Chapter 3
METHODICAL MAINTENANCE OF CRIMINALISTIC RESEARCH OF CARTRIDGES (AMMUNITION) TO MANUAL SMALL ARMS FIREARMS

3.1. Expert tasks solved during the examination of cartridges (ammunition)

Forensic ballistics, being a field of human activity aimed at the development and systematization of objective knowledge about specific objects of reality, combines special knowledge of a theoretical nature, as well as empirically accumulated data, which allowed it to become the basis of forensic ballistic examination as one of the traditional types of forensic examinations. Clarification of the content of forensic ballistic examination of cartridges (ammunition) and the possibility of using it in forensic and law enforcement activities necessitates the study of its essence, objectives, tasks to be solved within the framework of this examination.

Traditionally, in the legal literature, "special knowledge" is understood as a system of theoretical knowledge and practical skills in a particular science or technology, art or craft, acquired through special training or professional experience and necessary to address issues arising in the process of criminal or civil proceedings. Special knowledge usually does not include well-known and legal knowledge [221, p. 7]. Similar definitions of this term with some exceptions and additions are given in the works of other authors [203; 246]. In the dictionary and reference literature indicates that the word "knowledge" has two meanings: a result of knowledge, ie, a certain cognitive activity; a set of information in any area [183, p. 231].

In accordance with article 15 of the Code of Criminal Procedure of the Republic of Belarus (hereinafter — the CPC), an investigator or a person conducting an inquiry is obliged to take all measures provided for by law for a comprehensive, complete and objective investigation of the circumstances of the case [265]. To remove information from the material traces of a crime with the help of a person with special knowledge (expert), the legislation establishes the most rational way, which should correspond to the level of scientific and technological progress of society.

As noted in the literature, the worldview of the researcher shapes the focus of his thinking, the General and specific areas of scientific research, methods, principles and techniques, the means of knowledge; man as a subject of cognition in the process of existence expands your consciousness, i. e. conscious of the objective world through the study of the nature and phenomena of the objects; as a result, the conversion of the resulting research information is available for other people [289, p. 160].

This allows us to conclude that the expert study of cartridges (ammunition) as a cognitive activity, in turn, provides cognitive activity carried out by the criminal prosecution body. Being complex objects of the material world, characterized by different essence, properties and States, cartridges (ammunition) can be a source of information only after their proper research from the point of view of existing scientific concepts. The result of knowledge (actual data), obtained properly, is the ultimate goal of forensic ballistic research cartridges (ammunition) and intermediate-in relation to the objectives of the criminal process. In particular, R. S. Belkin and A. I. Vinberg note that "examination is always the establishment and explanation of the fact. Such facts can be the identity of the object, the presence of changes made in it, the suitability of the object for any action, etc." [13, p. 226]. The purpose of the application of special knowledge in the investigation of crimes is to detect, evaluate and study by a competent person with this knowledge, hidden forensic information that allows you to establish the facts that are essential to the case [302].

Being a complex phenomenon, the goal as an element of human activity consists of the following interrelated elements: subjective goal-an ideal image of the future phenomenon; material and spiritual means that are used to achieve the goal (legal, organizational, technical, etc.); object (thing, phenomenon or process), which is aimed at the subject-practical and cognitive activity; transforming activity of the subject [276, p. 534]. This fully applies both to the process of proof in General, and to the forensic examination of cartridges (ammunition).

The purpose of forensic ballistic examination of cartridges (ammunition) is based on the understanding of the purpose in a philosophical sense. In view of its dual nature, it can be considered both an objective and a subjective category, which manifest themselves depending on external conditions. The objective goal arises as a result of the influence of the facts of objective reality, reflects objective laws and is conditioned by them. The subjectivity of the goal stems from the fact that it is the result of conscious and organized activity of groups of people or an individual, existing in their consciousness, and is opposed to reality, because it expresses what is not yet [276, p. 534]. Thus the purpose defines features of activity of the person. V. N. Bibilo in relation to proving in criminal proceedings indicates that the expected result, which is the content of the goal, is not given by any, but by strictly defined actions performed in a strictly defined sequence, by strictly defined means [19]. A similar position is held by A. Yu. Vvedensky, who believes that the goal, acting as the end result of human activity (collective), predetermines the choice of appropriate means and a system of specific actions. It serves as a way of integrating various human actions into some sequence or system and acts as a direct motive, directs and reacts to various actions. It is the goal that is the main factor of the whole system for which it exists [33].

If from the philosophical point of view the goal is considered as "anticipation in consciousness of result on which achievement actions are directed" [276, p. 534], the when applied to forensic-ballistic expertise patrons (ammunition) under it should understand not removed any future, and only exclusively achieved through organized activities experts-faces, with appropriate ad hoc knowledge in science, technology, the arts, craft.

In relation to the type of forensic ballistic examinations studied in this work, the most justified is the consideration of the final and intermediate goals of forensic ballistic research of cartridges (ammunition).

In the philosophical sense, the ultimate goal is a stable, General, essential goal that expresses the main interests; it is the result, the completion of a series of successive actions associated with the implementation of intermediate (immediate and subsequent) goals. The need to separate the ultimate goal from other types (immediate, subsequent) is also due to the fact that the ways to achieve a common ultimate goal in specific conditions are specific [276, p. 534]. In relation to expert research, this division of goals has a conditional character, since as a result of cognitive activity and depending on the circumstances, the intermediate goal can become final and, conversely, the final goal-intermediate.

The foregoing allows to conclude that an expert study in forensic ballistic tests of cartridges (ammunition) is determined by the specific objectives, i.e. expected outcomes are ordered purposeful activities of a person with special knowledge used by law enforcement agencies in the implementation of production for materials testing and criminal matters. After determining the abstract model of the expected result, conducting appropriate research, the result of cognitive activity should acquire the necessary material-fixed form, reflected in the relevant conclusions contained in the expert's conclusion. In addition "since the criminal process has an informational nature, the special knowledge used in the field of criminal proceedings is used to explain the essence of the phenomenon under study (circumstances, material object) by means of directed assistance to the subjects of proof in the formation of evidence" [77].

The concept of the goal is closely interrelated with the concept of the task, which is understood as the formulation of specific issues to be addressed and consistently lead to the achievement of the desired result [183, p. 873]. Based on this, the tasks of forensic ballistic examination of cartridges (ammunition) can not be determined before the objectives and their priority are determined.

The task of forensic research as a logical-psychological category becomes such when it is presented to the expert for resolution. The expert understands it, defines it and looks for a way to resolve it. Thus, having understood the content of the task, having formulated it on the basis of the received task of a problematic nature, the expert performs a full cycle of productive thinking. Knowledge of the tasks solved in the course of a specific examination helps to understand what properties of the object are studied by this examination [29].

The doctrine of the types of expert tasks is currently one of the most developed in the theory of forensic examination. The subject of scientific discussions are the issues of building a system and classification of expert tasks. In relation to the forensic study of cartridges (ammunition) for hand-held small arms, expert tasks are based on the classification developed in the theory of forensic examination, according to which, according to the degree of generality of tasks, expert tasks are divided into *General*, *typical* and *specific*.

The General objectives of the examination determine its objectives in the most generalized form and outline the subject of examination of a certain kind (generic tasks of ballistic examination). Typical tasks of the type of examination, which are given in the reference literature, are formulated in relation to each object of this type and serve as guidelines for setting specific tasks (in this case — forensic ballistic examination of cartridges (ammunition)). Specific tasks are tasks assigned to an expert in the production of a specific examination of cartridges (ammunition)) [220, pp. 23–24; 221, p. 35; 222, p. 89]. From the above system of tasks in more detail consider the specific tasks of forensic ballistic examination of ammunition (ammunition).

Attempts of differentiation of expert tasks into separate groups by other criteria to have been in connection with the need of expert practices in resolving not only problems associated with identification (establishing the identity), but other tasks-finding properties as examined objects of judicial examination as a whole and their separate elements (properties and state of the research object) [95, p. 55]. Initially, these tasks were called non-identification [35] and were considered in the works of forensic scientists, including in the field of forensic ballistics [68; 180]. However, to agree with Yu. G. Koruhov, which indicates that forensic examination of a single-different categories of tasks that are permitted with this examination, therefore, speech should go not about the division of the forensics on the identification and opposite — deidentification, and the content of the task identification, diagnosis, classification, and possibly other, with a clear definition of their essence and specificity [107, p. 6].

On the basis of a number of theoretical works of forensic scientists, as well as analysis of the practice of various types of examinations, the opinion was formed that the content of forensic ballistic examination is wider than its narrow understanding from the point of view of the theory of identification, which was practically formed by the middle of the XX century. In the forensic literature it has been pointed out that identification is often the subject of forensic examination, but not the only one [255, p. 13].

Currently, most scientists (in particular, T. V. Averyanova, R. S. Belkin, A. I. Vinberg, Yu. G. Korukhov, N. T. Malakhovskaya) in their works distinguish four groups of expert problems: identification, diagnostic, classification and situational (situalogical) [38, pp. 159–160; 107, pp. 68; 110, pp. 432–433; 300, p. 129].

Forensic investigation of traces of hand-held small arms on elements of cartridges (ammunition) is carried out on the basis of the provisions of the theory of forensic identification. This theory is the doctrine of the General principles of identification (establishment) of various material objects on their displays for obtaining judicial evidence [15, p. 66].

The possibility of identification of rifled small arms firearms is based on the following theoretical provisions:

the doctrine of the individuality of trace trace-forming parts of small arms, interacting with the elements of the cartridge (ammunition);

the doctrine of the identification period and the relative stability of identification objects;

the doctrine of the mechanism of trace formation on the elements of the cartridge (ammunition);

the doctrine about dependence of display of signs of the microrelief forming traces of details of manual small arms firearms in traces depending on conditions of trace formation;

scientific provisions on the detection, fixation and removal of traces on the objects of forensic ballistic examinations;

provisions on assessment of properties and signs of the displayed traces of manual small arms at formulation of conclusions [95, p. 41].

Improvement of the theory of forensic identification and its conceptual foundations, developed by S. M. Potapov [213], supplemented by N. V. Terziev, G. M. Minkovsky and N. P. Yablokov, as well as other authors, the theory of "establishing group identity" [168; 255], allows us to define the theory of forensic identification in three aspects: as a private scientific forensic theory; as a research process; as a result of establishing identity, acting as evidence [230].

One of the main tasks of forensic ballistic examination is the task of establishing a sample of small arms firearms on its traces on bullets and casings. In the process investigations and disclosure crimes tools and means his committing are viewed, typically, in ties with establishing way committing crimes, personality criminal, however on some stage they can have independent significance, for example under search tools and the subsequent his identification for elucidation belonging suspect [71, p. 158]. The result of establishing group identity within the forensic and ballistic research in the initial phase of disclosure and investigation of crimes eliminated the inconsistency and uncertainty of the information received earlier, allowing the employee of body of inquiry (the investigator) to establish a causal relationship between specific facts, to check the validity of the previously submitted and to build a new version of the occurring event [72, pp. 5–8]. This circumstance is due to the forms of identification-the establishment of individual (group) identity and the establishment of the whole in parts.

A number of works by Soviet and Russian scientists are devoted to the theoretical substantiation of the establishment of group and individual identity, carried out in the framework of forensic ballistic examination [9; 60; 69; 79; 99; 100; 111; 112; 244; 248; 273; 274].

Currently, in forensic ballistics, it is customary to distinguish General and particular features peculiar to the individualized object of research, which is associated with a phased expert study of traces of hand-held small arms, displayed on the elements of the cartridge (ammunition) in the process of firing, which is characterized by a certain sequence [164; 165]. In addition, in the process of forensic ballistic examination, the object of study can be individualized only as a result of knowledge of the necessary set of its properties. From the above it follows that if the General characteristics of the object under study characterize all instances of manual small arms of the same model, the private — only its specific instance.

E. I. Stashenko proposed the division of signs of traces of the barrel of hand-held small arms into the following types: signs that display the features of the barrel of hand-held small arms; signs that characterize the qualitative state and degree of wear [244, p. 19]. It seems that this division is applicable to other parts that interact in the process of functioning of small arms not only with the bullet, but also with the cartridge case (ammunition), in particular the ejector, reflector, magazine, etc.

At identification of manual small arms firearms on traces on bullets and sleeves experts investigate, as a rule, the traces-displays characterizing individual features of a structure of trace-forming details of the mechanism of manual small arms firearms, abstracting from other traces which occurrence has no causal connection with the considered event.

With regard to the establishment of group (individual) belonging, the attribution of traces on bullets and cartridge cases (ammunition) to a group of models of hand-held small arms (a particular instance), as well as the division of signs into General and private facilitate the identification process, allow subsequently to exclude unreasonably advanced versions and facilitate the process of proof.

In this regard, the point of view expressed by B. N. Ermolenko B. M. Komarints is of interest, which is that the division into General and particular features is conditional, since a more detailed study of common features often leads to the fact that they pass into the category of private [70, p. 40; 101, p. 190].

In view of the above, the theory of “subclass signs” proposed by foreign scientists [306; 307] is quite justified. According to the proponents of this theory, these signs are traces of technological equipment of industrial equipment used in the manufacture of hand-held firearms, cartridges (ammunition) used for shooting from it. Such traces are formed as a result of the impact of the working parts of the tools during the production cycle and are displayed on the trace receiving surface in the form of static or dynamic traces.

In domestic of forensic science, such approach is widely used in technical examination of the products of mass production. Positive examples of the use of traces and production mechanisms on bullets in establishing a single source of origin, carried out in the framework of forensic ballistic examination, took place in the domestic expert practice [128].

Thus, the identification of hand-held small arms is impossible without interaction with the design elements of the cartridge (ammunition), which are the object-carrier of material traces formed as a result of their interaction with trace-forming parts in the process of preparatory, accompanying and final operations and firing processes.

V. A. Snetkov first introduced the term "diagnostic research" into forensic science [234]. This term (from the Greek. diagnosis-recognition, distinction, definition), borrowed from medical science, accurately indicates the essence and objectives of a significant amount of expert research, which is why finally established in the theory of forensic examination, including forensic ballistic [112, p. 106]. To approve I. V. Latysheva, based on scientific ideas forensic ballistic diagnostics as scientific knowledge of the expert diagnosis determines mainly the theory of criminalistic diagnostics and forensic ballistics, the totality of which creates the Foundation of scientific knowledge of diagnostic forensic ballistic expert studies [148].

A. R. Shlyakhov and V. F. Orlova in the work devoted to problems of classification of tasks of criminalistic examination as criterion of differentiation of tasks of judicial examinations allocated objectively existing divergences in their contents which are defined by the purpose and conditions of its achievement. According to these authors, the main elements of the expert task are the purpose and object. Thus it is noted that the purpose of diagnostic researches consists in establishment (reconstruction) of the occurred event in the past; establishment of the actions having character of private events makes the purpose of diagnostic researches and allows to allocate diagnostic tasks of examination [189].

T. V. Averyanova believes that the nature or state of a material object is the basis of diagnostic goals [3, p. 424]. A similar position is taken by S. V. Dubrovin, who defines forensic diagnostics as a forensic method of cognition, which is a system of cognitive techniques, the basis of which is the process of establishing the nature or state of the object having a certain relationship with the event of the crime under investigation [63, pp. 40–41]. According to A.V. Kokin, the subject of diagnosis is the essence of the object being diagnosed, which consists in the totality of its properties that are important for solving the problem, and it can be any information about the crime, contributing to the knowledge of this event [95, p. 59].

Thus, the generally accepted understanding of the essence of diagnostics and underlying laws does not yet exist and to date the content of its subject remains debatable. Nevertheless, on the basis of the above, it seems appropriate to support the point of view of I. V. According to which forensic-ballistic diagnostics — "the area of scientific knowledge of forensic ballistics, resolving mainly by means of forensic diagnostics and forensic ballistics questions of investigation of the nature, condition, properties and relations, event-related crime (offense), weapons, ammunition and traces of their actions, formulation on the basis of the data criminally significant value judgments about these objects, mechanism and other circumstances of the crime (offense)" [148].

When carrying out forensic ballistic examinations of cartridges (ammunition), not all properties of the object are investigated, but only those that characterize the object from the point of view of the question put to the examination resolution. Thus, the expert identifies the so-called informative features of the object under study, characterizing its properties. In relation to the forensic ballistic examination of cartridges (ammunition) for hand-held small arms, the diagnostic study establishes the suitability of the cartridge (ammunition) for firing, i.e., hitting the target as a result of a shot from the specified weapon, the compliance of the results with the established criteria [131].

At present, along with the diagnostic tasks solved in the production of examinations of cartridges (ammunition), the authors distinguish such a set of tasks as classification.

Proceeding from the generally accepted approach, classification studies include such studies in which the object is investigated and the task of the study is to determine to which class the object belongs [107, p. 68].

In General, the classification study can be considered as a clarification of the object belonging to a certain class. The class can be the only one, then the object belongs to itself. A class can represent a collection of homogeneous objects, and in this case, if the object belongs to a class, it must have at least one thing in common with this class [178]. V. F. Orlova and A. R. Shlyakhov defend the point of view, according to which "the classification problem is not an identification... the expert is not put before, and as a result of the study the goal of object identification is not achieved. It can not be considered diagnostic, because the object of study in the classification process is static, and the assignment of the object to the group is unequal to the establishment of an elementary particular event" [189, p. 8].

The specificity of this type of research is that a group (class), belonging to which should be established, is determined in advance. Such affiliation is established as a result of comparison of the parameters obtained in the course of expert research with a set of criteria defined for this class. A. A. Eisman characterizes this type of research as "determination of an object to a given characteristic" [295]. The same opinion, and N. V. Terziev, who believes that assigning an object to one or another group (class, subclass) is not enough to note the coincidence of certain signs, required a certain set; the content of the aggregate is determined by the classification of the corresponding objects defined by the criterion of practice [255, p. 27].

The decision of classification tasks of judicial-ballistic examination of cartridges (ammunition) on establishment of accessory of object to a certain class, in particular accessory of the cartridge to category "ammunition", involves application to the person storing it, norms of part 2 of article 295 "Illegal actions concerning firearms, ammunition and explosives" of the Criminal Code [266].

The founder of allocation of such type of examinations as situational (situalogical), is G. L. Granovsky who in 1977 as a result of generalization of expert practice formulated the basic theoretical provisions of criminalistic situational (situalogical) examination [50]. Subsequently, the position of the author was supported by other scientists, in particular A. I. Vinberg and N. T. Malakhovskaya, who identified in their work this type of expertise as an independent one [38, pp. 159–160]. It should be noted that the ideas of conducting such examinations were expressed by some scientists before. So, A. V. Dulov in 1957 pointed out: "In some cases, the examination should be appointed even when the situation of the scene is not violated… Thus, the investigator will provide the possibility of direct perception of the scene by the expert and will contribute to obtaining a more objective conclusion" [64, pp. 39–40].

The main objectives of situational (situalogical) examination are to establish the mechanism of the incident as a whole and its individual elements in the cause-and-effect relationship [62]; to determine the possibility or impossibility of the occurrence of facts in the specifically proposed circumstances.

In the course of situational (situalogical) examinations, spatial-temporal, substantive and causal relationships, material elements of the event are established [109]. In particular, in relation to the issue of expert research rounds (ammunition) solved the problem associated with the establishment of the possibility to use the murder weapon (gun) ammo (ammunition) specific type (cartridges replacement); the adequacy of the damaging properties of a welded element of the cartridge (ammunition) storage in specific conditions; the ability to display sledoobrazuyuschy parts manual small firearms on the construction elements of the cartridge (ammunition) specific of the manufacturer [1].

Thus, in the course of judicial-ballistic examination of the cartridges (ammunition) are solved by four main groups of tasks:

identification — identification (establishment) of various material objects on their displays;

diagnostic — understanding of the essence, identification of properties, determination of the state of the investigated cartridges used for shooting from small arms, elements of their design;

classification — differentiation of the studied objects and their assignment to a certain class (subclass) based on the established criteria;

situational (cytologically) — determination of the possibility (or impossibility) of the occurrence of the facts within the specified conditions.

It should be emphasized once again that the solution of certain tasks of the examination is due to the objectives of forensic research, which together with the object of the study determine the content of the methodology of expert research, as well as determine the sequence of application of appropriate methods and technical means, including forensic ballistic examination of cartridges (ammunition) as quite complex from the point of view of forensic examination of objects. Unambiguous understanding and clear differentiation of the purposes and tasks of forensic ballistic examination of cartridges (ammunition) is a significant condition for improving the quality of forensic activities and, as a consequence, the effectiveness of law enforcement practice.

I. V. Gorbachev proposed the following differentiation of tasks to be solved during the examination of cartridges used for shooting from small arms:

I. Problems about the type of model, caliber of cartridges and their elements. In this case, questions are raised about what kind of cartridge the cartridge belongs to; part of what cartridge is the bullet (sleeve, wad, etc.).

II. Problems about the type and model of hand-held firearms in which they are used for shooting. The following questions can be put to the permission of examination: for what manual small arms the given cartridge is intended; in what manual small arms the presented cartridge can be used for firing.

Based on the analysis of the content of these questions, it can be concluded that the semantic load and the volume of answers to the questions are unequal, since the second question is wider in content than the first. Which of the questions should be put to the permission of the examination, it is not possible to answer unambiguously and depends on the specific circumstances.

III. Tasks about establishment of a method of production of cartridges and their elements, a place and time of their release and the circumstances connected with production technology.

In respect of the present time on the territory of the Republic of Belarus there are cartridges (ammunition) of the World War II of Soviet and foreign production. Based on the results obtained during the expert study of these objects, the investigator (employee of the body of inquiry) can put forward a version of how they ended up with the suspect or in a certain place.

For cartridges (their elements) of self-made production it is expedient to pose the question, according to the type of industrial products they are made. To this group should also include the tasks associated with the technology of improvised (regear) rounds, with the production of the following issues: I whether filled cartridges with the use of devices; in this form were cast the study of the bullet is made whether the fraction using a single tool (fit).

The availability of on elements design patron (of ammunition) traces from use under their designing, equipment, peresnaryazhenii adaptations and equipment allows in some cases to decide question about unity source origin patrons, elements their design, materials, from which they are made.

IV. With regard to the individual elements of the cartridge, received for study in a disjointed form, the task can be set to establish whether they could previously constitute a single device [112, pp. 116–122]. Positive results of such studies have been obtained both in foreign and domestic expert practice in establishing the belonging of the bullet and the cartridge case to one cartridge [151; 215].

Nevertheless, in each specific case, the investigator (employee of the body of inquiry) is required to raise questions based on the specific circumstances and materials of the case, due to the subject of evidence.

Thus, on the basis of the above, the following generalized conclusions can be drawn:

1. The objective and subjective essence of the purpose of forensic ballistic examination of cartridges (ammunition) intended for shooting from small-arms firearms is determined by both the subject of proof and the existence of facts of objective reality, which ultimately determines the process of obtaining the necessary information about the object of research.

2. The solution of tasks within the framework of forensic examination of cartridges (ammunition) is determined by both final and intermediate goals (immediate and subsequent). The process of achieving them in each individual case is determined on the basis of a specific investigative situation. However the specified division is conditional, since the result of cognitive activity and depending on other circumstances, the ultimate goal could be an intermediate (further research will be conducted through a peer initiative) and Vice versa (in case of impossibility of solving the examination of the merits).

3. When carrying out forensic ballistic examination of cartridges (ammunition), not all properties of the object under study should be investigated, but only those that will allow to characterize it from the point of view of the question put to the examination resolution and are conditioned by the specifics of the relevant research. The list of such features should be fixed in the appropriate research methods of these objects, the implementation of which is aimed at improving the reliability and valid-

ity of the results. In particular, the determining criterion for assigning a cartridge to the category of ammunition is the possibility of hitting the target as a result of firing from the corresponding sample of hand-held small arms, i.e. ensuring the necessary ratio of mass, speed and size of the cross-sectional area of the thrown element.

3.2. Determination of the velocity of a single propellant element during ballistic examinations

Currently, the vast majority of forensic ballistic studies of hand-held small arms, ammunition is carried out in order to solve classification and diagnostic problems. Modern methods of expert research of hand-held small arms, cartridges (ammunition) used in it for firing should be based on knowledge of their internal and external ballistic characteristics, the processes occurring at a shot, use at carrying out expert researches of modern achievements of science.

The need for such an approach, due to the complexity of hand-held firearms, cartridges (ammunition), their versatility, the use of new materials and processing methods, technological processes in their manufacture, contributes to the development and improvement of means of obtaining quantitative measuring information about the properties of the object under study.

Providing the expert ballista with quantitative results of the velocity of the thrown element obtained as a result of experimental firing allows to establish functional connections between several physical quantities. In addition, obtaining reliable measurement information in the production of forensic ballistic examinations, in turn, ensures the reliability of the conclusions contained in the expert's opinion. This, in our opinion, cannot be explained in detail without taking into account the broad context, including the historical analysis of the development of ballistic measurements.

Experimental ballistics originated in ancient times, which was due to the need to obtain the maximum range of fire and action on the target of primitive artillery guns. However, providing artillery science with relatively accurate data on the ballistic capabilities of firearms became possible only by the middle of the XVIII century. During this period, as now, the measurement of the velocity of the projectile was made by indirect methods of measurement. For its determination, shooting from several guns installed with a single angle of elevation of the barrel was used, and if initially researchers were limited to the results of a single shot, by the end of the XVII century they began to use the arithmetic mean.

In view of the complexity of determining the speed of the projectile at different parts of its trajectory due to the force of air resistance, the researchers put forward the idea of measuring the speed in the immediate vicinity of the point of departure of the projectile — muzzle velocity. For the determination of this value by the French engineer and astronomer J. D. Cassini was designed ballistic pendulum — the first device designed to measure the speed of the projectile, the principle of which was to transfer the kinetic energy of the body of low mass to the body with a greater mass, resulting in its movement at a lower speed. Based on the descriptions contained in various literary sources, it was a wooden bar, moving on the surface as a result of being hit by a bullet. The main disadvantage of this method was that the coefficient of friction of the bar on the sliding surface was unstable.

In 1740, the British military engineer B. Robbins invented a swinging ballistic pendulum, which allowed more reliably determine the speed of the thrown element. On the basis of his experiments, Robins in 1742 published the book "New principles of artillery, containing certain forces of gunpowder and the study of the differences in the strength of air resistance for fast and slow movements", in which he described his invention and the results of experimental shooting with its use. Structurally, this device of B. Robinson was a tripod tripod with a swinging iron pendulum suspended on a horizontal axis; a wooden bar 180–200 mm thick was attached to the body of the pendulum, designed to catch bullets [55, p. 139].

Subsequently, devices for measuring the speed of bullets began to be designed in France and Germany. Despite the fact that these devices did not play a significant role in the development of experimental ballistics, their individual components and elements were used later, in particular in electric spark chronographs.

Bothe in 1764 developed a device, the principle of which was to apply marks on a rotating drum. Based on the speed of rotation of the drum, the distance between the marks on it, the bullet speed between the muzzle and the target was calculated.

Italian Matei in 1773 developed a device for measuring the speed of a bullet, placing on a rotating axis of the drum with two cardboard discs, which were fired. The speed calculation was based on the rotation speed of the axis and the angle between the bullet holes in the discs. Later, the French Colonel J. Grober somewhat improved the design of this device, extending its axis and causing radius marks on the discs. The measurement error of this device was 1/20 of the true value of the speed. Despite further improvements in this method of measurement production, it has not received wide distribution [55, p. 145].

In 1831–1832 in France the device of measurement of speed of the thrown projectile based on the principle of use of the law of universal gravitation was tested. When fired, the bullet or projectile severed the cord passed through the system of blocks and holding the target. When the cord broke, the target fell, and the speed was calculated from the height difference from the suspension point to the hit point. The measurement error in this way was about 4 % [55, pp. 144–146].

The results of the combat use of artillery in the Patriotic war of 1812 and the Russo-Turkish war of 1828–1829 in the Russian Empire showed the need to improve existing and design new weapons, providing greater range and accuracy. Achieving this goal without the use of appropriate means of measurement, allowing to assess the parameters of the shot with the necessary accuracy. Robbins and Grober's methods were cumbersome and primitive, and did not allow to determine the speed of the projectile thrown at different parts of the trajectory.

An innovative approach to determining the value of the velocity of the projectile was proposed by Second Lieutenant, and later Lieutenant General of artillery K. I. Konstantinov (1818–1871), who owned the idea of using electrical phenomena (electromagnetism) in the design of devices for measuring the velocity of the projectile. Using the results of scientific works of famous Russian physicists of the time E. H. Lenz, P. L. Schilling and B. S. Jacobi, he proposed the use of electromagnets. As a result of the break of the power circuit of the electromagnets, the pointed rods ceased to hold, marking the drum rotating at a constant speed [104].

While abroad "for the collection of useful information related to artillery", K. I. Konstantinov made attempts to manufacture a device of his own design — an electroballistic chronograph. To do this, in 1840, he turned to the English physicist Charles Wheatstone, and later, convinced that the device assembled by the latter did not meet the requirements, to Louis Breguet, the owner of a firm for the manufacture of precision instruments in Paris. In 1844, the Konstantinov device was manufactured (figure 3.2.1) and demonstrated in action at the artillery range in St. Petersburg.

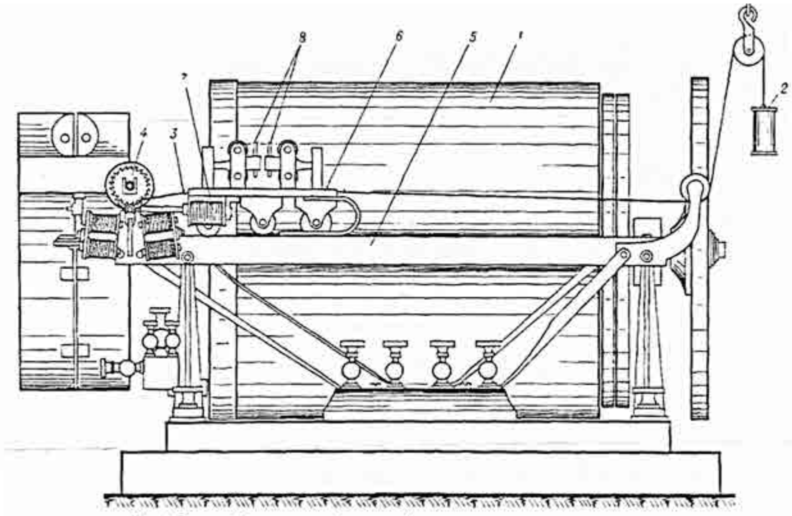

Figure 3.2.1 — **Electrophoretically chronograph by K. I. Konstantinov**:
1 — copper cylinder, 2 — cargo, 3 — cord, 4 — winch, 5 — rails,
6 — trolley, 7 — electromagnets, 8 — rods [104]

This device is several times superior to the accuracy of the ballistic pendulum, and also allows you to measure the speed on any part of the trajectory. Later C. Wheatstone and L. Breguet tried to challenge the superiority of K. I. Konstantinov in the use of electricity in ballistic measurements, but in 1847 fully recognized the authorship of the latter.

In connection with the use of rifling in the bore of weapons the number of inventions in the field of ballistic measurements of flight speed using electrical phenomena by the end of the XIX century has increased dramatically. The chronological series of these inventions can be presented in the following sequence: K. I. Konstantinov (1840, Russia), CH. Wheatstone (1842, England), L. Breguet (1843, France), J. G. Henry (1843, USA), Leonard (1846, Prussia), NAVET (1848–1849, Belgium), HIPP (1847, Grand Duchy of Baden), Vignotti (1854, France), Schultz (1857, France), M. de Brett (1858, France), Benton (1859, USA), Noble (1862–1863, England), P. le Boulanger (1863, Belgium), lers (1865, Belgium), F. Bashfort (1867, England) [104].

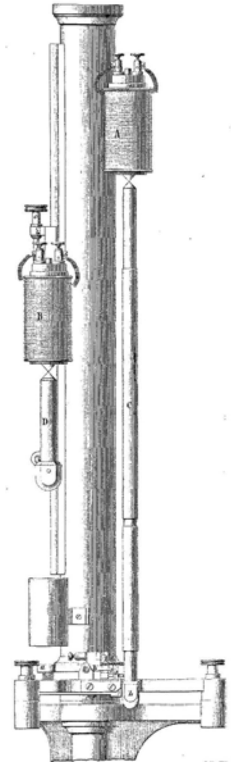

Figure 3.2.2 — **Chronograph by P. Le Boulanger** [179, p. 32]

To ballistic instruments measure speed by air, based on another principle, applies elektroballisticheskiy pendulum Nave, invented them in 1849 propulsion, time by air in which is determined by on street corner departures pendulum, beginning fall under rupture wire the first frame-targets. Devices with the same principle of action were subsequently designed by Vignotti (1855), Benton (1859), Lers (1865) and A. Shirsky (figure 3.2.3) [257, pp. 199–208].

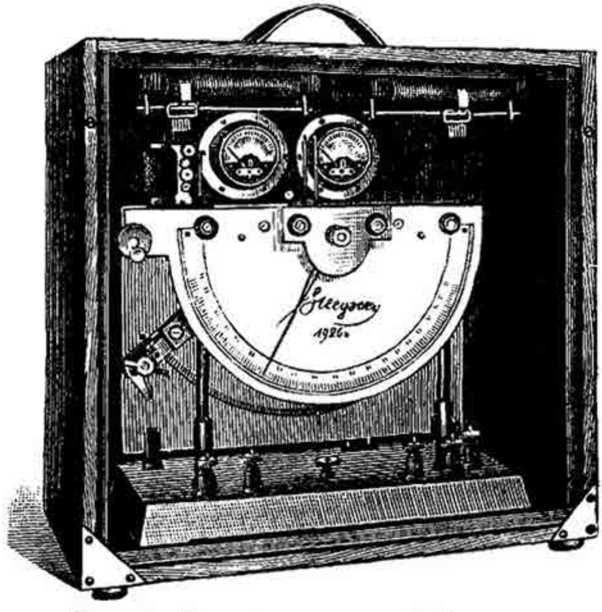

Figure 3.2.3 — **Millisekunder by A. Cherskogo** [given by: 257, p. 199]

Thus, by the beginning of the XX century, the main methods of measuring the velocity of projectiles were developed and tested, which were later borrowed from military science by forensic ballistics. It should be noted that the chronographs of P. Le Boulanger and A. Shirsky were used in the production of forensic ballistic examinations until the 1970s, until they were superseded by more advanced devices [257, pp. 83–84].

The methods used to determine the velocity of the thrown element can be divided into three main groups:

1) methods for determining the instantaneous velocity value at any point of the trajectory;

2) methods for determining the average speed on a certain section of the trajectory;

3) methods of continuous determination of the value of the velocity of the thrown element in different parts of the trajectory.

The first group of methods for measuring the velocity of the projectile element, namely methods for determining the instantaneous value of the velocity at an arbitrary point of the trajectory, include the ballistic pendulum method and the phenomenon of the formation of the head ballistic wave of a projectile flying at supersonic speed. By measuring the angle of the wave, it is possible to determine the velocity at a fixed point of the trajectory, which can be determined by a simplified formula:

$$v = \frac{a}{\sin\left(\frac{\alpha}{2}\right)},$$

where:

v — the speed of the throwing projectile;

a — the speed of sound in the air;

α — the angle of the shot ballistic waves [9, pp. 144–145].

The accuracy of the bullet velocity measurement with this method is about 5 %.

The second group of these methods, i. e., methods for determining the average speed on a certain trajectory based on determining the time of flight of the measuring projectile trajectory *l*. In this case, it is assumed that in the measured area the velocity of the projectile changes linearly, taking its average value for instantaneous. To reduce the errors introduced in the production of measurement, the length of the measuring section is selected as short as possible based on the allowable errors of the time interval registration [125].

The expert units use electronic chronographs, the principle of operation of which is based on the comparison of the measured time interval of the flight of the thrown element with the sum of the oscillation periods of the high-frequency quartz generator of electrical signals (KGVH) (figure 3.2.4).

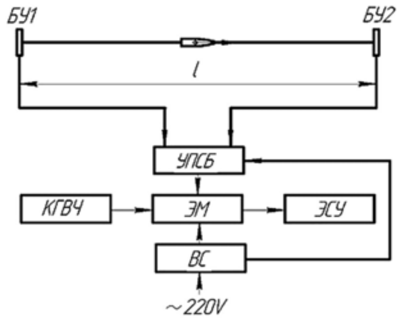

Figure 3.2.4 — **Block diagram of the chronograph device and operation:**
БУ1 и БУ2 — first and second blocking devices;
УПСБ — the device receiving signals of the locking device;
КГВЧ — high frequency crystal oscillator; ЭМ — electron multiplier;
ЭСУ — electronic reader; ВС — power supply [297, p. 105]

Currently, two types of sensors are used to block the beginning and end of the dimensional segment of the trajectory: contact and non-contact.

The simplest contact sensors are wire frames-targets with a wire spiral, as well as targets, the sensor of which is two sheets of metal foil, separated by a layer of dielectric material (paper). At the time of flight, the bullet opens (closes) the electrical circuit, starting or stopping the chronograph pulse counter. To ensure reliable rupture bullet of the winding wire to frame the target the distance between adjacent turns of 0,25 choose wire diameter. Winding at the same time is carried out with some tension to reduce the likelihood of pushing it to the sides and pulling.

Contact also include inertial sensors of the type that is installed as a secondary locking device. This sensor consists of a strong steel plate, which is suspended perpendicular to the plane of fire. The principle of operation of this type of lock is similar to the above. Chronometers with such blocking devices were widely used in expert institutions in 1960–1980. XX century (for example, the device LIS-2, made on the basis of decatron millisecond MS-1).

By non-contact methods of blocking include: acoustic, photoelectric and solenoid.

In the acoustic method, the blocking is carried out by two microphones that record the ballistic wave, which is formed during the flight of bullets flying at supersonic speed; at speeds below the speed of sound, this method is not suitable and practically does not change.

The photoelectric method of blocking is currently used in most of the devices for measuring the flight speed of the propellant element used by expert units (in particular, in the devices “Regula-6001”, RS-4M). When flying between a light source (led) and a photocell, the bullet crosses the light flux, causing an instantaneous change in illumination. The resulting electrical signal enters the electronic chronograph signal reception unit, controlling the pulse counter.

Solenoid interlock is based on the phenomenon of electromagnetic induction. The sensitive element of such blocking devices is the solenoid (inductor). This type of blocking is used in bullet velocity meters and IS-4 P, RUSH-MP, BIS-2. During the passage of the metal body changes the magnetic flux inside the solenoid and in the winding connected to the device receiving signals controlling the chronograph. A significant disadvantage of this type of blocking should be recognized as the inability to measure the speed of bullets made of polymeric materials.

Figure 3.2.5 — **The device of measurement of speed of flight of a bullet “Regula-6001”**

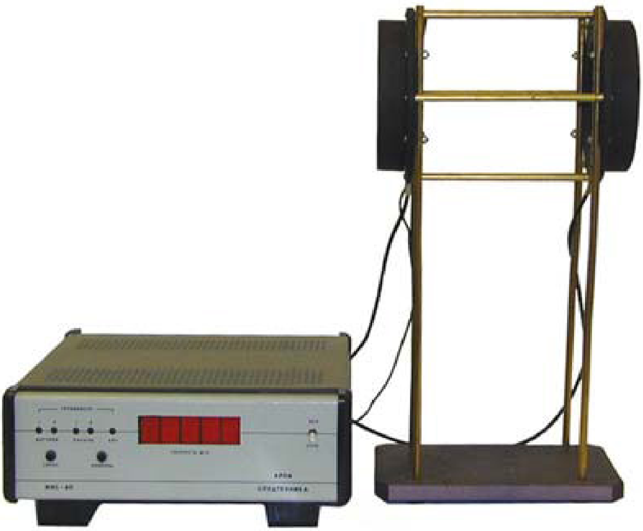

Figure 3.2.6 — **The unit of measurement of a bullet IIS-4P**

When measuring the velocity of the bullet, the blocking devices are placed on the trajectory so that the first blocking device is not affected by the powder gases formed during the shot (figure 3.2.7). Based on the analysis of established expert practice, the minimum distance from the muzzle of a hand-held small firearm to the first blocking device — $l_0 \geq 0{,}5$ m.

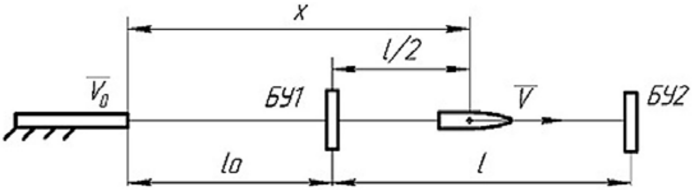

Figure 3.2.7 — **The layout is blocking the sensors on the trajectory** [297, p. 109]

The third group includes methods of continuous determination of the value of the velocity of the thrown element in different parts of the trajectory. Currently, measuring instruments are used in the design of which optical and radio principles of operation are used.

Optical measuring systems are goniometer devices designed for visual observation of a moving object. They are characterized by high accuracy and visibility of the obtained measurement results. For vnesh-netorgovogo of determining the velocity of the methane element method is applied cinetheodolites. In this case, the direction-finding method of measurement is used, which consists in the fact that two or three kinote-odolitnyh posts simultaneously conducted photo-video of the movement of the thrown element in space.

Measuring equipment, the principle of operation of which is based on the radio principle of action (Doppler effect), has greater versatility and range. A moving projectile causes a change in the radio frequency signal directed at it. Based on the magnitude of the frequency change of the signal reflected from the object, its speed is determined.

As already noted, when solving diagnostic problems of forensic ballistic examination, means of measuring the speed of the thrown element are used. In accordance with the current regulatory legal acts, legal entities are obliged to ensure the unity of measurements in the production of products, performance of works, provision of services, reliability of the results of verification, calibration, metrological confirmation of the suitability of measurement techniques.

In this context, the approach of O. R. Matov and A.V. Stalmakhov is interesting, the essence of which is that since the method of determining the specific kinetic energy of the propellant element ($E_{spec.}$) in forensic ballistic examination is indirect, then the error of determining the $E_{spec.}$ should be calculated as an error of indirect measurement. The spread of speed values and the use of mathematical expectation (arithmetic mean) imply the presence of a random error, and hence the corresponding statistical processing of the measurement results. At value $E_{spec.1}$ = 0.555 J/mm^2, $E_{spec.2}$ = 0.66 J/mm^2, $E_{spec.3}$ = 0.775 J/mm^2, by calculating the standard deviation and error and estimating the confidence interval with a reliability of 0.95, the final value E_{spec} = (0.663 ±0,27) J/mm^2, in which part of the interval is less than the minimum value established in forensic ballistics $E_{spec} \geq 0,5$ J/mm^2 [159].

The authors propose two ways to solve the problem: to produce at least ten shots to reduce the confidence interval or, as required by the methods of research of objects of forensic ballistic examination, to produce three experimental shots. Thus it is necessary in each case to calculate the value of $E_{spec.}$ c taking into account the systematic error. Thus, if as a result of all three shots, sufficient values of the striking ability of the bullet are obtained, the second and third arrows will serve as confirmation that this measurement result is not “random”.

The above allows us to make the following generalized conclusions:

1. One of the main tasks of the experiment carried out in the framework of forensic ballistic examination as the highest form of empirical methods of cognition of the properties and States of the objects of research is the organization of its production, including the selection of measuring instruments, metrological characteristics of which determine the reliability of the conclusions contained in the expert.

2. Requirements of metrological admissibility shall be fixed in provisions of techniques of the criminalistic research providing use of the empirical data received during experiment on the basis of which further calculations are carried out.

It seems that the accounting and the implementation of these insights would contribute to the compliance of measuring instruments, forensic laboratories and forensic investigation techniques to international standards, in particular the standard ISO/IEC 17025-2017 “General requirements for the competence of testing and calibration laboratories” and the development of a unified science-based requirements for forensic samples and techniques used in forensic ballistic examinations.

3.3. Diagnostics of the qualitative state of hand-held small arms used in the production of experimental shooting

A peculiar form of practice as a criterion of truth is experiment, which is a specific method of cognition of objective reality. By experiment, the investigated phenomenon can be isolated from the variety of other phenomena, facts and studied separately.

The method of the experiment is mandatory in determining the qualitative state of cartridges (ammunition) used for shooting from small arms firearms. In this case, the object of the experiment is the object itself (cartridge), while the indirect form of knowledge is excluded.

The analysis of law enforcement and expert practice confirms the need for mandatory experimental firing with measurement of energy characteristics of the thrown element of cartridges (ammunition) of homemade manufacture or re-loaded with the use of design elements of cartridges (ammunition) of factory manufacture.

In accordance with the provisions Of the methodology of forensic investigation of cartridges, the recommendations set out in the special literature on forensic ballistics, as a weapon used in the shooting of cartridges (ammunition) of factory manufacture, samples of factory-made hand-held small firearms with the appropriate parameters of the chamber and the barrel bore are used. This approach, due to the long-established expert practice of studying the properties of cartridges (ammunition), is described in detail in the works of famous scientists in the field of forensic ballistic examinations — V. S. Akhanov, V. A. Ruchkin, E. N. Tikhonov, A. I. Ustinov, etc.

Nevertheless, the issues of determining the qualitative state of hand-held firearms, available in full-scale collections of expert units and intended for the production of experimental shooting, have not yet been reflected in the forensic literature.

With respect to the subject it should be noted that in accordance with the established practice of small firearms in the Arsenal of organizations with a paramilitary structure, is subjected to categorization, i. e. the assessment of the degree of efficiency of a specific instance based on its quality status.

The classification of hand-held small-arms firearms into one or another category is not decisive in relation to hand-held small-arms firearms used in the production of forensic ballistic examinations. In this case, we should not talk about hand-held firearms, assigned to the employee and used in the exercise of his official activities, and experimental equipment designed to obtain criminally significant information about the object of research, in particular the speed of the projectile element of the cartridge (ammunition). Therefore, the requirements for such hand-held small arms should be different.

Hand-held small arms is a thermodynamic machine in which the released energy of chemical transformation is transformed into the thermal and kinetic energy of the movement of the system "throwing element-barrel". The phenomena occurring in the barrel channel of hand-held small arms when fired are associated with high pressures developed by gunpowder gases (1500–3000 at); high temperature of gunpowder gases (2.000–3.000 °C); short intervals of the phenomenon of the shot (0.01–0.001 s.).

Effects of physical and chemical factors that accompany the shot from a small firearm, interior dimensions, especially in the fields of the rifling, the initial section of the barrel (at the beginning of the rifling) and muzzle increase. Due to the wear of the bore, the ballistic characteristics of the shot change: the greatest pressure and muzzle velocity decrease, the technical dispersion of bullets increases.

The bullet cuts into the rifling occurs after it passes the worn section of the barrel channel (the bullet entrance) and by the beginning of the cutting will acquire some speed. Thus, depending on the degree of barrel wear, wear and tear of rifling, deterioration of the compression casing of the bullet its possible the "failure" of the rifling, a significant reduction in obturation, speed reduction and deterioration of accuracy of fire.

With a significant drop in speed (up to 10 %), an eight-fold increase in dispersion at the firing range or when cutting off the leading belts, the barrel of a hand-held small-arms firearm reaches the limit of ballistic survivability [46, pp. 57–58]. The influence of the degree of wear of the bore on the pressure in the discharge space and muzzle velocity is shown in the graphs (figure 3.3.1).

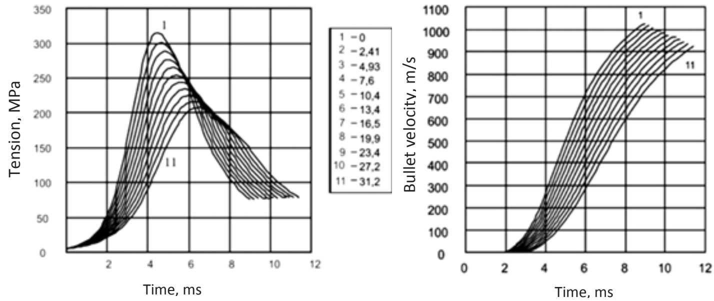

Figure 3.3.1 — **Change of average ballistic pressure and muzzle velocity depending on the degree of wear of the bore** [76, pp. 176–177]

In particular, for the majority of samples of manual small arms of the Soviet production check by the impassable caliber K-2 entered into a trunk from the muzzle section on a certain depth is applied. It is assumed that if the depth of the caliber entering the bore does not exceed the established values, the barrel has some (small) margin of survivability. Weapons with the same barrel wear is allowed for further use, provided that it satisfies the normal accuracy of the battle. Thus, in military and technical science, the main criteria for assessing the survivability of the barrel are:

1) drop initial speed of a bullet to a certain size;

2) increase of dispersion of bullets and emergence of failures of bullets from rifling [194, p. 114].

Table 3.3.1 provides data on the survivability of the bore of some samples of small arms of Soviet and foreign production [45, p. 138].

Table 3.3.1 — **The survivability of the bore of some samples of small arms firearms**

Type of hand-held small firearms	Number of shots
5.45-mm small-sized self-loading pistol (PSM)	3 000
5.45-mm Kalashnikov assault rifle (AK-74)	10 000
5.45-mm Kalashnikov light machine gun (RPK-74)	20 000
7.62-mm Shpagin submachine gun (PPSH-41)	20 000
7.62-mm submachine gun sudaev (PPP-43)	20 000
7.62-mm Dragunov sniper rifle (SVD)	6 000
7.62-mm Kalashnikov assault rifle upgraded (AKM)	10 000
9-mm Makarov pistol (Mak)	3 000
9-mm Stechkin automatic pistol (APS)	8 000
9-mm submachine gun MP-38 (MP-40)	20 000

In each case, the degree of wear of the barrel bore of small arms should be established individually using appropriate measuring equipment and by determining the consistency of ballistic characteristics based on the results of verification (certification) shooting. Only by meeting this requirements are to ensure objectivity and reliability in forensic ballistic examinations of the quantitative values of the speed of throwing item bullets (ammunition) [139].

Constancy of speed of the thrown element, proceeding from provisions of the theory of probability and mathematical statistics, it is necessary to make on ten test shots with measurement of speed of the thrown element. In this case, the average value of the speed deviation should not exceed ±20 m/s [297, pp. 113–115].

Before test from manual rifle firearms, enshrined in machine tool, produce one nezachetnyy shot for intermediate and rifle patrons and two shot being fired for pistol and revolver. Shooting should be made by cartridges (ammunition) of one party from one capping. In this case, the cartridges (ammunition) are kept at a temperature from 0 °C to 25 °C in a single layer in bulk for at least 1.5 hours — for pistol and revolver, 3 hours — for intermediate and rifle cartridges.

Velocity is determined as a result of shooting a group of ten shots, and then calculate:

the average speed — v_{mean}

$$v_{mean} = \sum_{i=1}^{10} v_i / 10.$$

For example, if the following results are obtained in the production of experimental shooting:

Table 3.3.2

Shot	1	2	3	4	5	6	7	8	9	10
Speed (m/s)	312	317	320	315	317	311	322	312	314	320

then:

$$v_{mean} = \frac{312+317+320+315+317+311+322+312+314+320}{10} = 316\ (m/s)$$

the highest value of the speed — v_{hv};

the lowest value of the speed — v_{lv};

the speed difference — v_Δ:

$$v_\Delta = v_{hv} - v_{lv} \quad .$$

The obtained value of ν_Δ is compared with reference data of ammo (ammunition) parameters used for test firing [297, pp. 113–115].

At the value ν_Δ ± 40 m/s from the nominal values given in the technical documentation for the sample cartridge (ammunition), which was fired, the weapon must be recognized as unsuitable for use in the production of forensic ballistic examinations. The above values are used in assessing the quality of small arms in industrial enterprises and do not cause doubts.

Observing these recommendations, in our opinion, it is possible to objectively assess the qualitative state of the barrel of hand-held firearms used for the production of experimental shooting.

Important aspects of ensuring the constancy of the obtained high-speed characteristics of the projectile element of the cartridge (ammunition) include the purity of the bore of hand-held small arms and its length.

In this regard, of practical interest are the information given in the literature on the development of cartridges 7U1 (with subsonic bullet speed) to the Kalashnikov AK-74 (report of the Central Research Institute of Precision Engineering "TSNIITOCHMASH"). In the course production experimental called the shots from four new ballistic barrels and two barrels with large nastrelom were forthcoming the next data about speed bullets (table 3.3.3) [58, p. 172].

Table 3.3.3

Shooting practice	**New trunks**	**138 shots**	**370 shots**	**670 shots**	**1 250 shots**
Number of barrels	4	2	2	1	1
ν_{cp} (m/s)	240–279	271; 279	253; 254	254	284

One of the reasons for obtaining unstable values of v_{mean} when firing from different barrels is the braking of the bullet on the last section of the barrel, "when the pressure force of gases on the bottom of the bullet becomes commensurate with the forces of friction between the surfaces of the bullet and the bore. In this case, the state of the bore can have a greater impact on the velocity value, the lower the energy characteristic of the bullet. At the last 100 mm of the barrel ... at a certain state of the barrel bore, the bullet velocity can become decreasing" [58, p. 172].

This question is not new: "...it is noted that the velocity variation of subsonic bullets cartridges the greater the greater the length of the barrel of the sample weapon. Thus, when firing from a Degtyarev machine gun (RPD) with a barrel length of 62 caliber (club), the spread of bullet speeds was 47 m/s, Kalashnikov assault rifle (AKM) with a barrel length of 50 klb — 33 m/s. The spread of the values of VSR from the new Kalashnikov AKS-74U was 38 m/s (160 m/s from the AK-74) after firing 180 rounds of 36 m/s (from the AK-74 40–120 m/s)" [58, p. 179].

As a result of repeated experimental firing from ballistic barrels with a shorter barrel length, it was found that the spread between the barrels on the v_{mean} was 11 m/s instead of 44 m/s before the trunks were shortened. In addition, according to the report on obtaining stable results when working out a cartridge with a subsonic bullet velocity, the limits and stability v_{Δ} of the cartridges depend more on the copper plating of the bore, i.e. on the friction of the bullet, than on its parameters and purity of processing. After nastrela 180 shots cartridges 7N6, for cartridges 7U1 (with subsonic bullet speed) v_{mean} = 280–442 m/s, after cleaning v_{mean} reduced to 234–322 m/s.

Thus, the conducted studies have proved that pre-firing (180 shots) significantly improves the stability (reduces the spread of values) of the initial velocities of cartridges due to copper plating of the barrel and gunpowder deposits — smoothing of small defects of the chrome coating. In addition, there was a higher stability of the velocity of the projectile element of the cartridge (ammunition) when firing from hand-held small arms with a non-chrome barrel channel, due to the lack of "roundness" of the rifling after applying a layer of chromium.

As another determinant condition, it is indicated that intensive cleaning of the barrel of hand-held small arms with a barrel cleaning solution (RFS) for 2–3 days leads to the removal of copper plating and a decrease in the bullet velocity by 10–20 % [58, pp. 178–181].

Thus, to obtain stable characteristics of the experimental firing in relation to use of the respective samples of small firearms shall comply with the following conditions:

1) preliminary "run-in" of the bore of hand-held small firearms used in the production of forensic ballistic examinations, firing cartridges of one batch of at least 180 shots;

2) use to determine the suitability for firing cartridges (ammunition) of hand-held small-arms firearms with the minimum possible length of the barrel bore;

3) ban on the use of cleaning and lubrication of hand-held firearms used in the production of experimental shooting, active chemical com-

pounds with “Razmednitels” components of the artillery charge, designed to reduce the copper plating of the inner surface of the bore when firing shells with a copper lead belt;

4) check of ballistic characteristics of the specified weapon at least once a year with indication of its qualitative condition and quantity of the made shots.

It appears that based on the above conclusions and proposals would contribute to the improvement of forensic activities, having a positive effect on expert practice in determining the qualitative state of small firearms used in forensic ballistic tests of cartridges (ammunition), to determine their suitability for shooting, thereby ensuring the accuracy of the results of energy characteristics of the throwing element and the validity of the conclusions contained in the expert opinion.

3.4. Criteria for assessing the damaging ability of cartridges (ammunition) to hand-held small arms

Differentiation of objects of criminalistic research is one of the most important tasks solved in the framework of examination of cartridges (ammunition) used for shooting from small arms. In this case, of particular importance, taking into account the theoretical provisions and practical experience of expert units, is the definition of uniform criteria for assessing the damaging effect of the throwing element of such cartridges (ammunition).

For the correct understanding by the law enforcement officer of terms “weapon”, “cartridge”, “ammunition” at investigation of illegal actions diagnostic research of the specified objects used by suspects for the purpose of their relevance to the corresponding categories is carried out [269, p. 4].

A crime committed with the use of weapons is a system of actions United by a single intention and aimed at achieving a criminal goal. The functional purpose of small arms reflects the purpose of the criminal act [106, p. 23]. Such crimes are usually thought out and planned in advance, taking into account external conditions and factors. At the same time, the weapon used in their Commission is an integral determinant element of the system, since its technical and design parameters have a significant impact on this event.

The appearance of objects with new, previously unexplored or insufficiently studied properties entails the possibility of using them, including to achieve a criminal goal. In objects structurally similar to firearms, the same principle of projectile throwing is used, the striking ability of which is on the verge of the minimum level of striking ability established in criminology for small arms firearms, and this in turn allows the guilty person to store, transport such a device without fear of legal liability, which greatly facilitates the preparation and Commission of the crime.

Currently, in criminal law, there are three groups of objects whose striking properties are used in the Commission of crimes:

1) hand-held small arms, cartridges (ammunition) used for firing from it, gas weapons, explosive devices, etc.;

2) special means that have a direct impact on the human body for the purpose of temporary destabilization of its functions (including manual small arms of traumatic action);

3) objects used as weapons in the Commission of a criminal act [269, pp. 7–8].

In this paper, based on the purpose of the study, we consider only the striking properties of the projectile element of the cartridge (ammunition) used for shooting from hand-held firearms, as one of the main criteria for classifying cartridges as “ammunition” in its forensic meaning.

Diagnostically significant properties of cartridges (ammunition) as objects of expert research are their signs used in establishing the nature, properties and condition of these objects. Among the properties possessed by firearms, cartridges (ammunition) used in it for shooting, practical significance for diagnostic expert research are only some of them. In this case, the expert actually evaluates not the property, but its reflection outside (the reflection of the property is a sign) [106, p. 41; 149, p. 333].

The striking properties of the projectile element of cartridges (ammunition) used for shooting from hand-held small arms determine the actions of a person when committing a crime. Thus, when analyzing the localization of injuries caused as a result of the use of firearms of traumatic action, attention is drawn to the predominant defeat of the head and neck not only of the dead, but also of the wounded (table 3.4.1) [261].

Table 3.4.1 — **The distribution of injuries by localization**

Localization	The frequency of damage, %		The nature of injuries among the wounded, %	
	dead	injured	penetrating	non-penetrating
Head, neck	100	52,1	18	52
Chest	–	15,1	21	79
Belly, pelvis	–	9,9	16	84
Limbs	–	22.9	43	57

High frequency of penetrating wounds at shots in the head and a neck, and also extremities is explained by that in these areas shots are made most often from range of 1–2 m for the purpose of the guaranteed approach proceeding from characteristics of striking action of wounding shells of the applied weapon and vulnerability of their elements of clothes. In cases where it was possible to establish the distance of the shot, shots were fired from a distance of 1–2 m in 73 % of cases, from a distance of 2–3 m — in 7 % and from a range of more than 3 m — in 20 % of cases [261].

Thus, an integral characteristic of weapons in General and hand-held small arms is their effectiveness, reflecting the level of their functions. The impact of weapons on the target in ideal conditions, when it acts flawlessly, and the target struck by them does not have any resistance, is expressed in the maximum performance of the action on the target, which theoretically can provide a particular sample of such weapons. However, in practice, when used in each case, the weapon may (or will) at some point have indicators of action on the target below their maximum theoretical values. Since it is not possible to determine the maximum level of effectiveness of the action of the projectile element on the target, based on the above circumstances, then when committing crimes with the use of small arms, a reliable indicator of its effectiveness will be the minimum possible level of the striking ability of the projectile element of the cartridge (ammunition) [129].

To confirm this conclusion, it is advisable to comprehensively consider the system "munition — weapon — target". The deterministic conditions in relation to the question under consideration for this system will be the following:

1) the striking ability of the projectile element of the cartridge (ammunition) used for shooting;

2) susceptibility and vulnerability of the biological target to damaging factors;

3) type of hand-held small arms depending on the action of the loading mechanism and the number of charges — single-charge(multi-charge), automatic (non-automatic).

In the technical literature on the design of cartridges (ammunition) for hand-held small-arms firearms, the following types of striking action of a bullet on a target are distinguished: 1) lethal; 2) stopping; 3) penetrating; 4) armor-piercing [54, pp. 113–114]. It should be noted that for further study of the issue related to the definition of reliable forensic criteria for assessing the damaging effect of the projectile element of the cartridge (ammunition), theoretical and practical interest are mainly the first three of these types.

Studies in the field of wound ballistics and forensic medicine have shown that the impact of the thrown element on the target is determined by a set of interdependent types of such impact, the consideration of which is isolated from each other when deciding on the minimum striking ability is debatable. As M. B. Shvyrkov notes, the understanding of the features of gunshot wounds is possible only when taking into account the data of wound ballistics in conjunction with the anatomy and pathology of gunshot wounds [287, pp. 17–18].

At present, the lethal effect of bullets of cartridges (ammunition) to hand small arms is understood to be the action of a bullet that provides defeat of a living target due to violation of vital functions of the organism [54, pp. 113–114; 91, p. 7].

From the above definition, it follows that the lethal effect of the projectile element of the cartridge (ammunition) is to destabilize the functions and violation of the integrity of vital human organs. Violation of the anatomical integrity of the organ and / or its basic biological functions, as a rule, is irreversible and is caused by a complex set of pathological processes that develop as a result of the impact of the thrown element.

When considering such a damaging factor as the penetrating effect of bullets of cartridges (ammunition) used for shooting from small arms, it should be noted that in military science it is understood as the property of the bullet to penetrate through viscous barriers [54, p. 114]. In Forensic Science, the penetrating power of a bullet is usually understood as a damaging factor characterizing the hypothetical ability of a wounding projectile to cause damage to vital organs located in the abdominal cavity of the human body, which is expressed in a certain value of the specific kinetic energy of the thrown element [232].

An attempt to solve the problem of determining the minimum striking ability of wounding projectiles of small arms for solving the problems of its diagnostic study was undertaken by A. I. Ustinov. It consisted in the study of the damaging ability of pistol bullets cylindrical shape caliber 5.6 mm, 6.35 mm, 7.62 mm, 9.0 mm when shooting at the corpses of people from short-barreled rifled weapons. The impact of a bullet on the target was studied by these scientists from the point of view of the possibility of hitting the most vulnerable organs of the human body located in the abdominal cavity (liver, kidneys, intestines, spinal column, aorta) [267, pp. 16–17].

At the same time, the affected area was chosen by A. I. Ustinov on the basis of cases known in practice, when serious bodily injuries or fatal injury were caused by injuring projectiles having a lower flight speed (for example, when hitting the temporal bone or eyeball).

Thus, the German criminologist F. Hausstein described the case of a fatal wound of a woman who was at a distance of 60 m from a passing river vessel. When the bullet hit, the lens of the glasses and the eyeball were pierced, from which the 4.5 mm “Diabolo” bullet was extracted. One of the ship’s crew testified that he fired an air rifle at seagulls sitting on the water. On the permission of examination the question is put: “whether energy of a bullet that after a ricochet from water it punched glass of points and eyes is Sufficient ?”. In the course of the study, it was found that the glass of the glasses was destroyed at a speed not lower than 60 m/s and the bullet “Diabolo” had such a speed after the ricochet [308]. However, as noted in the literature, the area of both human eyeballs relative to the projection of the entire body area is about 1 percent, and therefore the probability of hitting it is relatively small [284, p. 79].

The essence of the experiment conducted by A. I. Ustinov was that since the shooting was carried out by bullets with the same shape of the head, the ability to inflict penetrating injuries depended mainly on their speed at the time of defeat. As a result, the scientists found that the minimum speed at which the possibility of causing damage by bullets of this form remains is 100 m/s (the results of the bullet velocity were rounded to the specified value) [267, pp. 16–17].

L. F. Savran, based on the data of the experiment conducted by A. I. Ustinov, for the first time introduced a new value into forensic ballistics — specific kinetic energy (the amount of kinetic energy per unit cross-sectional area of a bullet) [231].

$$E_{spec.} = \frac{E}{S},$$

where:

$E_{spec.}$ — specific kinetic energy of the thrown element (J/mm ^{2});

E — kinetic energy of the thrown element (J);

S — cross-sectional area of the throwing element (mm^2).

This value characterizes the energy load of the bullet per 1 mm^2 of its cross-sectional area, i. e. its penetrating effect [232].

In the work of L. F. Savran, data on the value of specific kinetic energy for bullets of different diameters (excluding the shape of the head part) are given (table 3.4.2) [232] taking into account the minimum limit of the defeatability, that is, the velocity of the wounding projectile (V_b) at the biological target should be $V_b \geq 100$ m/s [267, pp. 16–17].

Table 3.4.2 — **The value of the specific kinetic energy of bullets of different diameters**

The nominal caliber of the bullet, mm	Bullet weight, g	Bullet velocity at the lower limit of the damage, m/s	Kinetic energy of the bullet, J	Cross-sectional area, mm^2	Specific kinetic energy of the bullet, J/mm^2
5.6	2,5	100	12.5	24.6	0.5
6.35	3,2	100	16	31.6	0.5
7.62	5,5	100	27.5	45.5	0.59
9	6,0	100	30	63.5	0.47

The results of the theoretical calculation of the specific kinetic energy for bullets of different diameters became the basis for the development of L. F. Savran “Methods for determining the minimum lethal force of standard and atypical firearms and ammunition” [232, pp. 17–20]. Currently, the value of the specific kinetic energy ($E_{spec.} \geq 0,5$ J/mm^2) is used in the methods of forensic investigation of cartridges, objects belonging to hand-held firearms, their serviceability and suitability for shooting [166] as a criterion for the minimum striking capacity of the wounding projectile (the projectile element thrown).

Opinion L. F. Savranya about how, that with criminalisticheskoy perspective specific kinetic energy ($E_{spec.}$) the most fully and accurately characterizes energy burden bullets on 1 mm^2 of its cross-sectional area and characterizes the penetrating power of bullets when hitting a biological target, has a reasonable character. However, for a full understanding of the essence of this phenomenon, it is necessary to additionally refer to the experiment conducted by A. I. Ustinov, who used rifled firearms of different calibers.

In spite of overall scientific significance of this experiment had some disadvantages:

first, as the main criterion, the possibility of destruction of certain (vital) organs located in the human abdominal cavity was chosen, i. e. only the penetrating ability of bullets was studied;

secondly, the movement of the wounding projectiles occurred at the lower limit of their stable gyroscopic stabilization in flight. At a speed of less than 100 m/s, the ricochet of bullets from the skin of biological material was observed;

thirdly, the penetrating power of bullets with a different (non-cylindrical — spherical) shape of the head part-oval and pointed-has not been studied.

In the framework of the issue under consideration, it is important to pay attention to the instructions of L. F. Savran that for bullets with a pointed and oval shape of the head part, this indicator may have a lower value [231; 232, p. 20].

In connection with the above, we note that to ensure a stable flight of bullets, two types of stabilization are mainly used:

the displacement of the center of resistance to bullets for the center of gravity by weighting the head part (characteristic arrow-shaped bullets);

giving the moving bullet a rotational motion around the longitudinal axis, as a result of which it acquires gyroscopic stability. The higher the rotation speed, the higher the stability on the flight path, respectively, when the rotation speed decreases below a certain limit, the stabilizing moment becomes overturning, and therefore the bullet sharply loses stability [90, p. 129].

The calculation of the angle of the rifling in the barrel of a small firearm is manufactured by industrial enterprises on the basis of certain parameters used for the shooting of it of the cartridge (ammunition): bullet shape, weight and dimension specifications, shell material, speed and others [54, p. 91].

Consider a specific example: determine the angular velocity of a caliber bullet d=5.6 mm at muzzle velocity V_1 =280 m/s and V_2 =100 m/s and the specified angle of rifling α=3° (the angle of rifling in the corresponding samples of hand-held small arms for this caliber).

Solution: the angle of inclination of the rifling (α) corresponds to a certain length of the rifling stroke (η), at which the bullet makes one complete revolution around its axis, expressed in the number of calibers (clb). The value of the angle of inclination of the rifling (α) for each weapon model is obtained by calculation based on the steady flight of the bullet [90, p. 130, 133]:

$$\eta = \frac{\pi}{tg\alpha\,(3^o)} = \frac{3.14}{0.0524} \approx 60\,(clb)$$

Find the angular velocity of the bullet (ω_1) at muzzle velocity V_1=280 m/s and the angular velocity of the bullet (ω_2) at muzzle velocity V_2=100 m/s [90, p. 156]:

$$\omega_1 = \frac{V_{1\partial}}{\eta d} = \frac{280}{60 \times 5.6 \times 10^{-3}} \approx 833\,(rps);$$

$$\omega_2 = \frac{V_{2\partial}}{\eta d} = \frac{100}{60 \times 5.6 \times 10^{-3}} \approx 298\,(rps).$$

The analysis of the obtained results shows that when the muzzle velocity changes three times as much as the angular velocity of the bullet decreases, and this factor has a significant impact on its ballistic stability.

In addition, as noted by experts in the design of cartridges for hand-held small firearms, the flight of the bullet is influenced mainly by three groups of factors: 1) elastic vibrations (vibration) of the barrel at the time of the shot; 2) conditions of movement and deformation of the bullet in the barrel channel, depending on which (taking into account the eccentricity of the center of mass of the bullet and the deviation of its dynamic axis from the axis of symmetry) the initial conditions of firing are formed at the time of leaving the muzzle of the barrel by the bullet; 3) movement of a bullet on a trajectory [57, p. 125].

If we take into account that during the experiment A. I. Ustinov shooting was made from short-barreled hand-held small arms (pistols), as well as a small range of fire, the vibrations of the barrel as a determinant factor affecting the flight of the bullet, in this case can be neglected.

The second significant factor affecting the stability of the bullet movement are the processes occurring in the initial section of the trajectory. Theoretically the bullet at the time of departure gets straight, but because of raznoshennoy shell in bullets two- and three-element structures, misalignment of head and tail parts of the center of mass is always slightly offset relative to the axis of geometric symmetry. When the bullet cuts into the rifling of the bore and moves along the bore at the moment of leaving the muzzle the bullet acquires the initial angle of precession. The value of the specified angle is determined by the dynamic unbalance of the bullet formed during its manufacture, the asymmetry of centering when cutting into the rifling and movement in the barrel.

Leaving the barrel, the bullet changes its axis of rotation: instead of the axis of the bore on the trajectory of its rotation axis becomes a dynamic axis passing through the center of mass of the bullet. Therefore, the motion of a bullet in flight is the sum of two motions: precessional (rotation of the bullet around the dynamic axis) and nutational (aperiodic oscillatory motion). In combination with the withdrawal of the bullet in the direction of gyroscopic rotation, the movement of its center of mass occurs along a spiral curve that deviates from the direction of fire.

Precession movement occurs at a speed 20 times less than the angular velocity of the bullet, but with a large radius of rotation of the head [57, p. 126–127]. F. Mann gives information that the main influence on the flight of the bullet is influenced by the eccentricity of the center of mass (50 %) and precession-deformation oscillations of the bullet on the trajectory (30 %) [309].

Thus, at the time of departure, meeting air resistance, due to the separation of the center of gravity and the center of pressure of the bullet, its body makes forced precessional and nutational oscillations relative to the flight path and the longitudinal axis of the bullet, respectively (figures 3.4.1, 3.4.2).

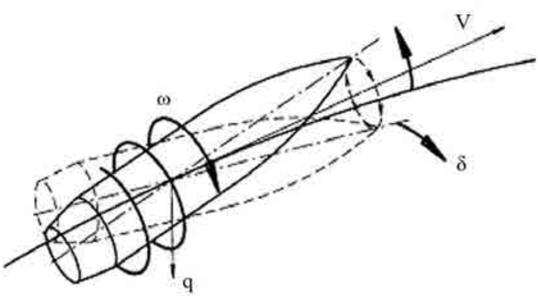

Figure 3.4.1 — **The nature of the rotating bullet movement:**
ω — angular velocity (rotational speed), V — the linear speed of movement, δ — the angle of precession, q — acceleration of gravity [54, p. 91]

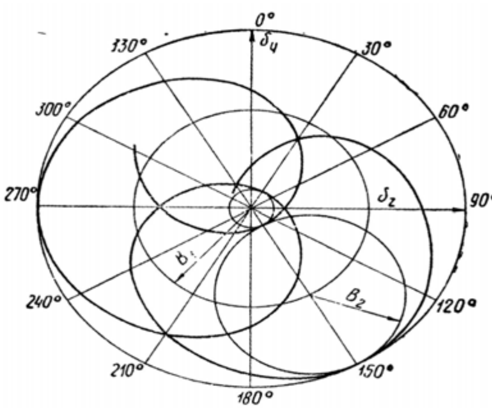

Figure 3.4.2 — **The nature of the motion of a rotating bullet near the center of mass**

The angle of these oscillations at the initial section of the trajectory of the bullet reaches 10°–15° and ends (the flight is stabilized) at a distance of about 5 m from the muzzle [184, p. 99], and therefore, the angle of its meeting with the obstacle at this distance is different from the normal.

So, for three-element bullet with a steel core regular cartridge 9×18Mak (51-H-181C) when shooting from pistol Mak on the phase of flight (2–23 m), the angle of precession is 37°–38°, due to the amount of rifling in the barrel, the magnitude of interference between the bullet and the barrel of his rifled pieces, the increased tendency of 9-millimeter bullets to the bias in pooling the entrance of the bore due to the length of the leading part of [57, p. 184]. It is these reasons that explain the ricochets of bullets at a target speed from 90 m/s to 115 m/s, recorded during the experiment by A. I. Ustinov [267, p. 14].

Thus, the conclusion of A. I. Ustinov that the lower limit of human lesions is due to the minimum velocity of the wounding projectile $V_{сн} \geq 100$ m/s, is hardly justified, since during the experiment, such factors as the shape of the head and the processes occurring in the initial section of the trajectory, on which the reliability of the results obtained depends, were not taken into account.

In 2003 A. G. Andreev made an attempt to repeat the experiment of A. I. Ustinov in the framework of the study related to the assessment of the damaging properties of homemade hand-held small firearms. Shooting was made by the reduced (reduced) charges according to the "top — down" scheme from a speed of 100 m/s and below from a hand-held small-arms firearm with a smooth barrel channel; biological tissues of an animal (pig) were used as a target [6].

During the pilot study established that the depth of penetration of the bullets with different shape of the warhead is sufficient to damage of vital organs of the human body, is achieved when the speed of the bullets ogive shape rounds of 5.45×39 is less than 60 m/s; bullets tsilindricheskoi form of cartridges 9×18Mak — more than 65 m/s; bullets tsilindricheskoi form of cartridges 5,6×10R — 110 m/s. Thus it became possible to define the minimum value of specific kinetic energy sufficient for defeat of vital organs of the person, at the various form of a head part of bullets of the following cartridges (ammunition): 5,45×39 — no more than 0,25 J/mm^2; 9×18Mak — 0,3 J/mm^2; 5,6×10R — 0,7 J/mm^2.

The results of the study allowed A. G. Andreev to conclude that the currently used value of the minimum specific kinetic energy, taken as 0.5 J/mm^2, is overstated — this value can be taken as 0.25 J mm^2, and that the difference in the shape of the head of the bullets (at equal speeds) affects the depth of their penetration into the barrier (biological target) [6, p. 107]. In addition, the author noted that bullets cartridge 5.45×39 at the given speeds were introduced into the biomaterial at an angle different from the normal, which is why the depth of their introduction in such cases was small [6, p. 105].

Similar results obtained under similar conditions (shooting the specified type of bullets with a reduced charge on the biomimitators — gelatin blocks), leads and V. N. Dvoryaninov, describing the tests of this type of bullets in the design of the cartridge 5.45×39: "when shooting on the reduced (reduced) charges, the nature of the movement of bullets in the control target is somewhat more unstable. The inlet openings are oval in shape, which indicates large angles of precession" [57; p. 485]. The above confirms the noted shortcomings concerning the conditions and results of experiments conducted by A. I. Ustinov and A. G. Andreev.

As mentioned above, the conditions of approach of the bullet to the target (before the immediate defeat) are determined not only by the speed of its translational motion, angular rotation, but also by the characteristics of precession-nutational oscillations, the values of which at the initial moment are random.

As an omission in the experiment conducted by A. G. Andreev, it should be noted that the 5.45×39 cartridge used by this researcher is intermediate and its bullet has other ballistic characteristics than bullets of pistol cartridges. To obtain more reliable results as a bullet with an oval shape of the head, in our opinion, it would be necessary to apply a bullet of a pistol cartridge 5.45×18 to a Pistol self-loading malogaba-ritnomu (PSM).

According to the technical task of the Ministry of internal Affairs of the USSR, one of the requirements in the design of this cartridge is minimal side effect of the bullets, in particular the scope of the temporary pulsating cavity formed by the bullet in said cartridge when conducting experimental firing at the design stage was 63 cm^3 (bullet cartridge 9×18Mak (51-H-181C) — 130 cm^3) [57, pp. 190–198], thereby minimizing the transfer of kinetic energy of the contacting tissues of the biomaterial in the moment of defeat and ensuring the maximum possible penetration depth in the target environment.

V. A. Fedorenko critically analyzed the results of the experiment conducted by A. I. Ustinov and the Method of determining the minimum lethal force of standard and atypical firearms and ammunition, developed by L. F. Savran, on the grounds that the lower limit of the biological target, characterized by a minimum value of the specific kinetic energy of the projectile 0.5 J/mm^2, is reliable only for wounding projectiles with a diameter of 5–9 mm and is characterized by a wedge-shaped action, indicating that the application of this criterion to the thrown elements of a different diameter (larger or smaller) is incorrect, since a change of the dominant striking factor is possible [269, p. 15].

The above allows us to conclude that the penetrating power of bullets largely depends on such a significant influence on the resistance to penetration into the target parameter as the shape of the head of the bullet.

As another parameter characterizing the damaging effect of bullets of cartridges (ammunition), it is necessary to consider the so-called side effect of the bullet in the defeat of biological tissues. It is known that a bullet fired from a hand-held small-arms firearm, when passing through soft tissues, forms a temporary pulsating cavity, exceeding the diameter of the bullet several times. For 5–10 microseconds, the cavity walls make forced damping pulsations and, colliding, destroy the integrity of adjacent tissue cells, damage capillaries and small vessels, cause molecular concussion and functional disorders; in addition, cells of tissues adjacent to the wound canal are damaged, causing a zone of secondary (sequential) necrosis [211, p. 26; 287, pp. 42–54].

Currently, the volume of the temporary pulsating cavity, according to experts in the field of wound ballistics, as an indicator of the characteristics of a gunshot injury is not yet scientifically substantiated, and therefore needs further, more in-depth study. There is no doubt only that the wounding projectile by virtue of its design features (shape, size, mass) and ballistic characteristics (speed, translational and rotational motion) in interaction with a certain organ forms a corresponding volume of a temporary pulsating cavity [80, p. 319]. As one of the criteria of the striking effect of bullets of cartridges (ammunition) used for firing from hand-held small arms, it is used by designers at the stage of their creation.

In particular, when shooting simulators for live tissues (blocks of 20 percent gelatin) assumes that pronounced damage of soft tissues with violation of the musculoskeletal function of the leg (severe limb injuries) occurs when the amount of the temporary pulsating cavity 350–600 sm^3, moderate damage with dysfunction of the limb segment (moderately wounded) — if the volume of 150–350 sm^3, slightly injured — in volume less than 150 sm^3 [57, p. 214].

In our opinion, the position of L. V. Belyaev, V. V. Kolkutin, I. Yu. Makarov and E. Kh. Mukhin on the study of the mechanism of formation of a temporary pulsating cavity by bullets of manual small firearms of oval shape at speeds below 340 m/s deserves attention. In particular, the named authors substantiates the mechanism of formation of the mentioned cavity in order that the dynamic impact of bullets and obstacles critical pressure deformation transmitted to the head part of the bullet (in the area of blunting the head portion) in the direction of its movement, resulting in the destruction of the damaged tissue (figure 3.4.3).

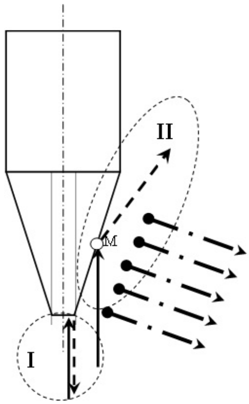

Figure 3.4.3 — **Scheme of interaction of the moving projectile with biological tissue at the normal position of the projectile** [176]

Biological tissues in contact with the head of the bullet at the place of its blunting (I) are reflected from the conical front part at an angle (II) in the “boundary” layer, i. e. directly at the point of contact (M), which is confirmed by the reverse emission of bone particles. Fabrics that are not directly in contact with the lateral surface are displaced perpendicular to the tangent of the lateral surface, i.e. forward and to the sides. This displacement of tissues, according to the researchers, is the “lateral” action of the wounding projectile, forming a temporary pulsating cavity [165].

This conclusion is confirmed by the indicator of the pressure distribution on the surfaces of the projectile at the time of flight on the trajectory, which is given in the literature on external ballistics (figure 3.4.4) [103, c. 24].

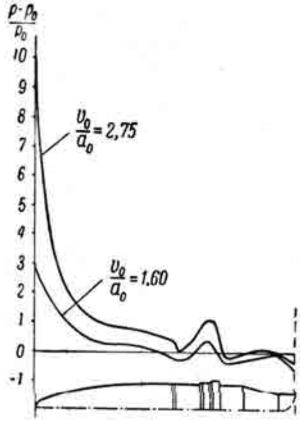

Figure 3.4.4 — **Pressure distribution on surfaces of the projectile** [176]

At bullet speeds in the range of 102–240 m/s the greatest pressure is exerted on its front surface (head part), at speeds in the range of 650–700 m/s — on its larger area. In this regard, the researchers justify the following conclusions: critical pressures are formed on the surface of the wounding projectile, reflect the tissues in the direction of its movement, thereby destroying them; a significant impact on the lateral action of the bullet at speeds below 340 m/s has a conical head of the bullet [176].

The analysis of the stated provisions concerning an assessment of various types of striking action of bullets, scientific substantiation of use of certain quantitative characteristics, other factors influencing morphology of a gunshot injury allows to draw a conclusion that the factors defining the mechanism of formation of a gunshot injury, are: 1) design characteristics of the wounding projectile (weight, shape, caliber, length); 2) features of bullet motion in the air (speed, precession-nutation oscillations, mass eccentricity); 3) anatomical and physiological properties of the affected part of the human body.

The ability of a bullet cartridge (ammunition) to hit a biological target depends on its design features and ballistic properties. Practice use of manual rifle firearms has shown, that action wounding projectiles on goal in moment destruction expands under other equal conditions with increase in diameter bullets, speed under meeting with goal, reducing length (blunting parent parts of), with violation of forms (deformation) under strike, sustainability its movement in body [89, p. 8].

The position of V. A. Fedorenko seems to be correct, who notes that the properties of a wounding projectile can be characterized by several types of damaging action at the same time, but at present no forensic methodology has been developed to assess the possibility of damage as a result of the simultaneous action of several damaging factors [269, pp. 9–11]. As a solution to this problem, the author suggests using the following: with the simultaneous action of N independent damaging factors, the total probability of defeat G is determined by the formula:

$$G = 1 - \prod_{i=1}^{N} (1 - G_i),$$

where G is the total probability of defeat, N is the number of considered damaging factors, Gi is the relative probability of defeat due to the action of the i^{-th} damaging factor, N is the sign of the product [269, p. 11].

Example: the calculation showed that the relative probability of damage to G1 due to the formation of a temporary pulsating cavity is 0,4 (40 %), and the relative probability of penetrating action G_2=0,6 (60 %).

Solution: the relative probability of hitting the target as a result of the combined impact of these damaging factors is equal to:

$G = 1 – (1 – G_1)×(1 – G_2) = 1 – (1 – 0.4)×(1 – 0.6) = 0.76$ (76 %).

The given approach has reasonable character from the point of view of the probability theory, but as separate types of striking action of bullets on a biological organism are not sufficiently studied and their minimum threshold values are not defined, now the specified technique of determination of set of striking factors cannot be applied in judicial ballistics. And these shortcomings are pointed out by the author himself [269, pp. 13–14].

If the criterion of the minimum striking ability was originally developed for expert research of single-shot manual small arms of primitive design, now for an assessment of striking ability of this or that type of the cartridges (ammunition) used for firing from manual small arms, it is necessary to consider also characteristics of vulnerability of the purpose in relation to injuring shells of multi-shot manual small arms or products structurally similar to it (automatic pistols or revolvers), allowing to make a series of shots in a relatively short time interval (1–2 sec.), the number of which depends on the capacity of the magazine or drum.

Thus, for research in expert institutions of the Republic of Belarus, the Russian Federation and Ukraine receive new samples of devices structurally similar to hand-held small arms, for shooting from which the Flaubert cartridge is used. The specific kinetic energy of the propellant when fired from such devices is below the generally accepted level in forensic ballistic examination of the minimum specific kinetic energy ($E_{spec.}$≥0,5 J/mm²) and is within 0,34–0,47 J/mm².

In particular, the experimental shooting of these devices was carried out in the State scientific research forensic center of the Ministry of Internal Affairs of Ukraine. The shooting was carried out on the corpses of people (in the projection of the torso) on the basis of the Kiev Bureau of forensic medical examination from revolvers “ME-38 Magnum-4R” и “ALFA mod.461” cartridges produced by Dynamit Nobel (Germany) and Sellier&Bellot (Czech Republic) from a distance of 3–5 m. According to the results of medical and biological research, the corpses were damaged, with signs of moderate and mild severity [305]. However, there is evidence that these devices, which do not meet the forensic criteria for classifying them as hand-held firearms, are at the same time capable of causing fatal injuries when a bullet hits the victim’s head [304].

As one of the ways to solve the problem of determining an objective criterion lethality should consider such characteristics as the conditional law of destruction G(m) that determines their effect on the single target, which implies a probability of damage when it hit m shells. The characteristic of the conditional law of defeat is the average required number of hits— ω, hich is the mathematical expectation of the number of hits at which the target is considered to be hit [10, p. 13]:

$$\omega = \sum_{m=0}^{\infty} \left[1 - G(m)\right].$$

The meaning of this law can be expressed by the following properties:

1) $G(m) = 0$ — in the absence of hits the target will not be hit;

2) $G(\infty) = 0$ — with an unlimited increase in the number of hits the defeat of the target becomes reliable;

3) $G(m)$ — non-decreasing function m (with an increase in the number of hits, the probability of hitting the target can not become less).

Example: the target you want to hit consists of three zones (conditional division): zone A, zone B and zone C (figure 3.4.5).

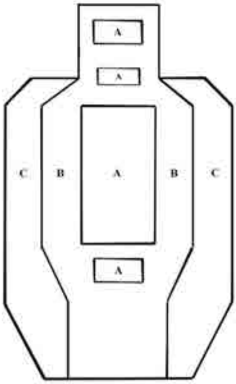

Figure 3.4.5 — **The affected area of the biological target (division conditional)**

When hit by a bullet in the area A the goal is considered to be affected; getting into the zone B cause damage, insufficient to defeat a target, and the second hit in this area entails a loss of purpose; the area C the least vulnerable, to defeat a target you must hit it at least three painful rounds.

Since man is a biological organism, he has the "property of accumulation of damage" [10, p. 13], which consists in the fact that the target can be hit by the combined damaging effect of two or more shells, none of which is individually able to hit the target. The target can be hit by one hit in zone A, one hit in zone B, a second hit in zone C, etc. Thus, the average number of hits required is equal to the sum of all additions up to one of the defeat law *G*(m).

To assess such an impact on the target V. A. Fedorenko proposes to use the method of calculating the total volume of damage caused by injuring projectiles, used in the forensic evaluation of the fragmentation effect of a hand-held offensive grenade [218, pp. 36–40; 269, p. 14]. If each individual wound projectile did not have enough energy to hit the target, it is necessary to calculate the total volume of wound channels ($V_{w.c.(joint)}$); at value $V_{w.c.(joint)}$>6 sm^3 it should be considered that the lower limit of the defeat of the target has been reached. The volume of the wound canal ($V_{w.c.}$), ormed by one striking element, is determined by the value of the specific kinetic energy ($E_{spec.}$) [232; 267]:

$$V_{w.c.}=6{,}7\times E_{spec.}+1{,}17\ (\text{sm}^3),$$

where E_y — is the specific kinetic energy of the thrown element (J/mm^2).

The sum of volumes of several wound channels will make the total volume of defeat of the biological purpose at action of *n* — wounding shells:

$$V_{w.c.(joint)}= V_{w.c.1} + V_{w.c.2} +...+V_{w.c.n}\ (\text{sm}^3),$$

where *n* — the number of wounding projectiles.

Taking into account the considered properties of system elements “ordnance — weapons — aim” with regard to the defeat of the biological targets of many wounding rounds with the level of specific kinetic energy below the set limit, but close to it, from repeating devices in a short time period (several seconds) to produce a series of shots at a single target (revolver, automatic pistol, etc.), such items would be appropriate for the firearms based on the amount of their total effect on a biological target that has a property of accumulation of damage [129].

Based on the above, it can be concluded that since it is possible to cause serious bodily injury or death from devices designed for firing Flaubert cartridges, then taking into account the injuries caused in the framework of a comprehensive forensic and ballistic study, such devices should be attributed to firearms.

Questions of interaction with biological tissues of the person of the thrown element of the cartridge (ammunition) till now in judicial ballistic examination remain not studied that is caused by a number of factors. To clarify the minimum quantitative value of the specific kinetic energy of the propellant element used in forensic ballistic examination when firing from small arms, we carried out experimental firing on biological material.

As previously stated, the characteristics of the affected area of the biological object in each case is random, but the result of the interaction of system elements “throwing item — target” is probabilistic, while the level of resistance of the tissues of the biological object is characterized by the probability distribution of penetration or no penetration depending on the properties of the wounding projectile (shape, speed), density, and structure of the targeted biological tissues, etc. There is no doubt that the resistance of biological tissues to the effects of single low-speed (<340 m/s) throwing elements can be determined in the course of experimental shooting under controlled conditions. As an imitator of human tissues, as a rule, the tissues of the pig breed "large white" weighing 50–60 kg are used [184, p. 259].

Because the properties of the tissues for each species individually, we in the production of the experimental firing was chosen as a criterion, reflecting the interaction of system elements "throwing item — target", as the limit of penetration, characterized by the value of speed of throwing item where the probability of a through-penetration or no penetration of the tissues of the biological object is 50 % (v_{50}).

The above parameters for assessing the susceptibility of tissues of a biological object to the action of a wounding projectile are due to the assumption that the higher the velocity of the thrown element, the higher the probability of penetration of the biological object, other things being equal.

Considering the resistance of tissues of a biological object to damaging factors from the point of view of probability theory and mathematical statistics, based on the level of confidence probability and depending on the number of experiments and the number of penetrations, it is possible to determine the lower limit of the probability of penetration.

The characteristic of resistance of tissues of a biological object to penetrating action of a wounding projectile is a statistical value. In experimental determination of the parameter v_{50} we carried out experimental shooting given the charges, during which they established a minimum rate of methane item (bullet cartridge 5.45×18) under the scheme "up — down", i. e. reducing its speed in the next experience after getting penetrated tissue (destruction of the biological object) or an increase in the result no penetration.

At the same time, the following were experimentally determined:

$v_{\text{max notpenetration}}$ — the maximum value of the velocity of the thrown element, at which the penetration of tissues of the biological object was not achieved, and above which only cases of penetration were observed;

$v_{\text{min penetration}}$ — the minimum rate of penetration of tissues of the biological object, i. e. the rate below which penetration during the experimental shooting was not observed.

As a result of the experimental study, it was assumed to obtain a zone of mixed results (in which both penetration and non-penetration of the biomaterial is observed).

In relation to the above conditions of production of experimental shooting, the conclusion about the non-penetration of the tissues of the biological object at a very low speed of the thrown element, as well as a reliable penetration at a significant speed, seems reasonable.

During the experiment, we used a biological sample of tissues of the anterior abdominal wall of a pig of the breed “great white” with dimensions of 400×200 mm, thickness of 3–5 cm, most fully meeting the requirements in terms of reliability of the results obtained and corresponding to the structure of human tissues.

The zone of mixed results (penetration and non-penetration) in this case fully corresponds to the theory of probability and mathematical statistics used in the processing of experimental knowledge. In the specified range it was necessary to receive not less than 5 nonbreaks at speeds less than $v_{\text{min penetration}}$ of samples and accordingly not less than 5 breaks at speeds more $v_{\text{max notpenetration}}$.

It was assumed that in this case, the values of breaks and non-breaks will be in some range of speed values, provided that they do not go beyond the range ±10 м/с. In addition, when conducting experimental shooting, the ratio of the results of experimental shooting, in which there is a through penetration of the tissues of the biological object, and experiments in which it was not in the scoring range of speeds, approached 50:50.

The distribution of the non-breaking frequency depending on the velocity of the thrown element was determined by calculation using the following assumptions:

all tests are independent;

the result of each test is alternative: penetration or non-penetration;

the nature of the change of probability of no penetration of the sample by changing the values of the rate — monotonic (increasing speed is time-housego item, the probability of no penetration decreases).

Shooting was carried out at a distance of 5 m from the biological object, with the measurement of the velocity of the projectile element of the weapon with a smooth bore length of 12 calibers to exclude the influence of precession-nutational oscillations on the introduction of the bullet into the barrier. Scoring were hits in which the bullet was embedded in the tissue of the biological object at an angle 90°.

In the range of the velocity of the throwing element during the experimental shooting from 58 m/s to 73 m/s, a zone of mixed results was observed, the ratio of breaks and non-breaks in which is 50:50. In the specified interval produced 25 scoring shots. Below the speed of 58 m/s there was a 100 percent non-penetration of the biological object, and at speeds above 75 m/s — its 100 percent penetration. It was required to determine the velocity parameter of the projectile in the range from 58 m/s to 72 m/s, at which the penetration of the biological object occurs, with a confidence probability 0.95.

The primary data for the calculation of the minimum velocity of the thrown element x, sufficient to defeat the biological object, were the obtained velocity values and the result: penetration (P) or unbroken (U), for example, given in the table 3.4.3.

Table 3.4.3 — **Experimental data for determination of stability characteristics of biological material**

Speed, m/s	**Result**	**Number of breakouts**	**Number of unbroken**	**Accumulated number of unbroken**	**Accumulated number of breakouts**	**Total number of accumulated results**
46	U	0	1	10	0	10
49	U	0	1	9	0	9
54	U	0	1	8	0	8
56	U	0	1	7	0	7
57	U	0	1	6	0	6
58	U	0	1	5	0	5
65	P	1	0	4	1	5
68	U	0	1	4	1	5
72	P	1	0	2	3	5
73	P	0	1	3	2	5
76	P	1	0	2	3	5
79	P	1	0	2	4	6
80	P	0	1	2	4	6
83	P	1	0	1	5	6
84	P	1	0	1	6	7
85	P	0	1	1	6	7
90	P	1	0	0	7	7

The results of the experimental shooting are shown in the diagram (figure 3.4.6).

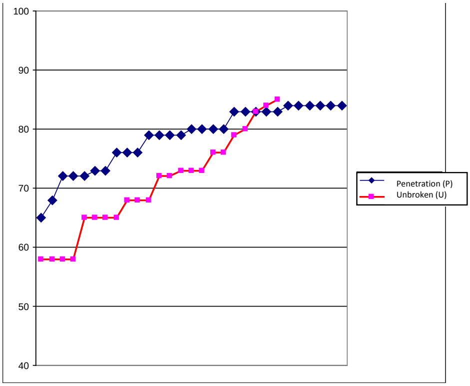

Figure 3.4.6 — **Experimental firing data on biological material**

Due to the bulkiness and complexity, calculations of the velocity of the wounding projectile were carried out in MS Excel according to the methodology set out in the textbook "using MS Excel to analyze statistical data" [11, pp. 50–58]. The values obtained as a result of data processing are given in the table 3.4.4.

Table 3.4.4 — **The results of the experimental firing**

Experience number	**Bullet speed, m/s**
1	65
2	68
3	72
4	72
5	72
6	73
7	73
8	76
9	76
10	76
11	79
12	79
13	79
14	79
15	80
16	80

End of table 3.4.4

Experience number	Bullet speed, m/s
17	80
18	80
19	83
20	83
21	83
22	83
23	83
24	84
25	84
26	84
27	84
28	84
29	84
The arithmetic mean value of speed	**78.55**
Standard deviation	**5.32**
Confidence interval	**1.93**
Extreme value	**65.00**
Maximum deviation	**2.55**

The final result of determining the calculation of the minimum value of the velocity of the thrown element at the penetration of biological material: $x = (78.55 \pm 2)$ m/s, with a confidence probability $\alpha = 0.95$.

Then in accordance with the accepted formulas in forensic ballistics calculation of the specific kinetic energy of a single wounding projectile:

where E — the kinetic energy of the bullet (J);

$$E = \frac{mV^2}{2} = \frac{2.4 \cdot 10^{-3} \cdot 78.55}{2} = 7.4\ (J),$$

m — bullet weight (kg);

V — bullet speed (m/s).

The cross-sectional area of the bullet:

$$S = \frac{\pi D^2}{4} = \frac{3.14 \cdot 5.45^2}{4} = 23.32\ (mm^2),$$

where S — bullet cross-sectional area (mm^2);

π = 3.14 (constant);

D — the diameter of bullet (mm).

Specific kinetic energy of the bullet:

$$E_{spec.} = \frac{E}{S} = \frac{7.4}{23.32} = 0.32\ (J/mm^2),$$

where E_y — specific kinetic energy of the projectile (J/mm ^{2}).

Thus, the judgment is confirmed that the value (E_y), accepted in forensic ballistic examination equal to 0.5 J/mm^2, hould be reduced to a value of 0.35 J/mm^2.

Thus, the study conducted in this section of the work allows us to formulate the following conclusions:

1. For the purpose of establishing an objective value of the minimum striking capacity of cartridges (ammunition) used for shooting from small arms, a comprehensive study of the properties of the elements of the system “ammunition — weapon — target”. The following should be considered as deterministic conditions: a) the striking ability of the wounding projectile of the cartridge (ammunition) used for firing; b) the susceptibility and vulnerability of the biological target to the damaging factors of the wounding projectile; c) the type of hand-held small arms depending on the action of the loading mechanism and the number of charges-single-charge(multi-charge), automatic (non-automatic).

2. The level of minimum specific kinetic energy equal to 0.5 j/mm^2, established at the present time by the Method of forensic investigation of cartridges for hand-held small arms, establishing their suitability for shooting, as well as the Method of solving the issues of belonging of objects to hand-held small arms, their serviceability and suitability for shooting, is not fully justified.

3.5. Method of measurement of parameters of traces of details of manual small arms firearms on bullets and sleeves

The essence of any type of forensic examination, including forensic ballistic examination of cartridges (ammunition) used for shooting from small arms, is the application of various methods of scientific knowledge in their conduct. Cartridges (ammunition) are systems with many elements, their properties, connections and relationships. Cognition of the totality of these properties, connections and relations is the main task of scientific cognition in the framework of forensic ballistic examination of these objects.

The model of solving research problems of forensic science can be presented as a kind of program for obtaining new scientific knowledge and developing methods and means of cognitive activity; such a program should determine the system of methods and means of solving a specific problem [52, p. 84]. The process of studying the objects of expert research assumes the presence of a set of cognition methods that determine meaningful thinking, with which it comprehends the object as a complete system of some elements, properties and features [247, p. 54].

O. S. Bocharova and O. M. Dyatlov, supporting the opinion of R. S. Belkin, according to which the methods of criminology are a system consisting of General, General scientific and special methods [27, p. 24], rightly point out that none of these methods can be absolutized, since they are implemented in theory and in practice in the relationship; only their totality can ensure the achievement of the goals of forensic knowledge of the phenomena of objective reality [27].

The connection of forensic examination with natural, technical and humanitarian Sciences is a natural result of the development of scientific knowledge in the theory and practice of expert research; the level of development of methods and technical means of research of various Sciences, in turn, largely depends on the development of methods, means and techniques of forensic examination [3, p. 279]. A special place among the technical means is occupied by means, the basis of the functioning of which is based on non-destructive methods of studying the properties of objects; the need for priority use of them is confirmed by the practical activities of expert institutions.

One of the main methods of forensic examination is measurement. This method is used in all types of forensic examinations, including forensic ballistic examinations of cartridges (ammunition). By means of measurement qualitative methods are supplemented with exact quantitative characteristics, as a result of which the transition from observation to mathematical abstractions (models) is carried out, real signs and properties of the studied objects are revealed, their essence is known.

The practical need of expert institutions in the process of solving the problems of forensic ballistic examination of cartridges (ammunition) involves not only the establishment of similarities or differences of the objects of study, but also the definition of numerical expression, which subsequently allows to correlate the values under consideration on the basis of their quantitative indicators. The analysis of expert practice shows that the solution of problems in the framework of expert research of cartridges (ammunition) is impossible without the use of appropriate means of measurement. This applies to the solution of all types of tasks in the process of expert research of cartridges (ammunition) for hand-held small arms — identification, diagnostic, classification and situational.

The acceleration of scientific and technological progress, the emergence of new types of hand firearms, cartridges (ammunition) to it, which are the objects of research forensic ballistic examinations, predetermine the trend of a constant increase in the requirements to ensure the reliability of obtaining relevant measurement information in order to increase the validity and reliability of the conclusions of forensic ballistic examinations. At the same time, the practical activities of expert units also lead to certain requirements, sometimes mutually reinforcing: 1) achieving high accuracy of measurements of research objects; 2) reduction of time of measurements and terms of production of examinations; 3) reduction of material costs for the acquisition, operation and maintenance of measuring instruments [81; 84; 92; 216].

Development of new technical, and also improvement of available means and methods for the purpose of their effective application in the course of carrying out judicial examinations is now one of priority directions of development of criminalistic science. Creation and application of methods of forensic examination as applied science and practical expert activity are subject to uniform laws, which include: the emergence of methods of knowledge as a result of the development of basic knowledge; borrowing of methods of related Sciences as a consequence of integration processes in science and development of means of knowledge; determining influence on the formation of research methods of increasing needs of expert practice; situational dependence of the method choice; situational dependence of the method application; regularities that determine the use of a complex of methods of both scientific and practical knowledge [37].

True is the position of A. A. Exarchopulo, the essence of which is that the role of forensic science in the creation of appropriate technical means should be as follows:

identification of the practical need for a technical means;

study of the current state, achievements and opportunities of science and technology;

identification of shortcomings of existing technical means used in forensic practice;

establishment of the circle of objects under study;

definition of conditions of application of the corresponding technical means;

establishment of technical requirements to be met by the device (technical device);

indication of the exemptions established by normative legal acts for the use of certain technical means in criminal proceedings [296, p. 83–84].

The activities of expert units often solve problems associated with the establishment of a model of hand-held small arms, as well as a specific instance of hand-held small arms, from which the withdrawn bullet or cartridge case was fired. This need arises not only in the investigation of crimes in the Commission of which hand-held firearms were used (murder, causing serious bodily harm, robbery, hooliganism), but also other crimes, in particular those related to illegal hunting. The above is relevant for forensic activities in the Republic of Belarus.

In scientific publications related to the practice of forensic ballistic examinations in the Russian Federation, it is also indicated the need to determine the source of origin of hand-held small firearms in its homemade manufacture or alteration of parts of weapons, parts and mechanisms of signaling, barrel gas and hand-held small firearms of factory manufacture [94].

One of the main parameters that allow you to determine the model and a particular instance of a hand firearm, are the dimensional and angular characteristics of the traces of the display of its parts on the surfaces of bullets and cartridge cases (ammunition). Traces of parts of hand-held small arms, formed on the elements of the design of cartridges (ammunition) as a result of contact interaction, are due to the phenomena and processes occurring in the process of their interaction, which have a direct and indirect influence on the mechanism of trace formation.

The degree of severity of trace-mapping depends on a number of factors: the materials from which the trace-forming and trace-perceiving objects are made, their physical and chemical properties; temperature conditions; the presence of foreign substances in the place of contact; kinetic characteristics of interaction, etc. Thus, taking into account the speed of the moving parts of automatic hand-held firearms in the process of functioning, which is 5–15 m/s [54, p. 224], as well as a significant mass of the locking mechanism parts (bolt, bolt frame, their totality), favorable conditions are created for the formation of traces of parts of hand-held firearms on the design elements of cartridges (ammunition) in the process of loading, shot production, extraction and ejection.

The traces on bullets and cartridge cases (ammunition) display features that individualize the type, model and specific sample of hand-held firearms. These features are characterized by an individual set of features and are due to the technological features of the process of manufacturing parts of the corresponding sample of hand-held small arms, for firing from which the cartridge (ammunition) was used). When determining the model of hand-held small arms, from which the bullet is fired, the diameter of the bullet, the number of rifles displayed on it, the width and angle of their inclination relative to its longitudinal axis are measured.

A. V. Kokin considered the possibility of determining the source of origin and method of manufacture from the point of view of establishing the characteristics of the traces of the bore of hand held small arms on the fired bulletsIt is known that the dimensional characteristics of the width of the rifling fields of hand-held small firearms are determined by the design documentation and are for Mak — $4,5^{+0.2}$; pistols PSM, IZH-75 — $2^{+0.1}$; for gun Baikal-442 — $3^{+0.2}$ mm. In addition, the angle of inclination of the rifling fields is important, which depends on the size of the pitch of the rifling in the barrel channel. Have pistols Mak and Baikal-442 step rifling equals 260 ±20 mm, a corner the tilt fields rifling — 6°23'; pistols PSM and IZH-75 — 290±20 mm and 3°28' respectively. The pitch of rifling barrels of small-caliber weapons produced by "Izhevsk machine-building plant" — 420±10 mm, the angle of the rifling— 2°24'; weapons produced by "Izhevsk mechanical plant" — 400±10 мм и 2°31' respectively. These values are calculated on the basis of the necessary external ballistic parameters for each type of cartridges (ammunition) of foreign manufacture at the design stage. Thus, as indicated in the scientific literature, the value of the angle of inclination of the traces of rifling fields on bullets fired from homemade barrels should differ significantly from the values established by the technical documentation [94; 95, p. 63; 243].

Measurement of parameters of traces of details of manual small arms on cartridges (ammunition) and elements of their design at carrying out identification forensic ballistic examinations is an integral condition of definition of a type and a concrete copy of manual small arms, definition of a source of its origin (factory, handicraft, self-made), degree of wear of the elements of a design forming traces. The above field width of grooves of different samples of small firearms, and angles of the marks on the bullets vystelennyh cause increased accuracy requirements held within these examinations of measurements, their reliability and of reasonable sufficiency. This, in turn, predetermines the need to use in the process of identification of the model (specific instance) of a hand-held small-arms firearm technical means of measurement, allowing with the necessary accuracy, minimum time and material costs to obtain the information required during forensic ballistic examination.

Besides, in practice of diagnostic ballistic researches of traces of manual small arms on bullets and cartridges of cartridges (ammunition) while such parameter as height of roughnesses of a profile remains unclaimed. At the same time, as E. I. Stashenko points out, the height and depth of the tracks in the traces on the fired bullets reflect the qualitative state of the surface of the fields and rifling in the barrel channel of hand-held small arms. So, from trace-forming surfaces of little-worn trunks traces in traces on a surface of bullets in height and depth from 3×10^{-4} to 8×10^{-3} mm are formed; trunks of average wear — from 11×10^{-3} to 15×10^{-3} mm; at a shot from a trunk with considerable wear — from 2×10^{-2} mm and more [244, pp. 30–31].

One of the parameters, the measurement of which until now was a certain complexity, was also the height of the profile irregularities (microrelief) traces of the rifling fields of the barrel on the fired bullets. Measurement of heights of roughness of a profile of traces of a bore on the thrown element (bullet) could be made only by means of a double microscope Linnik (MIS-11) — the difficult opto-mechanical device which principle of operation is based on use of a method of a light section [99, pp. 211–212]. However, the absence of this device in expert institutions still does not allow the full use of this parameter in the production of forensic ballistic examinations.

In order for the measurement result to be considered valid and subsequently used as evidence, it must meet certain criteria, i.e. be obtained:

an appropriate subject with special skills to carry out the relevant types of measurements;

from the proper source of factual data, information constituting the content of the evidence;

from the proper source of factual data, information constituting the content of the evidence;

with the observance of the proper order of the procedural action performed to obtain evidence [260, pp. 160–161].

In relation to measurements, the accuracy (reliability) of the result is determined by the methodically correct performance and competently justified (from a metrological point of view) estimates of errors (uncertainties) of the results obtained, as well as compliance with the requirements of regulatory legal acts [219].

Measurements performed in the process of forensic ballistic examinations, due to the need to determine the geometric parameters of the objects under study. In our opinion, measurements in solving diagnostic problems consist of the following stages:

measurement of parameters of research objects;

analysis of measurement results of dimensional characteristics;

comparison of the obtained set of quantitative values with the parameters of the proposed objects of the selected group;

formulation of the conclusion about the assignment to a certain class.

In the solution of identification tasks specified algorithm is supplemented by the integrated evaluation of measurement results taking into account visual comparison shaped characteristics of the traces and their characteristics with traces of parts of small firearms in the experimental samples, as well as the subsequent formulation of conclusions about the identity.

As a result of measuring the true value of a physical quantity cannot be obtained, the main issue is the allowable value of error of the measurements, wherein the deviation of the actual value of the measured value from its true value allows to use the result to solve expert problems [74, pp. 7–8]. The reliability of the measurement results is achieved by increasing the number of measurements under the mandatory condition — ensuring the necessary accuracy.

For the study of weapons traces on bullets and cartridge cases of cartridges (ammunition) are mainly used two methods: a) from the photos of the tracks; b) directly on the specified objects by means of the instrumental and comparative microscopes available at the disposal of expert divisions [8; 12; 185; 283]. Universal measuring microscopes can provide maximum accuracy of measurement of linear and angular parameters of traces, but in the majority of expert divisions such devices are absent.

For simplification of procedure of carrying out identification research developments in the field of automation of the specified process, creation of software and hardware complexes with application of computer technologies are now conducted. The state Committee of forensic examinations of the Republic of Belarus is currently using automated identification ballistic system TAIS-040 produced by JSC "LDI-RUSPRIBOR" (St. Petersburg, Russian Federation) [285]. Despite high efficiency of application, the specified system is expensive in this connection, taking into account rather rare need for its use, its acquisition for regional and regional expert divisions both practically, and economically inexpedient.

According to A. A. Artyushin and A. P. Patskevich, due to the impossibility at this stage to fully automate the identification process, the partial automation of expert studies is practically applicable, which due to greater accessibility and flexibility can significantly simplify the process of forensic ballistic examination. The availability of these methods can be ensured by the use of non-specialized tools, and conventional equipment using a personal computer [8].

This approach was implemented by us in the measurement tool developed within the framework of the study [82], based on the correlation analysis of digital stereo images of traces of hand-held small arms on bullets and cartridges with the help of specialized software installed on a personal computer, using the appropriate measurement methodology

[82]. To implement the correlation method of measuring the parameters and heights of the profile of rifling traces on bullets, a software application in the object-oriented programming language C++, in the programming environment, is developed C++Builder.

The developed software was included in the created software and hardware complex "Ballistic measuring analyzer "(hereinafter-PAK "BIZAN"). In addition to personal computer running the developed software application, in the PAK "BIZAN" includes stereoscopic microscope MSP-1 (is in service with expert divisions of the State Committee of judicial examinations of the Republic of Belarus), the coordinate object table with prepareoperation (intended for deployment and movement of the object of study when receiving a stereo image), a dial gauge ICH-10 (to measure displacement of the object), a digital camera and a stage micrometer (for preliminary calibration) (figure 3.5.1) [84].

Figure 3.5.1 — **General view PAK "BIZAN"**
for measuring the parameters of traces on bullets and cartridges

The principle of operation of the device for measuring linear and angular parameters, as well as the height of the profile (microrelief) traces is simplified shown in the functional diagram (figure 3.5.2). On the photodetector matrix (5) through the optical system of the microscope (4), the first digital image of the measured trace displayed on the surface of the object under study is formed. After formation of the first image by using the coordinate table of a microscope (microscopic unit (2)) the object of study moves through space in a horizontal plane at a distance L, then the formation of the second digital image. While using the application, only the first image from the stereo pair obtained during the photo shooting is displayed on the monitor screen.

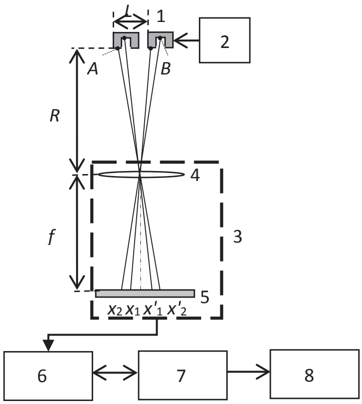

Figure 3.5.2 — **Functional diagram of the device for measuring the parameters of traces:**

1 — measured object, 2 — micro-displacement unit,
3 — digital microscope, 4 — optical microscope system,
5 — photodetector matrix, 6 — controller,
7 — processor, 8 — display unit

The obtained images are fed to the processor (7), where the profile heights, linear and angular dimensions are measured using the following algorithm.

The first image in the display unit (8) indicates the point of the object under study (scan window), to which you want to measure the distance. A scan window with similar coordinates is automatically generated in the second image. Next, the processor scans the first window relative to the second horizontally and vertically, and calculates the value of the two-dimensional normalized correlation function between the selected images in accordance with the expression:

$$R(\Delta x, \Delta y) = \frac{\sum_{x,y}(I_1(x,y) - \bar{I}_1)(I_2(x+\Delta x, y+\Delta y) - \bar{I}_2)}{\sqrt{\sum_{x,y}(I_1(x,y) - \bar{I}_1)^2 \sum_{x,y}(I_2(x+\Delta x, y+\Delta y) - \bar{I}_2)^2}}, \quad \bar{I}_n = \frac{\sum_{x,y} I_n(x,y)}{x_{\max} y_{\max}},$$

where I_1 — the signal of the scan window of the first image; I_2 — the signal of the scan window of the second image; x_{max}, y_{max} — the size of the scanning window horizontally and vertically respectively; Δx, Δy — horizontal and vertical shift respectively, $\bar{I}_1, \bar{I}_2$ — the average values of the signal in the first and second scan window respectively; n — количество фотоснимков в стереопаре (n = 1, 2).

From the above expression, it follows that the scanning is carried out horizontally and vertically, which compensates for the possible deviation of the object movement from the horizontal line. The position of the maximum value of the normalized correlation function (1) determines the shift between the images $\Delta x_A = x'_1 - x_1$. The range R_A to the selected point of the object is determined from the expression:

$$R_A = \frac{f \cdot L}{\Delta x_A},$$

where L — moving the object under study horizontally, f — the focal length of the camera. Similarly, the distance R_B to the point B f the object having coordinates on the first and second images x_2 and x'_2 respectively is determined. According to the position of the maximum value of the normalized correlation function (1), the shift between the images $\Delta x_B = x'_2 - x_2$, is determined, and the distance RB to point B is determined from the expression:

$$R_B = \frac{f \cdot L}{\Delta x_B}.$$

The height of the surface profile of the object is determined by the difference of distances to the specified points of the object under study (point A and point B) $\Delta R = R_B - R_A$.

The device allows you to measure the linear dimensions of the individual features of the trace (microrelief) on the object under study between these points. It is carried out in the following way. Having determined the value of the distance to the i^{th} object of measurement R_i and the dimensions of this object (the distance between the specified points) on the photodetector matrix, the width of the measured object D_i and the height H_i are determined from the expressions:

$$H_i = \frac{R_i \cdot y_i}{f},\ D_i = \frac{R_i \cdot x_i}{f},$$

where x_i, y_i — dimensions of the measured object (distance between points) on the photodetector matrix horizontally and vertically, respectively.

The system also measures the angle of inclination of the rifling marks on the bullets relative to its longitudinal axis. The expression for determining the slope angle of the cut trace α is as follows:

$$\alpha = arctg\left(\frac{X_2 - X_1}{Y_2 - Y_1}\right),$$

where X_1, Y_1 — coordinates on the photodetector matrix of the starting point of the trace cut, X_2, Y_2 — coordinates of the end point of the trail cut.

At the same time, it is not necessary to know the exact value of the distance between the sensitive elements of the photodetector matrix and the value of the focal length of the lens of the photography device, since these values can be determined during the calibration of the system according to the standard. Correlation image processing allows you to determine the position of the object on the matrix with an accuracy higher than one sensitive element (pixel) [82; 84; 92].

The high accuracy of the measurements is due to the increased requirements to their results imposed by both the Criminal Procedure Code of the Republic of Belarus [265] and technical normative legal acts aimed at ensuring the right to protect the legitimate interests of citizens from the negative consequences of unreliable results of measurements.

The accuracy of the measurements using the developed PAK "BIZAN" largely depends on the size of the photodetector matrix of the camera device. For example: the size of the photodetector matrix used in the measurement tool is 22.5×15 mm or 5472×3648 pixels, then the size of one pixel of the matrix will be:

$$n = \frac{x}{a} = \frac{22.5}{5472} = 4 \times 10^{-4}\ (mm),$$

where n — size of one matrix pixel (mm);

x — linear size of the matrix on one side (mm);

a — number of pixels on the selected side.

Thus, the deviation of the measured parameters from their true values will be no more than 4×10^{-4} mm, which in accordance with the provisions of GOST of the Republic of Belarus 8.051-81 "State System for Ensuring the Unity of Measurements. Errors Allowed When Measuring Linear Dimensions up to 500 mm" it will allow to measure the dimensional characteristics of traces up to the fifth quality (class) of accuracy (when measuring linear dimensions up to 10 mm) [49, p. 2].

In the Method, the identification of rifled guns on the trail on the bullets [164] and Methods of identification of firearms marks on cartridge cases [165] requirements to the accuracy of the measuring equipment is not installed. According to the data given in the forensic literature on the parameters of traces of hand-held firearms on the fired bullets, the difference between the upper and lower value of the angle of inclination of the rifling can vary within 0°10'– 1°30', the width of the trace of the field of rifling — from 0.1 mm to 1.5 mm [121].

In the works of I. A. Dvoryansky and V. V. Filippov, it is indicated that when measuring traces of hand-held small arms on bullets and cartridges, the values of 0.01–0.1 mm — for linear dimensions and 0°10'– 0°20' — for angular values [59; 274, pp. 10–17] are sufficiently accurate, similar parameters are given in the work of A. V. Kokin [95, p. 217]. B. M. Komarinets believes that when measuring the parameters of traces, the minimum accuracy should be when measuring the width of the traces of the rifling fields — 0.05 mm, when measuring the angle of inclination — 0°10' [99, p. 204].

Thus, the permissible error of measurements in the production of such measurements, used in the practice of expert units during identification forensic ballistic examinations, significantly exceeds the limit of error developed by us PAK "BIZAN".

The interface of the software application for measuring linear and angular characteristics of the PAK "BIZAN" includes the following user elements: information line; general tools (open, save, clear); functional tools (selection, moving, deleting), calibration, adjustment of display and measurement parameters; switching of view mode: enable / disable linear measurement, enable / disable angular measurement; enable / disable linear and angular measurement, active window (figure 3.5.3).

After activation of the software application the input of a photo image of the surface area of the object with the measured trace and calibration of the measuring instrument are carried out.

The calibration process is carried out before the measurement of each new object of study. The holder of the coordinate table of the microscope is fixed to the object of study and using the ocular ruler microscope produces a measurement of the distance between the two selected object points, for example between “fighting” (mark a) and “single” faces (mark B) trace of the thread (figure 3.5.4). In the software application select the tool enable the measurement of linear values (length) and connecting these points in the active window of the software application, specify in the box for the first line measured with a microscope distance, then press the tool “calibrate”. In the active window of the software application, the initial value of the dimension characteristic must change to the value entered during calibration. This completes the calibration process.

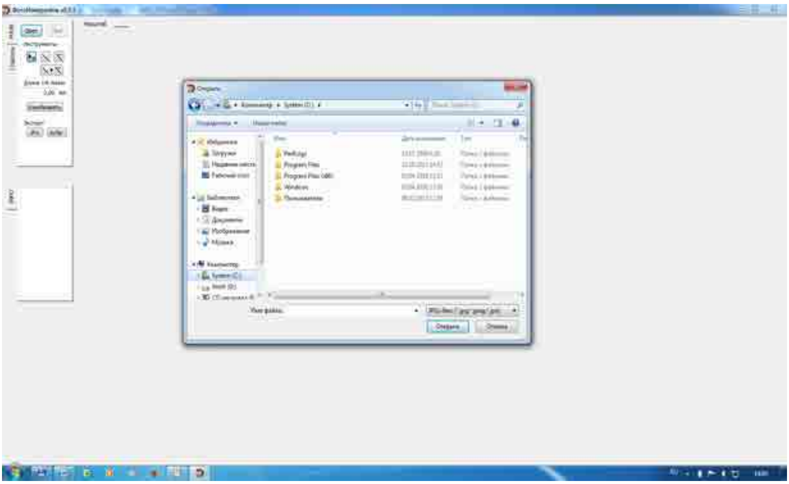

Figure 3.5.3 — **The interface of the software application PAK “BIZAN” when you activate the tab "Open”**

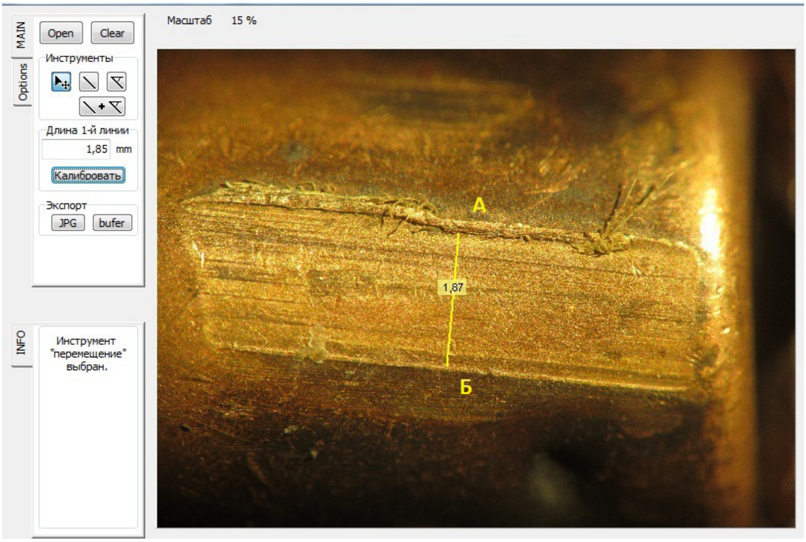

Figure 3.5.4 — **The view of the active window of the software application after loading the investigated image of the trace cutting the bore on the surface of the bullet and calibration**

Figure 3.5.5 illustrates an example of the measuring system during the measurement of linear and angular parameters of the traces of the rifling fields displayed on the bullet from a digital photo image. It should be borne in mind that the "primary" traces on the photograph of the fired bullet should be parallel to the bottom edge of the active window of the software application (this is due to the algorithm of the software application).

After the calibration of the system, the user, including the measurement modes of the necessary parameters of the object under study, makes a measurement in the active window of the software application using the mouse manipulator (left and right keys) by laying conditional segments in the "control" points of the image. Depending on the required parameter the corresponding linear and angular parameters are displayed next to the segments in rectangles with a yellow background. If necessary, the measuring periods can be remove and take the measurement again according to the above algorithm.

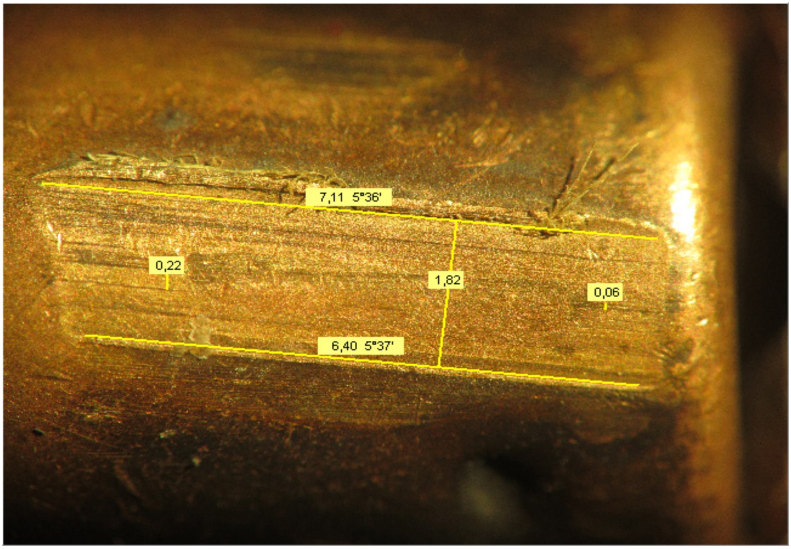

Figure 3.5.5 — **View of the results of measurement of linear and angular parameters, the trace of the cut field of the bore on the bullet cartridge 7,62×25, fired from a TT pistol** (the distances in the figure are in millimeters, the angles in degrees and minutes)

After the calibration of the system, the user, including the measurement modes of the necessary parameters of the object under study, makes a measurement in the active window of the software application using the mouse manipulator (left and right keys) by laying conditional segments in the "control" points of the image. Depending on the required parameter the corresponding linear and angular parameters are displayed next to the segments in rectangles with a yellow background. If necessary, the measuring periods can be remove and take the measurement again according to the above algorithm.

Figures on a yellow background show the distances between the selected points in the measured trace in millimeters and the angles of inclination of the traces from the "combat" and "idle" faces of the rifling to the longitudinal axis of the bullet in degrees. For example, the width of the cut mark on the bullet is 1.82 mm, and the length of the marks from the "combat" and "idle" faces of the cut is 7.11 mm and 6.40 mm, respectively. The angles of inclination of these traces relative to the longitudinal axis of the bullet are 5°36' and 5°37', respectively.

Figure 3.5.5 also shows the results of measuring the distances between the individual grooves displayed in the secondary cut trace of the bore, the distance between which is 220 microns and 60 microns, respectively.

In addition to the possibility of making measurements on shot bullets, this measuring system is able to measure the linear and angular parameters of the traces on the sleeves. Figures 3.5.6 and 3.5.7 show the results of measurements of linear and angular parameters of traces of weapons after the production of a shot on a cartridge sleeve 9×18Mak, fired from a pistol IZH-70-18ME. Thus, the illustrative material confirms the conclusion that the system provides sufficient accuracy of measurements with ease of use without the use of expensive and complex equipment.

Figure 3.5.6 — **View of the measurement results of linear parameters, traces striker striker, reflector, shutter dosylatelya cartridge sleeve 9×18Mak, shot from a pistol IZH-70-18ME**

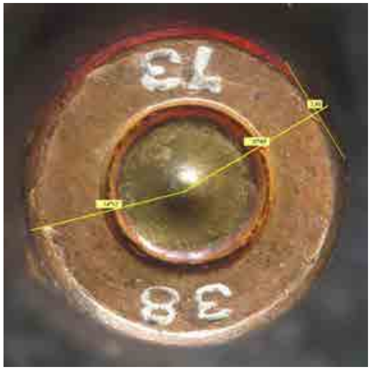

Figure 3.5.7 — **View of the measurement results of linear and angular parameters, the relative position of the ejector trace and the reflector trace on the cartridge sleeve 9×18Mak, fired from the pistol IZH-70-18ME**

By the difference of distances to the points of the object, you can determine the depth of the profile of the cut trace on the bullet at a certain point (figure 3.5.8). Thus, for the point located at the top of the image at a distance of R = 15.20 mm, the height of the trace profile is 390 microns R = 15.20 mm, the height of the trace profile is 390 microns (ΔR = 15.20–14.81 = 0.39 mm), nd for the profile point at a distance of R = 14.38 mm in the lower part of the trace image — 330 microns (ΔR = 14.38–14.05 = 0.33 mm).

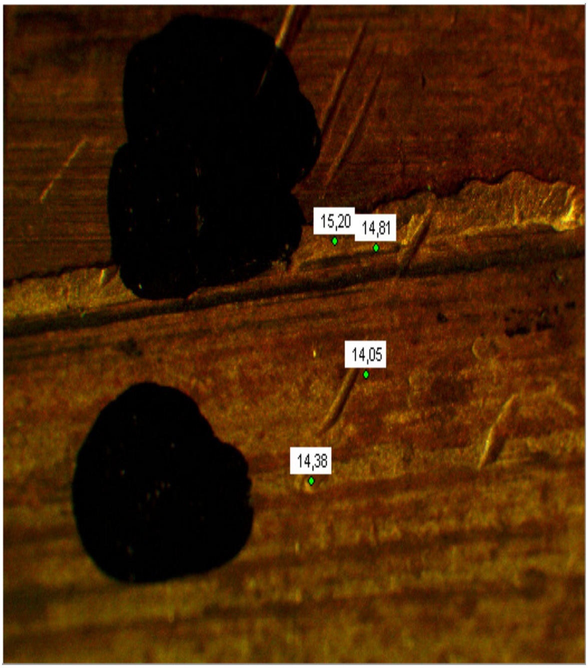

Figure 3.5.8 — **The results of measuring the heights of the irregularities of the profile section of the trace fields of the rifling of the bore on the bullet cartridge 7,62×25 by a round fired from a pistol TT**

Images of traces on bullets and cartridges with dimensional characteristics the software application allows you to save to the clipboard of the personal computer on which the software application is installed, or as a separate file in the format (.jpg) for subsequent use in the preparation of illustrative material expert opinion. The positive quality of the developed software application, which is part of the PAK "BIZAN", is that it does not require installation on the hard disk of the computer when working with portable media (memory cards), thereby providing mobility of use, including inspections of accident sites.

The results obtained during the testing of this device indicate the high efficiency of its work in solving identification and diagnostic tasks in the framework of forensic ballistic examinations of cartridges (ammunition).

Thus, the study conducted in this section allows us to formulate the following conclusions:

1. Use of cartridges (ammunition), elements of their design of technical means of measurement during forensic ballistic examinations is caused by process of scientific knowledge and practical need of use, along with methods of a qualitative assessment, quantitative assessment of essence and properties of objects of research of their set which establishment allows to increase validity of the received results and reliability of conclusions at carrying out forensic ballistic research.

2. Development of new and modernization of existing technical means of expert divisions as a result of their partial modernization are capable to provide the minimum material expenses at introduction of the developed PAK "BIZAN" in activity of expert divisions, having provided a certain economic effect.

3. Application of the developed PAK "BIZAN" for measurement of linear and angular parameters, heights of irregularities of a profile of objects of research at carrying out forensic ballistic examination of cartridges (ammunition) allows to receive measuring information of necessary accuracy and reliability, increases representativeness of quantitative indicators of the measured parameters. In addition, it will contribute to increasing the efficiency of the use of the equipment available in expert laboratories due to the fuller use of its functional capabilities, reducing time-consuming costs in solving all types of tasks of forensic ballistic examination of cartridges (ammunition) and hand-held small arms, in which they are used for shooting, and thereby reducing the cost of examinations and research.

3.6. Methods of forensic investigation of cartridges for hand-held small arms, establishing their suitability for shooting

Development science and technology, the emergence of new and upgrading the existing patrons (ammunition), used for called the shots from manual small arms firearms, determine the application of integrated approach to studying their properties with goal categorization ammunition and definitions suitability their for called the shots with the help appropriate methods and technical means in order, defined appropriate techniques.

Cartridges (ammunition) for hand-held small arms are the most common object of research forensic ballistic examinations. As already mentioned, in the total number of this type of expertise performed by the main Department of Forensic Examinations of the Central office of the State Committee of Forensic Examinations of the Republic of Belarus in 2017, cartridges were the objects of research in almost half of cases. In addition, according to the results of the earlier survey of employees of the State Committee of forensic examinations of the Republic of Belarus, the study received, along with factory cartridges (ammunition) and cartridges made by homemade means, as well as cartridges re-equipped with elements of cartridges of factory manufacture.

When carrying out these studies, experts established the fact that cartridges belong to the category “ammunition”, and also determined the state of their suitability for firing, since these properties are the determining criteria for the qualification of illegal acts.

Complication and expansion of special knowledge, necessity of the decision of the problems arising in expert practice, including at carrying out examination of cartridges (ammunition), objectively cause necessity of the address to exact, reliable and strict methods of research: mathematical, physical, cybernetic, etc. which efficiency is confirmed by concrete researches. At the same time in forensic science it is considered that only an integrative approach is able to achieve the desired result. From the information point of view, the methods should contain prescriptions that ensure the most optimal performance of a particular type of cognitive and practical activity [25, p. 62; 42, p. 186]. In the expert methodology, modern achievements of science and technology should be fully used in order to increase the representativeness of the conducted research, so that the results of the conducted expert research are available for perception by a person who does not have special knowledge [61].

In accordance with the definition contained in the dictionary and reference literature, the methodology of forensic examination is understood as a system of methods (techniques, technical means) used in the study of objects of forensic examination to establish facts relating to the subject of a certain kind, type and subspecies of forensic examination [233, p. 43].

In the literature on the theory of forensic examination contains a number of definitions of the term "technique", developed in the process of formation of this science. Thus, A. I. Vinberg and A. R. Shlyakhov proposed the following definition" the methodology of expert research is a system of scientifically based methods, techniques and technical means (devices, apparatus, devices), ordered and focused on the study of specific objects and solving issues related to the subject of expertise" [36]. D. Ya. Mirsky expert methodology is defined as a detailed program of study by a person with special knowledge, the properties of certain objects to establish the circumstances of evidence-based value, the content of which is the use in a certain sequence developed for this purpose, the system of research methods [169]. M. E. Bondar in the work "Expert technique as one of the main categories of the General theory and practice of forensic examination" defines the term as a program for solving an expert problem, consisting of successive practical and mental operations aimed at knowing the properties and connections of the objects under study and involving the use of a system of certain methods and means of research [24].

It seems that it is the systematic process of expert research allows you to objectively establish the properties of the studied object as a whole, and separately from each other. In this regard, we share the view of E. P. Orekhova that the understanding of the techniques of expert research through the category "system" means the purposefulness and orderliness of the use of methods (techniques, tools), when interconnected and forming a certain integrity methods are used in the established order (sequence) that depends on the expert tasks as well as specific conditions of implementation studies [188, p. 94].

As A. M. Mikhailov notes, the technique acts as a "technique" of a certain method, which was formed due to the application of the method to the study of a certain object. This scientist points out that the method, in contrast to the method, is always instrumental, always associated with a certain range of tasks, i.e. acts as a means of solving them. At the same time, the degree of formalization of the method in comparison with the method is much higher: many methods are algorithmized sequences of actions [170, p. 314].

In our opinion, the most complete and comprehensive content of the term "methodology of expert research" is disclosed in the definition proposed by T. V. Averyanova. Under this term, the author understands the system of prescriptions (categorical or alternative) for the choice and application in a certain sequence and in certain existing or created conditions of methods and means of solving the expert problem [3, p. 290]. This approach meets the practical activities of the expert units of the State Committee of forensic examinations of the Republic of Belarus.

The theoretical provisions concerning the methods of forensic investigation of cartridges used for shooting from small-arms firearms, the issues of their classification as ammunition, the establishment of suitability for shooting, to a certain extent covered in the scientific and methodological literature [31; 102; 112; 232; 248; 303]. At the same time, the continuous process of technical improvement of hand-held firearms, the development of scientific ideas and approaches to their design, combat and operational properties, the emergence of new complexes "weapon — cartridge" objectively entail the need to improve existing and develop new methods of expert research of cartridges (ammunition) used for shooting from hand-held firearms. In the legal literature it is noted that the goal of optimizing the structure of applied legal knowledge is especially relevant at the present time, when it is understood not as an abstract category, but as an intellectual tool focused on the practical needs of jurisprudence [25, p. 3].

In the framework of the study, the author, together with the staff of the State Committee of Forensic Examinations of the Republic of Belarus, developed a Method of Forensic Examination of cartridges for hand-held small arms, establishing their suitability for shooting (hereinafter — Methodology), aimed at improving the forensic study of cartridges, eliminating identified in the process of practical application of the previously existing methods of forensic research of cartridges inaccuracies of certain provisions, including taking into account modern theoretical approaches to the issues of forensic research of cartridges (ammunition) of small arms and firearms.

During the period of practical application Of the methodology of forensic research of cartridges in the activities of expert units, methodological omissions were identified: the lack of a clear structure, which led to inconsistency of the stated provisions, incomplete accounting of the features of the expert study of re-dressed and homemade cartridges. These and a number of other shortcomings and necessitated the development of a draft new Methodology.

Structurally, the Methodology includes the following sections: "Key terms and definitions, Tasks and examination questions to be solved by her conduct", the "examination Objects", "Entity methods", "Criteria for the assignment of cartridges to category of ammunition, small firearms", "the suitability of the cartridge for firing", "a Sequence of actions expert", "Specifics of the study a large number of cartridges, Equipment, tools and materials required for examination (research), Literature".

Within the framework of the issues considered in this section it seems reasonable to briefly disclose the content of some sections of the Methodology.

So, the importance of the "Basic terms and definitions", under Methodology, in contrast to previously existing methods of forensic examination of the cartridges is determined by the fact that until recently in the manufacture it is judicial-ballistic examinations used the terminology contained in the various technical, forensic, regulatory and other sources that, in practice, in certain cases, led to ambiguous understanding of the properties of the objects, the lack of unity in the order of their expert research, the findings of [4; 73; 96; 152; 133; 134; 145; 224]. The relevance of the question concerning the terms and their definitions used in the production of examinations of cartridges (ammunition) is also confirmed by the results of our survey of employees of the State Committee of Forensic Examinations of the Republic of Belarus.

To resolve the outlined problem, a separate section "Basic terms and definitions" is included in the Methodology, which fixes the definitions of common terms used in the production of forensic ballistic examinations of cartridges (ammunition). These terms and their definitions are in accordance with the provisions of GOST 28653-90 "Small Arms. Terms and definitions" [190], which eliminates the different understanding of the described processes and phenomena in order to achieve a uniform application in the practical activities of the units of the State Committee of forensic examinations of the Republic of Belarus. In addition, taking into account the established expert practice of forensic ballistic examinations of cartridges (ammunition), the provisions of this section of the Methodology determine the procedure for specifying the names of different cartridges in accordance with C. I. P. standards. The permanent International Commission for the testing of hand-held firearms (Fr. Commission internationale permanente pour l'épreuve des armes à feu portatives) [200; 306].

Thus, in accordance with the provisions of the European standard C. I. P., the name of the cartridge indicates its caliber, the length of the sleeve in millimeters, as well as the presence of a protruding flange (Rant). Less often, the type of hand-held small arms, the purpose of the cartridge and the weight of the bullet are indicated.

Based on discussed in section 3.1 of this Chapter basic expert tasks when carrying out it is judicial-ballistic examination of the cartridges (ammunition), it is assumed that by the practical implementation of the methodology contained in the regulations are solved by two groups of tasks: classification (of the object to the category of ammunition); diagnostic (regarding the method of manufacture, the origin of the object of examination of the functional (target) purpose, and establishing its suitability for hitting the target in the shooting). The solution of the specified tasks by application of requirements of a Technique allows to optimize process of carrying out forensic ballistic examinations of cartridges (ammunition), and to bodies of criminal prosecution, court, other interested persons — to understand its course and the received results, provides reliability of the conclusion of the expert.

Thus, the developed Technique belongs to a typical type of techniques and is intended for the solution of standard expert tasks, expresses the generalized practical experience of carrying out examinations of cartridges (ammunition) by experts of the State Committee of Judicial Examinations of the Republic of Belarus.

Based on the list of tasks given in the Methodology, the expert can formulate the following conclusions based on the results of the expert study of the objects submitted for examination:

about the type (type, caliber, sample) of the cartridge presented for research;

about reference (non-reference) of the cartridge of factory production to category of ammunition;

about accessory of cartridges of factory production to a certain group (fighting, sports, hunting, traumatic, gas, signal, educational, idle, etc.);

about the type (type, sample, caliber) of the weapon in which this cartridge is intended (or can be used) for firing.

According to point 4 of the earlier operating Technique of criminalistic research of cartridges accessory of cartridges to ammunition of small firearms was established on presence at cartridges of set of two groups of signs: 1) design features due to their intended purpose (includes the use of explosives (gunpowder), multicomponent and disposable); 2) signs that determine the serviceability and suitability of the object under study (cartridge) to defeat the target [163].

To establish compliance of the cartridge to the first group of characteristics the expert it was necessary to determine the presence in its design of necessary structural elements — methane elements (bullets, shot, buckshot), cartridge cases, primer (device trigger), the propellant charge, as well as set the similarity of the external structure of the cartridge with the samples of ammunition, which is ammunition for specific models of small firearms factory and handicraft production.

The presence of the cartridge features of the second group (characterizing the serviceability and suitability of the projectile element of the cartridge (ammunition) to defeat the target) was confirmed by establishing compliance with the technical security of the investigated cartridge to defeat the target. In addition, in some cases it was necessary to establish the sufficiency of the energy characteristics of the projectile (bullets, shot, buckshot) according to the results of experimental shooting.

The provisions of the developed Methodology, establishing the procedure for the study of cartridges (ammunition) improvised (or reequipped with the use of structural elements of ammunition (ammunition) factory production), the basis of foreign experience, according to which the expert review process data objects is divided into two main stages:

analytical, which establishes the presence of all structural elements of the cartridge (throwing element, propellant charge, initiation device, sleeve). The presence of these structural elements is determined by external visual inspection, technical means of non-destructive principle of action or (in exceptional cases) by partial dismantling of the object of study;

experimental, aimed at determining the suitability of the cartridge for shooting and evaluation of the striking ability of the thrown element — the value of the specific kinetic energy, on the basis of which the final conclusion is formulated. Thus determination of suitability of the self-made (peresnaryazhennogo) cartridge to firing is a part of research concerning its reference to category of ammunition [303, pp. 86–87].

Taking into account the characteristics defined in the framework of this work, characterizing the category "munition" in its forensic meaning, the following main criteria for classifying the object under study to this category were included in the Methodology:

1. Multicomponency is a structural amalgamation of different purpose of elements in a single device.

Multicomponency of cartridges (ammunition) used for firing from small arms, is established by the presence of a complex of necessary structural elements providing defeat of the purpose at distance by the thrown element actuated by energy of powder gases or other explosive as a result of a shot. This criterion assumes mandatory the availability of in design patron basic elements: propellant charge; metaemogo element of (single either multiple); means initiating; thimbles, through which enumerated components unite in a single device [112; 202].

If one of these four elements is missing from the factory-made cartridge submitted for study, then this cartridge does not meet the criterion of multicomponency and, accordingly, does not belong to the category of ammunition for hand-held small arms. However, in some samples of ammunition, both factory and homemade (for example, the cartridge Flaubert, self-made ammo, made of capsules-igniters of closed type) [112; 202; 305], the propellant as a separate subassembly can be absent, it is the role of pyrotechnic composition, placed in the sleeve or the means of initiation. The decisive criterion for the classification of cartridges of this design is the category of munitions is to achieve a welded element of the minimum level of lethality $E_{spec.}$ ≥0,5 J/mm^2 in experimental ejection of the cartridge (ammunition) by measuring the energy characteristics.

2. *Single use* — the property of the cartridge, consisting in the possibility of its single use for the intended purpose.

Single use implies the impossibility of reuse for the intended purpose of a particular instance of the cartridge without the use of special techniques to restore its original properties.

3. *Intended for destruction of the purpose* — property of the ammunition caused by ability of the thrown element as a result of firing from manual small arms firearms to cause the penetrating injuries dangerous to life and health of the person.

This criterion corresponds to cartridges (ammunition) of factory manufacture, equipped with a single or multiple throwing element (metal bullet, shot, buckshot) and intended for shooting in rifled or smoothbore firearms.

Intended for destruction of the purpose of cartridges of factory production is defined on similarity of the presented objects with samples of the cartridges which are ammunition for specific models of firearms. Thus compliance of an external structure (the form, the sizes, weight, marking designations, a design as a whole and its separate components) to analogs-samples of a certain type, type, caliber of the cartridges which are ammunition to manual small arms is established.

The theory of judicial-ballistic examination and practical expert activity confirm the validity of the assertion that the inclusion of ammunition factory manufacturing ammunition requires only the existence of the necessary elements in the design, the serviceability and suitability for use for the intended purpose (group of symptoms) is not the defining criterion, as cartridges (ammunition) of factory production according to the functional (target) appointment are intended for defeat of the purpose as a result of firing from manual small arms of firearms. The energy characteristics of the thrown element of such cartridges (ammunition) are many times higher than the amount of kinetic energy required to defeat a person [31, pp. 53–55; 231; 232, pp. 17–20; 267, pp. 16–17; 303, p. 80].

The analysis of law enforcement and expert practice confirms the need for mandatory experimental firing with measurement of energy characteristics of the thrown element of cartridges (ammunition) of homemade manufacture (or reloaded).

Based on the above, determine the energy characteristics of a welded cartridge element artisanal, improvised, as well as ammunition, to independently reequipped with the use of structural elements of ammunition (ammunition) factory made, for the purpose of assignment to categories. Measurement of energy characteristics of the thrown element shall be carried out with use of devices of measurement of speed of flight of the thrown element included in the State register of measuring instruments and passed the established metrological verification [125; 126];

4. One of the criteria for identification of ammunition improvised (reequipped with the use of ammo items factory manufacturing) is also the suitability of the cartridge to fire the cartridge's status, which provides the possibility of firing from a particular sample of the firearms presented on the study either a similar caliber barrel and (or) the parameters of the chamber.

The Methodology contains a provision according to which the suitability of the ammunition for firing is set by the peer experiment (pilot shooting) using weapons designed to fire cartridges of this type (type, calibre), or weapons-substitute. In case of absence in full-scale collection of the expert division of the weapon of the corresponding caliber for the decision of a question of suitability of the cartridge of factory production for firing use of the special equipment — the device of check of cartridges on operation is allowed. At the same time, it is clearly stipulated that the use of such a device is possible only when deciding on the suitability for firing factory-made cartridges that do not have significant external defects, the list of which is determined by the Methodology.

Thus, the essence of the developed Methodology is to regulate the actions of the expert associated with the establishment of:

compliance of a complex of signs of the investigated cartridges to a complex of the signs inherent in ammunition to manual small arms;

suitability of the cartridge (ammunition) for firing.

In contrast To the methodology of forensic investigation of cartridges, the provision on the possibility of solving such a problem as determining the serviceability of cartridges (ammunition) is excluded, since this does not correspond to the goals of forensic ballistic research of these objects. This approach is based on the provision of sub-paragraph 2.1 of paragraph 2 of GOST 27.002-89 "Reliability in technology. Basic concept. Terms and definitions", according to which the term "serviceability" is defined as the state of the object of factory production, in which it meets all the requirements of normative-technical and (or) design documentation, and, conversely, the faulty state is understood as the state of the object of industrial production, in which it does not meet at least one of the requirements of normative-technical and (or) design (design) documentation [174, pp. 2–3].

Thus, provisions of the Methodology cannot be used to assess the health of the cartridge (ammunition) improvised, as faulty as the state of the object of study is established in the analysis of the compliance with the requirements of normative-technical documentation of cartridges (ammunition) factory workmanship and does not cover improvised (reequipped) cartridges, requires the use of appropriate measuring equipment and tools. Such condition of the investigated cartridge, as serviceability, characterizes the investigated object from the point of view of possibility of performance by it of the functions and corresponds in General to provisions of GOST 27.002-89 "Reliability in equipment. Basic concept. Terms and definitions" [18; 174, pp. 2–3; 52].

The specified allows to draw a conclusion about two forms of suitability of the cartridge for firing (possibility of defeat of the purpose as a result of implementation of shots or a shot from small firearms in aggregate with preparatory, accompanying and finishing their receptions and processes): it is suitable for firing; it is unsuitable for firing.

The term "suitability" in this case characterizes the state of the investigated cartridge (ammunition), in which it is able to perform certain functions, and the properties identified in the process of research — to meet the criteria established by the Methodology (in particular, to provide the value of the specific kinetic energy of the thrown element when fired ($E_{spec.} \geq 0{,}5$ J/mm^2). The use of the term "suitability" in the production of forensic ballistic examinations of cartridges (ammunition) is due to the need to study the condition not only of factory-made objects, but also homemade, as well as re-dressed homemade cartridges using elements of cartridges (ammunition) of factory manufacture.

The provisions of the Methodology establish a clear sequence (algorithm) for solving classification and diagnostic problems in the examination of cartridges (ammunition) used for shooting from small arms. The envisaged procedure is based on the principle of consistency, since the process of any expert study (forensic examination) consists of a number of interrelated stages, the strict sequence of which largely determines the logic and validity of the findings, their consistency. In addition, this procedure will significantly ensure the assessment of the reliability of the findings of the criminal prosecution and the court, other interested parties.

It should be noted that currently there are two main approaches to determining the stages of expert research in the overall structure of the expert methodology. Proponents of the first approach (Russian scientists R. S. Belkin, T. V. Averyanova, E. R. Rossinskaya and A. R. Shlyakhov) distinguish the following stages: 1) preparatory stage (preliminary study); 2) analytical stage (separate study); 3) comparative study; 4) evaluation of research results and formulation of conclusions [3, p. 428; 291, p. 101].

Representatives of the second approach (Belarusian authors I. A. Anishchenko, E. Yu. Goroshko, N. V. Efremenko) refer to the main stages of expert research: 1) preliminary study; 2) detailed study; 3) evaluation of research results and formulation of conclusions; 4) registration of examination materials [47, p. 186; 256, p. 138]. The main difference between this position is the inclusion of comparative research and expert experiment in the stage of detailed research in connection with which it is more preferable, since it reflects the algorithm of the process of expert research used in practice. At the same time allocation of registration of materials of examination as a separate stage has debatable character as the specified process in essence is procedure of material fixing of a course and results of expert research which has basically organizational and technical character.

Nevertheless, the first (classical) approach to its construction was used in the development of the Methodology. The sequence of actions of the expert at these stages has no fundamental differences from the sequence, which was provided for by the previously existing methodology of forensic investigation of cartridges.

At the stage of preliminary study, the expert, after reviewing the content of order for inspection, packing inspection and photography examines the study of the objects on the list specified in the resolution.

At the stage of detailed research, photography of objects of examination (research) is carried out, technical and other characteristics of the object of research are determined: cartridge design (state of visible structural elements); General weight and size characteristics (total length, mass); type and type of the thrown element, its dimensional characteristics, method of attachment in the sleeve, color marking. If necessary and there are markings on the object, their decoding is carried out. In addition, the expert establishes the method of manufacturing the object of study, defects on the outer surfaces of the structural elements, the presence of traces indicating a possible homemade equipment or re-loading of cartridges of factory manufacture.

Upon completion of these actions, the expert may formulate the following preliminary conclusions:

about a method of production of object (factory, self-made, self-made (re-dressed) with use of elements of the cartridge of factory production);

about presence (absence) at the investigated cartridge of the signs characteristic of ammunition of small arms (smooth-bore or rifled);

about availability at the cartridge of the signs characteristic for traumatic, gas, signal, idle, auxiliary cartridges, the cartridges which are not intended for defeat of the purpose;

about presence on elements of the cartridge of external defects, etc.

With regard to the comparative stage of the study, the provisions of the Methodology provides a comparison of the findings in separate studies of technical characteristics and design features of the test cartridge (elements) with technical characteristics and design features of cartridges of different kind (model, caliber), their elements specified in the reference literature available in the field collections, and other allowable sources of information, the establishment of the identity of elements of complex structural elements known species, specimens, calibers of cartridges which are ammunition to manual small arms firearms, or establishment of similarity of a design (for cartridges of self-made production or overvoltaged).

One of key stages expert research patrons (ammunition) and definitions suitability their for called the shots, as already pointed out, is conducting expert experiment (experimental called the shots). With the help experiment in forensic-ballistic expertise tested a certain set of hypotheses, expedited fundamental significance under addressing expert tasks. On this occasion, R. S. Belkin notes that the experiment, being applied in the process of research, allows us to empirically verify the correctness of ideas about a particular fact or establish new ones [17, p. 10]. In relation to the situation in which during the experimental firing of the shot did not occur, the Methodology establishes the provision that, if necessary, the expert can dismantle the cartridge submitted for study and determine the cause of failure.

The experimental firing is necessarily preceded by the study of the external condition of the cartridges in order to detect defects, as well as the suitability for firing of hand-held small arms used for its conduct. In particular, defects such as thickening of the lubricant and contamination of the channel under the striker, small output of the striker, its excessive sharpness, blunting, nicks on its surface, contribute to an increase in the probability of misfires in the production of experimental shooting. For the machine gun (AKM), machine gun (PKK) and hunting rifled hand small arms (carbines “Boar”, “Saiga”), made on their basis, the output of the striker striker is from 1.4 to 1.52 mm; for the rifle (carbine) Mosin design — rom 1.9 mm to 2.41 mm; for Makarov pistol — from 1.1 to 1.35 mm. The size of the filling of the striker in the manual small arms of domestic production (combat, service and civil) is from 0.6 to 0.9 mm.

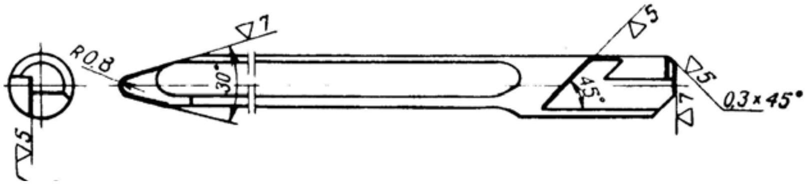

Figure 3.6.1 — **Repair drawing of 9-mm Makarov pistol drummer**

In case of absence of defects in cartridges of factory production ammunition and improvised equipment intended for firing from smooth-bore manual shooting ognestrela weapons, as well as the lack of the necessary caliber weapons in collections of weapons when deciding about the suitability of these cartridges for firing allowed the use of special equipment, e. g. devices to test bullets caliber 4.5–11.43 and hunting ammo to 12 gauge for suitability to the shooting.

If during experimental firing shots followed after the first blows of the striker, misfires were not observed, the conclusion about the suitability of cartridges for firing is formulated. If in the course of experimental firing cartridge failed, the examiner is required to re-attempt firing the cartridge, wherein the Method is recommended to use another instance of the weapon (the barrel multi-barrel guns). To complete the experiment should be carried out at least three attempted shots (with change of orientation of the cartridge in the chamber of the weapon) each cartridge with the misfires. If as a result of the first (or subsequent) impact of the striker on the Central ignition primer, a through penetration of the cap of the primer-igniter occurred without igniting the initiating composition, the experiment is terminated and a conclusion is formulated about the malfunction of the primer-igniter and the unsuitability of the cartridge for firing.

When evaluating the results of experimental firing, the following possible reasons for the absence of shots (the presence of misfires) should be taken into account: change in the physical and chemical properties of the primer-igniter (initiating composition); change in the physical and chemical properties of the propellant charge.

If necessary, the establishment of these reasons is carried out by an expert in the course of dismantling the unexpired cartridges by studying the state of the propellant charge, including the determination of the possibility of its ignition as a result of the use of a hot needle or a source of open fire.

With a satisfactory state of the propellant charge (bulk — grains do not form lumps, have a uniform color; there are no traces of ignition of the initiating composition — burnt powders, traces of thermal influence in the field of pilot hole liners, etc.) and the presence of severe outbreaks, rapid and complete combustion of when the primary supply of a red-hot needle (the source of open fire) to it, it draws conclusions about the unsuitability of cartridge for shooting due to the unsuitability for use of the initiating composition of the primer (the ignition device etc.).

In cases of slow burning, attenuation and (or) incomplete burning of the propellant charge, in the presence of traces of ignition of the initiating composition (burnt powders, traces of thermal action (soot) in the area of the fuse hole of the sleeve, etc.), the expert formulates a conclusion about the unfitness of the cartridge for firing due to the unfitness for the use of the propellant charge.

Some defects of cartridges may indicate a possible obstacle to placing in the chamber of the weapon or locking the bore when placed in the chamber of the weapon cartridge, namely:

protruding defects on the surface of the body of the sleeve (including the muzzle of the sleeve) or the leading part of the bullet, located on one side, if their value exceeds the established dimensional characteristics by 1 mm or more;

protruding defects from diametrically opposite sides on the surface of the sleeve body (including the muzzle of the sleeve) or the leading part of the bullet, if their total value exceeds the established dimensional characteristics by 1 mm or more;

defects on other structural elements of the cartridge fixing it in the chamber of the weapon (a flange, a forward cut of the case of a sleeve) if their value exceeds the established dimensional characteristics on 3 mm and more;

layering on the surface of the cartridge of foreign substances or the presence of corrosive changes (swelling of the material, including through damage), which caused a change in the thickness of the walls of the sleeve and (or) the shell of the bullet;

defects bullets (and / or) thimbles, in including dents, nadpilennye or nadrezannye shell bullets, fissures and through holes, backlash in place compounds (fastening) bullets with thimbles, “recessed” or protruding above established landing sizes bullets in thimbles.

In identifying these defects ammunition expert experiment to establish the suitability of these cartridges for firing should be conducted with weapons of the appropriate caliber. Before carrying out the experiment the expert is obliged to make attempts to remove these defects.

The provisions of the Method established that the layering of substances or corrosive changes should be tried to remove by repeated wiping with a rag, including oiled or soaked in a solvent (for example, for removing paint and varnish coatings). Point layers are removed by a single impact on them with a tool with a sharp edge (knife, scalpel, etc.). The use of sandpaper, sanding sponges, abrasive nets or abrasive tools to remove these defects is not allowed.

When removing defects, and to test the impact of the above defects on the opportunity of a shot is an expert experiment with the attempt of placing the cartridge in the chamber of weapons of corresponding caliber, locking bore and the shot.

If the experiment is successful, the expert formulates a conclusion about the suitability of cartridges for firing with the indication of conditions (for example: suitable for firing after removal of corrosive layers that prevented the cartridge from being placed in the chamber). If during the experimental shooting there were misfires, further conduct of the experiment and evaluation of its results are carried out in accordance with the above requirements.

If you cannot remove the above defects or inability of the placement of the cartridges in the chamber of weapons of the appropriate caliber or inability of locking the barrel when placed in the cartridge chamber of the weapon cartridge is formulated the conclusion about the unsuitability of ammunition for firing.

Noteworthy is the issue of the scope of the experimental study, in this case, the number of rounds to be investigated to obtain an objective conclusion. At the same time the established expert practice testifies to two approaches to the solution of the specified problem:

all objects submitted for forensic ballistic examination must be examined;

according to the previously identified features of a group of homogeneous objects, it is enough to analyze 25 % of the total volume of a homogeneous group to characterize the entire selected set of objects under study.

In addition, the decision on the number of cartridges studied in the experiment often depends on the time limit that ensures the end of the expert study in the terms established by regulatory legal acts, the availability of appropriate samples of hand-held small arms and their qualitative state, the state of the objects of study (for example, the presence of significant corrosion changes on their surface), the method of manufacturing cartridges (factory, homemade), etc.

It seems that in all cases, the determining criterion for choosing the form of the study of these objects ("solid" or selective shooting) cartridges should be the method of their manufacture.

According to provisions of a Technique at receipt for production of examination of cartridges in quantity more than 20 pieces for convenience of research and the description their division into groups is allowed. In this case, the grouping of cartridges can be carried out on various grounds, in particular the method of manufacture, design of cartridges, caliber of cartridges, type of projectile (bullet, shot or buckshot), as well as other grounds established by the Methodology.

However under conducting experimental called the shots bullets (ammunition) homemade assemble, equipped with with use of elements patrons factory assemble (teams), otstrelivayutsya in continuous order. This approach is due to the fact that each of these objects (in contrast to cartridges (ammunition) of factory manufacture) has individual criminalistically significant properties that are not regulated by technical regulatory legal acts in relation to industrial products of mass production.

Under study patrons (ammunition) factory assemble permissible their experimental shooting by an independent (random) sampling some their parts of from total number of received on study patrons one-style.

To obtain objective data on the required sample size from the group of cartridges subject to experimental shooting, the Methodology uses the Kolmogorov formula:

$$m = n\left(1 - \beta^{1/nq}\right),$$

where m — independent sample size (number of cartridges to be checked);

n — number of rounds submitted;

β — the probability of missing an unsuitable cartridge (accepted β=0.05–0.1);

q — the probability of choosing an unsuitable cartridge for firing (accepted q=0.05–0.1).

Table 3.6.1 — **Ratio of the number of cartridges to be shot**

No.	**Number of cartridges submitted for research, PCs.**	**The minimum number of rounds that must be shot, %**	**The maximum number of rounds that must be shot, %**	**The number of rounds that you want to shoot, PCs.**
1	10	90	99,7	9–10
2	15	75	97	12–15
3	20	68	95	14–19
4	30	53	87	16–26
5	40	45	78	18–31
6	50	37	70	19–35
7	60	32	63	19–38
8	70	27	57	19–40
9	80	25	53	20–42
10	90	22	49	20–44
11	100	21	45	21–45
12	110	19	42	21–46
13	120	17,5	39	21–47

If at selective shooting of cartridges of one group there was a misfire, shooting of the remained cartridges of homogeneous group is made in a continuous order.

However the above formula is applicable only for the number of not more than 150 pieces of checked cartridges of one sample. At receipt on research from 151 to 1000 cartridges of one sample experimental shooting is made on the basis of 10 percent sample from quantity of the cartridges arrived on research (but not less than 50 pieces). When more than 1000 cartridges of one sample are received for the study, the experimental shooting is carried out on the basis of a 5 % sample of the number of cartridges received for the study (but not less than 100 pieces).

In case of receipt of a significant amount of cartridges (ammunition) with corrosive changes for the study, all objects should be cleaned. After carrying out the experiment on placing the cartridge in the bore and establishing the possibility of locking it, all such cartridges or their sample, calculated by applying the Kolmogorov formula, are shot (if their number goes beyond the obtained interval in the direction of increase) [136; 141; 162].

For example, the study presented 120 rounds with corrosion changes on the bullets and sleeves. In accordance with data tables 12 should shoot group patrons volume of from 21 until 47 units. After cleaning and checking the possibility of placing in the chamber and locking the bore of the group was 55 pieces. In this case, it is necessary to shoot 21–47 rounds, and in the case of a misfire in the production of experimental shooting — and the remaining cartridges. If it is impossible to obtain as a result of cleaning a 10-percent sample when entering the study from 151 to 1.000 rounds of one sample (less than 50 rounds) or a 5-percent sample when entering the study more than 1.000 rounds of one sample (less than 100 pieces), the firing of the obtained group of cartridges should be carried out in a continuous order.

This approach, enshrined in the Methodology, allows during the production of forensic ballistic examination with the necessary reliability and sufficiency to determine the state of the objects of research of factory and homemade manufacture, as well as to qualitatively determine their properties, reduce time-consuming costs in the production of examination, increase the resource of hand-held small arms used in experimental shooting.

Measurement of energy characteristics of the thrown element is carried out for the purpose of establishment of conformity of cartridges of self-made production, including the reloaded, to criterion of intended purpose for defeat of the purpose. The experiment is carried out with the use of weapons designed to fire a cartridge of the appropriate type (type, caliber), and devices for measuring the speed of projectiles.

In practical expert activities are often investigated cartridges (ammunition) for rifled firearms, peresnaryazhennye homemade way using elements of cartridges (ammunition) factory production. Conclusion about suitability such patrons (ammunition) for called the shots and destruction goal is formulated in conclusion forensic-ballistic expertise on the basis their experimental shooting and calculation energy performance.

So, on judicial-ballistic research the cartridge found during carrying out survey of a scene arrived. This cartridge was compared with the description and graphic images of cartridges for hand firearms, placed in the manual edited by M. M. Blum and A. I. Ustinov “cartridges of hand firearms and their forensic investigation” [202, p. 41]. As a result, it was found to coincide with the 9×18 Mak cartridge, which is ammunition for the Makarov pistol, the Stechkin automatic pistol and other rifled firearms of 9 mm caliber manufactured for this cartridge. Matches are established by the form, dimensional characteristics of the elements and the device of the cartridge.

At the same time, it was established that the following changes were made to the design of the cartridge submitted for study:

lower (1.8 mm) fit of the bullet compared to the size characteristics for the cartridge 9×18 Mak, manufactured industrially;

increased by 0.2 g cartridge weight;

in the cartridge case, the non-standard method instead of the primer “boxer” is installed the primer “Zhevelo”, used when equipping hunting cartridges.

On the basis of the conducted research, the expert concluded that the specified munition was made by a homemade method (reloaded) using elements of the 9×18 Mak cartridge of factory manufacture (bullets and sleeves), the “Zhevelo” capsule and the propellant charge. It was not possible to determine the type of propellant charge in the course of the study due to the complexity of disassembling the specified cartridge and the lack of appropriate technical means.

A sample of the weapon for firing from which was designed the cartridge, the study was not submitted. In order to resolve the issue of the suitability of this object for shooting with a measurement in the index, it was shot from a 9-mm pistol IZH-71-18E, for which the cartridge 9×18 Mak is a regular.

During the experimental shooting, it was found that:

the shot occurred after the first blow of the striker on the primer without any misfires or delays with a weak sound of the shot;

the bullet lodged in the bore;

the cartridge case is not ejected out through the bolt window, wedged between it and the breech section of the barrel.

The analysis of the experimental shooting showed that the main reasons for this result could serve as:

the use of a non-standard slow-burning propellant charge in the cartridge under study, as a result of which the forcing pressure during the shot did not reach the required value;

firing a weapon, the automation of which is based on the recoil of the free bolt, locking the barrel bore in which is determined by the force of the return spring, the mass of the bolt and the sliding friction forces between the moving parts.

As is known, the principle of recoil of the free bolt is the basis of the Mak gun automatics. In the process production shot being fired gunpowder gases act simultaneously on bullet, on the walls and bottom thimbles, in a result what the latter component forces ceded the bolt. At the same time there are several multidirectional forces:

the pressure force of the powder gases tends to throw the projectile element (bullet) from the bore;

the pressure force on the bottom of the sleeve pushes it back from the chamber, overcoming the inertia of the shutter, the friction of the walls of the housing shells on the surface of the chamber and the force of compression return spring.

As a result of the simultaneous impact of these forces, the methane the element and the sleeve, held in the bolt ejector, begin to move in opposite directions, but at different speeds: if the speed of the bullet near the muzzle reaches 315 m/s, the maximum shutter speed usually does not exceed 4–5 m/s (for regular cartridge). In this case, the Mak design provides a condition in Which the bolt at the time of firing (before the bullet leaves the barrel channel) departs some distance from the breech section of the barrel (<3 mm), since the pressure on the bottom of the sleeve will be higher than the pressure acting on the bottom of the bullet (figure 3.6.1) [251, pp. 82–83].

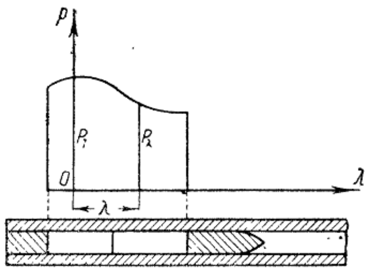

Figure 3.6.1 — **Pressure Distribution of powder gases in the discharge space in the preliminary and first periods of the shot**

Under normal conditions, the bullet leaves the bore, and the bolt ejector moves back, removing the sleeve from the chamber. In the studied case, at a certain point in time, when the sleeve will pass a distance of about 2 mm, the pressure of powder gases in the discharge space will reach a certain limit value, at which the pressure will be released through the gap between the cartridge case, not expanded when fired, and the chamber wall (in a slightly worn barrel Mak — 0.8 mm) and, as a consequence, the bullet will acquire a lower velocity.

This hypothesis was confirmed by the results of experimental firing from the Mak, in the chamber of which there was a through hole with a diameter of 5 mm. The reset pressure of the powder gases through the said hole the pistol did not work in normal mode, and the average velocity for ten rounds was 127 m/s (the data were rounded to whole numbers).

The average value of the velocity v_{mean} is determined by the formula:

$$v_{mean} = \sum_{i=1}^{10} v_i / 10$$

Shot	1	2	3	4	5	6	7	8	9	10
Velocity, m/s	120	144	122	127	121	125	124	131	127	132

$$v_{mean} = \frac{120+144+122+127+121+125+124+131+127+132}{10} = 127\ (m/s).$$

These circumstances in the application of non-standard propellant charge and a relative movement of parts of weapons don’t allow to create in the moment of firing, the pressure forcing in senaratna space where the bullet would leave the barrel before the cartridge case from the chamber and the pistol would work in a regular mode.

Given the above, it appears that to improve the efficiency of forensic ballistic research ammo (ammunition) to rifled firearms equipped in a makeshift way using ammo items factory manufacturing when failure or lack of a specific instance of the weapon for firing from which was manufactured the cartridge (ammunition), it seems appropriate to recommend experts for the admission of patrons to the design features and dimensional characteristics to the standard sample manual strelkovogo firearms, using in its design the principle of rollback of the free gate:

to make shooting of the specified cartridges from the samples of the weapon providing locking of the channel of a trunk by the fixed lock, or ballistic installation;

to provide a fixed fixation of the bolt of the substitute weapon in order to reliably lock the bore and create a sufficient level of pressure in the bore when fired [131].

Despite the fact that in terms of expert departments during the pilot shooting of rounds (ammunition) a weapon is used, the substitute options and breech of the barrel which correspond to the dimensional characteristics of the cartridge, in our opinion, this approach is debatable. In industry, for example, under conducting ballistic tests patrons (ammunition) to small arms (in including pistol) are used ballistic installations with longitudinally-sliding the bolt, locking canal trunk in which ensured zatsepleniem projections larvae the bolt with receiver box, than are achieved immobility the bolt and reliability locking canal trunk in moment production shot being fired under conducting tests [18].

At research of the cartridges made by a self-made way, including peresnaryazhennyh, together with self-made or converted weapon which parameters of a chamber correspond to parameters of cartridges, energy characteristics of cartridges are defined on the basis of results of their shooting from the presented copy of the weapon.

In the production of a series of shots to measure the energy characteristics of the projectile between the individual shots in the series must be paused for at least 2 minutes, it is necessary to make sure that there are no elements in the bore of the cartridge (wads, gaskets, etc.), used for the production of the previous shot. The bolt of the weapon (bolt frame with bolt) is thus installed in the extreme rear position and must be held in such a way that the barrel bore remains open both from the muzzle and from the breech. This provision of the Methodology is intended to ensure both the safety of the person performing the examination and the relative constancy of the ballistic characteristics of the throwing element during experimental firing due to the heating of the barrel of the weapon.

After the measurement of speed of flight of the projectile throwing expert is defined by its kinetic energy (E) according to the formula:

$$E = \frac{mV^2}{2} \text{ (J)},$$

where m — projectile weight (kg);

V — projectile velocity (m/s).

Then the calculation of the cross-sectional area (S) of the projectile is carried out according to the formula:

$$S = \frac{\pi D^2}{4} \text{ (mm}^2\text{)},$$

where π = 3.14 (constant);

D — diameter of projectile (mm).

Then the specific kinetic energy (E_y) of the thrown element is calculated by the formula:

$$E_y = \frac{E}{S} \text{ (J/mm}^2\text{)}.$$

In this case, the values of the results obtained when calculating the values (*E*), (*S*), (E_y), are rounded to hundredths.

If the obtained value of the value of the specific kinetic energy of the projectile $E_{spec.} \geq 0{,}5$ J/mm^2, this means that the cartridge is suitable for firing, meets the criterion of intended purpose to hit the target and belongs to the category of ammunition.

If the value of the specific kinetic energy of the projectile is less than 0.5 J/mm^2, this indicates that the cartridge does not meet the criterion of intended purpose for hitting the target, and therefore does not belong to the category of ammunition.

In the final stage of the expert study is carried out evaluation on the stages of preliminary and detailed research results, formulate the final conclusions in summary form that reflects the essence of the obtained results — the assignment (notesini) presents cartridges to the category of ammunition, small firearms, as well as a statement of fact suitability (unsuitability) for shooting them.

The Methodology contains a provision that the conclusion about the impossibility of solving the issue on placing a cartridge improvised the category of munitions and the establishment of the state of its suitability for shooting is formulated in the following cases: impossibility of definition of the size (sample, model) of the weapon for firing is applied to the study of the cartridge, or the lack of the ability production of the expert experiment.

Thus, the following conclusions can be formulated on the basis of what is stated in this section.

1. The methodology of criminalistic research of cartridges for hand small arms, the establishment of suitability for firing refers to the model type of methods, i. e. represents a method of expert solutions to com-

mon tasks, and is an expression of the generalized practical experience, expertise rounds (ammunition), which includes the following stages: preliminary study, detailed study, comparative study (including expert experiment), evaluation of research results and formulation of conclusions.

2. The scientific approaches fixed in the specified Technique are directed on the decision of the classification and diagnostic problems connected with expert research including the cartridges used for firing from manual small arms, obtaining necessary data on properties of the investigated objects, their reference to category of ammunition, determination of their suitability for firing, provide reliability of results of expert research and their representativeness.