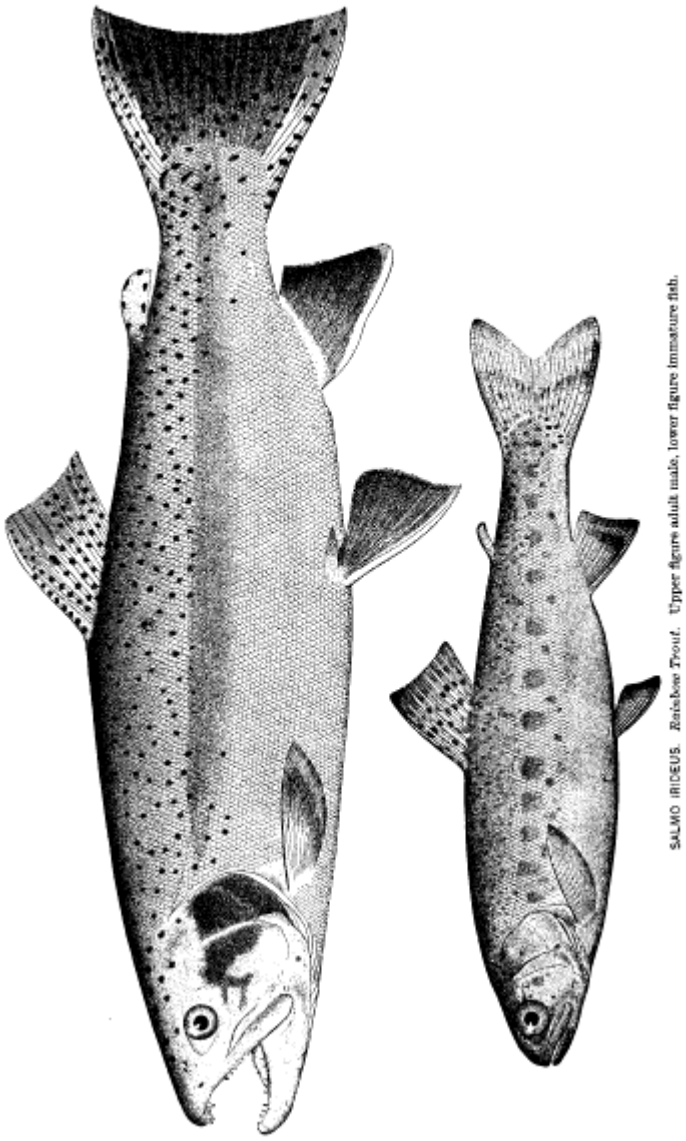
THE RAINBOW TROUT.

Report U. S. F. C. 1897. (To face page 71.) PLATE 20.



SALMO IRIDEUS. Rainbow Trout. Upper figure adult male, lower figure immature fish.

DESCRIPTION OF THE FISH.

The body of the rainbow trout (*Salmo irideus*) is comparatively short and deep, and is more elongate in males than in females. The average depth is contained about three and four-fifths times in the body length. The short head, which is obtusely ridged above, is about one-fourth the total length. The mouth is smaller than in other species of *Salmo*, the maxillary reaching scarcely beyond the eye, which is rather large, and is contained five times in the side of the head. The caudal fin is distinctly but not strongly forked. On the vomer are two irregular series of teeth. The dorsal rays number 11 and the anal 10. In the typical species there are about 135 scales in the lateral series, with 20 rows above and 20 below the lateral line; in the several subspecies the

number of rows of scales along the side is from 120 to 180. The color is variable, depending on sex, age, and character of water. Typical adult fish are bluish above, silvery on the sides' profusely and irregularly dark-spotted on the back and sides, the spots extending to the vertical fins, with a red lateral band and blotches and a nearly plain belly. The sea-run fish are nearly plain silvery. The chief distinguishing color characteristics of the varieties are in the number and position of the spots.

RANGE AND VARIATION.

The rainbow trout is not indigenous to eastern waters, its original habitat being the Pacific coast of the United States. It is especially abundant in the mountain streams of California. A few specimens, however, have been taken in salt water, and it is not unlikely that some find their way through the rivers into the sea.

The species is subject to considerable variation in form and color in different parts of its range, and the following varieties have received recognition by ichthyologists: The brook trout of western Oregon and Washington (*Salmo irideus masoni*), which rarely weighs as much as a pound and is locally abundant in the streams of the Coast Range from Puget Sound to southern Oregon; the McCloud River trout (*Salmo irideus shasta*), which attains a large size, is abundant in the streams of the Sierra Nevada Mountains from Mount Shasta southward, and is the rainbow trout which has received most attention from fish-culturists; the Kern River trout (*Salmo irideus gilberti*), which attains a weighs of 8 pounds, and is found only in Kern River, California; the noshee or nissuee trout (*Salmo irideus stonei*), which inhabits the Sacramento basin, and reaches a weight of 12 pounds; the golden trout of Mount Whitney (*Salmo irideus aqua-bonita*), which inhabits streams on both sides of Mount Whitney, California.

In the extensive section of the West in which the fish abounds its name varies in different localities; "red sides," "mountain trout," "brook trout," and "golden trout," besides "rainbow trout," are some of the popular appellations, while in the States east of the Mississippi River it is generally called "rainbow trout " or " California trout."

TRANSPLANTING.

The rainbow trout has been successfully transplanted in many of the mountain streams in different parts of the United States, where it grows and multiplies rapidly, as is shown by the many favorable reports. The best results, however, seem to have been obtained from plants made in streams of Michigan, Missouri, Arkansas, throughout the Alleghany Mountain ranges, and in Colorado, Nevada, and other Western States. It was introduced into eastern waters by the United States Fish Commission in 1880, but it is possible that specimens of it, or its spawn, had been brought east prior to that time by some of the State commissions or by private enterprise.

It is believed that this species will serve for stocking streams formerly inhabited by the brook trout (*Salvelinus fontinalis*), in which the latter no longer thrives, owing to the clearing of the lands at the sources of the streams, which has produced changed conditions in and along the waters not agreeable to the brook trout's wild nature. The rainbow is adapted to warmer and deeper waters, and is therefore suited to many of the now depleted streams which flow from the mountains through the cultivated lauds of the valleys.

Rainbow trout differ widely from brook trout and other pugnacious fishes, in that they feed principally upon worms, larvae, crustacea, and the like, and do not take readily to minnows as food. They should be planted in spring or early summer, when their natural food is abundant, as

they will then grow more rapidly and become accustomed to life in the stream; and when worms, larvae, etc., are no longer to be found, their experience and size will enable them to take a minnow or anything that may present itself in the shape of food.

In the Eastern States fry should not be planted in open waters until they are several months old, and then not until the temperature of the streams begins to rise; but fish hatched in December and January can safely be planted in April and May. On the Pacific slope the fry may be successfully liberated at any time after the umbilical sac is absorbed.

SIZE AND GROWTH.

The size of the rainbow trout depends upon its surroundings, the volume and temperature of the water, and the amount of food it contains. The average weight of those caught from streams in the East is probably less than a pound, but some weighing 6 3/4 pounds have been taken. In the Ozark region of Missouri they are caught weighing 5 to 10 pounds. In some of the cold mountain streams of Colorado their average weight is not more than 6 or 8 ounces, but in lakes in the same State, where the water becomes moderately warm in summer and food is plentiful, they reach 12 or 13 pounds, fish of this size being from 25 to 28 inches long. In the Au Sable River, in Michigan, they attain a weight of 5 to 7 pounds. In their native streams of California they are often caught ranging from 3 to 10 pounds, but average from 1 to 2 pounds. The largest specimen ever produced in the ponds at Wytheville, and fed artificially, weighed 6 1/2 pounds, but many others in the same ponds weigh from 1 to 3 pounds.

The average growth of the rainbow trout under favorable artificial circumstances is as follows: one year old, from 3/4 to 1 ounce; 2 years old, from 8 to 10 ounces; 3 years old, from 1 to 2 pounds; 4 years old, from 2 to 3 pounds. They grow until they are 8 or 10 years old, the rate diminishing with age. Some grow much faster than others under the same circumstances, but the rate of growth is largely a question of food, temperature of water, and extent of the range. In water at 60°, with plenty of food, fish 1 or 2 years old will double their size several times in a single season; while in water at 40°, with limited food, the growth is scarcely perceptible.

The rainbow, like the brook trout, will live in water with a comparatively high temperature if it is plentiful and running with a strong current, but sluggish and shallow water, even with a temperature of 70° F., is dangerous for brook trout. Rainbow trout will live in warmer water than brook trout, and are found in swift, rapid streams at 85° F., especially where there is some shade, but in ponds that temperature is dangerous even with shade and a good current. In its natural condition this trout is usually found in water varying from 38° F. in winter to 70° F. in summer, and in selecting a site for a trout hatchery spring water with a temperature of 42° to 58° is required.

The rainbow trout is a superior game fish, a vigorous biter, and fights bravely for liberty, though in the East it is somewhat inferior to the brook trout in these respects.

SPAWNING-PONDS.

In constructing ponds, one of the first considerations is to place the fish absolutely under the control of the fish-culturist, that he may be able to handle them without delay or inconvenience. At Wytheville they are constructed entirely of wood, about 15 by 50 feet and 3 to 3 1/2 feet deep, and shaped as shown in plate 22, and have been found very satisfactory. Excellent water circulation is obtained in all parts, and there are no corners for refuse to lodge in. The bottom of the pond is built with a gradual elevation, in the direction of the upper end, of 2 inches in the

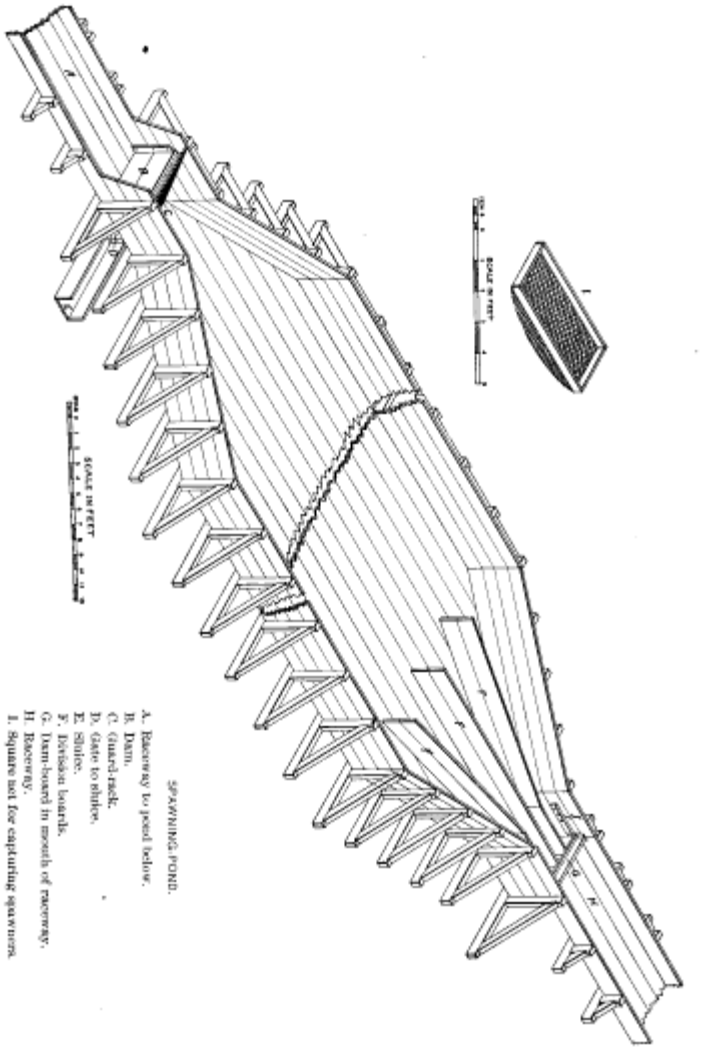
entire length of the pond. This makes it practically self-cleaning; nearly all of the foul matter will pass off and any remainder can be disposed of by drawing the water down low for a short period and then flushing the pond with fresh water. This method obviates the necessity of handling the fish, which is very important, especially when near the spawning time.

A guard-rack made of thin, narrow slats is arranged on an incline of about 45°, as shown at C. If the water is to be used again in ponds below, a receiver is built underneath the bottom of the pond at the lower end, between the foot of the guard-rack and the dam-boards, and the floor of the pond immediately over the receiver is cut away and fitted with a grating. This allows matter to fall through the receiver and from there it is washed through the sluiceway, which taps the receiver by drawing the gate shown at D. The sluiceway, E, is covered and leads off to a general waste-ditch.

The pond is provided with a spawning-race about a foot deep, 4 feet wide, and 25 feet long, placed at the upper end of the pond, as shown at H. Three division boards (shown at F), about 12 feet long and of suitable width to come within 1 or 2 inches of the surface of the water when the pond is filled, are firmly fixed at the bottom. The object of these boards is to form four avenues leading to the raceway, so that one or two pugnacious fish can not command the approach and keep back spawning fish inclined to enter. There is a dam across the raceway about 4 inches high (shown at G) for the purpose of bringing the water to that depth in the lower end, so that when the trout enter they will find sufficient water in which to swim freely, and not be inclined through fear to return to the pond.

The water in the pond is of sufficient depth to bring its surface within 6 inches of the top of the dam in the raceway, which will give the fish, in entering the raceway, a jump of 7 inches, allowing 1 inch for the depth of water on the dam in the raceway. This distance has been found more satisfactory than any other, and spawning fish alone will go up. If a jump of less than 7 inches is given, other fish can cuter the raceway without much exertion, and will ascend and disturb the breeding fish, which, when spawning, should be kept strictly by themselves.

There is no rule regarding the supply of water that applies to a spawning-pond at all times and in all places. It is necessarily governed by the temperature of the water, size and shape of the pond, size of the fish to be supported, the amount of shade, etc. For a pond such as has been described, where water is plentiful, at least 200 gallons per minute should be provided, with not less than 75 gallons per minute as a minimum, even where the temperature is from 50 to 55 degrees and all other conditions are favorable. While the former amount is not absolutely necessary for the support of the fish, it insures the pond being kept clean and the fish are more inclined to enter the raceway at spawning time. In order to maintain an even temperature in the pond the earth is banked against the sides and ends, covering the framework shown on plate 25, and the embankments are made broad enough on top to admit of a good footway around the ponds.



Such a pond as this can accommodate from 1,000 to 1,500 breeding fish. Fish must not be overcrowded, anti in estimating the capacity of a pond several modifying conditions must be considered, such as the size of the fish, water supply, temperature, and shade. In stocking the spawning-pond a good proportion is two females to one male. The breeding stock is selected carefully every year; only sound and perfect fish are retained for the next season, and the blind and emaciated fish of both sexes are destroyed.

TAKING THE SPAWN.

The spawning season varies with the locality and the temperature of the water. It is usually two to four weeks later in the streams than where the fish are kept confined in spring water. In the ponds at Wytheville the spawning fish may be found any time after the 1st of November; the season is well started by November 15, and generally closes about the 1st of March. December

and January are the best months. In California the season extends from the 1st of February to May, and in Colorado begins early in May and continues until July.

The natural nests of these fish are made on gravelly bottoms, and are round or elongated depressions about the size of a dinner plate. After the eggs have been deposited and fertilized they drop between the pebbles of the nest, where they lie protected until hatched.

Where spawning-ponds are provided with suitable raceways the fish will ascend from the ponds into them, seeking a place to make their nests, and may then be taken out and stripped of their spawn. To take the fish from the raceway, a square net (I, plate 22) is dropped in on the cleats nailed against the side walls in the approach, shown at J, the dam in the mouth of the raceway is raised, and the fish driven back into the net. The net is then lifted out of the water, and if it contains too many fish to handle conveniently a landing-net is used to take out part of them before the square net is moved. The ripe fish are then placed in tubs or other vessels provided for the purpose. If too many fish are put in the tub at one time they become restless and sick before they can be stripped of their spawn.

There are two methods of taking and impregnating the spawn of fishes, the "wet" and the "dry" methods. By the "wet" method the eggs are taken in a pan containing sufficient water to cover them and allow them to mix freely with the milt, which is immediately added. After the contents of the pan have been stirred for a few seconds with a feather, the eggs are set aside and left undisturbed during fertilization. The "dry" or "Russian" method is now in general use; the eggs and milt are taken in a moist pan and it makes little difference which is taken first, but one should immediately follow the other, and the contents of the pan be thoroughly mixed.

After the eggs and milt have had time for contact, and before the eggs begin to adhere to the bottom of the pan, water is added to the depth of about an inch, the eggs being kept in gentle motion, by turning the pan, to prevent adhesion. After 2 or 3 minutes the milt is poured off and clear water is put in the pan, in which the eggs are allowed to remain until they separate, which will be in from 15 to 45 minutes, depending on the temperature of the water. It is preferable to take the eggs to the hatchery before the milt and water are poured off, and there rinse them off and place them directly on the hatching-trays (previously arranged in the troughs) and then allow them to separate. In freezing weather it is advisable to strip the eggs in water or to use two pans, one set in the other, with water in the bottom pan to prevent the eggs from being chilled.

In taking spawn the manipulation of the fish without injury is a very delicate and exacting task, full knowledge of which can only be acquired by experience, as it is difficult to squeeze the spawn from the fish without injuring or even killing it. In taking hold of the fish in the spawning-tub the operator catches it by the head with the right hand, the back of the hand being up, and at the same time slips the left hand under the fish and grasps it near the tail, between the anal and caudal fins. A fish caught in this way can be easily turned over as it is brought out of the water, so that its abdomen is up and in the proper position for spawning by the time the spawning-pan is reached. If the fish struggles it must be held firmly, but gently, until it becomes quiet, and when held in the right position it will struggle only for a moment. A large fish may be held with its head under the right arm.

When the struggle is over the right hand is passed down the abdomen of the fish until a point midway between the pectoral and ventral fins is reached, then with the thumb and index finger the abdomen is pressed gently, and at the same time the hand is slipped toward the vent. If the eggs are ready to be taken they will come freely and easily, and if they do not, the fish is put back in the pond until ready to spawn. If the eggs come freely from the first pressure the operation is repeated, beginning at or near the ventral fin.

After the first pressure has been given, by holding the head of the fish higher than the tail, all of the eggs that have fallen from the ovaries and are ready to be expressed will fall into the abdomen, near the vent, so that it will not be necessary to press the fish again over its vital parts, the eggs having left that portion of the body. All of the eggs that have fallen into the abdomen below the ventral fin can be easily ejected without danger of injury to the fish, caused by unnecessary pressure over its important organs after the eggs have left that part of the body. If these directions are judiciously and carefully followed but little, if any, damage will result; and, as an illustration, it may be mentioned that fish have been kept for 14 years and their full quota of eggs extracted each season during the egg-producing term, which is normally from 10 to 12 years. The male fish is to be treated very much in the same manner as the female, except the milt must not be forced out, only that which comes freely being taken.

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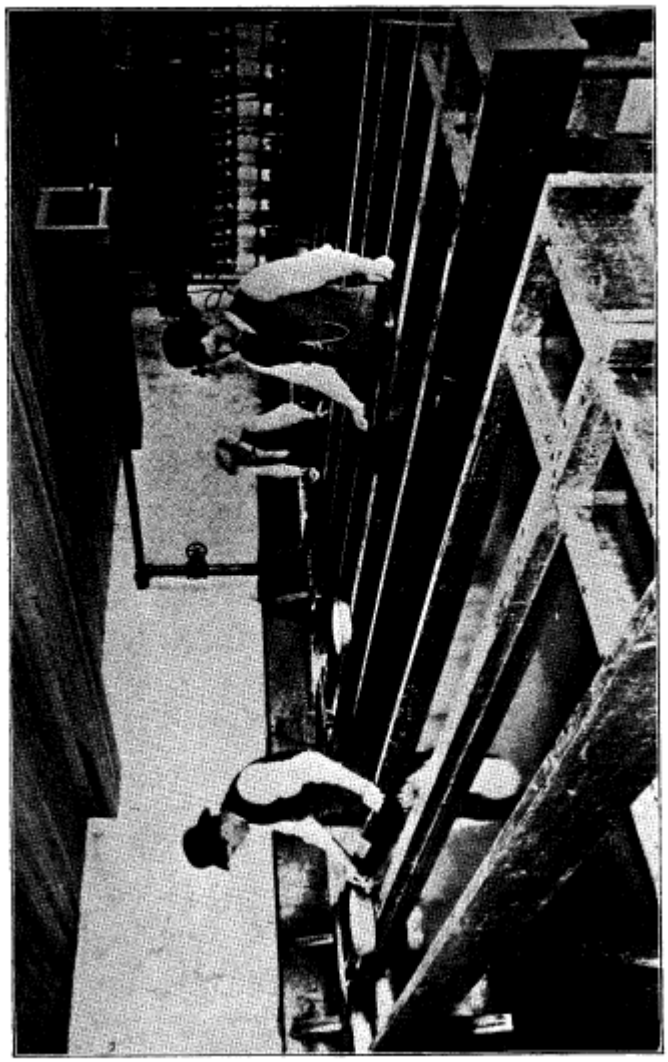


INTERIOR VIEW OF WYTHEVILLE HATCHERY, SHOWING MEN PICKING OUT DEAD EGGS.

After stripping, the fish are not returned to the spawning-pond, but spent females are placed in one pond and the males in another. The males are very pugnacious at this season, and sometimes

fight for an hour or more at a time, until they are entirely exhausted; they run at each other with open mouths, lock their jaws together and in that position sink to the bottom of the pond, where they lie for a short time, each holding the other in his grasp until rested, when they rise and resume the combat. As their teeth are abnormally long, they scar each other and even bite pieces of skin and flesh from the sides of their antagonists.

The males are good breeders at 2 years old, but very few females produce eggs until the third season, when they are from 30 to 36 months old. At Wytheville hatchery about 1 per cent of the females spawn at 2 years of age; about 50 per cent at 3 years, and about 85 per cent each season after that. About 15 per cent of the fully matured females are barren each season. It was at one time thought that the same individuals were barren each year, but experience has shown that such is not the case, as fish which were barren one season have been held over, in a separate pond, until the following year, when a large portion, if not all, produced eggs. This sterility may be the result of injuries received during the previous season, during the progress of spawning.

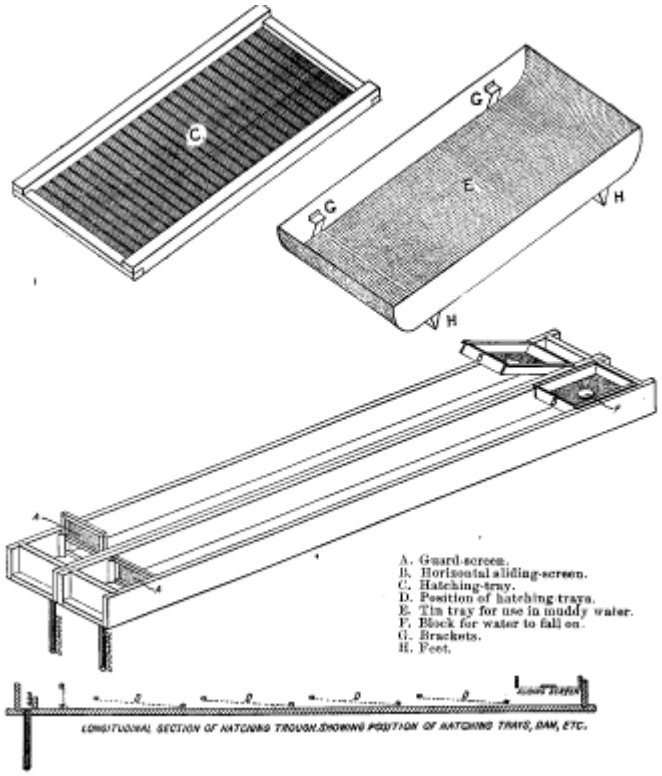
EGGS.

The number of eggs produced in a single season depends upon the size and age of the fish. The maximum from one 3 years old, weighing 1/2 to 1 1/2 pounds, is from 500 to 800; from one 6 years old, weighing 2 to 4 pounds, it is 2,500 to 3,000. The eggs vary in size from 4 1/2 to 5 eggs to the linear inch, and are of a rich cream color when first taken, changing to a pink or flesh-color before hatching.

THE HATCHING TROUGHS AND TRAYS.

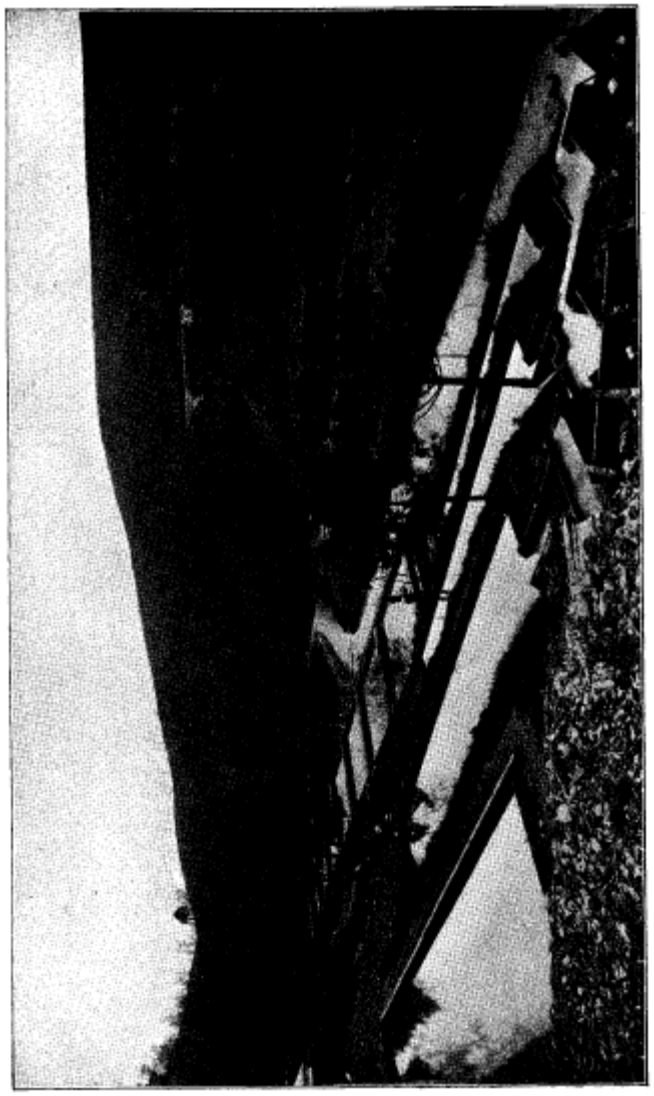
The eggs of rainbow trout are usually incubated on trays, placed in the water in troughs of various sizes and shapes. At Wytheville the troughs are set in pairs, as shown on page 78, are made of the best pine lumber dressed to 1 1/2 inches thick, and are 15 feet long, 14 inches wide, and 8 inches deep; 14 inches from the lower end inside is a guard-screen of perforated tin or wire mesh, fastened on a frame exactly fitted across the trough. Tin with perforations of 1/16 inch for very young fry, and larger ones as the fish grow, is preferable to wire. The screen is arranged to slide vertically between beveled cleats, that it may be kept clean easier. A plain board 3 1/4 inches wide is placed 4 or 5 inches from the lower end of the trough to serve as a dam.

In the upper end of the trough horizontal screens (B, page 78), made of perforated tin, are used. These are so constructed that they can be slipped forward or raised up (as shown in the illustration) in feeding the fry or cleaning the troughs, and the water falling on a small wooden brook in the center of the screen is thoroughly aerated before entering the trough. This arrangement possesses many advantages over the old method, where the screens were vertical, or nearly so, as it permits the fish to ascend to the head of the trough and receive the water as it falls from the screen, which is very beneficial. Its use not only keeps the fry clean even in muddy water, but also reduces the loss of fry from suffocation in the early stages, caused by their banking around the vertical screens, and obviates the necessity for trough covers to prevent jumping, as trout rarely jump where the horizontal screen has been adopted.



Hatching-troughs, Guard-screen, etc.

Hatching-trays (C), made about twice as long as wide, i. e., 28 by 13 1/2 are convenient to handle and adjust in the troughs. The sides of tile frame are made of good pine lumber, dressed, 1 inch square; the ends are dressed 1/2 by 1 inch, and are cut into the sides to form a smooth surface on the bottom for the wire filling. The wire used on the trays is woven with 8 threads to the inch, with a mesh 7/8 inch long, and should be well galvanized after it is woven, in order to prevent rusting at the laps.



TROUT-REARING-PONDS AT WYTHEVILLE STATION.

Four hatching-trays are placed in each trough and are secured by keys or wedges, and should be from 1 to 2 inches lower at the end next to the head of the trough, as shown at D, D, D, D, page 78. If placed in this way, each tray will hold from 12,000 to 15,000 eggs with safety. Muddy water during the hatching season necessitates the use of a tin tray with a perforated bottom (shown at E, page 78), which is 13 3/4 inches wide and 32 inches long. This sets inside of the hatching-trough on feet raising it an inch above the bottom of the trough. The hatching-tray containing the eggs is placed inside and rests on the brackets shown at G. The fish, as they hatch out, fall from the hatching-tray upon the perforated bottom of the tin tray, and by their movements work the sediment through, leaving them on a clean bottom and in no danger of being smothered. The tin trays are also useful in counting fish, or in holding. small lots of fish of different species in the same trough. Where supplementary trays are not used, the fry fall directly into the troughs.

Troughs 15 feet long will admit of four hatching-trays in a single row, each of which will

safely carry 12,500 eggs, making 50,000 to a trough; this is enough to work easily, but if it is necessary to make more room a double row of trays may be put in, one tray resting on the top of the other. Thus the trough could contain 100,000 eggs as its full capacity. The troughs will carry this number up to the time of hatching by placing the trays lower at one end than the other, as previously described.

When the hatching stage arrives, two trays of 12,500 eggs each are as many as should be left in one trough; with this number, by using the horizontal sliding-screen in the upper end, there is but little danger of the alevins congregating and smothering in any part of the trough. If it is necessary to hatch a much larger number than this in one trough, the sliding-screen is so arranged that the water falls well up against the end of the trough. This is done by raising the screen and turning it back against the reservoir, or by putting in a wedge-shaped block for the water to fall upon, turning the thin side of the block toward the upper end of the trough. Fifty thousand trout have been hatched in one trough prepared in this way without loss from suffocation, but it is not advisable to hatch such a large number together.

The amount of water necessary for hatching and rearing depends upon the temperature and the manner in which the water is applied. The water should receive as much aeration as possible before entering the compartments containing the fish and eggs. At Wytheville, where there is an even temperature of water of 53° in the hatchery, about the following quantities are used in the troughs containing fish and eggs:

100,000 eggs during incubation, 12 1/2 gallons per minute.

100,000 fish hatching to time of feeding, 30 gallons per minute.

100,000 fish from 1 to 4 months old, 50 gallons per minute.

100,000 fish 4 to 6 months old, 100 gallons per minute.

100,000 fish from 6 to 12 months old, 200 gallons per minute.

These amounts are ample, and probably even half would suffice if it were necessary to economize in the use of water. In rearing-ponds more water is required, as the circulation is not so good and the outdoor exposure causes the temperature to rise. If water is plentiful, double the amounts stated would be advisable for pond-culture.

During the last two seasons at Wytheville 80 to 85 per cent of the eggs taken produced fish, of which about 70 per cent were raised to three months old and 55 per cent to yearling fish. The loss in eggs was almost entirely due to failure in impregnation, very few being lost from other causes.

CARE OF EGGS AND FRY.

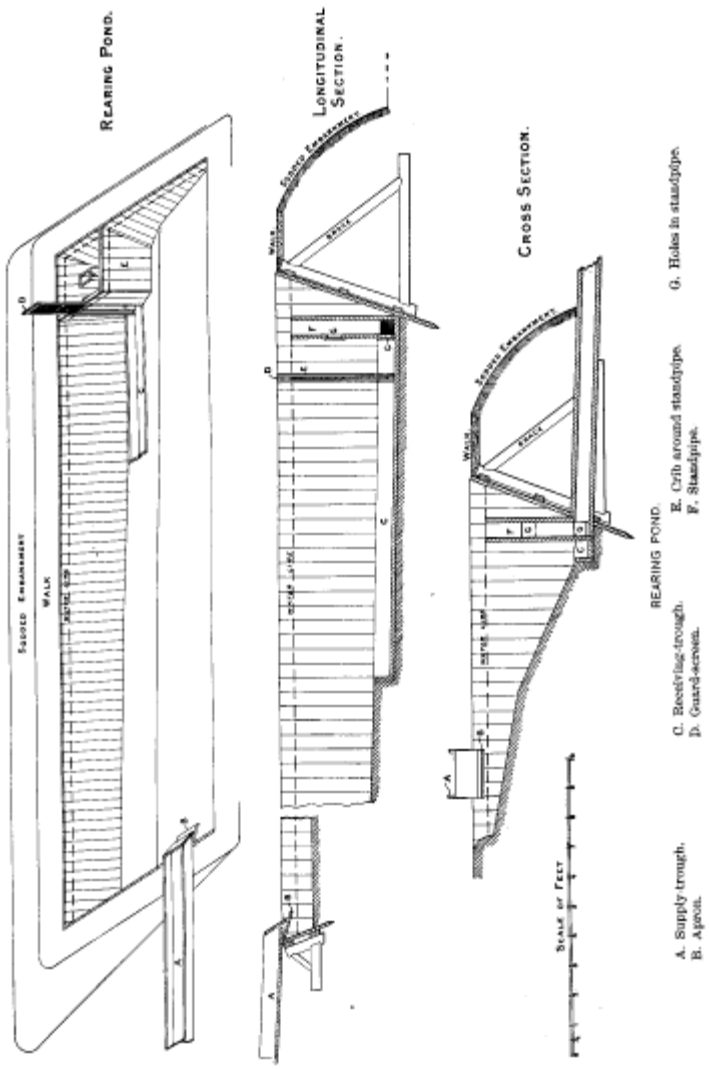
After the eggs are placed on the trays, the only attention necessary until the hatching begins is to keep them clean; the dead eggs, which may be known by their turning white, must be picked out at least once each day. After the eye-spot can be plainly seen it is well to run a feather through the eggs for the purpose of changing their position on the trays, and to disclose any foreign matter or dead eggs that may be hidden underneath. The greatest care should be exercised in handling the eggs at any time, particularly from the first or second day after collection up to the appearance of the eye-spot, and then only when absolutely necessary. During this period, the eggs are very delicate, and even passing a feather through them may cause a heavy loss.

The time required for hatching depends mainly upon the temperature of the water. Rainbow trout eggs will hatch in water at 50° in from 42 to 45 days, each degree colder taking 5 days longer, and each degree warmer 5 days less; the difference increases as the temperature falls and diminishes as it rises.

After the fry hatch they require but little attention until the umbilical sac is absorbed and the time for feeding arrives. They are examined each day, and the dead fish and decayed matter removed from the troughs, which are kept perfectly clean, and if possible provided with a thin layer of coarse white sand on the bottom, to keep the fish in healthy condition. As the fish grow they should be thinned out in the troughs, from time to time, as their size may require. When they first begin to feed, 12,000 to 15,000 fish to the trough are not too many; but by the time they get to be 1 1/4 to 1 1/2 inches long they must be divided into lots of 8,000 to 10,000 to each trough; while with fish averaging 3 inches in length, 3,000 to 4,000 are as many as one trough will accommodate. It is advisable to give as much room as is practicable.

REARING-PONDS.

Ponds for rearing trout are from 8 to 12 feet wide, and of any desired length up to 60 feet, which, for convenience in drawing them off and in feeding the fish, is about the extreme limit. The size, shape, and arrangement of the ponds must depend upon the ground on which they are to be constructed. If practicable, it is best to build them on a hillside, one above the other, with earth and piling embankments on the lower sides and at the ends.



A pond of this kind is shown in plate 25, and is the one here described. Various materials may be used for damming the water. The embankments may be made altogether of earth or lined with stone, brick, cement, or timber, according to circumstances. Where the ground is of a porous or loose formation it is necessary to use piling or cement for the inside of the embankments and possibly cement for the bottoms, but earth bottoms are best where the nature of the ground permits. The water enters the pond at one end and discharges from the lowest opposite corner. The bottom is graded as shown in the cross-section, plate 25, with a slope toward the outlet, so that when all the water is drawn out the fish are led into the receiving-trough (C), the top of which is flush with the earth bottom in that part of the pond.

The outlet for the water is an L-shaped pipe, shown at F, and is placed in the corner of the pond, the long end passing through the piling and underneath the pond embankment; the short end, called the standpipe, stands close to the inside corner of the pond, in an upright position.

The standpipe has two or more holes cut through (G) on the side next to the receiving-trough, to let the water pass out in drawing down the pond. The size of these holes is in proportion to the size of the standpipe, which, in turn, is governed by the size of the pond. The holes may have blocks of suitable size tacked over them to allow the pond to fill with water, or, what is more convenient, covered with blocks arranged to slip down in grooves, one block resting on the other. Surrounding the standpipe is a crib, the front of which is 15 inches or more from the pipe and contains an opening for a guard screen, which is 14 to 16 inches wide and made with copper or galvanized wire cloth, the size of the mesh depending on the size of the fish in the pond. In the bottom of the pond is a receiving-trough (C) for the fish, built in proportion to the size of the pond; 10 feet long, 16 inches wide, and 6 inches deep is a satisfactory size for a pond like the one described. This trough extends to and connects with the standpipe, and the guard-screen is arranged to fit down on the inside. Every part is made secure, to prevent fish from escaping when drawing off the water. The supply-trough or pipe is arranged to keep the fish from jumping into it from the pond, as shown at A.

STOCKING THE REARING-PONDS.

The rearing-ponds at Wytheville are stocked gradually, 500 to 1,000 fish being placed in the pond and trained to take food before more are added, as that number can generally find enough natural food to subsist upon until they learn to take artificial food. When they have been accustomed to hand-feeding another 1,000 fish are added, and in about ten days 2,000 more, this practice being continued until the pond is stocked with the desired number. When fish are first released in ponds they are wild and run away from the food given them; hence the necessity of teaching a few fish to eat before more are added. The number of fish that a pond of a given size can support depends upon the amount of water and shade and the temperature of the former. Ten thousand fish are ample for a pond 10 by 50 feet, with water deepening from 3 inches to 3 feet.

FOOD FOR FRY.

Beef or sheep liver, ground or chopped to a pulp, seems to be the most satisfactory artificial food for young trout. Fresh, hard-boiled eggs, grated fine, are good, but expensive. Efforts have been made to produce a natural or living food, such as insect larvae and small crustaceans and this may yet be accomplished for late spring and summer feeding, but for feeding the fry during the first three or four months of their lives, which is in the winter season, there is nothing better than liver. Shad and herring roe, put up in sealed tin cans, have been used to a limited extent with satisfactory results, and it is believed that they will furnish a wholesome and natural diet.

The manner of feeding young fry is very important, as the losses from improper feeding are greater than from all other causes combined. If there is undue haste the water becomes polluted, or the food is so distributed that some fish are prevented from getting their proper share. Polluted water is very injurious to the young fish, being apt to produce inflammation of the gills and a slimy, itching condition of the skin, which often causes heavy mortality.

The fry are ready to take food as soon as the sac is absorbed, the time required for this depending upon the growth of the fish, which is governed by the temperature of the water. Where the temperature is regular at 53° they will take food in about 30 days after hatching, and the time to commence feeding may be closely determined by watching the movements of the fish. Before the sac is entirely absorbed they will begin to break up the school on the bottom of the trough and scatter through the water, rising higher and higher from the bottom each day, until

they can balance themselves gracefully in a horizontal position, all heading against the current and swimming well up in the water. By dropping some small bits of cork or the nap from red flannel on the surface of the water it can be determined if they are ready for food; if they strike at the pieces as the current carries them down it is evident they are hungry.

The liver is prepared by chopping it very fine and, if necessary, mixing it with water' in order that it may be distributed evenly. It should be given to the fish by dipping a feather into the liver and gently skimming it over the surface of the water. After the fish grow to be 1 1/4 to 1 1/2 inches long they begin to take up the food that settles on the bottom of the trough; it is then not necessary to mix the food with water, and it can be given by hand. The young fry are fed five or six times a day and the food given slowly and sparingly. After they learn to take their food from the bottom of the trough it is necessary to feed them only three times daily, but more food must be given at each meal.

FOOD OF ADULT FISH AND YEARLINGS.

In domestication the rainbow trout is preferably fed upon a meat diet altogether, if it can be had plentifully and sufficiently cheap; otherwise a mixture of liver and mush may be used advantageously. The mush is made by stirring wheat shorts or middlings in boiling water until the mixture becomes thick; it will keep for several days, even in warm weather, if put in a cool place. The liver is ground is or chopped fine and mixed thoroughly with the mush in any desired proportion up to four-fifths of the whole, but it is better to mix only as needed. This mixture has been used satisfactorily for many years.

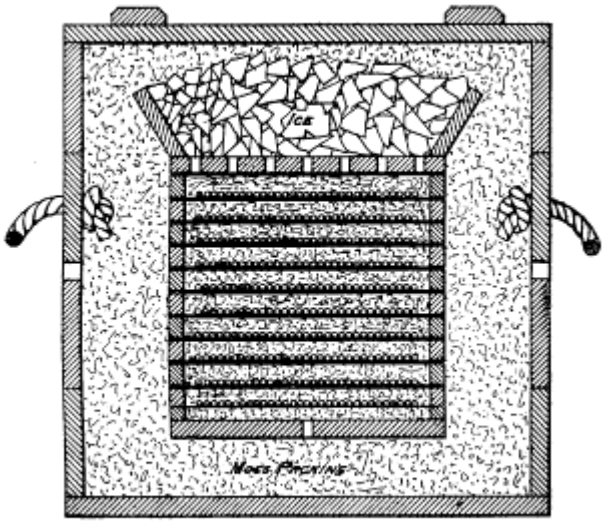
A meat-chopper may be obtained for grinding liver which will do the work in an excellent manner, leaving no strings or gristly chunks to choke the fish. There are several sizes of the machine made, with extra perforated plates having different-sized holes, from one-twelfth to one-fourth of an inch in diameter, so that the meat may be prepared coarse or fine, to suit the size of the fish to be fed. For small fry it is necessary to use the plate having the smallest holes and to grind the food over several times until fine enough to use.

The practice of throwing food into the pond in handfuls causes the fish to come together in great numbers and in a violent manner; and struggling with open mouths to get a bite of' the food, they often hurt each other, injure one another's eyes, sometimes even plucking them from the sockets. This is probably one of the main causes of blindness among pond-fed fish..

The most approved method of feeding is to walk along the pond its entire length to the upper end (the dish will soon learn to follow to that point), then scatter a handful of food along the surface of the pond so that it will fall to pieces. The fish follow and take up what has been thrown out and then return to watch for the next handful, and the operation is repeated until sufficient food is given. This manner of feeding induces all the fish to head in the same direction while eating, thus reducing the danger of injury.

The amount of food for a given number of trout depends upon the size of the fish and the temperature of the water, as fish will not take food as freely in a low temperature as they will in warmer water. With water from 50° to 60° a daily ration for 1,000 yearling fish ranging from 3 to 5 inches in length is about 3/4 of a pound; while for the same number, 8 to 12 inches long, about 12 pounds per day are required.

As the fish increase in size the amount of food should be increased proportionately. They are fed twice a day at regular hours, morning and evening, giving half of the daily allowance each time. This keeps them in a thrifty and growing condition.

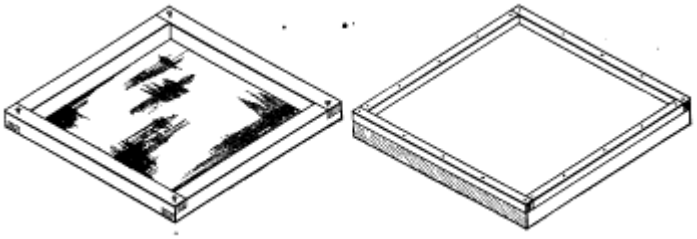


Cross-section through Box after it has been packed and closed.

PACKING EGGS FOR SHIPMENT.

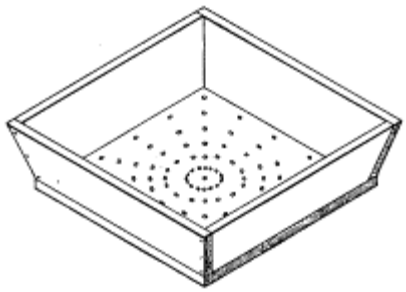
PACKING EGGS FOR SHIPMENT.

In packing trout eggs for shipment they are usually placed on trays and packed in wet moss and the eggs divided into from five to ten equal parts, according to the size of the shipment, using trays of suitable size to hold each part.

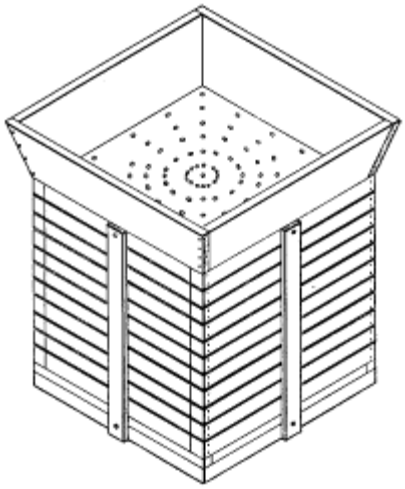


A. Egg-tray. B. Foundation-board.

If 30,000 eggs are to be shipped, ten trays are used large enough to contain 3,000 eggs each: if 15,000 eggs, ten trays containing 1,500 eggs each; 10,000 eggs, eight trays of 1,250 each, etc., and if over 30,000 eggs are to be shipped the shipment is made in more than one lot. In a package of more than ten trays, especially if the trays are large, the eggs on the lower trays are liable to be crushed by the weight above, and if less than five trays are used in a shipment the package is liable to become dry, and the eggs reach their destination either dead or in a shriveled condition.



C. Ice-hopper.



D. Egg-trays packed and cleated.

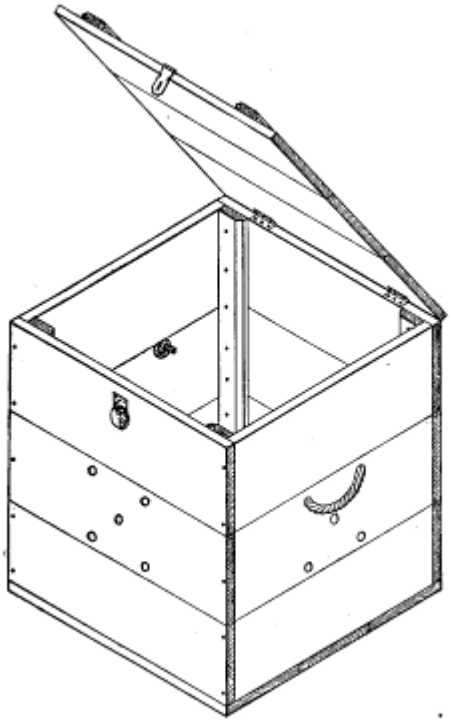
The frames of the trays are made of light, soft wood dressed to 5/8 by 7/8 of an inch, with a soft canton-flannel bottom tightly stretched and well tacked on. The trays are made large enough to contain their proportion of the eggs, with an allowance of 3/4 of an inch between the eggs and the frame of the tray. A foundation-board (B) is made with the same outside dimensions as the tray, with a strip nailed around the edge on the upper side to form a cushion of moss for the bottom tray. A hopper for ice (C) is used on the top tray. The outside case (E) is made 7 to 8 inches larger on the sides (inside measure) and 5 inches deeper than the outside dimensions of all the trays after they are cleated together, including the hopper and the foundation-board, as shown at D.

The trays having been prepared, the eggs are selected, those being taken which show eye-spots and are not too old to reach their destination before the time for hatching. Allowance is made for changes in temperature on the road which would cause them to hatch too soon.

The eggs are taken from the hatching-trays in pans, well cleared of all sediment, and given a slight concussion by allowing water to fall-on them from a small spout or sprinkling pot, which causes the dead and unfertilized eggs to turn white, when they are carefully removed. The eggs are then accurately weighed or measured (1 ounce may be weighed and counted, or the eggs for one tray counted and then weighed) and the required number placed in a single layer in the middle of the tray, leaving an empty space all round next to the frame.

The trays are then placed one above the other on the foundation-board, after each is covered with a piece of mosquito netting, which should be at least 2 inches larger each way than the tray, and the tray is filled with wet moss, the part immediately over the eggs in a loose manner, the

empty space around the eggs packed tight. This gives support to the next tray above and prevents the eggs from coming in contact with the wood and becoming dry and shriveled.



E. Outside case.

After all the trays are thus arranged the hopper is placed on top and the whole cleated together, as shown at D. They are then ready to be placed in the box or outside case (E). Dry sphagnum moss is placed in the bottom of the box to a depth of about 3 inches and the crate of trays placed as near the center of the box as possible. The sides are well packed to hold it firmly in position, and when the top of the hopper is reached with the packing it is well filled with ice, the remaining space in the box being filled with moss. Wet moss or wet packing of any kind should never be used for the cushion around the egg-crate, as it does not preserve an even temperature and is liable to freeze solid if exposed to a low temperature in transit. A cross-section of the box thus packed is shown on page 84.

The box containing the eggs should be provided with handles to facilitate moving during transportation, in order that the liability to injury from jarring or concussion may be reduced. For a long journey the lid of the box is provided with hinges and hasp and staple, so that the ice may be easily renewed. Eggs packed as described above have been shipped with safety to all parts of the United States and to foreign countries.

DISEASES OF FRY AND ADULTS.

The most common diseases of trout fry are the inflammation of their gills and a slimy skin disease, which may be caused by impure water; the food itself may produce it, especially if stale liver is used, but it generally follows fouling of the water while feeding. By watching the movements of the fish, the symptoms of disease can generally be detected before it reaches an alarming stage. If the gills are affected the fish will usually swim high in the water in an uneasy, restless manner, as if gasping for breath, and when this is observed the gills must be examined to

see if they are becoming inflamed and swollen. If a skin disease is attacking the fish, they generally indicate it by rubbing themselves on the bottom of the trough or against anything that may be convenient, or by diving down and giving themselves a quick, twisting motion against the bottom of the trough. If the progress of disease is not promptly checked, it will soon reach a stage where nothing can be done, and the fish grow weaker every day until they begin to die in alarming numbers. one of the best remedies for both diseases is salt sprinkled through the water after the ponds are drawn low, and for a bad case of skin disease a half pint of salt for every gallon of water in the trough is used, or about that proportion. The fish should be watched closely and allowed to remain in the salt water until they become restless and begin to turn on their sides. Then, as fresh water is turned on and the trough fills, a slime will arise and float on top of the water, like a white scum. Coarse sand should be kept in the trough for the fish to rub themselves against. Salt is also good for the diseased gills and will free them from adhering sediment.

Fungus, "blue swelling," and other diseased conditions sometimes occur, but the most serious diseases of the fry are those just described. Parasites sometimes attack the fish, but if the water is pure and the fish in a healthy condition, they are not troublesome. To keep the fish that are raised in troughs and tanks in a healthy state, it is well to give them a salt bath occasionally, and a small quantity of salt in their food will at times do them good. A little sediment from the reservoir, or such as collects on stones in the streams, is beneficial to fish if mixed with their food. It seems proper that they should have something of this nature, since all or nearly all of their natural food contains more or less sediment of the kind.

A very serious disease among adult rainbow trout shows the following symptoms: The afflicted fish refuse to take food, and very dark spots, from 1/4 to 1 inch in diameter, appear on different parts of the body, varying in number from two or three up to twenty or thirty on each fish affected, a light spot about the size of a green pea appearing on the head immediately over the brain. The fish become restless and seek the shallow water in the corners of the pond, hiding among the plants, and begin to die within twenty-four hours from the time the disease is noticeable. They jump and dart around in the water in a frightened manner, settling back on their tails and sinking to the bottom of the pond in their last struggles. This disease made its appearance at Wytheville in December, 1895; it was first observed among a lot of 637 yearling Von Behr or brown trout that had been delivered at the station on November 29. The first sign of the disease was noted about the 5th of December, and by the 12th of the month 455 of the 637 fish were dead.

These fish were in the nursery during the first stages of the disease. The water in which they were held passed from them through an empty pond into a second one containing about 1,000 large rainbow trout that had recently been stripped of their spawn. on the morning of December 23 the disease made its appearance among the latter, and by 4 o’clock in the afternoon of the same day 56 of them had died. Salt was applied and the water in the pond was drawn down to about 300 gallons, and 150 pounds of common salt were sprinkled evenly through it. The fish were allowed to remain in this brine about 15 minutes, when they showed signs of weakening by turning on their sides; then fresh water was turned on freely. Good results were at once noticeable, the fish became quiet and appeared to rest more easily, and steadily improved, another application not being necessary. The final result was that 70 per cent of the adult rainbow trout that had been treated with salt were saved, while of the yearling brown trout that were not thus treated nearly 71 1/2 per cent died.

Foul ponds cause disease, and if the fish become sick from this reason, they must be removed

to a clean pond at once and given a salt-and-clay bath, which is applied as follows: While the salt bath, before described, is being given, 2 or 3 bushels of clay are placed in the reservoir or supply-trough, and when the fresh water is turned on after salting, the reservoir is flushed for 30 minutes with roily water from the clay, and after the latter is washed away an increased amount of fresh water is turned on for ten days or more.

Adult fish are very liable to be affected with fungus, which generally appears after a bruise or hurt, or when the fish are in an emaciated condition. If the trouble results from an injury, it can often be cured before it spreads to the sound flesh, but if fungus spreads like a slimy web all over the fish, it is fatal. Fish must be handled very carefully during the spawning season to prevent scarifying the body in any way, as they are especially susceptible to fungus at that period. Should it occur, the fish must be caught at once, rubbed with salt on the affected part, and then release in a pond or tank by itself, where it can be caught for further treatment in a day or two, while those affected all over the body should be killed and thrown out at once.

"Glassy eggs" may be the result of overretention of the eggs on the part of the parent fish. If the eggs are not delivered within a reasonable length of time, say from 36 to 48 hours after they fall from the ovaries into the abdomen, they are surrounded with a thin watery fluid, having a glassy appearance, which if allowed to come in contact with water will turn milky white, and the eggs absorbing this fluid become hard and "glassy," after which fecundation is impossible. Many thousand eggs have been lost annually on this account, and many brood fish lost or rendered worthless from the same cause. The fish in captivity will not spawn of their own accord unless they have access to gravel or earth in which to make nests. If attention is not given to the spawning fish and their eggs taken when ripe, they soon become very dark in color, the abdomen swells, and sometimes the head will enlarge, causing the eyes to protrude. Under these conditions the fish will die in a few days, but with free and easy access to the raceway they will not often be thus affected.