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(54) **METHOD OF PRODUCING A FIRE EXTINGUISHANT AND SPRAY DUCT FOR THE IMPLEMENTATION THEREOF**

(57) The proposed group of inventions relates to the field of water spraying and fire-fighting and can be used for automatically or manually extinguishing fires and in stationary and mobile fire extinguishing systems. The present method of producing a fire extinguishant involves creating a flow of water and passing same through a spray duct. The spray duct is formed of a water flow supply duct and a nozzle, which are interconnected and are arranged one behind the other. The diameter of the nozzle is larger than the diameter of the water flow supply duct. The nozzle is shaped like a cup with each of the water flow supply ducts passing through its base. The smallest angle between the inside wall of the cup and the base of the cup is not more than 90 degrees. Thus, inside each spray duct at least one water flow stalling edge is formed which breaks down a passing water flow into a plurality of individual comoving microcapsules, whereupon said microcapsules randomly bounce off the inside walls of the spray duct and collide with one another, producing a finely dispersed spray of water at the exit from the spray duct. Technical result: increased penetration ability of the extinguishant produced.

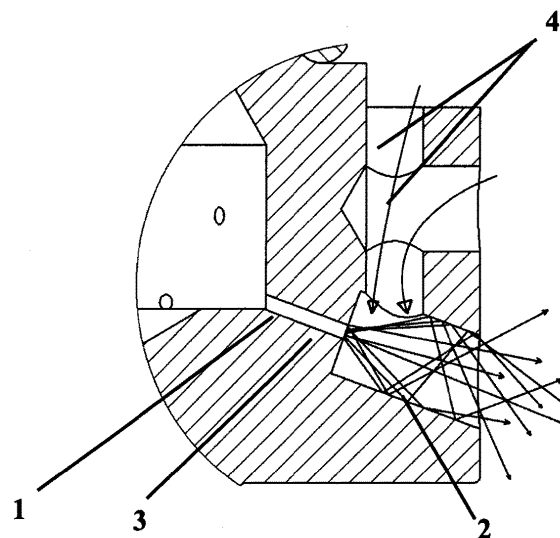


Fig. 1

Description

TECHNICAL FIELD

[0001] The proposed group of inventions relates to the field of water spraying and firefighting and may be used for automatic and manual extinguishing of fires, in stationary and mobile firefighting appliances.

PRIOR ART

[0002] A method is known from the prior art for producing water vapour by forced ejection of water at a pressure of 140-200 atm through spray heads [US5944113, IPC A62C31/05, A62C37/11, A62C37/14, B05B1/14, publ. 31.08.1999]. To provide the possibility of spraying mist with fine droplets in known nozzles of spray heads, through-holes are made, in which various mechanical obstacles are fitted. These mechanical obstacles may be, for example, a rotating component, a fixed blocking element of a particular shape, a helicoidal spring, etc.

[0003] A significant drawback when using such obstacles is that they reduce the efficiency of the spray head. This means that to obtain spraying of the required type it is necessary to provide considerable working power. Moreover, the presence of obstacles in the nozzles has the effect that the designs of the nozzles and spray heads become quite complex. Such nozzles are difficult to manufacture, and they must be enclosed in special nozzle housings, mounted in the body of the spray head. The result is an increase in the cost of manufacture of the spray head.

[0004] Another patent [US5881958, IPC A62C31/02, B05B1/02, B05B1/04, publ. 16.03.1999] describes a nozzle for delivering a mixture of finely dispersed liquids, similar to a mist. To obtain a uniformly dispersed mixture throughout spraying, surfaces with recesses are made in the nozzles, causing the liquid streams to create regions of negative pressure, remote from the surface of the front end of the nozzle tip. Formation of these surfaces with recesses requires special machining, due to their configuration.

[0005] A mist-forming nozzle is known [US2813753, IPC A62C31/22, B05B1/14, publ. 19.11.1957], which has through-holes ending in corresponding recesses, which are inclined at an angle relative to the corresponding through-holes. The recesses have a small ratio of length to diameter, which in conjunction with said slope makes it impossible to create a mist spray with high moment of momentum even at high pressures. Three mist forming mechanisms are described in the known document. In the first mechanism, water is discharged asymmetrically from a small through-hole opposite the wall of a recess at the periphery of the nozzle; in the second mechanism, water is discharged from small convergent through-holes for discharge, located opposite one another; in the third mechanism, water is discharged from a small through-hole for forcing at high pressure relative to the recess

without colliding with the recess. The first two mechanisms make it possible to create a mist at relatively low pressure, but the mist has a low moment of momentum even when the pressure is increased. The third mechanism only allows a mist to be created at high pressure.

[0006] A patent is known [RU2248826, IPC A62C31/02, 27.03.2005] in which several variants are described for creating a water mist with small particles (fire extinguishant) by means of various spray heads, in which channels that are interdependent with respect to length and width, produced by drilling, are located successively, one after another. Liquid that is forced out of a chamber at high pressure, 80-100 atm, passes through a channel of smaller diameter (water stream feed channel) onto the walls of a channel of larger diameter (nozzle) via a tapered transition from one diameter to another. Maximum turbulent dispersion of the liquid that is forced out is created utilizing the effect of surface tension in the larger-diameter channel. Maximum dispersion of the turbulent water stream in the method and devices described in said patent takes place on the outer edge of the larger of the two channels, i.e. on the outside of the spray head.

[0007] The drawbacks of said method and devices for implementation thereof are: 1. High pressure is required in the system (140-200 atm) to provide a pressure at sprayer inlet of 80-100 atm. Observation of the operation of these devices showed that at lower pressure, despite the opposite assertion in the patent, a mist effect is not achieved, for the reasons described in that patent itself. The most accurate description of the condensate state of the sprayed water at a pressure below 80 atm on a sprayer using said method and devices is a dew. 2. Requirement of maximum concentricity of the interdependent spray ducts, made by drilling. 3. Fixed interlinked dependence of lengths and diameters of the interdependent spray ducts. 4. Considerable consumption of water per specific unit of heat transfer of the seat of combustion. 5. High power consumption of the electric motors (15-37kW per 100 litres of water) for operating the high-pressure pumps at 140-200 atm.

DISCLOSURE OF THE INVENTION

[0008] The technical solutions described in this patent are taken as the closest prior art for the claimed technical solutions. Thus, in essence, the known method of producing a fire extinguishant consists of creating a water stream and passing it through at least one spray duct, and with a tapered transition for creating turbulence of the water stream provided inside each spray duct.

[0009] A known spray duct used for implementing the method described is in essence formed from two communicating, concentrically arranged channels for feed of the water stream and a nozzle, the diameter of the nozzle being larger than the diameter of the channel for feed of the water stream. Moreover, a conical transition of the water stream is formed at the point of transition from the channel for feed of the water stream into the nozzle.

[0010] The problem to be solved by the present group of inventions is to create a novel method of producing a fire extinguishant and a spray duct used for implementation thereof, achieving the following general technical result: increase in the efficiency of extinguishing local and volumetric seats of fire of classes A and B of any category of complexity by increasing the penetrating power of the fire extinguishant created.

[0011] This problem is solved with respect to the method in that in the known method of producing a fire extinguishant, comprising creating a water stream and passing it through at least one spray duct, according to the present invention, at least one edge for break-away of the water stream is formed inside each spray duct, after passing over which the water stream is broken up into a plurality of individual microdroplets moving together with subsequent initiation of a process of chaotic repulsion thereof from the inside walls of the spray duct and collision with one another, obtaining a finely divided water mist on discharge from the spray duct to the outside.

[0012] A variant is possible, in which, after break-up of the water stream, it is saturated with atmospheric air by drawing atmospheric air into the spray duct after the edge for break-away of the water stream, but before discharge from the spray duct to the outside.

[0013] The problem with respect to the spray duct is solved in that, in a known spray duct used for producing a fire extinguishant, formed from at least one channel for feed of the water stream and a nozzle, communicating and located one after another, the diameter of the nozzle being larger than the diameter of the channel for feed of the water stream, according to the present invention, the nozzle is a cylinder, through the bottom of which each channel for feed of the water stream passes, moreover the minimum angle between the inside wall of the cylinder and its bottom is not more than 90 degrees.

[0014] A variant is possible, in which at least one channel for feed of air, communicating with the nozzle near the bottom thereof, is additionally introduced.

[0015] Thus, by means of the claimed group of inventions, the efficiency of extinguishing local and volumetric seats of fire of classes A and B of any category of complexity is increased by increasing the penetrating power of the fire extinguishant created, owing to the ability of the substance created, which is a super-dense, finely divided water mist, to fill the protected volume of the premises instantly, and high efficiency of extinguishing local and volumetric seats of fire of classes A and B of any category of complexity, which is mainly characteristic of gaseous volumetric fire extinguishing systems.

[0016] It should be noted that with possible mixing of the finely divided water mist with atmospheric air by drawing it into the stream of finely divided droplets of the sprayed water stream, there is an increase in efficiency of the fire extinguishant obtained by means of the main technical solution.

[0017] Moreover, compliance of the claimed group of inventions with the criterion of inventive step is substan-

tiated by the following.

[0018] The liquid medium sprayed by the present method, in contrast to all the methods and devices described above, is defined as a stream of a plurality of individual microdroplets moving together, receiving an excess charge of kinetic energy by excess pressure, forcing the droplets of the water stream into translational motion and their tendency to release the accumulated energy. Release of the accumulated energy of each individual microdroplet occurs at the moment it emerges, on the edge for break-away of the water stream, which is formed by passage through the channel for feed of the water stream through the bottom of the nozzle, located at an angle of not more than 90 degrees to the inside wall of the nozzle. Moreover, the stream of fine droplets that have broken away from the edge impinges on the inside walls of the nozzle. Each microdroplet acquires an individual acceleration and trajectory of motion, depending on the amount of accumulated kinetic energy. In the physical sense, all the droplets tend to repel one another, increasing the runaway distance. The further trajectory of motion of the vast majority of the individual droplets is deflected by nozzle walls, directing the reflected droplets towards one another. There is then further collision of droplets moving towards one another, with even greater dispersion and increase in the number of droplets moving freely and chaotically. The process of chaotic repulsion and collision of free droplets continues with increasing intensity. On leaving the spray duct they form a finely dispersed fire extinguishant, formulated as a super-dense finely divided water mist, possessing high penetrating power, the ability to fill the protected volume of a room instantly and high efficiency of extinguishing local and volumetric seats of fire of classes A and B, of any category of complexity.

[0019] When atmospheric air enters the nozzle, the microdroplets, possessing a high charge of kinetic energy, capture weakly charged air molecules from the air stream, drawn in by injection into the stream of charged microdroplets, thereby increasing the intrinsic volatility. Thus, a process of injection of air into the nozzle is formed, with subsequent formation of an air/droplet finely dispersed fire extinguishant.

[0020] In contrast to other methods previously described, where formation of a finely divided aqueous substance is achieved by the effect of surface tension and the associated vortical turbulence of the water stream, which is at a pressure of 80-100 atm at sprayer inlet, sprayed on the outer edge of known sprayers. It is only by adhering to the stated conditions of the proposed method, according to the claims, that a finely dispersed fire extinguishant is formed, formulated as a super-dense finely divided water mist, possessing high penetrating power, the ability to fill the protected volume of a room instantly and high efficiency of extinguishing local and volumetric seats of fire of classes A and B, of any category of complexity. In essence, a suspension is formed by the claimed method, i.e. a plurality of water droplets, covering

and enveloping the seat of the fire, the conditions for their dispersal being created by means of the spray duct.

[0021] Moreover, if air is drawn in, a two-component substance is formed (mixture), since the water and air interact, in contrast to the prior art, in which they form a one-component substance.

[0022] It was established experimentally that the effect of the super-dense finely divided water mist, able to fill the volume of a protected room instantly, is achieved at significantly lower pressure of the substance, equal to 30-60 atm (and pressure in the fire-fighting system of 50-80 atm, respectively), which ensures much lower electric power consumption required for the operation, as a minimum, of one pump unit forming the water stream supplied to the break-away edge.

BRIEF DESCRIPTION OF THE DRAWINGS

[0023] The essential features of the claimed group of inventions and the possibility of practical implementation thereof are explained by the following description and drawings.

Figs. 1-7 show variant embodiments of a general type of spray duct (sectional side view).

Figs. 8-9 show the nozzle used in various types of spray heads.

Fig. 10 shows the application of the claimed group of inventions as a conical spray head of the sprinkler type (sectional side view).

Fig. 11 shows the application of the claimed group of inventions as a cylindrical spray head of the sprinkler type (sectional side view).

Fig. 12 shows the application of the claimed group of inventions as a conical spray head of the drencher type (sectional side view).

Fig. 13 shows the application of the claimed group of inventions as a cylindrical spray head of the drencher type (sectional side view).

IMPLEMENTATION OF THE INVENTION

[0024] The method of producing a fire extinguishant (Figs. 1-13) comprises creating a water stream and passing it through at least one spray duct, formed from at least one channel 1, communicating and located one after another both concentrically and non-concentrically at an angle different from 180°, for feed of a water stream (designed with possibility of communicating with the valve channel of the spray head) and a nozzle 2, the diameter of the nozzle 2 being larger than the diameter of each channel 1 for feed of the water stream. Nozzle 2 is in general a cylinder, through the bottom of which each

channel 1 for feed of the water stream passes, the angle between the inside wall of the cylinder and its bottom being not more than 90 degrees ($\leq 90^\circ$), aiming at the smallest of the angles formed. Thus, inside each spray duct, at least one edge 3 for break-away of the water stream is formed, after passing over which the water stream is broken up into a plurality of individual micro-droplets moving together with subsequent initiation of the process of their chaotic repulsion from the inside walls of the spray duct and collision with one another, obtaining a finely divided water mist on discharge from the spray duct to the outside.

[0025] After break-up of the water stream it can be saturated with atmospheric air by drawing atmospheric air into the spray duct after the edge 3 for break-away of the water stream, but before discharge from the spray duct to the outside. For this, at least one air feed channel 4 may additionally be introduced into the spray duct, said air feed channel communicating with the nozzle 2 near the bottom thereof, namely between the bottom and the place where the main stream of droplets collides with the inside walls of the nozzle. The channel 1 for feed of the water stream enters the bottom of nozzle 2 at an angle such as to prevent most of the water stream going into the air feed channel 4, i.e. the relative disposition of the air feed channels 4 and of the channels 1 for feed of the water stream is taken into account when designing the spray duct. A variant is possible in which the air feed channel 4 meets the wall of nozzle 2 immediately after the edge 3 for break-away of the water stream (Figs. 1, 2, 4-7, 10-13). In this case the air feed channel 4 is usually formed with a drill. It may be composite, i.e. in the form of a set of several communicating channels, leading externally into the nozzle 2. Another variant is possible, in which there is an air chamber 5 (Figs. 2, 4, 9, 10, 12), formed by means of an upright 6, in which holes are made for passage of air into nozzle 2, located between channel 1 for feed of the water stream and nozzle 2, and the air feed channel 4 is formed around the nozzle 2. Moreover, there may be several air feed channels 4 and they may be arranged in a circle around nozzle 2 (Fig. 8).

[0026] It should be noted that in the closest prior art, the nozzle is manufactured used a drilling method, which results in formation of a taper therein. In the claimed spray duct, the nozzle 2 is formed by milling, which precludes formation of a taper and allows several variants of design of the bottom, for example flat (Figs. 1, 2, 6, 7) (not taking into account process rounding at the edges owing to the use of a milling cutter), concave or of any other shape for which the minimum angle between the bottom and the inside wall of the cylinder of nozzle 2 is not more than 90 degrees ($\leq 90^\circ$). That is, in the case when a concave bottom is formed, the angle is reckoned between the wall and the tangent to the circle containing the bottom, and in the case of a sloping bottom (Fig. 6) it is the smallest of two angles between the bottom and the wall; there is also a possible variant embodiment of the bottom in the form of a depressed cone (Figs. 3-5), with the channel 1

for feed of the water stream passing through its vertex. Moreover, the walls of the nozzle 2 may also be sloping (Fig. 6). There may be several channels 1 for feed of the water stream (Fig. 7), with an edge 3 for break-away of the water stream formed at the point of transition from each channel 1 into the nozzle 2.

[0027] Moreover, the angle at which the channel 1 for feed of the water stream passes through the bottom of the nozzle 2 does not affect achievement of the technical result, nor does the shape of the bottom and the concentricity or non-concentricity of the disposition of the channel 1 for feed of the water stream and of the nozzle 2. Because what is most important is the edge 3 for break-away of the water stream that is formed on passage of the channel 1 for feed of the water stream through the bottom of the nozzle 2, actually inside the spray duct, in contrast to the closest prior art, where a break-away edge is formed at the outlet from the spray duct to the outside, for a water stream already made turbulent by means of a tapered transition. In the claimed technical solution, everything is done so that, at the point of transition from the channel 1 for feed of the water stream into the nozzle 2, there is no swirling of the water stream, and on the contrary there is multiple break-up thereof.

[0028] The nozzle 2 and the air feed channels 4 may be formed both in the body of the spray head, and may be made in the form of a separate nozzle 7 (Figs. 8, 9), inserted or screwed into the spray head with respect to the channel 1 for feed of the water stream.

[0029] In the spray head it is possible both to use spray ducts separately (Fig. 3), and together with the air feed channel 4 (Figs. 1-2, 4-7, 10-13), as well as various combinations thereof (Figs. 10, 12).

[0030] By means of the claimed group of inventions, it is proposed to create a fire extinguishant containing, as active components, fresh water or desalinated seawater and atmospheric air (if it is drawn in).

[0031] At least one spray duct is used in a fire-fighting system (not shown in the drawing), comprising spray heads (Figs. 10-13), the system (not shown in the drawing) made up of the elements listed above, a connecting pipeline (not shown in the drawing), pipe joints (not shown in the drawing), hoses (not shown in the drawing) and connections (not shown in the drawing), control valve devices (not shown in the drawing) and pump units (not shown in the drawing) with electric and pneumatic drive, together providing feed of fire extinguishant to the source of combustion.

[0032] Figs. 10-13 show the application of the claimed group of inventions for various types of spray heads.

[0033] Fig. 10 shows a conical spray head of the sprinkler type. The conical shape of the body 8 of the head is due to the need to direct the outlet orifice of the nozzle 2, located inside the screw-in nozzle 7, which also has an air chamber 5 and at least one air feed channel 4, at an angle of 75-30 degrees to the surface to be protected. The nozzle 7 is threaded and is screwed into the body 8 of the spray head or the channel 1 for feed of the water

stream. The body 8 is provided with a seal 9 and a thread (shown conventionally in the drawing) for assembling the head in a pipe adapter (not shown in the drawing). On the opposite side, a threaded nut 10 is screwed into the body 8, with at least one through-hole (not shown in the drawing), providing feed of water from the pipe (not shown in the drawing), through a pipe adapter (not shown in the drawing) into the valve channel 11 of the head, a rubber seal 12 and a gauze filter 13 preventing any mechanical impurities or suspended matter getting into the head. Inside the head, a valve channel 11 is drilled, allowing movement of the stem 14 of the shut-off valve and communicating with the channel 1 for feed of the water stream. The stem 14 of the shut-off valve with rubber seals 15 is arranged inside the body 8, lengthwise to the valve channel 11, together with the nut 10 of the body 8, ensuring retention of water in the pipeline (not shown in the drawing) until the time of operation (rupture) of the heat-dependent bulb 16. The heat-dependent bulb 16 is arranged in the holder of the body 8, which has at least one milled window 17 for ensuring that air heated by the seat of the fire is supplied to the bulb 16. The bulb 16 retains the stem 14 of the shut-off valve inside the nut 10 and is fixed by a set screw 18. The set screw 18, which has a thread and is screwed into the end face of the holder of the body 8, is intended for retaining and locking the heat-dependent bulb 16 in the working position. On rupture of the bulb 16, the stem 14 of the shut-off valve is released and water at a pressure of 40-60 kg/cm² is discharged from nut 10, thereby providing feed of water through the valve channel 11 into at least one spray duct, and the fire extinguishant formed therein is expelled towards the surface to be protected.

[0034] Fig. 11 shows an embodiment of the claimed group of inventions for the example of a cylindrical spray head of the sprinkler type. The operating principle of this head fully coincides with the operating principle of the conical head of the sprinkler type described above. The cylindrical shape of the body 8 is due to the need for interlinked arrangement of the channel 1 for feed of the water stream, to connect it with the nozzle 2, and the associated air chamber 5 and air feed channel 4 strictly with respect to one another, and to direct the outlet orifice of the nozzle at an angle of 75-30 degrees to the surface to be protected.

[0035] Fig. 12 shows an embodiment of the claimed group of inventions for the example of a conical spray head of the drencher type. The conical shape of the body 19 is due to the need to direct the outlet orifice of the nozzle 2, located inside the screw-in nozzle 7, which also has an air chamber 6 and at least one air feed channel 4, at an angle of 75-30 degrees to the surface to be protected. The nozzle 7 is threaded and is screwed into the body 19 of a conical spray head of the drencher type or the channel 1 for feed of the water stream. The body 19 is provided with a seal 20 and a thread for assembling the head in a pipe adapter (not shown in the drawing). The threaded nut 21, with at least one through-hole (not

shown in the drawing) is screwed into the body 19, to provide feed of water from a pipe (not shown in the drawing), through a pipe adapter (not shown in the drawing) into the valve channel 22 of the head, a rubber seal (not shown in the drawing) and a gauze filter 23 preventing any mechanical impurities or suspended matter getting into the head. An internal chamber (valve channel 22) is drilled inside the head. On command, after opening of the external shut-off device (not shown in the drawing), the head of water, at a pressure of 40-60 kg/cm², passes through the nut 21, the internal chamber (valve channel 22) and at least one channel 1 for feed of the water stream to the edge 3 for break-away of the water stream as a plurality of individual microdroplets, impelled towards the walls of the nozzle 2. By means of the air chamber 5 and at least one air feed channel 4, located together with the nozzle 2 inside the nozzle 7 screwed into the body 19, atmospheric air is fed in, captured by the chaotically moving microdroplets, the whole constituting the stream that is drawn in and mixed, which in its turn rushes out of the head, releasing the accumulated potential energy of the microdroplets, thereby forming a highly dispersed cloud of water mist saturated with air molecules, otherwise called a "dense finely divided water mist".

[0036] Fig. 13 shows an embodiment of the claimed group of inventions for the example of a cylindrical spray head of the drencher type. The operating principle of this head fully coincides with the operating principle of the conical head of the drencher type described above. The cylindrical shape of the body 19 is due to the need for interlinked arrangement of the channel 1 for feed of the water stream, and the respective arrangement of the nozzle 2, with the associated air chamber 5 and air feed channel 4 strictly with respect to one another, and to direct the outlet orifice of the nozzle 2 at an angle of 75-30 degrees to the surface to be protected.

[0037] Release of the accumulated energy of each individual microdroplet occurs through the valve channel 6 of the spray head 7 at the moment of discharge from the outlet channel 4. Each microdroplet acquires an individual acceleration and trajectory of motion, depending on the amount of accumulated kinetic energy. In the physical sense, all the droplets tend to repel one another, increasing the runaway distance. The further trajectory of motion of the vast majority of the individual droplets is deflected by the walls of the mixing chamber 5, directing the deflected droplets towards one another. There is then further collision of the droplets moving towards one another, with even greater dispersion and increase in the number of droplets moving freely and chaotically. The process of chaotic repulsion and collision of the free droplets continues with increasing intensity. The microdroplets, possessing a high charge of kinetic energy, capture the weakly charged air molecules from the air stream, thereby increasing the intrinsic volatility. There is thus development of a process of air injection through channel 3 for feed of atmospheric air into the mixing chamber 5, with subsequent formation of an air/droplet finely dis-

persed fire extinguishant, formulated as a super-dense finely divided water mist, possessing high penetrating power, the ability to fill the protected volume of a room instantly and high efficiency for extinguishing local and volumetric seats of fire of classes A and B, of any category of complexity.

[0038] After carrying out a number of experimental studies, it was established that the most effective size for the diameter of the channel 1 for feed of the water stream is 0.5-1.0 mm, and the diameter of the nozzle 2 must be a multiple of the diameter of the channel 1 for feed of the water stream in the proportions 1:5 - 1:10. The length of the channel 1 for feed of the water stream must be at least 2 mm and at most 10 mm, and the length of the nozzle 2 must be 2-3 times its diameter. To ensure formation of the air stream and effective drawing-in of air molecules into the stream of charged microdroplets at a pressure of 30-60 atm, at least one air feed channel 4 is arranged as close as possible, but not closer than 1.0 mm to the edge 3 for break-away of the water stream, at an angle of 35-45° to the plane of the edge 3 for break-away of the water stream. The effective diameter of the air feed channel 4 must be 1.0-3.0 mm.

Claims

1. Method of producing a fire extinguishant, comprising creating a water stream and passing it through at least one spray duct, characterized in that at least one edge for break-away of the water stream is formed inside each spray duct, after passing over which the water stream is broken up into a plurality of individual microdroplets moving together with subsequent initiation of a process of chaotic repulsion thereof from the inside walls of the spray duct and collision with one another, obtaining a finely divided water mist on discharge from the spray duct to the outside.
2. Method according to claim 1, characterized in that after break-up of the water stream it is saturated with atmospheric air by drawing atmospheric air into the spray duct after the edge for break-away of the water stream, but before discharge from the spray duct to the outside.
3. Spray duct, used for producing a fire extinguishant, formed from at least one channel for feed of the water stream and a nozzle, communicating and located one after another, the diameter of the nozzle being larger than the diameter of the channel for feed of the water stream, characterized in that the nozzle is a cylinder, through the bottom of which each channel for feed of the water stream passes, the minimum angle between the inside wall of the cylinder and its

bottom being not more than 90 degrees.

4. Spray duct according to claim 3, **characterized in that** at least one channel for feed of air, communicating with the nozzle near the bottom thereof, is introduced additionally. 5

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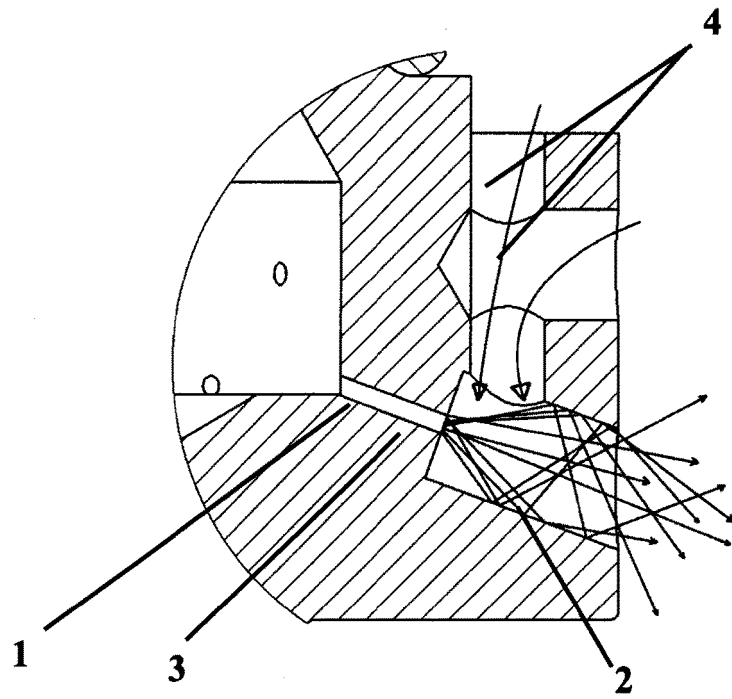


Fig. 1

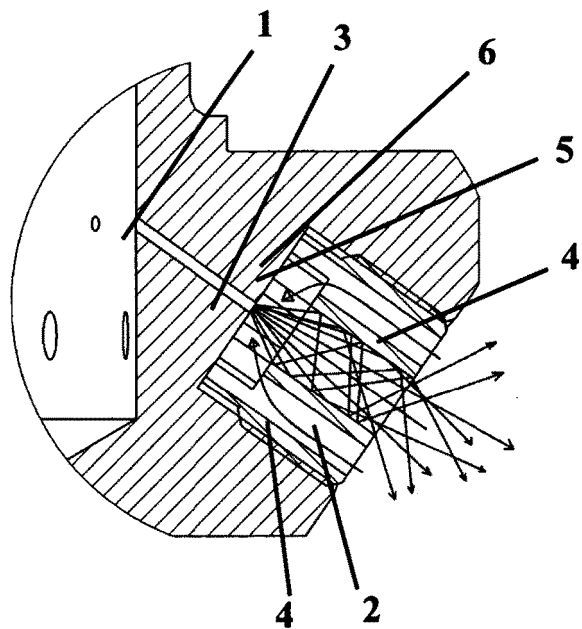


Fig. 2

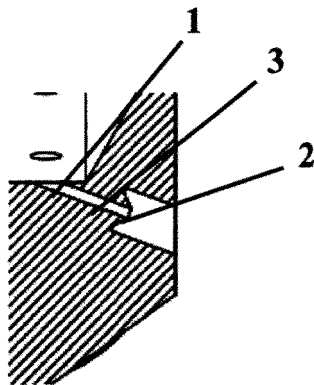


Fig. 3

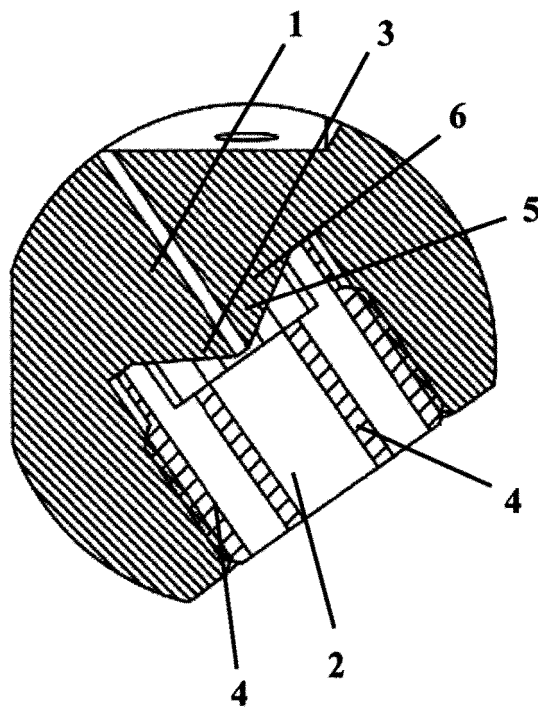


Fig. 4

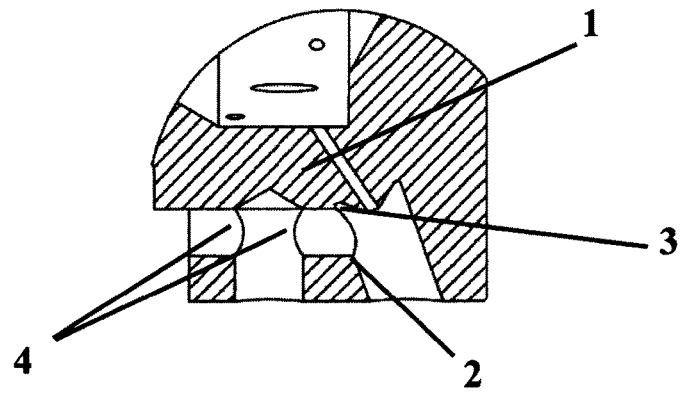


Fig. 5

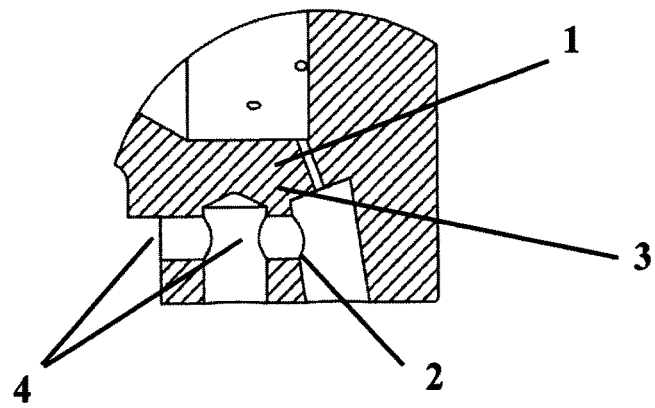


Fig. 6

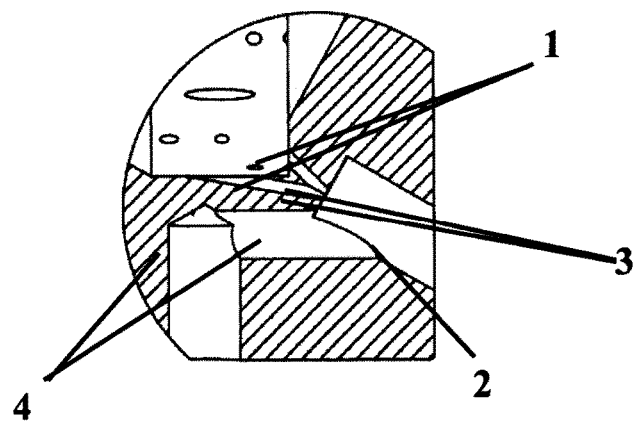


Fig. 7

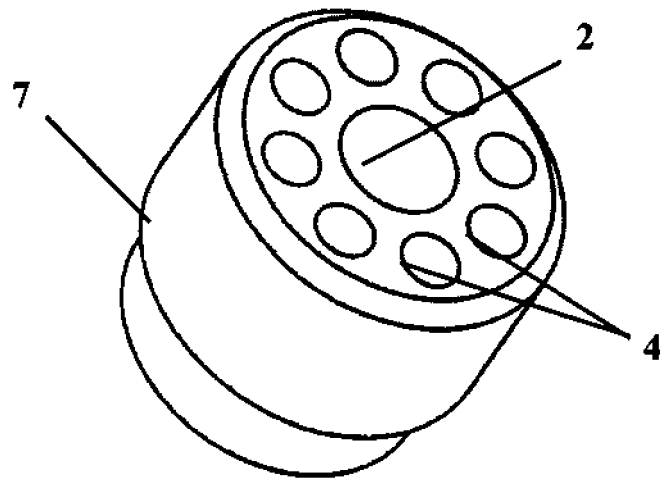


Fig. 8

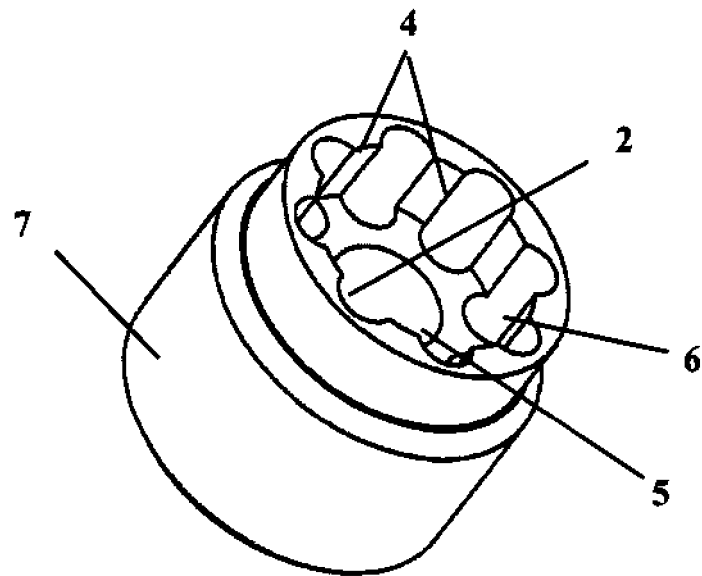


Fig. 9

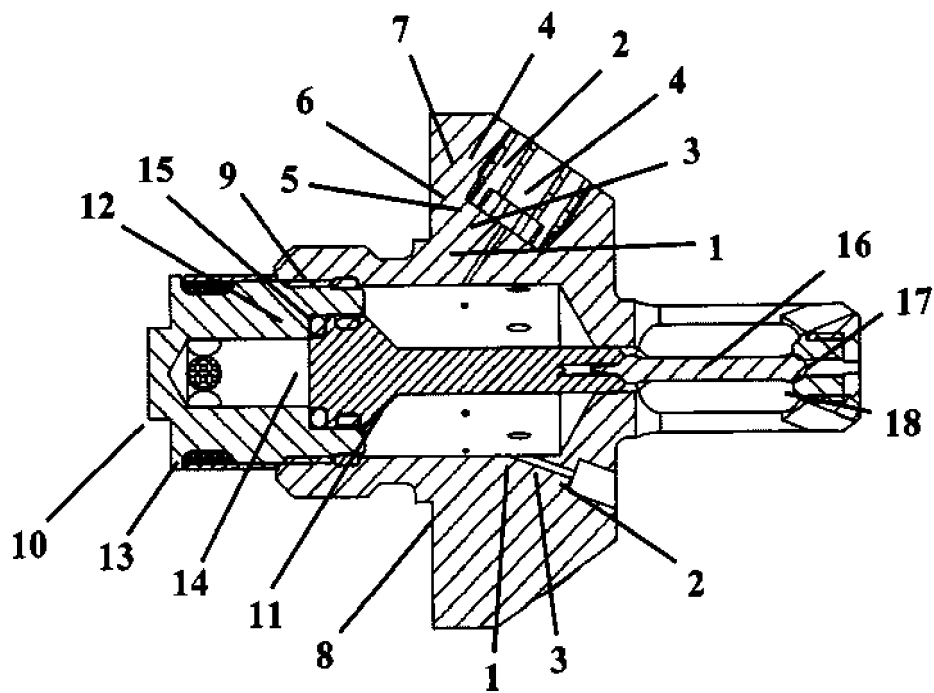


Fig. 10

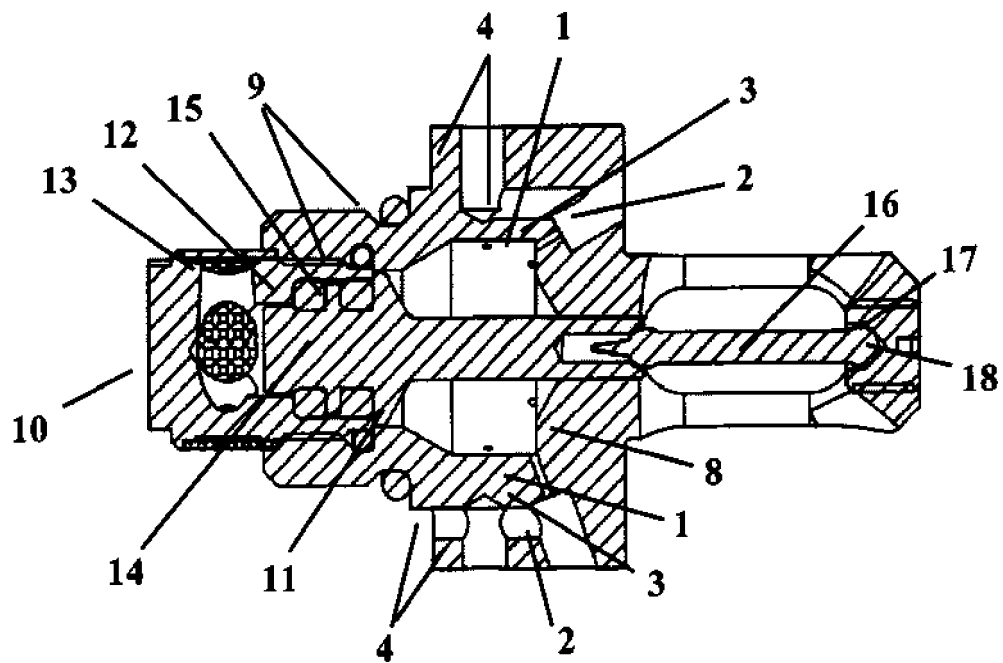


Fig. 11

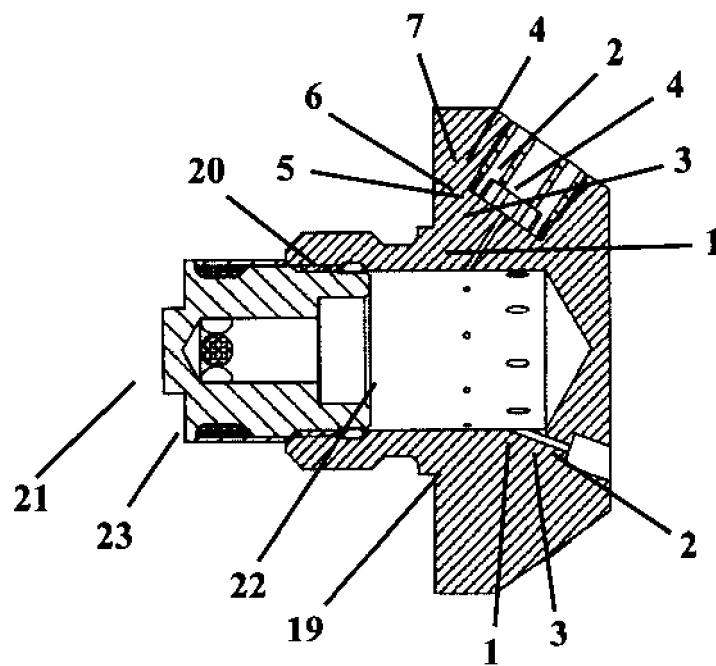


Fig. 12

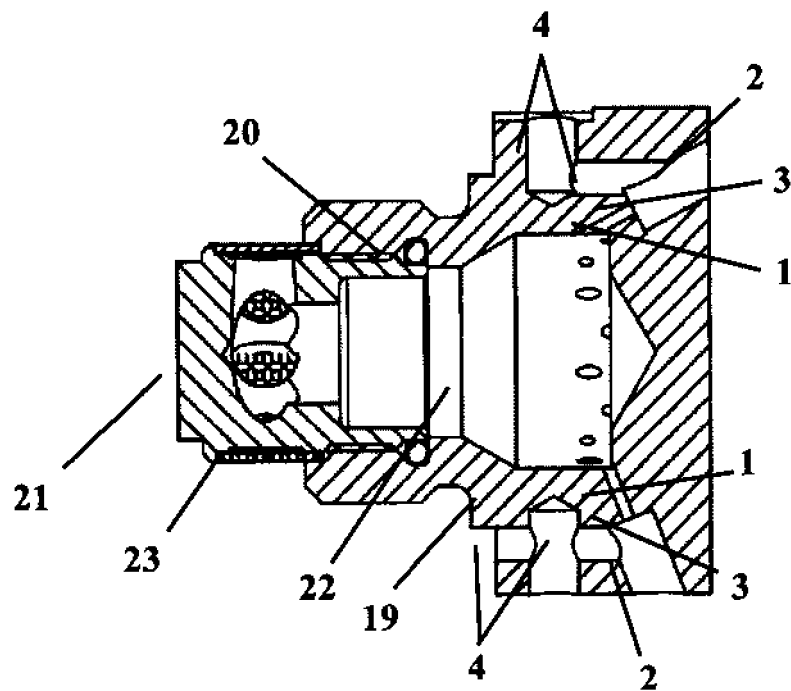


Fig. 13

INTERNATIONAL SEARCH REPORT

International application No.

PCT/RU 2016/000931

A. CLASSIFICATION OF SUBJECT MATTER

A62C 31/02 (2006.01) A62C 31/05 (2006.01) B05B 1/02 (2006.01)

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

A62C 31/00-31/05, 37/00-37/11, B05B 1/00-1/14

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

PatSearch (RUPTO internal), Esp@cenet, RUPTO

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	CN 204338357 U (XIHUA UNIVERSITY) 20.05.2015, paragraphs [0010] - [0013], fig. 2	3-4
A		1-2
A	RU 2248826 C2 (MARIOFF KORPOREISHN OI) 27.03.2005	1-4
A	RU 2570756 C2 (ZAKRYTOE AKTSIONERNOE OBSHCHESTVO "TEKHNOS-M") 10.12.2015	1-4
A	CN 102434102 A (UNIV CHINA PETROLEUM) 02.05.2012	1-4

☐ Further documents are listed in the continuation of Box C.
 ☐ See patent family annex.

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Date of the actual completion of the international search

01 June 2017 (01.06.2017)

Date of mailing of the international search report

08 June 2017 (08.06.2017)

Name and mailing address of the ISA/

Authorized officer

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REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- US 5944113 A [0002]
- US 5881958 A [0004]
- US 2813753 A [0005]
- RU 2248826 [0006]