XXXV.—UTILIZING WATER BY FISH-CULTURE.

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ANALYSIS.

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I.—INTRODUCTION.

While for many years the greatest activity has been displayed in the various branches of agriculture, with the view to increase the productivity of the soil by improved methods of farming and stock-raising, by far too little attention has been given to the utilization of the water. It is a very common occurrence to see ponds, swamps, and small sheets of water lie entirely useless, to see marshy meadows produce a small quantity of almost useless grass, whilst in these very localities ponds could be constructed with very little trouble, which without great labor or capital would yield a rich harvest of fish. This is all the more humiliating, as our ancestors have in many places carried on pond-culture in a systematic manner and with considerable success, as old chronicles

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show that many waste places centuries ago produced large quantities of fish, no pond or puddle, be it ever so small, being allowed to lie idle.

At this very time, when it is the principal object of land-owners to make the sale as productive as possible, when the fisheries in our inland waters are seriously injured by river improvements, by the pollution of the water through industrial establishments, and by reckless fishing; we have every reason to give our fullest attention to pond-culture, all the more as, thanks to the better means of communication, the sale of fish is no longer limited to the immediate neighborhood of the places where they are caught, but as fish can easily and cheaply be sent to considerable distances, an overproduction or a decrease in the value of fish is prevented.

Many a person will therefore welcome some brief and simple hints as regards the construction and proper management of ponds, especially if he is the owner of suitable land, and has a justifiable horror of voluminous manuals and expensive experiments.

By ponds we understand sheets of standing water of different sizes, which, if desirable, can be laid dry, and again filled with water. According to the source from which the water is supplied we may distinguish (1) brook-ponds, (2) river-ponds, (3) spring-ponds, and (4) sky-ponds. Brook and river ponds receive their supply of water from brooks and rivers which either flow through them or are connected with the ponds by means of ditches or canals. Spring-ponds have at their bottom or along their edges springs, which, if flowing very freely, make up for the loss of water from evaporation, and keep the water at an even depth, but if flowing very freely, cause a brook or river to take its rise from the pond. Sky-ponds are those ponds which, without having any supply of water from rivers and springs, are fed simply by the water from the atmosphere which either falls into them as rain, or flows into them from the surrounding higher ground. In accordance with this classification of ponds, these different kinds of ponds possess varying qualities which are either helpful or hurtful for certain purposes, and which have to be taken into consideration in making use of them. River and brook ponds possess the advantage of having a constant supply of fresh water, whereby the overheating of the water in summer and the suffocating of the fish in winter under a thick cover of ice is prevented. In other respects these ponds are unfavorable for certain purposes, because it is difficult or impossible, even by very narrow grates, to prevent young fish of prey and other enemies of the fish from entering the river or brook. Springs will prevent the overheating of the ponds in summer, but their temperature is frequently so low as to render them unfit for the same purposes, especially if the ponds are deep, and the flow of water from the springs is plentiful. If the water comes from a great depth, and does not before entering the pond pass through layers of soil containing air, it frequently contains so little oxygen that the fish are suffocated, especially under the ice in winter. In this respect

it is preferable to have the springs located at some little distance from the edge of the pond. If springs contain much iron, lime or different gases, they will make the water of a pond entirely unfit for fish-culture.

Sky-ponds share this advantage with spring-ponds, that, owing to the absence of a supply of water from a river or brook, they are tolerably well protected against enemies of the fish, although occasionally the spawn of pike and other fish is introduced into them by aquatic birds. During hot summers these ponds have the disadvantage that, especially if they are not very deep, the water easily becomes too hot, or even evaporates entirely. It is therefore a great advantage for sky-ponds if a number of water-pipes empty into them.

Ponds may be dug out, or, by using the existing grades of the land, be constructed in such a manner as to prevent the outflow of the water by means of dikes. This last-mentioned method may be specially recommended as being cheap and as the quickest way of reaching the object in view. In this manner large or small, deep or shallow ponds may easily be constructed in any country which is not absolutely level. By a skillful use of the ground small sheets of water measuring but a few meters in length will suffice for the construction of large ponds.

For centuries pond-culture has been almost exclusively devoted to the raising of carp, which owing to its rapid growth, its hardiness, its quick increase, and its great and general popularity as a food-fish, is on the whole the best paying fish for pond-culture. We shall, therefore, principally treat of carp-culture, and afterwards give a brief review of the raising of other fish in ponds.

A distinction should be made between fish-*culture* in ponds and the *keeping* of fish. The former aims at increasing the number of fish and raising them until they have reached a sufficient size to make them marketable, whilst the latter confines itself to fattening the fish which have been obtained from fish-culturists when quite young. Any pond or puddle having suitable water, and a depth of $\frac{1}{2}$ to 1 meter, is suitable for the keeping of fish, even if there is no chance to let the water off; whilst regular fish-culture in ponds requires a number of different and properly arranged ponds.

It will be best to construct carp-ponds in the midst of fertile fields, surrounded by gentle hills, protected against the east and north winds and quite open towards the south, so that during the day the sun may shine on them and heat them. The most favorable bottom is clay, which does not allow the water to filter through into the depths of the ground, and which offers the greatest advantage for the development of rich fish-food. Marshy or sandy bottom is not so good; the latter especially is very poor and particularly apt to let the water filter through, unless the entire bottom of the pond is covered with a thin layer of clay. Shallow ponds are preferable to deep ones, because the production of fish-food does not depend on the quantity of water, but on the extent of the bottom, and because deep ponds do not so easily reach the desired de-

gree of temperature, and also require very high and broad and consequently expensive dikes. If ponds are constructed on strongly-sloping ground, it may be recommended to construct several small and shallow ponds, one above the other, in preference to one large pond which would be very deep on one side.

II.—CONSTRUCTION OF THE PONDS.

As a general rule it will only pay to construct ponds that need but few earth-works. The best way is to use broad and flat valleys, with a gentle fall, whose sides are high enough to prevent an injurious overflow of the water into the surrounding fields, and which in some places approach so near to each other that it needs only short dikes to connect them. Such gentle valleys are found in nearly every part of the country, unless it is absolutely level, and frequently they produce nothing but a small quantity of sour grass. Frequently they extend with a gentle fall for a considerable distance, so as to make it easy to construct a number of ponds one above the other, which is particularly advantageous, because small and shallow ponds are, as a general rule, much more productive than large and deep ponds. In that case the ponds can easily be drained, beginning at the lowest one, and be filled again from the highest one. (Plate I, Fig. 1.)

In such valleys it will be easy to find the most suitable place for the principal dike after, by simple leveling, the fall is ascertained and thereby the size of the pond is determined. The pond is of course deepest next to the dike, and gradually grows shallower towards the other side. For most purposes it is best not to exceed an average depth of 2 meters; as a general rule ponds having an average depth of 0.50 to 1 meter are the best; the outflow of the water must be carried though the dike, and a ditch of sufficient breadth and suitable fall must be supplied for it.

The dike may be constructed of different material. The simplest and cheapest are earth-dikes which meet all requirements, and which can be constructed without hiring foreign laborers. We shall therefore confine ourselves to a description of such earth-dikes. Even in wood and stone dikes the main body of the dike is made of earth, which towards the side of the pond is protected by a wall constructed of stones or cement or of beton. The principal use of such walls is to protect the dike against the action of the waves in large ponds, whilst in small ponds this protection may be obtained in a much simpler and cheaper manner.

The best material for constructing the dike is clayey soil which does not contain much sand. Wherever such soil cannot be obtained, except by going a considerable distance, the main body of the dike may be constructed of gravel or some other material, and be made water-tight by a layer of clay 20 to 30 centimeters thick, which is either placed on the side of the dike toward the pond, or is made inside the dike whilst

it is being constructed. A gravel or sand-dike of course resists the *pressure* of the water as much as one constructed of clay, and all that is necessary is to prevent the water from *oozing through* by providing a strong layer of clay. The first work is to stake off the sole, or foundation, of the dike, and clear away all grass, shrubs, &c. The same of course applies also to the edges of the valley on which the dike is to rest. If by this work an impenetrable foundation has been laid bare, the construction of the dike may be commenced at once, but if marshy soil or gravel has been brought to light, it will have to be removed along the entire extent of the ground which the dike is to cover, until firm, impenetrable soil is reached, because otherwise the water would ooze through below the dike, thereby occasioning not only a gradual decrease of water in the pond, but also the slow but sure destruction of the dike. As soon as suitable soil has been reached along the entire extent of the dike, it is well, especially in dikes which are not very broad, to dovetail the dike with the foundation. For this purpose two or more ditches are dug along the entire length of the proposed dike and parallel with its edges, measuring about 50 centimeters in breadth and depth; the bottom of these ditches is made broader that the top. Only after these ditches have been filled with the same material of which the dike is to be constructed, which is well rammed down, the construction of the dike is commenced. If the main body of the dike can only be constructed of gravel or other porous material, the ditch nearest to the waterside should be filled with clay, and, as the building of the dike progresses, the layer of clay, referred to above, should be begun on this ditch and continue through the entire dike.

It is of the utmost importance for the durability of the dike to give it the proper degree of consistency and shape. The sole of the dike must be twice as broad as the proposed height of the dike, and the top of the dike should be half as broad as it is high. The slope and sole should, therefore, form an angle of about 50 degrees. Steeper slopes are not to be recommended, and there may be circumstances which make it advisable to have an angle of only 45 degrees. The height of the dike will, of course, be regulated by the proposed depth of water. To avoid any damage to the top of the dike it may be well to make it a meter higher than the normal height of the water.

It is important to select a suitable season and favorable weather for constructing the dike. If the material is to gain some consistency, the work must not be done in frosty weather, nor when the weather is very damp. If it is unavoidable to work during wet weather, the material of which the dike is constructed must be thoroughly rammed down, which, of course, is hardly necessary when the soil that is heaped up is dry and loose. To guide the workmen the outlines of the dike must be staked out at distances of 2 meters by poles and laths. (Plate 1, Fig. 2.)

It is absolutely necessary to have the work properly superintended;

care should also be taken that no wood, roots, and other articles get in the dike, which would gradually decay and cause the dike to shrink in some places, thus diminishing its firmness, and making it possible for the water to enter. Along the scarps and on the top of the dike the soil must be well beaten down, or rammed down. After the dike is finished it will take it some time to settle. No water should be let into the pond till one-half year after the dike has been completed; and if the dike is large, one whole year should be allowed.

While the earth of which the dike is constructed is heaped up, the outflow pipe, to which I shall refer further on, must, of course, be inserted and well rammed down in a bed of clay.

To protect the dike it is absolutely necessary to cover its scarps. The simplest way to do this is to use square pieces of turf, cut regularly, measuring from 30 to 40 centimeters on each side, and 10 to 15 centimeters in thickness. For this purpose thickly-grown turf should be selected, with short fine grass, taken from black meadow-soil. The sod had best be cut in moderately moist weather, and be laid, beginning at the sole of the dike and progressing towards the crest, in such a manner that the different pieces are joined closely together, the perpendicular sides of the pieces of one row always standing in the middle of the pieces of the contiguous row, on the same plan as bricks are laid (Plate I, Fig. 3).

The lowest row is embedded in the ground. On the pond side of the dike, which to distinguish from the other side or the back is generally called the front, it is well to make the cover of the dike up to the level of the water of fibrous peat, wherever such can be obtained, as the grass will generally die under the water, and the decaying of its roots will tend to loosen the soil of the dike. The pieces of peat may be cut larger and have a thickness of about 10 centimeters; they will form a strong and durable cover which is not liable to decay. Both sod and peat are fastened to the dike with pegs. For this purpose it is advisable to use live branches of the basket willow, which soon take root and cover the scarp with a dense growth of willows whose branches may be cut at stated times and be used for wicker work (Plate II, Fig. 4). The best willows for this purpose are the *Salix viminalis*, and for sandy or gravelly dikes the *Salix caspica*. To keep the dikes in good repair, it is necessary to examine them frequently, and immediately to repair any damage, however small. Whenever the water has been let off, the scarps of the front of the dike should be carefully examined, and repairs made at once wherever needed.

The bottom of the pond should slope towards its deepest place near the dike, and should be as smooth as possible. Holes in which the water might be retained, when the pond has been drained, should be filled up as much as possible. A porous bottom can be made impervious by placing on it a thin, even layer of clay. In large ponds a well-defined pit of even depth (the fish pit) should be dug close to the dike;

and the lower part of the outflow pipe should be on a level with the bottom of this pit. To make the pit more durable, its sides are frequently lined with boards, and from it a ditch, gradually growing shallower, should extend the entire length of the pond. In very large ponds smaller ditches should start from the main ditch on both sides, forming a sharp angle with it (Plate II, Fig. 5).

When the water is drained off, the fish will gradually retire to these ditches and thence to the fish pit, where they can be caught with very little trouble. As a protection against fish thieves, it is well to drive into the bottom of the pond small posts at intervals of a few meters, which should protrude 20 to 30 centimeters above the bottom, thus preventing the use of drag nets. The best posts for this purpose are young pine trees, which are freed from their branches and driven into the ground at the thin end, a few centimeters of the branches being allowed to remain round the top (Plate II, Fig. 6). If no pine trees can be obtained, simple posts are driven into the ground and a number of nails fastened to the top, whose heads, however, should not be very sharp, to prevent the fish from getting hurt.

The arrangements for the outflow of the water serve two different purposes: first to drain the pond either in part or completely, and second to take off superfluous water caused by sudden rains or brought into the pond from the ditches which supply the water.

The first purpose is served by sluices and taps, and the latter by weirs and flood ditches.

In many of the older ponds one still finds sluices such as are used in mills (Plate III, Fig. 7). In new ponds it is not advisable to introduce them, as they require a good deal of carpenter's work, and easily get out of repair. They, moreover, have this disadvantage, that, even when they are only partly opened, the water rushes through the opening with full pressure corresponding to the depth of the pond, carrying with it fish and other objects, and if the opening is made larger carrying away parts of the bottom and sides of the outflow ditch.

The tap outflow (Plate III, Fig. 8) consists of a pipe of wood, clay, or masonry led right through the base of the dike, open at the end which is outside the pond, but closed at the one projecting into the pond. The width of bore of this pipe, which generally consists of a single trunk of an oak or pine tree, is as a rule 25 to 30 centimeters. In large ponds several such pipes are sometimes led through the dike side by side. At the end of the pipe projecting into the pond one or several meters, a conical hole of about 20 centimeters is bored in the top, which may be closed by a tap of the same size. This tap is connected with a strong pole which rises perpendicularly from the water. At equal distances from this pole (about 30 centimeters) four square posts are firmly driven into the bottom of the pond, which rise to an even height above the surface of the water, and to which horizontal beams are fastened by means of which the pole may be raised or lowered, and

be retained in any desired position by screws or bolts. Up to the surface of the water the four square posts are connected by horizontal laths, which form a grating with intervals of 2 to 3 centimeters. This is intended to keep out fish, leaves, &c. Above the surface of the water the posts are connected by closely-joined boards and protected on the top by a roof. This whole contrivance, which, in large ponds having several tap-outflows, assumes considerable dimensions, is called the tap-house (Plate III, Fig. 9). In order to show the tap-pole the upper boards have been left out of the drawing. Whenever the tap is raised the water flows into the pipe through the conical hole and through the pipe finds its way outside the pond. Fish are kept back by the grating. The tap-outflow is much cheaper than a sluice, but has the same disadvantage that the water from the bottom of the pond flows out at a high pressure and easily damages the outflow ditch.

Of late years such outflows are in large ponds constructed of masonry, and, instead of the taps, valves are employed which are raised by screws. But even these outflow arrangements have the above-described disadvantages.

The so-called "monk" or stand-pipe outflow (Plate IV, Fig. 10 and Fig. 11) is without doubt the best outflow arrangement. As in the tap outflow, a horizontal pipe is led through the base of the dike. This pipe may be constructed of masonry, but generally it is made square in shape, of strong oak boards, which are carefully joined and thoroughly embedded in tough clay. The height of the opening is generally 20 to 30 centimeters, the breadth the same in small ponds, whilst in large ponds it may be much larger; in this case, however, strong props should be inserted at intervals to support the roof of the pipe, and protect it against the pressure of the soil on the top. At the end of this horizontal pipe, which projects about 1 meter into the pond, a vertical pipe of the same diameter is fastened, which projects about one meter above the highest water-mark. This is, if necessary, supported by strong buttresses, and its side towards the pond is open from top to bottom (Plate IV, Fig. 11). On the inside of the side planks two thin, but strong, strips are nailed down, which form a deep and broad groove, in which run a number of closely-fitting boards, measuring 15 to 20 centimeters in height (Figs. 10 and 11). By the pressure of the water these boards are pressed against the inner side of the groove, which should therefore be very broad, fastened firmly, and—as well as the boards themselves—be planed down very smoothly. The boards, however, should have room enough in the groove to prevent their sticking fast and make it easy to remove and insert them again. If broad "monks" are used, the side planks must of course be firmly joined by horizontal beams on the side towards the pond. In order to prevent the bending of the boards through the pressure of the water, the horizontal pipe should be divided into two halves by a strong board, so that the center of the boards meet with a firm resistance in this partition wall (Plate IV, Figs. 12, 13). In the center of

every board a strong ring of galvanized iron is firmly fixed by screws, so that the boards can easily be raised with a hook. It is not advisable to make these boards higher than 20 centimeters, as in that case they are difficult to handle, and whenever a board is raised the water rushes into the "monk" with too great force. The very circumstance that the water always flows off at the top, and consequently flows off with little pressure, thus neither carrying fish away with it, nor injuring the bottom or sides of the outflow ditch, is one of the principal advantages of this arrangement. Another advantage is this, that by means of the boards the level of the water can easily be brought to the desired height, at which it will remain; and when the opening of the "monk" is sufficiently large, even large masses of water, occasioned by violent rains, are easily led out in a very short time. To exclude the possibility of the fish escaping, a grate of galvanized iron is inserted in a wooden frame above the upper board. To prevent any unauthorized person from meddling with the boards, the top of the "monk" is closed by a lid on hinges. To prevent the stopping up of the grate by aquatic plants, dead leaves, and other articles of the kind carried along by the current, which mostly float on the surface, or immediately below it, it may be recommended to place a box constructed of two boards joined at a sharp angle in front of the pond side of the perpendicular outflow pipe. This box should rise 20 centimeters above the highest water-mark and be as far distant from the bottom of the pond. The water will then unhindered flow into the "monk," whilst all objects floating on the surface will gather in the box, whence they can easily be removed from time to time. After it has been ascertained what time it takes the level of the pond—after one of the boards has been removed—to sink to the edge of the next board, one will always know in what time the pond can be drained, which is of considerable importance, as sometimes the fisheries have to take place at a certain time.

The outer end of the horizontal outflow pipe (both in the "monk," and in the tap outflow), after it has left the dike, is generally extended 1 to 2 meters, in order to prevent damage to the dike such as being washed out from below. It will also be well to cover the first 5 to 10 meters of the bottom of the ditch with stones to prevent the ditch from being washed out, which might easily cause its walls to tumble down.

As wooden pipes will keep best when under water, it is advisable to place a small sluice in the outflow ditch, high enough to keep the outflow pipe under water all the time. When the pond is drained this sluice must, of course, be removed, so that the bottom of the pond may be laid entirely dry.

In ponds located in level country "monks" of suitable width will suffice to quickly lead out the superfluous water and maintain the normal level of the pond, even during violent rains or when the snow melts in spring. Ponds located between mountains or hills, or those fed by brooks or rivers which are apt to overflow, must be protected against

inundations and consequent injuries to the dike by weirs or ditches for carrying off the superfluous water.

The weirs (Plate V, Figs. 14, 15), are generally constructed at one end of the dike where, owing to the less depth of water, they are not exposed to any high pressure. According to the size of the pond and the probable quantity of superfluous water, the breadth of these weirs varies from 3 to 10 meters or more. The edge of the weir should, according to circumstances, lie ½ to 1 meter lower than the crest of the dike. The scarps, which in that part of the dike where the weir is constructed should not be near as steep as in the rest of the dike, meet in the edge of the weir in the shape of a roof, and are covered with thick boards closely joined together. The side walls of the weir must also be supported by firm buttresses. If the top of the dike is to be used as a road, a bridge should be thrown across the weir.

To prevent fish from being carried over the weir in high water a grating is placed upon it, or in front of it (Plate V, Fig. 14 *a*), generally of wood or galvanized iron (Plate V, Fig. 16), which in broad weirs runs parallel with the edge of the weir, but in narrow weirs is generally placed at a sharp angle against the current (Plate V, Fig. 14 *b*) so as to give more openings for the water to flow out, and to prevent leaves, &c., from stopping up the passage. If this nevertheless should happen, a floating beam (Plate V, Fig. 14 *c*) or a strong board is fastened in front of the grate obliquely against the current. Such a beam, or board, will stop all objects floating on the surface, and drive them towards the shore, where they will accumulate and whence they can easily be removed.

Wherever rivers or large brooks flow through ponds, it will be well to construct weirs in them before they enter the pond, so that the high water and the mud, &c., which it is apt to carry with it, do not enter the pond at all. To prevent the fish from escaping from the pond into the river or brook, its mouth should be closed by a grating or by a brush weir. Brush-weirs are made of fascines of thin brushwood measuring from 1½ to 2 meters in length, which are laid in the direction of the current, and must protrude about one-half meter above the highest water-mark. It will also be well, in order to prevent any stoppages, to place a floating beam in an oblique direction in front of the brush weir.

Ditches for carrying off the superfluous water are particularly required in ponds located in glens or valleys, so as to catch the snow and rain water flowing down from the heights, which generally carries with it sand, gravel, &c., and would soon fill the pond with its accumulations. Such ditches should, therefore, as a general rule be constructed parallel to the edges of the valley and of the pond, and should be broad and deep enough to contain and carry off all the superfluous water which may reasonably be looked for. Such ditches may also be required for catching and carrying off injurious water from places where flax is rotted, or from tanneries, dye establishments, and other factories.

III.—FILLING THE PONDS.

After the construction of the pond has been completed, and the dike has become thoroughly settled, the pond may be filled with water. New ponds whose dikes have not yet been tested had better not be filled to the desired height at once, but gradually. In sky ponds it will of course take the water a longer time to gather, and in order to have them full in spring, water should be allowed to gather in them in autumn. Wherever the quantity of water needed for filling the pond can be obtained at any time from springs, brooks, rivers, or lakes, it is advisable, for reasons to which we shall refer later, to let the bottom of the pond be dry during winter and until a short time before the pond is needed for use.

The filling of the pond is done by closing up the outflow-openings, either by closing the sluice, by putting in the tap, or by placing the flood-boards in the "monk," according to circumstances. In sky-ponds, and those ponds whose supply of water is scant, every opening should be firmly closed, so as to prevent a loss of water, which, in connection with the loss occasioned by evaporation, might easily prove very injurious to the fish. The tap should, therefore, be driven in firmly, and if necessary closed up with clay. The boards should also close firmly.

Even in filling the pond, the "monk" proves superior to all other outflow arrangements, as it allows the level of the water to be raised quite gradually. For various purposes, however, it is of great advantage to keep the water of the pond low in the beginning, and to have no more water in it after it has been in use for some time.

IV.—THE MANNER OF USING THE PONDS.

For a complete fish-cultural establishment different kinds of ponds are needed—spawning-ponds for propagating the fish, raising-ponds of the first and second class for fish one and two years of age, ponds for older fish (growing-ponds), winter-ponds for wintering fish of different ages, and stock-ponds for keeping the fish which are intended for sale.

1. THE SPAWNING-PONDS.

Good spawning-ponds form the basis of well-regulated carp-culture. These ponds should be of such a character as to offer to the fish the most favorable conditions for spawning, and to favor as much as possible the development of the eggs and the young fish.

The best spawning-ponds are small sky-ponds having an area of only one-tenth and, at most, one-half hectare. The bottom of these ponds should be impervious clayey soil or a clayey sand soil. Wherever it is impossible to construct suitable sky-ponds, ponds fed from rivers or lakes may be used; before entering the spawning-pond the water should, however, be filtered through large pits or boxes filled with coarse, washed

gravel, so as to prevent, as much as possible, fish and other injurious animals from entering the pond. Even sky-ponds are allowed to lie dry during winter, in order to destroy frogs, small crustaceans, insects, &c., and are only filled a short time before they are stocked. When a pond is known to contain much vermin, it is advisable to cover the bottom in autumn, after the fisheries have come to a close, with coarsely-grained lime. This will kill all vermin, and after the lime has been slacked, it is of course not injurious to the fish. To lay the pond dry during winter has also this advantage, that the soil by freezing becomes loose and loses its acidity. The pond should, therefore, be crossed by one, or, if the pond is large, several ditches, one meter deep. The depth of the pond should be from 20 to 30 centimeters, and the edges should be very shallow, with a thick growth of *Glyceria fluitans*, on whose floating leaves the carp like to deposit their spawn. As heat is one of the principal conditions for spawning and for the development of the young fish, the spawning-pond should be in a sheltered location, and entirely exposed to the sun, so that it can quickly be heated through. It is necessary that the pond should be protected against wind, so as to prevent the formation of waves which would kill the spawn deposited on the shallow shores. The depth of water should be as even as possible during the spawning-season, as its lowering would lay the eggs dry and kill them. Hurtful birds, such as herons, ducks, and geese, should be kept away from the pond; no cattle should be watered in it, as they would either devour the spawn with the floating leaves of the *Glyceria fluitans* or kill it by treading on it. Frogs also devour large quantities of young fish. Considering the importance of the spawning-ponds for the entire carp-culture, and their small size, it is advisable to surround them with a close wire-fence.

The spawning-ponds should not be stocked with spawning carp until the water has reached a temperature of 15° to 20° C. The spawners should already be selected in autumn when the fisheries are in progress. During winter they are kept in a good winter-pond; in spring they are examined once more, and the sexes kept separate in deep basins until the spawning-ponds are ready for stocking. As with the raising of any animals, so also with the carp, the selection of exceptionally good spawners is of the utmost importance. Although under favorable circumstances good fry may also be obtained from old carp, young carp, weighing from 2 to 4 kilograms, are preferable. It is advisable to select from among the fish of the same age the largest and best shaped, having a small head, a broad back, and slender body. The sexes can easily be distinguished during the autumn fisheries. As a general rule the belly of the spawner is, especially in its lower part, broader and rounder, the genital aperture appears larger and reddish, and has thicker lips, while with the milter it forms a narrow slit. It is a great mistake to press the fish for the purpose of ascertaining their sex, so much as to squeeze out immature milt or spawn. Such a procedure frequently

makes the fish sick and incapable of propagation. Any person using such rough methods should keep away from fish-culture.

Opinions differ as to the number of spawning fish to be placed in a spawning-pond of a given size, and as to the proportion betwen the sexes. If all the other conditions are favorable good results may be obtained by different methods. Of late years the common practice seems to be to count per hectare 8 to 10 spawners and 4 to 6 milters of the same size, in addition to which 2 to 3 small milters are put in the pond. For a spawning-pond of $1\frac{1}{10}$ hectare one would, therefore, take one spawner, a milter of the same size, and a smaller milter or two milters of somewhat smaller size than the spawner. If these fish are taken from a basin with cool water, and placed in a spawning-pond, whose temperature has already reached 15° C., one may with tolerable certainty count on the spawning process taking place on the following day or the day after. The spawning process generally takes place during the early morning hours. If you approach the pond cautiously about that time you may see the fish swim splashingly round the shallow shores, where they deposit their spawn on plants, or on juniper branches, which for that purpose have been laid in the water, and which may also be used for shipping the spawn. The eggs which are deposited by the spawners, and which adhere to aquatic plants, are impregnated by the milt which is ejected by the milters, and which by the violent movements of the fish is thoroughly incorporated with the water. After a while the eggs may be seen covering the leaves and stalks of aquatic plants in large numbers, and resembling transparent or slightly yellow beads of the size of grains of mustard. The number of eggs deposited by a spawner varies according to its size from 300,000 to 700,000, of which of course, especially in large ponds, a large number perish, so that it must be considered a favorable result if 1,000 to 1,500 young fish are produced in autumn from every spawner. In small spawning-ponds, managed in a rational manner, however, it is possible to obtain eight and ten times that number. Carp generally deposit their stock of eggs in three periods, separated from each other by intervals of eight or more days, so that in large spawning-ponds one may find young fish of three different sizes. In order to get the full benefit of the productivity of the fish, and to further the growth of the young fish, it will be found advantageous to catch the spawning carp after they have thoroughly spawned once in a small pond (which can easily be ascertained by examining the plants growing on the edge of the pond), in a fish-bag with long wings, and to transfer them immediately to another small spawning pond, where they will soon spawn again. From this pond they may be transferred to another spawning-pond, where they will spawn a third time. Another reason why it is advisable to remove the old carp from the spawning-pond is this, that they diminish the quantity of food intended for the young carp, and even devour some of the young fry with as much relish as they eat larva, worms, and tadpoles.

Any one who, without properly distinguishing the sexes, and without selecting carp of the proper size, simply places a number of carp in deep ponds for purposes of propagation, as is unfortunately still done in many places, need not be astonished if from numerous spawning carp he only raises a few sickly young fish.

From four to eight days after the eggs have been deposited, the young carp slip out of them and soon sport about in a lively manner among the leaves of the aquatic plants. The small umbilical bag which they carry with them from the egg is soon consumed, and the little fish will then begin to hunt for infusoria, very young larvæ of insects, crustaceans, &c. The quantity of food, however, soon becomes to small for the enormous number of young fish; and, under ordinary circumstances, a very large percentage perish very soon simply from lack of food, and the survivors do not grow as rapidly as would be the case, if they had ample food. The method practiced by Mr. Dubisch on the estates of Arch Duke Albrecht near Teschen, is therefore to be strongly recommended. It consists in gradually transferring the young fry raised in a small pond, and kept in it for a short while, to numerous other ponds, where they will grow rapidly and suffer but few losses. The first transfer is made five to eight days after the fish have been hatched. They are taken up with fine gauze-nets, collected in a floating tank with a wire bottom having very narrow openings, and thence are taken out in a small sieve, holding about 1,000, and placed in the transporting vessels. The ponds intended to receive these young fish are of the same character as the spawning-ponds. Until they are stocked with fish, they should, if possible, lie dry, so as to be free from enemies of the young fish, and full of fish-food. During the time that the young fry remain in the spawning pond proper—*i. e.*, as long as they have their umbilical bag, and even a few days longer—Dubisch counts 100,000 young fish to 3 hectares pond area of ponds of the second class (the pond to which the fish are removed from the spawning-pond proper). From data which he has furnished to Mr. Von dem Borne, it appears that the fish grew several centimeters in length in these ponds during a period of about four weeks, and decreased about 25 per cent. in number. They continued to grow well, after they had again been transferred to another pond. The spawning-ponds of the second class have previously been planted with some kind of grass, which has been properly harvested, after which they should lie dry for some time before being stocked with fish. They are stocked at the rate of 1,050 young fish per hectare, of which number there should remain in autumn 1,000 fish weighing one-quarter of a pound a piece. If these ponds are stocked with only 300 to 500 fish per hectare, they are said to reach the weight of one pound in autumn. Supposing, therefore, that in a spawning-pond proper of an area of 0.1 hectare a spawner had deposited 100,000 eggs, and that the young fish hatched from these eggs are distributed, after eight days, over a pond-area of 3 hectares, there would be 75,000 left after four weeks, which would be

sufficient to stock 71 hectares at 1,050 fish per hectare, and which would yield in autumn about 71,000 fish having a total weight of 8,000 to 9,000 kilograms.

On carp farms, managed in the usual manner, one is generally satisfied to get in autumn 1,000 to 1,050 young fish from one spawner, of which 100 will weigh 1 to 2½ pounds, therefore in all 5 to 19 kilograms, instead of the 8,000 to 9,000 obtained by following Dubisch's method.

Although Dubisch's data, which I have not yet had occasion to test practically, are surprising, I do not by any manner of means consider them improbable, as I myself have obtained in a very good spawning-pond, in which the majority of the fish perished by an accident, and where, consequently, there was an ample quantity of food for the survivors, young fish measuring 20 to 22 centimeters in length, and weighing as much as 150 grams. Dubisch's method seems specially important for populating lakes and rivers with these valuable fish, which, placed in them when measuring about 20 centimeters, will grow well, even if their number will not increase much in such waters.

It is a great mistake to place in large spawning-ponds, besides carp, other fish, especially crucians, as was formerly done quite frequently, and is still done in some places. Looked away from the fact that such fish, by diminishing the quantity of fish-food, will retard the growth of the young carp, the crucians will with the carp produce bastards, which have a high back, and are thin and full of bones. Such fish are the *Carpio Kollari* Heck., which will soon damage the reputation even of a good carp farm.

2. THE RAISING-PONDS.

"Raising-ponds" are those ponds in which the young carp are placed to grow. The young fish produced in the spawning-ponds are taken out either in autumn or next spring, and transferred to the raising-ponds.

This may be the proper place, in order to avoid repetitions, to give names for the carp of different age. Very strange names have been given to them in different places. Thus, people will speak of one year's, two years', and three years' fry, of spawning fry, of deposit, seed, &c. Some will call those fish three years' fry, which others call "one summer's fish," and the confusion of terms has become so great that when people speak of one year's carp they may mean carp of three months, as well as those of twenty months.

It seems proper to understand by "fry" those fish which have been hatched in spring or early summer, and call them by that name till autumn, or, since carp do not grow during winter, till next spring, or till they have completed their first year. The simplest way, however, is to distinguish the carp by the number of summers which they have passed, therefore, one summer's carp, two summers' carp, three sum-

mers' carp, &c. During the autumn of the year in which they are born, and till the following spring, the carp are one summer's carp, in the following autumn and spring they are two summers' carp, &c. These terms cannot possibly be misunderstood. It will be much more inconvenient to distinguish the carp by the number of years, for in order to avoid confusion the two summers' carp would have to be called one and one-half year old in November, one and three-quarter year in February, two years old in May, &c.

As small fish do not flourish if put in one and the same pond with larger fish of the same kind, because they will thus be deprived of some of their food, it will be well to have different raising-ponds for carp of different years, whilst when the carp have grown to a larger size, it is no longer necessary to keep them separate.

One summer's carp are placed in spawning-ponds of the first class and two summer's carp in those of the second class. To accommodate myself to the terms employed in Dubisch's method, I have called those ponds to which the fish are repeatedly transferred during the first summer, "raising-ponds for fry," of the first and second class.

The raising-ponds proper of the first class should, if possible, resemble the spawning-ponds and "raising-ponds for fry" as to location and character. They may, however, be much larger, and cover an area of several hectares; in accordance with the size of the fish, their depth may vary from ½ to 1 meter. Their edges should be flat, and be planted with *Glyceria fluitans*. A moderate quantity of reeds (*typha*) and lilies (*iris*) on the edges of the pond will not only be an ornament, but also cause the development of various low grades of animals which serve as food for the fish. In raising-ponds fed by rivers and lakes, aquatic plants, such as *Potamogeton*, *Lemna*, and others, will soon make their appearance, which in moderate quantity are very desirable, but which should not be allowed to grow too rank. Raising-ponds may be used for watering cattle, as their dung deposited in the water favors the development of infusoria, insects, &c., and as there is no longer any danger that the fish will be injured thereby. No other fish besides carp should be allowed in the raising-ponds. According to the quantity of food contained in the ponds, from 300 to 800 one-summer's carp may be counted per hectare, which, if weighing 10 grams each when placed in the pond, should in autumn reach a weight of one-half to one pound. According to Dubisch's method, the raising-pond intended for one-summer's carp (which have reached a weight of one-quarter pound in the "raising-ponds for fry") is stocked with 520 fish per hectare. These, in the autumn, when their number has decreased to 500, should weigh 1 to 1½ pounds each.

The raising-ponds of the second class, intended for two-summers' carp, may be larger and deeper than the former class, and also contain more plants. As a general rule, they are stocked with from 200 to 400 carp, weighing one-half to one pound per hectare, which in autumn will have

reached a weight of 1¼ to 1½ pounds. Dubisch counts 206 of his two summers' carp, weighing 1 to 1½ pounds per hectare, and in autumn catches 200 fish weighing about 2 pounds. If only 154 carp per hectare are placed in the pond there should be in autumn 150 carp weighing as much as 4 pounds. It will not hurt to keep in these ponds, besides carp, some tench and eels, which root more in the ground than the carp, and there seek food which would be no good to the carp.

As with spawning-ponds and "raising-ponds for fry," it is also best if the raising-ponds are fished clear in autumn, and are allowed to lie dry during winter. Only in exceptional cases, and taking the proper precautionary measures, such ponds should be allowed to remain filled during winter.

3. Ponds for older fish (growing-ponds).

These ponds are intended for three-summers' carp, and here, according to the quantity of food contained in them, they will in one to two years reach a weight of 2 to 2½ pounds. In Dubisch's method the raising-pond for two-summers' carp takes the place of the pond for older fish, no other pond being required, as it will be found most advantageous to sell the fish when they weigh from 2 to 2½ pounds, because at a more advanced age they use the same quantity of food as younger fish, but produces less flesh. As ponds for older fish, large and deep sheets of water may be used, which, according to circumstances, are only fished every two years. As deep and cool waters produce less food for carp than shallow ponds, the ponds for older fish, especially if they are only to be fished every two years, should not receive as many fish as the raising-ponds, 150 to 250 per hectare generally being counted sufficient. It will not hurt to put a considerable number of tench and eels in these ponds. It is also advisable to place in these ponds a number of small fish-of-prey. Especially in ponds which are connected with other waters, there are generally found large quantities of fry of the bleak, the red bream, and other fish of this kind. Even into ponds which have no connection with other waters the spawn of such fish is frequently brought by wild ducks and other aquatic birds which often carry large quantities of it on their wings. These worthless fish, which only take away the food from the carp, ought to be destroyed by perch and pike, and thus be transformed into valuable fish flesh. It also frequently happens that in hot seasons the carp spawn already in the ponds for older fish, when of course the fry, being in cool water, and in the company of larger fish, do not develop well. Even such useless fry is to be transformed into valuable fish flesh by being devoured by fish-of-prey. This is the advantage of having "a pike in the carp pond," that it frees the carp from useless competitors for its food, whilst it grows quickly, and its flesh becomes particularly tender and well flavored. The old fables that the pike chases the lazy carp and forces them to take food, and that it pre-

vents the carp from spawning, because the female carp considers it useless to deposit any spawn, which would only fall a prey to the pike, are no longer believed by any one.

As a general rule one puts with 100 three-summers' carp 5 small pike, and, wherever they can be obtained, as many perch-pike.

As the ponds for older fish are well suited for wintering fish, and with the view not to crowd the winter-ponds too much, they are generally stocked in autumn at the time when fisheries are in progress in the raising-ponds. As the fish in them are only taken out to be sold they may be fished whenever it suits, either in autumn or spring.

4. WINTER-PONDS.

Winter-ponds are needed for wintering one-summer's and two-summers' carp, whilst the ponds for old fish are generally of such a nature as to afford a safe abode for fish during winter. The different raising-ponds, even if they should be capable of wintering fish, should be laid dry every autumn, and their fish placed in the winter-ponds, as on the one hand it would be difficult to bestow the proper care in winter on a large number of ponds, and as, on the other hand, it thus becomes possible to destroy all the vermin in these ponds, and as finally it becomes necessary in a well-regulated pond-farm, to ascertain in autumn how the fish in the different ponds have flourished. Good winter-ponds are therefore absolutely needed in well-regulated carp *culture*, as in places where they do not exist one will have to confine oneself to the mere *keeping* of carp. On large pond-farms there should be several winter-ponds for receiving carp of different ages and fish-of-prey. The winter-pond should be in a sheltered location, have always the same depth of water—2 to 4 meters—and if possible a regular supply of water. Spring-water, which in winter has a higher temperature than river or brook-water, is to be preferred to the latter. Lakes and ponds may also be used to advantage for constantly or temporarily feeding winter-ponds.

The banks of the winter-ponds should have a steep slope, the bottom must be firm, but neither hard nor muddy, and have a suitable depression (pit) in one place. In this place the carp gather, as soon as frost sets in, and remain there quietly, until the water again gets warmer, sleeping more or less soundly according to the varying temperature of the water. Here they should be entirely undisturbed, as when they become scared they will swim around wildly, and in ponds whose banks are not very steep, get into shallow water, where they frequently freeze to the lower side of the ice and thus perish. No persons or wagons should therefore cross the ice of the winter-ponds, and skating should be a strictly prohibited as well as the cutting of ice for ice-houses. Every unusual agitation of the water by violent currents, which will occur especially in spring, when the snow begins to melt, or during long-

continued rainy seasons, likewise disturbs the carp and causes them to seek the surface, where frequently large numbers of them perish, if severe frosts set in late in the winter season. Winter-ponds located among hills should, therefore, in all cases be provided with ditches for carrying off the superfluous water.

Ponds which have a regular and abundant supply of water may safely keep their fish during an entire winter without air-holes in the ice. It is, however, advisable even in such ponds (as it is necessary in ponds whose supply of water is scant) to make 3 or 4 large air-holes at some distance from the fish-pit. These holes should be kept open all the time so as to admit air into the water. The freezing of these holes may be prevented by sticking into them large bunches of straw in a perpendicular position. It is still better, after a firm cover of ice has formed on the pond, to lower the level of the water from 10 to 20 centimeters, so that extensive places filled with air may form near the banks under the ice which slopes towards the center of the pond. In these air-holes, which should be examined every day, there will show themselves, wherever any deterioration of the water has taken place, gas-bubbles of different size, rising from the bottom, dead beetles, and other insects; the water will gradually assume a dingy color, and the fish will come to the surface trying to catch a breath of air. If aid cannot be afforded, by quickly airing the water or renewing it in part, the ice should at once be broken all over the pond, and the water let off, so as to save at least some of the fish by transferring them to other winter-ponds.

The airing of a pond is done in the most primitive manner, by repeatedly and violently pushing into the water large brooms or pieces of wood or leather fastened to long poles. A more satisfactory method, however, is to use a force-pump, whose hose is led to the bottom of the pond. In order to distribute the air in as many small particles as possible, the end of the hose is filled with a sponge, through which the air escapes in numberless small bubbles.

As winter-ponds are only used for harboring carp at a time when they do not take any food whatever (their loss of weight being only 2 to 3 per cent. during this period, owing to the pause in all the functions of life) they can receive quite a large number of fish—all the more the more abundant the supply of air and water. More small than large fish may of course be placed in the same pond area. As a general rule one may count per hectare 50,000 to 100,000 one-summer's carp, 30,000 to 40,000 two-summers' carp, 15,000 to 20,000 three-summers' carp, and still fewer older carp.

The carp had best be removed from the winter-ponds when the water in the raising-ponds has reached a temperature of 10 degrees C. or more; therefore, generally towards the end of April or the beginning of May. For wintering the spawning carp which are already selected when the other ponds are fished, special small winter-ponds are constructed,

which should be particularly well protected and have an abundant supply of water.

In the winter-ponds proper, but still more so in the ponds of older fish when used as winter-ponds, frogs and toads should not be allowed in any considerable number, because in early spring they cause the sickness and death of a large number of fish, by settling on their heads and placing their fore feet on the eyes of the fish, thus sometimes preventing them from taking food for weeks. Old carp-raisers who were well acquainted with such occurrences, thought that the frogs ate the eyes and brain of the carp, or sometimes used the carp as a horse, to carry them quickly to some good feeding-place where they would snatch the food from the mouth of the poor fish. These explanations are entirely erroneous. The male frogs and toads—and only such are found on carp—will often sit on the females for weeks before spawning, so as to impregnate the eggs the moment they are laid. The sexual desire of the male frog is so strong that he will not even let go of a dead female, and if no female can be found, he will even mount another male frog or any other object that comes in his way. The head of the carp, which during the spawning season of the frogs is still in a sort of torpor, appears to the frog as a very suitable object for his purpose, and when the ponds were drained in spring hundreds of carp, and sometimes even trout, were found with frogs firmly adhering to them.

Another most dangerous enemy to the fish in the winter-ponds is the otter, which, when a favorable opportunity presents itself, will kill more fish than it can devour, and which, if found in large numbers, may destroy the entire stock of fish. A constant watch should therefore be kept for any traces of this bitter enemy of the carp.

5. The stock-ponds.

The stock-ponds are small basins, frequently with brick or wooden walls, having an abundant supply of water, which serve for keeping those fish which are shortly to be sold. Their bottom should be of clay. If they have a sufficient supply of water, and if the fish are not to stay in them for any great length of time, they may be stocked at the rate of 50 kilograms carp per one square meter.

6. The pond-fisheries.

During summer—apart from the transplanting of young fry necessary in Dubisch's method—one should not fish in the carp-ponds with nets, because this disturbs the fish, most of which, moreover, either slip away under the net, or leap over it. Fish may, however, occasionally be caught, when they are needed, with fish-pots, or with hooks and lines, unless one should prefer to construct small stock-ponds for keeping the fish intended for home consumption. In such stock-ponds the fish must of course be fed, and can easily be taken with a small purse-net.

In the spawning-ponds, the raising-ponds, and the ponds for older fish the fisheries take place regularly late in autumn, and in the winter-ponds in spring. Cool weather is absolutely necessary, in order that the fish may not suffer, when crowded together in a very small sheet of water, or when entirely out of the water. Fishing at noon-time should, therefore, be avoided. The water should flow off gradually, so that, especially in large and shallow ponds with a luxuriant vegetation, the fish do not suddenly get on dry land, but have time to retire to the ditches, and ultimately to the fish-pit. The pond-farmer should, of course, know what time it will take each pond to be laid dry, and should arrange it so that fishing commences early in the morning. Before the autumn fisheries commence, the winter ponds and the ponds for older fish about to be stocked, and before the spring fisheries, the spawning-ponds and raising-ponds should be thoroughly put in order, so that the carp may be transferred to their new abode without delay. It often happens that old ponds of great size, especially when they contain springs, cannot be laid dry completely. Then all that can be done is to crowd the fish together in one place having a moderate depth of water, when it becomes necessary to employ small drag-nets, and sometimes even light boats. In small and well-constructed ponds, however, all the fish will gather in the fish-pit, whence they can easily be taken with purse-nets. When taken out of the water they are, if necessary, washed in tubs with clean water, and taken to the shore on wooden frames (see Plate V, Fig. 17), covered loosely with a net, which are carried by two men. When on shore they are numbered, weighed, and placed in the transporting vessels, which, as soon as they have received their full load, are at once shipped to their destination. All the fish should be treated very carefully, and be neither pressed nor thrown any distance. Sick and damaged fish should be eliminated at once. When the fisheries take place in the ponds for older fish, the more tender pike, perch, and perch-pike should be taken out before the carp, and placed in suitable receptacles. The spawning-carp for the following year should be selected with special care, and be kept separate. Tench and crucians are taken out after the carp, and any small perch-pike which may be found are placed in separate ponds as food for pike.

As in every well-regulated farming operation, so also in carp-culture, it is necessary to ascertain exactly the increase in weight of the carp, the losses, and the products of the different sheets of water. This is done by counting and weighing. Large fish are *counted* one by one, and the one summer's fish are measured in small dippers, whose capacity has been ascertained by counting the number of fish of two or three different sizes which such a dipper will hold. The *weighing* of large fish is done by means of scales, the one intended for the fish being made of wickerwork and capable of holding about a hundred pounds of fish. Smaller fish had better be weighed in small baskets capable of holding 10 to 20 kilograms, in order to prevent the fish from pressing upon each

other. If the size of a pond, the number and weight of the carp placed in it, and the number and weight of the carp caught in it are known, it will be easy to ascertain the yield of the pond per hectare.

Short distances, from one pond to the other, the carp can be transported in baskets or portable nets, and also in wagons, packed in moist straw. In this way they can be transported several hours. For greater distances they have to be put in barrels, having a capacity of 1 to 5 hectoliters. These barrels should be watered for a long time before being used; they must be quite smooth on the inside, and when intended to receive fish, be filled two-thirds with water. For journeys occupying several days, the fish have to be prepared, by keeping them in running water for several days, and not giving them any food, in order that they do not pollute the water in the barrels with their excrements. It is best not to put more than 150 to 200 pounds of fish in a barrel holding 5 hectoliters. The water should be partly renewed several times a day, and its temperature should not exceed 10° C.; if necessary, it should be cooled with ice. It is strongly to be recommended to introduce air direct by means of bellows to which a long rubber tube is attached. The bellows can be worked by hand, or by the turning of the wagon-wheels.

7. The cleaning and planting of the ponds.

As has been stated above, it is advisable to let the ponds lie dry during winter, in order to destroy the vermin. In most ponds mud will gradually accumulate, partly brought from the surrounding heights by the rainwater, and partly formed by decaying vegetable matter. On the edges of the pond mud becomes valuable, because it offers food for numerous small animals, but in the depths it becomes hurtful, because it is stirred by the violent motions of the fish and makes the water turbid. When the ponds are laid dry it should therefore be carted away once a year, or at longer intervals; and when piled up in heaps it has been allowed to dry, it can generally be used as a fertilizer for meadows and fields.

By the planting of ponds we understand their use for cultivating grass, clover, oats, &c., for a period of one to two years after they have served the purpose of fish-culture for three to six years. The advantages of this system of rotation have been known for centuries, and consist in this, that by plowing, and by roots of plants entering the bottom of the pond, it is loosened, and from the roots and stubble receives many substances, which are dissolved in the water, and serve as food for fish directly or indirectly. The mud which has accumulated in the pond during the period of fish-culture is moreover extremely fertile, and will need no manure in order to produce a rich crop. The ponds are generally sowed with timothy grass, clover, or oats, which yield a rich harvest. In some places it is customary to plant the ponds with turnips, and to fill the pond with water in autumn, without taking them out.

Especially in ponds which are not traversed by a brook or river this is a dangerous practice, as the water can easily be polluted thereby; under all circumstances such a pond should not be stocked till the following spring.

8. The feeding of carp.

The growth of fish depends on the quantity of food to a much higher degree than that of our domestic animals. In order, therefore, to obtain satisfactory results in fish-culture, it is of the utmost importance to give the fish an ample quantity of food. In the first place the ponds should not be overstocked, and should be made to produce more fish-food, by planting them from time to time. Many attempts have been made to artificially increase the small animals which serve as fish-food. Infusoria, diminutive crustaceans, and larvæ of different insects will develop in greater quantities in shallow, calm, and warm water than in deep water; and it is therefore an advantage if the edges of the ponds are shallow. Occasionally small pits are dug near the banks, and connected with the pond by a narrow ditch. In these pits it is sought to produce the conditions which attract insects about to deposit their eggs, and which favor the development of these insects. Strongly diluted manure water is a favorite place for gnats to deposit their eggs, and the pits will soon swarm with larvæ, large numbers of which will reach the pond by means of the narrow ditch. If this process can be aided by letting a small stream of water flow through the pit into the pond, it is all the better. For filling these pits Stenzel recommends the leaves of the alder, poplar, and beech. It is very desirable that systematic experiments should be made relative to this manner of increasing insects, &c., which form an excellent fish-food, especially for young fish. The spawn of frogs forms an excellent food for fish, as also young tadpoles. It may also be recommended to place above the surface of the water a number of boxes with wire bottom, containing moderately sized pieces of meat, which are soon covered with the larvæ of the blow-fly. As soon as these larvæ have became large and heavy, they fall into the water in great numbers and form a welcome food for the fish.

From times immemorial, attempts have been made to fatten carp by giving them artificial food, and a number of vegetable and animal substances are suitable for this purpose. Only such substances, however, should be employed which can be obtained cheaply, and which bear in themselves the guarantee that the capital invested will bear rich interest. Systematic experiments as to the comparative nutritiousness of the different substances mentioned in this connection have not yet been made anywhere, although they would be of great value to carp-culturists. Scientific institutions are generally not prepared to make such experiments, as but very few of them have any ponds at their disposal; and fish-culturists who of late years have often sought advice from nat-

uralists have not yet deigned to make such exceedingly simple experiments which are of the greatest importance to them. Nothing is needed for such experiments but a number of ponds of the same character, whose size is known. These ponds should be stocked with the same carefully ascertained weight of carp of equal size per are; in one of these ponds no food should be given to the carp, and in the other ponds different articles of artificial food, whose price is well known, should be fed to the fish, in even quantities; and during the autumn fisheries the increase of weight per are should be calculated for every pond.

For the time being we do not feel justified in recommending any particular food, and can only mention the kinds most commonly in use; and any one may from this list select those which he can obtain cheapest. The food is thrown into the water near the edges of the pond either by itself or kneaded together with clay, and it will soon be seen whether the fish take to a food or not. This is of special importance in ponds through which flows no river or brook, as food which is not consumed by the fish would decay in them and pollute the water. Some people recommend the dung of cattle, sheep, and hogs, also fine flour, bran, husks, maltsprouts, boiled lentils, beans, lupines, peas, potatoes, turnips, the solid refuse from distilleries, the remnants of beets from sugar-refineries, the refuse from dairies, boiled blood, &c. It may be well to mix a number of these articles and knead them with clay. In some places some of the articles of food mentioned above, mixed with clay, are made into flat loaves, which are dried either in an oven or in the sun, and can then be kept for a long time. Occasionally snails, cockchafers, and worms—wherever they can easily be obtained in large quantities—may be mixed with this food. It is not advisable to throw into the ponds the flesh of worthless animals; it is especially to be avoided to have entire dogs, sheep, or quarters of beef or horses thrown into the pond, as is done in some places, because the water easily becomes polluted thereby, and because the fish cannot bite off pieces. They can only eat such articles of food as they can take into their mouths and devour at once. They always like meat chopped fine, especially if it is mixed with flour.

Recently various articles of food mixed on scientific principles have been recommended, and it is very desirable that they should be subjected to a systematic examination; wherever a systematic method of feeding will quickly, and without any great outlay, increase the yield of ponds, it is of course to be recommended.

9. The relative size of the ponds.

As in agriculture, so in pond-culture, a rational use of a given area only becomes possible, if based on a proper system. It is of special importance to maintain the proper proportion in the relative size of the spawning-ponds, the raising-ponds, and the ponds for older fish. If

there is not a sufficient area of raising-ponds for the fish produced in the spawning-ponds, the ponds will be overstocked, there will be consequently a lack of food, and the fish will not grow as well as in ponds which are not so crowded, and where they find ample food. The pond-farmer will have to ascertain by experiments the productivity of his different ponds, and should know what quantity of fish every are of his ponds can produce, under normal circumstances. It is, therefore, absolutely necessary to have a thorough system of books, recording every fact relative to the ponds. In the method generally employed it has been found that the following distribution of a given pond area is best suited for the purpose: 4 per cent. should be taken for spawning-ponds, 12 per cent. for raising-ponds of the first class, 18 per cent. for raising-ponds of the second class, 60 per cent. for ponds for older fish, and 6 per cent. for winter-ponds. The matter is entirely different if Dubisch's method is followed, when a much larger quantity of young fish are raised. In that case one should count to a 0.1 hectare spawning-pond, 3 hectares raising-ponds of the first class, 71 hectares raising-ponds of the second class, and for the fish obtained during the first year (one summer's fish) in the following year 137 hectares raising-ponds, and during the third year 333 hectares raising-ponds. To correspond with these ponds, the number of winter-ponds should also be gradually increased.

10. The different races of carp.

Among the common carp, which have regular scales, there are occasionally found, both in ponds and in open waters, fish which have either no scales (leather carp) or only a few very large scales, which generally extend in a row on each side from head to tail (mirror carp). Both these varieties are specially raised in some places, and are considered to grow faster and have a more delicate flavor than the ordinary carp; but no comparative experiments have been made relative to this question, and all the conditions being equal, there will be but little difference between these varieties. If the people in some locality show a special liking for one or the other of these varieties, pond-farmers will of course have some regard to it. Young fry and spawning fish of the different varieties can easily be obtained in many places.

Of late years the so-called "blue carp" has become a great favorite. This fish comes originally from Bavaria; when out of the water its color is a grayish blue, and in the water a beautiful dark blue, whilst as a general rule the back of the carp has a darkish-brown, and its side a leather or bronze color. It is said that the blue carp needs warmer water than other carp, spawns later in the season, and when it has reached a more advanced age is quieter and more inclined to seek its food. Among the blue carp there are also found leather and mirror carp. On the whole the blue carp are still confined to a few localities,

and it remains to be seen whether they will everywhere retain their much talked of excellence.

11. THE YIELD OF THE CARP-PONDS.

The question whether carp-raising will pay is of course of great importance to landed proprietors. It has often been said that a carp-pond will yield more revenue than the same area planted with wheat. This assertion does not seem to be borne out by the fact that, in many places where formerly there were numerous carp-ponds, they have been laid dry and abandoned in course of time. In the north of Germany and many parts of Central Germany this circumstance is easily explained by Luther's Reformation, and the very imperfect means of communication in those days. The abolition of the numerous fast days observed in the Roman Catholic Church, which necessitated the maintenance of regular and extensive pond-farms in connection with the convents, greately diminished the demand for fish, and as matters stood in those days, the transportation of fish to any considerable distance was not thought of. Under these circumstances it was of course more profitable to drain the ponds and use them for agricultural purposes. To-day all this is changed; on the one hand the price of grain has been lowered by foreign competition, and on the other hand our improved means of communication make it possible to send all those fish which are not needed or home consumption to other places, and thus derive some profit therefrom.

In judging of the revenue to be obtained from carp-culture, it should be taken into consideration that it requires less labor than agriculture, and is much less dependent on changes of the weather.

The production of fish of course depends on the quality of the ponds, and it would be a mistake to compare worthless ponds with good fields, and good ponds with poor fields. Unfortunately it is hardly possible to give exact data as to the average quantity of fish-flesh produced per are or acre, by good, medium, and poor ponds. An exact system of book-keeping, which is necessary for this purpose, may be in force on large pond farms whose pond area amounts to hundreds and thousands of hectares, but it is rarely found on small farms, whose proprietors often do not know the size of their ponds, nor the cost of labor, nor the weight and number of the fish placed in the ponds and taken out during the fisheries. C. Nicklas, in his admirable Manual of Pond-culture (Stettin, 1880), gives very valuable hints how to keep the books of a pond farm.

It is generally presumed that good carp-ponds, if properly managed, produce annually 70 to 90 kilograms of carp-flesh per hectare; and in following Dubisch's method the yield would be 130 kilograms per hectare. In poor ponds the yield is of course much smaller. On an average the kilogram of carp-flesh when sold to dealers will realize 1 mark (23.8 cents), whilst when sold at retail the same quantity will frequently fetch

1.50 marks to 2 marks (35.7 cents to 47.6 cents). One summer's and two summers' fish, when sold to pond-farmers, will often fetch even better prices.

It should, however, also be taken into consideration that by stocking lakes with carp of suitable size, which owing to their large number find no room in the ponds, the revenue from the lakes may be materially increased. Some account should also be taken of the income from the grass growing along the edges of the ponds, from the mud, from the willows on the dikes, and in large ponds from the reeds. Wherever the ponds are numerous some of them will be planted every year and will yield a rich harvest of hay or oats without any outlay for fertilizers. It may therefore be considered as a matter beyond doubt, that wherever the conditions are favorable for carp-culture, it should be urgently recommended as a most profitable industry.

V.—CULTIVATION OF OTHER FISH.

In ponds adapted to carp-culture, other fish, of kinds resembling the carp, may be raised. As they are generally of less value than carp, only inferior ponds will be used for this purpose.

The tench (*Tinca vulgaris* Cuv.) is in some localities esteemed as highly as the carp. It is extremely prolific, loves calm, muddy waters, and principally lives on food which it roots up from the ground. Wherever it occupies a pond with carp, it will not diminish the carp-food, and may therefore safely be kept in limited number in raising-ponds of the second class and in growing-ponds (ponds for older fish). They may be allowed to spawn in separate small spawning-ponds, and their young fry may be profitably used for stocking shallow and muddy lakes, having a good deal of vegetation, in which they will grow rapidly, frequently reaching a length of 50 centimeters, and a weight of 2 to 3 kilograms. To raise tench in special raising-ponds, is hardly to be recommended.

The crucian (*Carassius vulgaris* Nils.) is, when it reaches a good size, a fine fish, which is highly esteemed by many people. It is exceedingly frugal in its tastes, will flourish in the most turbid water, and even in small puddles multiplies so rapidly, that the fish, from want of food, do not grow much longer than a finger. For utilizing muddy puddles, small ponds in court-yards, marl-pits, &c., the crucian may be highly recommended. By frequent fishing, the survivors reach a considerable size, and the little fish which are taken out can be placed in muddy lakes, and branches of rivers, where they will grow rapidly. In some places it is customary in spring to place a few small pike in the puddles swarming with crucians. By feeding on these the pike grow with extraordinary rapidity, and their flesh becomes particularly tender and of an excellent flavor. In autumn the pike should be caught, as during winter they would suffocate under the ice. By the side of them the thoroughly decimated crucians grow rapidly. Wherever there is a lively

demand for large crucians, they may be placed in growing-ponds with carp; but the young carp fry found during the fisheries can, even more than otherwise, be only used for feeding fish of prey, or for stocking rivers and lakes, as apart from their small size they are mostly worthless bastards of crucians.

The goldfish, a gold-colored variety of the crucian, can be raised in small, warm ponds, without much trouble, entirely on the same plan as carp are raised. If there is a steady demand for one summer's and two summers' fish the culture of goldfish may, under certain circumstances, prove very profitable.

The golden ide (*Idus melanotus* Heck. & Kner., var. *miniatus*) is but of little importance as a food-fish, but is highly esteemed as an ornament for garden and park ponds, as it resembles the goldfish very much in its color, and reaches a length of 40 to 50 centimeters. These fish will stay near the surface in large numbers, but are so sly and quick that it is not easy to catch them. Persons who desire to raise these fish on a large scale will have to follow the rules laid down for raising carp. This can only be recommended, however, in localities where there is a certain sale, at a good price, of large numbers of young fry.

The bleak (*Leuciscus rutilus* L.), the red bream (*Scardinius erythrophthalmus* L.), and the "*Uckelei*" (*Alburnus lucidus* Heck.) can be raised in many places to considerable advantage as food for fish of prey. All these fish are satisfied with small, shallow ponds, and increase very rapidly. As the object is only to raise an enormous number of young fry, which are caught when quite young and fed to other fish, it is not necessary to construct raising-ponds and growing-ponds; on the other hand the ponds destined for these fish must offer the most favorable conditions for depositing spawn, and for the development of the young fry. The ponds should be shallow, so that they can be quickly heated, and it is advisable to construct so-called "spawn-beds," such as are sometimes used in carp-ponds. These "spawn-beds" are raised places on the bottom of the pond, resembling garden-beds, which are laid out in rows at suitable intervals, and whose surface is planted with grass, water-cresses, and other plants which grow well in moist meadows, or are covered with sod taken from such meadows. These beds should be 10 to 20 centimeters below the surface of the water. The fish take a particular delight in spawning in these places; the eggs, adhering to the grass and the plants, develop very rapidly in the shallow water, and the young fry finds welcome hiding-places and ample food among the plants. The fish can easily protect themselves against strong heat by retiring to the deep ditches between the beds. Such ponds furnish an almost inexhaustible supply of food for trout-ponds, and the beauty of it is that the food-fish grow at the same rate as the fish to which they are fed.

The bream (*Abramis brama* L.) is one of the most valuable fish for large and deep lakes. It reaches a length of 50 to 70 centimeters, and

a weight of 10 to 15 pounds and more, and enormous quantities are caught, especially in winter, under the ice.

This fish is less adapted for raising in ponds, but it is well to let it spawn in good ponds, provided with spawning beds; and when the young fry (which have been produced in enormous numbers) are several weeks or months old, they can be transferred to lakes. The simplest plan is to construct the spawning-ponds close to the lakes and connect them by small ditches, and have grates in these to prevent fish-of-prey from entering the lakes.

VI.—THE RAISING OF LOACH AND GUDGEONS.

The loach (*Cobitis barbatula* L.) is one of our finest fish, which seldom reaches a length of more than 15 centimeters, but is highly esteemed in many places. In small ponds with sandy and gravelly bottom, or where a river or brook flows through it, these fish can easily be kept, and increase rapidly. The best way is to construct loach-ponds in brooks by gathering the water in some suitable place, and inclose a portion of the brook by fences of wicker-work. The fish thus remain in their natural surroundings, and if fed with the same food as the carp, grow very rapidly. It is quite common to place in the ponds baskets filled with sheep-dung. The best way to catch loach is to use small fish-pots of narrow wicker-work, in which husks, boiled potatoes, boiled blood, cheese, &c., are placed as bait.

In a similar way the gudgeon (*Gobio fluviatilis* Cuv.) can be kept Although very small, it forms a savory dish when baked.

As both these kinds of fish increase enormously, it will be well to construct several small ponds, so that from time to time those which are over-crowded may have some of their fish transferred to other ponds.

VII.—THE RAISING OF FISH-OF-PREY SPAWNING IN SUMMER.

The raising and keeping of fish-of-prey spawning in summer is much less common than that of the carp and other fish of the same family, for the simple reason that it is much more difficult to provide the necessary food. The only fish which can be mentioned in this connection are the pike, the perch, and the perch-pike.

The pike (*Esox lucius* L.) is a most voracious fish-of-prey; and its raising can only be profitable where there is an unlimited supply of worthless food-fish, and where pike fetch a good price in the market. In most cases it will be best to place young pike in raising-ponds and growing-ponds for carp, or in ponds for crucians, in which they grow rapidly, and also propagate, and from which they can easily be removed before they have grown too large. Water containing many frogs is particularly well suited for keeping pike, as frogs form the favorite food of this fish.

The perch (*Perca fluviatilis* L.) is an excellent food-fish, but is hardly ever raised in ponds by itself, but generally in raising-ponds and growing-ponds for carp, and in ponds for crucians, in which it grows rapidly and increases enormously. As, besides small fish, its favorite food is worms and insects (the same food which the carp likes), it should not be placed in carp-ponds in too large numbers, unless it fetches a higher price in the market than carp.

The perch-pike (*Lucioperca sandra* Cuv.) is esteemed higher and fetches a better price in most places than the perch; it feeds on the same kind of food, and is frequently kept in large and deep growing-ponds for carp. It loves deep, cool, and pure water, and a hard, sandy or gravelly bottom; and in such ponds it will increase very much, especially if suitable spawning-places are provided. For this purpose it may be recommended to put stumps of trees with branching roots near the banks, or to construct in various parts of the pond cone-shaped piles of stones and gravel, measuring about 1 meter in height. In shallow ponds with a soft bottom the perch-pike will also grow, provided there is an ample supply of food, but they will not increase. For stocking deep lakes with a hard bottom, the fry of the perch-pike is well suited.

VIII.—KEEPING EELS IN PONDS.

It is well known that eels only propagate in the sea, where the male fish stay all the time, whilst the young fry in spring or early summer, when measuring only a few centimeters in length, ascend all fresh waters in enormous numbers, work their way over weirs and rocks, in order to reach the upper course of the rivers, and the lakes situated near them, and are at that time without sexual distinction, but without exception develop into females. These, in order to propagate the species, have to return to the sea, and on these migrations, which are undertaken during the summer and autumn months, the great eel-fisheries in most of our rivers depend. Under no circumstances can an increase of eels in fresh water be counted on; but it is possible to facilitate their journey up the rivers by constructing eel-ways, and also to introduce them into waters which without human aid would always remain closed to them.

From time immemorial the ascent (*montée*) of the young eels up the rivers, which takes place in France every year in exceptionally large proportions, is used for collecting large numbers of the small fish, which are sent considerable distances, packed in moist grass, and used for stocking ponds, marl-pits, and peat-bogs. Also in Germany large quantities of young eel-fry, from France and Italy, have for a number of years been successfully planted in ponds and lakes. When these fish arrive in May, they are about 6 or 8 centimeters long and 2 or 3 millimeters thick, and about 1,000 of them make a pound; but in autumn of the same year they have generally reached a length of 20 to 25 centimeters, and the

thickness of a small finger; in the following autumn they reached a length of 50 to 60 centimeters; and their growth may therefore truly be termed very rapid. According to information furnished by the well-known French fish-culturist, Millet, 1 kilogram of young eels placed in an extensive peat-bog near the river Aisne, in 1840, had increased so rapidly that five years later 2,500 kilograms of large eels were caught. For stocking small ponds with a soft bottom, marl-pits, and peat-bogs, and also large lakes, the young fry of the eel can be highly recommended.

Nets cannot be used for catching eels, because they generally root deep in the ground; they are, therefore, only discovered after the pond has been laid dry, by drawing a rake through the mud. They are easily caught, however, with fish-pots, purse-nets, and with a hook and line.

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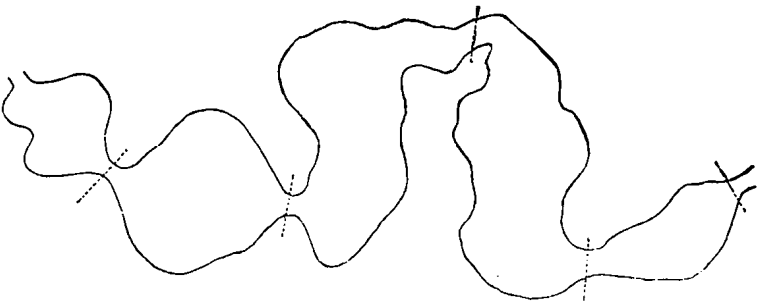


FIG. 1.—Valley, to be transformed into ponds by means of dikes.

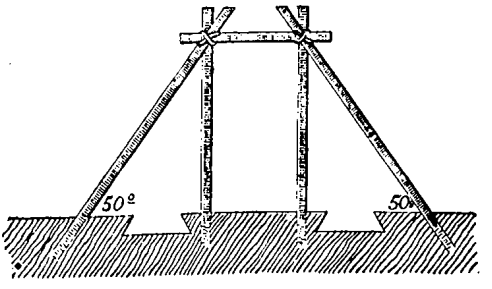


FIG. 2.—Staking out the dike.

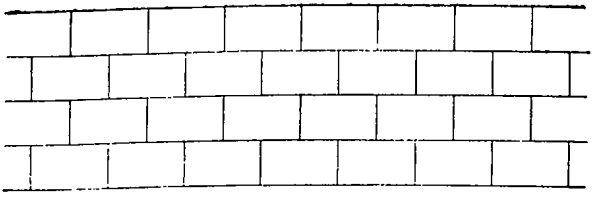


FIG. 3.—Position of the pieces of sod.

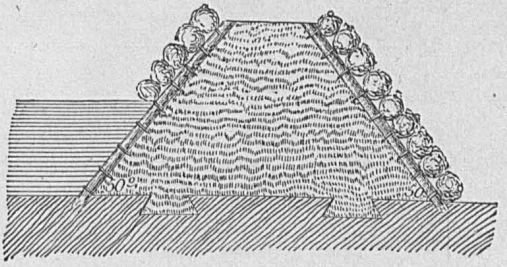


FIG. 4.—Section of dike.

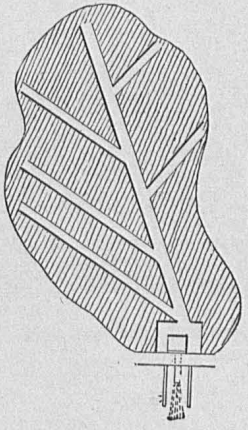


FIG. 5.—Fish-pit and ditches.

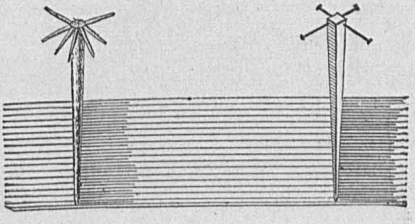


FIG. 6.—Protection posts against thieves.

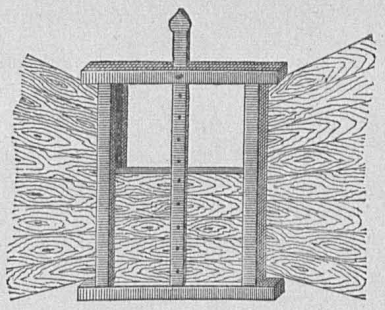


FIG. 7.—Sluice.

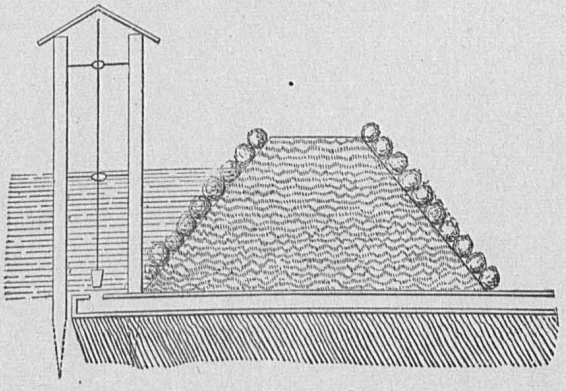


FIG. 8.—Tap-outflow.

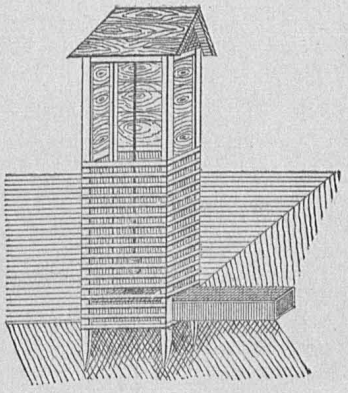


FIG. 9.—The tap-house.

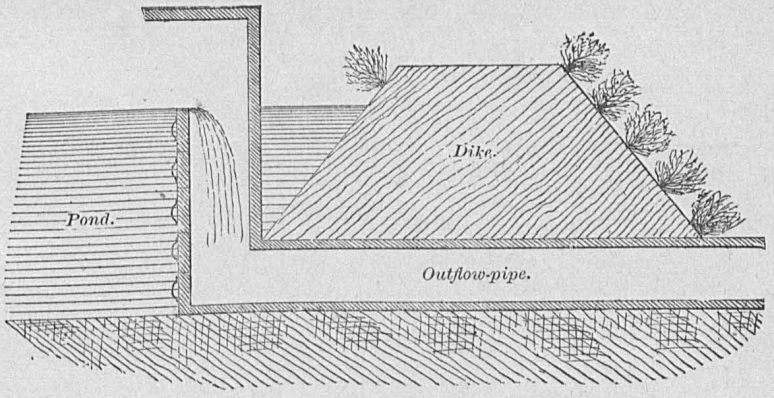


FIG. 10.—Section of a "monk."

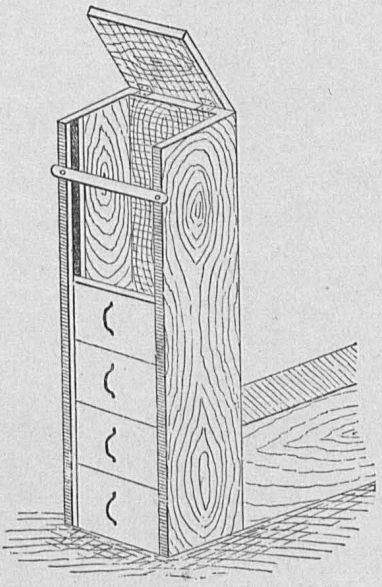
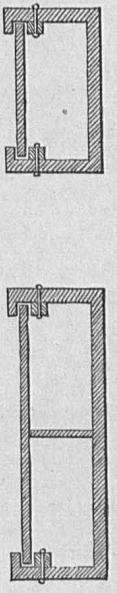
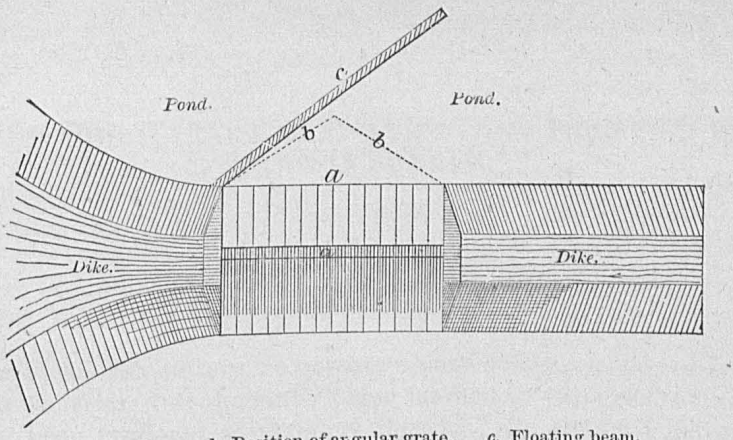


FIG. 11.—Perspective view of a "monk."



FIGS. 12 and 13.—Transverse section of the perpendicular pipe of a narrow and broad "monk."



a. Grating. *b*. Position of angular grate. *c*. Floating beam.

FIG. 14.—Dike with weir, grating and floating beam, viewed from above.

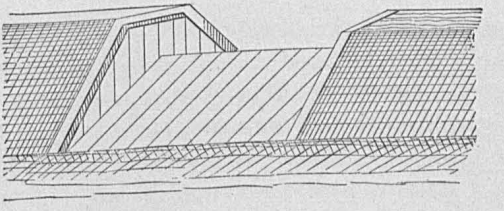


FIG. 15.—Weir.

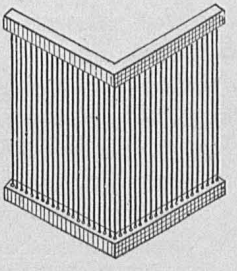


FIG. 16.—Angular grate.

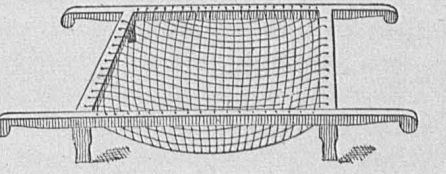


FIG. 17.—Portable net for carrying carp.