Part 5

DECREASE IN PHYSICAL FACTORS IMPACT FROM POWER OBJECTS ON ENVIRONMENT

5.2. Fish protection technologies and constructions in power engineering

5.2.2. A choice of FPS universal construction for different water intakes

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Selection criterion of FPS universal construction

A method of FPS optimal construction selection is widely used in process of designing of fish protection for water intakes of different purposes and productivity. However, development of FPS, unique to every water intake, can't be always reasonable. It is explained, first of all, by that at application of optimal types of separate functional elements and the whole construction during selection, it is inevitably necessary to squander, developing different devices at each object. At the same time, it is often meaningful to concentrate the forces and means at designing, researches and approbation of only one or two FPS constructions, which application is possible at water intakes of different purposes. In this connection, along with creation of unique constructions, the analysis of functional elements types, well-known in the modern fish protection, is reasonable enough for purposes of selecting each type of the most universal element for further development of the FPS universal construction from them. Basic criteria of universality of the selected functional elements and FPS itself, should be the following:

- their ultimate applicability in any conditions, regardless of the situation, occurred at the certain water intake;
- the best compatibility of separate functional elements in limits of the combined universal FPS;
- meeting all the requirements, set for separate functional elements as well as for universal FPS itself, as a whole.

Selection of the universal stream-forming element of FPS

Since stream-forming elements are responsible for arrangement of necessary hydraulic structures of transit stream for protection of fish, it's reasonable to analyze them, depending on their way of watercourse impact. In this connection, stream-forming elements can be divided into two main groups:

- passive, forming the necessary hydraulic structure for fish protection only at flow of the transit stream around them. They work automatically and do not consume power resources. However, a field of their application is restricted by their installation either in the transit current, or in FPS of internal action, in which the process of fish protection is inside the transit water conduit, specially arranged for it;
- active, compulsory forming a hydraulic structure of inflowing stream into the device. For this they use the supplied additional energy (pressure water, air and mechanisms). By this, independence of work from hydrology of water source considerably widens the field of their application. So, as opposed to passive active stream-forming elements, FPS of superficial action are also applied, where a process of fish protection occurs at the immediate inflowing of water from the water source into water intake through a protective and water-receiving surface.

In connection with this, from the point of view of universality, the active stream-forming elements are discovered to be more preferable.

If now it is necessary to identify the most universal type among them, a choice should be made in favor of devices, feeding the water streams into current - stream generators.

It is explained by the following reasons:

- firstly, stream generators, affecting the watercourse by water streams, at a great extent and more naturally than others, influence on the forming of its hydraulic structure that is necessary for fish protection;
- secondly, from the point of view of universality that is the most important, that water intakes, where fish protection is required, are mostly equipped with pumps, i.e. they have already a source of pressure water, necessary for stream generators operation;
- thirdly, with a help of water streams, the basic algorithm of fish protection is more logically determined: fish live in water, in water it falls and ingresses into a water intake, i.e. it should be protected, using water.

Thereby, the conclusion could be made, that the most universal stream-forming element of FPS is a stream generator.

Selection of the universal protective and water-receiving element of FPS

Selecting the universal working organ, its the most important characteristics are mutually exclusive functions: carrying capacity and fish protecting ones (that is, stopping, not fish carrying capacity). Ideally, the universal working organ should have these two functions in a maximum extent. Withdrawal hole has the most full-capacity. This hole is not additionally equipped with any protective and water-receiving surface. At the same time, as it is known, for effective preventing of fish ingress into water intake, the flow should overflow in it at speeds not exceeding the critical values for the protected fish, but in this zone the speed of transit fish-withdrawal current should exceed the flow speed as well as the critical one for fish. If now, similar to a choice of the universal stream-forming element, working organs are considered from the point of their affection activity on fish, three basic groups can be marked:

- *passive*, blind screens, being a mechanical barrier for fish, partitioning off the fish habitable zone from dangerous source;
- *compulsory-active*, permeable, stationary or moving screens, which are washed by the transit current and along the surface of which a dangerous zone, stimulating an independent outgoing of fish from it, is formed;
- *active*, making a direct influence upon physiology, character of swimming ability of fish approaching to the. By its effect they make fish leave independently or compulsory the dangerous zone of water intake coverage.

It is obvious, that from the point of view of universality, the most preferable organs are active working ones, ensuring the necessary influence upon fish regardless of the situation, occurred in the water intake and of a complex of functional elements and a quality. At the same time, by character of fish reaction to outgoing from the dangerous zone, the active working organs can be divided in three groups:

- *independent*, or repellent, which scare the fish, making

it independently leave the source of danger (electric, light and sound fields);

• *independently-compulsory*, or directive, which exert a complex, repugnatorial-transporting influence upon the fish that makes it keep independently from falling to a source of danger and stimulates it to fall in the safety direction (turbulent water current, air-bubble and air-and-water screens);

• *compulsory*, or transporting, which actively form a track of passive migrations of fish into safety direction (high-speed water current).

Since the most natural habitat of fish is the aqueous medium and the main object of protection is passive falling of young fish, at selection of universal type of active working organ it is rather reasonable to consider a possibility of high-speed current use that is compulsory created and transit directed along the zone of water intake coverage.

It is obvious that this current is quite possible to create by the same stream generator, nozzles of which are directed along the border of stream overflow zone in water intake with speeds, not exceeding critical values for fish.

Selection of the universal fish withdrawal element of FPS

Different situations, occurring in hydro technical object, exert a considerable influence upon constructions of fish withdrawal. Mainly, it is a flowage of the water source. So, in watercourses the transit natural current (passive) of watercourse itself can be used as the fish withdrawal, but in basins it can be only compulsory, artificially arranged, i.e. active. If in the riverbed option of water intake combination often it is enough to locally take the protected fish aside from the faint flowing basin, at presence of a long canal, the options with the fish withdrawal track device, set in a safety place of the basin, are considered. Therefore, regardless of any characteristics of hydro technical object, the main points of a contact of all fish withdrawal types are their independence from the water source flowage and the length of fish withdrawal structure. In other words, universal fish withdrawal should be active, compulsory, artificially arranged and should locally remove fish from the water intake of immediate action. By this, a refusal from the long fish withdrawal device can be based only on condition of contactless fish protection provision, which doesn't absolutely harm the young fish at all stages of its protection and at presence of a safety zone in the basin, into which the local fish withdrawal is realized.

Considering that stream generator and water current, created by it, are selected as universal stream forming and working elements, at selection of universal fish withdrawal it's reasonable to pay attention at the transit current, directed into the safety zone and arranged by the stream generator.

Selection of the universal FPS

As universal types of functional elements, the single artificially created high-speed transit stream was selected. This stream flows along the water-receiving surface at the border of water overflow with speeds, not exceeding critical values for the protected fish. By this, the present transit stream does not just extend over the border of water overflow into water intake, but forms the extensional zone of some sort, in which fish is protected from its ingress into water intake. It is obvious that this extensional transit stream is the universal FPS at the same time.

In comparison with water intakes, located on basins and watercourses, the constructions and operational schemes of universal FPS are in some way different (Fig. 5.49).

So, in basins the device includes upper and lower water-distributive branch pipes of stream generator, with which each withdrawal hole of water intake is equipped by sides. At water-distributive branch pipes the nozzles, setting off the withdrawal hole pairwise, symmetrically to an axis at an angle to the withdrawal front, are installed. Water-distributive branch pipes are connected to a source of pressure water.

The device works as follows.

A speed of water flowing into withdrawal holes exceeds the critical values for the protected falling young fish; therefore, the fish is protected in a zone of water intake affection, where the current speed of streams, directed into it, does not exceed the critical values. For that, before withdrawal holes the hydraulic screens are arranged by water streams, jetting from the symmetrically located stream-generator nozzles. These screens are located in zones of water overflowing into water intake with "insignificant" speeds and protect the withdrawal holes from the basin side. By this, hydraulic screens fusing in tops of the created triangle zone – *a volumetric hydraulic screen*, form the cumulative stream. This stream has the "increased" current speed and transporting ability, acting in a zone of "insignificant" speeds of water flowing into water intake and provides a capture of the young fish and the floating garbage as well as their withdrawal from the water intake coverage into a safety place.

If the water intake front includes several holes, equipped with fish protection, then before it a "hydraulic rack" is formed, i.e. a system of local currents, located along the length of the whole water intake front and directed normally from it to a safety place of the basin. Between the teeth of a "rack" at a distance from the water intake, the local whirlpools, catching and keeping inside them the young fish, coming to the water intake, are formed. Thanks to a constant water cycle between water whirlpools and hydraulic screens, transforming to the cumulative streams, the permanent carrying-out of fish from the water intake backwards to a safety place of the basin, occurs.

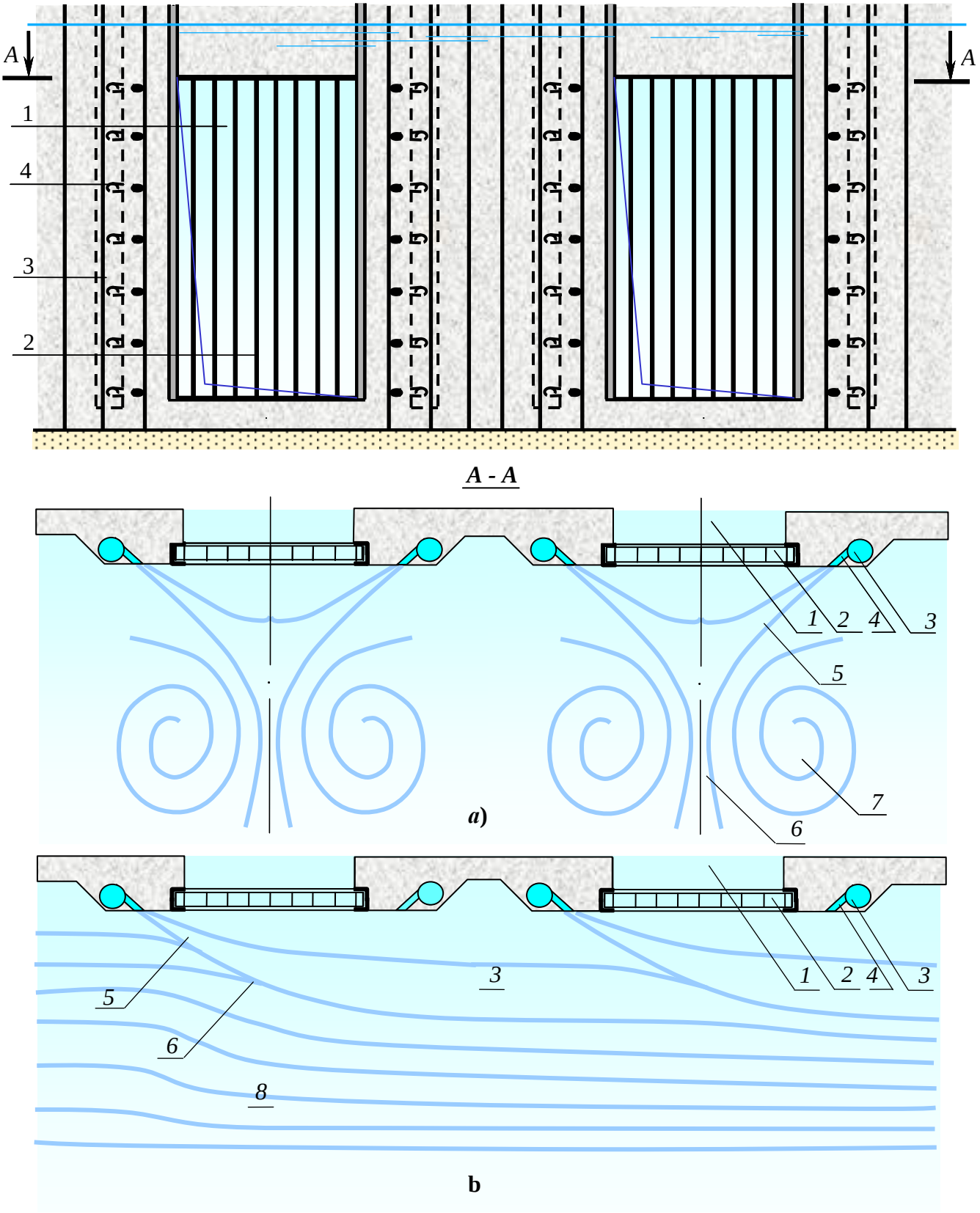

Fig. 5.49. A block-diagram of FPS operation "Volumetric hydraulic screen":
A – in basin; b – in water course; 1 – water intake hole; 2 – coarse lattice; 3 – pressure nozzle of stream generator; 4 – nozzle of stream generator; 5 – hydraulic screen; 6 – cumulative fish withdrawal stream; 7 – whirlpool zone; 8 – transit current

Thereby, several hydraulic factors exert simultaneous influence on forming of the young fish migration paths trajectory in water intake coverage. These factors prevent fish ingress in depth of the water intake front and keep it at a distance from the dangerous zone of water intake affection as well as outcome them backwards to a safety place. This way fish protection is arranged, being contactless and making no harm to the young fish, preventing it from ingress into water intake.

For equipping the water intakes, located at watercourses, with universal FPS, the simplified construction and a scheme of stream generator operation is used. So, at watercourse speed, exceeding the critical values for the protected fish, arrangement and operation of the only superficial stream generator is reasonable. By that, superficial hydraulic screen, created by the stream generator, changes a trajectory of the fish falling in such a way that it is taken from the artificially formed current into the transit watercourse and inside it the fish is carried out from the water intake coverage down the stream.

Modifications of the universal FPS of "Volume hydraulic screen" type are developed and introduced in 2003 at water intakes of the JSC "Salavatnefteorgsintez" in the river Belaya (watercourse) according to a patent of RF [3] and at the production association "Electric and chemical plant" in the river Kan (the controlled watercourse – a basin) according to a patent of RF [4].

Investigation of both constructions and operational schemes of hydraulic screen showed its high fish protection efficiency at supplying pressure water of 3 to 5% accordingly, reaching 94,7% [5] for stream-formation at different operational schemes, that considerably exceeds the standard requirements (70% by SanPiN 2.06.07 – 87 [1]).

In this connection, a conclusion has been made about the possibility of FPS application as an independent one:

- upper and lower stream generators with nozzles, framed withdrawal holes in pairs, symmetrically to its axis and located at an angle to the water intake front, for application in basins and watercourses;
- upper stream generator with nozzles framed withdrawal hole and located at an angle to the water intake front for application at watercourses.

Having studied the test results and having taken into consideration the reached level of fish protection efficiency, the federal state agency "TSUREN" said that it isn't against of application of contactless FPS of "Volume hydraulic screen" type at the water intakes of different destination [6].

Absence of moving elements in the device facilitates its construction and maintenance, but absence of reticulate screens significantly decreases its hydraulic resistance. Costs for water receiving organ operation are also reduced. Arrangement of stream generator supply from the power network of water consumer provides an automatic switching-on of the device together with the water intake. Equipping withdrawal holes by the device, it is no use in replacing the present coarse garbage-keeping reticulates in them with the special protective and water-receiving screens.

This FPS is absolutely not affected by harmful environmental influence (waves, ice drifts, alluviums, etc.) because of an absence in it of any detail, carried out to the basin. Only water streams effect.

Apart from fish, the volumetric hydraulic screen takes effectively aside different floating garbage and plankton from the water intake that has a favorable impact on operation of the rotating water-cleaning grids of the pumping station and returns the nutrition into a basin, required for the young fish fattening.

In volumetric hydraulic screen functions of all three functional elements are harmonically concentrated in the volumetric high-speed transit current. Simultaneously this current is the most natural water habitat of fish and self-sufficient FPS, performing the necessary functions, namely: providing of the required amount of water, passing to consumer, preventing from fish ingress and death in water intake, ensuring of viability of the young fish and its taking from the limits of water intake affection zone into a safety place of fish habitable basin for the following natural reproduction. Therefore, universal contactless volumetric hydraulic screen can be named as a high-efficiency FPS of the new generation.

Presently there are also designed the projects of universal FPS for water intakes of Krasnoyarskaya CHPP-2 in the river Yenisei and Nazarovskaya SDPP in the river Chulym in Krasnoyarsk Region [4], for the canal Gzhat – Yauza in Smolensk Region [3].

The annual economic effect of introduction of universal FPS in water intake of Nazarovskaya SDPP was 102,7 thousands rubles per 1 m^3/s of water intake consumption.

Novelty of universal FPS of "Volume hydraulic screen" type consists in application of the artificially created water currents as all functional elements and it provides the most natural fish protection and excludes arrangement of any mechanical structure in the basin.

Universal FPS can be set in water intakes of different destinations at any fish habitable water object (basins and watercourses).

Completion of the new generation FPS in accordance with requirements set for fish protection

Fish protection structure should not only protect the young fish from ingress into water intakes, but also provide its withdrawal in viable condition into a safety place. Nevertheless, at present the majority of the most claimed FPSs either have no fish withdrawal at all (electric fish ejector), or its "range" is not high (air-and-water screens), that does not guarantee fish regress into a zone of water intake affection. In spite of that, the volumetric hydraulic screen provides contactless, not harming and the most natural protection of the young fish in water currents. Simultaneously with the help of this, the screen was created as FPS that can compete with above-mentioned constructions. In this connection, this screen has the same defect, namely, insufficient "long-range" fish withdrawal. In spite of the fact that at volumetric hydraulic screen operation before the water intake conditions for safety fish habitation are created, the opportunity of its regress into a zone of water intake direct coverage is not excluded. At a great extent, lowering of lightness at dark time of the day and wind wave onset to the water intake side contributes in that. In order to eliminate this defect, namely, to keep fish in a safe place, distant from the water intake, and to create conditions that allow fish to independently keep from falling into water intake, it's suggested to arrange a fish habitable asylum in a zone of fish concentration, taken from the water intakes. It was equipped with visual and tactile orientators and shelters that differ it from environmental conditions of basin in a zone of water

intake affection and create conditions being the most favorable for fish habitation, lightning up at the dark time of the day (Fig. 5.50).

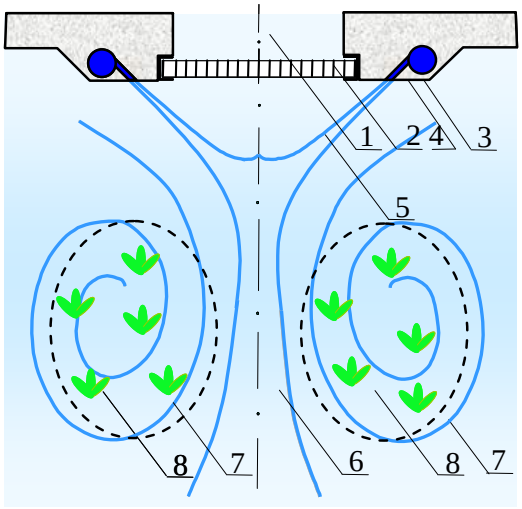

Fig. 5.50. A layout of additional equipment of the universal fish-protection unit of "Volume hydraulic screen" type with fish-inhabited shelter
1 — water intake window; *2* — trash rack; *3* — jet generator branch pipe; *4* — jet generator nozzle; *5* — hydraulic screen; *6* — "a tooth of the hydraulic comb" – a cumulative fish off-taking jet; *7* whirl zone; *8* —fish-inhabited shelter

The device works in the following way. In a dark time of the day fish goes into water intake coverage zone by falling inside the drain currents. Going through the lighted asylum it restores the ability to orientate in the flow and stop falling by keeping itself inside the asylum. If it flows through the asylum into water intake, then it enters the effective zone of the volumetric hydraulic screen and will be caught by this screen and taken aside inside the local fish withdrawal current, created by it, from the water intake. Fish is transported by this current along the lighted asylum. Having restored its visual orientation, fish flows independently into asylum and is kept in it from the repeated falling into the water intake. This way fish is exerted by a complex of mutually complementary protecting influence:

Firstly, asylums, constructed before the water intake, by catching and keeping a part of fish inside themselves, allow to decrease the intensity of its falling into the water intake;

Secondly, the volumetric hydraulic screen arranges protection of the falling young fish from ingress into the water intake;

Thirdly, asylums admit and keep inside themselves the fish, protected and taken from the water intake;

Fourthly, the volumetric hydraulic screen protects the fish, gone or washed away independently from asylum by the drained current into water intake, and returns them backwards into asylum or fish in a local fish withdrawal current, passing the asylum aside, is carried away from the water intake coverage zone to the basin.

Using of water streams for fish protection at hydropower stations

At hydropower station the main complexity of fish protection device is the necessity of overcoming great masses and water consumptions, which flow into water intake of hydropower station. At the same time, it is well known that falling young fish mostly concentrate before the hydropower station into superficial whirlpool zone, which is formed by the water intake current. During night-time, losing visual orientation and dispersing at depth, the fish is washed away from this zone and falls into hydraulic units and die. Using peculiarities of fish behavior before hydropower station, its protection can be organized as protection from its ingress into sunken water intakes of practically any productivity. For that, a zone of superficial layer overflow into the sunken water intake is blocked by a rising hydraulic screen, which is similar to water intake current.

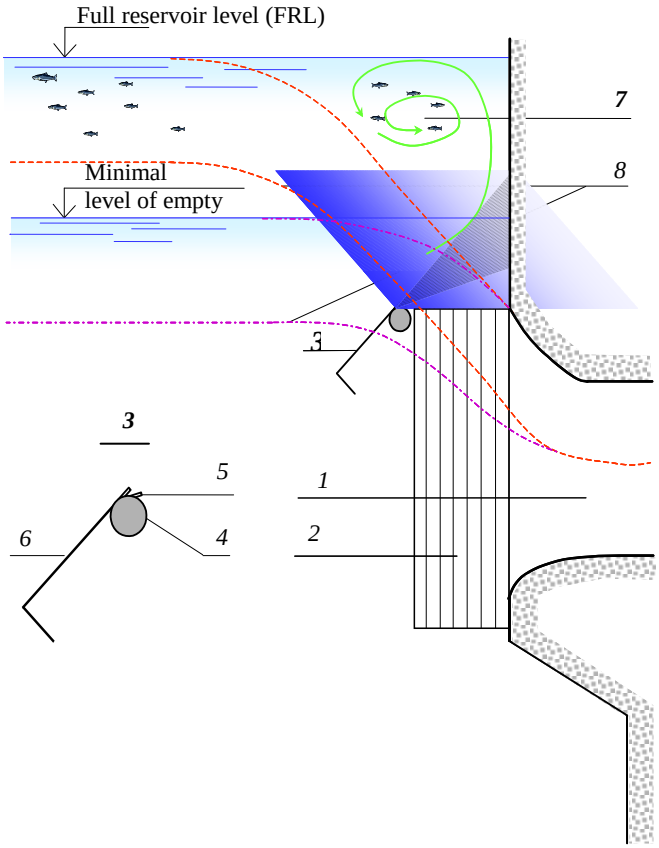

Fig. 5.51. Using of water streams for fish protection at hydropower station:
1 — water conduit of hydropower station; *2* — volume garbage keeping array; *3* — fish transporting device; *4* — water distributive manifold; *5* — nozzles of stream generator; *6* — stream-forming fender screen; *7* — whirlpool fish habitable zone; *8* — border of fish habitable layer without fish protection.

Hydraulic screen is completed by a fender stream forming screen. Mutually they reorientate a top layer of water intake current and direct it together with falling young fish backwards to superficial whirlpool fish habitable zone. At orientation of water streams, forming the hydraulic screen, also along the water intake front, flowage of whirlpool zone and taking aside of the falling young fish in whirlpool current from the water intake coverage is provided (Fig. 5.51).

Present hydraulic FPS was designed with using of RF patent [3] for temporary water conduits Bureyskaya hydropower station with overall efficiency of more 660 m^3/s. Cost price of this device designed for large hydropower station, in calculation for $1m^3/s$ of its expense, is at two times lower than cost prices of other well-known constructions of fish protection. So cost saving of the device introduction at permanent water conduits of Bureyskaya hydropower station will be of more than 250 million rubles.