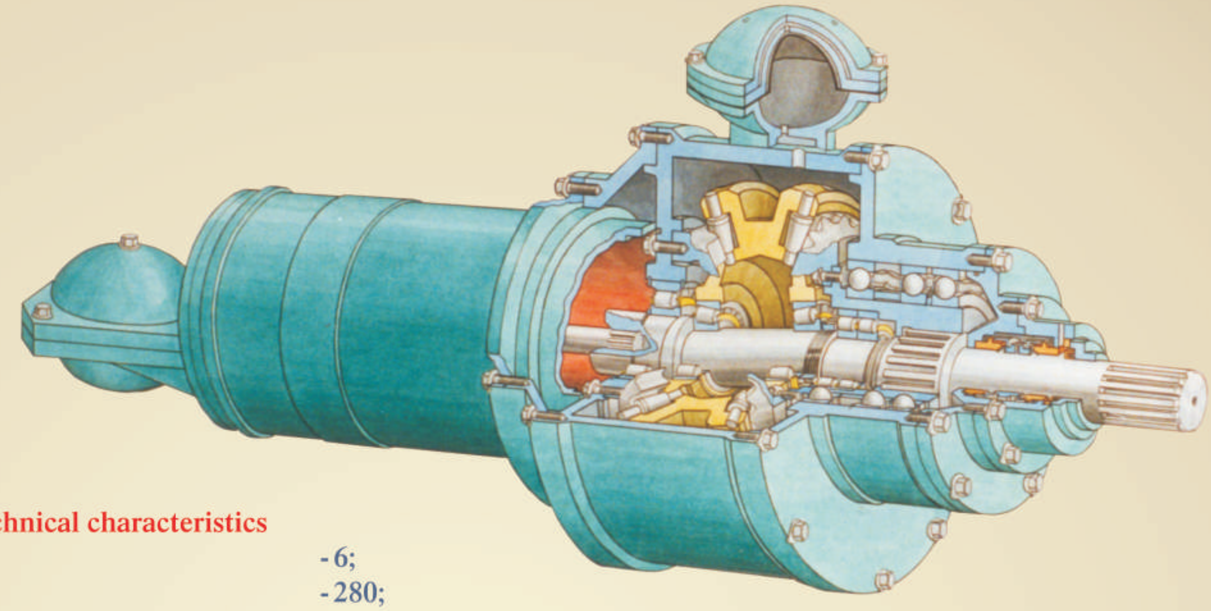
Precessional reducer of the robot complex drive mechanisms

Technical characteristics

Power level kW	- 74;
Gear ratio	- 575;
Efficiency	- 0,7;
Torque moment, Nm	- 370000;
Specific material consumption, kg/Nm	- 0,022.



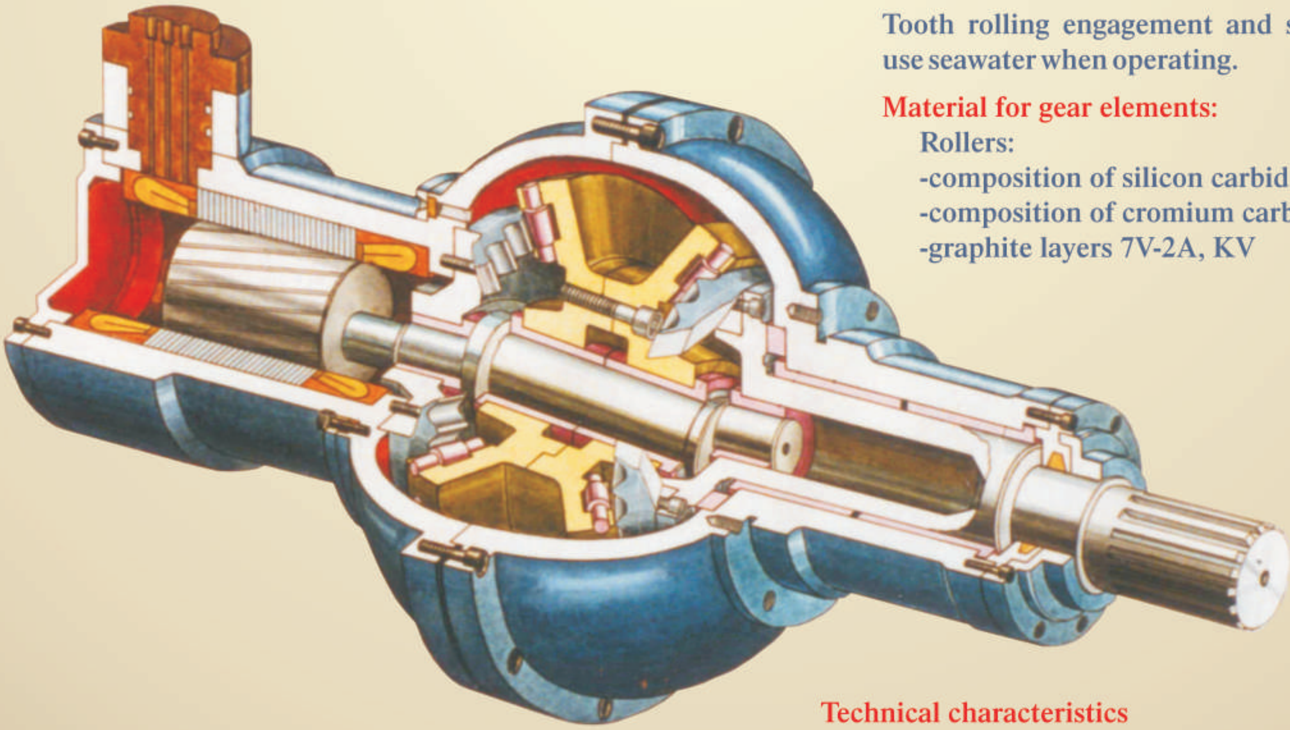
Precessional motor-reducer for submersible techniques



Technical characteristics

Power level, kW	- 6;
Gear ratio	- 280;
Efficiency	- 0,75;
Torque moment, Nm	- 15000;
Specific material consumption, kg/Nm	- 0,049.

Non-pollute precessional motor-reducer of the self-propelled set drive for RCEC from the World Ocean bottom



Tooth rolling engagement and sliding bearings use seawater when operating.

Material for gear elements:

Rollers:

- -composition of silicon carbid SUGVAM;
- -composition of cromium carbide KHN15Pr;
- -graphite layers 7V-2A, KV

Technical characteristics

Gear ratio	- 279;
Efficiency	- 0,75;
Torque moment, Nm	- 15000;
Specific material consumption, kg/Nm	- 0,03.

PRECESSIONAL ELECTROMECHANICAL MODULUS FOR THE COSMIC FLYING DEVICES

Basic advantages of kinematical planetary precessional transmissions (PPT) are high kinematical accuracy, due to gearing multiplicity (100% teeth pairs gearing simultaneously) and axial positioning of the pinion and central wheels.

These advantages favour the mediation of transmission structural errors, technological errors and of those errors which have been generated by the de-formability of all constituent parts of the gear. Axial positioning of gears allows for self-adjustment of games occurring in the result of unavoidable wear of contact surfaces.

In 1984-1990 within research/development projects with the Institute for Space Research of the Academy of Sciences (USSR), "Cometa" Research and Development Enterprise (Moscow), enterprise No. 4805 Krasnoyarsk (Russian Federation), the following results have been researched, designed and implemented (see pictures in the prospectus, pages 12 – 13):

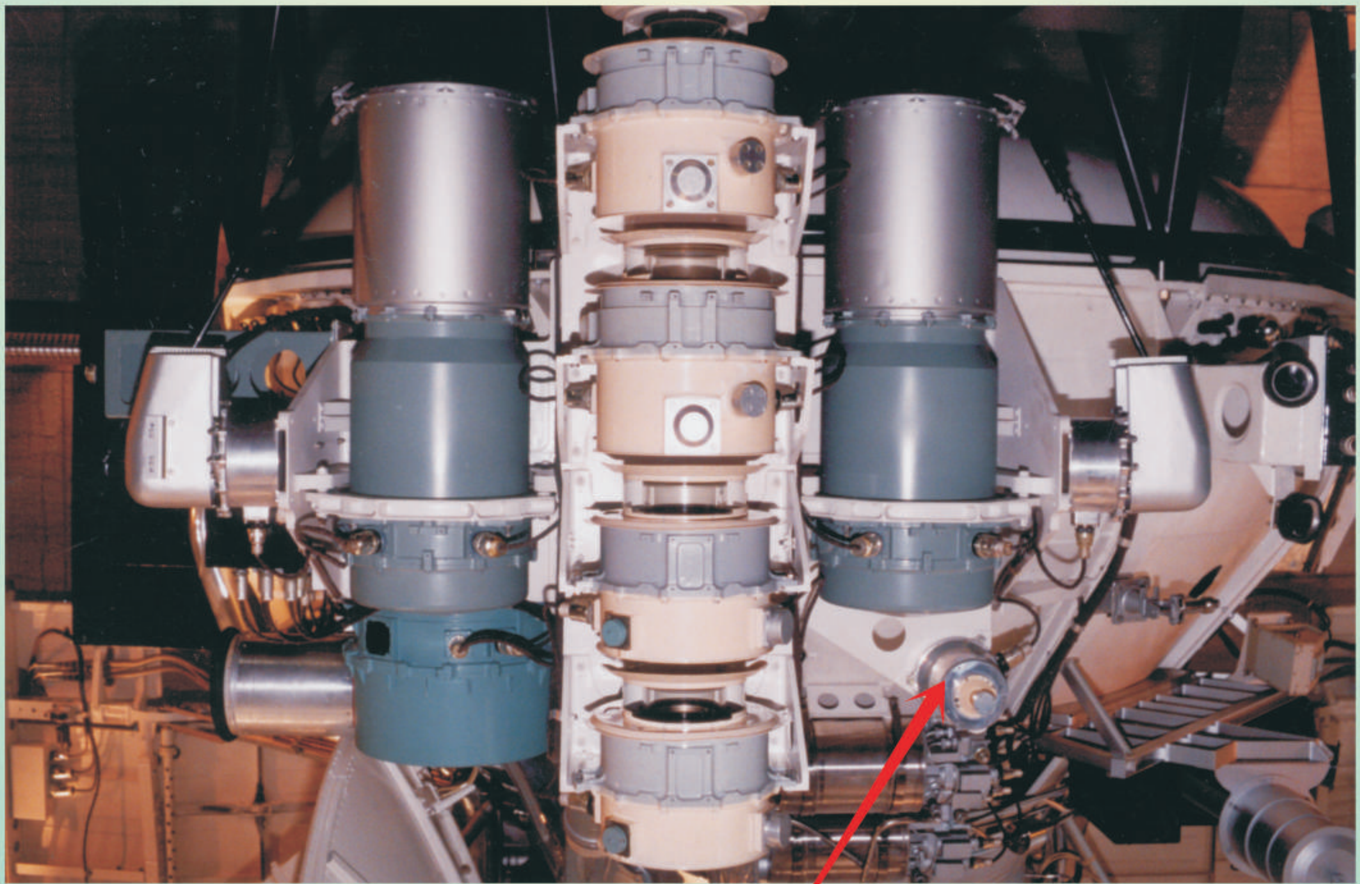
· precessional electromechanical modulus with orientation transducers for Vega-6 flying space device was implemented by Enterprise No 4805, protocol approved on 08.07.1986, Krasnoyarsk, USSR;

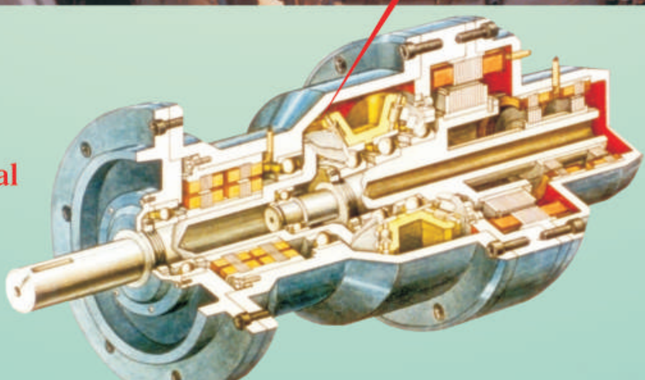
· antenna positioning precessional electromechanical modulus for flying space device was endorsed for implementation by the decision of the Special Design Office of the Academy of Science Cosmic Research Institute, USSR, protocol of 06.05.1989;

· planetary precessional transmission with high kinematical accuracy (40 angular seconds) was endorsed for implementation, the protocol No 1/29DCP of 29.07.1988, approved by „Cometa" Research and Development Enterprise, Moscow, USSR;

· a large range of driving mechanisms for industrial robots with high positioning accuracy, etc., which are protected by 21 patents.

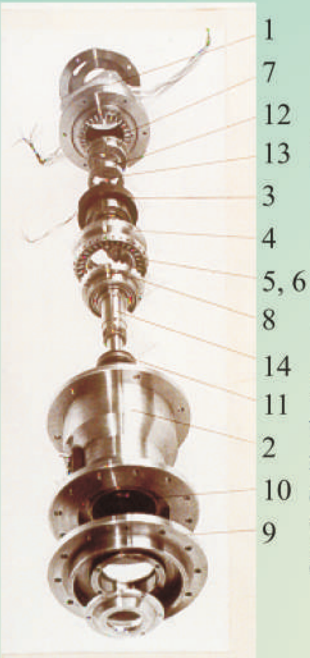
Vega - 6 fliyng space device (former USSR)

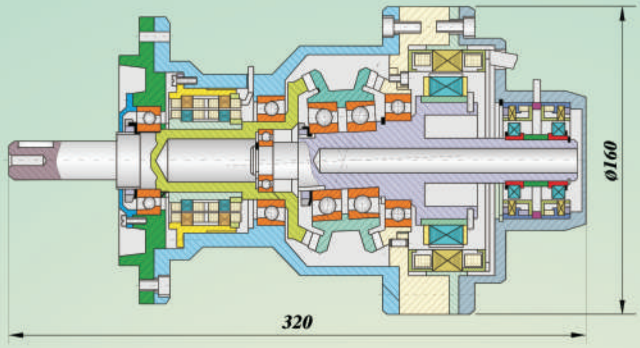




Precessional electromechanical modulus

Precessional electromechanical modulus with orientation transducers for Vega-6 flying space device





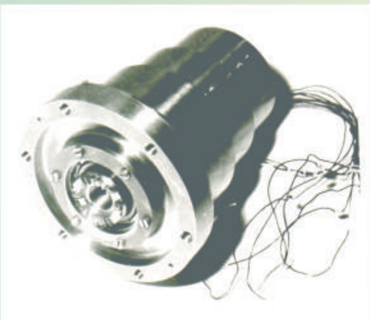
Implemented by enterprise No. 4805
Krasnoyarsk, USSR

1- torque motor DBM-120; 2-housing; 3-single throw crankshaft; 4-planet pinion; 5,6-rolling rims; 7,8-fixed and movable central wheels; 9-end shield; 10,11-rotating transformers DU-71; 12,13-rotating transformers VT-60; 14-driven shaft.

Technical characteristics

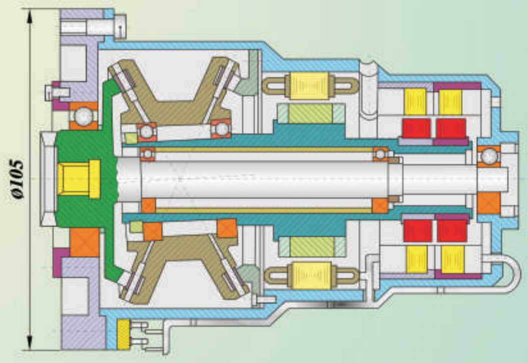
Power level, W	- 120;
Torque moment, Nm	- 95;
Gear ratio	- 299;
Efficiency	- 0,75;
Kinematic accuracy, ang/sec	- 60;
Acoustic power level, dBa	- 60...75.

Antenna positioning precessional electromechanical modulus for flying space device



Technical characteristics

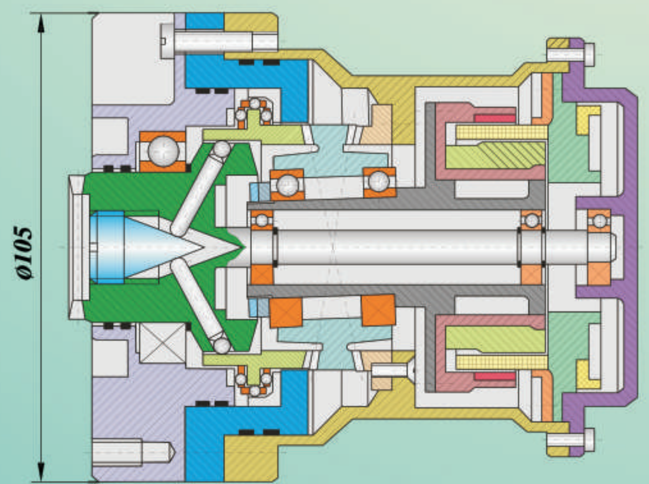
Power level, W	- 80;
Gear ratio	- 840;
Efficiency	- 0,7;
Kinematic accuracy, ang/sec	- 70;
Acoustic power level, dBa	- 60...75.



Planet rolling unit of pinions is obtained by means of sintering from metal powder.

Elaborated with the OKB IKI
Specialised Design Office of the
Institute for Space Research, USSR

Precessional electromechanical modulus with high kinematical accuracy



Technical characteristics

Power level, W	- 80;
Gear ratio	- 2115;
Efficiency	- 0,6;
Kinematic accuracy, ang/sec	- 70;
Acoustic power level, dBa	- 60...75.

Planet rolling unit of pinions is obtained by means of sintering from metal powder.

Elaborated with the “Cometa” Research and Development Enterprise, Moscow, USSR

PRECESSIONAL REDUCER OF THE SUBMERSIBLE PUMP FOR OIL EXTRACTION

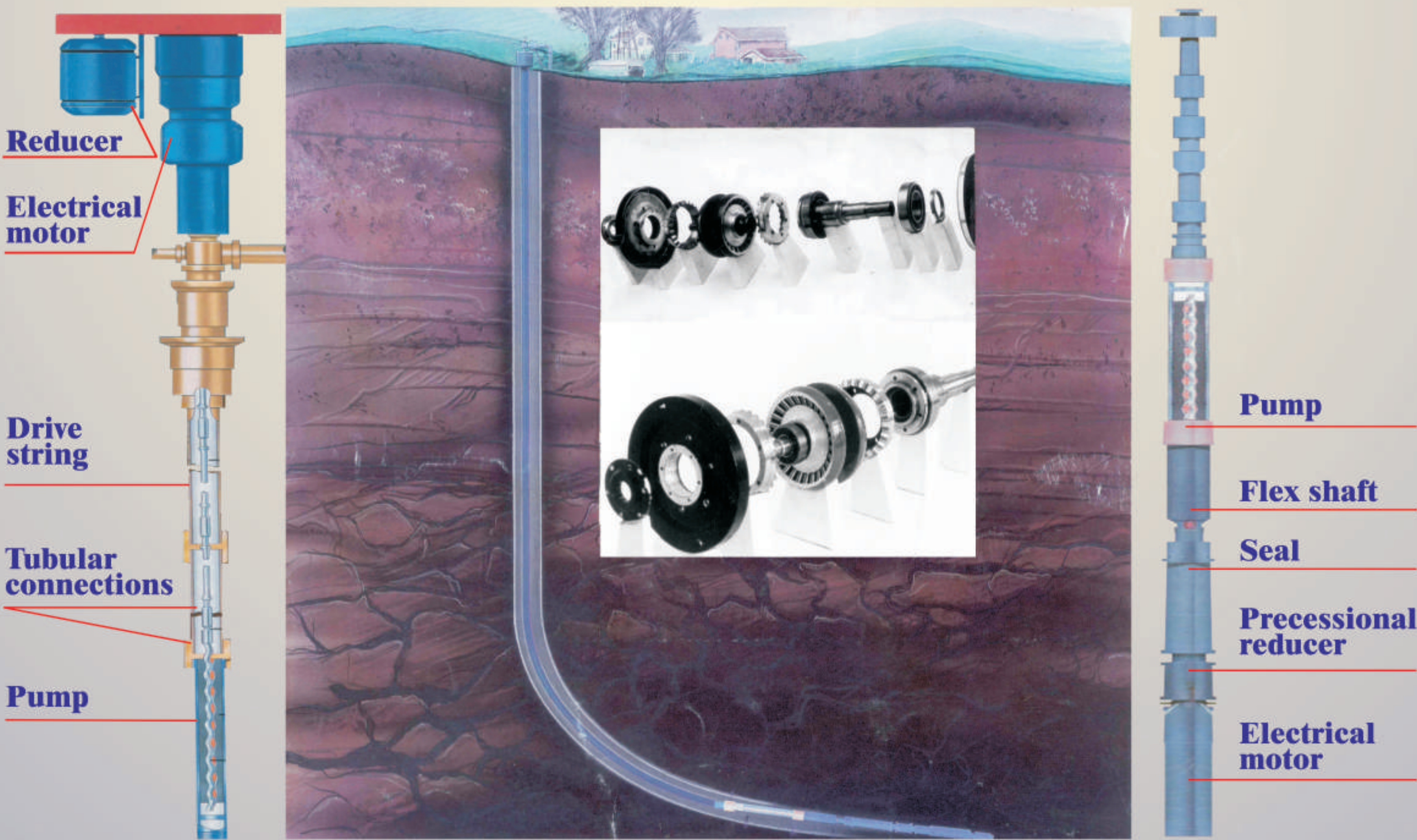
In the classical equipment of oil extraction from big depths the electrical motor and reducer are placed at the surface. The pump is put into motion by means of a long, flex shaft. In these cases the power losses are big, the reliability is reduced, especially such are frequent cases when the auger meeting hard rocks deviate from its vertical direction.

In conformity with the modern technologies for oil extraction from big dephts, the electrical motor, the reducer and the pump are placed at depth in the pumping zone. But, in this case, some very rigid restrictions are required regarding the diametrical dimensions of the electrical motor and the reducer, which must be placed in down-hole tubes of a small diameter (for ex. Ø108 mm and Ø133mm).

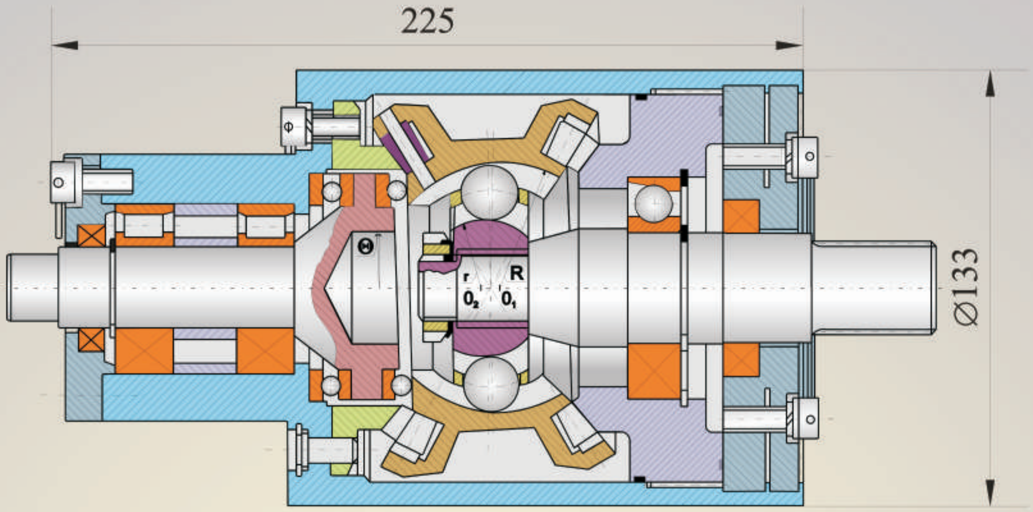
The utilization of reducers in the equipment for oil extraction with submersible location of the driving mechanism becomes more and more important due to the strict requirements to the bearing capacity and small dimensions. These requirements can be followed strictly by utilizing precessional reducers with multipair gear already containing patented elements.

At the order of the firm MOYNO from Canada, there were elaborated 2 variants of reducers, having special schemes at their basis.

CLASSICAL TECHNOLOGY **MODERN TECHNOLOGY**



Precessional reducer of the submersible pump for oil extraction (ø133)



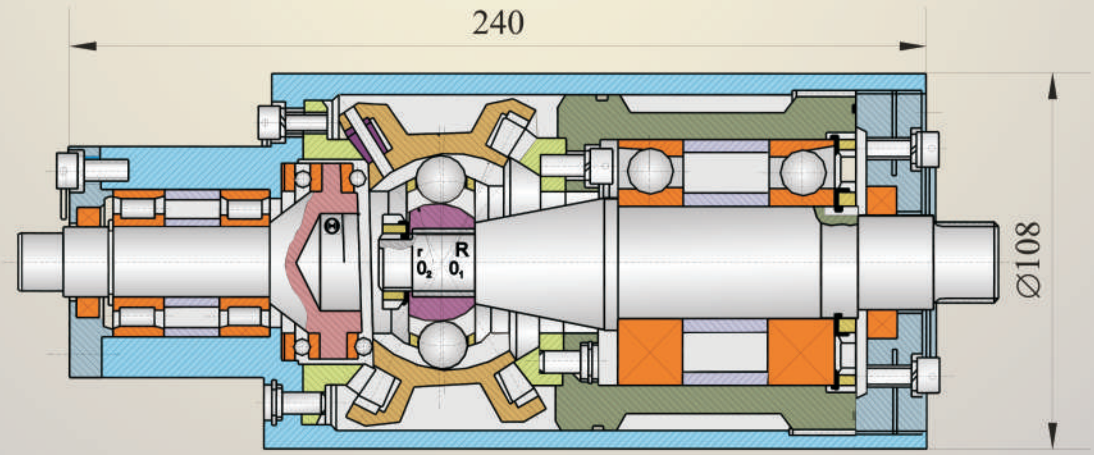
Technical characteristics

Torque moment, Nm	- 1100;
Rotation frequency, min^{-1}	- 4500;
Gear ratio	- 15;
Life service, h	- 10000.

PATENTED ELEMENTS

- Multiple precessional gear
- Multiple frontal generator
- Coupling placed in the centre of the precession with balls in the bisectoral plane.

Precessional reducer of the submersible pump for oil extraction (ø108)



Technical characteristics

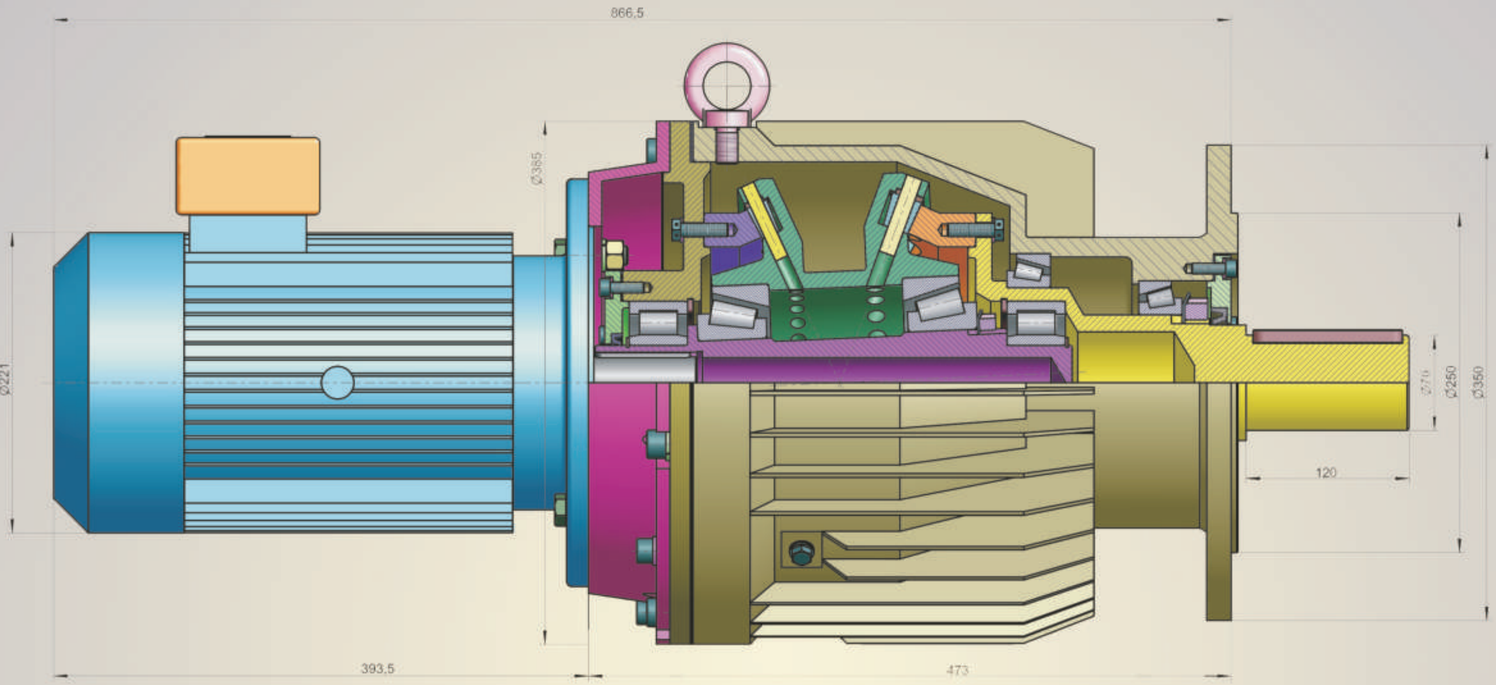
Torque moment, Nm	- 1700;
Rotation frequency, min^{-1}	- 4500;
Gear ratio	- 15;
Life service, h	- 10000.

PATENTED ELEMENTS

- Multiple precessional gear
- Multiple frontal generator
- Coupling placed in the centre of the precession with balls in the bisectoral plane.

Precessional Gear Motor with aluminum housing

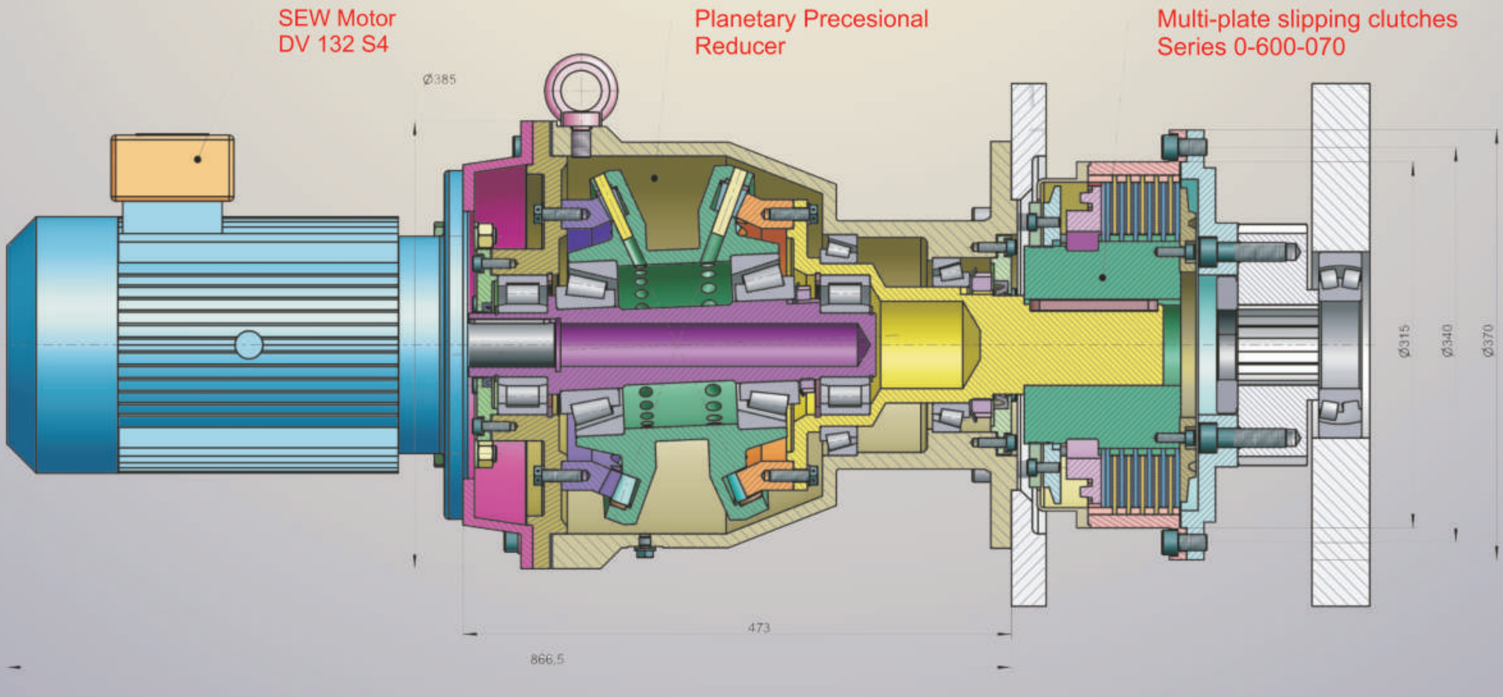
Elaborated: TUM, Chisinau, Republic of Moldova; UAS, Konstanz, Germany.
The technical documentation in electronic version was transmitted for manufacturing to the ARP enterprise, Maschinenbau GmbH Alpirsbach - Peterszell, Germany



Technical characteristics

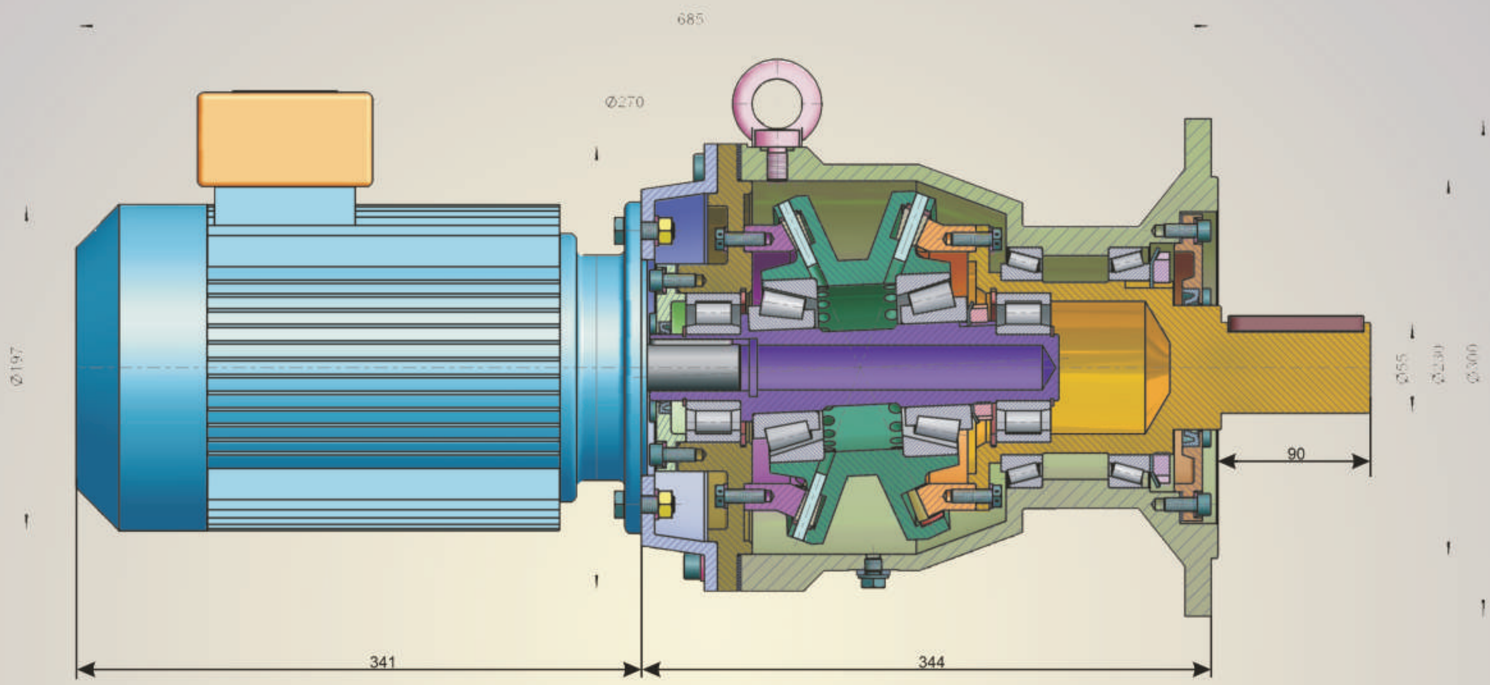
Power level, kW	- 5.5;	Rotation frequency, min^{-1}	- 1430;
Gear ratio	-106.3;	Weight, kg	- 120;
Torque moment, Nm	- 4000;	Size, mm	- Ø385x473.

Assembly of Motor - Reducer with technological equipment



Precessional Gearmotor with steel housing

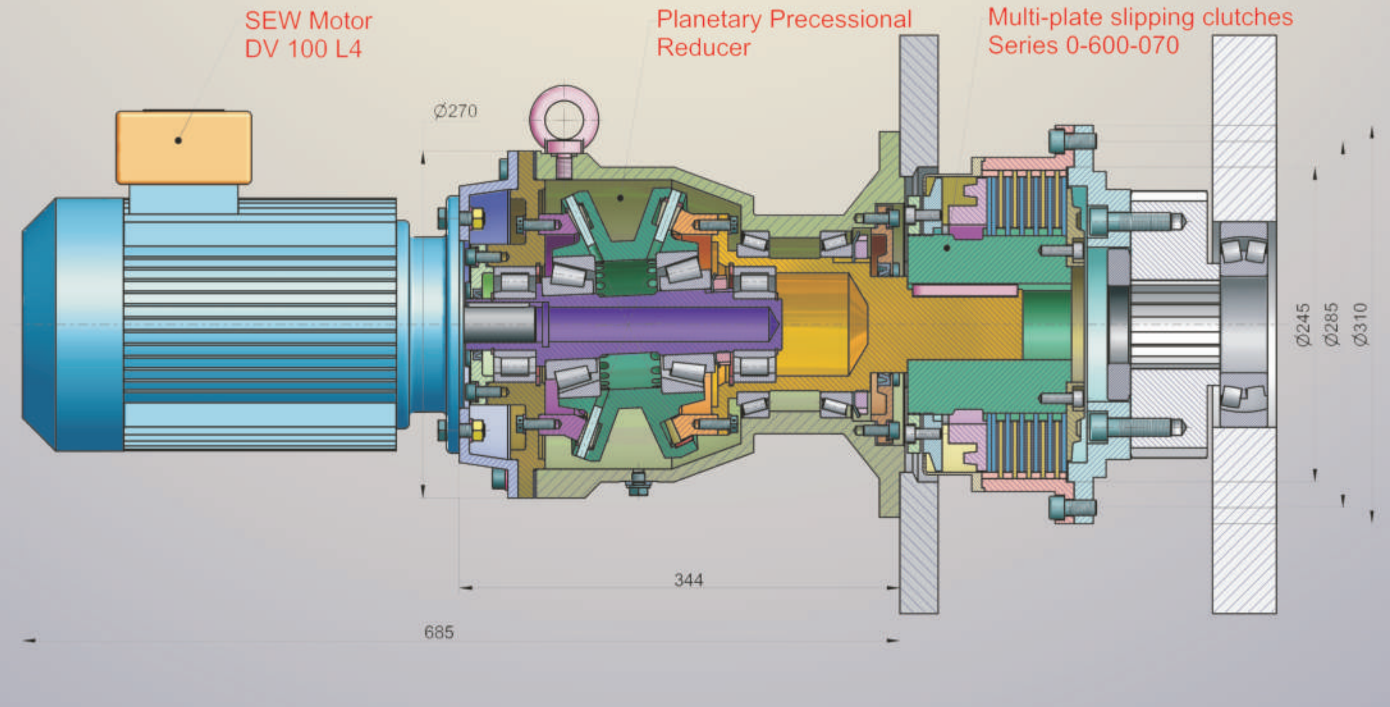
Elaborated: TUM, Chisinau, Republic of Moldova; UAS, Konstanz, Germany.
The technical documentation in electronic version was transmitted for manufacturing to the ARP enterprise, Maschinenbau GmbH Alpirsbach - Peterszell, Germany



Technical characteristics

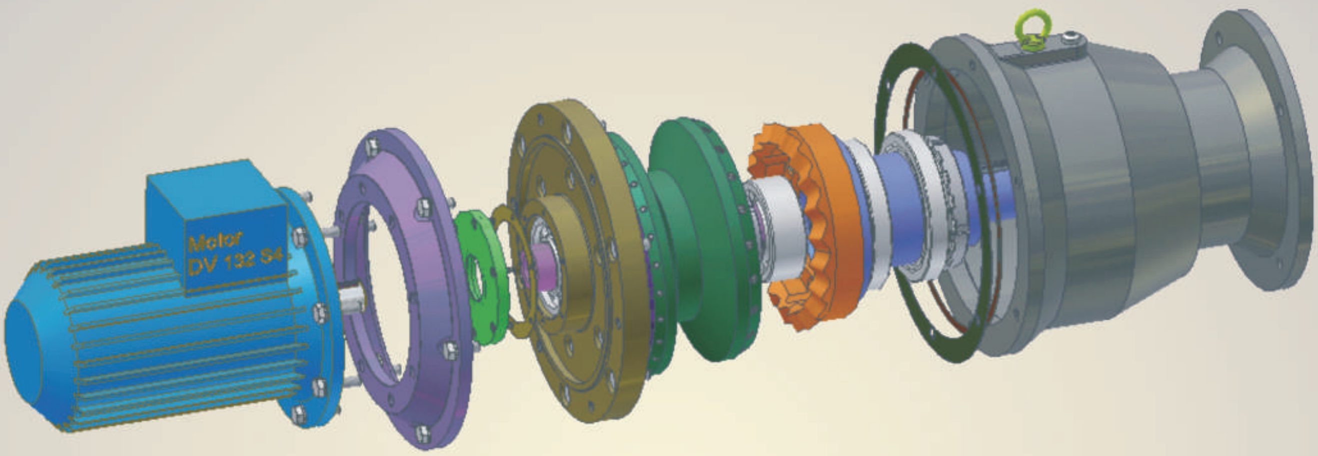
Power level, kW	- 3.0;	Rotation frequency, min^{-1}	- 1400;
Gear ratio	-80.0;	Weight, kg	- 50;
Torque moment, Nm	- 1480;	Size, mm	- Ø270x344.

Assembly of Motor - Reducer with technological equipment

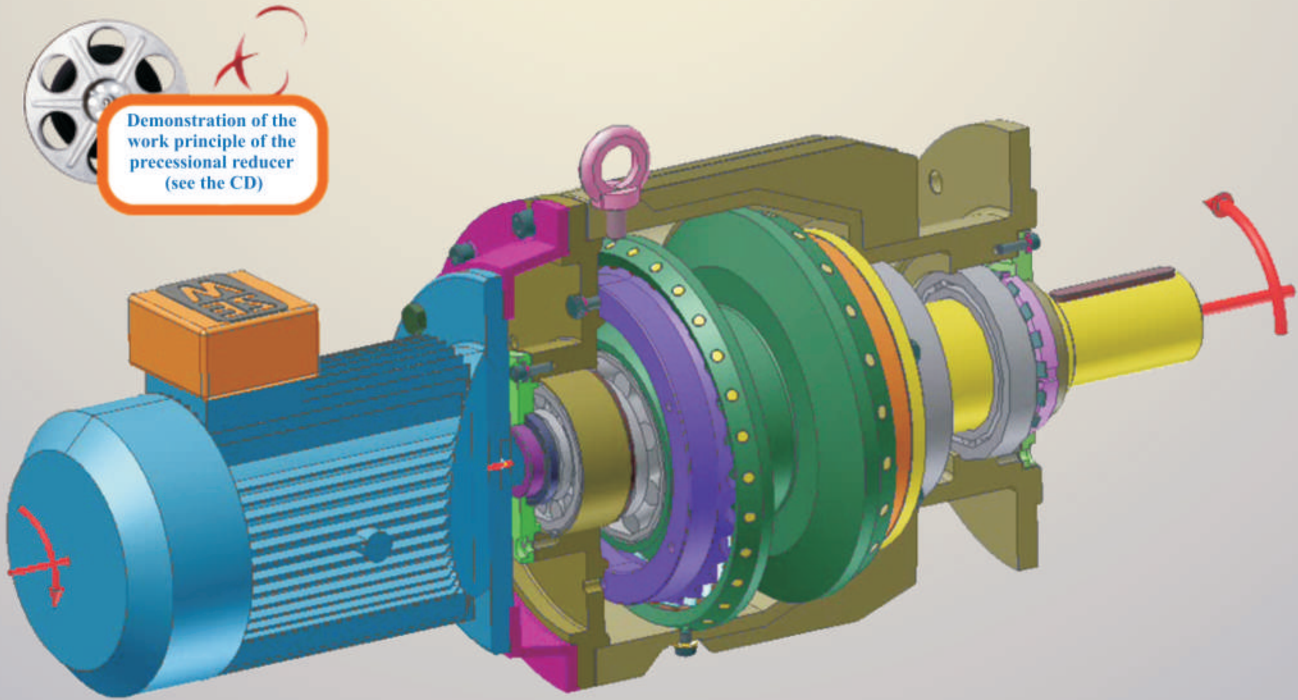


Compositional structure of the precesional motor-reducer, i = 80, T=1480Nm

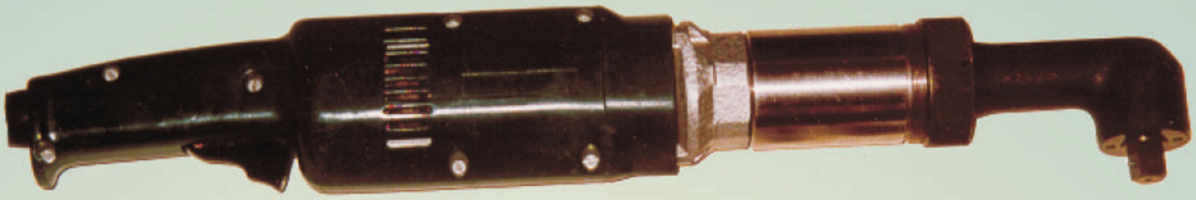
Elaborated: TUM, Chisinau, Republic of Moldova; UAS, Konstanz, Germany.
The technical documentation in electronic version was transmitted for manufacturing to the ARP enterprise, Maschinenbau GmbH Alpirsbach - Peterszell, Germany

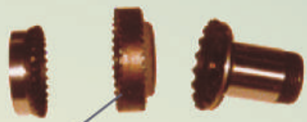


Demonstration of Precessional Motor - Reducer



Nut wrench

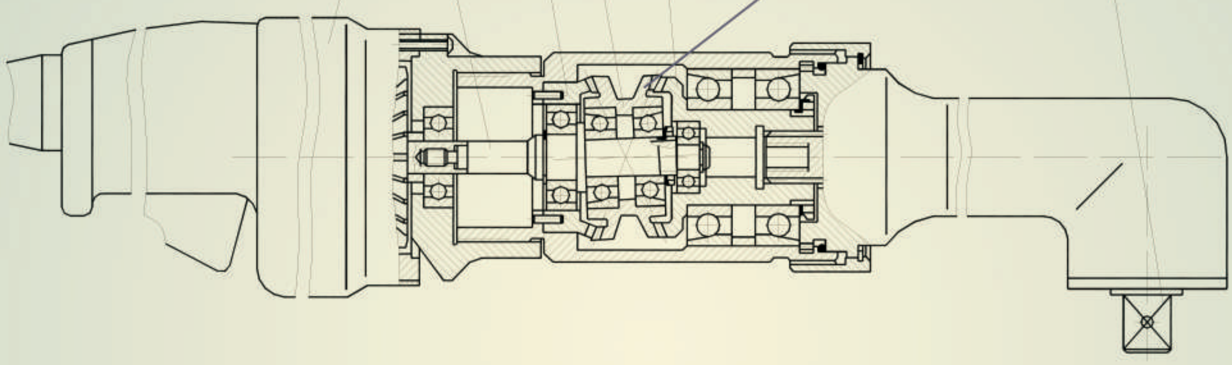




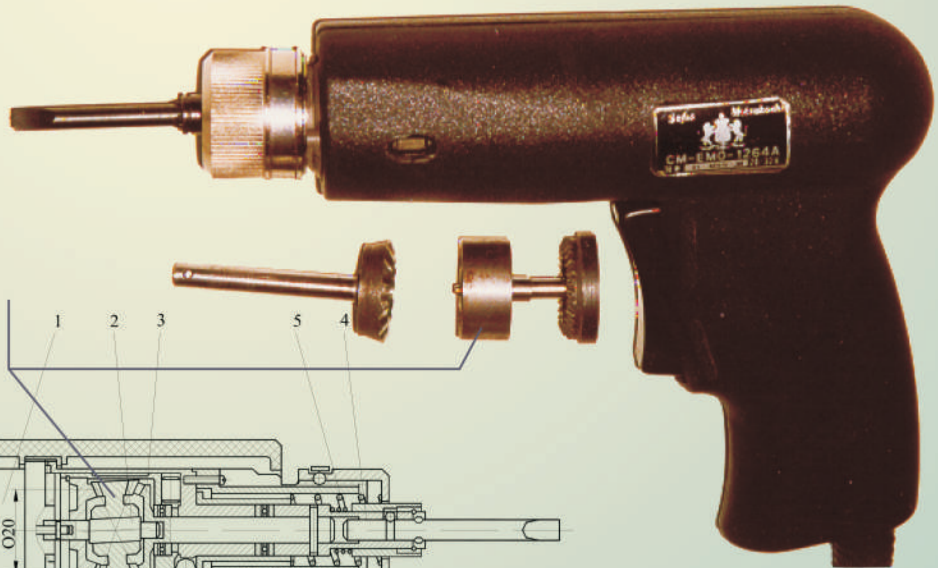
Technical characteristics

Power level, W	- 470;
Gear ratio	- 72;
Torque moment, Nm	- 100;
Frequency, min^{-1}	- 12000.

Planet rolling unit of pinions is obtained by means of sintering from metallic powders.



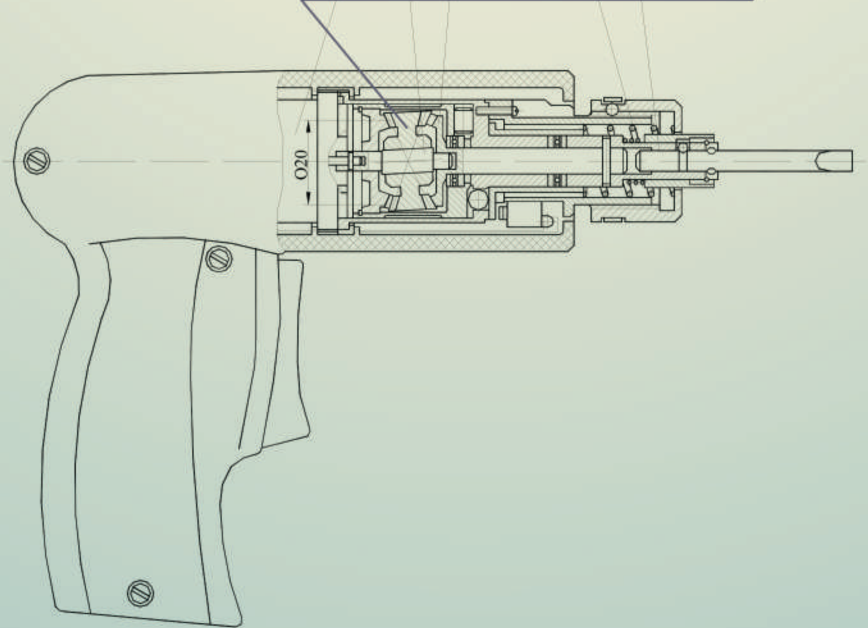
The electromechanical screwdriver



Technical characteristics

Power level, W	- 80;
Gear ratio	- 36,2;
Torque moment, Nm	- 3;
Frequency, min^{-1}	- 6000.

Planet rolling unit of pinions is obtained by means of sintering from metal powder.



ELABORATION AND IMPLEMENTATION OF PLANETARY PRECESSIONAL TRANSMISSIONS

Kinematical planetary precessional transmissions

Fast automation of various processes demands efficient low cost drive mechanisms. Kinematic precessional transmissions own obvious advantages comparatively to other types of transmissions.

The kinematical planetary precessional transmissions have high performances permitting their successful application in various fields: fine mechanics, mechatronics, kinematic drive mechanisms for cars, etc.

Most of the advantages of precessional reducers are reasoned by the new type of toothed-rolling engagement with convex-concave teeth profile with all teeth simultaneously mating.

In precessional transmission the gear wheel produces spherical-spatial motion round a fixed point. It is known that the body which produces spherical motion has three degrees of freedom. The position of the body, which produces precessional motion, is determined by Euler angles:

ψ - precessional angle; θ - nutating angle; φ - self rotating angle.

The rotating motion of the crankshaft is transformed into spherical-spatial motion of the block pinion with two teethed crowns, which are rolling without sliding on the immovable and driven toothed wheels. In this case the number of teeth of the gearing wheels differs.

Within an unusually wide reduction range, various reduction rates can be achieved with the same number of parts by simple varying of the toothing parameters. This drive technique requires just a few components that can be injection-moulded at a low price.

Possibilities for the Kinematical Precessional Transmissions

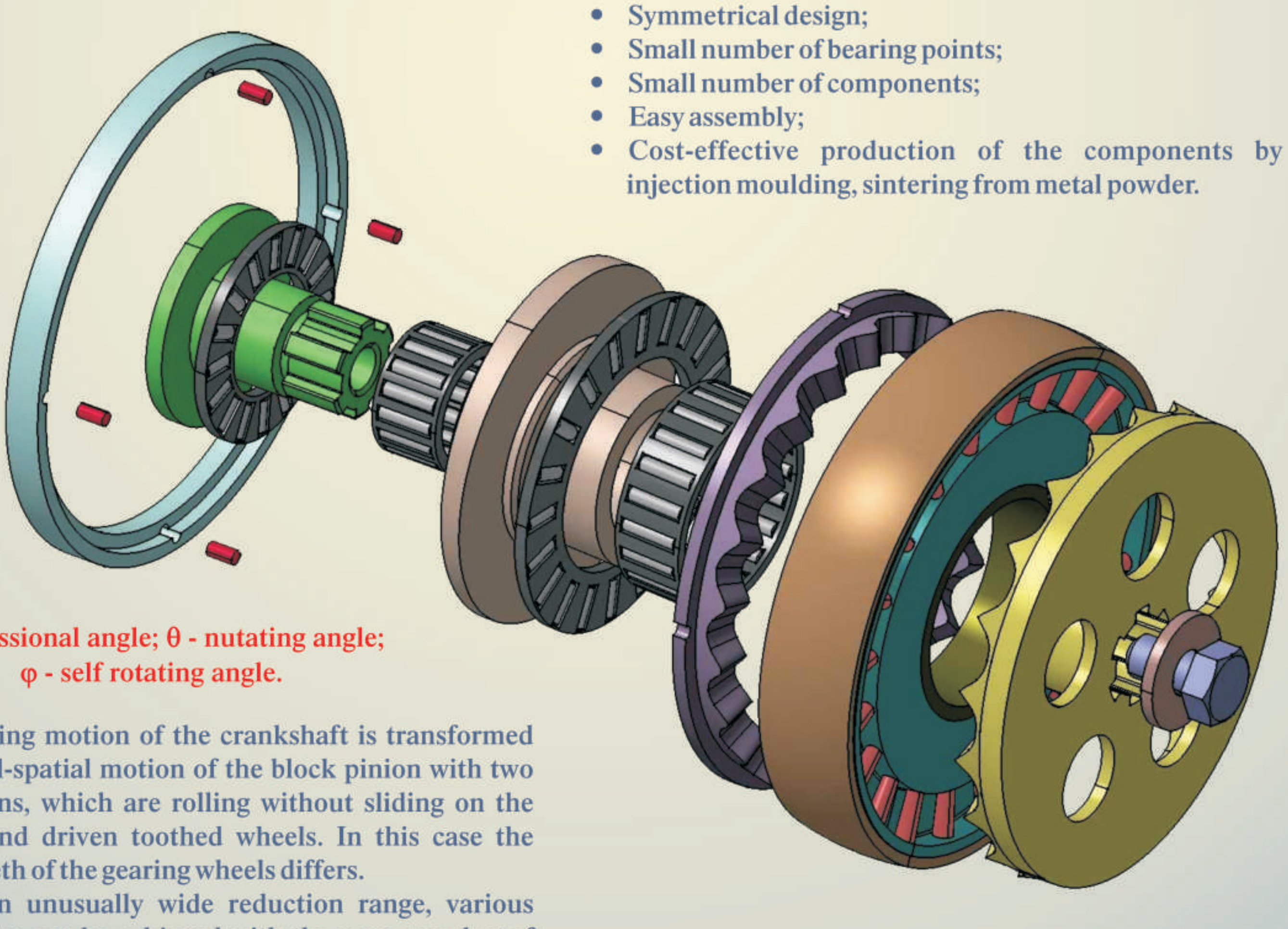
✓ For every specific application we can design a special gearing with consideration of the specific character of spherical-spatial (precessional) motions;

✓ To obtain a large reduction ratio (i to 14000000) it is possible to elaborate a special precessional transmission based on the "matreshca" principle.

Advantages of the Precessional Transmissions

as compared to conventional gear units:

- Coaxial arrangement of input and output shaft;
- Reduction ratio of $i = 8 \dots 5000$ possible in one stage;
- Several teeth (about 100%) are engaged simultaneously (higher power density);
- High transmission efficiency;
- High kinematical accuracy;
- Symmetrical design;
- Small number of bearing points;
- Small number of components;
- Easy assembly;
- Cost-effective production of the components by injection moulding, sintering from metal powder.



“HIGH-TECH” with “Know-How” elements at “LOW COST”

Field of application for the kinematical precessional transmissions

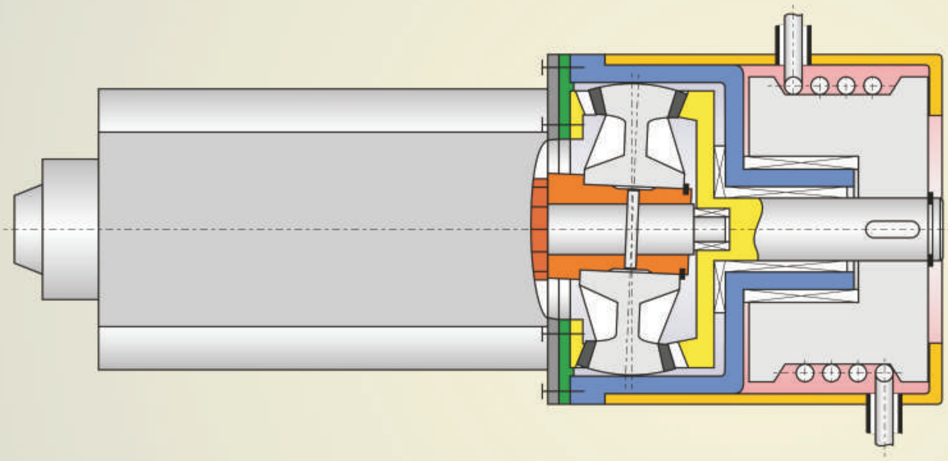
The kinematical precessional transmission is especially suitable for actuators and positioners, preferably for intermittent operation. In this context it is possible to achieve high reduction ratios at a low weight and high performance density as they are required for instance:

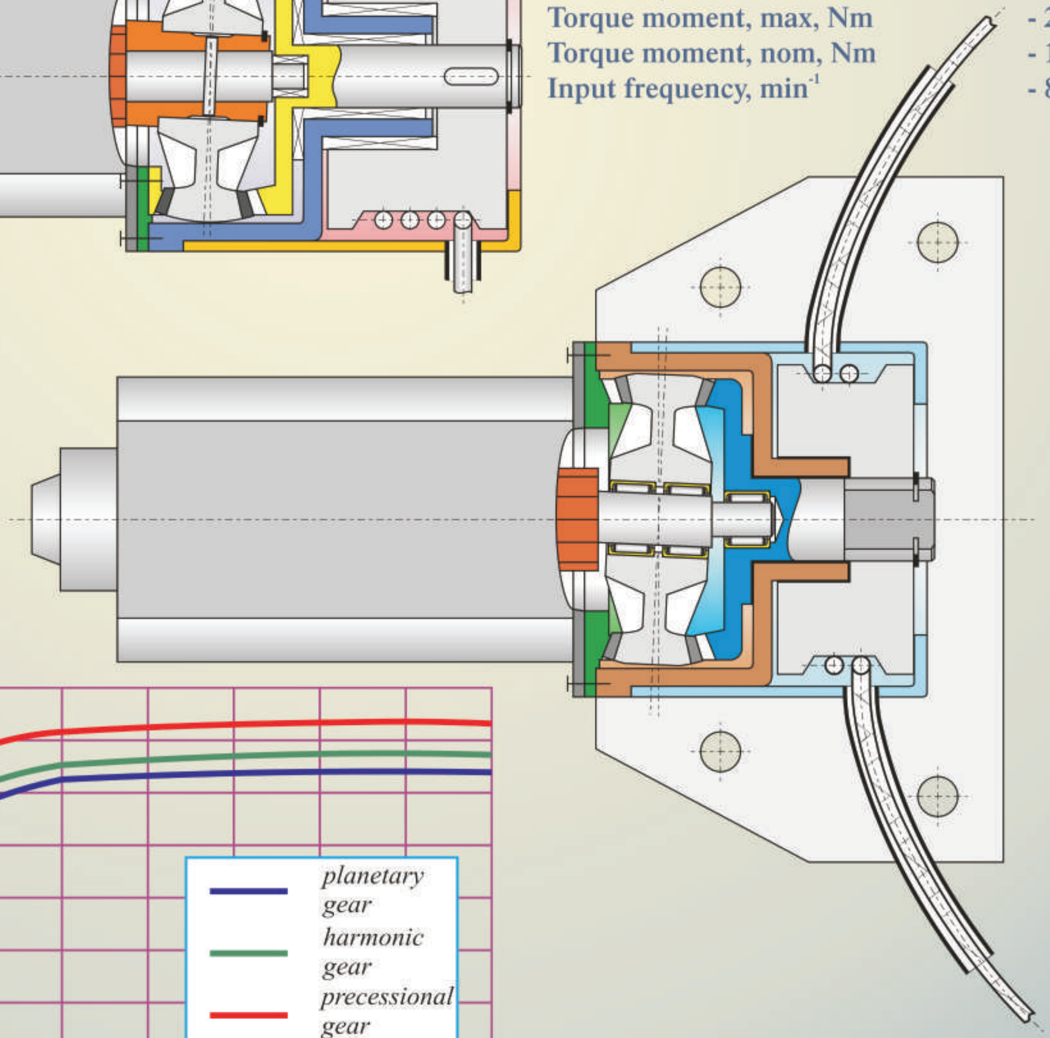
- ✓ in the automotive industry motion: mechanisms for brake, headlamp beam and mirror adjustment, flap drives for air-conditioners, power windows, sliding roof adjustment, central locking systems, antenna drives, seat adjustment, etc.;
- ✓ in building engineering and air-conditioning: drive mechanisms for gates, doors, windows, shutters, roller blinds, and awnings, as well as ventilation flaps and valve actuation;
- ✓ in the field of fine mechanics: positioning drives, general actuators, medical equipment, in astronomical observation for the following of the telescope due to the high degree of freedom from play required in this field, as well as for optical equipment.

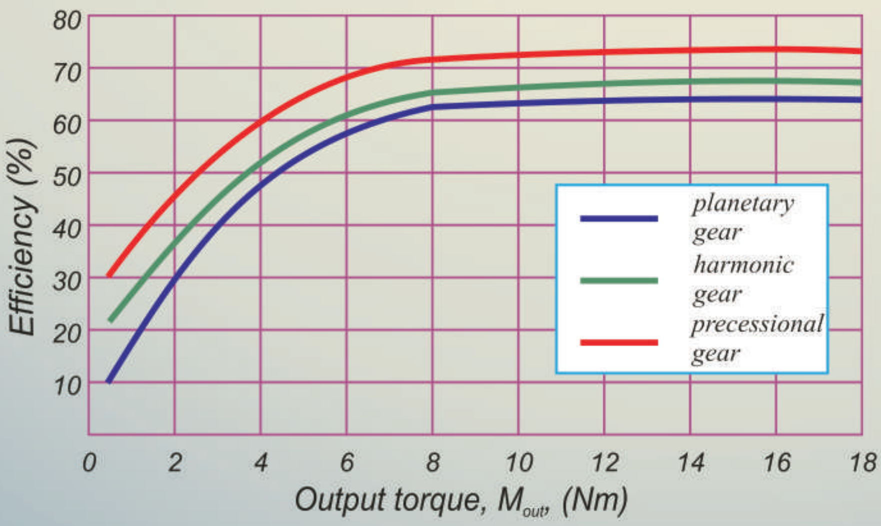
Precessional drive mechanisms for power windows of car

Technical characteristics

Outside diameter of housing, mm	- 60;
Middle diameter of gear, mm	- 46;
Gear ratio	- 144;
Efficiency	- 0,8;
Torque moment, max, Nm	- 25;
Torque moment, nom, Nm	- 18;
Input frequency, min^{-1}	- 8000.



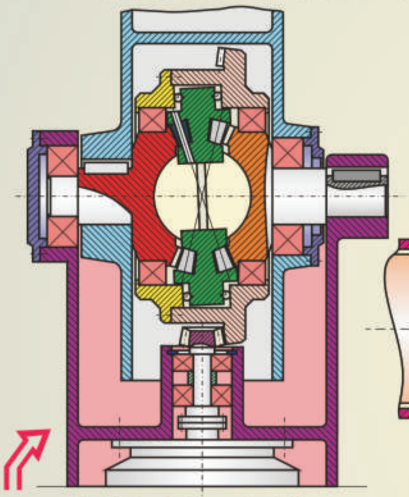




The planetary precessional transmissions in diverse technological equipment

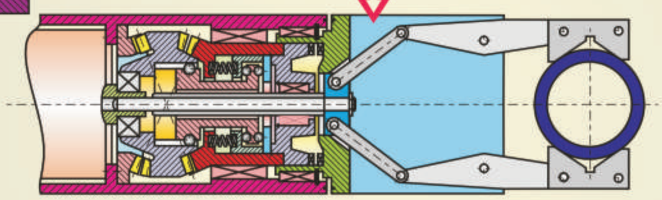
Having high kinematical accuracy ($\Delta\varphi$=30...90''), low specific material consumption (0,022...0,05 kg/Nm), small dimension, simple construction and technological production, being based on powder technology, the precessional reducers are widely practised in robot gear trains, technological equipment fine mechanics, etc. The construction and production pilots of some precessional motor reducers were elaborated.

The reduced material consumption, simple construction and technology based on high productive technology of metal powder are important factors that provide small cost of products, favour the utilisation on a large scale of the planetary precessional transmissions in diverse technological equipment. As result of research in this area it was elaborated the electromechanical spanner, boring head, screwdriver, drilling machines, etc. The elaborations are protected by 12 patents.

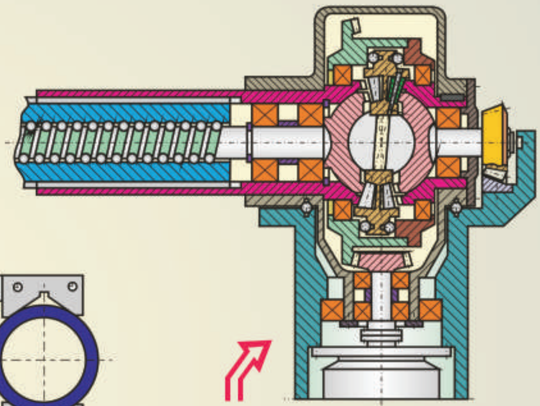


Technical characteristics

Power level, kW	- 1...6;
Gear ratio	- 100...300;
Efficiency	- 0,9...0,85;
Specific material consumption, kg/Nm	- 0,05...0,07.

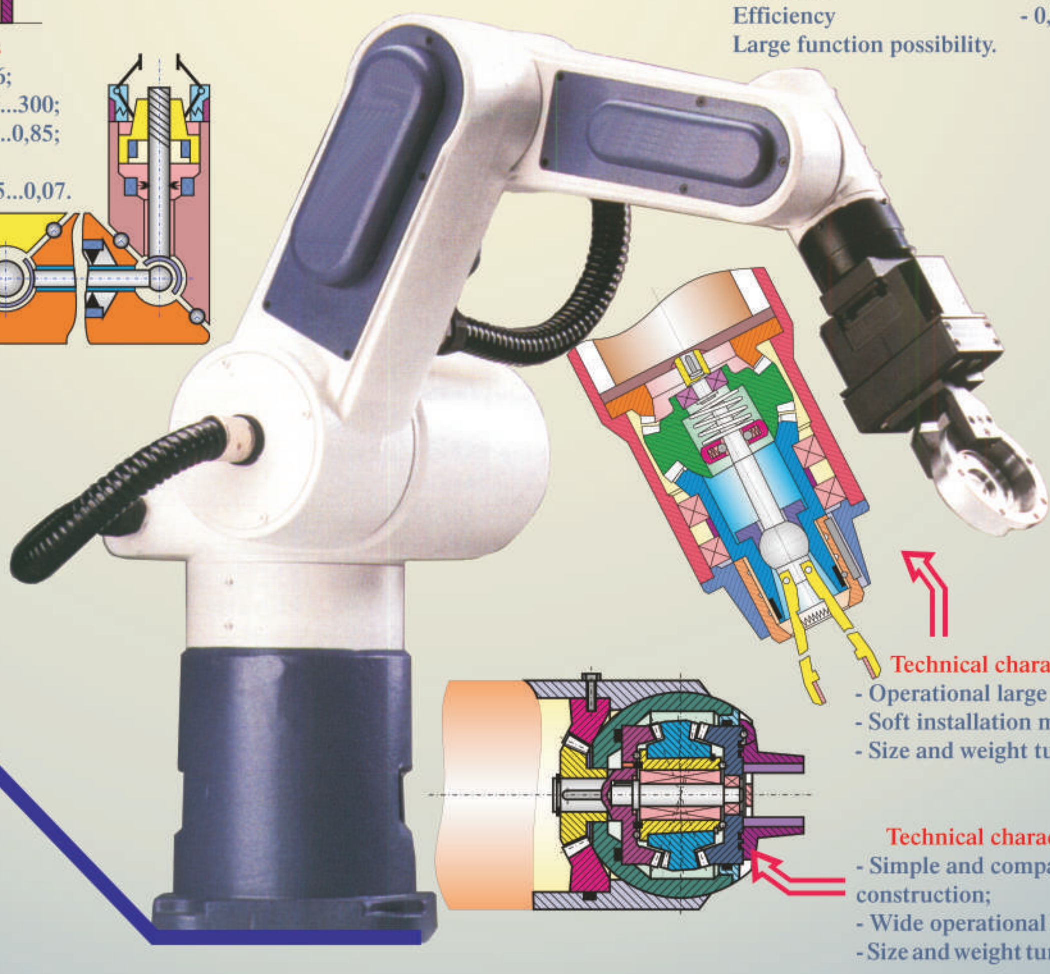


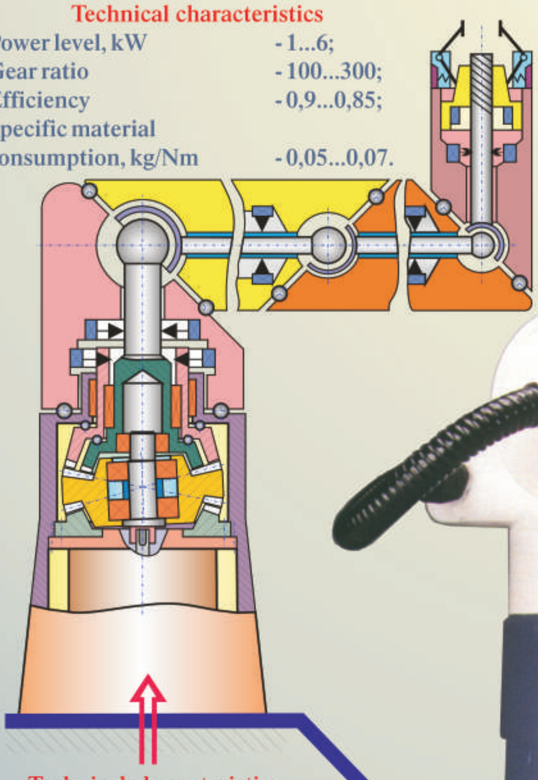
Technical characteristics
- Supervise force / position;
- Size and weight turns.



Technical characteristics

Power level, kW	- 37;
Gear ratio	- 144;
Efficiency	- 0,82;
Large function possibility.	





Technical characteristics
- Structural simplicity;
- Wide operational space;
- Accuracy of a high position.

Technical characteristics
- Operational large space;
- Soft installation movement;
- Size and weight turns.

Technical characteristics
- Simple and compact construction;
- Wide operational space;
- Size and weight turns.

Precessional multiplier for the wind turbine

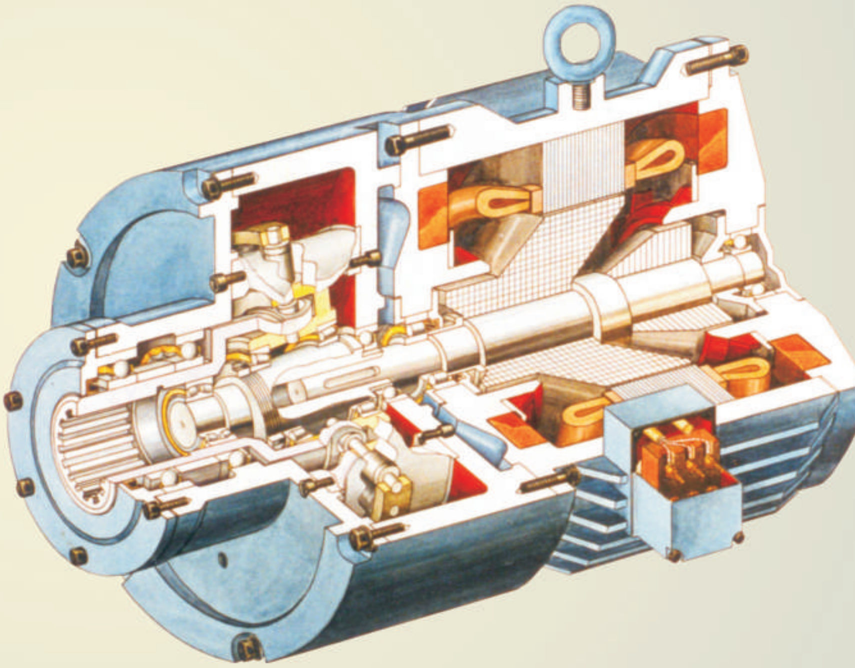
Non-traditional sources of energy which are practically inexhaustible must take up their well-earned place, inclusively for their innocuous action upon nature ecological balance. An important unit of the electrical Aeolian station whose quality index influences directly the characteristics of the station is the multiplier.

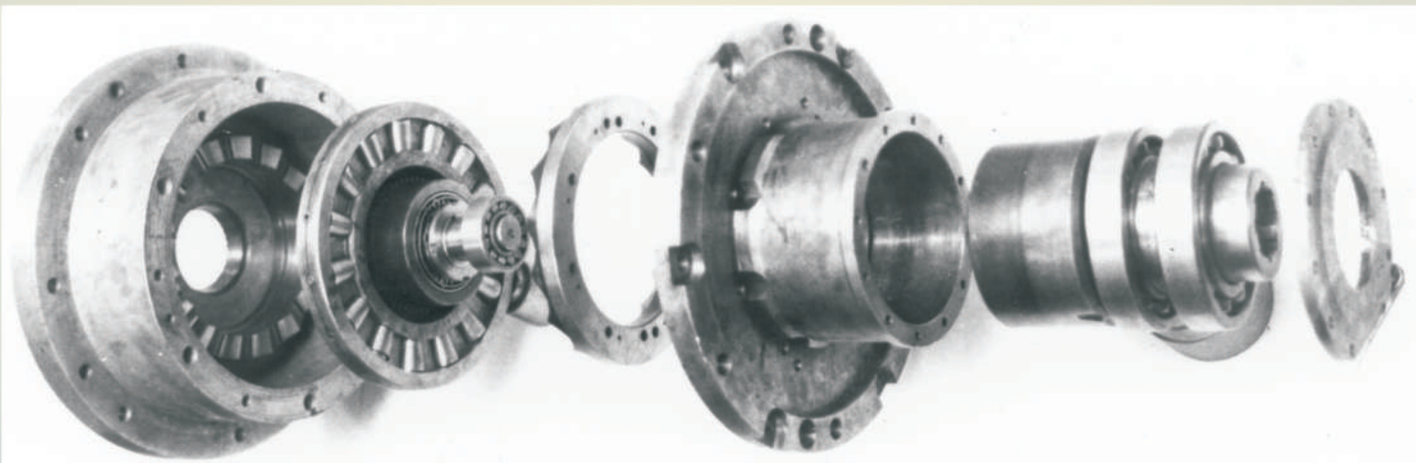
Such indexes as overall dimensions and small weight, a high efficiency, low demands to their maintenance are typical for the precessional multiplier. Multiplier with a capacity of P=2…2500 kW can be elaborated.

The multiplier (see fig.) has been designed for the electrical Aeolian set ABE-16 with a capacity of 16 kW and is based on precessional transmission with lantern-wheel gear. High lifting capacity and small dimensions of the multiplier are ensured by high multiplicity of convex-concave engagement (to 100% pairs of teeth on both sides of planetary pinion are simultaneous gearing) obtained by simultaneous gearing of the planetary pinion teeth and by the gear wheel teeth fixed on both sides of the planetary pinion.

Technical characteristics

Power level, kW	- 16;
Gear ratio	- 19;
Efficiency	- 0,85;
Specific material consumption, kg/Nm	- 0,035...0,05.





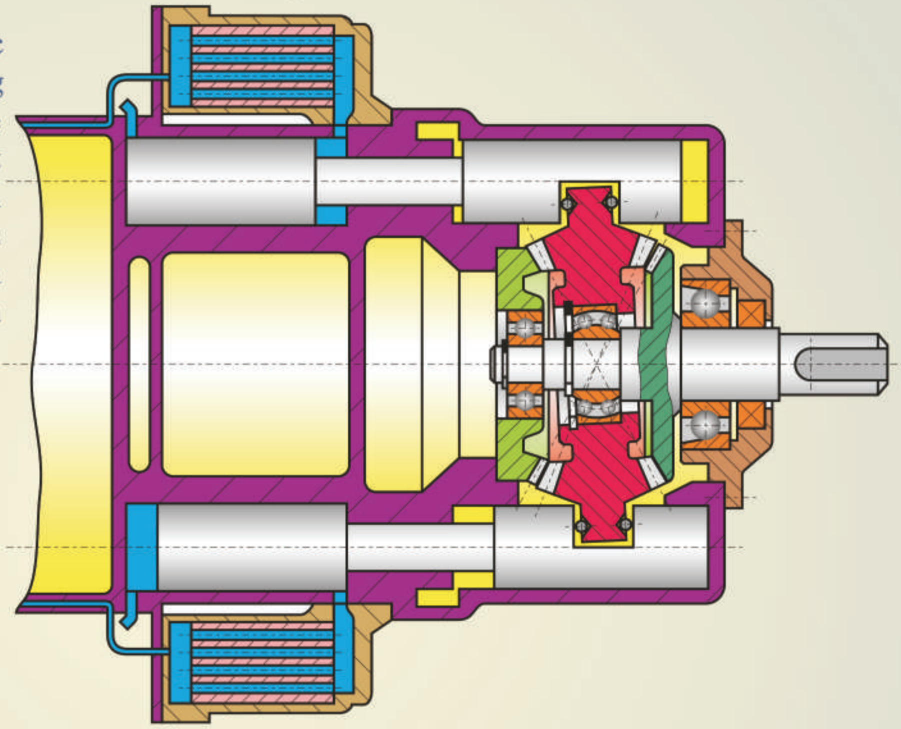
For many years we collaborated with the Production Scientific Association NPO "Vetroen" from Istra, Moskow region. The co-operation aimed to elaborate the multiplier for the electrowind station ABE-8 and ABE-16 with a capacity of 8 and, respectively, 16kW.

Energetic installation with planetary precessional transmissions

The problem of non-traditional energy utilizations is very important and should be solved urgently because of the energetic crisis and the global problems of the Climate Change. Having high efficiency, reduced mass and dimensions, coaxial disposition of the shaft the precessional transmissions are utilized in motors for the transformation of thermal energy into mechanical one, Stirling motors, turbine etc., that are protected by 6 patents.

Motor Stirling

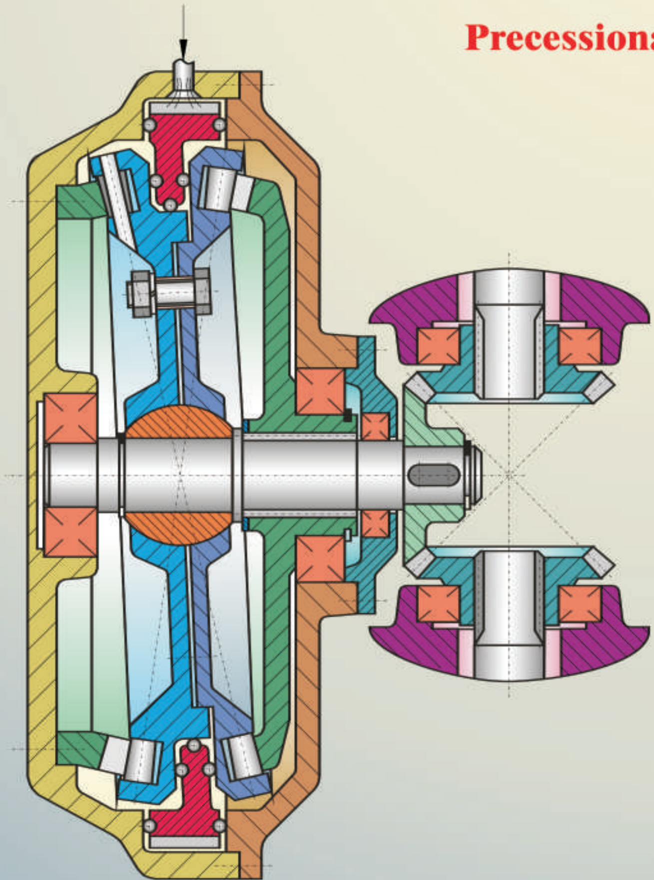
During a long time gigantic automobile enterprises have been working on at the elaboration of the future automobile. From this point of view a great interest presents the Stirling motor. A variant of the Stirling motor was elaborated. The motor is supplied with a power amplifier in the form of a precessional transmission.



The construction of the elaborated Stirling motor ensures:

- Efficient functionality with different types of fuel;
- Functional efficiency;
- Simple construction;
- Compactness and small weight.

Precessional turbomachine



The inevitable energetical crisis challenges us to look for new solutions in the field of automobile construction and especially in the field of automobile drive construction.

The turbomachines present a new direction in automobile construction.

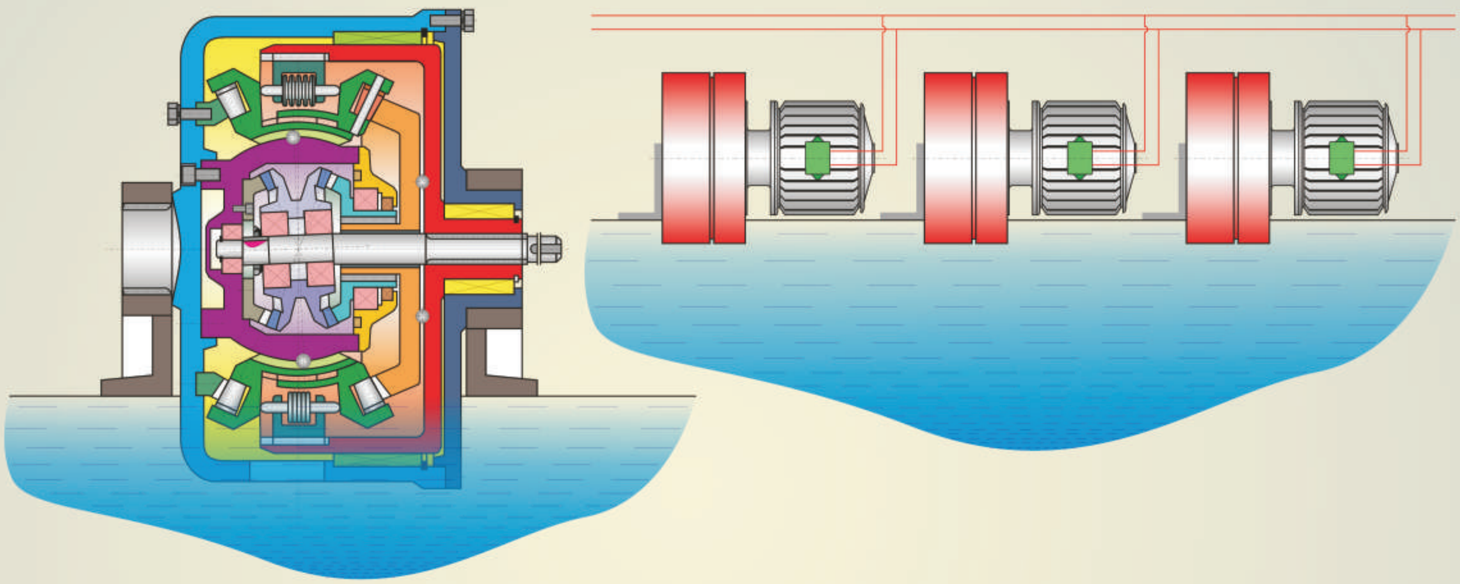
Thanks to the constructive and kinematical particularities (one of gear's element makes a spherical-spacial movement) the precessional transmissions can find a large utilisation in the construction of turbomachines.

Below, there is presented a precessional turbomachine that posesses:

- High energetic efficiency;
- Simple construction;
- High reliability;
- Compactness and small weight.

Installation to transforming of thermal energy into mechanical energy

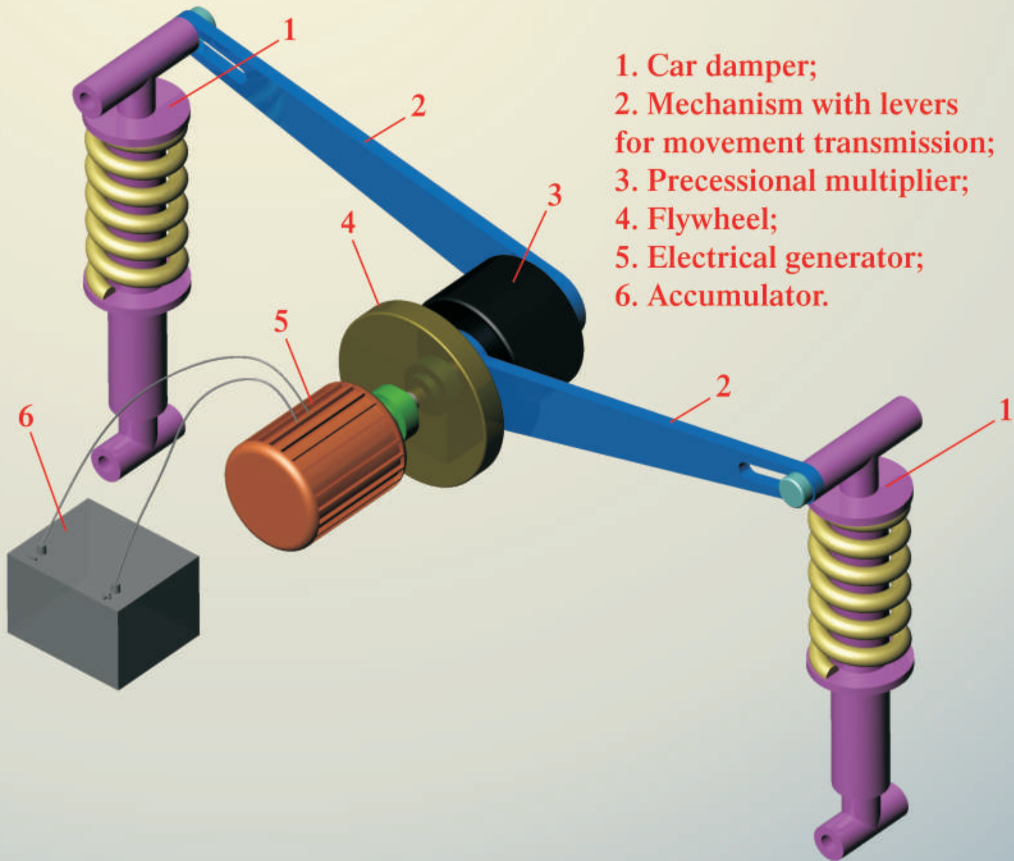
It is very important in this direction to use technologies based on the utilization of the thermal waters energy. A special device was elaborated to transform thermal energy into mechanical energy based on precessional gear with toothing rim of the planetary pinion executed, for example, in the form of a silphon filled in with working agent or some component elements performed from metal which possess the memory of the shape (nichel-titanium alloy). The rotating planetary pinion brings the working elements into various media with a difference of temperatures. The energy produced by these elements is transmitted to the working device.



Multifunctional suspension of car

It turns any oscillating movement of seesaw into a continuous, unidirectional, rotating movement. It uses two free wheels that work in the opposite direction on an oscillating axle, and rotating unidirectional movement to the driving shaft of the precessional multiplier is obtained by means of two overrunning clutches.

It can be applied to an electric alternator and reload 12 volts. Batteries, to impel an outboard, a compressor, a refrigerator, a dialysis equipment, a respiratory equipment or any motive usage.



1. Car damper;
2. Mechanism with levers for movement transmission;
3. Precessional multiplier;
4. Flywheel;
5. Electrical generator;
6. Accumulator.

Precessional reducers for the gasline fittings

Chokes are critical for the safe and economic production of the world's oil and gas reserves. A number of factors changed the demands on chokes. Safety and reliability are becoming increasingly important. And finally, the economics of the equipment, seen over the life of the field, are vital for the profitable development of the field.

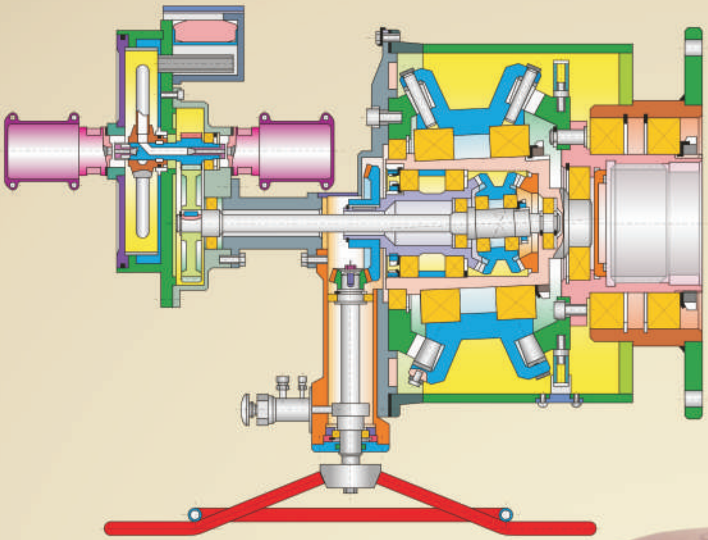
In gaslines, condensed gas and other liquid and gas substances we can utilise devices, which fulfil switching on-cutting off function of atmosphere motion in gaslines. These devices include drives with very high transmission ratio (i=20000…100000).

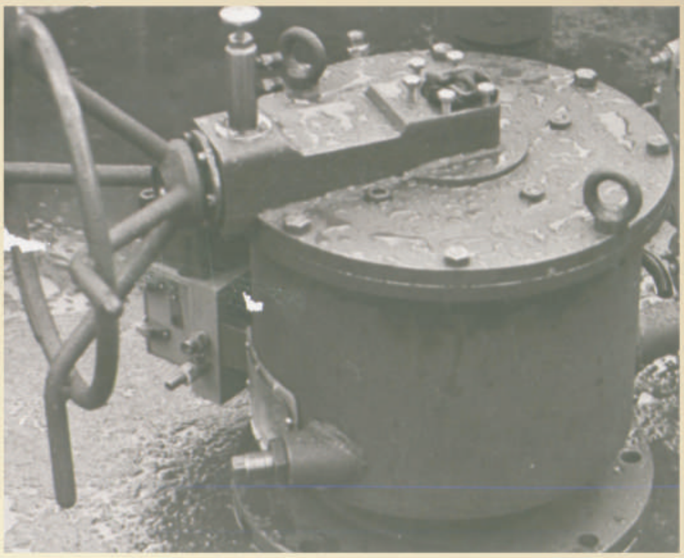
In this direction it was elaborated a precessional jet turbo-motor construction which functions utilizing the transported medium energy through gaslines. The turbo-motor has the following technical characteristics:

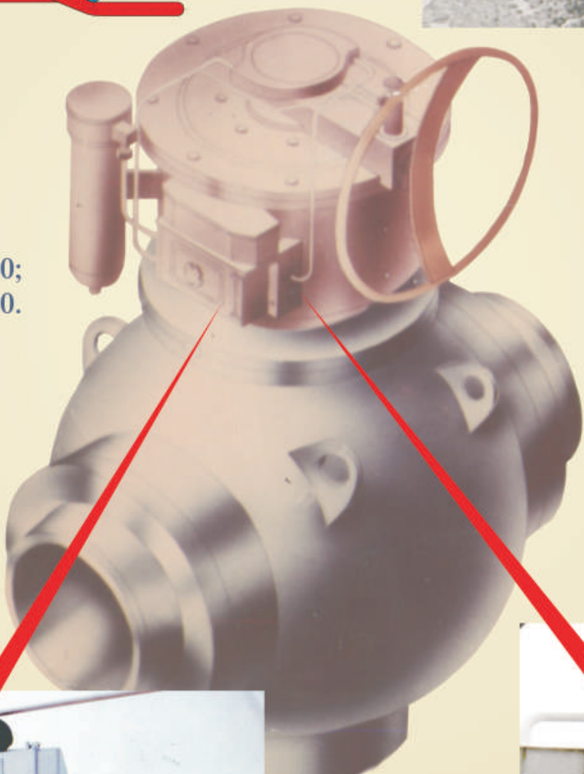
Diameter of the conventional passage, mm - 500;
Conditional pressure, MPa - 8;
Torque moment, Nm - 30000;
Transmissions ratio - 20000;
The temperature of the working medium, °C - 60 … +80;
Working agent - natural gas.

Technical documents were elaborated and the production pilot was assisted at the Compressormas plant, Sumy, Ukraine. In this context it was also elaborated 6 typo-dimensions of precessional reducers (T=16000 Nm, i=-624; T=30000 Nm, i=-20000; T=85000 Nm, i=-624; T=360000 Nm, i=-624).

Superreduction precessional gear





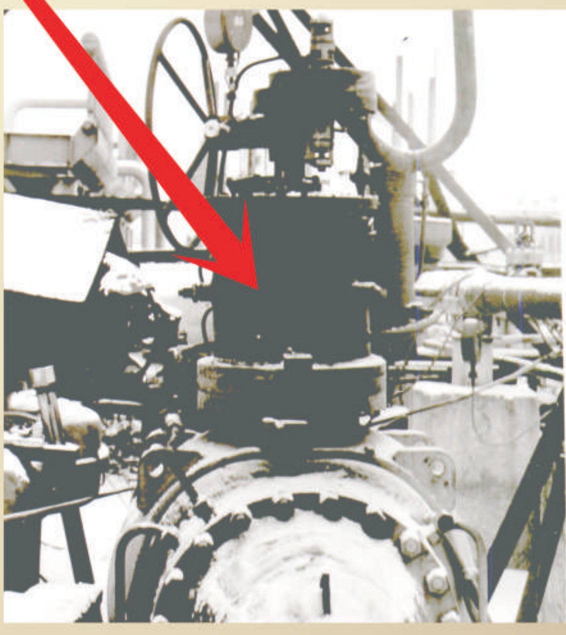


Technical characteristics

Torque moment, Nm	- 30000;
Gear ratio	- 20000.

Gas main

Precessional jet "turbo-motor"



SYSTEMS FOR RENEWABLE ENERGY RESOURCES CONVERSION

An important reserve of renewable energy can be obtained in the result of utilisation of hydraulic micro-stations for flowing river water kinetic energy conversion into electrical or mechanical energy. It was stated that the utilisation of kinetic energy of Amazon River water would allow the satisfaction of demand for electrical energy all villages and cities located on its banks without affecting the aquatic environment by constructing dams. Micro-hydro-power stations are widely used in the world as decentralised energy sources. For example, in Switzerland there are about 7000 micro hydro power stations. About 76000 micro power stations have been mounted in the period 1970-1985.

Decentralised systems for the production of electrical or mechanical energy out of the flowing river water kinetic energy (micro-hydro-power stations) utilise turbines which do not demand construction of dams or barrages. Water kinetic energy is a recommended energy source available 24 hours per day and can be operated efficiently by micro-hydro-power stations.

The leading working element of micro-hydro-power stations is: the blade rotor with inclined axis of Garman or Darieus type or the multi-blade rotor;

In the framework of the State Programme of the Republic of Moldova „Assurance of the industrial products competitiveness in machine building based on innovations, Know-How elements, new materials and advanced technologies" (coordinator I.Bostan) the project „Micro hydro power stations for flowing river water kinetic energy conversion" has been developed.

Within this project the design concept of the turbine with NACA hydrodynamic profile of blades was elaborated. The blades possess individual orientation depending on the water flow rate and blade positioning concerning the turbine axle (author I.Bostan).

Theoretical research and elaboration of rotor with blades with NACA aerodynamic profile

Theoretical research was reduced to the optimization of construction parameters of blades with various symmetrical NACA profiles (0012, 0014, 0016, 0018, 63012, 63015, 63018, 66015, 66018, 67015 – 32 profiles have been researched in total), with account of the maximal moment of torsion of the rotor shaft.

The hydrodynamic force F (fig. 1) has its components in directions O′x and O′x named lift and drag forces, respectively, given by:

$$F_L = \frac{1}{2} C_L \rho_\infty V_\infty^2 S_p,$$

$$F_D = \frac{1}{2} C_D \rho_\infty V_\infty^2 S_p,$$

where ρ_∞ is the fluid density, V_∞ is the flow velocity, S_p=*ch* (*c* is *AB* the chord length, *h* is the blade height) represents the lateral surface area of the blade, and C_L and C_D are the dimensionless hydrodynamic coefficients, lift and drag coefficient. Coefficients C_L and C_D are dependent on the angle of attack α, the Reynolds number *Re* and the aerodynamic form of the blade profile.

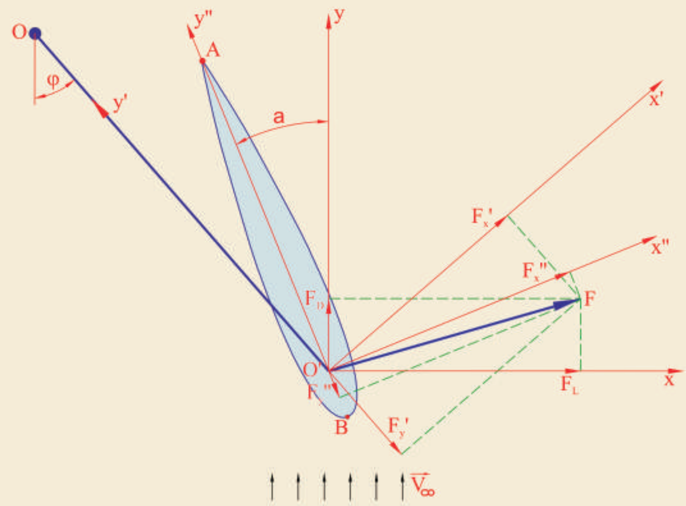


Fig. 1

The components of the hydrodynamic force in the coordinates system *O′X′Y′* are given by

$$F_{x'} = -F_L \sin\varphi + F_D \cos\varphi,$$

$$F_{y'} = F_L \cos\varphi + F_D \sin\varphi.$$

The torsion moment at the rotor axis *OO′* developed by the blade *i* is

$$T_{r,i} = F_{x'} \cdot |OO'|$$

and the total torsion moment developed by all blades

$$T_{r\Sigma} = \sum_{i=1}^{Npal} T_{ri}$$

where N_{pal} is the number of the rotor blades.

Since the hydrodynamic force does not have its application point in the origin of the blade axis system *O′*, it will produce a pitching moment with respect to a reference point. Following a standard convention, the reference point is located at a ¼ of the chord distance from the leading edge *B*. The pitching moment, is computed by

$$M = \frac{1}{2} C_M \rho V_\infty^2 c S_p$$

where C_M represents the pitching moment coefficient.

Computation of the hydrodynamic coefficients

Initially, the incompressible potential flow model is considered. Velocity $\vec{V} = (u, v)$ at a field point *P(x,y)* is given by

$$u(x,y)=\frac{\partial\Phi}{\partial x},\ v(x,y)=\frac{\partial\Phi}{\partial y},$$

where Φ is the flow potential obtained by superposition of the uniform velocity flow $\vec{V}_\infty=(V_\infty\cos\alpha, V_\infty\sin\alpha)$ and a distribution of sources and vortices over the profile C.

Therefore,

$$\Phi(P')=V_\infty x\cos\alpha+V_\infty y\sin\alpha + \int_C \frac{q(s)}{2\pi}\ln(r)ds-\int_C\frac{\gamma(s)}{2\pi}\theta\, ds.$$

In order to compute Φ numerically, a collocation method is implemented. Thus,

$$\Phi=V_\infty x\cos\alpha+V_\infty y\sin\alpha + \sum_{j=1}^{N}\int_{E_j}\left(\frac{q_j}{2\pi}\ln(r)-\frac{\gamma}{2\pi}\theta\right)ds.$$

with the unknowns γ and q_j, $j=1,...,N$ are determined from the boundary condition and Kutta condition. The local pressure coefficient on the discrete contour of the profile is given by

$$C_{p,j}=1-\left(\frac{u_{\tau j}}{V_\infty}\right)^2$$

The hydrodynamic force acting on the boundary element j is given by

$$f_{xj}=C_{p,j}\left(y_{j+1}-y_j\right),\ f_{yj}=C_{p,j}\left(x_{j+1}-x_j\right),$$

and the pitching moment is computed by

$$c_{m,j}=-f_{xj}\left(\frac{y_{j+1}-y_j}{2}\right)+f_{yj}\left(\frac{x_{j+1}-x_j}{2}-\frac{c}{4}\right)$$

The total force is the sum of contributions from each boundary element

$$F_x=\sum_{j=1}^{N}f_{xj},\ F_y=\sum_{j=1}^{N}f_{yj},$$

and the lift and moment coefficients are given by

$$C_L=-F_x\sin\alpha+F_y\cos\alpha,\ C_M=\sum_{j=1}^{N}c_{m,j}.$$

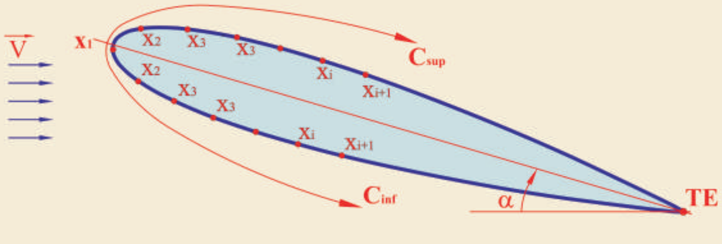


Fig. 2

Laminar boundary layer

In order to compute the drag coefficient a boundary layer analysis must be performed. The boundary layer analysis is divided into two parts: laminar and turbulent boundary layer.

The laminar boundary layer begins in the stagnation point and follows the flow along the lower or upper sides of the profile in the direction of the trailing edge. As soon as the stagnation point is determined, consider a uniform arc length partition of the upper and lower sides with the nodes being numbered toward the trailing edge.

The Thwaites model is used for the laminar boundary layer analysis. Introduce parameters: the displacement thickness δ^* given by

$$\delta^*=\int_0^\infty(1-\frac{u}{V})dy,$$

the thickness of impulse loss θ defined by

$$\theta=\int_0^\infty\frac{u}{V}(1-\frac{u}{V})dy,$$

and the thickness of energy loss θ^*

$$\theta^*=\int_0^\infty\left(1-\left(\frac{u}{V}\right)^2\right)\frac{u}{V}dy,$$

where V represents the velocity of the potential flow in a given point, and u is the tangential velocity in the boundary layer at this point. Consider the Von Karman integro-differential equation

$$\frac{d\theta}{dx}+\frac{\theta}{V}\left(2+\frac{\delta^*}{\theta}\right)\frac{dV}{dx}=\frac{1}{2}C_f,$$

where C_f denotes the local coefficient of the friction force on the profile surface given by

$$C_f=\frac{\tau_w}{\frac{1}{2}\rho V^2},\quad \text{with}\quad \tau_w=\mu\left.\frac{\partial u}{\partial y}\right|_{y=0}.$$

Introducing parameter $H=\frac{\delta^*}{\theta}$, we get

$$\frac{d\theta}{dx}+\frac{\theta}{V}(2+H)\frac{dV}{dx}=\frac{1}{2}C_f.$$

Integrate to get the integral equation for the kinetic energy of the boundary layer

$$\frac{d\theta^*}{dx}+3\frac{\theta^*}{V}\frac{dV}{dx}=2C_d,$$

where C_D is the dissipation coefficient. Introducing the second parameter $H^*=\frac{\theta^*}{\theta}$, we obtain

$$\theta\frac{dH^*}{dx}+\left(H^*(H-1)\right)\frac{\theta}{V}\frac{dV}{dx}=2C_d-H^*\frac{C_f}{2}.$$

The supplementary conditions are based on the Falkner-Skan semi-empirical relations. A resulting system of differential equations is numerically solved with a backward Euler method. The method is used either until the transition from laminar to turbulent boundary layer is predicted or until the trailing edge is reached. The transition is localized by Michel's criterion

$$\mathrm{Re}_\theta > \mathrm{Re}_{\theta\,\max} = 1.174\left(1 + \frac{22.4}{\mathrm{Re}_x}\right)(\mathrm{Re}_x)^{0.46}$$

where $\mathrm{Re}_x = \mathrm{Re}\cdot V \cdot x$

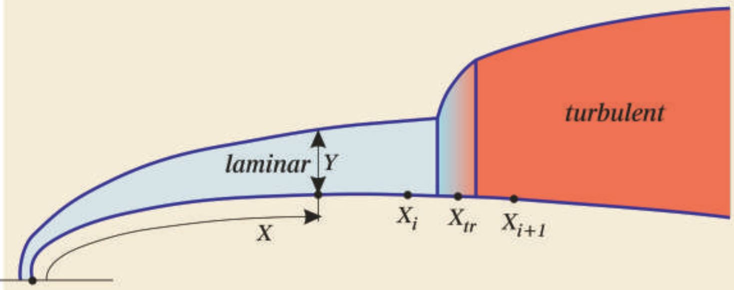


Fig. 3

Turbulent boundary layer

Similar to the laminar boundary layer, the Von Karman integral equation for turbulent boundary layer is considered. Computations of the turbulent boundary layer parameters are done by applying the Head's model. Let

$$Q(x) = \int_0^{\delta(x)} u\,dy$$

be the volume rate of flow through the boundary layer. Then $\delta^* = \delta - Q/V$. Introducing the flux velocity $E = dQ/dx$, we get $E = d\left(V\theta H_1\right)/dx$, where $H_1 = (\delta - \delta^*)/\theta$. Head supposed that the dimensionless velocity E/V is dependent only on $H_1 = H_1(H)$. Cebeci and Bradshaw considered the semi-empirical relations

$$\frac{E}{V} = 0.0306(H_1 - 3)^{-0.6169}$$

$$H_1 = \begin{cases} 3.3 + 0.8234(H - 1.1)^{-1.287}, H \le 1.6 \\ 3.3 + 1.5501(H - 0.6778)^{-3.064}, H > 1.6 \end{cases}.$$

The last equation used to find the unknowns θ, H, and H_1 is the Ludwieg-Tillman skin friction law

$$C_f = 0.246\left(10^{-0.678H}\right)\mathrm{Re}_\theta^{-0.268}.$$

Combine the Von Karman integral equation with the above equations to obtain a system of differential equations:

$$\frac{d}{dx}Y = F(x, Y) \text{ ,where } Y = (\theta, H_1)^T \text{ and}$$

$$F = \begin{pmatrix} -\dfrac{\theta}{V}(2 + H)\dfrac{dV}{dx} + \dfrac{1}{2}C_f \\ -H_1\left(\dfrac{1}{V}\dfrac{dV}{dx} + \dfrac{1}{\theta}\dfrac{d\theta}{dx}\right) + \dfrac{0.0306}{\theta}(H_1 - 3)^{-0.6169} \end{pmatrix}.$$

Initial values are the final values provided by the laminar boundary layer. Numerical integration is done by a second order Runge-Kutta method. The method is applied either until the trailing edge is reached or until the separation of the turbulent layer takes place.

In order to compute the drag coefficient C_D, the Squire-Young formula is used. Given θ, H and V at trailing edge A, the drag coefficient is given by

$$C_D = \left(2\theta|_A \cdot (V|_A)^\lambda\right)_{C_{\sup}} + \left(2\theta|_A \cdot (V|_A)^\lambda\right)_{C_{\inf}}$$

with $\lambda = (H|_A + 5)/2$.

Moment of torsion and power applied to the rotor with hydrodynamic profile blades

In what follows, we compute the hydro-dynamic coefficients for a rack profile standard, and, in particular, NACA profile with chord length $c=1,3m$. The model and numerical methods described previously are implemented in MATLAB. The coefficients corresponding to NACA0016 profile with chord length $C_{ref}=1,0m$ are $C_{L,\,ref}$, $C_{M,\,ref}$ and $C_{D,\,ref}$. The coefficients corresponding to the profile with chord length $1,3m$ are then obtained from relations

$$C_L = C_{L,ref}\cdot 1.3,$$
$$C_M = C_{M,ref}\cdot (1.3)^2,$$
$$C_D = C_{D,ref}\cdot 1.3.$$

Fig. 5 shows the hydro-dynamic power modulus F, which acts on the rotor blade together with its tangential and normal components F_X', F_Y' versus the positioning angle. Fig. 6 shows the moment T_{ri} developed by one blade versus the positioning angle, and Fig. 7 represents the total moment of torsion $T_{r\Sigma}$ versus the positioning angle.

Theoretical and experimental research, digital modelling and computer simulations of the interaction effects „NACA hydrodynamic profile of blades-fluid" allow the optimisation of blade profile constructive parameters. Also the turbine kinetic parameters are optimised by decreasing the turbulence effects, as well.

The maximum hydrodynamic effect is obtained by optimum orientation of blades under the action of the fluid with the utilisation of a "feedback' system with KNOW-HOW elements.

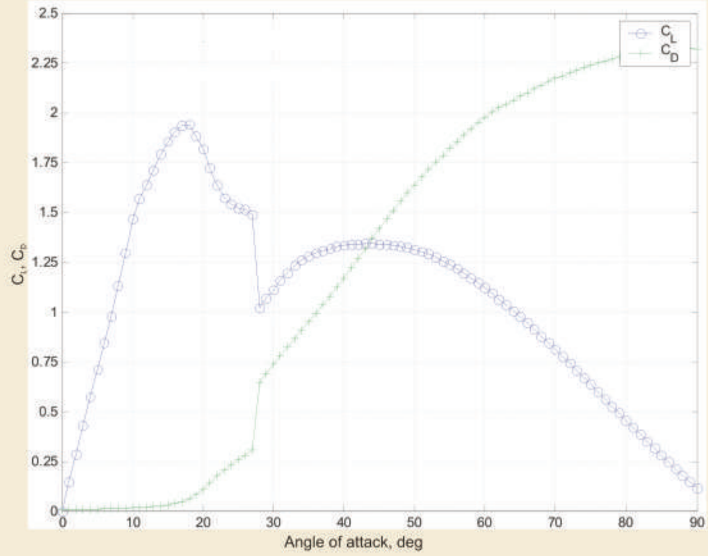


Fig. 4. Lift and drag coefficients C_L and C_D.

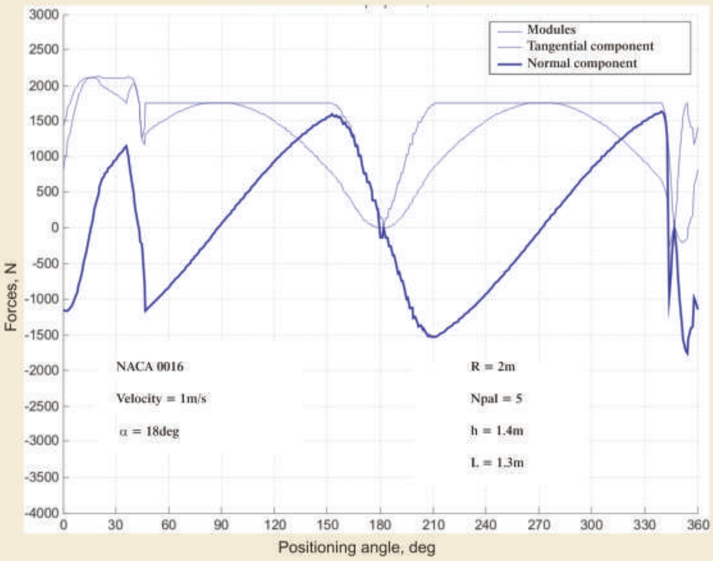


Fig. 5. Hydrodynamic force vs positioning angle φ.

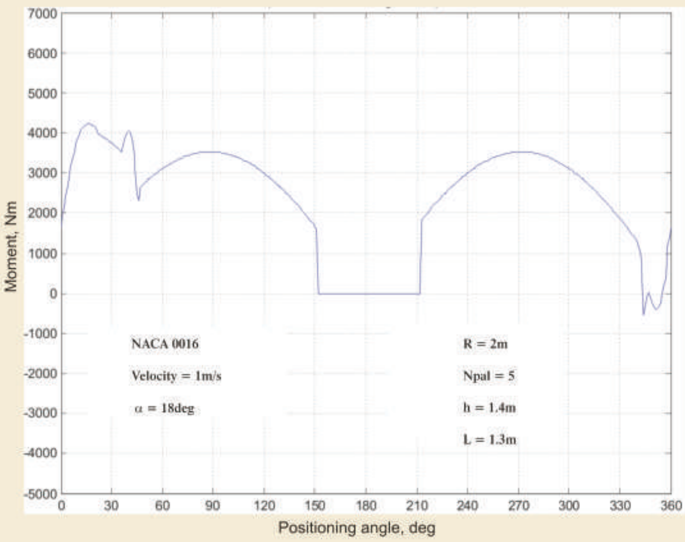


Fig. 6. Moment of torsion T_{ri} vs positioning angle φ.

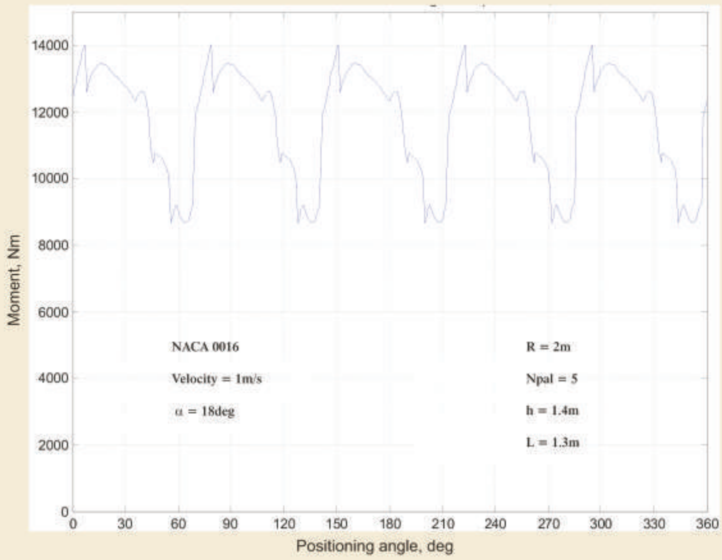


Fig. 7. Total moment of torsion $T_{r\Sigma}$ vs positioning angle φ.

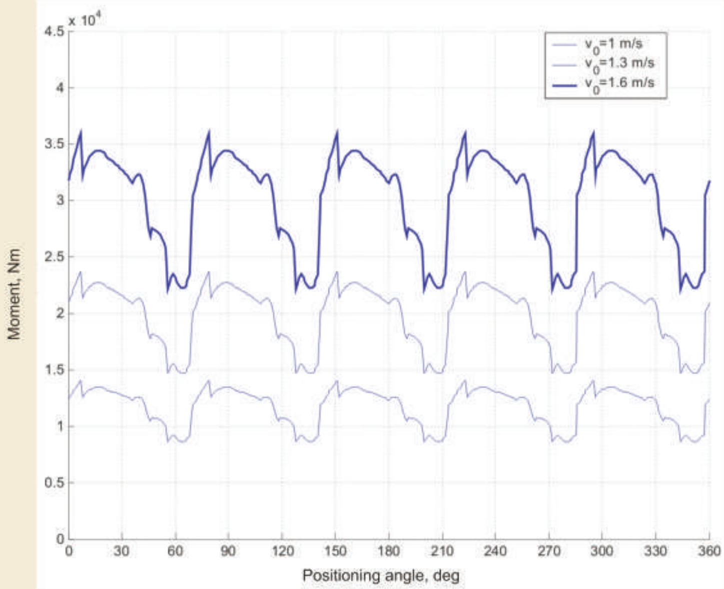


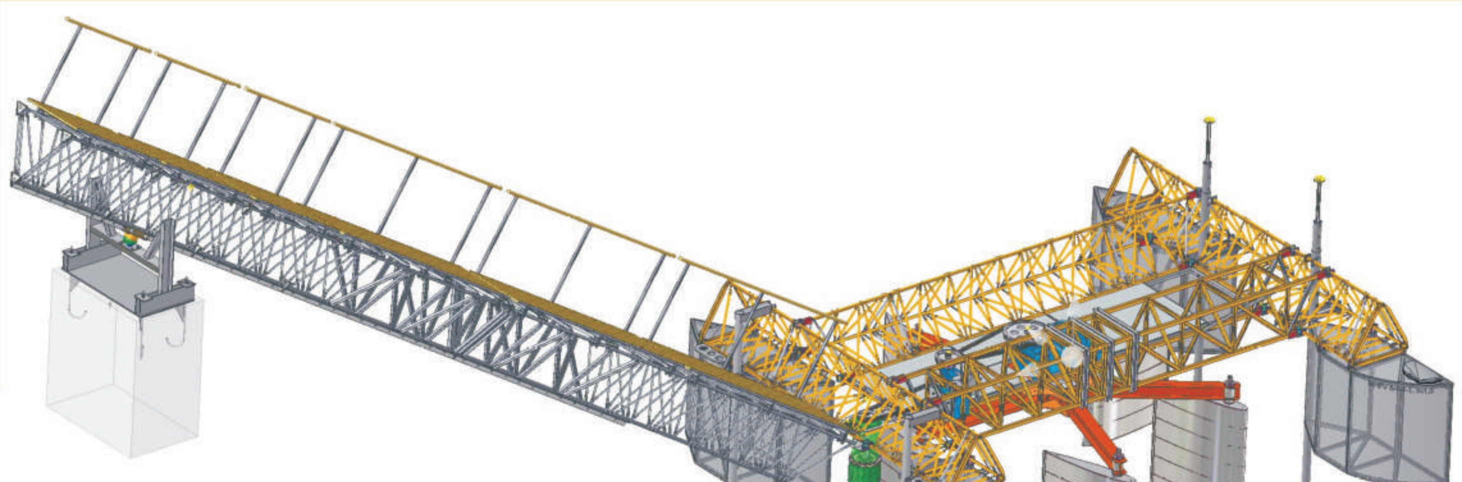
Fig. 8. Total moment T for different flow velocities. NACA 0016.

Based on the research results there were developed and fabricated the industrial prototypes of the generator with permanent magnets (*N=5kWt*) and of the centrifugal hydro pump in three steps (*Q=40m3/hour, H=20m*) with a frequency of *300 min*$^{-1}$ revolutions.

The pilot micro hydro power station is in the process of fabrication. After its testing in real conditions on the PRUT River at a flow rate of (*0,8-1,7m/s*) we will develop the industrial prototype of the micro hydro power station which will be produced in the Republic of Moldova (see pictures in the prospectus, pages 28 – 30).

The novelty of the technical solutions is protected by more than 10 patents and author copyright.

Flotable Micro Hydro Power Station for conversion of kinetic energy of reveirs running water (Prut, Nistru, Raut)



I. Constructive parameters

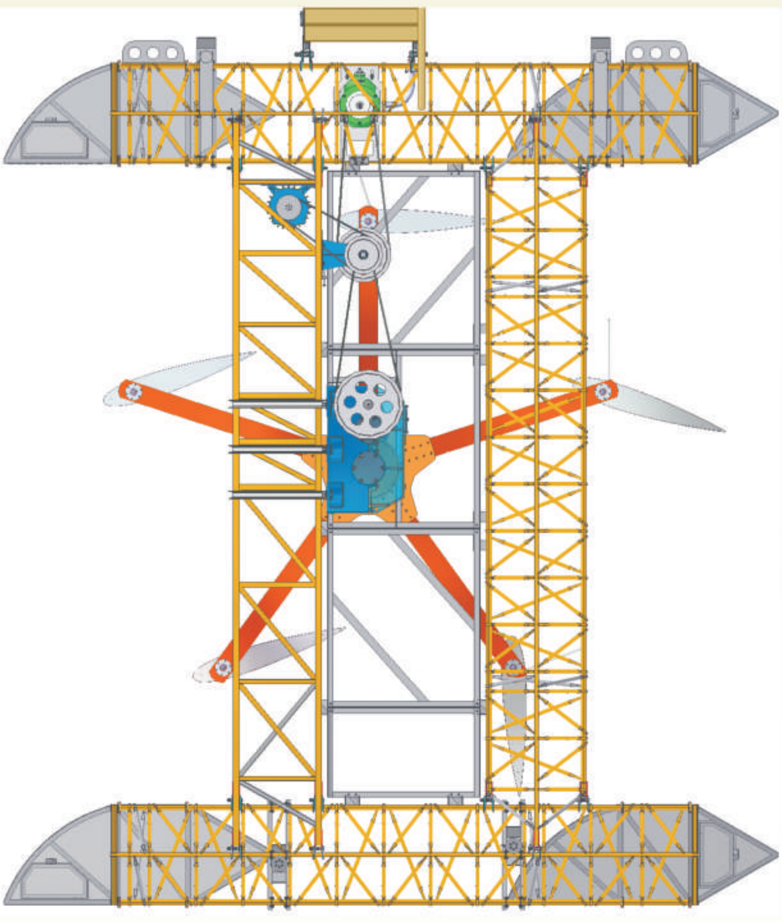
Rotor diameter, *m*	4
Number of blades	5
Blade dimensions: - chord length, *m* - blade effective height, *m*	 1,3 1,4

II. Functional parameters

Water flow rate, *m/s*	1	1,3	1,6
Rotor torque moment, *Nm*	1200	1900	2800
Multiplying ratio	-	-	-
Magnets generator power, kWt	1,8	3,0	4,8
Hydraulic pump productivity, m^3/24h Pumping height - 10m	1200	2000	3200

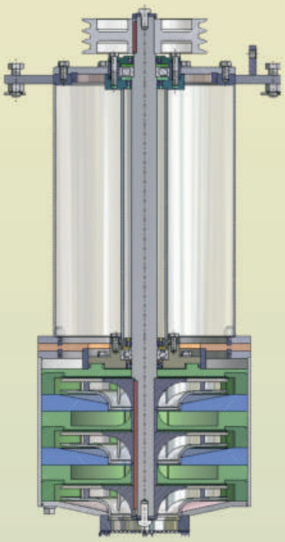
Caracteristics of the technical level

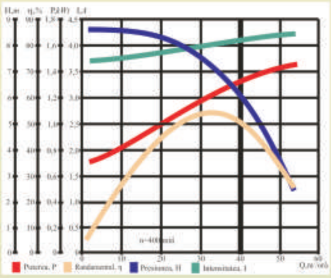
1. Utilisation of the hydrodynamic effect of the NACA aerodynamic profiles.
2. Automatic positioning of the blades with NACA profiles depending on river stream.
3. KNOW - HOW in the systemic optimisation: NACA profile - variable positioning of the blades depending on water flow rate and regime - parameters of the mechanism for controlling the blades position.
4. KNOW - HOW in technical solutions for:
   - deacreasing fluid turbulence in individual zones of blades action;
   - assurance of stability of blades position under the optimum adjustment angle for efficient energy conversion;
   - decreasing of batch with negative influence over the kinematical chain coupling;
   - integral neutralisation of the hydrodynamic effect (M=0).

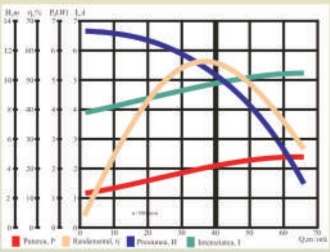


Working parts of the micro hydro power station

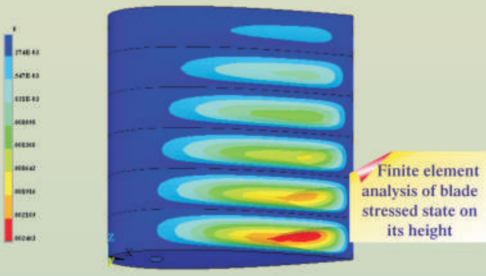
Characteristic of the PSS 40-10/500 pump driven by electrical motor

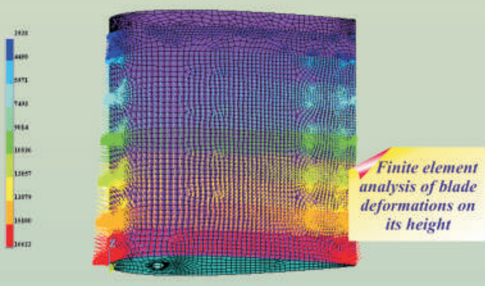


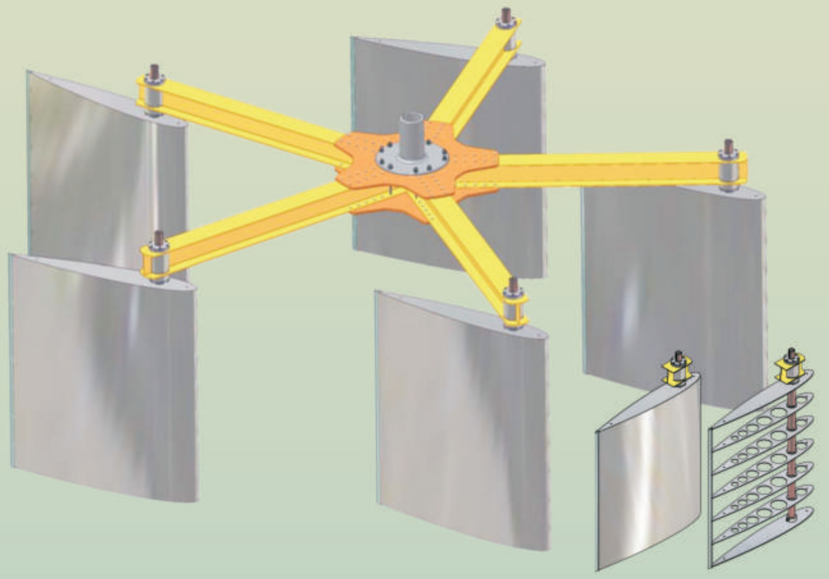




Multi-blade rotor turbine







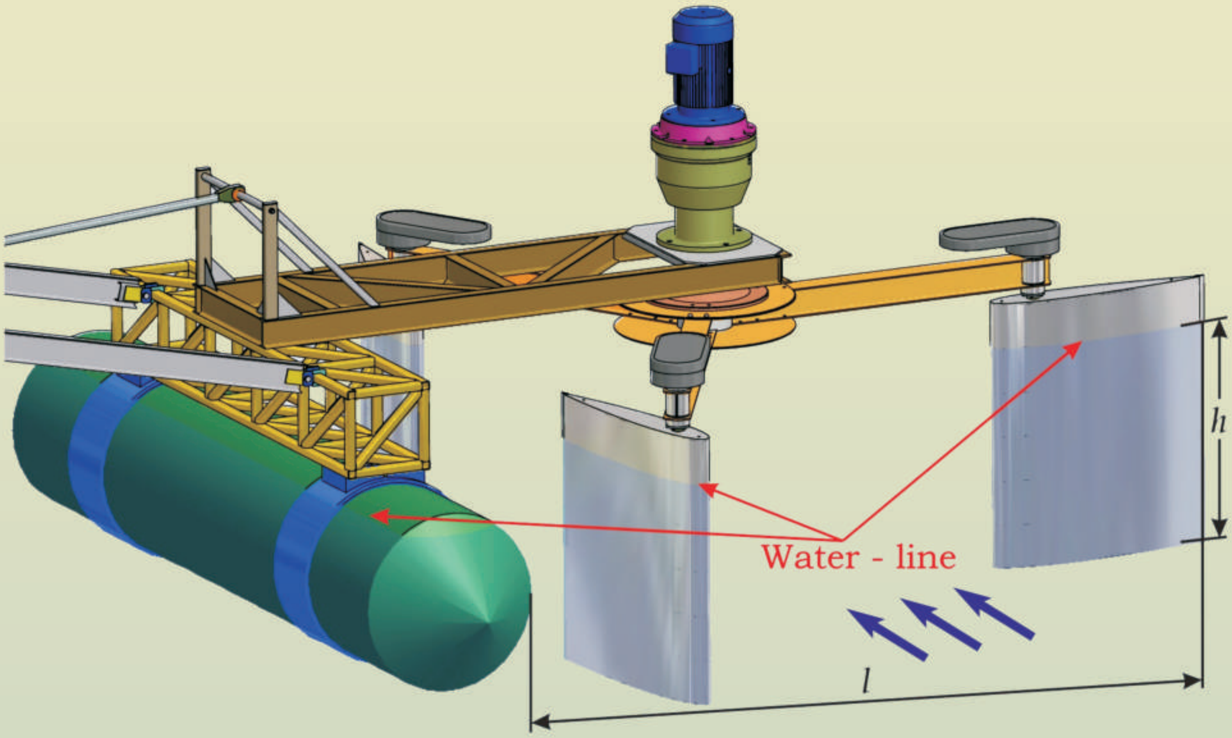
Micro hydro power station fabricating stages

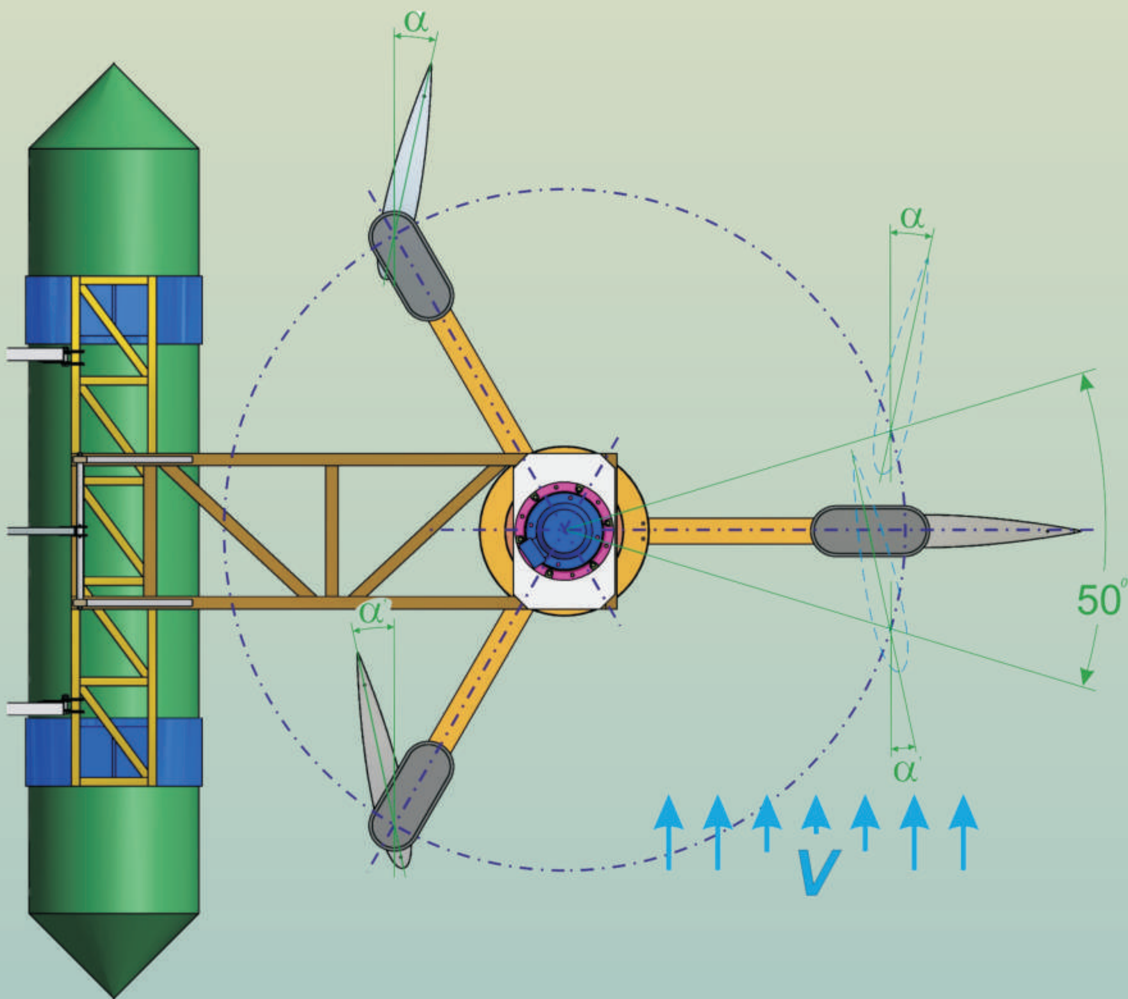
Centrifugal pump

Electrical generator

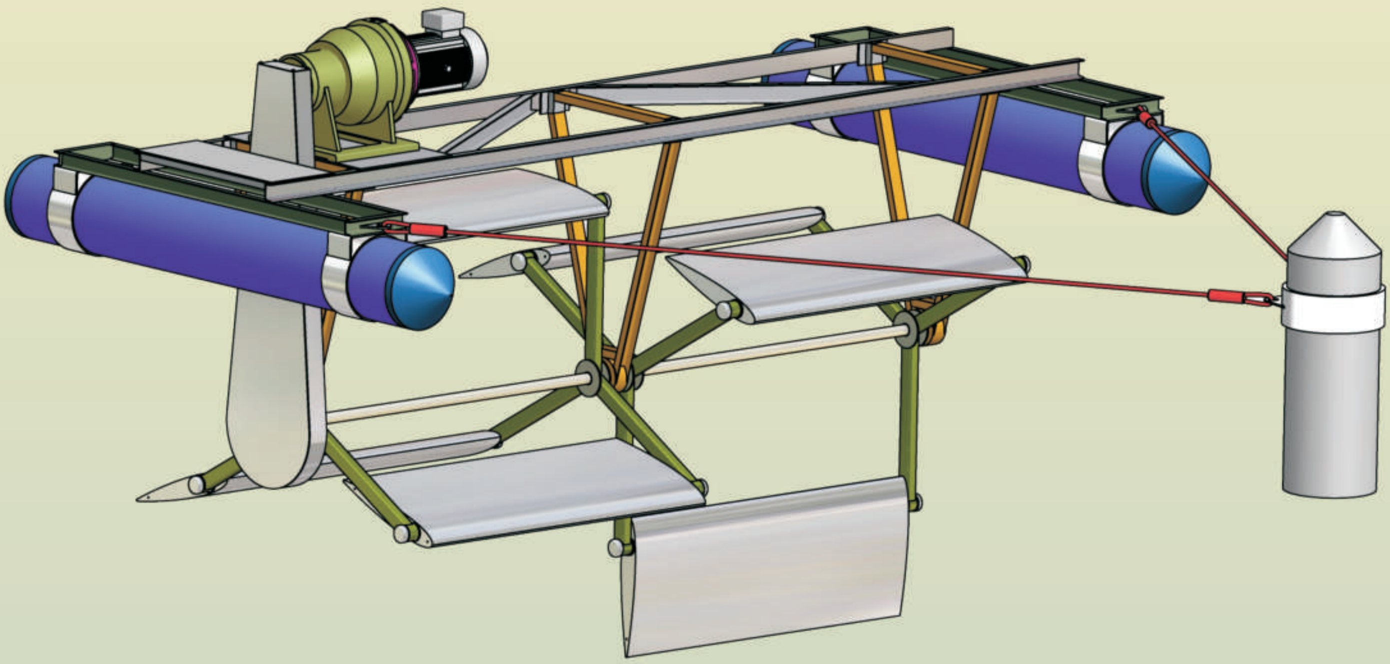
Floatable micro hydro power station with pintle for running water kinetic energy conversion

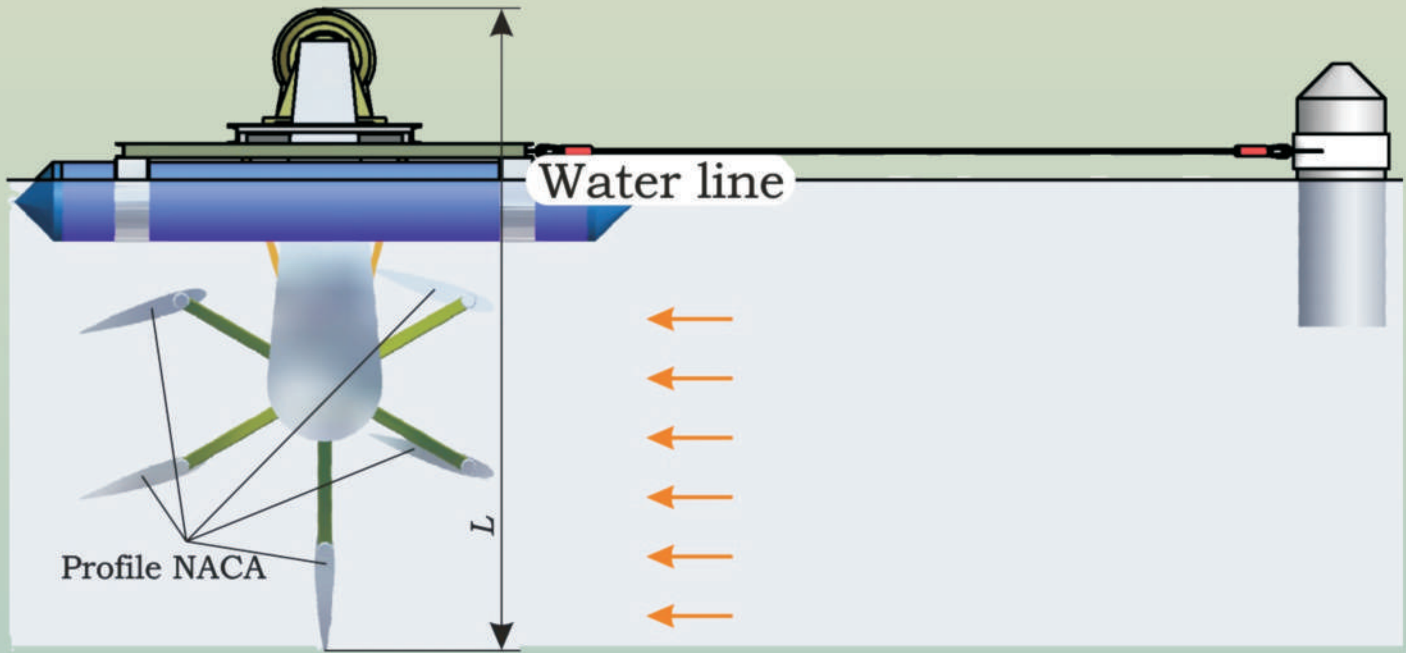
Comercial Version





Floatable micro hydro power station with horizontal axle for running water kinetic energy conversion
Comercial Version





Advantaje: **Turbine fully immersed in the flowing water stream.**

Foucault Pendulum-Gravitational Clock with Interactive Kinematics

In cooperation with the European Physical Society (Project No. 516938/P15, programme 516938, dedicated to the international year of physics WZP-2005) in the period 2005-2006 at TUM there has been elaborated the kinematical-constructive concept of the "Foucault Pendulum-Gravitational Clock" which allows the recording of local time continuously (author I. Bostan).

Foucault Pendulum-Gravitational Clock with Interactive Kinematics designed at the Technical University of Moldova represents a conceptual development of the classical system and allows a continuously recording of the Earth's rotary motion and geographical position of the Republic of Moldova in a fixed coordinate system.

The innovation aspects of the pendulum consist in the development of the interactive kinematical system which allows for the angular repositioning of the clock face with high accuracy in terms of the pendulum location latitude on the Globe ($\varphi=47^{o}01'45''$). Another innovative element is the development of a feedback system between „the maximum deviation of the pendulum sphere and the value of the energetic impulse" communicated at each semi-oscillation of the sphere depending on the aerodynamic resistance and on the wire cable deformation in the plane of pendulum suspension.

Innovative elements will permit to carry out experimental research in the period of lunar and solar eclipses which are frequent in the pendulum location latitude (Republic of Moldova) with the purpose of quantitative recording of the supposed deviations of Foucault pendulum oscillation planes. These phenomena are interesting to the physicists.

Foucault Pendulum-Gravitational Clock with interactive kinematics has been already fabricated at Moldovan enterprises and has been assembled at the Technical University of Moldova. Nowadays, experimental adjustment works are carried out (coordinator Ion Bostan) (see pictures in the prospectus, pages 31, 34).

Technical and functional parameters of the Foucault Pendulum-Gravitational Clock

Location: Main Administrative Building of the Technical University of Moldova, Bd. Stefan cel Mare 168, Chisinau, Republic of Moldova, 2004;

Coordinates: Latitude $\varphi=47^{o}01'45''$ N
Longitude $28^{o}49'27''$ E

Length of the Pendulum's cable (distance between the suspension plane and the centre of mass of the ball) $l=17200$ mm

Oscillation amplitude $A=1210$ mm

Deviation angle from the vertical position of the ball $\gamma=4.87^{o}$

Oscillation period $T=8.32$ sec.

Number of ball's oscillations in an hour $N=432.7$

Angle of the rotation of the oscillation plane

In one hour $\beta=10.97^{o}$

In 24 hours $\beta=263.28^{o}$

Length of the arc described by the ball's centre

In one hour $d=230$ mm

In 24 hours $d=0.53$ mm

Mass of the ball $m=108.3$ kg

The Foucault Pendulum-Gravitational Clock with interactive kinematics contains over 1000 original components.

Foucault Pendulum-Gravitational Clock in expluatation (photo)

PLANETARY PRECESSIONAL TRANSMISSIONS and RENEWABLE ENERGY CONVERSION SYSTEMS

THE PLANETARY PRECESSIONAL TRANSMISSIONS AND RENEWABLE ENERGY CONVERSION SYSTEMS HAVE BEEN PATENTED BY 170PATENTS, INCLUDING:

Multiple gears and manufacturing technologies

- CA 1455094 (SU), CIB F 16 H 1/32. *Precessional gear transmission* /I. Bostan; Polytechnic Institute of Chisinau. - Nr. 406848/25-28; Decl. 13.05.86; Publ.B.I.-1989.-Nr.4.
- Patent 1563319 (RU), CIB F 16 H 1/32. *Precessional transmission* /I. Bostan, I. Babaian; Polytechnic Institute of Chisinau.-Nr. 4307404/2-28; Decl.29.09.87.; Unpublished; Registered on 16.06.95.
- Patent 1646818 (RU), CIB B 24 B 53/08. *Shaped grinding circle stropping process* /I. Bostan, M.Ţopa, S. Mazuru, I. Babaian; Polytechnic Institute of Chisinau. - Nr. 4448694/08; Decl. 27.06.88; Publ.B.I.-1991.-Nr. 7; Registered on 16.06.95.
- Patent 1663857 (RU), CIB B 23 F 9/06. *Wheel tooth machining method of precessional gear* /I. Bostan, I. Babaian; Polytechnic Institute of Chisinau. - Nr.435937/08; Decl. 05.01.88; Unpublished; Registered on 16.06.95.
- CA 1732138 (SU), CIB G 01 B 5/20. *Device for bevel gear control* /I. Bostan; V. Dulgheru Polytechnic Institute of Chisinau.- Nr. 4651372/28; Decl. 17.02.89; Publ.B.I.-1992.-Nr. 7.
- CA 1758941 (RU), CIB B 21 D 43/00; B 30 B 15/30. *Method of bevel gear pumping and device for its realization* /I. Bostan, V. Dulgheru; Polytechnic Institute of Chisinau. - Nr.4845624/27; Decl. 23.04.90; Publ. B.I.- 1992.- Nr.32; Registered on 16.06.95.
- Patent 483 B1(MD), CIB B 23 F 9/00. *Process of barrel-shaped teeth treatment* /I. Bostan, V. Dulgheru, S. Mazuru; TUM.- Nr.95-0334; Decl. 10.07.95; Publ. 31.10.96, BOPI.-1996.-Nr.10.
- Patent 496 B1(MD), CIB G 01 B 5/20. *Arrangement for bevel gear control* /I. Bostan, V. Dulgheru; TUM. - Nr. 95-0337; Decl.10.07.95; Publ. 31.10.96, BOPI.-1996.-Nr.10.
- Patent 549 B1(MD), CIB B 21 D 43/00; B 30 B 15/30. *Method of bevel gear pumping and device for its realization* /I. Bostan, V. Dulgheru; TUM. - Nr.95-0270; Decl.16.06.95; Publ.31.05.96, BOPI.-1996.- Nr.5.
- Patent 550 B1(MD), CIB B 23 F 9/06. *Wheel tooth machining method of precessional gear* /I. Bostan, I. Babaian; TUM. - Nr. 95-0269; Decl.16.06.95; Publ. BOPI.-1996.-Nr.5.
- Patent 552 B1(MD), CIB B 24 B 53/08. *Shaped grinning circle stropping process* /I. Bostan, M.Ţopa, S. Mazuru, I. Babaian; TUM. - Nr.95-0272; Decl.16.06.95; Publ. 10.11.96, BOPI.-1996.-Nr.5.
- Patent 560 B1(MD), CIB F 16 H 1/32. *Precessional transmission* /I. Bostan, I. Babaian; TUM. - Nr. 95-0271; Decl. 16.06.95; Publ. 30.11.96, BOPI.-1996.-Nr.11.
- Patent 1886 B1 (MD), CIB F 16 H 1/ 32; B 23F9/ 06 *Precession gear and process for realization thereof* /I. Bostan, M. Ţopa, V. Dulgheru, M. Vaculenco; TUM.-Nr. 2000-071; Decl. 13.10.2000; Publ.BOPI-2002.-Nr.3.
- Patent 2120 B1 (MD), CIB 23 F 9/ 06. *Process for realization of precessional gear* /I. Bostan, S. Mazuru, S. Scaticailov; TUM. - Nr. 2000-0106; Decl. 19.04. 2001; Publ. BOPI-2003.-Nr.3.
- Patent 2608 (MD), CIB B 23 F 9/ 06. *Device for precessional gear – wheels working* / I. Bostan, V. Dulgheru, I. Dicusară, A. Olevschi; TUM. - Nr. 2003-0261; Decl. O3.11.2003; Publ. BOPI-2004.- Nr.11.
- Patent 2703 (MD), CIB B 21 D 37/ 12. *Device for blank die forming* / I. Bostan, V. Dulgheru, N.Trifan; TUM. - Nr. 2001-0200; Decl. 25.06.2001; Publ. BOPI - 2005. – Nr.2.
- Patent 2791 (MD), CIB B 21 H 5/ 04, 1/ 06; B 21 D 53/ 28. *Device for plastic deformation of gear - wheels* / I. Bostan, V. Dulgheru, N. Trifan; TUM. - Nr. 2003-0213; Decl. 10.09.2003; Publ. BOPI-2005.-Nr.6 (1).
- Patent 2815 (MD), CIB B 23 F 9/ 06. *Process and device for precessional gearwheels working* / I. Bostan, V. Dulgheru, I. Dicusară; TUM. - Nr. 2003-0221; Decl. 10.09.2003; Publ. BOPI-Nr.7.

Precessional gear

- CA 1020667 (SU), CIB F 16 H 1/32. *Planetary precessional transmission* /C. Gluşco, I. Bostan, A. Oprea, N. Bostan; Polytechnic Institute of Chisinau. - Nr. 3244564/25-28; Decl. 11.02.81; Publ.B.I.- 1983.-Nr.20.
- CA 1044868 (SU), CIB F 16 H 1/32. *Planetary gear* /I. Bostan, V. Dulgheru; Polytechnic Institute of Chisinau. - Nr. 3442411/25-28; Decl. 21.05.82; Publ. - B.I. 1983.- Nr.36.
- CA 1190116 (SU), CIB F 16 H 1/32. *Planetary precessional transmission* /I. Bostan, A. Oprea; Polytechnic Institute of Chisinau. - Nr. 3609056/25-28; Decl.23.06.83; Publ.B.I.- 1985.-Nr.41.
- CA 1272033 (SU), CIB F 16 H 1/32. *Precessional hermetic transmission* /I. Bostan, V. Dulgheru; Polytechnic Institute of Chisinau. - Nr. 3910523/25-28; Decl. 17.06.85; Publ.B.I.- 1986.-Nr.43.
- CA 1364791 (SU), CIB F 16 H 1/32. *Precessional transmission* /I. Bostan, V. Dulgheru; Polytechnic Institute of Chisinau. - Nr. 3955441/25-28; Decl. 23.09.85; Publ.B.I.- 1988.-Nr.1.
- CA 1421930 (SU), CIB F16 H 37/02. *Planetary precessional transmission* /I. Bostan, V. Dulgheru; Polytechnic Institute of Chisinau. - Nr. 3955442/25-28; Decl. 23.09.85; Publ.B.I.- 1988.-Nr.33.
- CA 1453092 (SU), CIB F 16 F 1/32. *Planetary precessional transmission* /I. Bostan, A. Oprea, I. Babaian; Polytechnic Institute of Chisinau. - Nr. 4151488/25-28; Decl. 25.11.86; Publ.B.I.-1989.-Nr.3.
- CA 1481539 (SU), CIB F 16 H 1/32. *Planetary precessional reduction gear* /I. Bostan, V. Dulgheru; Polytechnic Institute of Chisinau. - Nr. 4236297/25-28; Decl. 02.04.87; Publ.B.I.-1989.-Nr.19.
- CA 1594329 (SU), CIB F 16 H 1/32. *Planetary precessional transmission* /I. Bostan, V. Dulgheru; Polytechnic Institute of Chisinau. - Nr. 4499327/25-28; Decl. 03.10.88; Publ.B.I.-1990.- Nr.35.
- CA 1601909 (SU), CIB B 64 C 27/04. *The main helicopter reducer* /I. Bostan, V. Dulgheru; Polytechnic Institute of Chisinau. - Nr. 4396349/40-23; Decl. 23.03.88; Unpublished.
- CA 1657806 (SU), CIB F 16 H 37/02. *Planetary precessional transmission* /I. Bostan, V. Dulgheru, V. Peticov; Polytechnic Institute of Chisinau. - Nr. 4601188/28; Decl. 01.11.88; Publ.B.I.-1991.-Nr.23.
- CA 1677416 (SU), CIB F 16 H 1/32. *Precessional reducer gear* /I. Bostan, V. Dulgheru; Polytechnic Institute of Chisinau. - Nr. 4421871/28. - Decl.05.05.88; Publ.B.I.-1991.-Nr.34.
- CA 1758322 (SU), CIB 5 F 16 H 57/12; F 16 H 1/32. *Reducer* /I. Bostan, S. Mazuru; Polytechnic Institute of Chisinau. - Nr. 4847170/28; Decl. 04.07.90; Publ.B.I.-1992.-Nr.32.
- Patent 470 B1(MD), CIB F 16 H 1/32. *Planetary precessional reducer gear* /I. Bostan, V. Dulgheru; TUM. - Nr. 95-0328; Decl. 10.07.95; Publ.30.09.96, BOPI.-1996.-Nr.9.
- Patent 471 B1(MD), CIB F 16 H 1/32; G 01 M/32. *Planetary precessional gear* /I. Bostan, V. Dulgheru; TUM. - Nr. 95-0332; Decl. 10.07.95; Publ. 30.09.96, BOPI.-1996.-Nr.9.
- Patent 472 B1(MD), IB F 16 H 3/50. *Planetary precessional gear* /I. Bostan, V. Dulgheru; TUM. - Nr. 95-0323; Decl.10.07.95; Publ. 30.09.96, BOPI.-1996.-Nr.9.
- Patent 474 B1(MD), CIB F 16 H 37/02, 1/32. *Planetary precessional gear* /I. Bostan, V. Dulgheru, V. Peticov; TUM. - Nr. 95-0330; Decl. 10.07.95; Publ. 30.09.96, BOPI.-1996.-Nr.9.
- Patent 495 B1(MD), CIB F 16 H 1/32. *Planetary precessional transmission* /A. Scoibeda, C. Gluşco, I. Bostan, V. Dulgheru, A. Oprea; TUM. - Nr. 95-0322; Decl. 10.07.95; Publ.31.10.96, BOPI.-1996.-Nr.10.
- Patent 622 B1(MD), CIB F 16 H 15/52. *Planetary speed variator* /I. Bostan, V. Dulgheru, V. Peticov, G. Oglinda; TUM.- Nr.95-0335; Decl. 10.07.95; Publ.30.11. 96, BOPI.-1996.-Nr.11.
- Patent 622 B1(MD), CIB F 16 H 15/52. *Planetary speed variator* /I. Bostan, V. Dulgheru, V. Peticov, G.Oglinda; TUM. - Nr. 95-0335; Decl. 10.07.95; Publ.30.11. 96, BOPI.-1996.-Nr.11.
- Patent 1421 F2 (MD), CIB F 16 H 1/ 32. *Planetary precessional reduction gear (variants)*/ I. Bostan, V. Dulgheru, M. Vaculenco; TUM. - Nr. 97-0271; Decl.26.09.97; Publ. BOPI-2000.- Nr.2.
- Patent 2024 (MD), CIB F16 H 1 / 32. *Precessional gear* / I. Bostan, V. Dulgheru, V. Odainâi; TUM. - Nr. 2001 – 0100; Decl. 13.04.2001; Publ. BOPI-2002.-Nr. 10.
- Patent 2177 (MD), CIB F 16 H 1/ 32. *Precessional reduction gear* / I. Bostan, V. Dulgheru, V. Odainâi; TUM. - Nr. 2001-0112; Decl. 15. 03. 2001; Publ. BOPI-2003.-Nr. 5.
- Patent 2729 (MD), CIB F 16 H 1/ 32. *Precessional transmission* / I. Bostan, V. Dulgheru, D. Vengher; TUM. - Nr. 2003-0220; Decl. 10.09.2003; Publ. BOPI-2005.-Nr.3.
- Patent 2821 (MD), CIB F 16 H 1/ 32 *Planetary precessional gearing* /I. Bostan, V. Dulgheru, A. Sochireanu; TUM. - Nr. 2003-0217; Decl. 10.09.2003; Publ. BOPI-2005.-Nr.7 (I).
- Patent 2918 (MD), CIB F 16 H 15/52. *Precessional variable – speed drive (variants)* / I. Bostan, V. Dulgheru, T. Cozma; TUM. – Nr. 2003-0218; Decl.10.09.2003; Publ. BOPI-2005.-Nr. 11.
- Patent 2943(MD), CIB F16 A 01/32. *Frontal gear (variants)* / I. Bostan, V. Dulgheru, I. Dicusară; TUM. –Nr. 2004-0156; Decl. 28.06.2004; Publ. BOPI -2005.-Nr.12.
- Patent 3153 (MD). *Planetary precessional multiplier* / I. Bostan, V. Dulgheru, O. Ciobanu, R. Ciobanu. BOPI -2006.-Nr.9.

Precessional gear in industrial devices drive

- CA 1240514 (SU), CIB B 32 B 31/16. *Self centring chuck* /I. Bostan, V. Vişneacov, A. Oprea; Polytechnic Institute of Chisinau. - Nr. 3862984/25-08; Decl. 06.03.85; Publ.B.I.- 1986.- Nr.24.
- CA 1693832 (SU), CIB B 25 J 9/00. *Manipulator* /I. Bostan, V. Dulgheru; Polytechnic Institute of Chisinau. - Nr. 4133527/08; Decl. 29.07.86; Unpublished.
- CA 1511120 (SU), CIB B 25 J 17/00. *Manipulator* /I. Bostan, V. Dulgheru; Polytechnic Institute of Chisinau. - Nr. 4316516 /31-08; Decl.12.10.87; Publ.B.I.-1989.- Nr.36.
- CA 1514508 (SU), CIB B 23 B 45/00. *Hand drill* /I. Bostan, C. Gluşco, V. Dulgheru; Polytechnic Institute of Chisinau. - Nr. 4220321/31-08; Decl. 02.04.87; Publ.B.I.-1989.-Nr.38.

- CA 1514595 (SU), CIB B 25 J 11/00. *Manipulator* /I. Bostan, I. Botez, V. Dulgheru, V. Popa; Polytechnic Institute of Chisinau.- Nr. 4316515/31-08; Decl.12.10.87; Publ.B.I.-1989.-Nr.38.
- CA 1558661 (SU), CIB B 25 J 15/00. *Moving industrial robot* /I. Bostan, I. Botez, V. Dulgheru; Polytechnic Institute of Chisinau. - Nr. 4421870/31-08; Decl. 05.05.88; Publ.B.I.- 1990.-Nr.15.
- CA 1583285 (SU), CIB B 25 J 15/00. *Industrial robot clamp* /I. Bostan, V. Dulgheru; Polytechnic Institute of Chisinau. - Nr. 4386938/25-08; Decl. 04.03.98; Publ.B.I.-1990.-Nr.29.
- CA 1620294 (SU), CIB B 25 J 9/00. *Driving device of the industrial robot* /I. Botez, B.Lovchet, I. Bostan, V. Dulgheru; Polytechnic Institute of Chisinau. - Nr.4651369/08; Decl.17.02.89; Publ.B.I.-1991.-Nr.2.
- Patent 462 B1(MD), CIB B 25 B 21/00. *Nut Wrench* /I. Bostan, V. Dulgheru, I. Botez, A. Marin; TUM. - Nr. 95-0324; Decl. 10.07.95; Publ. 30.09.96, BOPI.-1996.-Nr.9.
- Patent 606 B1(MD), CIB B 25 B 21/02. *Nut wrench* /I. Bostan, V. Dulgheru, I. Babaian, A. Marin; TUM. - Nr. 95-0327; Decl.10.07.95; Publ.30.11.96, BOPI.-1996.-Nr.11.
- Patent 2081 (MD), CIB F 16 H 31/ 06. *Fittings driving mechanism (variants)* / I. Bostan, V. Dulgheru, N. Trifan; TUM. - Nr. 2001-0092; Decl. 04.04. 2001; Publ. BOPI-2003.-Nr. 1.
- Patent 2330 (MD), CIB B 23 B 29/ 034. *Boring head* / I. Bostan, V. Dulgheru, D. Golban, I. Dicusară; TUM. – Nr. 2001-0411; Decl. 14.12. 2001; Publ. BOPI-2003.-Nr. 12.

Precessional gear in transportation facilities

- CA 1383657 (SU), CIB B 60 K 7/00; 17/06. *Motor-wheel* /I. Bostan, C. Gluşco, V. Dulgheru; Polytechnic Institute of Chisinau. - Nr. 4098219/31-11; Decl. 23.07.86; Publ.B.I.-1988.-Nr.11.
- CA 1439900, CIB B 60 K 7/00. *Engine-gear wheel reducer of transportation facilities* /I. Bostan, V. Dulgheru, G. Oglinda; Polytechnic Institute of Chisinau. - Nr. 4220865/31-11; Decl.02.04.87. - Unpublished.
- CA 1657460 (SU), CIB B 66 13/02. *Drive reducer for lift cabin doors* /I. Bostan, V. Dulgheru, S. Mazuru; Polytechnic Institute of Chisinau. - Nr.4641364/11; Decl. 27.01.89; Publ.B.I.-1991.-Nr.23.
- CA 1597478 (SU), CIB F 16 H 3/50. *Planetary gear-box* /I. Bostan, V. Dulgheru, C. Gluşco, I. Botez; Polytechnic Institute of Chisinau. - Nr.4405118/25-28; Decl. 05.04.88; Publ.B.I.-1990.-Nr. 37.
- CA 1724486 (SU), CIB B 60 K 7/00. *Electromobil drive* /I. Bostan, V. Dulgheru, V. Filatov; Polytechnic Institute of Chisinau. - Nr. 4700858/11; Decl. 12.10.89; Publ.B.I.-1992.-Nr.13.
- CA 1781950 (SU), CIB 5 B 60 K 7/00. *Engine-wheel of transportation facility* /I. Bostan, V. Dulgheru, C. Gluşco, G. Oglindă; Polytechnic Institute of Chisinau. - Nr.4340680; Decl. 08.12.87. - Unpublished.
- CA 1781951 (SU), CIB B 60 K 7/00. *Engine-wheel of transportation facility* /I. Bostan, V. Peticov; Polytechnic Institute of Chisinau. - Nr.4372161/11; Decl. 02.02.88. - Unpublished.
- Patent 463 B1(MD), CIB B 60 K 7/00. *Engine-wheel* /I. Bostan, V. Dulgheru; TUM. - Nr.95-0321; Decl. 10.07.95; Publ. 30.09. 96, BOPI.-1996.-Nr.9.
- Patent 464 B1(MD), CIB B 60 K 7/00. *Electromobil drive* /I. Bostan, V. Dulgheru, V. Filatov; TUM. - Nr.95-0329; Decl. 10.07.95; Publ. 30.09.96, BOPI.-1996.-Nr.9.
- Patent 485 B1(MD), CIB B 60 K 7/00; 17/06. *Motor-wheel* /I. Bostan, C. Gluşco, V. Dulgheru; TUM. - Nr. 95-0320; Decl. 10.07.95; Publ. 31.10.96, BOPI.-1996.-Nr.10.
- Patent 610 B1(MD), CIB B 64 C 27/04. *The main helicopter reducer* /I. Bostan, V. Dulgheru; TUM. - Nr. 95-0331; Decl. 10.07.95; Publ. 30.11.96, BOPI.-1996.-Nr.11.
- Patent 2142 (MD), CIB B 60 G 17/ 06. *Suspension of a transport facility* / I. Bostan, V. Dulgheru, I. Bodnariuc; TUM. - Nr 2001-0065; Decl. 15.03.2001; Publ. BOPI-2003.-Nr.4.
- Patent 2636 (MD), CIB B 62 D 55/ 00. *Undercarriage drive of the transport facility.* / I. Bostan, V. Dulgheru, N. Trifan; TUM. - Nr. 2001-0081; Decl. 27.03.2001; Publ. BOPI-2004.-Nr.12.
- Patent 2365 (MD), CIB F 16 H 1/ 00. *Motor – gear box* / I. Bostan, V. Dulgheru, V. Odainâi; TUM. - Nr. 2001 – 0367; Decl. 14.11.2001; Publ. BOPI-2004.-Nr.1.

Precessional gear in hydromotors

- CA 1247579 (SU), CIB F 03 C 1/06. *Hydromotor* /I. Bostan, A. Corcimari; Polytechnic Institute of Chisinau. - Nr. 3624559/25-06; Decl. 19.07.83; Publ.B.I.-1986.-Nr.28.
- CA 1353925 (SU), CIB F 03 C 2/08. *Hydromotor* /I. Bostan; Polytechnic Institute of Chisinau. - Nr. 4073599 /25-06; Decl. 04.06.86; Publ. B.I.- 1987.-Nr.43.
- CA 1704525 (SU), CIB F 03 C 1/04. *Hydromotor* /I. Bostan, S. Mazuru; Polytechnic Institute of Chisinau. - Nr. 4214576/06; Decl. 24.03.87.
- CA 1795684 (SU), CIB F 03 C 1/26. *Hydromotor with precessional gear* /I. Bostan, S. Mazuru; Polytechnic Institute "S.Lazo" of Chisinau.- Nr. 4351619/29; Decl. 28.12.87; Unpublished.
- Patent 2433 (MD), CIB F 15 B 15 / 12; F 04 C 9/ 00. *Displacement pump* / I. Bostan, V. Dulgheru, R. Ciupercă; TUM. – Nr. 2002-0042; Decl.28. 12. 2001; Publ. BOPI-2004.-Nr. 4.

Fine mechanics

- Patent 476 B1(MD), CIB G 04 B 29/02. *Electromechanical clock* /I. Bostan, I. Botez, V. Dulgheru, V. Sireţeanu; TUM. - Nr. 95-0325; Decl. 10.07.95; Publ.30.09.96, BOPI.-1996.-Nr.9.
- NB 2073 (MD), CIB B 23 K 9/ 12. *Welding wire feeding mechanism* / I. Bostan, V. Dulgheru, A. Oprea, V. Odainâi; TUM. - Nr. 2001-0071; Decl. 20. 03. 2001; Publ. BOPI-2003.-Nr. 1.
- NB 2711 (MD), CIB F 16 1/ 00. *Planetary Precessional transmission* / I. Bostan, V. Dulgheru, M. Vaculenco, I. Bodnariuc; TUM. - Nr. 2001-0368; Decl. 14.11.2001; Publ. BOPI-2005.-Nr.2.
- Patent 2713 (MD), CIB G 01 F 1/ 06, 3/ 00. *Liquid mater* / I. Bostan, V. Dulgheru, I. Madan, M. Vaculenco; TUM. - Nr.2001-0082; Decl. 27.03.2001; Publ. BOPI - 2005.-Nr.2.
- Patent nr 2961(MD). *Actuator mechanism* / I. Bostan, V. Dulgheru, I. Dicusară. Publ. BOPI nr. 1/2006.
- Patent nr 2995. *Friction precessional variator* / I. Bostan, V. Dulgheru, T. Cozma. BOPI nr. 2/2006.
- Patent 3157 (MD). *Follow-up system* / I. Bostan, V. Dulgheru, I. Dicusară, A. Olevschi. Publ. BOPI nr. 9/2006.

Systems for Renewable Energy Conversion

- CA 1671956 (SU), CIB F 03 G 7/00. *Equipment for thermal-to-mechanical energy conversion* /I. Bostan, V. Dulgheru, V. Filatov, M. Oboroc; Polytechnic Institute of Chisinau. - Nr. 4737969/06; Decl. 31.07.89; Publ.B.I.-1991.-Nr.31.
- Patent 469 B1(MD), CIB F 03 G 7/00. *Apparatus for transformation of thermal energy in the mechanical energy* /I. Bostan, V. Dulgheru, V. Filatov, M. Oboroc; TUM. - Nr. 95-0333; Decl. 10.07.95; Publ. 30.09.96, BOPI.-1996.-Nr.9.
- Patent 494 B1(MD), CIB F 03 D 11/00. *Energetic installation* /I. Bostan, V. Dulgheru, G. Triboj, M. Oboroc; TUM. - Nr. 95-0336; Decl.10.07.95; Publ.31.10.96.-BOPI.-1996.-Nr.10.
- Patent 2106 (MD), CIB F 03 D 1/ 06. *Wind Helical turbine* / I. Bostan, V. Dulgheru, A. Ţopa, A. Oprea, TUM. - Nr. 2000-0170; Decl. 12.10.2000; Publ. BOPI-2003.-Nr.2
- Patent 2288 (MD), CIB F 03 B 7/ 00. *Hydraulic station* / I. Bostan, V. Bogdan, V. Dulgheru, N. Bostan, R. Ciupercă ;TUM. - Nr. 2001-0301; Decl. 13. 09. 2001; Publ. BOPI-2003.-Nr. 10.
- Patent 2431 (MD), CIB F 03 D 1/ 00; 7/ 02. *Wind – driven electric* / I. Bostan, V. Dulgheru, D. Vengher, R.Ciupercă, A. Sochireanu; TUM. - Nr. 2002-0243; Decl. 10.01.2002; Publ. BOPI-2004.-Nr.4.
- Patent 2643 (MD), CIB F 03 D 17/ 06; 3/ 06. *Wind turbine* / I. Bostan, C. Gluşco, V. Dulgheru, R.Ciupercă; TUM. - Nr. 2001-0413; Decl.14.12 2001; Publ. BOPI-2004.-Nr.12.
- Patent 2679 (MD), CIB F 02 B 75/ 26 *External combustion engine* / I. Bostan, V. Dulgheru, Nicu Tudor, R.Ciupercă; TUM. - Nr. 2001-0064; Decl. 15.13.2001; Publ. BOPI-2005.-Nr.1.
- Patent 2888 (MD), CIB F 03B7/00. *Hydraulic station* /I. Bostan, V. Dulgheru, R. Ciupercă, O. Ciobanu, R. Ciobanu; TUM. – Nr. 2005-0067; Decl.04.03.2005; Publ. BOPI-2005.-Nr.10.
- Patent 2916 (MD), CIB F 03 B 7/00. *Floating hydroelectric station*/I. Bostan, V. Dulgheru, V. Cartofianu, R. Ciupercă, O. Ciobanu; TUM. – Nr. 2005-0065; Decl. 04.03. 2005.-Nr.11.
- Patent nr 2965(MD). *Self-orienting solar plant* / I. Bostan, V. Dulgheru, I. Dicusară. Publ. BOPI nr. 1/2006.
- Patent 2994 (MD). *Helical wind turbine* / I. Bostan, V. Dulgheru, R. Ciupercă, O. Ciobanu. Publ. BOPI nr. 2/2006.
- Patent 3017 (MD). *Mechanism for transforming the variable rotary motion into unidirectional rotary motion* / I. Bostan, V. Dulgheru, V. Bostan, R. Ciobanu, A. Sochireanu. BOPI nr. 3/2006.
- Patent 2981 (MD). *Hydraulic station* / I. Bostan, V. Dulgheru, V. Bostan, R. Ciupercă. BOPI nr. 2/2006.
- Patent 2991 (MD). *Hydroelectric station* / I. Bostan, V. Dulgheru, V. Bostan, O. Ciobanu, A. Sochireanu. BOPI nr. 2/2006.
- Patent 2993 (MD). *Hydraulic turbine* / I. Bostan, V. Dulgheru, V. Bostan, A. Sochireanu, N. Trifan. BOPI nr. 2/2006.
- Patent 2990 (MD). *Station for wave power conversion to electric power* / I. Bostan, Fl. Ionescu, V. Dulgheru, V. Bostan, T. Cozma, A. Sochireanu. BOPI nr. 2/2006.
- Patent 2996 (MD). *Mechanism for transforming the variable rotary motion into unidirectional rotary motion (variants)* / I. Bostan, V. Dulgheru, V. Bostan, T. Cozma, A. Sochireanu. BOPI nr. 2/2006.
- Patent 2989 (MD). *Station for wave power conversion to electric power (variants)* / I. Bostan, Fl. Ionescu, V. Dulgheru, V. Bostan, T. Cozma, A. Sochireanu. BOPI nr. 2/2006.
- Patent 3058 (MD). *Pane crane actuator mechanism* / I. Bostan, V. Dulgheru, A. Sochireanu, V. Bostan, O. Ciobanu, R. Ciobanu. BOPI nr. 3/2006.
- Patent 2992 (MD). *Hydraulic station* / I. Bostan, V. Dulgheru, V. Bostan, A. Sochireanu, O. Ciobanu, R. Ciobanu, I. Dicusară. BOPI nr. 2/2006.
- Patent 3104 (MD. *Hydraulic station* / I. Bostan, V. Dulgheru, V. Bostan, A. Sochireanu, O. Ciobanu, R. Ciobanu, I. Dicusară. BOPI nr. 7/2006.

UNIVERSITATEA TEHNICĂ A MOLDOVEI

Bd. Ştefan cel Mare şi Sfânt nr. 168, Chişinău

2007

PENDUL FOUCAULT – OROLOGIU GRAVITAŢIONAL

elaborat şi fabricat de către studenţi şi ingineri - absolvenţi ai U.T.M.

Primul proiect în Republica Moldova (nr. 516938/P15) a demarat în anul 2005, finanţat de către Societatea Europeană de Fizică prin intermediul Societăţii Fizicienilor din Moldova.

Construcţia unică a Pendulului Foucault – Orologiu Gravitaţional permite urmărirea şi înregistrarea cu precizie a mişcării de rotaţie a Planetei Pământ.

Universitatea Tehnică a Moldovei instruieşte specialişti de înaltă calificare conform cerinţelor Procesului Bologna în domeniile:

- Inginerie şi tehnologii industriale
- Inginerie mecanică
- Energetică
- Inginerie electrică
- Electronică şi comunicaţii
- Ingineria sistemelor şi calculatoarelor
- Ingineria şi tehnologia transporturilor
- Ingineria şi managementul calităţii
- Tehnologia produselor alimentare
- Textile, vestimentaţie, încălţăminte şi prelucrarea pielii
- Tehnologia materialelor
- Biotehnologii
- Arhitectură şi urbanism
- Construcţii şi inginerie civilă
- Ingineria mediului
- Cadastru şi organizarea teritoriului
- Informatică
- Contabilitate
- Marketing şi logistică
- Business şi administrare
- Economie mondială şi relaţii economice internaţionale
- Drept (patrimonial)
- Servicii transport

ianuarie

L	Ma	Mi	J	V	S	D
1	2	3	4	5	6	7
8	9	10	11	12	13	14
15	16	17	18	19	20	21
22	23	24	25	26	27	28
29	30	31				

februarie

L	Ma	Mi	J	V	S	D
			1	2	3	4
5	6	7	8	9	10	11
12	13	14	15	16	17	18
19	20	21	22	23	24	25
26	27	28				

martie

L	Ma	Mi	J	V	S	D
			1	2	3	4
5	6	7	8	9	10	11
12	13	14	15	16	17	18
19	20	21	22	23	24	25
26	27	28	29	30	31	

aprilie

L	Ma	Mi	J	V	S	D
						1
2	3	4	5	6	7	8
9	10	11	12	13	14	15
16	17	18	19	20	21	22
23	24	25	26	27	28	29
30						

mai

L	Ma	Mi	J	V	S	D
	1	2	3	4	5	6
7	8	9	10	11	12	13
14	15	16	17	18	19	20
21	22	23	24	25	26	27
28	29	30	31			

iunie

L	Ma	Mi	J	V	S	D
				1	2	3
4	5	6	7	8	9	10
11	12	13	14	15	16	17
18	19	20	21	22	23	24
25	26	27	28	29	30	

iulie

L	Ma	Mi	J	V	S	D
						1
2	3	4	5	6	7	8
9	10	11	12	13	14	15
16	17	18	19	20	21	22
23	24	25	26	27	28	29
30	31					

august

L	Ma	Mi	J	V	S	D
		1	2	3	4	5
6	7	8	9	10	11	12
13	14	15	16	17	18	19
20	21	22	23	24	25	26
27	28	29	30	31		

septembrie

L	Ma	Mi	J	V	S	D
					1	2
3	4	5	6	7	8	9
10	11	12	13	14	15	16
17	18	19	20	21	22	23
24	25	26	27	28	29	30

octombrie

L	Ma	Mi	J	V	S	D
1	2	3	4	5	6	7
8	9	10	11	12	13	14
15	16	17	18	19	20	21
22	23	24	25	26	27	28
29	30	31				

noiembrie

L	Ma	Mi	J	V	S	D
			1	2	3	4
5	6	7	8	9	10	11
12	13	14	15	16	17	18
19	20	21	22	23	24	25
26	27	28	29	30		

decembrie

L	Ma	Mi	J	V	S	D
					1	2
3	4	5	6	7	8	9
10	11	12	13	14	15	16
17	18	19	20	21	22	23
24	25	26	27	28	29	30
31						

Concept şi proiect elaborat de academician I. Bostan.

În realizarea proiectului au participat:

Studenţi: A. Boico, O. Bîrlădeanu, Iu. Colesnic, N. Cocoş.

Doctoranzi: M. Vaculenco, I. Dicusară, O. Ciobanu, R. Ciobanu, A. Sochireanu, D. Vengher, N. Trifan, T. Cozma, V. Odainai, V. Secrieru, C. Munteanu.

Cadre didactice: S. Rusu, V. Podborschi, V. Nastasenco, V. Bostan, M. Traci, Iu. Liunenco.

Fabricat la întreprinderile idustriale din Republica Moldova:
"Etalon - U.T.M.", "Topaz", "Tracom", "Moldovahidromaş", "Acvila Group", "Hidrotehnica", "Incomaş", "Restauratorul", "Azurit", "Arta pentru Viaţă".

Cofinanţare: Asociaţia Fizicienilor din Moldova – preşedinte al A.F.M. academician al A.Ş.M. V. Canţer, membru corespondent al A.Ş.M. I. Jeru.

© U.T.M., 2006