Stabilizing mechanisms for personnel parachute systems

"…I lay on my back. The center of spinning is somewhere near my neck. My feet are going in a large circle, my head in a small one. I am spinning with frightening speed. I have do get out of this corkscrew spin, otherwise it will be bad. I am making reverse jerks, throwing out my right arm. With difficulty I get out of the spin, but I don't see the ground…..I don't even know in what position I am falling. Blood rings in my ears. In order to equalize the pressure I try to sing. But the song doesn't work. Then I simply start to yell, like a town crier, the first words that come to mind….Losing orientation, I again can't see anything. I am shaken, thrown from side to side, twisted and rolled. I am stunned and can't figure out what I need to do in order to stop this torture…"

This is an extract from a story of one the pioneers of Soviet parachuting, the well known sport jumper Nikolai Evdokimov, about the record setting jump with a 142 second delay from a height of 8100 meters made by him on July 17, 1934. The first parachutists, starting to master jumps with delayed openings, were confronted with what is now called unstable freefall. At that time they didn't know how to control it.

UNSTABLE FREEFALL

In addition to jumps with an immediate opening of the parachute, when the parachute is opened immediately after exiting from the aircraft by a staticline, it is sometimes necessary to make jumps with a delayed opening. In this situation the parachutist encounters many difficulties as a result of the physical laws of motion governing an object falling through the air.

After exit from an aircraft the rate of decent increases with every second (up to that particular value when, because of the resistance of the air and non-uniformity of the atmosphere, the rate of decent is possible to call constant). Calm and impalpable in the beginning, the air becomes springy. Not being able to achieve stable free fall, a parachutist falls into the power of the elements. He becomes powerless, the air currents throw and roll him and often force an early opening of the parachute. The force of the air currents become so strong and so powerfully spin the parachutist that his body will start to make several revolutions per second. The centrifugal force of the spin attains such a magnitude that it is difficult to reach the rip cord handle. The parachutist experiences such psychological and physical stress that he is unable to either keep track of the time of falling or to observe the earth. All of this is very fatiguing and hard to stop. In order to learn to control your body in freefall and contend with the elements, it is necessary to expend a sufficient amount of time and complete a large quantity of jumps. That is, for consistent jumps, it is necessary to train the parachutist.

In the beginning of the “parachute era”, when practically nobody possessed such experience, there appeared the idea of artificially stabilized fall with the help of a special device. It is of course possible in an air war or an accident that a person will have to make a delayed jump, not having the required training. Not being able to control his body, he would be in a dangerous position.

A jump with parachute system D-5 series 2 and the stabilizing system immediately after exiting the aircraft.

FIRST EXPERIMENTS

So how to make free fall stable? Carrying out simple experiments, it is possible to notice that any falling object becomes stable in the air and stops tumbling when it is connected to a long tail in the form of a ribbon. Besides stabilizing the falling body, such a device also slows the rate of decent a little. There is such a technique applied for communication of a pilot with the ground when there is no radio on the aircraft. This device is named a “pennnant” (message streamer) and consists of a small container with a long ribbon. The bright ribbon is meant for visibility in the air and on the ground and also for the slowing the rate of decent of the container. For making reports to the ground, the pilot simply throws out the pennnent with a message. Observing the fall of a pennant, it is possible to see that it behaves in the air with sufficient stability. For stabilizing the fall of a parachutist through air the pennant would be significantly larger.

The inventor of the first parachute in a container, Gleb Kotelnikov, proposed stabilizing the fall with a special small parachute. In comparison to a pennant, the canopy of a parachute works more effectively and occupies a much smaller space when packed. They tried to make such parachutes early on, but they didn’t provide any stability – the parachutes oscillated wildly or spun around the vertical axis together with the parachutist. The idea required serious study.

In 1940, after the end of the Finnish war, they decided to work on this more seriously. Development and testing of a stabilizer for falling parachutists was done by Igor Glushkov, Stanislav Karamshev, Pofiri Polosukhim, Sergey Shukin and Yakov Moshkovski. Studying the inadequacies brought out earlier, Igor Glushkov suggested his own design of a stabilizer for use with the parachutes that were then available. The stabilizer consisted of a small square parachute with lines that were gathered at a lock that was sewn to the main lift webbing of the harness. The lock for the stabilizer was made by Stanislav Karamishev.

The lock was for the release of the stabilizer before the opening of the main parachute in order to eliminate any possible entanglements with the main canopy while it was opening. Since the lock was mounted on the main lift webbing (on the "saddle"), the stabilizer would stabilize the fall of the parachutist in a "head down" position. In the opinion of the developers this was the safest position for the body of the parachutist. This method of attachment worked without serious consequences on the harness of any of the then current parachutes. The work of the lock was first tested on the ground. They hung the parachutist Polosukhin in full parachute gear from a cable on a ceiling beam of the sewing loft. Looking at him, Glyshkov, Shukin and Karamishev checked the position the parachutist would have during a fall with the stabilizer. Seeing that the fall would be comfortable, the parachutist pulled the handle for the lock and dropped into the arms of his comrades. The lock worked reliably! After this they tested the lock in the air. Poposukhin and Shukin jumped with the prototypes from a balloon at a height of 5500 meters.

For the first experiment of the stabilizer they didn't pack it in a bag. In the balloon gondola Yakov Moshkovski held them in his hands to make sure they wouldn't hook on anything and he let them go at the moment of exit. They worked normally and ensured an excellent and somewhat slower rate of decent. No twisting, no spinning, no oscillations. Only a single undesirable characteristic: the parachutist's body didn't once change position, and because of the poor selection of the point for connecting the stabilizer, the parachutist faced down the entire time. That is, the decent went upside down and his face was strongly beaten by the wind and it was hard on the eyes.

For this jump the delay was 50 seconds. To open the parachute, they had to first release the stabilizer by pulling on a special ring. Poposukhin, when he extended his left hand to the handle for the lock, by accident got the ripcord. The parachute opened, but did not snag the stabilizer. The opening shock with the decreased decent speed was weaker than for typical delayed jumps. For Shukina everything went normally. He separated from the stabilizer and then opened his parachute.

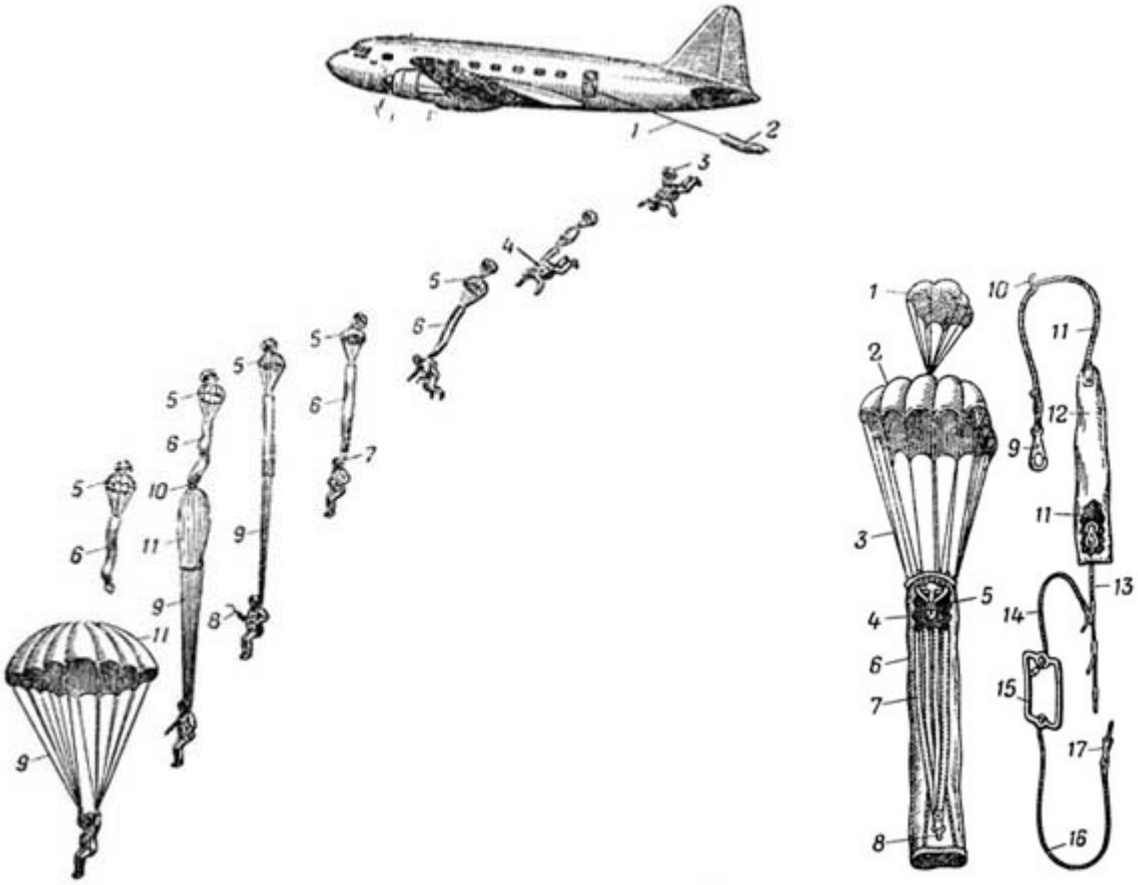
For these first experiments, the stabilizing system worked independently and could be used with any type of the then available parachutes. That is, its function was only the prevention of the unstable freefall of the parachutist. For the opening of the main parachute the stabilizing system did not play a role, therefore it was released before opening.

SPORT-TRAINING PARACHUTES WITH VARIABLE SPEED DECENT

After the Great Patriotic War parachuting again began to develop in our country and again the questions came up of using a stabilizer for a parachutist during a high altitude jump. Then appeared a new "sport-training parachute with variable speed decent", the PDPC-48, developed by a collective of designers under the leadership of N. Lobanov.

Jumps from an Il-76 with the parachute system D-6 series 4. Well seen are the drogue parachute and the orange cap.

The PDPC-48 was first displayed at the air show at Tushino during the summer of 1955. The new parachute had a square canopy with an area of 70 m^2, just like the PD-47 that was made by the same designers earlier. The variable speed decent, as they then called stabilized freefall, was provided by a stabilizing parachute with a square form and an area of 3.3m^2. The stabilizing canopy was attached to a loop on the upper edge of the sleeve of the main parachute by 16 suspension lines with a length of 1.6m. Unlike modern parachute systems, the PDPC-48 had a lock to attach the stabilizing parachute located not on the container, but on the harness. The harness had a “two-strap pyramid” for mounting the lock. The lock was for the separation of the stabilizing parachute and the main sleeve from the harness. This parachute had still one important improvement in comparison to the first one used on experimental jumps with a stabilizer in 1940 – the parachutist was stabilized in a sitting position with legs down. This position of the body was much more comfortable than falling head first and provided a smooth opening of the main parachute.



Operation of the parachute system PDPC-48 (on the left)

1- Staticline; 2 – pilot chute and drogue d-bag; 3 – pilot chute;4 – main parachute container; 5 – drogue parachute; 6 – sleeve; 7 – two-strap pyramid for stabilizing the parachutist; 8 – handle for releasing the drogue; 9 – suspension lines of the main canopy; 10 – break cord (short and long); 11 – main parachute canopy

Design of the stabilizing system (right)

1 – pilot chute; 2 – drogue parachute; 3 – drogue parachute suspension lines; 4 – bridle for the sleeve; 5 – stowing loops for the drogue suspension lines; 6 – sleeve; 7 – reinforcing tape; 8 – small lock hook; 9 – carabineer PKM-1; 10 – loop a break tie on the staticline; 11 – staticline; 12 – pilot chute and drogue d-bag; 13 – cable with locking pins; 14 – cable to handle; 15 – drogue release handle; 16 – cable to drogue release; 17 - pin

The opening of the container took place with the help of a staticline during the parachutist's exit from the aircraft. Immediately after the opening of the container a pilot chute with a spring was put into service and it pulled from the container the stabilizing parachute and the sleeve with the main parachute packed in it. Up to the moment of

opening the parachutist fell with the sleeve of the main parachute pulled out to its full length, and it was pulled from its top by the stabilizing parachute. For stopping the stable decent and introducing into action the main parachute, and also for the hand deployment of the parachute incase of a malfunction of the initial opening of the container, was a ripcord. The ripcord of the PDPC-48 had two cables – one for the opening of the container and the other for the opening of the lock for the sleeve. After opening the lock, the stabilizing parachute pulled the d-bag from the main canopy and the sleeve landed separately together with the pilot chute.

Otherwise, the PDPC-48 was designed very similarly to the well known parachute PD-47. This parachute didn't receive wide use, for the reason that all sport jumps were then made with stable freefall. By that time parachutists had accumulated the required experience and found the training method for stable freefall.

JUMPS FROM HIGH SPEED AIRCRAFT, THE RETURN TO AN OLD IDEA

In the middle of the 1950's, there arrived a new transport aircraft for the airborne forces, the Tu-4D. It was a bomber outfitted as a transport. The Tu-4D had advantages in comparison with older aircraft and allowed an air assault of personnel at higher speeds than before. At that time the airborne was equipped with the parachute D-1, fully constructed to its own technical specifications and reliability.

Decent with the parachute system D-1-8 series 3. Stabilized decent immediately after exiting the aircraft.

But the first mass jump from the Ty-4D showed several problems: the main canopy turned itself inside out and tore, suspension lines twisted to the very skirt of the canopy. There are recorded instances of the canopy malfunctioning and rolling into a lump wrapped with the suspension lines! Several parachutists received contusions to the head and face from the risers, others lost consciousness from opening shock….

How was this so? The earlier reliable parachute D-1, widely used in the airborne forces for already several years, turned out unfit for use!

A specially created commission of experts, studying all these events, came to the conclusion that the parachute failed because of this, that it could not withstand the loads of opening at such a speed. A simple increase in the delay of the opening of the parachute didn't bring the required effect. That is, the parachutist after exiting maintained the speed of the aircraft rather long. To strengthen the parachute also didn't appear possible because of the appreciable increase in the

extent and cost of such a modification. Something new was needed.

The brothers Nikolai, Vladimir, and Anatoly Doronin suggested using a stabilizing parachute to lower both horizontal and vertical components of speed. With a short delay the stabilizing parachute would allow the lessening of the relative speed of the parachutists by taking on itself part of the dynamic load during opening. Besides this it would be possible take advantage of the main property of the stabilizing parachute – the stabilization of the parachutist in a position much more comfortable for the working of the main parachute. The main canopy with suspension lines stayed unaffected to permit the use of currently available parachutes. The Doronin's began to modify the parachute D-1 for jumps at high speed.

In 1959, after all the modifications, the new parachute D-1-8 was introduced for outfitting paratroopers. In fact, it appeared to be a complete modernization of the parachute D-1. Experiments for the design had already been done for the stabilizing system of the PDPC-48. The new D-1-8 structurally repeated this method of operation although the design was significantly different.

The new system worked this way: After exit from the aircraft the staticline opens the container, a flap is pulled to the side under the action of bungees. At the same time the staticline pulls a lanyard that starts an AAD. From the opened container comes out the pilot chute that opens under the action of a spring. Having filled, the pilot chute pulls out the d-bag of the stabilizing parachute and stretches it out. The inflated canopy of the stabilizing chute in its turn pulls from the container part of the main canopy sleeve. The lower part of the sleeve, still held in a pocket in the container, is not pulled out since it is held in the container by means webbing straps with rings on the sleeve that are attached to a two-cone lock.

In this method with the inflated stabilizing canopy and the partially extended sleeve the parachutist descends stably. At the end of a designated time the parachutist pulls a drogue release handle, in result of this a loop on the end of the cable turns the bolt of the two-cone lock and the rings on the closing webs are freed from the lock. The sleeve is stretched to its full length, the suspension lines come out of the stows on the sleeve and the main canopy inflates. After the full inflation of the main canopy the sleeve separates from the main parachute and lands separately with the stabilizing parachute. The pilot chute with the stabilizing chute d-bag also lands separately.

The method of operation of the parachute using this stabilizer is shown in the drawing:

Method of operation of the parachute D-1-8 (left) and the drogue parachute (right)

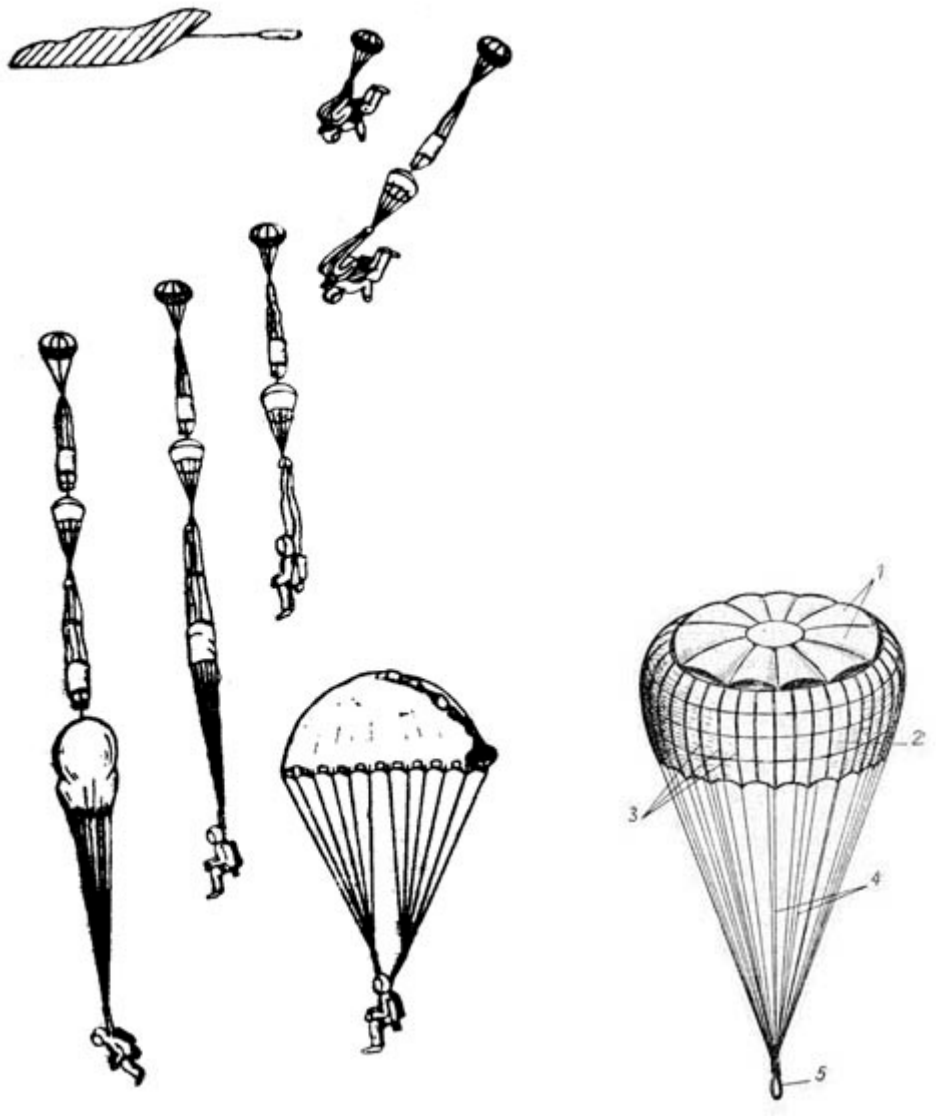
The new parachute turned out very successful and didn't require serious retraining of personnel in packing and use. Also was preserved the possibility to use the parachute without the stabilizer for jumps from several aircraft using a staticline for direct bag deployment of the main canopy. Following this, on several occasions the parachute was improved and there arose different series and completely new parachutes like the D-3 and PCN-66.

FURTHER DEVELOPMENT OF STABILIZING SYSTEMS

As the experience and number of jumps with the new system increased, there began to appear new problems and new solutions. It was necessary to understand of what size the stabilizing parachute should be, in what position to stabilize the parachutist, and to decide a multitude of other problems that appeared in the process of utilization.

In order to speed up and normalize the inflation of the stabilizing parachute, it was decided to sew special pockets (a “cap”) to the canopy of the stabilizing parachute in the form of a “stretching out” system. It turned out that these pockets reduced the rotation of the entire system during the decent, so it was extremely opportune. On jumps with a long stabilized decent it turned out, that because of poor position or because of a protuberance of equipment, the parachutist often started to spin around his axis and on opening the suspension lines of the parachute were twisted into a rope. This could lead to a malfunction. Spinning hindered in part pulling the sleeve from the main canopy, and the long tail of the stabilizer, consisting of the stabilizing parachute and portion of the main canopy sleeve pulled from the container, interfered with the use of the reserve parachute in the event of a malfunction of the system. This reason, plus the increased experience in use and modernization of such systems, was the reason for the development in principle of a new system of stabilization, which also meant new parachutes.

Parallely went the refinement of the parachutes D-1-8 and D-3. There was a shift in concern about the stabilizing system. The separation of the stabilizer together with the sleeve was an inconvenience for the parachutist, since after the jump they had to look a long time for their sleeve. Then came the parachutes D-1-8 series 3P and 6-P and D-3 series 3P and 6P (the letter”P” stands for “attached”). The parachute worked the same as before except that the earlier separated parts (the pilot chute from the d-bag of the stabilizing parachute and the stabilizing parachute from the d-bag of the main parachute) were now connected together to the apex of the main canopy. After the opening of the parachute the stabilizer now lay on top of the canopy and didn’t fly off all over the drop zone. Employing such a system, it was clear that it was possible to simplify the design and eliminate the pilot chute with the d-bag of the stabilizing parachute by immediately deploying the stabilizing parachute with a staticline.



Method of operation of the parachute systems D-1-8 series 3P and series 6-P and system D-3 series 3-P and 6P (left)

Design of the drogue parachute (right):
1 – cap; 2 – body of the canopy; 3 – reinforcing tape GLK-13-70; 4 – suspension lines; 5 - eyelet

A variant was tried in the design of the parachute D-4 that had in the process of deployment first the opening of the stabilizing parachute, on which the paratrooper descended until the moment of operation of the AAD or the pulling of the ripcord. After the opening of the two-cone lock the stabilizing parachute opened the container and pulled out the spherical pilot chute that had the main canopy d-bag attached to it.

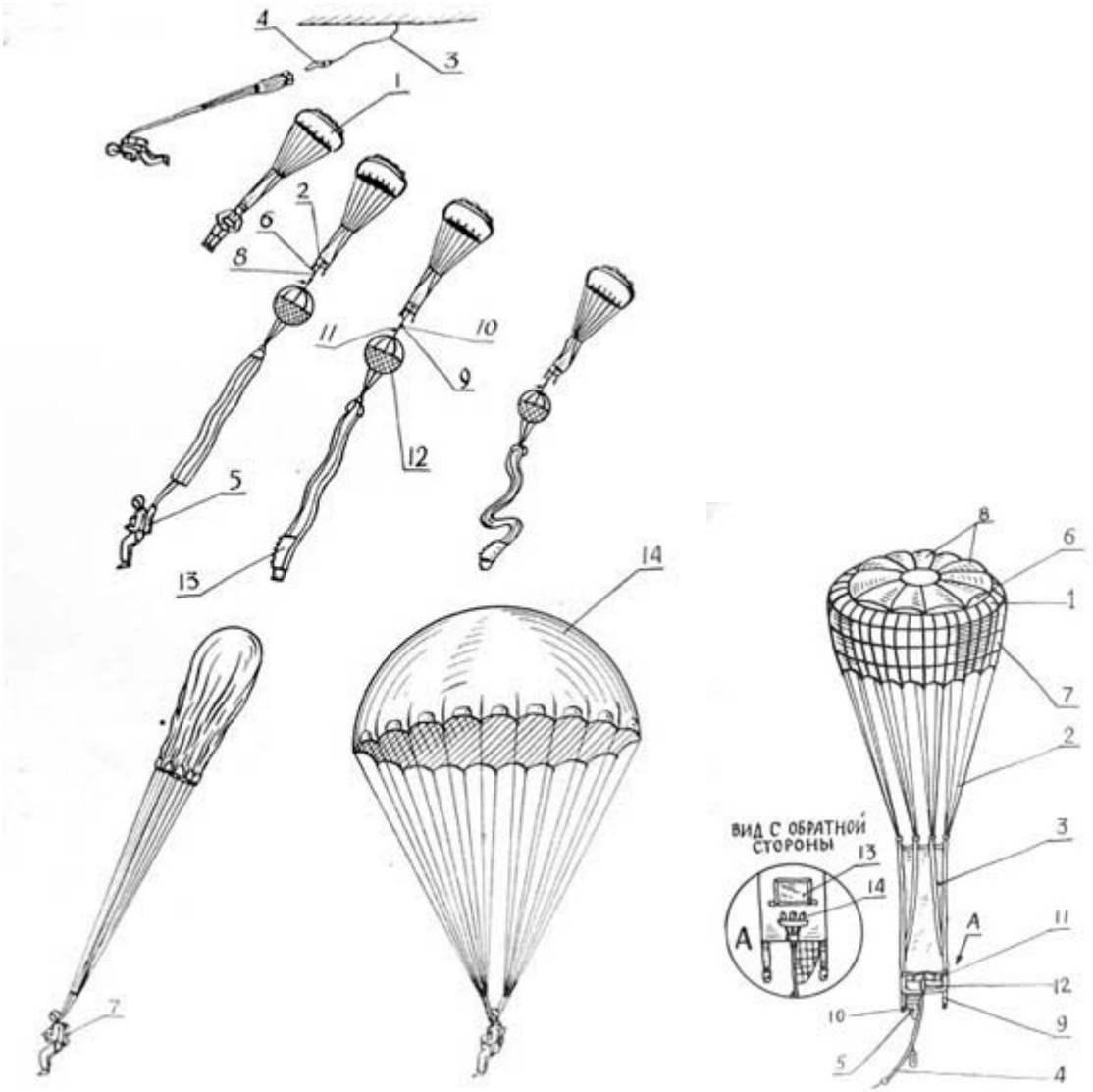
The system worked in this way: With the exit of the parachutist from the aircraft a drogue parachute is deployed by means of a staticline and direct bag deployment. The drogue d-bag is stowed in a rigging pouch located on the drogue bridle. It is pulled out by a staticline that is attached inside the aircraft. For this the staticline pulls out of three elastic stows located on the drogue container, opening the drogue container and pulling out the drogue d-bag. Then from the open end of the drogue d-bag is pulled out the part of the drogue bridle rigged inside it, then the lines of the drogue and then the canopy. Hitting the air stream, the canopy inflates and the paratrooper starts to descend under the drogue parachute. After the opening of the two-cone lock by the AAD or the ripcord the stabilizing parachute separates from the main container. During the separation of the stabilizing parachute a lanyard with a ring is stretched out. The ring breaks a safety tie and more lanyard is pulled out of a pocket on the container. The lanyard is attached to the apex of the pilot chute, resulting in a connection between the drogue and the pilot chute.

After this the lanyard of the stabilizing parachute pulls out a pin from a locking loop thereby releasing the flaps of the container, which under the action of elastic bands are pulled to the side. The pilot chute is deployed by action of a spring. However, the drogue continues to pull on the pilot chute and the main canopy sleeve attached to it since it is still attached the pilot chute.

Further, the main canopy sleeve is stretched out of the pocket in the bottom of the container where it was located. The lines stows near the risers are pulled out of rubber band stows at the bottom of the container and open the pocket. The risers are pulled up from the bottom of the container and are stretched out. The suspension lines are pulled out of the fixed stows on the sleeve. Pulling out the locking stows opens the closing flap of the sleeve. The sleeve comes off the main canopy and the canopy inflates. The drogue parachute together with the pilot chute and sleeve descend separately.

The spherical pilot chute of the D-4 parachute was used for reliability of the opening of the main parachute, but the drogue parachute could also fulfill the function of a pilot chute. As it turned out, this parachute system was experimental. It quickly became clear to the developers, that it was possible to eliminate the pilot chute, leaving only the drogue.

In comparing the D-1-8 and D-3 parachutes with the D-4 appears one important change: the stabilizing parachute was taken to the outside of the container and placed inside a special pocket on the drogue bridle, and the sleeve of the main canopy wasn’t pulled out of the container during the time of stabilization. This meant that the container remained closed during the time of stabilizing, thereby guarding the main parachute from the chance premature opening in the wind stream during a jump from a high speed aircraft. Also, it eliminated pulling from the container a portion of the sleeve during the time of stabilization which had increased the problem of twisting and spinning.



Method of Operation of the parachute system D-4 (left)

1 – drogue parachute; 2 – rigging pouch; 3 – static line; 4 – drogue d-bag; 5 – AAD; 6 – 2-cone release rings; 7 – main container; 8 – lanyard; 9 – rings; 10 – terminal end of the pilot chute lanyard; 11 – pin; 12 – pilot chute; 13 – main canopy sleeve; 14 – main canopy

Design of the drogue parachute (right)

1 – canopy; 2 – suspension lines; 3 – bridle; 4 – lanyard; 5 – gusset???; 6 – body of the canopy; 7 – canopy reinforcement; 8 – cap; 9 – nylon locking straps; 10 – 2-cone release rings; 11 – packing pocket; 12 – elastic stows for the staticline; 13 – flap; 14 – elastic stows for closing the packing pocket

The drogue parachute of the D-4 had a bridle in the form of a wide and long panel that, it appeared, was intended for reducing spinning and outwardly resembled the pulled out sleeve of the D-1-8 and D-3. The bridle had a special packing pocket into which was placed the drogue d-bag.

As in the case of the D-1-8 and D-3, the designers kept the possibility to use the parachute without the drogue for jumps with direct bag deployment with a staticline from certain aircraft.

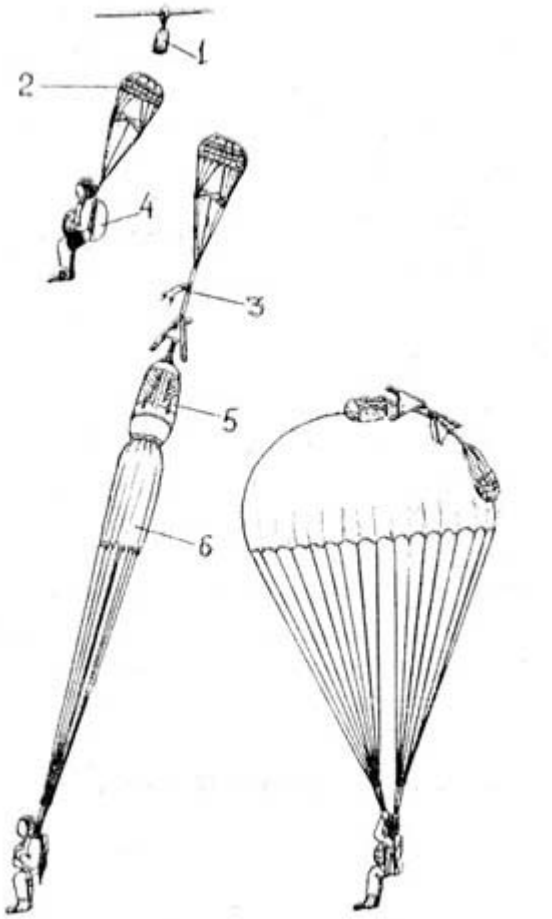
Design work didn't stop and a new scheme for a parachute system was suggested, that is, excluding the large and awkward spherical pilot chute with spring. The drogue parachute would be located in a special pocket (which still resembles the BLM drogue d-bag without a staticline), into which it was rigged without any d-bag. The pocket would be attached to the cable inside the aircraft by a carabineer (sometimes with the use of a special extender) and remain in the aircraft after the jump. By this method, it was managed to get rid of the staticline. The simplification of design had several advantages – reducing the cost of the parachute, simplifying packing the parachute, increasing reliability of operation and significantly reducing the weight and bulk of the system, which for a paratrooper is very important. Besides this, eliminating the pilot chute allowed to change the design of the container, appreciably simplifying it and reducing its bulk.

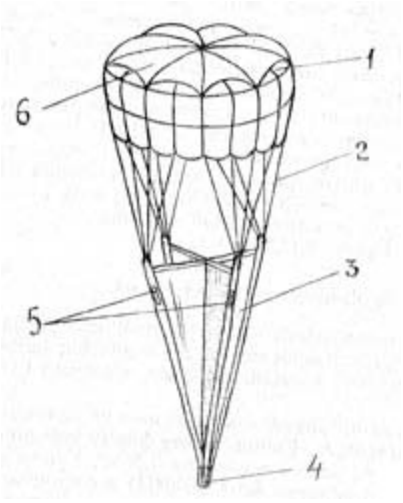
The new parachute, created in 1969, was called the D-5. The engineer responsible for this parachute was Klavdia Petrovna Balakireva. In design the D-5 in place of a sleeve for the main canopy a d-bag was used, that during the time of stabilization was located in the closed container and was not used as part of the stabilizing system. The stabilizing system worked separately and consisted only of the canopy and suspension lines, the pocket, d-bag for the lines and bridle. The lines for the stabilizing parachute were rather long length (1.3m) and so that these lines wouldn't tangle and snag on a piece of equipment, they were packed in special stows that were sewn to the pocket of the drogue canopy, and the remaining slack of lines were closed in a special container on the stabilizing canopy, that were stretched out at the moment of opening on the stabilizing canopy. The bridle now was simple webbing, and again was put the question of spins and twists!

This time they decided to change not the bridle, but the lines of the stabilizing parachute. In place of the long lines they began to use a stabilizer, in the form of two pieces of fabric which had the form of isosceles triangles. The fabric was made from grey nylon and stitched together along the central axis, forming a four vane stabilizer. On the outside edge of every vane was sewn webbing, forming a loop at the top corner, to which were attached lines and to the lower end – a link, like a rope eye. On the webbing near the top of the side of the vane was sewn a ring. The rings on the vanes were tied with a safety tie to a ring on the stabilizing parachute d-bag.

The stabilizer stopped the spinning, seriously lessened the twisting, and allowed simplification of construction, making it more reliable. Removing the long lines and

container for the lines of the stabilizing parachute allowed simplifying the drogue d-bag. The drogue lines remained, but much shorter. The shorter lines (0.5m and 0.52m) did not have to be stowed and it was enough to simply gather them in s-folds and place them in the container together with the canopy of the stabilizing parachute. The modified stabilizing system and simplification of construction of the container of the D-5 became the D-5 series 2.





Operation of the parachute system D-5 series 2 (left)

1 – pocket (d-bag) of the drogue parachute; 2 – drogue parachute; 3 – bridle; 4 – container; 5 – main canopy d-bag; 6 – main canopy

Design of the drogue parachute (right)

1 – canopy reinforcement; 2 – suspension lines; 3 – stabilizer; 4 – eyelet; 5 – rings for a breakcord tie on the d-bag opening; 6 - cap

The new parachute system worked so: During the exit of the parachutist from the aircraft the drogue parachute is pulled from the pocket (drogue d-bag) which is attached by a carabineer to a cable. In the aircraft An-12, An-22, An-26, Il-76, and helicopter Mil-8 it is stretched out inside the cargo bay at the rear door opening. An extender is used in the aircraft An-2 and helicopter Mil 6 and the drogue deploys under the fuselage. At the moment of inflation the drogue bridle is stretched out and pulls out a flexible pin from the AAD PPK-U-1165/AD or AK-ZYD-165 that is connected to the drogue bridle with a 0.36m long lanyard.

After the inflation of the drogue canopy the parachutist falls stably. During this time the container of the main parachute remains closed. Termination of the stabilized decent, the release of the container flaps and the entering into action of the main canopy occurs after the opening of the two cone lock by hand (using the ripcord) or by the AAD, in result of which the stabilizing parachute pulls out the main canopy d-bag from the container.

As the main canopy d-bag is pulled away from the parachutists the suspension lines are pulled out smoothly from their stows. With the full extension of the suspension lines the locking stows on the d-bag are pulled and the lower free part of the canopy, the lower 0.2m not being contained by an elastic ring, is exposed. As the d-bag is pulled farther away the remaining part of the canopy is exposed until it is entirely stretched out. The inflation of the main canopy starts after it is pulled out of the d-bag about half way and is completed after the d-bag is pulled completely off.

The idea of using a stabilizing device exploded (expanded wildly) and in a short time period there were many modifications of the parachute D-5. Using different canopies, but keeping the general structural parachute system (container- drogue) already worked out on the D-5 serial 2, new systems were designed for different purposes (for example, D-6, PCN-71,PV-3, CN-74, PTL-72, T-4C, Lesnik, PA, PCN-80, Lesnik-2, D-10). The container and drogue remained, practically, one and the same.

Parachutes changed, new ones were developed, but the stabilizing system of the parachute D-5 series 2, having performed very well, has been used practically unchanged for already 40 years. The extensively used parachute systems D-6 and D-10 have in their makeup the insignificantly changed stabilizing system, first used in 1970.

NEW PARACHUTES – NEW DECISIONS

With the development of parachute technology began to appear new systems. This was not done without experiments. This involved stabilizing systems: they tried canopies of different sizes, different quantity of vanes on the stabilizer, lines of different lengths, d-bags, containers, bridles – practically all the elements of the stabilizing system in these

or other variances underwent changes. Parrallely went the research of the development of completely new designs of stabilizing systems.

Paratroopers with D-6 series 4 parachute systems in an Il-76 before completing a jump. Well seen in the stabilizing parachute in the d-bag, attached to the overhead cable.

One of these projects was an effort to use for stabilizing the parachutist in the air several supporting parachutes that didn't play a role in the process of opening the main parachute. Deploying the main parachute was done by a special pilot chute. That is to say, the pilot parachute and the stabilizer by design were separated and worked independently.

Supporting stabilizing parachutes were meant for the stabilization of a falling parachutist in the necessary position until the moment the pilot chute came into action. They were using this principle to make the first experiments in 1940. Experimental parachute systems were developed with several supporting parachutes of small size, for example the D-8 and the experimental variant TP-6 (Paraavis).

Parachute system D-8. Well seen are the supporting parachutes on the risers.

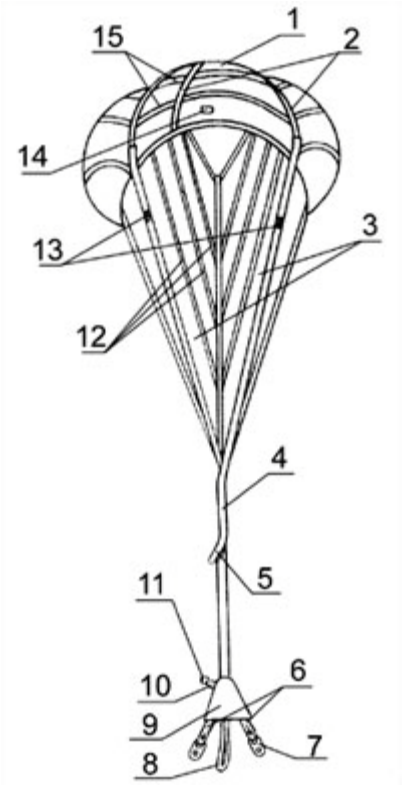
The concept appeared so: After exit from the aircraft, a staticline opened a flap on the container and put into operation four supporting parachutes, which by design were mounted on the risers and were intended to support the falling parachutist by the shoulders, more accurately by the risers, while the main parachute was still in the container. After the action of the AAD or the pulling of the ripcord main canopy deployment was accomplished by a pilot chute.

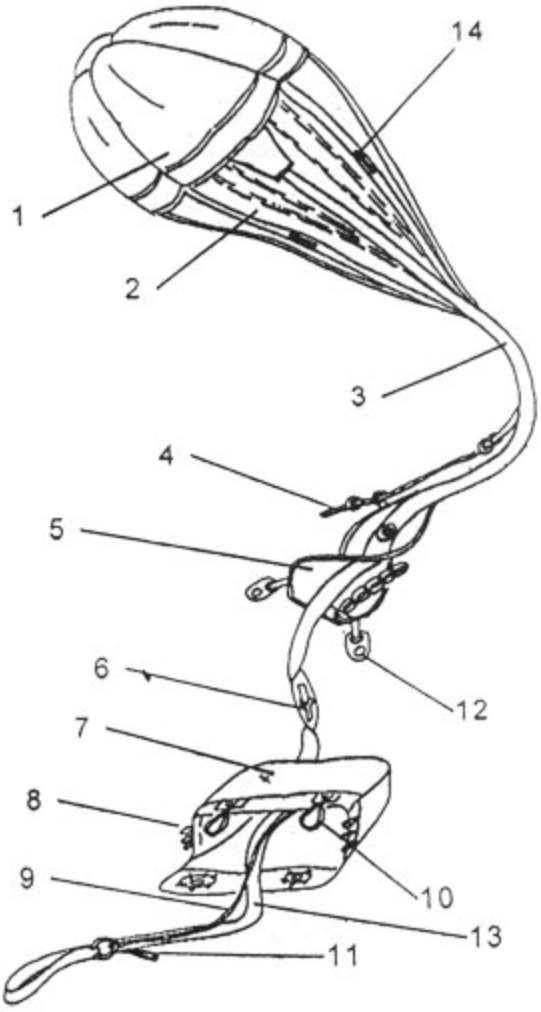
An example of this system is the parachute D-8, which is shown in the photo. One of the advantages of this system, it appears, is that a special lock for the stabilizing system is not required. But, in all probability this design turned out unsuccessful and it had no particular advantage over the current system. However the supporting parachutes have found wide use in multi canopy cargo parachute systems.

Further development in the classic design of stabilizing systems was the lineless drogue.

The lineless drogue was first used in several modifications of the parachute D-6 around 1990. The main difference in this design is that the vanes of the stabilizer are attached directly to the canopy and make up with it the entire suspension system. Removing the lines succeeded in significantly simplifying packing, lessened the weight and packed

volume and increased the reliability. Besides this, the production of such a parachute is more streamlined and much cheaper than with lines.





Lineless drogue parachute D-6 and D-10 (left)

1 – canopy; 2 - reinforcing radial tapes; 3 – vane; 4 – bridle; 5 – loop for the AAD flexible pin; 6 – closing webbing; 7 – 2-cone release rings; 8 – loop; 9 – gusset; 10 – webbing; 11 – ring to guide the AAD pin lanyard; 12 – reinforcement tape; 13- rings for a closing tie at the d-bag opening; 14 – stamp panel; 15 – reinforcing tape

Design of the drogue parachute Lesnik-3 and Arbalet-2 (left)

1 – drogue canopy; 2 – vanes; 3 – bridle; 4 - flexible pin; 5 – reinforcing triangle; 6 – container closing pin; 7 – main d-bag; 8 – rubber band stows; 9 – reefing line; 10 – locking stows; 11 – ring; 12 – 2-cone release rings; 13 – reefing line limiting bridle; 14 – ring for break tie at the drogue d-bag opening

The drogue parachute had become used with ram air canopies. But because the ramair parachute is a “wing”, the stabilizing parachute has significant enough area, located behind the main canopy and inflated from the airflow, to seriously degrade the performance of the main ramair canopy. Using the classic stabilizing parachute with lines, for example is the parachute Lesnik-2, which must accept this disadvantage. But a lineless stabilizing parachute would have the possibility too completely without consequence collapse. For this is used a single useful device – a reefing line.

After the main parachute has been pulled from the d-bag, the reefing line system of the stabilizing parachute is pulled tight and pulls in the apex of the stabilizing parachute. That results in the full collapse and lessing of the aerodynamic drag. In this way the collapsed stabilizing parachute doesn’t hinder the gliding decent of the parachute system.

The reefing line is used on modern sport parachute systems for collapsing soft pilot chutes. Probably, the idea transferred from the sport parachute system to the system with a stabilizing parachute. The lineless stabilizer of this type received wider use in modern gliding systems for special purposes like the Arbolet-1, the Arbolet-2, the Arbolet-3 and the Lesnik-3.

Gliding parachutes Lesnik-2 (left) and Arbalet-2 (right). Well seen are the inflated drogue of the Lesnik-2 and the collapsed lineless drogue of the Arbalet-2.

DEPLOYING AND STABILIZING TWO-PLACE PARACHUTE SYSTEMS

In recent years tandem parachute systems that are used for jumps with untrained people are widely spread. One of the parachutists is the “tandem master”, the other is the “passenger”. These systems stand alone in our list of those utilizing stabilizing parachutes because it is very difficult to furnish stabile free fall of two parachutists (instructor and passenger).

Current systems structurally are close to sport systems. The tandem master is required to have specific experience and corresponding qualifications. Since these systems developed from sport systems, a pilot chute is used as a stabilizer. Therefore the design of the stabilizing system of these parachutes is very simple and lacks the fins of a stabilizer and lines. It is possible to compensate for spinning around the vertical axis with the hands and legs because of the required experience.

Tandem parachute system Arbalet-3 (left) and Stealth-tandem (right)

Tandem parachute systems work in this way: The instructor and passenger exit the aircraft freely and so fall for some time. Then the tandem master by hand deploys the drogue parachute, pulling it out from a special pocket on the lower flap of the container and letting it go in the wind stream. The drogue, having opened, stabilizes both in the face down position creating the illusion of freefall. For the opening of the main parachute, the tandem master pulls a handle for opening the lock of the drogue (a three ring release). A cable is pulled from a loop to free the rings of the lock. The rings of the

lock in turn release from an interlocking arrangement, because of this the lock releases the stabilizing parachute from the harness.

After release from the harness, the drogue extracts a pin from a loop locking the lower compartment of the container thereby freeing the flaps of the compartment of the container.

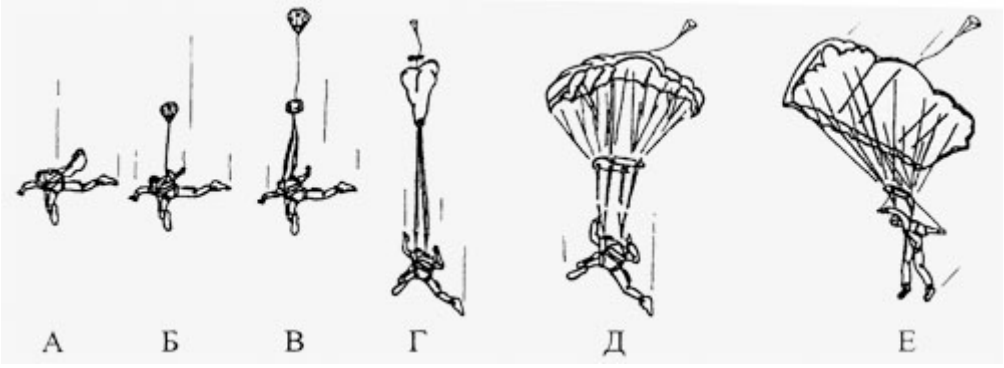
Following this the drogue parachute takes off from the container and in turn pulls out the main canopy d-bag from the lower compartment of the container; the suspension lines from loops and stows on the d-bag; the canopy from the d-bag. After the inflation of the main canopy the reefing line pulls in the apex of the drogue and collapses it in full.

Such a system has only hand activation to deploy the drogue. Such systems include the Stealth-tandem (Paraavis) and Arbalet-3 (PO Zvesda).

The same method (by hand) is used in deploying the stabilizing system of the parachute system Arbalet-1 when packed in the variation “for a jump in stabilized fall”. The drogue parachute there is used to give stability to a falling parachutist making a jump with a chest mounted cargo container for 50 kg of cargo. The parachutist with the cargo container is stabilized in the position “lying” face down.

Work of stabilizing with this system is practically the same as the tandem parachute system, only in place using a pilot chute a regular lineless drogue with vanes and a reefing line is used– the same as on the other systems of gliding main parachutes and forced into action of the drogue parachute.

On the apex of the drogue parachute is sewn a special plastic pud that the parachutist uses to pull it from a special pocket located on the lower flap of the container and pulls it immediately into the airstream.



Operation of the gliding parachute system Arbalet-1 using the drogue

A – pulling the drogue out into the airstream; B – decent on the drogue; C – pulling the main d-bag out of the container and lines from the line stows; D – pulling the main canopy from the d-bag; E – inflation of the main canopy; F – gliding decent

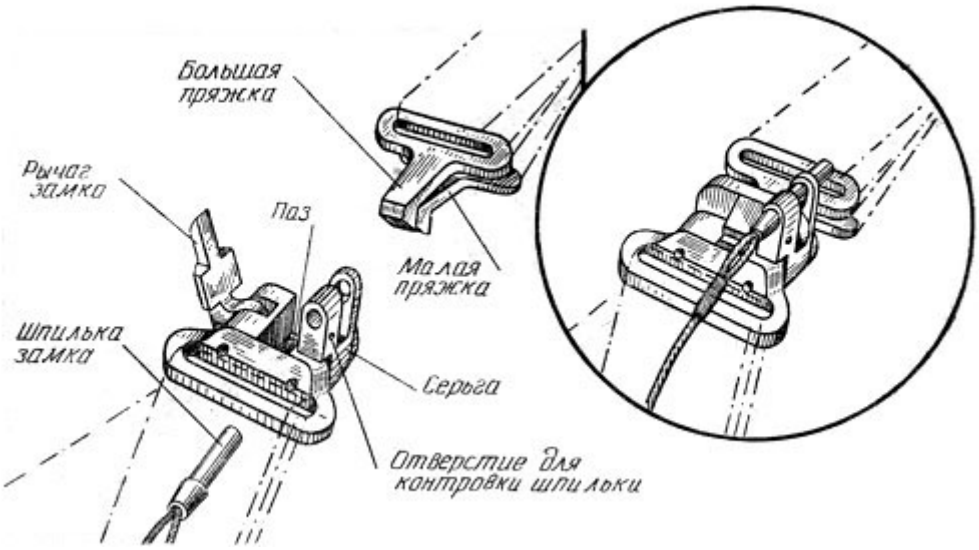
LOCKS

So that the main canopy does not open during the decent under the drogue, a special lock is needed. On opening, this lock should release the stabilizing system from the container or harness and allow the drogue to pull from the container the main parachute.

When the parachute design changed, the lock changed also. But it has turned out that there are not so many locks for the stabilizing systems. Actually, this is not surprising, since practically any lock can be used with any parachute.

As was already written earlier, the first lock was made by Stanislav Karamishev in 1940. But since there wasn't any practical value from the jumps with stabilized decent in that year, work on the creation of devices and experiments were fully experimental. The lock was mounted on the harness, on the main lift web. And it was opened by a special ring with a cable. For opening the container of the main parachute was used a different ring. Unfortunately, no examples of this system are to be found.

Z-51: The second attempt to make a system "with changing speed of decent", that is with the possibility of stabilized decent, was after the Great Patriotic War and designed by Lobanovim. It was the parachute system PDPC-48 with the original lock Z-51. The rip cord of this parachute had two cables – one to open the container, and the second the lock for the d-bag. The lock was mounted on the harness on a special two-webbing pyramid. With the aid of the lock the harness was attached to the d-bag and stabilizing parachute.



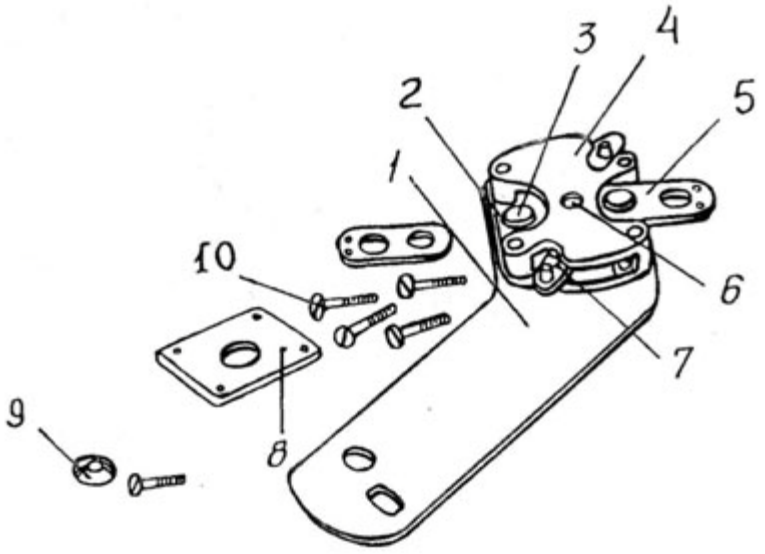
Lock Z-51 for the parachute system PDPC-48

The lock consisted of the body, a pin, and two hooks. In the body of the lock was a groove in which are inserted the hooks that are sewn to the d-bag. The hooks were held in the lock by a lever that was latched to body by a pin. For protecting the head of the parachutist from the possibility of a blow by the lock, a bag made from fabric with batting was put over the lock, the bag was fastened with four snaps.

The lock Z-51 turned out too complicated and unreliable and, probably because of this was not used in other systems.

The two-cone lock: Working on the parachute D-1-8, the brothers Doronin concluded that for the work of the system was needed a special lock, which they in the future developed. In 1959 work started on a new lock. In the process of development 17 different designs were developed and constructed. And in 1969 appeared the lock that fulfilled all the parameters. The lock turned out very successful – simple and easy to produce. It was called “two-cone”.

2-cone lock on the container of the parachute system Arbalet-2



2-cone lock

1 – mounting plate; 2 – body with the cones; 3 – cones; 4 – cover; 5 – ring; 6 – cover screw; 7 – bolt with two cones; 8 – reinforcement; 9 – bolt; 10 - screw

The two-cone lock of the brothers Doronin has already more than 40 years been used in military parachute systems.

To be fair it should be mentioned, that in the beginning a different lock was used with the D-1-8, but it turned out insufficiently reliable. Its unreliability was the reason for the development by the brothers of the new design. Unfortunately, I wasn't able to find any information on this lock.

The two-cone lock is mounted on the upper part of the container and intended for the locking of the rings of the closing straps of the stabilizing parachute or the lacing strap of the main parachute d-bag (like the D-1-8, D-3, PCN-66). Loops of the cable for hand opening and the cable of the AAD (KAP-3M, PPD-10, PPK-Y-165-D or AD-ZU-D-165) attach to it for opening.

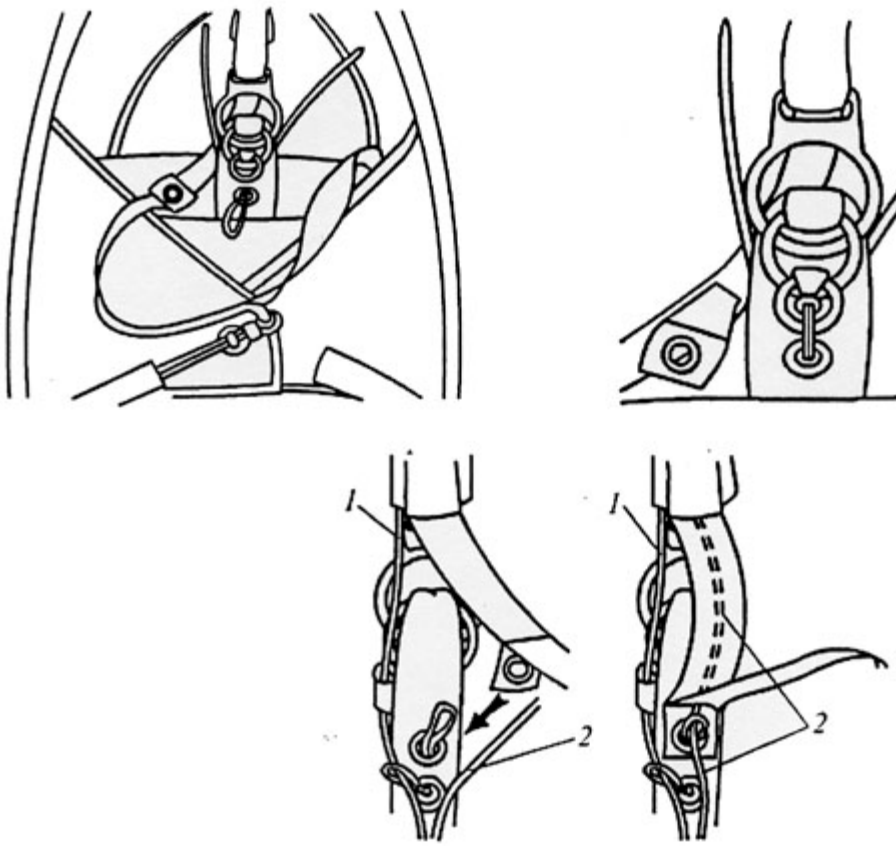
The two-cone lock consists of a mounting spacer, body with two cones, bolt with two cones, cover, two links, mounting plate, a cover plate screw, five screws and one nut. It is attached to the container with four screws.

It has turned out that the two cone lock couldn't be used on several parachute systems. For example, the two place tandem systems, both the Russian and foreign models. Therefore recently more often is used a simple and reliable devise, intended for releasing risers on sport parachutes – the three ring release, consisting of three rings of various diameters, a cable and loop.

For example, it is used on the TP-5, the TP-6, the Kentavr, the Stealth-tandem, the Arbalet-1 and the Arbalet-3.

The three ring release – a simple and reliable device, it doesn't require maintenance, and is very simple in manufacture and use. Three rings of different diameters go one through another and are locked in place by a cable. The cable runs through a loop that is passed through a grommet. In order to open the device, it is required simply to pull out the locking cable from the loop, which had that way the strain of the entire system. Moreover the exertion for pulling out the cable is inappreciable.

Such devises for stabilizing systems for personal parachutes still haven't received wide spreading possibly because of its young age; however the idea continues to be developed. At the current time are used both the two cone lock and the three ring release.



3 ring release of the parachute system Arbalet-1

1 – cable from the emergency handle (main release); 2 – cable from the drogue release handle

Tandem system Stealth-tandem. Well seen is the three ring release.

It should be noted that the two cone lock is significantly more complicated in production and requires serious manufacturing capability, and also periodical regulation work periodically to locks on parachute systems.

ADVANTAGES AND DISADBANTAGES

Parachute systems with stabilizers, in comparison to systems of free action have a number of merits and deficiencies. But the appeared disadvantages are not significant in comparison with that possibility that allows to receive the presence of a stabilizing system on a parachute.

Advantages:

Allows to lower the speed of free fall and horizontal component of speed during a jump from a high speed aircraft, and means a substantially simpler design of the main canopy.

There is not the requirement to train the parachutist a stable free fall. Independently from the action of the parachutist, the stabilizing system puts his body in a position better for the working of the parachute system and the comfort of the parachutist.

Simplifying the design of the deployment system and the system of arming the AAD.

Disadvantages:

More complicated method of exit of the parachutist from the aircraft than with a system without a stabilizer. During exit it is necessary to eliminate the chance of staging the stabilizer on part of the body and equipment of the parachutist.

The requirement to have a special lock, closing the container during stabilization that requires service.

More complicated packing in comparison with a system without a stabilizer.

Impossibility to use the majority of these systems on unequipped aircraft.

FUTURE DEVELOPMENTS

Without a doubt, stabilizing systems will be further developed. They already widely are used not only in personnel parachute systems, but in multiple canopy cargo chute systems for dropping cargo and military equipment. Stabilizing systems have found also their use in emergency parachutes and in ejection seat systems. Further development in my view will be in the direction of lineless drogues. It allows significantly shorter time to pack and raises the reliability in use. And the use of modern materials allows to use unseen before quality – compactness, small weight, durability, the required permeability.