Conclusion

We are here in order to contribute to this world. Otherwise, why should we be here?

Steve Jobs

Recommendations on Using TRIZ Tools

Main TRIZ tools were described above. Let us see, how they can be used most efficiently in solving problems. The sequence of execution is presented in the form of an algorithm (Fig. A.1).

At first it has to be made clear, if this ***type of problem is known*** to the problem solver.

If it is ***known***, it is a ***standard problem*** and *the type of contradiction*, which is characteristic of this problem, *is known*. Such a problem is solved using **knowledge base** (*inventive principles* and *resources* were described in this manual).

If this ***type of problem*** is ***unknown*** to the solver, then it is a ***nonstandard problem*** and *the type of contradiction,* characterizing this problem, *is unknown*. Such problem is solved using **a chain of contradictions**.

Recommendations in Improvement of TRIZ Knowledge

The objective of this book is to acquaint the reader with the main elements.

As it is known, mastering any subject consists of three stages:

- Knowledge;
- Skills;
- Habits.

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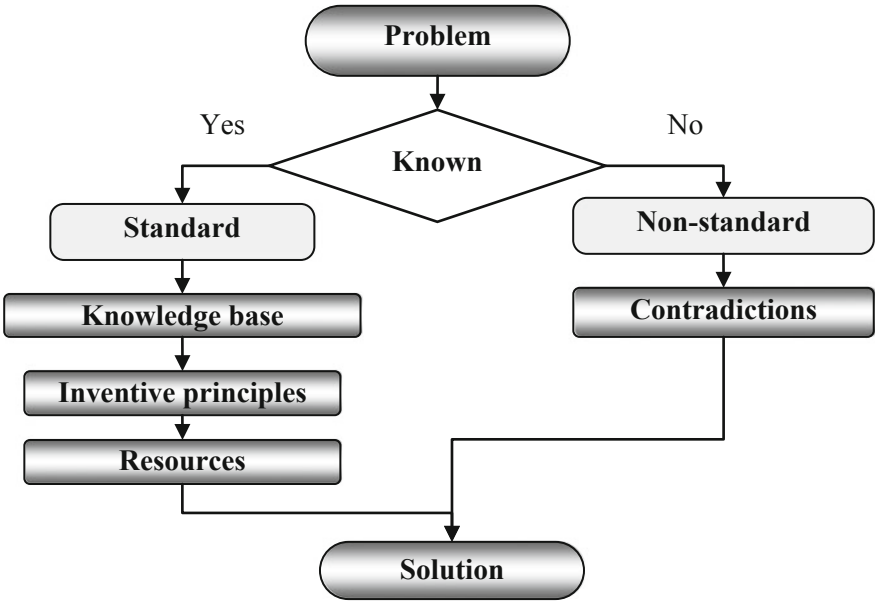

Fig. A.1 Algorithm of using TRIZ tools for performing the function "solving a problem"

Having read the book, you only got certain *knowledge* of TRIZ; however, theory is dead without practice. It is impossible to learn to swim on the shore, using the best manual. *Skills* are developed through practice. Applying particular elements several times leads to automatic performance of these actions—obtainment of *habits*.

If you want to obtain not only habits in using TRIZ, but also change your thinking, make it *inventive thinking*, TRIZ thinking, painstaking target-oriented work. It will be necessary for you not only to follow the below recommendations, but also to develop your thinking in a goal-oriented way.

There are certain constituents of inventive thinking:

1. System thinking;
2. Evolutionary thinking;
3. Thinking through contradictions;
4. Thinking through resources (resource thinking);
5. Thinking based on models;
6. Development of creative imagination (DCI).

System thinking is understood by the author as an ability to see the constituents of the system, its *elements*, *hierarchy of the system*, *mutual influence* of system elements and interaction between system and supersystem and environment, taking into account the changes *in time* and *according to condition*, *historical development*, *goal statement chain*, *identification of demands*, creation of *function model,*

of tree of дерева *operation principles*, *system level*. This kind of thinking will be considered in manuals of higher level.

Evolutionary thinking has two constituents:

(a) *Identification of regularities of evolution (trends)* in any phenomena, for example, as it is done in texts on logics or IQ (e.g., the following sequence: triangle, square, pentagon, what next?).
(b) *Use of trends of system evolution* for development of a particular system.

Thinking through contradictions implies the identification and resolving of contradictions.

Resource thinking is the ability to identify resources and to use them.

Modeling*is the ability to solve problems through creation of models*. Besides different methods of mental modeling, it is desirable to create simplest models of cardboard, plasticine, etc. It is desirable to use different kinds of mathematical and computer modeling. This kind of thinking will be analyzed in manuals of a higher level.

DCI is targeted at ***controlling psychological inertia***. All known inventive principles and methods are used for the development of creative imagination. This kind of thinking will be analyzed in manuals of a higher level.

Apply each of the above-listed tools for improvement (for the sake of improving the objects, processes and notions, which surround us and which we encounter. This work should become usual and daily for you like training sessions for an athlete and rehearsals for a musician.

Use the system of trends for the development of existing objects and try to predict the objects of the future. Use each of the trends thoughtfully and unhurriedly. First, pay special attention to the uniqueness of the idea, not at its implementability. In order to develop practical thinking, it is necessary to do special exercises. Don't try to combine them, at least at the initial period of inventive thinking development.

In solving problems using a chain of contradictions, pay attention to adhering to the preset sequence. If the analysis of the problem does not correspond to the logic of ARIZ, return to the place, where the «failure» took place and analyze the problem once more. Do it until your analysis of the problem completely corresponds to the logic of ARIZ. It would be better to do it first with the problems, the answer to which is already known.

Alternate the training of each method with techniques of DCI.

Training sessions aimed at developing habits of inventive thinking should not be long (10–20 min per day), but should be often—ideally, they should take place every day.

I'd like to offer you some recommendations concerning the methods of acquiring habits related to indicated directions.

Optimization of Habits

Here are some recommendations on improvement of knowledge, skills and habits:

1. **The mastering of the material requires attentive reading of this book several times**.

Solve all problems yourselves and analyze examples. The answers to the problems and examples are already known to you. In case of repeated analysis, pay attention to correctness of using the tool—to methodological side, not to obtainment of the answer. Thus, you will perfect your skills of using the tool.

Try to solve problems and examples, using other TRIZ tools, than the ones described in this section.

Find other solutions, maybe, still better ones, than those, quoted in the book.

2. **Read and study in greater detail other books**, indicated in TRIZ reference list.
3. **Study the materials, which are found at the fundamental Web sites on TRIZ in the Internet** (see Appendix A).
4. **Solve practical problems** from your professional field or from contiguous field. Try to solve the problems of your acquaintances.

The goals, which you would like to reach with the aid of TRIZ, can be fairly various. Let us consider some of them, which are encountered most often:

1. **Solve problems, forecast the evolution of systems**, and obtain promising solutions.

Solve problems from:

- your own area of knowledge (most often, this refers to technology);
- contiguous fields of knowledge;
- any field of knowledge.

Forecast the evolution of systems:

- Forecast in your own area of knowledge (most often, this refers to technology).
- Forecast in contiguous fields of knowledge.
- Forecast in any field of knowledge.

2. **Teach TRIZ**.

TRIZ can be taught to children and grown-ups, connecting it with different specialties. The courses can be trial ones, basic ones, advanced, professional, specialized and qualification upgrade ones.

Besides knowledge of TRIZ, the trainer should know psychology, pedagogy and has good habits of eloquence.

3. **Do research and development work in TRIZ**.

If you would like to deepen your knowledge and improve skills on sections of TRIZ, which are described in this book, first of all you will have to seriously study all sections, described in Introduction.

If you are going to become a TRIZ trainer, you will need beside excellent knowledge of all sections of TRIZ and habits of using them, also habits of eloquence, art of lecturing, knowledge of fundamentals of pedagogy and psychology of communication. Besides, it is necessary to use system approach in preparing and conducting training sessions.

TRIZ researcher, besides above-listed skills and habits, should necessarily be observant and possess the skill of analyzing, digesting and systematizing of information and of setting forth new ideas, which might seem to be «crazy» at a glance, ability to develop and substantiate them.

Each person, who is engaged in TRIZ, should necessarily conduct a personal **card catalogue**. As a rule, at first such card catalogue contains examples related to different sections of TRIZ. This work is fairly painstaking, since in order to obtain the information, which interests you, it is necessary to study numerous reference sources and to spend hours in the Internet. Further on, new ideas are included with the card collection as well as unsolved problems, analysis of solved problems, methodological and research materials.

TRIZ is constantly developing and penetrates other areas of knowledge. We think that one of the explorers and developers of TRIZ will be you, dear reader.

We wish you great success in improvement and enhancement of your creative capacities.

Send your questions, remarks and proposals to:
Vladimir Petrov E-mail: vladpetr@013net.net.

Appendix A
Analysis of Problems

In this section, we shall show our variant of analysis of certain problems.

IFR

Problem 4.3. Clay Pigeon Shooting
Condition of the problem

One of the kinds of sports is clay pigeon shooting. Pieces of these "clay pigeons" are scattered throughout significant area. Quite a number of employees are required to clean this area, which is rather expensive. What is to be done?

Analysis of the Problem

Use **ideal final result (IFR)**.

IFR: The splinters take themselves away. Still more ideal is the following: Splinters should disappear.

Solution

The pigeon should be made of ice. Liquid nitrogen is used for this purpose.

Use of physical effect—phase transition.

Problem 4.4. Waterwell
Conditions of the problem

Imagine the following situation. You die from thirst, and on your way, you encounter a well. The problem is that you have neither a bucket, nor a piece of rope.

How can you satiate your thirst?

Analysis of the Problem

Use **IFR**.

IFR: Water raises itself.

Method of solving

Use of *resources*.

What resources can be used for raising the level of water in the well?

V. Petrov, *TRIZ. Theory of Inventive Problem Solving*,
https://doi.org/10.1007/978-3-030-04254-7

One has to fill the inner volume inside the well, so that the water level would be raised.

What surrounding resources could be used for that?

Solution

It is necessary to throw enough stones into the well; then, the water level in it will be higher. The number of stones should be such that the level might rise to the height, enabling to get water with one's hand.

Resources

Problem 5.6. Support for a Plate

They usually eat sitting at the table, having placed a plate and the necessary objects on it. How to make a support for the plate, so that one could eat standing, sitting in an armchair or in a different place, without using the table. Suggest what resources, which are available at home, can be used.

Possible solutions

It is absolutely possible to buy special tables, for example, Fig. A.2.

Some of the possible solutions were described in Problem 7.4 (Buffet reception, Fig. 7.8b). It has to be noted that the plate should be held in hand. If only one could hang the plate like a wine glass, as it is shown in Fig. 7.8a.

One eccentric fellow proposed to use an object for this purpose, which is to be found in every apartment (Fig. A.3).

Contradictions

Problem 6.11. Radiolocation Station

Conditions of the problem

There is a powerful radiolocation station (RLS) with rather a heavy antenna of great area. Antenna is fixed on shaft; however, it turns on it rather seldom and, therefore, has no drive, but is turned manually. After being turned, the antenna is

Fig. A.2 A table for a sofa (URL: https://www.everafterguide.com/greenco-bamboo-foldable-breakfast-table-laptop-desk-bed-table-and-serving-tray-bamboo-by-greenco-b60d6d1bcb0bc258.html, https://www.amazon.com/dp/B01MXINT49?psc=1)

Fig. A.3 A support for a plate (URL: http://www.zimei5.com/a/207488)

fixed on a shaft with the aid of a fixing device and bolt joint. The force required for holding a heavy antenna on a shaft is significant, and therefore, the bolts have to be tightened rather tightly; however, because of strong tightening the shaft is deformed and it is practically impossible to turn it next time.

What is to be done?

Analysis of the Problem

Administrative contradiction (AC).

AC has been practically already formulated in description of source situation: A fixing element is needed, which would exclude the deformation of antenna shaft. ***Undesirable effect (UE)****is the deformation of the shaft*.

Technical contradiction (TC).

Fixation of the shaft leads to its *deformation*.

Ideal final result (IFR).

The shaft should be *fixed*, but should *not get deformed*.

Physical contradiction (PC).

Fixing element should be **hard**, in order to *fix*, and should be **soft**, in order not to *deform the shaft*.

Resolving the contradiction.

Such contradiction can be resolved by changing the **structure** of fixing element.

Solution

The shaft is held in an easy-to-melt substance, which melts as a result of the turn. It dawned upon the inventors to create a buoy at the end of the shaft. In melted state, the fluid will support the antenna and it will be easier to place it in a new position (author's certificate 470 095).

Problem 6.12. Avalanche in the Mountains

Condition of the problem

It is very difficult to find a person covered by an avalanche in the mountains. Many active devices have been invented, like transmitters, which issue a signal informing about where a person buried in snow is. However, these devices are unworkable under real conditions. First of all, only a few tourists would agree to carry such a transmitter just to be on the safe side. Secondly, the batteries providing for functioning of these transmitters quickly get discharged, and if there is a button on the device for issuance of emergency signals, which has to be pressed at the right moment, it would naturally be impossible to switch on such a unit, if a person is poured with snow of the avalanche.

What is to be done?

Analysis of the Problem

Administrative contradiction (AC).

It is necessary to minimize the weight of the device intended for detecting a person, covered by the avalanche and to make this device workable during long time. Decrease of the dimensions of the transmitter is accompanied by reduction of energy intensity and duration of work—this is a ***non-desirable effect (NE)***.

Technical contradiction (TC).

Reduction of weight and dimensions of the transmitter are effected due to reduction of power source, i.e., due to reduction of time of their continuous operation.

Ideal final result (IFR).

The transmitter operates without a power source as along as needed. **Physical contradiction (PC)**.

*The power source should be***great**, in order to provide *long period of operation of the transmitter*, and should be **small** (zero), *in order not to increase the dimensions and weight* of the transmitter.

Or **there should be***a power source* and **there shouldn't be** any power source.

Resolving a contradiction.

Such contradiction can be resolved through changing the structure.

Solution

Swiss company "Sulab" proposed a device, which has the shape of a metal bracelet, which would be given to everybody, whoever stays in the mountains. The bracelet is a passive receiver, which has an antenna made of metal foil, however, devoid of power source and transmitter. Antenna made of foil receives the signals of the lifesavers, which have a powerful transmitter. Its power is sufficient for inducing a current in the bracelet, as it is done in detector sets. The current supplies energy to nonlinear circuit, which doubles or divides into two the frequency of the signal and transmits it with the help of the same antenna made of foil. The lifesavers hear the

reflected signal at doubled frequency or at half-power frequency and using a directional antenna can identify where the signal comes from. The system operates permanently, even if the person, who finds himself inside an avalanche, is unconscious. In this case, the duration of functioning of its batteries is not restricted by the cell, which could get exhausted. It simply does not exist.

Problem 6.13. Integrated Microchip

Condition of the problem

Usually, the conductors in integrated microchips (IMCs) are made of gold, which has the smallest specific resistance to electric current, however, inadmissibly bad adhesion to the material of the substrate.

What is to be done?

Analysis of the Problem

Administrative contradiction (AC).

How to improve adhesion of gold to the substrate—this is a ***non-desirable effect*** (NE)—poor adhesion.

Technical contradiction (TC).

It is the contradiction between *electric conductivity and adhesion*.

Ideal final result (IFR).

Conductor in integrated microchips (IMCs) should have *good conductivity* and *good adhesion*.

Physical contradiction (PC).

In order that the conductor in IMC should have *low resistance (good conductivity)*, it should be made **of gold**, while in order that the conductor should have *xgood adhesion* with the substrate, it should be made **of a different material**. In a shorter and more aggravated form, PC could be formulated in the following way: The material of the conductor should be made **OF GOLD** and **NOT OF GOLD**.

Resolution of contradiction.

Such contradiction could be resolved by changing structure.

A typical resolution of this physical contradiction is the use of Principle **24**. **Principle of INTERMEDIARY**.

Solution

At first, the **underlayer** is applied, which has a good adhesion with a substrate and with gold, and then, the gold is sprayed over it. Nickel or titanium is taken as an underlayer.

Problem 6.14. Hotel

Conditions of the problem

The management of a very old, high-class and expensive hotel «Atrium» in Darwin (Australia) decided to completely repair and re-equip its rooms. For this purpose, it was necessary to quickly get rid of everything, what was kept in the rooms. But it appeared that no money for vacating the premises was provided for the calculation of expenditures on repair and re-equipping of hotel rooms.

What is to be done?

Analysis of the Problem

Administrative contradiction (AC).

How to get rid of old things without spending money?

Non-desirable effect (NE)—expenditures on getting rid of old furniture.

Technical contradiction (TC).

It is the contradiction between necessary *expenditures on getting rid of scrap* and the *absence of money* in the budget.

Ideal final result (IFR).

The hotel is relieved of all equipment free of charge.

Physical contradiction (PC).

In order to *get rid of unnecessary equipment*, the management should **spend***a certain sum of money; however, in order to adhere to a definite budget, the management***cannot spend money** on carrying away the unnecessary equipment.

Resolution of contradiction.

Use **resources**.

Resources of the hotel. Employees and guests.

Solution

The management of the hotel made a proposal to its guests. For 699 dollars, one could rent a room for the night and to take out everything the guest wanted from the room.[1]

Problem 6.15. Sale of Coal

Conditions of the problem

According to the conditions of the contract, coal mine owner Hugo Stinnes was obliged to sell coal through a syndicate; however, it practically gave him no profits. If Stinnes sold coal himself, the syndicate would start a legal case against him and bring him to ruin. However, it is better to sell coal independently—it gives coal mine owner an advantage. It was in 1898.

What should Stinnes do?

Analysis of the Problem

Administrative contradiction (AC).

How to sell coal independently, without violating the conditions of the contract?

Non-desirable effect (NE)—violation of the conditions of the contract.

Technical contradiction (TC).

It is the contradiction between the necessity to *sell coal independently* and *violation of the conditions of the contract*.

Ideal final result (IFR).

The coal is *sold independently*, *without violating the conditions of the contract.*

Physical contradiction (PC).

The coal **should be sold** independently, in order to *have a good income*, and **should not be sold**, in order *not to violate the conditions of the contract* with the syndicate.

Resolution of contradiction.

Resolution of the contradiction in the *structure*.

Use Principle **28**. **Change of mechanical system**. Not the coal is sold, but its derivatives.

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[1]Egon Fine. Surprising Facts.—M.: AST Publishers, 2000.

Solution

Stinnes began to sell to the local power plant cheap steam from the boilerhouse of the mine, not the coal itself.

The syndicate started a legal case against Hugo Stinness, however lost the case, since in due time it never dawned upon the "fathers" of the syndicate, that coal can be sold in the form of steam—it was never reflected in any documents as a prohibition.

Problem 6.16. Checking the Programs

Conditions of the problem

Checking all developed computer programs and "hunting" for all errors (bugs), known as debugging, are a painstaking work, which occupies a lot of time. This is not only associated with the expenditures of the company, but also leads to such a situation, when the marketable goods enter the market later.

What is to be done?

Analysis of the Problem

Administrative contradiction (AC).

How to reduce time and expenditures on checking computer programs?

Non-desirable effect (NE)—expenditures on checking programs.

Technical contradiction (TC).

It is the contradiction between *the program quality* and *time expenditures*.

Ideal final result (IFR).

The program checks itself.

Physical contradiction (PC).

In order to obtain a *high-quality program* (without mistakes), it is necessary **to spend much time** on checking the program, while in order to *quickly present it at the market* and *reduce the expenditures on development*, **one does not need to spend time on checking the program**.

Resolution of contradiction.

Resolution of contradiction **in time** and in **structure**.

The check is carried out after the sale by people who are not the employees of the company.

Principles: **16**. **«Partial or excessive solution»**, **20**. **«Continuity of useful action»** and **28**. **«Change of mechanical system»**.

Solution

Microsoft issues beta-version and offers it at a much lower price to those, who take up the testing of it and who promise to inform the company concerning the mistakes.

Microsoft went even further: With the program Windows XP and with the more advanced programs, the occurrence of a bug results in reporting of the bug by a special program «Error Reporting»: It advises the company concerning the type of an error.

A new problem emerged. It is necessary to correct all stamps. This is a fairly great work.

The specialists of the company acted in keeping with the Pareto trend. They selected 20% of bugs, which are encountered in 80% cases and processed only 20% cases, which led to the elimination of 80% problems.

Principles of resolving contradictions

Problem 7.23. Pregnant Woman

Conditions of the problem

During pregnancy, the woman cannot lie on her stomach. What is to be done?

Analysis of the Problem

TC between the wish of a pregnant woman to lie on her stomach and the occurrence of a possibility to do harm to the fetus.

Let us use Principle **3**. **Local quality**.

Solution

A special orifice is made for the stomach in an inflated mattress (Fig. A.4).

Such contradiction was resolved differently with animals.

Principle **1** was used. **Segmentation**.

For example, with cats the uterus has two horns, in which the fetuses of kittens are located. When the cat lies on her stomach, the fetuses are arranged along the edges of the stomach.

Problem 7.24. Car Lights

Conditions of the problem

Long lights of the car can blind an oncoming driver.

Fig. A.4 Mattress for pregnant women

Fig. A.5 Asymmetrical car lights

Analysis of the Problem

TC. The necessity of the car to light the road with car lights leads to blinding of the oncoming driver.

Let us use Principle **4**. **Asymmetry**.

Solution

The lighting is made asymmetrical. In case with right driving, the car light is shifted to the right, while in case with left driving it is vice versa (Fig. A.5).

Problem 7.25. Transportation of Window Glasses

Conditions problem

Window glasses intended for transportation are placed inside a wooden box. The glass is covered with a kind of a "soft" material, for example, sawdust, polyurethane.

With such a method of packing, glass breaks in transportation and as a result of non-careful unloading. Besides, a lot of wood is necessary for packing (wood planks, sawdust or cuttings).

What is to be done?

Analysis of the Problem

TC. The necessity to transport thin glass panels requires additional packing materials and leads to breaking them.

Let us use Principle **5**. **Merging**.

Solution

In order to reliably pack glass panels, it is sufficient to cover the surface of each panel with mineral oil and to frame a pack of panels with a plastic frame or a rubber band, for example, to insert edges of glass panels into a hose, cut into two halves. Oil wastes can be used for ointment: engine oil, vaseline oil, transformer oil or spindle lubricant.

Glass packed in such a way can be openly stored in winter and in summer. It does not break even in case of careless unloading. If the glass is covered with a layer of oil, it is easier to clean it from dirt and lime.

Problem 7.26. Robin Hood

Conditions of the problem

When shooting the film «Robin Hood» at Lenfilm studio, it was necessary to shoot an episode; when an arrow is shot from the bow, then its flight is shown and

then the spectators saw how the arrow got into the body of the victim. The film director insisted that it should be life shooting, not the combined one.

They decided to place a wooden plank under the clothes of the actor, who played the role of the victim, and invited the best bow shooters of the country. Nevertheless, there was a danger that even the best shooter could miss and injure the actor.

How to arrange for the arrow getting exactly into the wood plank?

Analysis of the Problem

TC. It is necessary to shoot the episode of arrow hitting the body of the victim, which can lead to damaging to the bodyof the actor.

Let us use Principle **10**. **Preliminary action**.

Solution

Principle «Preliminary action» makes us think that it is necessary to do something in advance, in order that the arrow should accurately follow the trajectory, which is assigned in advance and hit the spot, which was initially assigned. It is possible in such a case, when the trajectory is strung in advance; for example, a thread is strung between the bow and the target, along which the arrow should move. In order that the thread should not be seen in the film, it is made of transparent angling line (Principle **32**. **Changing color**). This solution was used while shooting the film.

Problem 7.27. Boats of the Coast Dwellers

Conditions of the problem

Boats of the coast dwellers are characterized by rather high reliability. This reliability is attained through making boats of single pieces of wood. However, there is an interesting thing: The width of the boat is three times greater than the width of the biggest tree. How could the coast dwellers manage to build boats like this?

Analysis of the Problem

TC. The necessity to have broad wooden planks for building boats enters into a contradiction with natural opportunities—absence of trees characterized by such broadness.

PC: The tree should be broad, so that a boat might be made of it, and should not be broad, since such trees don't grow anywhere.

Let us separate contradictory features **in time**.

Let us make use of Principle **10**. **Principle of preliminary action**.

Solution

The tree is made broad in advance—when it grows. In spring, a wedge is hammered into a tree and the tree "circumvents" this wedge. After that, another wedge is hammered, etc. It is done during many years, and thus, a boat is gradually «grown».

The father grows a boat for his son.

Problem 7.28. Barber's Armchair

Conditions of the problem

The barbers often serve their clients, visiting their homes. As a rule, the client hasn't got a special armchair, which is convenient for the barber. He has to do the haircut, using a chair or an armchair, which is inconvenient for him.

What is to be done?

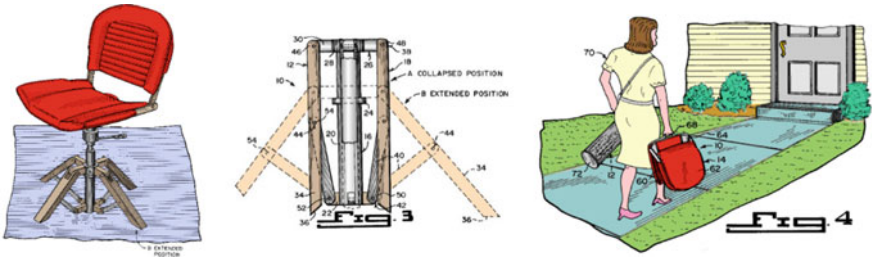


Fig. A.6 Portable barber's armchair. US Patent 5 505 524

Analysis of the Problem

TC. It is better to use a special armchair for haircutting, but it is impossible to place such an armchair in a car.

Let us use Principle **15**. **Dynamicity**.

Solution

A portable armchair for the barber was invented, so that he could carry it in the luggage compartment of the car (Fig. A.6). US Patent 5 505 524.

Problem 7.29. Soldering the Wires

Conditions of the problem

There are polystyrene spools with a thin insulated wire and metal legs. Soldering the wire to the legs is performed by submerging the wire into a bath with soldering alloy at 280°. However, it was necessary to clean the ends of the wire. In order to increase the efficiency, it was proposed to conduct the soldering under such conditions, when the temperature of the soldering alloy equals 380°. At this temperature, the insulation of the wire burns and the tin plating of the wire takes place. However, at such temperature the legs of the spool are overheated, polystyrene softens, and the legs start to slant, which is inadmissible. What is to be done?

Analysis of the Problem

TC. High temperature enables to clean the wire from insulation, but spoils the spool.

This problem is solved by using Principle **16**. **Partial or excessive solution**.

Solution

Legs with the ends of the wires are preliminarily submerged into an exothermic mixture with the combustion temperature of 350–400 °C, and then, soldering is conducted as it was done before—by submerging it into a soldering flux with the temperature of 280 °C. Insulation burns out as a result of explosion of exothermic mixture, while the polystyrene spool does not get softened.

Except the indicated principle, this solution uses principles **3**. **Local quality** (exothermic mixture acts only upon the insulation of the wire) and **21**. **Skipping** (insulation is submerged only for a very short time).

Problem 7.30. Annihilation of German Mines

Conditions of the problem

During World War I, one of the German submarines placed quite a number of mines near the entrance to Port Waterford (Ireland).

What is to be done?

Analysis of the Problem

TC. Mines must be cleared up; however, their location is unknown.

Let us use Principle **22**. **«Convert harm into use»**.

Solution

British counterintelligence sent to famous Germans a coded message that the mines had been cleared. The submarines soon came to install new mines and exploded on one of the mines, which had been installed previously.

Problem 7.31. Sunken Vases

Conditions of the problem

The vessel transported precious vases intended for the Japanese Emperor and sank. The divers could not get the vases, since it was too deep for them.

What is to be done?

Analysis of the Problem

TC. It is necessary to get the vases, but the divers cannot attain such depths.

Let us use Principle **24**. **«Intermediary»**.

Solution

Octopuses were used. They were tied and lowered down on a rope. The octopuses got into the vase, and then, it was raised to the surface.

Problem 7.32. Pipe

Conditions of the problem

Alcalinous liquid was fed through the pipes. The sediment occluded the inner space of the pipes. Acid liquid was fed through other pipes. The acid attacked the walls of the pipes. What is to be done?

Analysis of the Problem

Let us use Principle 25. **Self-service**.

Solution

It was suggested that acid and alkali should be fed through each pipe in turns. The acid etches the sediment formed by the alkali. The pipe does not get clogged and does not wear out.[2]

Besides, Principle **5**. **Merging** was used.

Problem 7.33. Detecting a New Star

Conditions of the problem

The astronomers watch starry sky. They make photographs of certain parts of the sky with a preset periodicity (Fig. A.7). In order to detect the appearance of a new star in the sky, the photographs are compared. There are thousands of stars in a single photograph, and comparative analysis is rather a complicated process.

How can one simplify this process?

Analysis of the Problem

Let us use Principle **26**. **Copying**.

[2]Author's certificate 239752.

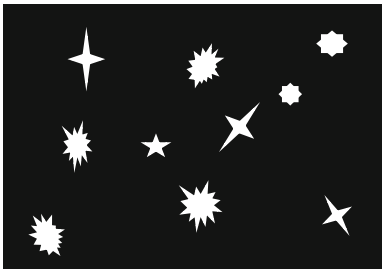
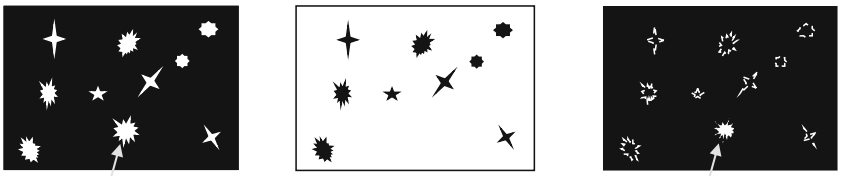


Fig. A.7 Photograph of a starry sky



a) Positive photograph b) Negative photograph c) Combining photographs a) and b)

Fig. A.8 Detecting a new star

Solution

The comparison is effected via overlapping of positive and negative pictures. One of the photographs, which are compared, is presented in the form of a "positive" (Fig. A.8a), while the other is a "negative" (Fig. A.8b). Or other mutually exclusive contrastive pictures may be used, for example, red and blue. As a result of their overlapping, only a new object will be seen on the starry sky according to author's certificate 359 512 (Fig. A.8c). Today, the comparisons can be effected by combining electronic pictures.

Problem 7.34. Bandage

Conditions of the problem

The bandage enables to insulate the wound from environment, contributing to healing, but in order to monitor the process of healing it is necessary to remove the binding, traumatizing the wound. This is especially important for healing all wounds, which badly succumb to healing during the phase of granulation and epithelization (trophic ulcers, pressure marks, burns of first and second degree, scratch marks in places, where split skin grafts are taken). How to improve the process of monitoring the wound without taking off the bandage?

Analysis of the Problem

AC: How to improve the process of monitoring the wound without taking off the bandage?

Fig. A.9 Transparent bandage

TC: It is the contradiction between the **process of cicatrization** and **monitoring the wound**.

IFR: The bandage does not hinder the process of wound monitoring.

PC: The wound should be ***open*** (without the bandage), in order to be accessible for **monitoring**, and the wound should be ***closed*** (covered with a bandage), in order that the wound should **cicatrize**.

Principles for resolving contradiction.

Resolution of contradiction in **structure**.

The bandage does not hinder the process of cicatrization or the «missing» bandage insulates the wound from environment.

Principle **32**. «**Change of color**».

Solution

A transparent hydrogel bandage has been created. It is possible to evaluate the condition of the wound without changing the bandage (Fig. A.9).

Problem 7.35. Toaster

Conditions of the problem

When the bread is being fried in the toaster, the degree of frying is not seen. It is possible to roast for a shorter period than is required, or, on the contrary, overroast the toast.

What is to be done?

Analysis of the Problem

TC. The necessity for monitoring the process of bread frying enters into a contradiction with the impossibility to carry out this process because of toaster walls.

Let us use Principle **32**. **Change of color**.

Solution

A transparent toaster was created. This way it is easier to monitor the degree of frying (Fig. A.10).

Fig. A.10 Transparent toasting oven

Problem 7.36. Steamboat Squeezed in the Ice

Conditions of the problem

The ship «Gauss» of the German Antarctic expedition (1901–1903), led by Erich von Drygalski,[3] was squeezed by the ice (Fig. 7.55) not far from Antarctic and could not move further. From that site, the Polar explorers travelled by sledge and by balloon to Antarctic in order to make investigations. Finally, they decided to free the ship from ice. In spite of the fact that they were 600 m far from open water, the sailors could not make their way through the ice. Using explosives, they managed to free only 6 m. The work progressed rather slowly. What is to be done?

Analysis of the Problem

Let us use Principle **32**. **Principle "Change of color"**.

Solution

Problem was solved by using available *resources*.

What resources were available?

At that time, the ships had a steam engine. Steam was obtained by heating a boiler with water by the flame generated via combusting coal in the furnace. After coal combustion ashes remained, which has black color.

The sailors strew the ice with ashes from the furnace. The dark ashes excellently «attracted» rays of bright polar sun, thus absorbing energy and the ice melts. Thus, they made a pass for the steamboat (Fig. A.11b [drawing A11.8b is from the software program IWB (InnovationWorkBench) of Ideation International Inc., USA]).

Resources of the steamboat were used in this solution.

[3]Erich von Drygalski (1865–1949). URL: http://www.south-pole.com/p0000085.htm.

a) The steamboat is squeezed by the ice

b) Use of ashes

Fig. A.11 Steamboat squeezed in the ice: **a** The steamboat is squeezed by the ice, **b** use of ashes

Appendix B
TRIZ-Related Web Sites

Web Sites Containing TRIZ Materials

Official G. Altshuller Foundation. URL: http://www.altshuller.ru
Methodologist. URL: http://www.metodolog.ru
TRIZLAND.RU. URL: http://www.trizland.ru
OTCM-TRIZ. URL: http://www.trizminsk.org
TRIZ developers summit. URL: http://www.triz-summit.ru

Web Sites of TRIZ Organizations

Web site of MATRIZ. URL: http://www.matriz.ru
Web site of European TRIZ Association (ETRIA—European TRIZ Association). URL: http://www.etria.net
Web site of The Altshuller Institute. URL: http://www.aitriz.org
Web site of Summit Developers TRIZ. URL: http://www.triz-summit.ru
Web site of TRIZ. URL: http://www.osaka-gu.ac.jp/php/nakagawa/TRIZ/eTRIZ/eTRIZforum.html
Web site of KATA (Korea Academic TRIZ Association). URL: http://www.koreatrizcon.kr

V. Petrov, *TRIZ. Theory of Inventive Problem Solving*,
https://doi.org/10.1007/978-3-030-04254-7

Appendix C
List of Examples, Problems, Illustrations, Tables and Formulas

List of Examples

No.	Example number	Example name	Page number			Tool
			Condition of the problem	Analysis of the problem	Solution	
1.	1.1	Icebreaker	12	12	13	Psychological inertia
2.	1.2	Supersonic aircraft	13	13	14	Psychological inertia
3.	1.3	Phase changes	14	14	14	Psychological inertia
4.	1.4	Car engine	15	15	15	Psychological inertia
5.	1.5	Flowers in the Alps	15	15	15	Psychological inertia
6.	1.6	Water	15	15	15	Psychological inertia
7.	1.7	The first steam boat	16	16	16	Psychological inertia
8.	1.8	Steam locomotive with legs	17	17	17	Psychological inertia
9.	1.9	The first car	17	17	18	Psychological inertia
10.	1.10	Icon symbol for computer programs	18	18	18	Psychological inertia
11.	1.11	The parable of the blind men	19	19	19	Absence of system thinking

(continued)

V. Petrov, *TRIZ. Theory of Inventive Problem Solving*,
https://doi.org/10.1007/978-3-030-04254-7

(continued)

No.	Example number	Example name	Page number			Tool
			Condition of the problem	Analysis of the problem	Solution	
12.	1.12	Midas	20	20	20	Absence of system thinking
13.	2.1	Pointer—Level 1	31	31	31	Levels of invention
14.	2.2	Pointer—Level 2	31	31	31	Levels of invention
15.	2.3	Pointer—Level 3	32	32	32	Levels of invention
16.	2.4	Pointer—Level 4	32	32	33	Levels of invention
17.	2.5	Laser and computer	33	33	33	Levels of invention
18.	3.1	Aircraft	50	51	51	System approach
19.	3.2	Sentence (in the language)	51	51	51	System approach
20.	3.3	Telephone	51	51	51	System approach
21.	3.4	Algorithm	51	51	51	System approach
22.	3.5	Synergic effect	52	52	52	System approach
23.	3.6	Computer	53	53	54	System approach
24.	3.7	Telephone	54	54	54	System approach
25.	3.8	Car	54	54	54	System approach
26.	39	Tree	54	55	56–58	System approach
27.	3.10	Sea iguana	58	58	59	System approach
28.	3.11	The runner	59	59	60	System approach
29.	3.12	Telephone	63	63	63	System approach
30.	3.13	Car	63	63	64	System approach
31.	3.14	Tree	65	65	66	System approach
32.	3.15	Car	66	67	687	System approach
33.	3.16	Changes in time	68	68	68	System approach
34.	3.17	Changes according to condition	68	68	69	System approach
35.	4.1	Arrest of hemorrhage	73	73	73	Ideal system. Ability to appear at the required moment
36.	4.2	Print-on-demand	73	73	73	Ideal system. Ability to appear at the required moment

(continued)

(continued)

No.	Example number	Example name	Page number			Tool
			Condition of the problem	Analysis of the problem	Solution	
37.	4.3	Masons in Saint-Petersburg	74	74	74	Ideal system. Self-embodiment
38.	4.4	Putting the tire on car wheels on a conveyor	75	75	75	Ideal system. Self-embodiment
39.	4.5	Washing machine	75	75	75	Ideal system. Self-embodiment
40.	4.6	Self-cleaning glass	75	76	76	Ideal system. Self-embodiment
41.	4.7	Capsule endoscopy	76	77	77	Ideal system. Self-embodiment
42.	4.8	DVD-ROM	78	78	78	Ideal system. Function
43.	4.9	Ideal computer keyboard	78	78	79	Ideal system. Function
44.	4.10	Ideal screen	79	79	79	Ideal system. Function
45.	4.11	Dish-washing process	79	80	80	Ideal system. Function becomes needless
46.	4.12	Communication	80	80	81	Ideal system. Function becomes needless
47.	5.1	Picture processing	92	92	92	Resources
48.	5.2	Integrated Services Digital Network	92	92	92	Resources
49.	5.3	Iglu	94	94	94	Resources
50.	5.4	Car and environment	95	95	95	Resources
51.	5.5	Cellular communication	95	95	95	Resources
52.	7.1	Sectioned tire	118	118	118	Inventive principles
53.	7.2	Multi-sectioned tire	118	118	119	Inventive principles
54.	7.3	Washing machine	119	119	119	Inventive principles
55.	7.4	Portable electric generator	120	120	120	Inventive principles
56.	7.5	The burglar	120	120	120	Inventive principles

(continued)

(continued)

No.	Example number	Example name	Page number			Tool
			Condition of the problem	Analysis of the problem	Solution	
57.	7.6	Barking of the dog	120	120	120	Inventive principles
58.	7.7	Collisions with birds	121	121	121	Inventive principles
59.	7.8	Umbrellas	124	124	125	Inventive principles
60.	7.9	Asymmetric connectors	125	125	126	Inventive principles
61.	7.10	Asymmetric tires	126	126	126	Inventive principles
62.	7.11	Multifunctional device	126	126	127	Inventive principles
63.	7.12	Oven combined with a fridge	127	127	127	Inventive principles
64.	7.13	Vertical take-off machine	128	128	128	Inventive principles
65.	7.14	General motors conception of AUTOnomy	129	129	129	Inventive principles
66.	7.15	Smartphone	129	129	130	Inventive principles
67.	7.16	Foldable aircraft	130	130	131	Inventive principles
68.	7.17	Foldable ironing board	131	131	132	Inventive principles
69.	7.18	Curtain	133	133	133	Inventive principles
70.	7.19	Fyodorov's "chamomile"	133	133	133	Inventive principles
71.	7.20	Safety belt	134	134	134	Inventive principles
72.	7.21	Safety cushions	134	134	134	Inventive principles
73.	7.22	System WHIPS	135	135	135	Inventive principles
74.	7.23	Children's safety armchair	135	135	136	Inventive principles
75.	7.24	Body of the car	136	136	136	Inventive principles
76.	7.25	Explosion place	136	136	136	Inventive principles

(continued)

(continued)

No.	Example number	Example name	Page number			Tool
			Condition of the problem	Analysis of the problem	Solution	
77.	7.26	Radar	137	137	137	Inventive principles
78.	7.27	Training of the runners	137	137	137	Inventive principles
79.	7.28	Training of the swimmers	138	138	138	Inventive principles
80.	7.29	Pedestrian crossing	138	138	139	Inventive principles
81.	7.30	A device for sleeping	141	141	142	Inventive principles
82.	7.31	Dyeing the components	142	142	142	Inventive principles
83.	7.32	Door of the car	144	144	144	Inventive principles
84.	7.33	Umbrella collects water	145	145	145	Inventive principles
85.	7.34	Home slippers	145	145	144	Inventive principles
86.	7.35	No-load trips	146	146	146	Inventive principles
87.	7.36	Cars in the trains	146	146	147	Inventive principles
88.	7.37	Cars in the trains	147	147	147	Inventive principles
89.	7.38	Cars on trains	147	148	148	Inventive principles
90.	7.39	Cutting the pipes	148	148	149	Inventive principles
91.	7.40	Fire extinguishing	151	151	151	Inventive principles
92.	7.41	Bread cutting	151	151	151	Inventive principles
93.	7.42	Fabric for car seats	155	155	155	Inventive principles
94.	7.43	Getting into the car and out of it	155	155	156	Inventive principles
95.	7.44	Police car	156	156	156	Inventive principles
96.	7.45	Disposable dishes	158	158	158	Inventive principles

(continued)

(continued)

No.	Example number	Example name	Page number			Tool
			Condition of the problem	Analysis of the problem	Solution	
97.	7.46	Chameleon	160	160	160	Inventive principles
98.	7.47	Metal file	161	161	161	Inventive principles
99.	7.48	Algorithm of quick sorting	161	161	162	Inventive principles
100.	7.49	French wine produced by J. P. Chenet	162	162	162	Inventive principles
101.	8.1	Development of radioelectronics	173	173	174	Trends of system evolution
102.	8.2	Telephone	177	177	177	Trends of system evolution
103.	8.3	Car	177	177	177	Trends of system evolution
104.	8.4	Telephone	178	178	179	Trends of system evolution
105.	8.5	Car	179	179	179	Trends of system evolution
106.	8.6	Telephone	180	180	180	Trends of system evolution
107.	8.7	Car	180	180	180	Trends of system evolution
108.	8.8	Telephone	180	180	180	Trends of system evolution
109.	8.9	Car	181	181	181	Trends of system evolution
110.	8.10	Telephone	182	182	182	Trends of system evolution
111.	8.11	Car	182	182	182	Trends of system evolution
112.	8.12	Substance in solid state	182	182	182	Trends of system evolution
113.	8.13	Substance in liquid state	182	182	182	Trends of system evolution
114.	8.14	Substance in gel state	182	182	182	Trends of system evolution
115.	8.15	Substance in gas state	183	183	183	Trends of system evolution
116.	8.16	Transportation of objects	183	183	183	Trends of system evolution

(continued)

(continued)

No.	Example number	Example name	Page number			Tool
			Condition of the problem	Analysis of the problem	Solution	
117.	8.17	Telephone	184	184	184	Trends of system evolution
118.	8.18	Telephone	184	184	184	Trends of system evolution
119.	8.19	Telephone	184	184	184	Trends of system evolution
120.	8.20	Umbrella	187	187	187	Trends of system evolution
121.	8.21	Autopilot	187	187	187	Trends of system evolution
122.	8.22	RAM	189	189	189	Trends of system evolution
123.	8.23	Processing center	189	189	189	Trends of system evolution
124.	8.24	Computer	189	189	189	Trends of system evolution
125.	8.25	Clock	190	190	191	Trends of system evolution
126.	8.26	Calculation machines	191	191	192	Trends of system evolution
127.	8.27	Computer memory	186	186	187	Trends of system evolution
128.	8.28	Writing on atom	188	188	188	Trends of system evolution
129.	8.29	Recording on DNA	188	188	188	Trends of system evolution
130.	8.30	Quick memory element	188	188	188	Trends of system evolution
131.	8.31	The airplane	189	189	189	Trends of system evolution
132.	8.32	Smartphone	190	190	190	Trends of system evolution
133.	8.33	School blackboard	190	190	190	Trends of system evolution
134.	8.34	Static electricity	191	191	191	Trends of system evolution
135.	8.35	Footwear	191	191	191	Trends of system evolution
136.	8.36	The doll	191	191	192	Trends of system evolution

(continued)

(continued)

No.	Example number	Example name	Page number			Tool
			Condition of the problem	Analysis of the problem	Solution	
137.	8.37	Space station	192	192	192	Trends of system evolution
138.	8.38	Rhythm of functioning	192	192	192	Trends of system evolution
139.	8.39	Cutting glass	192	192	192	Trends of system evolution
140.	8.40	Noise extinction	196	196	196	Trends of system evolution
141.	8.41	Car	194	194	194	Trends of system evolution
142.	8.42	Toothbrush on a finger	194	194	195	Trends of system evolution
143.	8.43	Toothbrush—ions	195	195	195	Trends of system evolution
144.	8.44	Bullet	196	196	196	Trends of system evolution
145.	8.45	Electric toothbrush	196	197	197	Trends of system evolution
146.	8.46	Hybrid car	197	197	197	Trends of system evolution
147.	8.46	Hybrid hard disk	197	197	197	Trends of system evolution
148.	8.48	Fork and spoon	198	198	198	Trends of system evolution
149.	8.49	Toothbrushes	198	199	199	Trends of system evolution
150.	8.50	Computer	200	200	200	Trends of system evolution
151.	8.51	Development of society	200	200	200	Trends of system evolution
152.	8.52	Development of economy	200	201	201	Trends of system evolution

List of problems

No.	Problem number	Problem name	Page number			Tool
			Condition of the problem	Analysis of the problem	Solution	
1.	4.1	The Zoo	84	84	85	IFR
2.	4.2	Selling footwear	85	85	85	IFR
3.	4.3	Clay-pigeon shooting	87	218	218	IFR
4.	4.4	Waterwell	87	218	218	IFR
5.	5.1	Measuring temperature of a little child	92	92	92	Resources
6.	5.2	Competition between software companies	93	93	93	Resources
7.	5.3	"Worm" program	93	93	94	Resources
8.	5.4	Chassis of the aircraft	94	94	94	Resources
9.	5.5	Boxing	95	95	95	Resources
10.	6.1	Bus	99	100, 101	110	Contradictions
11.	6.2	Power unit	101	101	101	Contradictions
12.	6.3	Spectacles	103	103	103	Contradictions
13.	6.4	Adhesive patch	103	103	104	Contradictions
14.	6.5	Jet aircraft	104	104	104	Contradictions
15.	6.6	Computer	104	104	105	Contradictions
16.	6.7	Armor suit of the knight	105	105	105	Contradictions
17.	6.8	Automated device for liquid medium pouring	106	106	106	Contradictions
18.	6.9	Powerful transistor	106	106	107	Contradictions
19.	6.10	Sleep of the dolphin	108	108	108	Contradictions
20.	6.11	Radiolocation station	111	219	219	Contradictions
21.	6.12	Avalanche in the mountains	112	220	220–221	Contradictions
22.	6.13	Integrated circuit	112	221	221	Contradictions
23.	6.14	Hotel	112	222	222	Contradictions
24.	6.15	Selling the charcoal	113	223	224	Contradictions
25.	6.16	Checking the programs	113	223	224	Contradictions
26.	7.1	Football stadium	120	121	121	Inventive principles

(continued)

(continued)

No.	Problem number	Problem name	Page number			Tool
			Condition of the problem	Analysis of the problem	Solution	
27.	7.2	Decrease of wave resistance	122	122	122	Inventive principles
28.	7.3	Smoking in a café	123	123	123	Inventive principles
29.	7.4	Buffet reception	123	124	124	Inventive principles
30.	7.5	Algorithm of archiving	125	125	125	Inventive principles
31.	7.6	Thin glass processing	128	128	128	Inventive principles
32.	7.7	Billbug	128	129	129	Inventive principles
33.	7.8	Dyeing the wood	132	132	132	Inventive principles
34.	7.9	Dynamic car	139	139	140	Inventive principles
35.	7.10	Stump clearance	140	140	141	Inventive principles
36.	7.11	Shooting from round the corner	143	143	143	Inventive principles
37.	7.12	Stunt men	149	149	150	Inventive principles
38.	7.13	Potatoes	150	150	150	Inventive principles
39.	7.14	Mist in the airport	151	151	151	Inventive principles
40.	7.15	Deaf hunter	152	152	152	Inventive principles
41.	7.16	Tube cleaning	152	152	152	Inventive principles
42.	7.17	Railway cleaning	152	153	154–155	Inventive principles
43.	7.18	Clothes for Porthos	157	157	157	Inventive principles
44.	7.19	Yad-Vashem	157	158	158	Inventive principles
45.	7.20	Training the barbers	158	158	158	Inventive principles
46.	7.21	Boiling eggs	159	159	159	Inventive principles

(continued)

(continued)

No.	Problem number	Problem name	Page number			Tool
			Condition of the problem	Analysis of the problem	Solution	
47.	7.22	Boat	159	160	160	Inventive principles
48.	7.23	Pregnant woman	164	224	224–225	Inventive principles
49.	7.24	Car lights	164	225	225–226	Inventive principles
50.	7.25	Transporting window glass panels	164	226	226	Inventive principles
51.	7.26	Robin Hood	165	227	227	Inventive principles
52.	7.27	Boats of the coast dwellers	165	227	227	Inventive principles
53.	7.28	The armchair of the barber	165	228	228	Inventive principles
54.	7.29	Soldering the wires	165	228	229	Inventive principles
55.	7.30	Destroying the German mines	165	229	229	Inventive principles
56.	7.31	Sunk vases	166	229	229	Inventive principles
57.	7.32	The pipe	166	230	230	Inventive principles
58.	7.33	Detection of a new star	166	230	231	Inventive principles
59.	7.34	Bandage	166	231	231–232	Inventive principles
60.	7.35	Toaster	167	232	232–233	Inventive principles
61.	7.36	Steamboat squeezed by the ice	167	233	233–234	Inventive principles

List of Illustrations

No.	Fig. number	Name of the drawing (scheme)	Example number, problems	Page number
1.	1.1	Process of solving the problem belonging to known type	—	9
2.	1.2	Process of solving the problem belonging to unknown type	—	9

(continued)

(continued)

No.	Fig. number	Name of the drawing (scheme)	Example number, problems	Page number
3.	1.3	Method of “trial and error”	—	10
4.	1.4	The first steamboat (2 fig.)	E. 1.8	16
5.	1.5	Steam locomotive with legs	E. 1.9	17
6.	1.6	The first car	E. 1.10	18
7.	1.7	Data filter icon	E. 1.11	18
8.	1.8	Blind men		
9.	2.1	Level of invention	—	31
10.	2.2	Structural scheme of TRIZ	—	35
11.	2.3	Structural scheme of TRIZ for problem-solving function	—	37
12.	—	Su-Field	—	39
13.	2.4	Solving standard problems	—	42
14.	3.1	System levels	—	50
15.	3.2	Hierarchy of the tree	E. 3.9	52
16.	3.3	Tundra	E. 3.9	54
17.	3.4	Flora of the desert	E. 3.9	55
18.	3.5	Structure of systematicity	—	58
19.	3.6	Structure of trend of increasing systematicity	—	59
20.	3.7	System operator	—	61
21.	3.8	System operator—tree	E. 3.14	62
22.	3.9	System operator—car	E. 3.15	63
23.	3.10	Arresting of the wheel	E. 3.15	64
24.	4.1	Putting on car tires (2 fig.)	E. 4.4	71
25.	4.2	Self-cleaning glass	E. 4.6	72
26.	4.3	Ideal keyboard	E. 4.9	75
27.	4.4	The process of idealization of dish washing	E. 4.11	76
28.	4.5	T-shirt intended for communication	E. 4.12	77
29.	—	Structural scheme of TRIZ for problem-solving function	—	84
30.	5.1	The general algorithm of identification and utilization of resources	—	86
31.	—	The general algorithm of identification and utilization of resources	—	94
32.	—	The general algorithm of identification and utilization of resources	—	110
33.	7.1	Sectioned tire	E. 7.1	114
34.	7.2	Multi-sectioned tire	E. 7.2	114
35.	7.3	Washing machine (2 fig.)	E. 7.3	115

(continued)

(continued)

No.	Fig. number	Name of the drawing (scheme)	Example number, problems	Page number
36.	7.4	Portable electric generator	E. 7.4	115
37.	7.5	Football stadium (2 fig.)	P. 7.1	116
38.	7.6	Nose bulb	P. 7.2	118
39.	7.7	Glass cap for smokers	P. 7.3	119
40.	7.8	Buffet reception (2 fig.)	P. 7.4	120
41.	7.9	Umbrellas for footwear (2 fig.)	E. 7.8	120
42.	7.10	Umbrella for a photo camera	E. 7.8	121
43.	7.11	Asymmetric connectors (3 fig.)	E. 7.9	122
44.	7.12	Asymmetric tire	E. 7.10	122
45.	7.13	Multifunctional machine	E. 7.11	123
46.	7.14	Oven combined with a fridge	E. 7.12	123
47.	7.15	Machine X-50A Dragonfly (2 fig.)	E. 7.13	124
48.	7.16	Concept of the car AUTOnomy (GM)	E. 7.14	125
49.	7.17	Smartphone (5 fig.)	E. 7.15	126
50.	7.18	Multi-purpose aircraft (3 fig.)	E. 7.16	127
51.	7.19	Foldable ironing board (2 fig.)	E. 7.17	128
52.	7.20	Curtain for sleeping	E. 7.18	129
53.	7.21	Fyodorov's "camomile" (3 fig.)	E. 7.19	129
54.	7.22	Safety belts	E. 7.20	130
55.	7.23	Safety cushions (4 fig.)	E. 7.21	130
56.	7.24	WHIPS System (3 fig.)	E. 7.22	131
57.	7.25	Children's armchair	E. 7.23	131
58.	7.26	Rigid elements and zones of deformation of the car body (2 fig.)	E. 7.24	132
59.	7.27	Training of the runners (2 fig.)	E. 7.27	133
60.	7.28	Training of the swimmers (2 fig.)	E. 7.28	133
61.	7.29	Dynamic zebra crossing (3 fig.)	E. 7.29	134
62.	7.30	Dynamic car	P. 7.9	135
63.	7.31	Stump clearance (2 fig.)	P. 7.10	136
64.	7.32	Mask for sleeping	E. 7.30	137
65.	7.33	Device for sleeping (4 fig.)	E. 7.30	137
66.	7.34	Shooting from round the corner (2 fig.)	P. 7.11	138
67.	7.35	"Falling" door (4 fig.)	E. 7.32	139
68.	7.36	The umbrella collects water	E. 7.33	140
69.	7.37	Slippers	E. 7.34	141
70.	7.38	AutoShuttle conception of transporting the car (3 fig.)	E. 7.36	142
71.	7.39	Conception of the platform of the company Autran Corp	E. 7.37	142

(continued)

(continued)

No.	Fig. number	Name of the drawing (scheme)	Example number, problems	Page number
72.	7.40	The conception of transporting a car by AVT-Solatrek Trains (4 fig.)	E. 7.38	143
73.	7.41	Pipe cutting (2 fig.)	E. 7.39	143
74.	7.42	The stunt man	P. 7.12	144
75.	7.43	Bird feeder	E. 7.41	146
76.	7.44	Railway cleaning (3 fig.)	P. 7.17	148
77.	7.45	Action of fabric on an acarian (7 fig.)	E. 7.42	149
78.	7.46	Getting into the car and out of it (3 fig.)	E. 7.43	150
79.	7.47	A plywood mockup of a police car	E. 7.45	150
80.	7.48	Costume for Portos	P. 7.18	151
81.	7.49	Boiling eggs	P. 7.21	153
82.	7.50	Transparent boat	P. 7.22	154
83.	7.51	Chameleon	E. 7.46	154
84.	7.52	Quicksort algorithm	E. 7.48	156
85.	7.53	French wine Chenet	E. 7.49	157
86.	7.54	A photograph of a starry sky	P. 7.33	161
87.	7.55	Steamboat in the ice	P. 7.36	162
88.	8.1	S-curve of growth	—	165
89.	8.2	Uneven (leap) evolution of the system	—	167
90.	8.3	Enveloping curve	—	168
91.	8.4	Evolution of electronics	—	169
92.	8.5	Diagram of trends of system evolution	—	169
93.	8.6	Structure of trends of system organization	—	170
94.	8.7	Structure of trends of system evolution	—	170
95.	8.8	Main system elements	—	171
96.	8.9	Structure of trends of system evolution	—	180
97.	8.10	Structure of trends of system evolution	—	182
98.	8.11	Structure of trends of system evolution	—	184
99.	8.12	Structure of trends of system evolution	—	189
100.	8.13	Structure of trend of system evolution	—	191
101.	8.14	Structure of trends of system evolution	—	193
102.	8.15	Toothbrush on a finger (3 fig.)	E. 8.42	195
103.	8.16	Toothbrush—ions	E. 8.43	195
104.	8.17	Trimmed spoon and fork	E. 8.48	198
105.	8.18	Toothbrushes	E. 8.49	199
106.	8.19	Structure of trends of system evolution	—	199

(continued)

(continued)

No.	Fig. number	Name of the drawing (scheme)	Example number, problems	Page number
107.	A.1	Algorithm of using TRIZ tools for performing the function "solving a problem"	—	209
108.	A.2	A table for a sofa (2 fig.)	P. 5.6	216
109.	A.3	A support for a plate	P. 5.6	217
110.	A.4	Mattress for pregnant women (3 fig.)	P. 2.23	223
111.	A.5	Asymmetrical car lights	P. 7.24	224
112.	A.6	Portable barber's armchair (3 fig.)	P. 7.28	226
113.	A.7	Photograph of a starry sky	P. 7.33	229
114.	A.8	Detecting a new star (3 fig.)	P. 7.33	229
115.	A.9	Transparent bandage	P. 7.34	230
116.	A.10	Transparent toasting oven	P. 7.35	230
117.	A.11	Steamboat squeezed in the ice (2 figc.)	P. 7.36	231
Total			**190**	

List of Tables

No.	Table number	Table name	Section	Page number
1.	2.1	Process of inventive creativity	2.2	30
2.	2.2	Functions and structure of TRIZ	2.5	44
3.	5.1	Structure of resources	5.1	90

List of Formulas

No.	Formula number	Formula name	Section	Page number
1.	4.1	Degree of system idealization	4.1	81
2.	6.1	Cause-effect relations	6.1	101
3.	6.2	Main line of solving a problem	6.2	108

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Index

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