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PHYSICAL CONTRADICTIONS RESOLVING WITH INVENTIVE PRINCIPLES

Physical Contradiction (PhC) is an outcome of third part of ARIZ[1]. PhC is the most concise and precise formulation of a technical problem. In the language of mathematics, PhC is the equation of a technical problem. And just as in mathematics, there are methods of solving different types of equations, so there are methods (Inventive Principles) for resolving the PhC by transforming the system for which this PhC is formulated (step 5.3 of ARIZ).

These Inventive Principles were identified and used for a long time as methods of resolving Technical Contradictions (TCs). More than 40,000 patents and inventor's certificates[2] related to inventions of level 3 and above were analyzed. The analysis of these inventions revealed the most frequently occurring Inventive Principles and Inventive Principles used less often, but always giving very strong solutions.

However, the use of a powerful information fund of Inventive Principles for resolving the TCs turned out to be ineffective due to the comparative weakness of the TC itself. Indeed, TC is only an auxiliary intermediate stage of solving a technical problem (although it is mandatory). The basis of TC, its cause is always a physical contradiction. While the TC characterizes the conflict in the whole system, the PhC refers to a single well-defined part of the system that is subject to change in order to meet the requirements of Ideal Final Result (IFR). PhC is based on the formulation of IFR, which determines its heuristic power.

While TC is a conflict of technical characteristics (productivity, ease of operation, etc.), PhC is a collision of physical, deeper properties (hot-cold, solid-liquid, etc.). In PhC the conflict is exacerbated to the extreme: the same object must possess opposite properties. This is a truly dialectical contradiction.

TC is an ascertaining of the fact that contradiction exists, while PhC makes clear contradictory demands to a system and therefore it is much easier to resolve it.

General characteristics of Inventive Principles

Inventive Principles are used as tools for changing the Engineering System (ES), for which the PhC is formulated.

All ES's changes according to the Inventive Principle are aimed at resolving the PhC and implementing of IFR.

Inventive Principles are revealed by analyzing a large number of top level inventions:

a) Very common Inventive Principles,

b) Rare, but highly effective Inventive Principles.

The main regularities in the development of Engineering Systems are manifested in Inventive Principles: striving for an ideal machine, the transition of the system to the supersystem, the transition from the macrolevel to the microlevel, the coordination of the subsystems in the system, etc.

Ways to resolve the PhC

There are three main ways to resolve the PhC (see table: "Selecting the method for PhC resolving"):

1. Separating contradictory demands:

a) In space,

b) In time.

2. Satisfying contradictory demands in one place and at the same time through changing the physicochemical parameters of the system.

3. Bypassing contradictory demands (removal of the PhC without separation and satisfaction of contradictory demands) through a system transition:

a) Transition to the super-system,

b) Transition to the subsystem,

c) Substitution of the system - transition to alternative systems,

d) Transition to the antisystem.

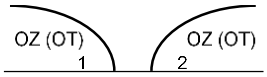
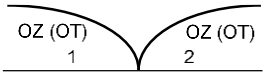
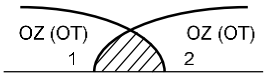
Each way of PhC resolving is implemented by specific Inventive Principles. When working with Inventive Principles, it is desirable to consider their action at both the micro and macro levels.

Here are the main Inventive Principles for resolving PhCs:

[1] ARIZ is an acronym for the Russian phrase "Algorithm for Inventive Problem Solving"

[2] Inventor's certificate is a form of inventor's recognition formerly available in the Soviet Union and a number of Socialist countries. Also called "Author's certificate".

Table. Selecting the method for physical contradiction resolving

Relative position of operational zones (operational times) for two conflicting actions	Recommended Direction for PhC resolving	Example of Inventive Principles use
Operational zones (OZ) or operational times (OT) do not intersect 	The most convenient way is using of separation opposite requirements in space or time	During welding the steam pipe crack under pressure the patch is thrown off by a steam jet - it is suggested to replace the patch with a steam valve (during welding the valve is opened and then after welding closed/sealed). Welding and sealing are separated in time.
Operational zones (OZ) or operational times (OT) are contiguous (at a point, along a line, or a plane) 	Most effective way is changing the physical or chemical parameters of the system	There is a conflict during optical glass grinding – polisher in polisher-glass contact area should be both hard for polishing and liquid for cooling. Conflict is resolved by making an ice polisher (abrasive grains is frozen into ice). During operation the polisher thaws and emits coolant (cold water).
Operational zones (OZ) or operational times (OT) intersect 	Most effective way is using of system transition to a super-system or sub-system	A conflict is highlighted in the problem of the vacuum cleaner noise – all the time during operation and in the whole tract the vortices must be small (to avoid noise) and large (to ensure the productivity). Conflict is resolved by a system transition - each vortex is small, and all together they constitute a big vortex (turbulent flow).

1. INVENTIVE PRINCIPLES FOR SEPARATION OF CONTRADICTORY DEMANDS IN SPACE

1.1. **Division into parts** - to divide the system into many independent parts with opposite properties.

Example: Safe fuel tank, divided by partitions into isolated compartments. Part of the compartments is filled with fuel, and part is filled with substance that extinguishes the flame. PhC: fuel in the tank must be combustible for the operation of the machine but it must be incombustible for fire safety in case of an accident.

Example: The third rail in the metro - the contact part - is made of a steel base with an aluminum conductor. PhC: the contact rail should be resistant to abrasion (steel) but it should have high electrical conduction (aluminum).

Example: Tray for moving the cargo with the help of its own weight. The sliding surface is formed not by a smooth sheet, but by a series of parallel tensioned wires/rods, thereby reducing friction. PhC: the plane must be to support the load but it should not be to avoid friction.

1.2. **Taking out** - to separate from the system its part having one of the properties required in the PhC (undesirable or only necessary).

Example: Tape record with the scream of frightened birds is used to scare the birds off the aerodrome. PhC: frightened birds should be to drive other birds away with their scream but they should not be to avoid birds keeping.

Example: The plug bayonet - bayonet, inserted into the barrel of the gun - did not allow shooting during bayonet charge. The harmful property disappeared with the outer fastening of the bayonet. PhC: The bayonet should be in order to stab but it should not be to shoot.

Example: When the thickened due to cold temperature liquid is heated in the tank, the layers that adjoin the walls are dangerously overheated. The solution is to heat not the primary tank, but a small buffer tank, feeding the heated liquid out of it and gradually melting the whole thickened liquid.

1.3. **"Nested doll"** - to place parts of the system with opposite properties one inside the other.

Example: /inventor's certificate 272705/ Device for applying the fertilizer to the soil, characterized in that, in order to regulate the working width of the gripper, the metering screw is made of two sections where one screwed into other. PhC: the metering screw should be long to cover a large area but it should be short so as not to take up space.

Example: /inventor's certificate 358824/. The ship has a propeller with detachable blades. In case of repair blade passes through hole that is made in the ship stern projection. PhC stern projection should be to protect rudder and propeller but it should not be so as not to obstruct the removal of the propeller blades during repair.

Example: The vibrator is located inside the pile.

1.4. **Local quality** – to impart the required property to any part of the system.

Example: Only a thin surface layer is carburized and hardened in the vice jaws. PhC: the vice jaws should be hard so as not to change their shape when clamping some part but they should be soft so as not to break from the clamping force.

Example: /inventor's certificate 271174/ A way to regulate the humidity in the incubator chamber by local heating the water in the tank. PhC: The water must be hot to evaporate and increase the humidity but it must be cold so that there is no energy consumption.

Example: Concrete sleepers with wooden inserts in the places of rail fastening. PhC: railway sleeper should be rigid so as not to wear out but it should be soft so as not to destroy the train.

Example: Eyedropper should be sharp (capillary) but it should be blunt so as not to injure the eye.

A special case of principle “Local quality” is

1.5. **Asymmetry / local form** - to switch from a symmetrical form to an asymmetric one for separation of contradictory requirements.

Example: Shaped skid of Finnish sleigh - high in the footboard area and low in the rest of the length. PhC: the skid should be high so that the foot does not scrape through the snow but it should be low so that it have small weight.

1.6. **Transition to another dimension** – the PhC associated with the movement /motion/ along the line is resolved by the transition to the plane, the volume. Use a multi-story arrangement, the reverse side of the plane, and the slope of the system. Move from rectilinear parts to a circle, sphere.

Example: It is proposed to make the movable belt dial in the form of a Mobius strip with divisions applied on both sides. PhC: tape should be long to accommodate all the digits but it should be short so as not to take up space.

Example: The design of a circular aerodrome with endless runways in the form of concentric circles is developed, which significantly reduces the area compared to the traditional one. PhC: runways should be long so that large aircraft can fly but it should not be long to reduce the aerodrome area.

Example: The trolley is moved over the train with a turn of 90°. PhC: trolley should be high for high capacity but it should be low for moving over the train.

1.7. **Copying** – to impart contradictory properties not to the system, but to its simplified copy or its image in the necessary scale.

Example: To make and measure a photo for measuring the logs on the platform. PhC: logs should be long for work but they should be short to facilitate measurement.

Example: Shape control of the balls for small precision bearings is performed by increasing their shadows by 20,000 times on the screen. PhC: balls should be small for work but they should be large for measurement.

Example: To test the hollow cones they are filled with water, their photos are taken and then examined.

1.8. **Intermediary** – to impart required according to PhC property not to the system, but to the external element.

Example: To increase the strength of the cans they are coated with a special coating. PhC: the can should be thick for strength but it should be thin to reduce weight.

Example: To protect the monument from contamination and vandal inscriptions its surface is covered with an easily removable lacquer film. PhC: the surface of the monument should be movable, easily removable for discarding inscriptions, contamination, etc., but it should be fixed to ensure aesthetic perception.

1.9. **Use of flexible shells and thin films** – a very thin layer of substance is used for the resolving of the PhC like "the substance should be present in order to ..., but it should not be present in order to...".

Example: To prevent splattering during the preparation of a tenderized steak, beating the meat is carried out in a plastic bag. ChP: the x-element should be present to prevent splattering but it should not be present so as not to interfere with the beating.

Example: The doors of the furniture are made of a thin film that can be rolled into a tube. PhC: the door should be present for protection from dust but it should not be present to save the space required to open it.

1.10. **Use of foam** – use a foamed substance consisting mainly of air to overcome the PhC like "the substance should be present in order to ..., but it should not be present in order to...".
Example: Slag foam, which is an excellent heat insulator, is formed on the surface of liquid slag to prevent its solidification during transportation in the ladle. PhC: lid on the ladle should be present to prevent solidification but it should not be present for slag discharge.

2. INVENTIVE PRINCIPLES FOR SEPARATION OF CONTRADICTORY DEMANDS IN TIME

2.1. **Dynamization** - to impart conflicting properties to a system at different times it is made changeable, make it possible for its parts to move relative to each other.

Example: Subsonic aircraft MIG-15 had air inlets with blunt lips, supersonic MIG-19 had sharp ones. Aircraft MIG-21 have a system for adjusting the angle of the air inlet. PhC: lips of the air inlet should be blunt for good performance at subsonic speeds and they should be sharp for work at supersonic ones.

Example: The English inventor R. Pace proposed a sewing needle made of two twisted steel filaments with welded ends. It is as thin as the usual one, but for threading it is untwisted by fingers and forms a wide gap, into which any thread is easily goes through. PhC: Needle eye should be narrow so as not to obstruct sewing but it should be wide for threading.

Example: A pan with an eccentric collar allows to form any slit for water draining by lid rotation. PhC: slit should not exist during cooking and storing food but it should exist when draining the water.

Example: Seesaw for different in weight people /parent and child/ do with the seats that can move along the plank. PhC: the seats should located at the same distance from the pivot for people with the same weight but they should located on different distance for people with different weights.

The highest form of dynamization is

2.2. **Discarding and recovering** – the part of the system that became unnecessary should be discarded. Consumable parts of the system should be restored during operation.

Example: In Sweden are produced plastic bottles that self-destruct under the influence of sunlight and ground acids. PhC: the bottle should exist for liquid storage but it should not exist for not clogging the environment.

Example: /US Patent 3,160,950/ So that at the start of the rocket sensitive devices are not affected, they are immersed in a plastic foam, which, after performing the role of a shock absorber, evaporates in space. PhC: shock absorber should exist for the protection of devices but it should not exist in order not to take up space in the rocket.

Example: During plasma cutting in a carbon-containing medium the consumable electrode is restored by depositing carbon on it from the disintegrating in the cutting zone at high temperature medium. PhC: Carbon should be consumed for cutting but it should not be consumed to prevent frequent replacement.

2.3. **Preliminary action** – to give the system the required property in advance /completely or partially/.

Example: A method of the wood dyeing before the tree was cut down was proposed in Japan – a dye, introduced into the soil, is carried by saps throughout the tree trunk. PhC: wood should be dyed to improve the appearance and it should not be dyed in order not to spoil the wood surface when dyeing.

A special case of preliminary action is

2.3.1. **"In-advance cushioning"** – emergency means are preliminarily prepared in order to compensate the low reliability of the system. "Cushion" should work at the time of the accident, but it should not affect the operation of the system in the rest of the time, thereby PhC resolving is ensured.

Example: /US Patent 3,624,849/ A float, connected by a line with the ship, is attached to them in advance with a soluble adhesive for detecting the location of wrecks. When immersed, the float is unstuck and floats up. PhC: the ship should be present on the water surface for the possibility of visual detection but it cannot be there, since it sank.

2.4. **Periodic action** – the alternate provision of two contradiction demands of PhC.

Example: A pulse sprinkler, which supplies water to the soil in the form of drops, is proposed. PhC: water should be present for irrigation but it should not be present in order to prevent soil erosion.

Example: For pulse grinding the grinding wheel have form of a pinion with teeth, what reduces the temperature by half and raises the labor productivity. PhC: grinding wheel should be grinding for processing the product but it should be non-grinding to reduce the temperature.

A special case of periodic action is

2.4.1. **Mechanical vibration** – vibration alternately carry out two states of the system, corresponding to different sides of PhC, thereby resolving the PhC.

Example: Vibro-conveyor for moving luggage was offered in England. Coordinated oscillations with an amplitude of just a few microns are sufficient to move the goods.

2.5. **Skipping** – impart one of the conflicting requirements to the system for a very short period of time.

Example: /inventor's certificate 112889/ It is offered to unload timber-carrying ship by sharp jerk. PhC: to unload the timber-carrying ship it needs to be heavily tilted, but it can overturn.

Example: /West Germany Patent JN1134821/ Knife cutting the plastic pipe so quickly that it does not deform. PhC: knife should be pressing to cut the pipe but it should not be pressing so as not to crumple it.

2.6. **Use of pauses, continuous useful action** – a contradictory demand is carried out in pauses of the action that fulfills the main demand. Blank and intermediate motions are eliminated, useful work is conducted continuously.

Example: /inventor's certificate 302625/ The method for controlling the thermocouple by heating it and checking the thermal electromotive force (EMF) in the circuit, characterized in that, in order to reduce the monitoring time, the thermocouple is heated by current pulses, and in the intervals between them, the presence of a thermo-EMF is checked.

Example: Thyristor power controller creates strong impulse noise in the circuit when switching thyristor. It is proposed to carried out switching at the moment of the mains voltage transition through zero /pause of the operating action of the current/.

2.7. **Pneumatic structures, hydraulic structures** – a typical PhC "system should be big in order to ..., but it should be small in order to ..." is resolved

Example: To lift a damaged aircraft above the ground device should be large but it should be small for easy transportation to the accident site.

Example: The dam is made of bags of water.

Example: The keel of the tipping barge is made of water.

A special case of pneumatic structure is

2.7.1. **Vacuuming** – allows you to hold the object at the right time without special devices. In this case, the PhC is resolved close to IFR, since pressing is carried out by atmospheric pressure.

Example: /inventor's certificate 340576/ Pressing the cargo in the ship hold is provided by covering cargo with an elastic, airtight gasket and subsequent air evacuation.

2.8. **Excessive action / after-action** – for resolving of the PhC like: "there must be a lot of substance in order to ..., but there must be little substance in order to ...", excess amount of substance is introduced, and then the unnecessary part is removed.

Example: /inventor's certificate 242714/. For an exact painting of the cylinders they are first dipped in a tank with paint, and then rotated to remove the surplus by the centrifugal force.

Example: A strong flame is created for reliable sealing of ampoules, and excess heating is removed with a water bath.

3. INVENTIVE PRINCIPLES FOR SATISFYING OF CONTRADICTORY DEMANDS THROUGH CHANGING THE PHYSICOCHEMICAL PARAMETERS OF THE SYSTEM

3.1. **Changes in volume properties** – the properties of the system change in the same volume due to changes in the aggregate state, concentration, and degree of flexibility. The PhC is resolved due to the features of the new state of the system which combining the available property with the required one.

Example: When oxygen is blown through the metal, it is proposed to use liquid oxygen to reduce the smoke formation. PhC: oxygen should be volatile for blowing through a metal but it should be non-volatile to reduce smoke formation.

Example: /inventor's certificate 260506/ Unloading of bulk raw sugar from the bottom of the tanker with hydro-transport means by dissolving the sugar with hot water until a saturated solution is obtained.

Example: A flexible auger for transportation of particles of different sizes. PhC: auger step should be small for small parts but it should be large for large ones.

3.2. **Application of phase transitions, thermal expansion** – use coexistence in one place of the simultaneously opposite properties arising at the phase transition: liquid-solid, heat-dissipation-absorption, increase-reduction of volume, etc.

Example: For polishing of optical glasses the polisher must simultaneously have abrasive properties, i.e. be hard, and constantly supply the coolant, i.e. be liquid. It is proposed to make an ice polisher with an abrasive powder. When working, the surface of the polisher constantly thaws, releasing the coolant.

Example: For the destruction of larvae of beetles in the groats, it is mixed with a substance having a Curie temperature above the temperature of death of the larvae, but below the temperature of the spoilage of the groats. Induction heating is performed. PhC: groats should be hot to destroy the larvae but it should be cold, so as not to spoil.

3.3. **Use of fields** – conflicting requirements are met by replacing the substance with a field.

Example: /Edison's task for newly employed staff/ it is necessary to store an absolute solvent that dissolves any substance. PhC: vessel should be present to store the solvent, and it should not be present so as not to dissolve. The solution: a) use a magnetic field to hold the solvent if the solvent is sensitive to it; b) use of the thermal field – freezing of the solvent and storage in the usual way; c) the gravitational field – storage in zero gravity.

Example: For marking a long pipe from the inside to cut it at any angle, instead of a set of tin patterns, the lamp with an annular slot is placed on the ball joint.

Example: For easy indication of the displacement of the part a changing field is used: electrical – piezoelectric sensors, odor – ampoules with perfume. PhC: the part should be strongly changing for easy indication of the displacement but it should not be changing to continue to work.

3.4. **Change in color, transparency** – use of coloring additives, luminophores to observe poorly visible objects.

Example: /US Patent No. 3,425,412/ The wound dressing is made of transparent material, which allows you to observe wound condition without its removing. PhC: wound dressing should be present to protect the wound but it should not be present to observe the wound.

3.5. **Contrast substances** – the use of substances that, by their physicochemical properties, simultaneously satisfy contradictory demands.

3.5.1. **Strong oxidizers** – enriched air, oxygen, ozone. Instead of an additional device, the intensity of the process is increased by an increase in the oxidizing capacity of the external medium.

Example: In plasma arc cutting of steel pure oxygen is used as the cutting gas.

3.5.2. An **inert medium** is used to eliminate the harmful process.

Example: To extinguish fires on submarines nitrogen is added to the air to a level at which combustion is not maintained. PhC: air should be rich in oxygen for breathing but it should be oxygen-deficient for fire extinguishing. The addition of nitrogen retains the amount of oxygen in the air, but reduces its partial pressure to a level that does not support combustion.

3.5.3. **Explosives, gunpowder**.

Example: /US Patent No. 32281153/ explosive anchor device for power line supports, radio masts and the like. In the device, immersed in the required depth of the drilling rig, a charge of explosives is laid, which creates a cavity in the ground and firmly anchors there the paws of the anchor device. PhC: the fixing device

should be present so that the support holds hard and it should not be present to avoid special underground work.

3.5.4. **Capillary-porous substances** – simultaneously possess the properties of solids and gaseous substances.

Example: The porous asphalt is proposed, the road from which does not need drainage facilities. PhC: road covering should be dense to resist loads but it should be not-dense to let in water.

3.5.5. **Exothermic substances**

Example: It is proposed to use termite composition applied in small doses directly to the soldering / piercing zones for soldering thermosensitive chips. PhC: the temperature in the solder zone should be high for melting solder but it should be low so as not to damage the chip.

INVENTIVE PRINCIPLES FOR PHC REMOVING THROUGH TRANSITION TO THE SUPERSYSTEM

4.1. **Unification** – every system that is part of the supersystem has a certain property, and the entire supersystem has opposite property.

Example: To measure the temperature of the weevil /it is necessary to fight it/ the inventor Kachugin suggested to collect a glass of beetles and measure in the usual way with a conventional thermometer. PhC: beetle should be large for measuring temperature but it should be small so as not to differ from the usual pest.

Example: /inventor's certificate 235547/. For the transportation of objects exceeding the dimensions of the elevator cabin, two cabins are located in the common shaft, and the adjacent walls are made opening. PhC: cabin should be large for the transportation of large items but it should be small in order not to take up much space.

Example: To increase the load-lifting capacity of the aircraft in the air a "flying wing" module is formed from several aircraft that join in the air. PhC: the aircraft should be large to increase the carrying capacity but it should be small for the convenience of takeoff and landing.

Example: Weak individually, the soldiers, united by A.Macedonsky in the phalanx, turn into an invincible force.

Example: To fight cancer Nobel laureates of 1984 Koller and Milstein proposed a hybridoma - a combination of a cancer cell that rampantly multiplies, and a lymphocyte that synthesizes the desired antibodies.

4.2. **"Blessing in disguise"** - a harmful property in the supersystem can play a useful role or be compensated by other harmful properties.

Example: Waste car tires are used for waste water treatment. PhC: the tire should exist for the operation of the car but it should not exist to avoid clogging the environment. The contradiction is removed due to the transition to the supersystem jointly with the sewage treatment system.

Example: When passing high frequency currents through the metal only surface heating takes place – it was a harmful effect. This was used to create a method of high-frequency quenching of steel ingots.

4.3. **Homogeneity -** PhC is removed by the coordination of components in the super-system.

Example: /inventor's certificate 116569/ So that the particles of the rod that transmits ultrasonic vibrations to the molten metal do not contaminate the metal, the rod is made of the same material. PhC: rod should be present to create ultrasonic vibrations but it should not present in order not to contaminate the metal.

4.4. **Equipotentiality** - rebuild the system so that there is no need to lift a heavy system. Contradictory demands of heavy-light are not separated, instead, the system lift is eliminated in the supersystem.

Example: Transportation of heavy large-size reinforced concrete pipes carries out with a pipe-track that get in the section of the pipe, slightly lifting it with a jack and in this position carrying it.

5. INVENTIVE PRINCIPLES FOR PHC REMOVING THROUGH TRANSITION TO THE SUBSYSTEMS

5.1. **Segmentation** – the system itself has some property, and its subsystems - the opposite.

Example: /inventor's certificate 259949/ Traffic light, the pole of which is made of hingedly connected elements. PhC: a traffic light should be high for main work but it should be short for easy repair.

Example: For the move of one of the Scottish libraries to a new location, its director suggested for all the readers to take several books /in addition/ in order to return them in two weeks to a new place. PhC: there should be many books in the library for providing a great choice but there should be few books for the convenience of moving.

5.2. **Composite materials** - each piece of material has its own property, but in general the composite has a different, required property.

Example: The material for the road pavement “rubit” is developed in Sweden – a mixture of asphalt, crushed stone and rubber. Due to the elasticity of the pavement the danger of icing of the road is reduced, since the ice crust is cracking under the wheels of the car. PhC: pavement should be elastic to reduce icing but it should be hard for strength.

5.3. **Cheap short life instead of expensive durability** – instead of a one firm, durable, dense object, it can be used a few fragile, weak, short-lived.

Example: In the US, a rotary internal combustion engine is used, called the "dying rotor". After 500 hours of operation it is ejected and replaced with a new one.

Example: A single-use diaper with a filler like the multi-layer blotter.

6. INVENTIVE PRINCIPLES FOR PHC REMOVING THROUGH REJECTION OF THE SYSTEM

6.1. **Self-service** – the system itself performs auxiliary functions without the use of special maintenance systems.

Example: When constructing canals, the structural elements are moved to the place of installation by water along the already finished part of the channel, which is closed by temporary diaphragms and filled with water. PhC: transport should be present for the delivery of new elements but it is should not be present in order not to complicate the construction.

Example: To protect aluminum or steel from corrosion the oxide layer of this metal is used.

Example: A caseless cartridge in which the function of the case is performed by the compressed part of the explosive is proposed.

Example: /inventor's certificate 1245300/ Matchbox without a tray is proposed.

Example: Self-cleaning of exhaust gases of quarry dump trucks by passing them through the rock in the dump body.

6.2. **Universality** – the system performs several different functions to avoid the need for other systems.

Example: It is suggested to use a hollow frame as a fuel tank in a motorcycle.

Example: The toilet seat has a function of scales.

Example: /inventor's certificate 163473/. Before collecting eggs the poultry worker puts on the finger a special fingerstall with a stamp. Collecting eggs, she/he also marks them.

Example: The handle of the briefcase in the form of a hand trainer (finger strengthener) is proposed.

7. INVENTIVE PRINCIPLES FOR PHC REMOVING THROUGH TRANSITION TO THE ANTISYSTEM

7.1. **System inversion** - the tool and the product are interchanged.

Example: Pool for training swimmers, in which a hydraulic pump is installed, creating a water flow, which compensates for the swimmer's speed - while remaining in place one can train in long-distance swimming. PhC: swimming pool should be long for training but it should be short so as not to take up space. PhC is removed by the transition from the problem "a person is swimming along the pool" to the problem "the pool is swimming along the person".

Example: Instead of pouring hot liquor into the chocolate shell, it is suggested to pour hot chocolate over frozen liqueur. PhC: liqueur should be hot for pouring but it should be cold so as not to melt the chocolate shell.

7.2. **Anti-action** – to compensate harmful action with others, the opposite.

Example: To compensate the tensile stresses destroying the concrete /under wind loads/ in the Ostankino television tower, the concrete structures are reinforced with tensioning ropes compressing them.

Property opposite to inadmissible can be given to the object in advance.

Example: pre-stressed reinforced concrete.

A special case of anti-action is

7.2.1. **Anti-weight** – the weight of the object is compensated by different lifting forces.

Example: Balloons are used to lay the underwater cable in large ponds.

Example: /inventor's certificate 358689/ In the centrifugal sensor in order to reduce the overall dimensions and weight, the load weight are made in the form of a wing to create a lifting force during rotation that compensates for part of the weight.

In conclusion, it should be noted that all Inventive Principles for resolving of the PhC can be used not only separately, but they can also form combinations and even be transformed into each other. The problem can be solved by separation the contradictory demands both in space and in time. The combination of Inventive Principles gives a stronger solution than a single Principle.

Consider as an example such a problem: heavy objects, for example, washing machines, packed in

cardboard boxes, are very inconvenient to carry. The bottom of the box does not stand the load and falls apart. The use of wooden boxes is very expensive. Solving this problem, we came to the following PhC: the bottom should be in one piece with a box for protecting the cargo but it should be separate from the box, so as not to collapse.

Solution. We divide the bottom into parts /Inventive Principle 1.1/. Some will protect the cargo, others that are not bound to the box, will carry the load. Now we use the Principle "Nested doll" /1.3/ - we will place the supporting parts inside the protective ones. And, finally, we take out /Principle 1.2/ the ends of the load-bearing parts outwards, so that it would be convenient to hold them. What do we get as a result?

A loop of a thick rope is skipped through the box under the load. We will use this loop to lift the load jointly with the box. In general, we used Inventive Principle 7.1, replacing the task of lifting the box with the load on the task of lifting the load with a box fixed on it.

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