XLIII.—CHEAP FIXTURES FOR THE HATCHING OF SALMON.

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1.—SCOPE OF THE PAPER.

It is proposed to limit this paper to the consideration of the construction, fitting, and management of the simplest houses and apparatus suitable for the hatching and rearing of salmon up to the complete absorption of the yolk sack, that being the time when it is customary to turn the young fish out to shift for themselves; and it is hoped that the instructions given will be so plain and yet so complete that a person previously entirely ignorant of the whole business can without further direction set up an efficient establishment. No attempt will be made to explain the construction of the more elaborate devices that have lately come into so general use, since these devices have for their main purpose the saving of space in establishments where large quantities of eggs are to be developed up to the shipping point, and few or none to be hatched out; though some of these are also available for hatching, and to a certain extent for the rearing of the young fish.

For the most part the same apparatus and management are applicable to Atlantic and land-locked salmon, Pacific salmon, and brook trout. The Atlantic and land-locked salmon, both in the egg and in the sack stage, are so closely alike as to be practically indistinguishable. Indeed, the latest conclusion of special students of the *Salmonidæ* is that they all belong to the same species, *Salmo salar*. Be this as it may, their habits and requirements during these early stages are, so far as known, identical. On these fish my personal observations have been mostly made, and to them, therefore, the instructions of this paper may be considered as more especially applicable. Yet the difference between the treatment they require and that applicable to Pacific salmon is so slight that all the rules laid down may, it is believed, with perfect safety be followed in the management of the latter, except in certain minutiæ, which depend mainly on the greater size and hardihood of the Pacific salmon, partly on their adaptation to warmer water, and when not specially mentioned will readily suggest themselves to the common sense of the operator. Similar observations may be made with reference to the brook trout. The same apparatus, with some possible change in management, will answer also the very best purpose in the hatching of lake trout.

2.—WATER.

The first thing to be sought is an ample supply of wholesome water, on a site where it can be brought completely under control and the requisite fall secured. In this matter there is quite a range of choice. The very best is the water from a stream fed by a clean lake taken a short distance below the outlet of the lake, with an intervening rapid. Such water is commonly quite even in volume and temperature, and comparatively free from sediment and harmful impregnations. It is cold in winter and warms up slowly in spring, giving assurance of a slow and normal development, which is more conducive to health and vigor than a very rapid development. The passage down a rapid, though by no means an essential point, will further improve this water by charging it highly with air. After this, I would choose the water of a brook that is fed largely by springs, so as to insure constancy in the supply and some moderation of the temperature on warm days; but it is better to have the water flow a long distance in an open channel before using, and, if possible, over a rough and descending bed, that it may be well aerated, and in cold weather somewhat cooled down from the temperature with which it springs from the ground. Thirdly, choose pure spring water; but in all cases where this is necessary provide a cooling and aerating pond, that you may have the original warmth of the water subdued by the cold of the air before it reaches the hatching troughs, and that it may absorb more or less air by its wide surface. Lastly, choose ordinary river or brook water, as clean as possible. These kinds are considered inferior to spring water by reason of their liability to floods, drought, muddiness and foulness of other sorts, and in cold climates to anchor ice. The water of a stream that has its source in a not very distant lake or spring is not considered *ordinary* river or brook water, but is advanced thereby into the first or second rank. Between these different sorts there is of course an infinite number of gradations. If lake water cannot be obtained, it would be of some advantage to have a supply of both spring water and brook water, depending for ordinary use on the brook water or a mixture of the two, and on the spring water for emergencies, such as the freezing, drying, or excessive heating of the brook, floods with accompanying muddiness, etc. Avoid water that comes from boggy and stagnant ponds and marshes; for though excellent water, capable of bringing out the most vigorous of fish, may sometimes be had in such places, yet when not supplied by springs it is dependent for its freshness and good qualities upon sufficiently copious rains, and if these fail, as they are liable to, the water may become foul and unfit. The best time to select a site for a hatching establishment is in time of extreme drought. If the site in question has at that time an ample supply of pure, sweet water, the first requisites are fulfilled. But if such an examination discloses any lack in this respect, the site must be rejected. It would be well, also, to visit the place in time of flood and, if in a very cold climate, in severe winter weather, to know what dangers are to be guarded against on those scores.

The volume of water necessary will depend on several circumstances, mainly on the following: 1st, the proposed capacity of the establishment; 2d, the temperature of the water; 3d, its character as to aeration; 4th, the facilities existing in the house for the aeration and repeated use of the water. With water of the highest quality and low temperature and with unlimited facilities for aeration, possibly a gallon a minute or even less can be made to answer for the incubation of 100,000 eggs of salmon. As the temperature rises or the facilities for aeration are curtailed, a larger volume becomes necessary. In case of spring water, cooled only to 40°, and aerated only by exposure to air in a pool of about a square rod surface, with no facilities in the house for aeration, and with the eggs and fry crowded in the troughs at the rate of 4,000 per square foot, 4 gallons a minute is the least that can be trusted to support that number, (100,000,) while 6, 8, or 10 gallons per minute would be much better. While the minimum is, as stated above, possibly less than a gallon a minute, no novice can be advised to trust to less than 3 gallons per minute for each hundred thousand eggs or fish under the most favorable circumstances. These statements are about as definite as can be made. The question of volume must be decided for each case according to the peculiar circumstances existing, and the novice must first acquaint himself with the mode of arranging the fixtures in the house, and especially with the means and facilities for aeration, for which directions will be given below, and then study the possibilities of the proposed site. It should be borne in mind that the volumes of water stated above are strictly minimum quantities, meant to apply to the very lowest stage of water that can possibly occur during the hatching season.

If the water supply is to be drawn from a small brook or a spring, it will be necessary to measure the volume carefully. The following is an easy and accurate mode, applicable to most cases. Take a wide board one inch thick, (or two or three of them carefully jointed or matched,) and bore a smooth inch hole through the middle of it. With this make a tight dam across the stream so that all the water will have to flow through the hole. If the water on the upper side rises just to the top of the hole, it indicates a volume of 2.3 gallons per minute; a rise of half an inch above the top of the hole indicates a volume of 3½ gallons per minute; 2 inches rise, 5 gallons per minute; 3 inches, 6 gallons per minute; 6 inches, 8 gallons per minute; 12 inches, 12 gallons per minute. If two one-inch holes are bored, the same rise will of course indicate twice the volume. The volume vented by holes of different sizes is in proportion to the squares of their diameters; thus a two-inch hole vents four times as much as a one-inch hole. A cylindrical tube whose length is three times its diameter will vent 29 per cent. more water than a hole of same diameter through a thin plate or board.

3.—SITE.

A satisfactory supply of water having been found, it is next necessary to select a site for the hatching-house that combines in as great a degree as possible the various desiderata, of which the most important are, first, facilities for creating a head of water to provide for the requisite fall into and through the troughs; second, security against inundation; third, if in a cold climate, security against too much freezing; fourth, general safety and accessibility.

The fall required in the hatching-house cannot be stated very definitely, but it can hardly be too great. The minimum for the most favorable cases is as low as three inches, but only under the most favorable circumstances in other respects will this answer, and even then it is subject to several very serious disadvantages. It is only admissible where there is an ample supply of aerated water, and the troughs are very short, and there is absolutely no danger of inundation; and the disadvantages are the impracticability of introducing any aerating apparatus and the necessity of having the troughs sunk below the floor of the hatching-house, which makes the work of attending the eggs and fish very laborious.

A fall of one foot will do pretty well if there is entire safety from inundation. This will permit the troughs to be placed *on* the floor instead of below it, (a better position, though still an inconvenient one,) and some of the simpler aerating devices can be introduced. Better is a fall of three feet, and far better a fall of six feet. The latter will allow the lowest hatching-troughs to be placed two feet above the floor, to the great relief of the backs of the attendants, and leave ample room for complete aeration. Of course the necessities of the case are dependent largely upon the volume and character of the water. If there is plenty of it, and if it is well aerated before reaching the hatching-house, there will be no occasion in a small establishment of additional aeration in the house, and, therefore, no need of more than three feet fall, and, except for convenience in working and for guarding against inundation, one foot fall is enough.

As to liability to inundation, actual inspection of the premises at time of floods will generally suggest what safeguards are needed. If located by a brook-side, the hatching-house should not obtrude too much on the channel, and below the house there should be an ample outlet for everything that may come. By clearing out and enlarging a natural water-course much can often be done to improve an originally bad site.

In a cold climate it is an excellent plan to have the hatching-house partly under ground, which will protect it wonderfully against outside cold. When spring water is used there is rarely any trouble, even in a cool house, from the formation of ice in the troughs; but lake, river, or brook water is, in the latitude of the northern tier of States, so cold in winter that if the air of the hatching-house is allowed to remain much below the freezing point, ice will form in the troughs and on the floor, if there is any leakage, to such an extent as to be a serious annoyance, and sometimes, if not watched, will form in the hatching-troughs and extend so deep as to freeze the eggs and destroy them. Stoves are needed in such climates to warm the air enough for the comfort of the attendants; but the house should be so warmly located and constructed that it may be left without a fire for weeks without any dangerous accumulation of ice. The easiest way to effect this is to have the house partly under ground; but if the site does not permit this, the same result can be brought about by thorough construction of the walls and by banking well with earth, sawdust, or other material. In warmer climates no trouble will be experienced from this source.

4.—DAMS AND CONDUITS.

In some cases the best way to get the requisite head is to throw a dam across the stream and locate the hatching-house close to it. The dam will form a small pond which will serve the triple purpose of cooling, aerating, and cleansing the water. But unless the character of the bed and banks of the stream be such as to warrant against undermining or washing out at the ends of the dam, it is best not to undertake to raise a great head in this way. With any bottom except one of solid ledge there is always great danger, and to guard against it when the dam is more than two feet high may be very troublesome. If there is any scarcity of water, or if it be desirable for any other reason, for aerating or other purposes, to secure a considerable fall, it is better to construct the dam at some distance above the hatching-house, on higher ground, where a very low dam will suffice to turn the water into a conduit which will lead it into the hatching-house at the desired height.

The conduit is best made of wood. A square one of boards or planks, carefully jointed and nailed, is in nearly all cases perfectly satisfactory. For an ordinary establishment a very small conduit will suffice. The volume of water that will flow through a pipe of given form depends first, upon the the size of the pipe, and second, upon the inclination at which it is laid. A straight cylindrical pipe, one inch in diameter, inclined one foot in ten, will convey about eleven gallons of water per minute. The same pipe, with an inclination of one in twenty, will convey eight gallons per minute; with an inclination of one in fifty, five gallons per minute; with an inclination of one in one hundred, three gallons and a half per minute; with an inclination of one in one thousand, one gallon per minute. A two-inch pipe will convey about 5½ times as much water as an inch pipe; a three-inch pipe nearly fifteen times as much. A one-inch pipe with an inclination of one in 1,000 will convey water enough for hatching 25,000 eggs; with an inclination of one in fifty, enough for 100,000 eggs; with an inclination of one in twenty, enough for nearly 200,000 eggs. A square conduit will convey one-quarter more water than a cylindrical pipe of same diameter. If there are any angles or abrupt bends in the pipe its capacity will be considerably reduced. It should be remembered that if the water completely fills the aqueduct it is thereby entirely shut out from contact with air during its passage, whereas if the pipe be larger than the water can fill the remainder of the space will be occupied by air, of which the water, rushing down the incline, will absorb a considerable volume and be thereby greatly improved. It will therefore be much better, when practicable, (and this includes nearly all cases,) to make the conduit twice or thrice the size demanded by the required volume of water. If the bottom and sides be rough, so as to break up the water, so much the better; and the wider the conduit is of course the more surface does the water present to the air. It is not at all necessary to cover the conduit, unless from its position it is exposed to inundation or to pollution by the visits of mischievous animals or other agencies, or unless, as may sometimes, but rarely, occur, the water would be in danger of freezing up. If the water comes from springs or a spring brook, or a lake or pond, there is no danger on that side, unless the aqueduct is a very long one; on the contrary, the spring water will only receive a wholesome cooling down.

5.—AERATION.

This is perhaps the most important branch of the whole subject. The water which fishes breathe is but the medium for the conveyance of air, which is the real vivifying agent. Without air every fish and every egg must surely die, and with a scanty supply the proper development of the growing embryo becomes impossible. Water readily absorbs air whenever it comes in contact with it, and the more intimate and long continued the contact the greater the volume it will absorb. The ample aeration of the water to be used in the hatching-house has already been mentioned as a desideratum of the first importance, and some of the devices by which it is to be secured have been incidentally alluded to. But a little more remains to be said.

Water from either a brook or river that has been torn into froth by dashing down a steep bed has absorbed all the air that will be needed in ten or twenty feet of hatching-trough, and demands no further attention on this score. But if the water must be taken from a lake, a spring, or a quiet brook, its burden of air is much less and is liable to become so reduced before it gets through the hatching-house as to be unable to do its proper work. It is therefore desirable to adopt all practicable means of re-inforcing it. If the site of the hatching-house commands a fall of five feet or more, the thing is easily done. Either in the conduit, outside the house, or in the hatching-troughs themselves, a series of miniature cascades may be contrived. The broader and thinner the sheet of water, the more thoroughly it is exposed to the air, and if, instead of allowing it to trickle down the face of a perpendicular board, we carry it off so that it must fall free through the air, as in Figure 1, both surfaces of the sheet are exposed

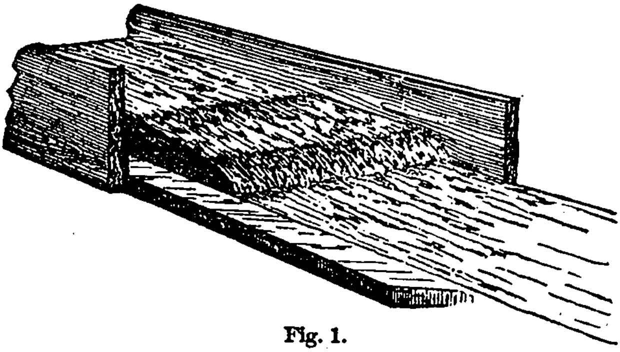


Fig. 1.

and the effect doubled. When the circumstances permit, it is best to introduce these in the conduit, which, as already suggested, may be made wide and open for that purpose. If the aeration cannot be effected outside the house there is still opportunity inside. Two long troughs may be placed side by side, leveled carefully, and the water be received in one of them and pour over into the other in a sheet the whole length of the trough, which, of course, would be a very thin sheet, and very effective. In the hatching-troughs themselves, also, there is an opportunity for aeration, either by making short troughs with a fall from one to another, or by inclining the troughs and creating falls at regular distances by partitions or dams, each with its cascade, after the fashion already described.

The only serious difficulty is encountered where the ground is very flat, so that the requisite fall cannot be obtained. In this case the best that can be done is to make a very large pool, several square rods at least, outside the house, and make all the conduits as wide as possible, so that the water shall flow in a wide and shallow stream.

It will of course be borne in mind that the better the aeration the smaller the volume required to do a given work; and on the other hand it is equally true that the greater the volume the less aeration is necessary. When so large a volume as six gallons per minute for every hundred thousand eggs is at command a comparatively low degree of aeration will answer. But so far as known the higher the degree of aeration the better the result, without limit, other things being equal, and it is therefore advised to make use of *all* the facilities existing for this purpose.

6.—FILTERING.

Before the introduction of wire or glass trays for hatching fish-eggs it was customary to lay them on gravel, and under these circumstances it was absolutely necessary to filter all but the purest water. Even ordinary spring water deposits a very considerable sediment, which might accumulate upon the eggs to such an extent as to deprive them of a change of water and thereby smother and destroy them. When the eggs are deposited on trays, however, even though their upper sides be covered with sediment, underneath they are clean and bright, and remain in communication with the water beneath the tray, though of course the circulation of water through the tray is not perfect. The trays, moreover, offer the best facilities for cleansing the eggs as often as may be necessary, and establishments for the hatching of eggs of the *salmonidæ* do not commonly receive them until they have arrived at the stage when they can be safely subjected to whatever washing and disturbance may be desired. It is not, therefore, deemed necessary to introduce any considerable devices for filtering water which is naturally very pure, as are lake and spring water commonly when not subject to intermixture with surface water during rains. There are, however, so many cases in which it is necessary to use water subject to constant or occasional turbidness that some directions for filtering are indispensable.

In the first place, let the water from the conductor be led into a deep tank, which may be termed the "settling tank," where the coarser and heavier dirt will sink to the bottom. This may as well be located outside the hatching-house, and for a small establishment a hogshead sunk in the ground will answer. From the settling tank the water should be led into a filtering trough inside the house, as shown in Figure 2, which exhibits

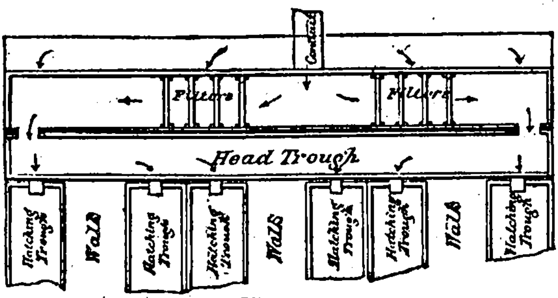


Fig. 2.

one out of many convenient arrangements. This trough may be just the length of the head or distributing trough alongside which it lies, or may be much shorter, four feet answering well where little work is demanded of it. For depth and width 15 to 18 inches are convenient dimensions. If the water is introduced near the middle of the filtering trough the current may be subdivided, part going to the right and part to the left, each part through its own set of filters, as shown by the arrows. This makes the single long trough equivalent to two shorter troughs, and since the shorter trough would be amply long to receive the requisite screens, the filtering capacity of the trough is thus doubled. When either the volume or excessive turbidness of the water demands an extraordinary capacity in the filter, the water may be introduced at several points by means of an additional long distributing trough placed alongside the filtering trough, as shown by the dotted outline in Figure 2, and each of the separate currents be subdivided as already described. In this way six separate sets of filters may be introduced into a single trough 12 feet long.

The filters to be used with the foregoing arrangement are made by stretching woolen flannel on wooden frames. The best device consists of two separate frames, one fitting inside the other, (without nails,) as in Fig. 3, and holding stretched between them a piece of flannel considerably larger than the frame, to allow for shrinkage and for a margin

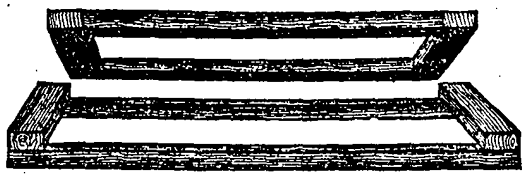


Fig. 3.

to close the interstices on either side and at the bottom between the frame and the trough. This filter slides down into the trough obliquely, between two pairs of cleats on opposite sides, as shown in Fig. 4. Strips of wood half an inch thick are suitable for the construction of these frames, giving a total thickness of

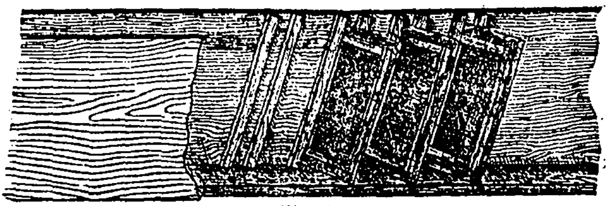


Fig. 4.

one inch to each filter, and if it is desired to save room, the space intervening between the frames may be as narrow as half an inch, so that it is possible to get eight filters into a single foot of the length of the trough. They should slide easily into place, so that they may be removed whenever necessary to clean them. The cloth can be removed from the frames and washed or dried and brushed. There should be a large surplus of them on hand, so that a clean one for immediate use should always be ready. The filters should not come quite to the top of the trough, so that if they become completely clogged with dirt the water may flow over their tops to the hatching-troughs; for dirty water is much better than stagnation. It is better to have flannel (or baize) of several grades of fineness, and pass the water through the coarser ones first. If leaves and other coarse rubbish are liable to enter the filtering-trough they must be arrested by a coarse grating of wood or metal above each set of filters; it is better to stop all such coarse material outside the house.

The filters will of necessity obstruct the water somewhat, and a slight head be created by each one,—perhaps an inch each will be a rough approximation to the truth. Allowance must be made for this by having the filtering-trough several inches higher than the hatching-trough. But do not draw the water away from the lower sides of the filters so as to expose them to the air, for the water will pass through much freer when it is backed up nearly as high on the lower side as on the upper. The number of filters to be used depends upon the amount of foreign matter in suspension in the water, and can only be determined by observation and experiment in each case.

Another mode of filtering sometimes resorted to, either alone or in connection with the flannel screens, consists in passing the water through a bed of gravel; but the method already described will answer every purpose and is much easier of application.

As already remarked, there are many places where it is a waste of effort to filter the water, but the advantages of cleanliness are so great that every one who proposes to use water liable to become at any time muddy is advised to put in the necessary troughs, or at any rate to leave space for them. If, however, a hatching-house has been already fitted up without any provision of this sort, a set of filters can be fitted into the upper part of each hatching-trough and be just as effective as if in a trough by themselves.

7.—HATCHING-TROUGHS AND FITTINGS.

We come now to the hatching apparatus proper, the troughs and trays. Whatever may be the advantages derived from the use of very compact apparatus, some forms of which allow us to mature 30,000 eggs to every square foot of trough room, they do not pertain to the hatching out and rearing of the fry. For this work nothing has yet been found better than a long, straight, shallow trough. Ten feet is the length I would recommend as most desirable. In no case have them longer than fifteen feet. In passing down a well populated trough fifteen feet any ordinary volume of water will be deprived of so much of its air and oxygen that a new supply is needed, and if necessary to make further use of this water it is best to let it fall in a thin sheet into another trough set a few inches lower. In some cases, where the water as introduced into the house is deficient in aeration, it is best to make troughs as short as five feet, or, what will amount to the same thing, (though a less convenient and less satisfactory mode,) incline the trough from one to two or three inches for every five feet in length, and check the water and keep it up to the proper height in different parts of the trough by a series of transverse partitions or dams. Under ordinary circumstances, with well aerated water at the start, a trough ten or fifteen feet long may be set perfectly level.

Figure 5 shows the interior of a hatching-house supposed to have a

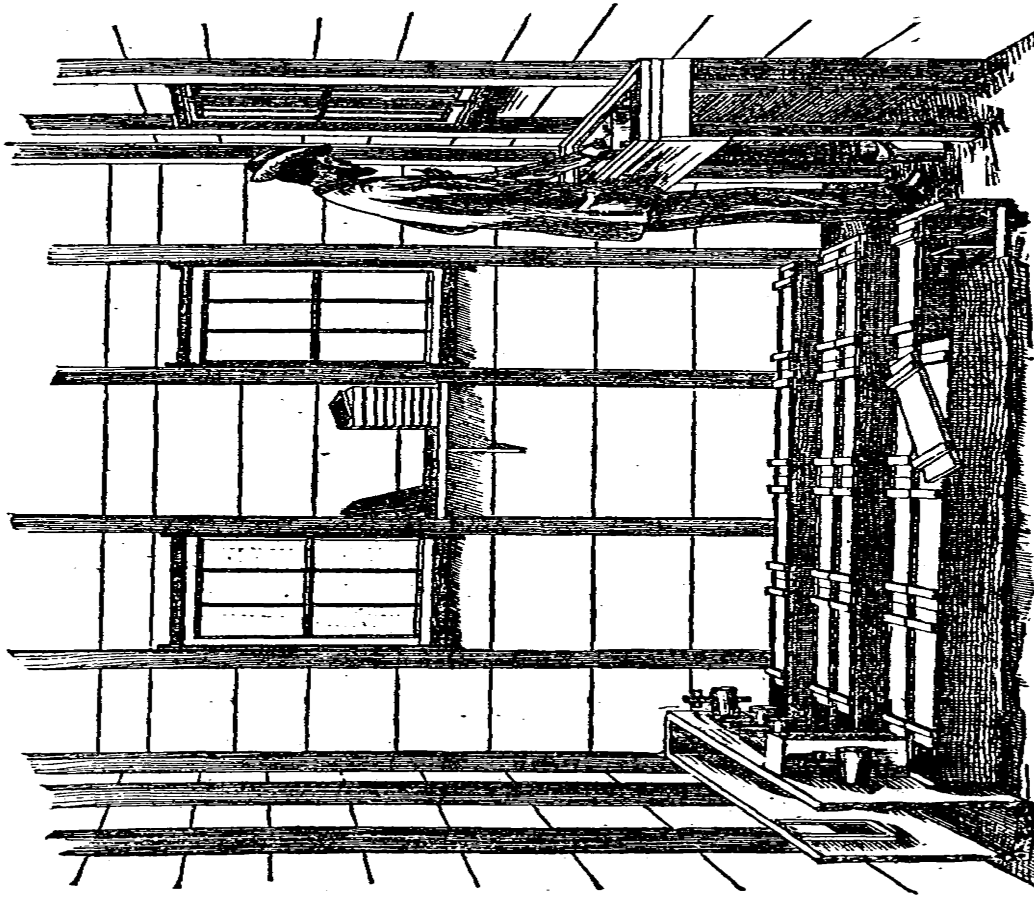


Fig. 5.

capacity of 150,000 Atlantic salmon, or say 100,000 to 125,000 Pacific salmon. The troughs are about ten feet long and six inches deep, arranged in pairs (except the one next the wall) with walks between. These troughs are placed upon the floor, but when circumstances permit well aerated water to be brought into the house high enough, it is better to place them two or three feet above the floor. This is, however, entirely a question of convenience for the attendant. The water used is supposed to be unfiltered, and is therefore received in a deep and wide head trough, which will serve as a settling tank. From the head trough the water is delivered by wooden faucets to the hatching-troughs, the fall at this point affording an opportunity for aeration, which can be improved by letting the water fall on a slanting board, from the edge of which it will fall in a thin sheet into the trough. It is important to have the faucets all exactly on the same level; otherwise those which are lowest will, unless carefully regulated, rob the others of their share of the water. The style of faucet represented is very convenient and safe, but a plain spout of lead or wood, three or four inches long, and closed by a slide on the upper side, as shown in Figure 6, is just as good and easier made. Avoid any kind of a faucet that is liable to be accidentally closed, like a molasses faucet, an occurrence that I have known to be followed by very serious results. The bore of the faucet should not be less than one inch for a trough a foot wide.

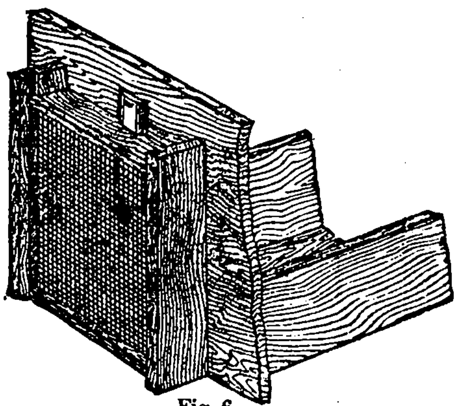


Fig. 6.

A very convenient outlet for a hatching-trough is formed by a two-inch lead pipe set into the bottom of the trough and running down through the floor. The water is maintained at the proper height by a movable partition, or dam of thin boards sliding down between cleats nailed to the sides of the trough, as shown in Figure 5. The height of the water depends upon the number of pieces brought into use at any time. These boards must be carefully jointed and fit nicely between the cleats, that there be no waste of water. A dam of the same sort should be used to hold the water at several points in an inclined trough.

The troughs should be fitted throughout with light board covers from two to four feet long, with cleats or other fittings convenient to lift them by. The faucets may be covered by a box, as shown in Figure 5, on the second trough. Screens fine enough to shut out all vermin should be placed at both ends of the trough.

Almost any kind of easily worked wood may be used for building the troughs. White pine is the favorite wood in northern sections. Arborvitæ, (*Thuja occidentalis,*) known in the north as white cedar, is unfit; water in which shavings of this wood have been soaked is deadly to grown trout. Caution should also be used in employing the southern white cedar, or cypress, (*Cupressus thyoides,*) red cedar, or savin, (*Juniperus virginiana,*) or any other odorous woods.

Inch boards are heavy enough for troughs not more than six inches deep, whatever their length or width. For deep distributing or filtering-troughs use plank an inch and a half or two inches thick.

All the wood-work about the troughs should be varnished with several heavy coats of asphaltum varnish, thoroughly dried in before the wood is wet. This makes a smooth, shining black surface, very easy to clean.

8.—WIRE TRAYS.

The practice of covering the bottom of the hatching-trough with gravel and depositing the fish eggs directly upon that has deservedly become nearly obsolete. Its principal disadvantages are, that it is impossible to spread the eggs evenly on such a bed; that there is great danger of suffocation by sediment because of the absence of any circulation of water beneath the eggs; that the operation of cleaning them is tedious in the extreme, and that the gravel seriously interferes with moving the fish about in the trough or even dipping them out.

The receptacle for the eggs which in one form or another has come into general use is a shallow tray, made by attaching wire-cloth to a narrow wooden frame. In its original form this was known as the "Brackett tray," and that name properly applies to the sort recommended below. The prominent advantages of this piece of apparatus are: first, the more perfect circulation of water amongst the eggs, insuring a better supply of the air demanded for their healthy development; second, almost entire safety from suffocation by sediment; third, the facility with which the eggs can be cleaned and moved about in the trough or be taken out for cleaning and examination. These advantages are so great and save so much labor that the wire tray is almost indispensable.

Trays of the following construction will be found most serviceable: Make the frame of any easily worked wood, ("white wood," the product of the tulip-tree, *Liriodendron,* is firstrate.) Half an inch in width and thickness are the best dimensions of material. Stouter frames would be likely to float the wire, whereas it is better that they should sink. The completed frame should be 12½ inches wide. This precise width is chosen because it is best fitted to receive wire-cloth one foot wide,—the size found to be most eligible. If the cloth were cut of the full width of the frame there would be many projecting rough edges, which would be an annoyance by scratching up everything they came in contact with and would be constantly rusting. Trays of this width fit well in troughs $12\frac{3}{4}$ inches wide. Their length may be equal to their width, as I prefer, or greater.

The wire-cloth heretofore commonly used is woven of annealed iron wire, in square meshes. This answers admirably when the wires are from $\frac{1}{8}$ to $\frac{1}{6}$ inch apart, (not wider than $\frac{1}{7}$ if brook-trout eggs are in hand,) so long as the fishes remain in the egg. But as soon as hatched they begin to poke their heads and tails down through the meshes, or sometimes their sacks are drawn through, and being unable to extricate themselves, they perish miserably. If, therefore, square meshes are to be used they should be very small,—not over $\frac{1}{12}$ inch wide. This sort of wire-cloth has, however, still this slight drawback,—that while the eggs are hatching the picking must be done in the trough, or if the trays are taken out the young alevins must come out into the air also. There is not, to be sure, much danger of injuring the fry by exposure for a moment to the air, but a good deal of extra care is involved, and it is much better not to have to take them from the water at all. These little troubles are all avoided by using cloth with a long mesh, (see Fig. 7,)—for Atlantic and land-locked salmon a mesh $\frac{1}{6}$ inch wide and $\frac{5}{8}$ to $\frac{3}{4}$ inch long,—through which the soft bodies of the fishes easily slide

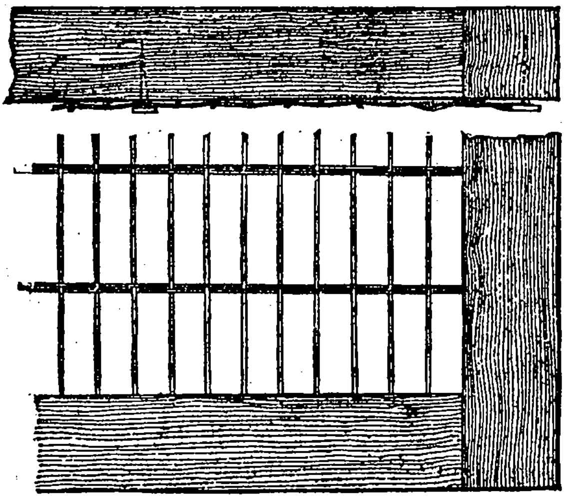


Fig. 7.

as soon as they have broken the shell, while the whole eggs are retained upon the trays and can at any time be lifted out without lifting the fish. Any one who is so situated as to get wire woven to order had better adopt the long meshes, woven of wire as small as can be well worked, which may be left to the judgment of the weaver. If, however, this cannot be had, then choose common wire-cloth, 12 wires to the inch or finer. The article sold at all the hardware shops for window screens is very suitable; being already painted thoroughly it requires but a single coat of asphaltum varnish to fit it for use.

All iron wire must be protected from rust by painting or varnishing in a most thorough manner. The commonly used material for this purpose is asphaltum varnish. The so-called paraffine varnish, a coal-tar product, is much inferior. It is very uneven in quality, but generally dries very slowly and has a penetrating and disagreeable odor. It is best to have the wire-cloth cut of the proper size, rolled perfectly flat, and then varnished with two or three coats on the edges that are to lie against the wooden frame. The rest of the varnishing can be done after the wire is attached to the frames. Two good coats, very carefully laid on, is the least that will answer for iron not previously painted, and three coats are much to be preferred. For nailing to the frames use tinned tacks.

There is, after all, a good deal of trouble in securing a thorough spreading and adhesion of the varnish, and it is much to be hoped that some better material will soon be discovered. I have tried iron wire, tinned after cutting up, and for a single season it has worked well; but I fear the tin will not be permanent enough. Brass wire, nickel-plated, is admirable but expensive,—costing about 60 or 70 cents per square foot. For the present, therefore, iron wire is recommended. There should always be a surplus of trays, so that if any of those in use are found to rust badly they can be exchanged for newly varnished ones.

9.—ARRANGING THE TRAYS FOR WORK.

The trays must not be placed on the bottom of the trough, but on a support raised a little distance above the bottom. As it is very desirable to have the trough as free as possible from obstructions, it is best to provide a temporary support for the trays, like that shown in Figure 8. Take a long, narrow strip of wood a quarter of an inch thick and drive through it, at proper distances, nails one inch long. Set the points of the nails a quarter of an inch into the floor of the trough and the top of the strip will then be three-quarters of an inch above the floor. On two of these supports, placed at a distance of a quarter or half inch from the sides and running the whole length of the trough, rest the hatching-trays. Supports touching the sides of the trough will not answer, because they form, with

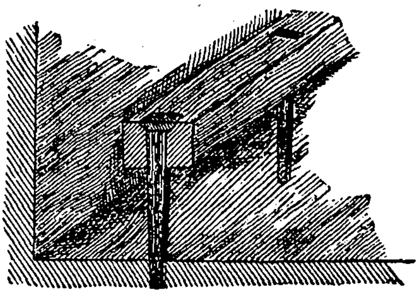


Fig. 8.

the trays and the sides, narrow crevices into which the young fish may wriggle, to the great danger of being crushed to death. After all are hatched the trays are no longer of service, and the support can then be taken out without injuring the fish, leaving an unobstructed floor.

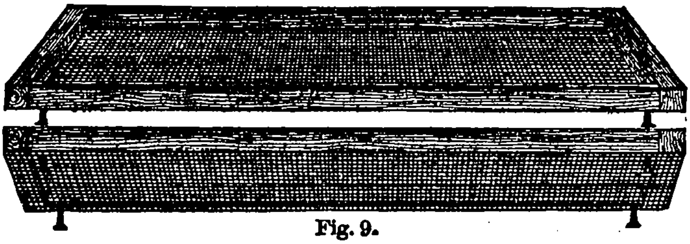
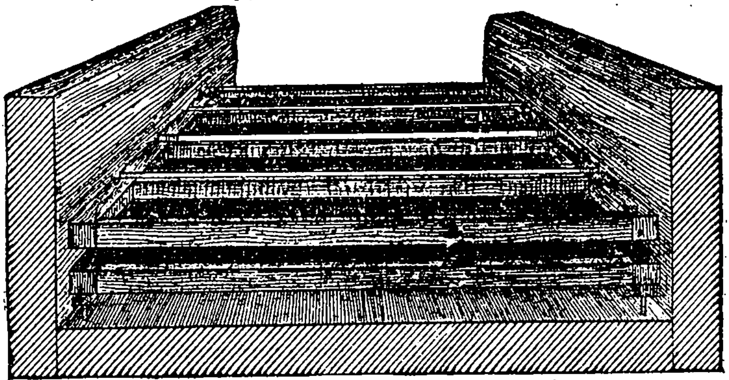


Fig. 9.

The trays which rest on the supports just described need no legs. To use a trough to its full capacity, however, another series of trays, resting on the first series, is necessary, and sometimes a third series resting on the



Fig, 10.

second. The trays used in these upper series must be provided with legs half an inch long, obtained by driving four nails into the under side of the frame. (See Figures 9 and 10.) This keeps the trays half an inch apart, the proper distance when there is a space of three-quarters or an inch under the lower trays. It is, however, recommended to partially close the lower space at first by a few movable cleats, which can be removed when the fish begin to come out of the shell and accumulate on the floor. These precautions are to guard against a too free flow of water underneath the trays, where it would at that time be wasted, and perhaps leave a scanty supply for the eggs above. As a further precaution, with the same end in view, if the trays do not fit the troughs pretty closely they may be placed obliquely, so that two opposite corners will prevent a draft of water down the side. (See Fig. 11.)

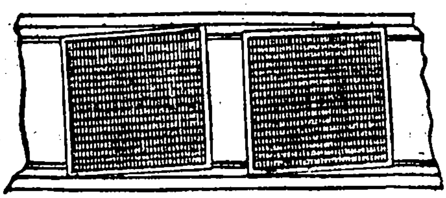


Fig. 11.

10.—CAPACITY OF THE TROUGHS.

The trays may be placed close together, allowing merely space enough to admit the fingers when handling them. Each tray should receive a single layer of eggs. They will count, of Atlantic salmon, about 2,000 per square foot; of Schoodic salmon, about 1,800, and of California salmon, about 1,200 per square foot. Allowing for all the waste space, a trough ten feet long with a single series of trays will hold about 13,000 eggs,* a very light stock. On two series of trays there would be 26,000 eggs—a fair stock—and on three series of trays, 39,000 eggs. The latter number would give us, after hatching, about 4,300 alevins for every square foot of trough-floor. With plenty of well-aerated water, a person with some experience will have no difficulty in bringing as heavy a stock as this through in safety. Indeed I have known a stock of over 5,000 per square foot to be brought through without serious loss. If the fish would lie evenly distributed over the floor there would be no difficulty, but at certain times they are seized with a perverse inclination to collect together in heaps, and, if they remain so a long time, those underneath are suffocated. Therefore, though it is wonderful how much crowding they will endure, the novice is advised not to attempt more than two series of trays, or 3,000 fish per square foot of trough.

11.—SCREENS.

If the trough is level there will be no occasion for any dams or barriers until the eggs are hatched, but, as something of the sort is needed to keep the alevins well distributed, it is better to provide for it in the beginning. At regular distances, not more than five nor less than two feet apart, attach to the opposite sides of the trough pairs of cleats, as if for a dam, such as has already been described for the outlet. Connect these opposite pairs of cleats by a low cross-piece or sill about half an inch high. As soon as the fish begin to move about a fine wire screen can be slipped down between the cleats until it rests upon the cross-piece; this is shown near the lower end of the front trough in Figure 5. The screen should not be coarser than twelve wires to the inch, and finer still will be better. Wherever dams occur in the trough or at its outlet the fish must be kept away from them by similar screens placed a few inches above the dams, or by one of another pattern, shown in Figure 12, which may be termed a safety screen. This form is worthy of special recommendation.

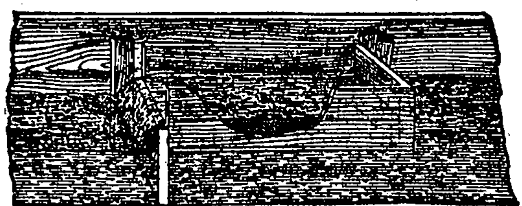


Fig. 12.

* Eggs of Schoodic salmon referred to when not otherwise specified.

The water passes through from below upward, and the weight of the fishes constantly tends to keep them away from it and assists them to clear themselves if once drawn against it. If there is a very strong current this is the only safe screen. It is nothing unusual for young fish to get against an upright screen and, the current being pretty strong, be unable to get away from it, and if the screen be too coarse their sacks are often drawn through, to their almost certain destruction. The safety screen should be sunk an inch or two below the top of the dam.

12.—TREATMENT OF THE EGGS.

If the foregoing instructions for the erection and fitting of the hatching-house have been judiciously followed, the task of caring for the eggs and young fry will not be a very difficult one, but will nevertheless demand constant alertness.

When eggs are received from other stations, it is important to lose no time in opening the package and ascertaining their condition. If the eggs are packed in moss, plunge the bulb of a thermometer into the moss under several layers of eggs, taking care to admit the least possible amount of outside air; cover it up and wait fifteen or twenty minutes, when it can be examined and the general temperature of the package ascertained pretty nearly. If it is within six degrees of the temperature of the hatching-water the eggs may be immediately placed on the hatching-trays. If, however, the temperature of the moss is six degrees higher or lower than the hatching-water, it is better to drench the boxes with water of intermediate temperature, several times if the difference be very great, to bring the eggs gradually to the temperature of the water. After this the sooner the eggs are placed on the trays the better. If it is impossible to avoid waiting, (over night, for instance,) let the packages stand in a room of safe and uniform temperature, (hatching-house or cellar,) but *never let packages of eggs stand in water.* If the eggs are packed in the mode now commonly adopted, between folds of mosquito net and layers of moss, first remove the upper moss carefully and then lift them out, a whole layer at a time, on the cloth on which they lie, and turn them into a pan of water, from which bits of moss, &c., can be picked out or rinsed off. An even distribution of them on the trays will be facilitated by measuring them out in a measure holding just enough to cover a tray.

Once deposited on the trays the necessary work is comprised in a simple routine. The dead eggs and fish turn white and must be removed before they taint the water. It is better, but not essential, to have a table or sink to do this work on, and a broad shallow square or oblong pan to set the tray of eggs in while picking, that they may not remain long out of water. This pan will also be convenient to rinse the eggs in, should they become very dirty. At any time after the eyes of the embryo become black a good deal of rough handling can be practiced without the slightest harm, and they can be safely shaken about upon the tray until thoroughly washed. A pair of tweezers will be needed to pick out the white eggs, and I would recommend a home-made article, shown in Figure 13, consisting of two pieces of wood tacked together and tipped with

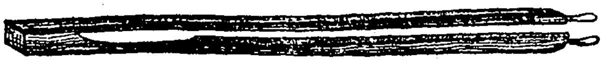


Fig. 13.

wire loops. They are much easier to the hand and altogether better than metallic tweezers. In water of 46° F. the dead eggs should be removed daily; at 45°, every two days will answer; at 40°, every three days; at 33°, once a week; but these are maximum periods and should never be overstepped.

If the eggs are neglected, the first result is that the dead ones begin to decay and taint the water, rendering it unfit for the healthy eggs. In the next place, if left long enough in the water, the decaying egg is attacked by a fungoid growth, of which the technical name is *Achlya prolifera*. This is what is commonly termed "fungus," though some writers have applied the term "fungus" to a totally different plant, a kind of *Conferva* or slime, which is either colorless or green, grows in long fine threads, and where too much light is admitted to the trough multiplies often to such an extent as to prove a nuisance, but never is troublesome in a darkened trough, and never, so far as known, feeds on animal matter. The *Achlya*, on the contrary, feeds on animal matter, and, so far as my own observations go, always on *dead and decaying animal matter*, never attacking a living egg. It grows in long white threads which radiate from the object upon which it is feeding, giving it a woolly appearance. It grows rapidly, spreads over all surrounding objects, and may do harm to good eggs by shutting off the circulation of water from them and thus exposing them to the poisonous exudations from the decaying substance. The presence of this growth in a hatching-trough is a sure sign of neglect; for, if the dead matter is removed before decay sets in, *Achlya* will never make its appearance.

The screens and filters must be daily or oftener examined to see that they are not choked up, for a few hours' stoppage of the flow might have disastrous results. If any emergency arises requiring a stoppage of the water for several hours, before the fish have broken the shell, it can be safely done if, at the same time, the water be drawn off from the trough, for which purpose a movable plug should be put in the bottom of every trough. Eggs are not injured by exposure to the air for however long time, provided they do not freeze nor get too warm nor dry up. But after the fish are hatched of course this cannot be done.

The height of the water in the hatching-troughs should be carefully attended to, so that it be high enough to have a current over the upper trays but not high enough to let the bulk of the water flow over the tops, depriving the lower layers of their share. If through neglect this robbery takes place, a lot of eggs with white stripes across them will be found some day, and close examination will show that the trunk of the embryo in each one is white, opaque, and dead—sure symptoms of suffocation.

The trays must be carefully watched, and those that rust be exchanged for newly varnished ones. The change is easily made by turning the new tray bottom up over the eggs, when, by a dexterous movement of the hands, the two are inverted and the eggs fall upon the new tray. This should be done over the broad pan, but the knack of doing it with very little spilling is soon acquired.

Strong light should not be allowed to shine for any great length of time on the eggs. Total darkness is as good as anything. But if covers are provided for the troughs, the house may be kept well lighted, and no harm will come from leaving the covers of a single trough off long enough to do any necessary work. In examining and picking the eggs, too, they may be brought into a strong light. But sunshine should never touch them.

13.—TREATMENT OF THE FISH.

After the eggs are all hatched the trays may be removed from the troughs. The principal thing to be looked after now is that the fish do not crowd up in heaps and smother each other. As soon as they begin to move about a great deal the screens described above should be put in place to prevent their congregating too much. If it becomes necessary to move them about in the troughs, to disperse improper gatherings, or to get them away from a spot that it is desirable to clean, it can be easily done by means of a sweeping board, (Fig. 14.) This effective implement is simply a thin board, a little shorter than the width of the trough, with the lower corners cut away as shown, so that they cannot touch the sides of the trough and perchance catch and crush the young fry. It depends for its efficiency on the fact that if a surface current is created in the trough in any direction there will be a corresponding bottom current in the opposite direction, and if this bottom current be moderately strong it will sweep along the young fish with it. To move the fish down the trough the sweeping board is placed in about the position shown in the cut and moved *up* the trough.

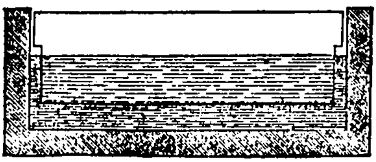


Fig. 14.

If the young fish are to be set free this must be done as soon as the yolk sack is absorbed, which will be from three weeks to three months after they are hatched, according to the temperature of the water. It is better to be too early than too late in this matter. For the young fish is well able to take care of himself, and in fact will sometimes begin to feed some days before the sack has entirely disappeared, while we know not how serious may be the result of two or three days' hunger. To remove them from the trough a scoop nearly as wide as the trough, made of a wooden frame with a shallow bag of mosquito net attached, after the fashion of Figure 15, will do good service. If the troughs are raised above the floor of the hatching-house the fish can also be drawn out from the outlets with water into a pail.

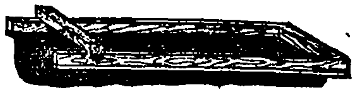


Fig. 15.

It is sometimes desirable to keep fish over night ready for an early morning start on a journey. This can be accomplished by taking a long box that nearly fits a hatching-trough, knocking out the ends and supplying their places with wire-cloth fine enough to hold the fish. When the time comes to put them into the cans they can be poured in from the box. When several cans are to be filled the fish for each may be put into a separate box.

14.—CONCLUSION.

In conclusion it is urged upon every person attempting the management of spawn and young fish that, however careful the construction of the houses and fixtures, the necessity for constant watchfulness is not to be escaped. There is no insurance so good as frequent and careful inspection. Especially in case of a severe storm or uncommonly cold weather, the attendant should be on the alert early enough to watch for the coming of danger and avert it. Nothing must be taken for granted until the establishment has demonstrated its security. Experience will show how far vigilance can afterward be safely relaxed.

Another matter that cannot be too strongly urged upon the attention of fish-culturists is the importance of complete records of all occurrences at the hatching-house. Not only the receipts of spawn and its condition, the losses occurring from day to day, and the shipment of young fish should be promptly, fully, and carefully entered upon the record-book, but the temperature of the air, the temperature, volume, and condition of the water should be regularly observed and recorded, and occasional notes made regarding the hatching and behavior of the fish, the presence and progress of maladies, if any occur, and any other phenomena of importance or interest. In no other way can the results of experience be so well preserved and made available, and it is much to be regretted that it has not been the practice of all fish-culturists to keep such records.

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