5.—THE MOST RECENT METHODS OF HATCHING FISH EGGS.

BY WILLIAM F. PAGE.

The purpose of this article is to attempt to establish a proper basis for the work of hatching fish eggs. The writer believes that a larger measure of success can be achieved by the use of the McDonald universal automatic hatching jar for developing not only semi-buoyant but heavy fish eggs. The results of my experience and observation during the past seven years are herein embodied.

At the Central Station of the U. S. Fish Commission and at other hatcheries the following species of fish eggs have been successfully hatched in this apparatus: Shad, Whitefish, Brook trout, California trout, Rangeley trout, Lake trout, Atlantic salmon, California salmon, and Land-locked salmon.

THE WATER.

So much has been written on the subject of water, the kinds best adapted to the purpose, and the kinds that can be made to answer; the highest and lowest temperatures allowable; the absolute clearness desirable; and the best means of aerating, filtrating, etc., that a delicacy is felt in entering on this branch of the subject. Undoubtedly temperature has an important bearing upon fish-culture. Nature's laws of heat and cold when rudely violated will work injury to fish as well as man.

It is unquestionable that clear water offers many advantages; the condition of the eggs and fry can be better ascertained, and the labor of removing the sediment is obviated. Ordinary river-water, such as is furnished for household purposes in most of the larger cities on the Atlantic slope, is capable of doing excellent hatching work for nearly all the kinds of fish spawning in fresh water, though scarcely any of it south of Maine is capable of rearing any of the species of Salmonidæ. No better water for hatching can be found than that in the cities bordering on the Great Lakes. It may be stated, as a general rule, that water suitable for drinking purposes is avail able for hatching fish. Though the water be very muddy, filtration is not absolutely necessary for hatching, and any one who has been compelled to work with the "wire screens for coarse trash," "bagging for small trash," and "flannel trays for fine mud," can testify how arduous and totally unavailing such efforts have been. Filters for hatching are not the necessity now that they once were, because the hatching apparatus is changed. In the autumn of 1888, while at the centennial exposition of the Ohio Valley and Central States, held in Cincinnati, Ohio, I had charge of the hatching of 45,000 California salmon eggs. At the time of their arrival the temperature of the water was 78° Fahr. and it was quite muddy even for Ohio River water.

These eggs were hatched in two McDonald jars with gratifying success. I would not be understood as advocating muddy water in preference to that naturally clear, but to prove that clear water is not absolutely necessary to successfully hatch the eggs of fishes spawning in fresh water.

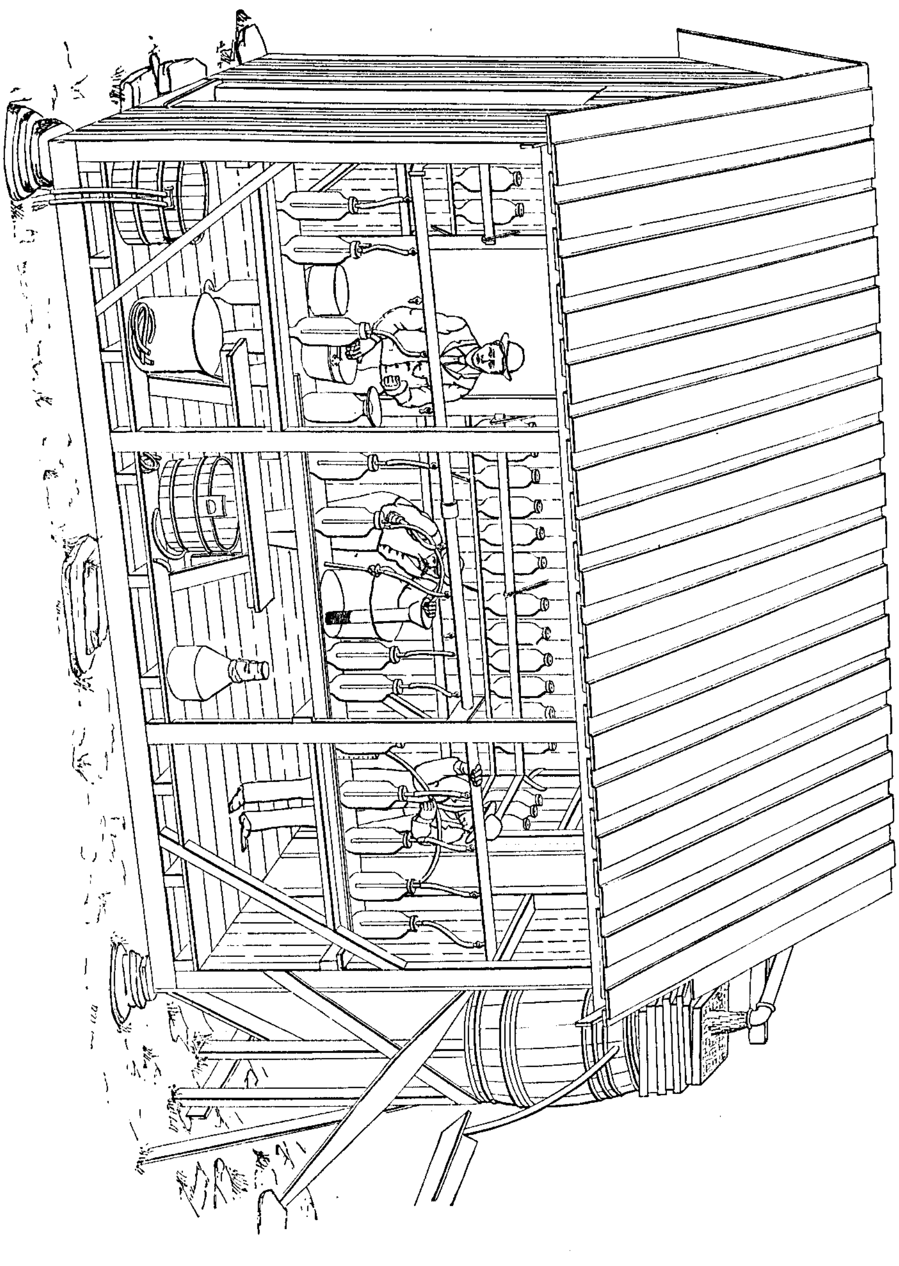
The prime requisite is an unfailing water supply of a pressure as nearly constant as is attainable. For hatching semi-buoyant eggs the pressure should not be less than 6 pounds per square inch at the point where the water is to be drawn from the pipe; a variation of 2 pounds will not materially affect the results, as it can, to a large measure, be corrected by raising or lowering the central tube of the jar. For eggs of the Salmonidæ less pressure will answer; three or even two pounds per square inch can be used. If the water is taken from a spring, race, or other abundant or cheap source, and carried into a supply tank by means of a flume, the tank may be kept always full and an overflow maintained. (Plate 30.)

When the water is taken from the main of a city water-works it should be discharged into an open tank through a ball-cock, which, working automatically, will preserve a nearly uniform level or pressure. (Plate 31.) The bottom of the tank for semi-buoyant eggs should be not less than 6 feet above the top of the hatching-table. The water is taken by iron pipes from the bottom of the tank and distributed to the hatching-tables. (Plate 32.)

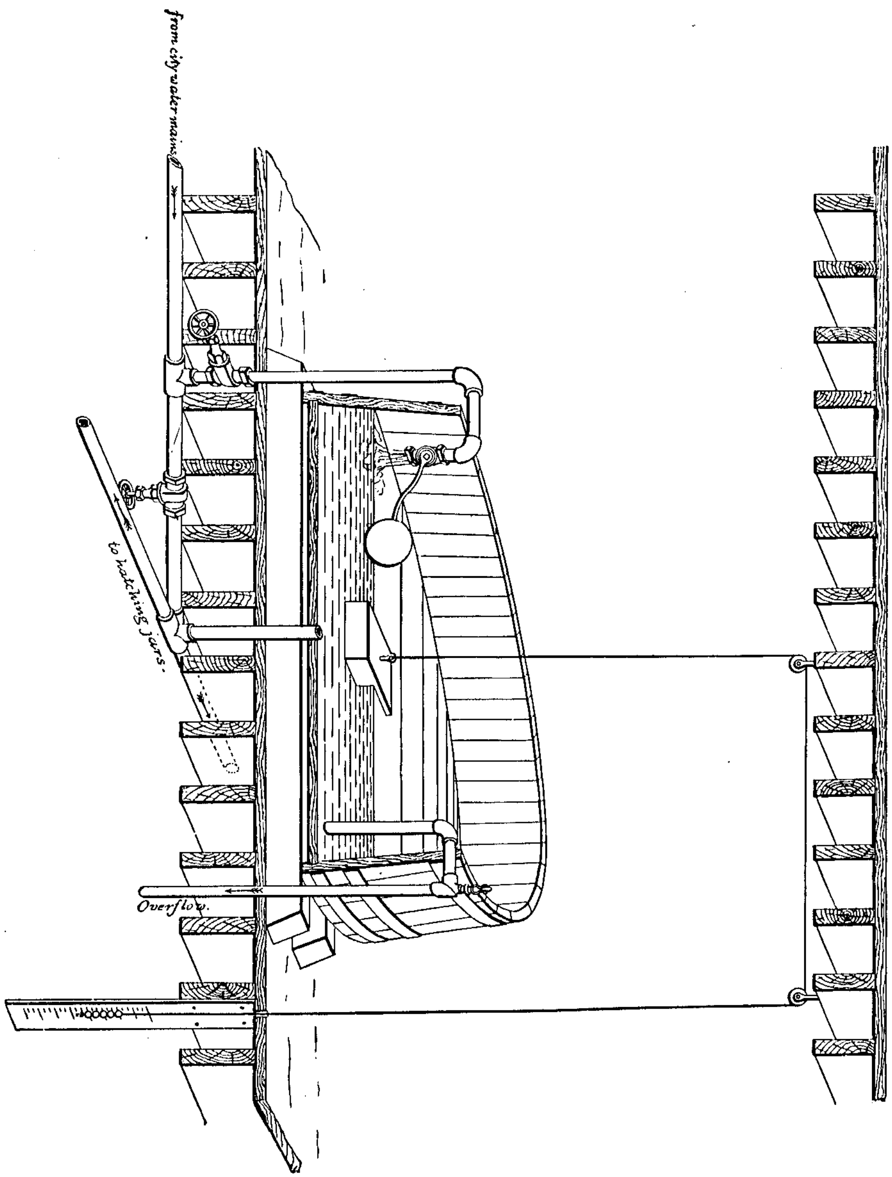
A point especially to be guarded against is the presence of bubbles of air in the pipe. If the regulating tank is of sufficient dimensions the bubbles coming in with the supply will rise and escape from the surface. But if the level of the water is allowed to get low in the tank the water will drag air down with it into the supply pipe. To guard against the possibility of this I have devised the following apparatus: A float is placed in the tank from which a line, passing over pulleys, extends down into the hatching-room. On the lower end of the line is a weighted rod, carrying a metallic index sliding in a groove; to either side of the groove are affixed contact points of an electric circuit. Two contacts are placed where the index would mark 8 inches, which amount is regarded as extreme low water in the tank. If desirable, other contacts may be arranged to indicate high water. As the metal index passes up and down, consequent upon the fluctuation of the water in the tank, it meets a contact, closes the electric circuit and thereby rings a vibrating alarm bell. (Plate 33.) This bell can be placed at any convenient point. As the greatest degree of fluctuation of pressure occurs in city water mains during the night, it has been found desirable, in hatcheries where no night watchman is maintained, to run an auxiliary alarm to the sleeping quarters. The ringing of the alarm bell calls attention to the fact that more or less water is needed, which can be easily remedied if a proper system of valves has been provided.

The quantity of water necessary for hatching a given number of eggs must necessarily vary, not only with the supporting quality of the water, that is the relative amount of oxygen it contains, but to a considerable extent it depends upon its muddiness. In hatching semi-buoyant eggs it will be found necessary to employ considerably more water if it be very muddy; a part to support the eggs and an additional quantity to wash away the mud. Allowing for air vents and other wastes it will be safe to estimate for 7,000 gallons of water each twenty-four hours for every million eggs of shad, and 4,000 gallons per twenty-four hours for each million whitefish eggs. Thirty gallons an hour through one jar will easily hatch 25,000 eggs of any of the Salmonidæ.

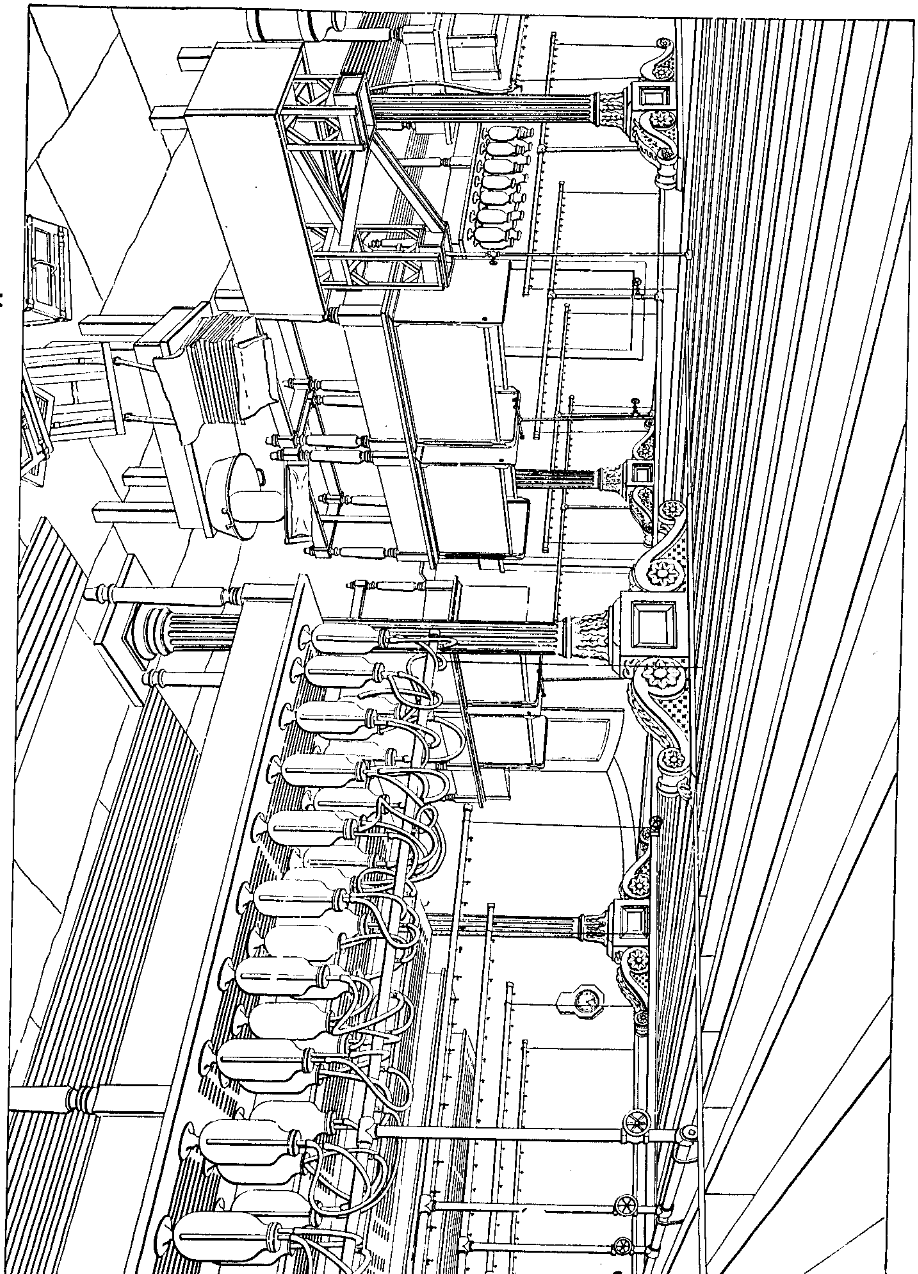
PLATE XXX.



METHOD OF REGULATING WATER SUPPLY FROM A SPRING. (See page 208.)



TANK FOR REGULATING SUPPLY FROM WATER-MAINS.



MANNER OF DISTRIBUTING WATER TO THE HATCHING TABLES. (See page 208.)

DESCRIPTION OF THE McDONALD UNIVERSAL HATCHING-JAR.

The jar consists essentially of a cylindrical glass vessel with hemispherical bottom. These are not blown, but pressed, in order to secure regularity of the interior surface, upon which depends to some extent the perfect working of the jar. The jar is supported upon a tripod of three glass lugs, which form of attachment was adopted to prevent the distortion of the bottom of the jar—a defect frequently found in jars resting upon a single foot. The top of the jar is made with threads to receive a screw cap, and both the bottom and top surfaces are ground so that the plane of each shall be at right angles to the axis of the jar, and so that when the jar is resting upon its feet its axis shall be perfectly vertical. These are all-important considerations to secure good results in hatching eggs.

The top of the jar is closed by a metallic disk, perforated with two holes five-eighths of an inch in diameter; one central, which admits the glass tube that introduces the water into the jar; the other, equally distant from the central hole and the edge of the metal plate, admits the glass tube which carries off the waste water. The central tube is connected by a half-inch rubber pipe with the jet cock which should furnish a supply of water under a constant head. A groove in the inner surface of the metallic plate carries a rubber collar, and when the plate is in place the tightening of the metallic screw cap seals the opening hermetically. It will sometimes be found that a slight defect will cause a small leak even after the metal screw cap is down tight. This can nearly always be corrected by the employment of two rubber collars or washers. Both the inlet and outlet tubes pass through stuffing boxes provided with gum washers and binding screws. The central or feed tube is provided with stuffing boxes, one on top of the disk and one on the bottom, the better to hold it in a true center. The outlet tube is provided with only one stuffing box, and moreover the binding ring is beveled, the purpose of which will be explained later. In fitting the jar for work it will be found advantageous to fit in the side tube first. The glass tubes should be wet, the gum washer slipped on the tube about 1 inch from the end, and introduced into the opening; holding the tube perpendicular to the face of the plate, press fairly on the tube, and the washer, rolling on itself, will fall into the seat provided for it. Screw on the binding ring, and test by seeing that the tube slides freely back and forth in the stuffing box. If not, it should be refitted with a heavier or lighter washer, as may be required. The glass tubes can not be procured of absolute uniformity in size, and the gum washers, being hand made, also vary; therefore in order to secure a neat fit use large washers with small tubes and *vice versa*. Water is the only lubricant that should be used about the jar fitting.

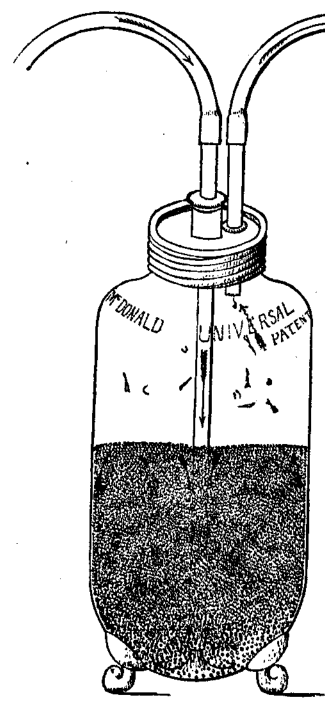


Fig. 1.

With a proper quantity of semi-buoyant eggs in the jar and the water turned on and regulated, the movement of the current establishes a regular boiling motion in the mass of eggs, which brings each in succession to the surface. The intensity of the boiling motion may be regulated at will without altering the quantity of water employed. By loosening the upper binding screw of the central stuffing box and pushing the feed tube down until it almost comes in contact with the bottom of the jar, the motion of the eggs is increased. If the jar is working properly the dead eggs when brought to the surface do not go down to mix again with the live eggs, but remain on top, forming a distinct layer. By pushing down the outlet tube a suitable distance the dead eggs are lifted up by the escaping current and taken out, leaving a mass of clean, live eggs in the jar. The beveled edge of the binding screw permits the swinging of the outlet tube over a large portion of the surface of the eggs. By careful manipulation in this way it is possible to remove every dead egg without the loss of one live egg.

The hatching is done on tables arranged for the work. The dimensions and arrangement of the tables are capable of indefinite modification. Working drawings of the tables used at the Central Station of the U. S. Fish Commission at Washington, D. C., are here given. (Plate 34.)

When the period of hatching has arrived among the semi-buoyant eggs, instead of allowing the water from the hatching-jars to pass directly into the sink, it is necessary to conduct it into a receiving tank.

In the shad and whitefish hatching at Central Station, large rectangular glass aquaria are used as receiving tanks, six or eight and sometimes ten jars discharging their fish into a common receiver. (Plate 35.)

As receiving the fry of semi-buoyant eggs is practically the same with all forms of hatching apparatus, it will not be further described. The handling of the heavy eggs and their fry by this apparatus being entirely different from all others, it will be mentioned under a separate paragraph.

MANIPULATING THE JAR WITH SEMI-BUOYANT EGGS.

The eggs are introduced into the jar by means of a shallow funnel (Fig. 2), as shown in the cut. The funnel is made of tin and is provided with a rim of perforated tin or wire gauze. The jar, thoroughly clean, is filled with fresh water (never stale) and placed in a sink or pan to catch the overflow. The funnel is inserted in the jar so that the water will stand as high in the funnel throat as possible, and the eggs poured in from a pan or washed in from the transportation trays by means of a jet of water. In this operation care must be used to have the eggs fall but a short distance and drop into the water. On no account suffer any fish scales or other

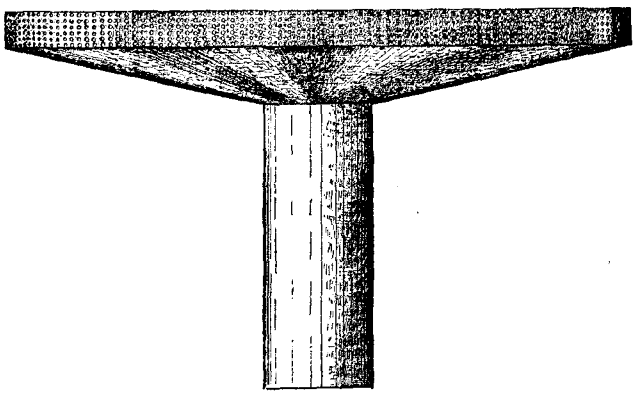
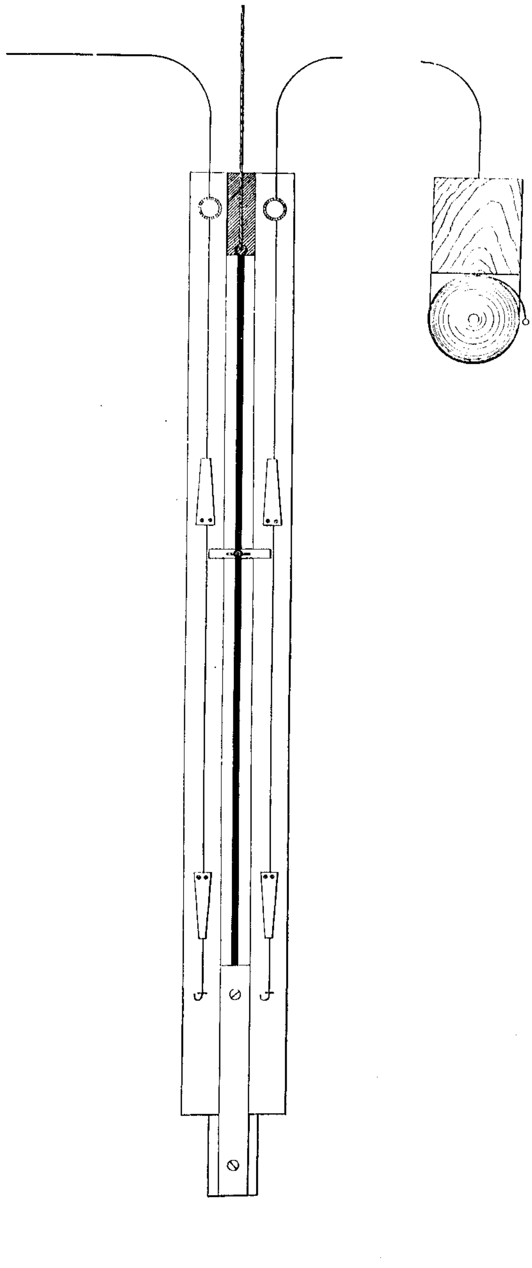


Fig. 2.



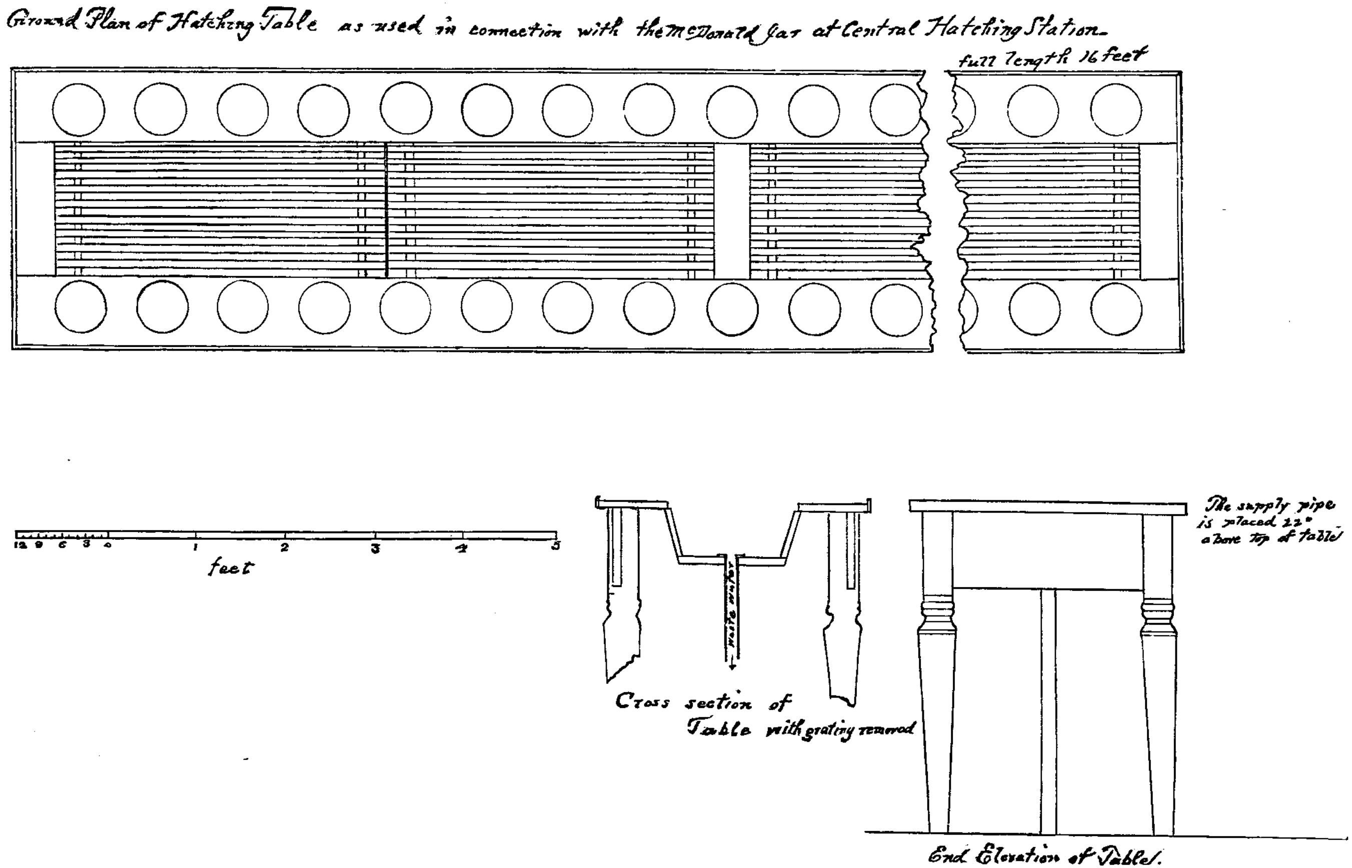
ELECTRIC INDEX AND ALARM-BELL TO WATER-TANK. (See page 208.)

foreign matter to enter the jar. The presence in the jar of anything but water and eggs renders a proper motion of the mass impossible, and generally results in the loss of a large proportion of the eggs. No absolutely definite law can be established as to the correct number of eggs for each jar, because the conditions are never the same in any two hatcheries, and vary from day to day in any particular hatchery. With shad eggs it will not generally be found advisable to put more than three quarts, or about 85,000 eggs, in a jar. If the water is very clear, or temperature low, an additional pint of eggs can be safely added; or if the eggs are known to be very bad the quantity can be increased to a gallon (about 115,000 eggs), provided the boiling motion, at first, be very slow. After thirty minutes, the dead eggs being partially separated, may be drawn off and a faster motion given to the remaining live eggs. Whitefish eggs when first taken are somewhat glutinous, and, if not properly managed, liable to become "lumpy" and require breaking up or separating. When the whitefish are new they should be worked quite rapidly under a full current. (This also applies to a limited extent to shad eggs.) Care should be exercised at this point that the end of the inlet tube reaches nearly to the bottom of the jar for the double purpose, first, that the eggs may not be caught under the inlet and pounded on the bottom of the jar; and, second, that the boiling motion may be increased without any unnecessary waste of water. An experienced workman can easily tell when the eggs are entirely "free" and reduce the motion accordingly. I am aware that the fish-culturists of the lake region claim that it is absolutely necessary to have an open jar in which to hatch whitefish, to more conveniently "feather" or separate the lumps; but actual practice has determined that the McDonald jar is capable of satisfactorily incubating whitefish eggs in all stages of hatching. When the whitefish eggs are new, three quarts (about 108,000 eggs) is a sufficient quantity for a jar. As they advance to the eye-spot period the quantity of eggs may be doubled, so that each jar will have between 4 and 5 quarts (from 145,000 to 180,000 eggs). This will not only leave fewer jars for attention, but economize water.

The requisite number of eggs being in the jar, it is put in its proper position on the hatching-table and closed. Before closing, be sure that both the inlet and outlet tubes slide freely in their stuffing boxes, and that the rubber washer as well as the screw-cap is in its proper position. If the tubes should have become gummed so as not to slide freely, this can often be remedied by allowing water to trickle down around the binding screws. To close the jar, turn on the water, place the feed-tube in the jar, turning off the water immediately after the feed-tube has passed beneath the surface of the water in the jar. The object of this is to expel all the air from the feed-tube, else it would rise in bubbles, throwing a portion of the eggs out through the outlet-tube. After expelling the air from the feed-tube place the washer and metal plate in position and screw down the screw-cap. When the water is turned on semi-buoyant eggs for the first time the action is often peculiar, and the jar should be watched closely until a regular motion has been established. When eggs from any cause have stood fifteen or twenty minutes in the jar before the water is turned on, they do not readily yield themselves to the boiling motion, but seem to have become packed so that they tend to rise in a solid mass to the top of the jar. By quickly starting and stopping the current the mass is readily disintegrated. A jar should never be left till the attendant is thoroughly satisfied that the regular boiling motion has been established. The degree or intensity of motion the egg should have will be found to vary not only with the age and condition of the eggs, but also with the condition of the water. If the water is muddy, the motion should be quite rapid, rapid enough, in fact, to prevent mud settling either on the eggs or in the bottom of the jar. Under ordinary conditions of clearness (and absence of glutinous coating) the best motion will be found to be that which readily brings the dead eggs to the surface. After the hatching has progressed far enough to dispose of a portion of the eggs, there is, of course, less resistance to the current and it should be reduced by shutting off a part of the supply or by slightly lifting the central tube. In fact the motion should be reduced somewhat when the hatching-out begins. If the motion is not reduced from time to time as the hatching-out progresses it will be found that the shells will be carried over into the receiving tank with the fish, and being very light, will be drawn against the outlet-screen, soon causing an overflow. The motion should be so gentle at the time of the greatest hatching as barely to induce the fish to swim out of the jar and leave their cast-off shells behind. Under the combined conditions of very healthy eggs, bathed in bright direct sunshine, the hatching is so rapid that the combined effort of the swarming mass of young fish will establish sufficient current to draw some shells over into the receiving tank. This can not be entirely prevented, but may be modified by placing a screen between the jar and the light. The shells under normal conditions remain and form a cloud-like layer above the mass of working eggs. As they accumulate in quantities they should be removed by shoving down the outlet-tube until they are drawn up with the escaping water. A good plan is to draw several jars in succession, catching the "draw-off" in a large pan, from whence any fish coming over with the shells may be ladled into the receiving tank. Towards the latter part of the incubation it will be noticed that a remnant of eggs will be very long in hatching. These eggs should be poured into a large pan and exposed to bright sunlight. The pan should be clean and bright. It is not recommended to put over 5,000 eggs in one 3-gallon pan. After a lapse of five or ten minutes, depending upon the stage of the eggs and intensity of the sunlight, the eggs will all be hatched out and the fish may be ladled into the receiving tank.


Fig. 3.

Sometimes in the course of hatching it may be found necessary or convenient to break the connection between the rubber tube and the jet cock. The handle of the jet cock may wear loose, so that the current of water drags in bubbles of air, mud, trash, iron rust; or small fish will occasionally clog the jet cock, stopping off the supply; or it may be desired to move the jar to another part of the hatchery. Any of these conditions would necessitate breaking the connection between the feed-tube and the jet cock, filling the former with air. When the connection is broken, be careful that the rubber tubing attached to the glass feed-tube does not drop down and siphon the eggs from the jar. In reconnecting it will be necessary to again expel the air from the feed-tube before turning on the water. To do this without unscrewing the jar top, draw the feed and outlet tubes up high in the jar until the ends are



WORKING DRAWINGS OF HATCHING TABLE. (See page 210.)

nearly to the metal plate (Fig. 3), turn on a full head of water, and the air in the feed-tube will pass in bubbles above the eggs, leaving the jar by the outlet-tube. The eggs will not be disturbed. After the air is all out, close off the supply, shove down the central tube to its proper position, and turn on the water again.

A scaff-net, small enough to easily enter the mouth of the jar, fixed to a handle several inches longer than the height of the jar, will be found a convenient tool for removing particles of foreign matter that will occasionally, in spite of every precaution, find its way among the eggs.

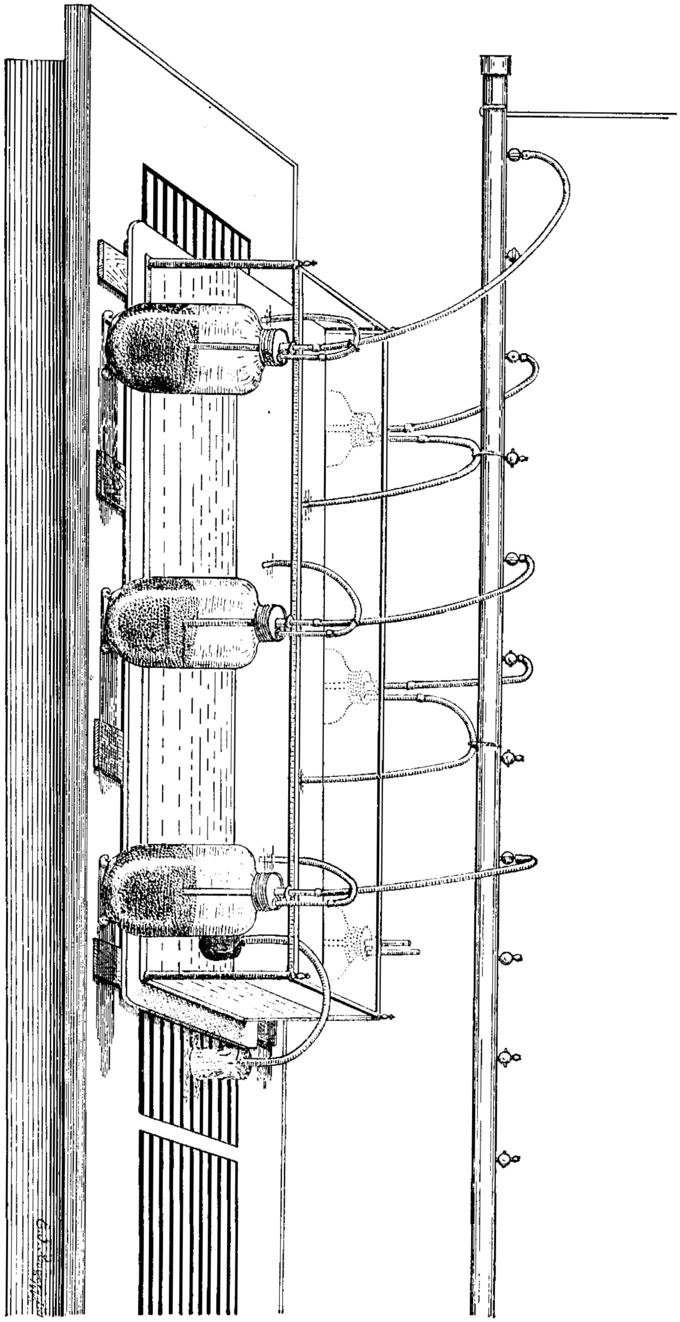
MANIPULATING THE JAR WITH HEAVY EGGS.

Practically there is little difference in handling any of the varieties of salmon and trout eggs, so little that no difference will be recognized in treating of their management. Such small differences of treatment of the eggs and fry as may be necessary will readily suggest themselves to the veriest tyro, and it is safe to assume them known to the expert. The term "heavy eggs" will be used as a general term to designate all species of salmon and trout eggs.

When the eggs are received at the hatchery the first step is to ascertain their temperature. It is supposed of course that the hatchery has a fairly accurate thermometer. Remove the outer case and carefully introduce the thermometer into the egg package, allowing it to remain about twenty minutes, carefully withdraw it and observe the temperature. If there is a variation of more than four or five degrees between the temperature of the eggs and the water in which they are to be hatched, the package should be allowed to stand in the hatchery until the temperatures are equalized, or nearly so. If the packing material is frozen, frequent drenching with cold water, or even submerged in cold water 33° to 35°, is recommended. If the precaution is taken to gradually equalize the temperature, it will prevent the shock which would otherwise result to the eggs by a too sudden change of temperature. If the eggs are packed in shallow cotton or flannel bottom trays, covered with mosquito-netting and moss, they are easily washed into a pan by a jet of water. Should they be packed in alternate layers of moss between netting, pick off the moss, take up the lower netting by the four corners, and pour the eggs into a pan of water. Any bits of moss or other foreign matter may be picked out with tweezers and the eggs thoroughly rinsed. The dead eggs are now picked out. This operation is one demanding some amount of skill. Dead eggs are white, but it is not safe to assume that every white egg is dead. In all cases give the egg the advantage of any doubt and remove none that are not known to be dead. If an egg be really dead, a few hours more will definitely settle the question.

The apparatus used in connection with the McDonald jar for picking over heavy eggs are a shallow square or oblong tin pan, filled nearly to the top with water, in which floats a tray with a wire-cloth bottom, a pair of ordinary tweezers, a small scaff-net, and several feathers from a turkey's wing. The tray should be of some light wood, one inch less in length and breadth than the pan. A wire-cloth bottom of oblong mesh (one-sixth of an inch by 1 inch) should be generally used for trout-hatching. Tweezers of wood are generally recommended above those of metal. The scaff-net is conveniently made by bending a piece of copper wire for the frame and twisting the ends to form a handle. A good size is 4 by 2½ inches. Over this frame sew a piece of mosquito netting.

With the scaff-net transfer a portion of the eggs from the pan to the floating tray. A slight sifting motion of the tray will cause any remaining trash to fall through the meshes, and, at the same time, level off the eggs. The dead are picked out with the tweezers and the living are put in a jar. By counting the number of trays or layers the proportion of the entire lot can be ascertained for each tray or layer. Knowing this, it can approximately be determined what quantity each jar is to receive. With heavy eggs it is not advisable to fill the jar more than one-third full, though excellent results have been obtained with the jar three-fourths filled with Atlantic salmon eggs. With heavy eggs the boiling motion is neither necessary nor desirable. The amount of water for each jar is about the same as that required for shad, possibly a little less, and it can be used under much less pressure than that needed for semi-buoyant eggs. No motion being given to the heavy eggs, there is of course no automatic separation and picking of the dead eggs. To remove the dead eggs the jars have to be unsealed, the eggs poured into a pan and picked with tweezers in the same manner as when they arrived. This slight trouble, however, is abundantly compensated for, because in this apparatus the heavy eggs do not require picking for several days. So perfectly is every egg supplied with the constantly-changing envelope of fresh water that they remain healthy for a much longer period than in the forms of apparatus employing horizontal currents. In the jar there are no dead angles for stale and eddy water. Should the water become muddy, as it does at times in nearly all hatcheries, eggs exposed under horizontal currents are in constant danger of asphyxiation from deposits of sediment. In the McDonald jar, the water coming from below and passing upwards, all sediment deposited is on the upper side of the egg. Gravity prevents any accumulation on the under side, which always presents a clean surface to the incoming current. The time elapsing between the "pickings," even with a uniform temperature, will vary; and here again the attendant must be guided by close observation and judgment. Mr. Charles G. Atkins says that in water of 40° Fahr. the eggs should be picked once in every three days. This rule was established with the old trough-and-tray system employing horizontal currents, and was undoubtedly correct for that system. During the season of 1883–'84, at Central Station, in Washington, D. C., a jar containing 30,000 Lake trout eggs remained closed from January 6 to January 21, when it was opened more for the purpose of washing than picking, but no unusual mortality could be detected. The temperature of the Potomac River water during that time varied from 41° to 38° Fahr., and averaged 39.5° Fahr. It may be interesting to note that during this period the water was unusually muddy. As often as is thought desirable the sediment may be washed from the eggs without opening the jar. Grasp the jar firmly at the bottom and top, lift clear of the table, and turn it rapidly so that the sides may generate a double cone, the center of the jar forming a common apex. In this operation care should be taken that the turning of the jar is not so violent as to throw the eggs up to a height that they will pass off through the outlet-tube. The eggs rolling upon themselves cut off the sediment, which readily passes off with the waste water. This operation will cleanse the eggs thoroughly, and, if judiciously repeated, will obviate all danger of asphyxiation by deposit of sediment. During the time when the fry are breaking from the shells the jar should be opened somewhat oftener, the dead picked out, shells removed, and the fry transferred to proper rearing quarters. The eggs should now be handled with more care than formerly, for while a salmon or trout egg is quite tough and will stand a good deal of rough handling at certain periods, as the



ARRANGEMENT OF JARS AND AQUARIA FOR FRY OF SHAD AND WHITE FISH. (See page 210.)

time of hatching-out approaches it has become tender and there is danger of prematurely bursting the shell. Pour the eggs carefully into a pan nearly full of water. With the scaff-net slightly disturb the water, and as the shells rise skim them off. After all the shells are removed, put a part of the eggs on the picking-tray and remove any dead. By gently sifting the tray and turning the eggs over with a feather, the fry can be made to drop through the meshes into the pan below, from whence they are easily transferred to the rearing quarters prepared for their reception.

MEASURING THE EGGS.

The question of measuring the eggs is a most important one to the fish-culturist, and yet, to judge from the various ways of measuring eggs, it is one that has received little attention. Every branch of trade has a standard measure, but fish-culture has remained without standard or rational unit; each workman establishing for himself a system of determination, and varying that system from year to year as the exigencies of the season demanded. There has not only been a want of harmony in the various so-called measures used, but the "measures" themselves have lacked the elements of reliability, being in many cases the most arbitrary and irrational. The records of results of work in the earlier days of fish-culture were but wild guessing, and, sad to say, many records are yet made in the same manner.

The practice of arriving at the number of any given lot of eggs by estimating each parent fish to contain an unvarying quantity of eggs, and multiplying this quantity by the number of females spawned has justly gone out of use. How various and how far wide of the mark such estimates were is shown by the following: Seth Green estimates a shad to contain from 20,000 to 28,000 eggs;[1] C. C. Smith, of Connecticut, puts it at 50,000;[1] Dr. H. C. Yarrow estimates a shad to contain from 100,000 to 150,000 eggs;[2] and Prof. J. A. Ryder, embryologist of the U. S. Fish Commission, says a shad may have 250,000 ova in process of maturation at one time in her roes.[3] These statements are made to show the absurdity of the old method of determination. There is no desire to attach odium to any one; but the wish is earnest to call to the attention of all interested the necessity of some recognized standard of measurement to be known and used by all fish-culturists. Not unfrequently has it happened that a consignment of eggs when estimated by the recipient has fallen short of the invoiced number. Sometimes these occurrences have led to accusations of fraud. In a former article in a Bulletin of the U. S. Fish Commission, I have shown that the discrepancy may often result in part from other causes, and instead of being actual is to some extent but apparent. Whitefish and shad eggs, and possibly others, after several hours in the packing-crates, undergo a shrinkage, amounting to nearly 12 per cent. of their bulk. After being several hours in the jars the eggs reabsorb the water and resume their normal size. But the main reason for the discrepancy in the measurements at the receiving and shipping points will be found in the want of harmony in the methods of measuring.

In many hatcheries, especially those hatching heavy eggs, the system of determination is based on the diameter of the egg. It will be found very difficult to estab-

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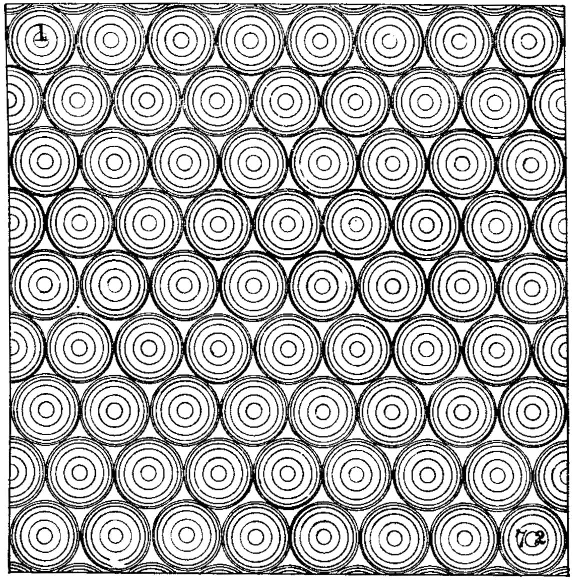
[1] U. S. Fish Commission Report, Part II, p. 427.
[2] Ibid., p. 455.
[3] U. S. Fish Commission Bulletin, Vol. III, p. 196.

lish by calculation, based on the diameter, a standard for measuring eggs on trays; and the difficulty amounts to almost impossibility when it is attempted in like manner to determine the number of eggs in a given bulk. This at once becomes apparent by reference to the accompanying diagram. To determine the number of eggs on a tray, the general practice has been to count the number of eggs on two of its adjacent sides and multiply them together; it being assumed that the product was the number of eggs on the tray. This would be true if the eggs arranged themselves as shown in Fig. 2, Plate 36. As a matter of fact the eggs really group themselves in a different manner (see Fig. 1, Plate 36), nearly obliterating the void space between the eggs. Theoretically but sixty-four eggs, one-eighth of an inch in diameter, will occupy 1 square inch; practically we get over seventy-five. When we come in like manner to estimate eggs in bulk occupying a known cubic space, the error becomes greater by reason of the obliteration of the void. The eggs on the second layer do not occupy a position directly above those on the first layer; that is to say, the nadir of an egg on the second layer does not coincide with the zenith of an egg on the first layer, but falls in the center of a void formed by three contiguous eggs. From this it follows that the altitude of two layers is less than two diameters of an egg. It is a legitimate conclusion that a bulk 1 inch deep of eggs one-eighth of an inch in diameter will have more than eight layers of eggs. It will require a higher knowledge of applied mathematics to solve this problem than is generally possessed by fish-culturists.

While employed at the Central Station of the U. S. Fish Commission, at Washington, D. C., in charge of hatching, from 1882 to 1888, I devised a system of measuring fish eggs and fry. It is applicable to all classes of semi-buoyant and heavy eggs, and is, I believe, based upon rational principles. No one recognizes better than I that it still possesses inaccuracies, which only time, close observation, and determined practice can obliterate. The basis of this system is the number of eggs in a standard quart of the United States (57.75 cubic inches) determined by actual count of each egg. In the table here given some of the varieties of eggs were not obtainable for counting; these have been computed from their known diameter, due allowance being made from absorption of the voids. In all cases stated to be counted, the count has been made of each egg in the measure.

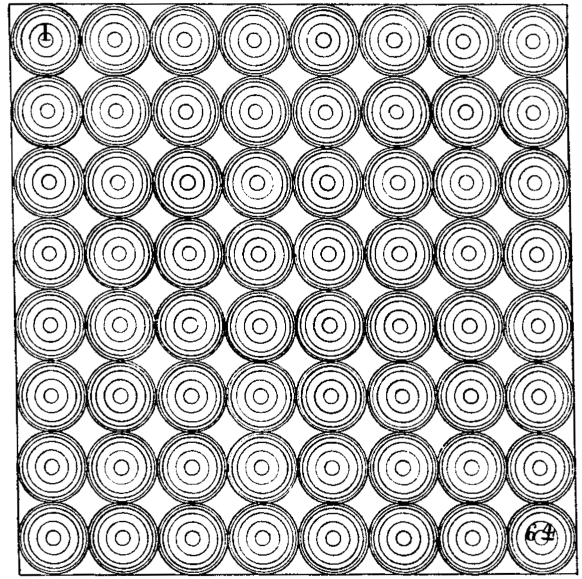
Bull. U. S. F. C. 1888.—(To face page 216.) Page. Hatching Methods.

Fig 1.



ACTUAL.

Fig. 2.



THEORETICAL.

DIAGRAMS ILLUSTRATING THE ARRANGEMENTS OF FISH EGGS IN A SQUARE INCH. (See page 216.)

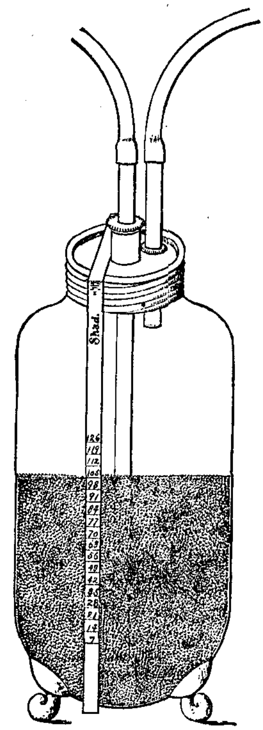
Species.	Number of eggs to a standard quart, 57.75 cu. in.	Authority.	How determined.	Reference.
Spanish mackerel[1]	1,267,728	R. E. Earll	From diameter	F. C. Report, 1880, p. 450.
Codfish[2]	335,000	H. C. Chester	do	
Wall-eyed pike[3]	120,000	James Nevens		July 7, '87, Forest and Stream.
Whitefish[4]	36,800	F. N. Clark	Count part of quart	F. C. Report, 1880, p. 575.
Do	34,800	W. F. Page	Count of 1 quart	Central Station, season 1884-'85.
Do	33,450	do	do	Central Station, Feb., 1887.
Shad[5]	28,239	do	do	Central Station, season of 1886.
Do	28,800	W. P. Sauerhoff	Count of 1 gill	Battery Station, May, 1886.
Do	22,750	do	do	Do.
Rockfish[6]	24,363	S. G. Worth	From diameter	
Rainbow trout[7]	12,800	F. N. Clark	Count, 1 fluid ounce	F. C. Report, 1882, p. 820.
Do	9,485	G. A. Seagle	Count, 4 cubic inches	Personal letter, Wytheville Station.
Rainbow trout, three and four years old fish, domesticated.	7,625	E. M. Robinson	Count, 8 cubic inches	Do.
Rainbow trout from Baird, Cal.	6,875	do	do	Do.
Do	6,624	W. F. Page	Count of 1 quart	Central Station, 1884.
Do	6,536	do	Count, 1 pint	Central Station, Feb., 1887.
Von Behr trout[8]	9,935	do	Count, 15 ounces	Central Station, Mar., 1887.
Do	8,301	*E. M. Robinson*	Count, 8 cubic inches	Personal letter, Wytheville Station.
Brook trout[9]	11,092	William Buller	Count of 1 quart	Personal letter, Corry, Pa., hatchery.
Do	13,998	W. F. Page	Count, 13 ounces	Central Station, Feb., 1887.
Brook trout, eggs from Michigan.	13,590	E. M. Robinson	Count, 36 cubic inches	Personal letter, Wytheville Station.
Brook trout, eggs from Connecticut.	12,063	do	do	Do.
Lake trout[10]	5,720	W. F. Page	Count of 1 quart	Central Station.
Do	5,780	do	do	Central Station, Dec., 1887.
California salmon[11]	8,696	do	From diameter	
Atlantic salmon[12]	4,272	do	Count of 1 quart	Central Station.
Land-locked salmon[13]	3,300	do	do	Do.

[1] Scomberomorus maculatus.
[2] Gadus morrhua.
[3] Stizostedion vitreum.
[4] Coregonus clupeiformis.
[5] Clupea sapidissima.
[6] Roccus lineatus.
[7] Salmo irideus.
[8] Salmo fario.
[9] Salvelinus fontinalis.
[10] Salvelinus namaycush.
[11] Oncorhynchus chouicha.
[12] Salmo salar.
[13] Salmo salar, var. sebago.

An examination of the table will show certain apparent discrepancies between the counts made from year to year. It is undoubtedly true that in some kinds of eggs there is a slight variation from season to season. Where the count is made of a full quart, and of eggs matured under like conditions, the discrepancy in number will be but trifling. We can not expect an equality in size between the eggs from wild and domesticated fish, between "scrub" and "improved" stock.

The McDonald jar presents an easy, quick, and safe means of applying the knowledge contained in the table. The measurements in all cases are made while the eggs are in the jar, and with the cap screwed down. To ascertain how many eggs have been lost or hatched or are on hand are questions constantly arising. It would be cumbersome and tedious were we obliged to open the jar and measure the eggs in a graduate every time such information was needed. Moreover, we have to know the quantity of eggs in each jar at a period in their development when such procedure would be exceedingly hazardous.

The measuring scale is a light square made of wood, not so liable to break the jar as metal. The long leg of the square is 15 inches long, half an inch wide, and quarter of an inch thick. The short leg is of the same breadth and thickness and half the length. (Fig. 4.) The long leg is graduated to read from the bottom upwards. The first grade is at a height corresponding to the level attained in the jar by a measured half pint of water; the succeeding grades are determined by the introduction of additional half pints of water. When constructing a scale the feed-tube should be stopped at the lower end, so it may displace an amount of water equal to the amount of eggs it will displace in practice. It is desirable to have a separate scale for each variety of eggs hatched. All measurements are made with the feed-tube in place, the water shut off, and the eggs allowed to thoroughly settle. All semi-buoyant eggs should be in the jar several hours before measuring, so that they may swell to their normal size. The short leg of the square is placed over the top of the jar, the long leg hanging down, and the scale read from the point where the top layer of eggs shows in the jar. Reference has been made to measuring the fish. It is possible to obtain by measurement an almost correct estimate of the number of fish produced by a jar of semi-buoyant eggs. Just before the time of hatching all dead eggs should be carefully drawn off, and when the first fish is seen swimming in the jar the eggs should be again measured. It is an ascertained fact that scarcely any semi-buoyant eggs die, under proper conditions, after hatching out has commenced, so that the last measure furnishes us a close approximation to the number of fish.



No. 4.