resistance galvanometer has its terminals then connected first to the extremities of the standard low resistance and second to the terminals of the copper circuit of the transformer which is under test. The ratio of these two deflections gives us at once the ratio of the resistance of the transformer circuit to that of the standard low resistance, and in this manner the copper resistance of each circuit of the transformer can be measured. This copper resistance, however, if measured at the ordinary temperature of the air, has to be corrected to determine what it is when the transformer has reached its constant temperature. When a transformer is put to work, whether on open circuit or closed secondary circuit, it soon reaches a final temperature, which ought never, under any circumstances, to be more than 100° Centigrade.

In order to determine what this temperature is, one of the easiest methods is to connect the transformer on open secondary circuit for five or six hours to the high pressure circuits, and when the transformer has reached its final and constant temperature to suddenly switch

FIG. 38.

it off, and quickly make a measurement of the copper resistance of the secondary circuit as above described. Then, when the transformer is quite cold, another measurement of the copper resistance may be taken, which will be found to be much less, since the high conductivity copper employed in transformer manufacture has a temperature coefficient of about 0.4 per cent. per degree Centigrade. It is very easy to calculate from these two measurements what is the final and constant temperature of the transformer. Having then measured the copper resistances and calculated what it will be at the final temperature of the transformer, we have next to measure the secondary drop between full and no load. For this purpose an electrostatic voltmeter is connected across the secondary circuits, and its reading taken when the primary terminal potential difference is also known. The transformer is then loaded up to its full load on its secondary side, and the primary potential difference being kept at the same amount, the secondary potential difference will be found to have fallen, and the amount of difference between its value when the transformer is fully loaded and its value when the transformer is on open circuit is called the secondary drop. It is sometimes difficult to make this measurement with great accuracy, especially when the transformers are working off commercial circuits, but it can always be done in the way shown in the diagram in Fig. 39, if we possess two identical transformers and a low reading electrostatic voltmeter. The two transformers are connected up with their primary circuits in parallel, and with their secondary circuits opposed to one another through the voltmeter. The voltmeter then reads, not secondary volts to either transformer, but the difference between the two differences.

If one transformer is loaded up to full load, the volt-

Diagram of Connections for measuring the Drop in Volts of a Transformer.

FIG. 39.

meter will read directly the secondary drop, and since both transformers are affected equally by any variation of the primary pressure, it does not affect their difference, and, therefore, there is no difficulty in getting the measurement with any required degree of accuracy. Having in this manner measured the iron core loss at no load, or on open secondary circuit, the copper resistance when the transformer is warm, and the secondary drop, we have all the information necessary to enable us to make a complete report on the transformer. It has been abundantly shown by experiments which were carried out by me in the year 1892,* that when a transformer is gradually loaded up, the iron core loss is constant at all loads, and that it is only the copper losses that vary.

Hence, if we know the iron core loss, that is to say, the loss due to eddy currents and hysteresis in the core when the transformer is on open secondary circuit, we have only to add to this loss the copper losses in the

transformer, that is, energy losses due to the resistance of the copper circuits, in order to obtain the total power absorption in the transformer at any load. Let P_1 be the total power in watts given in a transformer on the primary circuit, and let P_2 be the total power in watts given out on the secondary circuit to some external resistances, such as lamps. Let I be the total iron losses in the transformer and C the total copper losses. $P_1 = I + C + P_2$. Hence the difference between P_1 and P_2 is a quantity which can be calculated when we know I and C ; and the efficiency of the transformer is given by the ratio of P_2 to P_1 , expressed as a percentage.

The copper losses can be calculated with sufficient accuracy in the following manner: Let us suppose that the transformer under test is a 10 kilowatt transformer, that is to say, is constructed to permit 10,000 watts being taken out from the secondary circuit, and that the secondary watts are intended to be 100. Then the transformer at full load will give out a current of 100 amperes. If we imagine the full load of the transformer to be divided into 10 parts, then when the secondary circuit is delivering 10 amperes at 100 volts the transformer is on 1-10 load, when it is delivering 20 amperes at 100 volts the transformer is on 2-10 of full load, and so on. If the transformation ratio of the

FIG. 40.

transformer is known, that is the ratio between the secondary volts and the primary volts, or secondary terminal potential difference and primary terminal potential difference, when the transformer is on open secondary circuit, then the primary current can always be calculated with approximate accuracy from the secondary current by simply multiplying the secondary current by the number expressing the transformation ratio.

Hence we can calculate the primary and secondary currents corresponding to each decimal fraction of full secondary load. Knowing the resistances of the two circuits of the transformer when warm, we can, therefore, calculate the copper losses in each circuit, because if R is the resistance of a circuit, and C the R. M. S. value of the current flowing through it, then $C^2 R$ is equal to the mean power wasted in that circuit. Calculating in this way the total copper losses for the two circuits corresponding to each decimal fraction of the full secondary load, we can add these values to the constant iron core loss experimentally determined, and obtain the total power lost in the transformer, corresponding to each decimal fraction of full load. We have, therefore, the difference between P_1 and P_2 , corresponding to known values of P_2 . Hence we can calculate the ratio of P_2 to P_1 for each decimal fraction of the full secondary load, and therefore we have the efficiency of the transformer, and the total loss in the transformer given to us at each fraction of the full secondary load. This is by far the best method of determining the efficiency of very large transformers, because it does not necessitate loading up the transformer to its full load on an actual resistance; and even if this can be done,

FIG. 41.

the measurement which we actually require is the difference between two large observed quantities, and is, therefore, very liable to be affected by an error in either of them. Having obtained in this manner the total losses in the transformer for the various decimal fractions of the full secondary load, the most convenient graphic method of representing the results is by a total loss diagram.

A horizontal line is taken, and is divided into 10 equal parts representing the decimal fractions of the full secondary load. At each part a vertical line is set up, representing the total losses in the transformer, both the copper and the iron losses, and two curves are drawn, as in Fig. 40, one representing the variation of the total copper losses in the transformer with the secondary load and the other representing the constant iron loss at all loads. From this curve another curve, called the efficiency curve, can be drawn in the following manner (see Fig. 41). A horizontal line is taken, representing the secondary output, and divided into 10 equal parts representing the decimal fractions of the full secondary load. At each point a vertical

line is set up, representing the ratio between the power given out by the transformer to the power taken in by the transformer, expressed as a percentage, and the curve delineated by these points gives us the efficiency curve of the transformer. In a well designed transformer this efficiency curve is a square shouldered curve, rising very rapidly up to 90 per cent. at one-tenth of full load, and to 96 or 97 per cent. at full load. A fairly good estimate of the value of a transformer from an efficiency point of view can be obtained by taking its efficiency at one-tenth of full secondary load. Even quite small transformers are now made which have an efficiency of 80 per cent. at one-tenth of full load. Large transformers of 30 to 50 kilowatts and upward can be made to have an efficiency of 90 per cent. at one-tenth of full load. Ten years ago it was difficult to get any transformer having more than 40 to 50 per cent. of efficiency at one-tenth of full load.

It should be noted, however, that the form of this efficiency curve, as well as that of the current curve, depends upon the nature of the curve of primary E. M. F. The diagram in Fig. 30, Lecture II, shows the difference which may exist in the efficiency curves in the case of the same transformer tested in two different alternators, a Ganz and a Wechsler.

(To be continued.)

FISH NETS.

SOME ACCOUNT OF THEIR CONSTRUCTION AND THE APPLICATION OF THE VARIOUS FORMS IN AMERICAN FISHERIES.

By C. H. AUGUR.

WE know of ten distinct devices for the capture of free-swimming fish—the spear, the snare, the hook, the dip net, the seine, the pound, the cast net, the gill net, the trammel net, the beam trawl. We think that any appliance called by any other name whatever will be found to embody the basic principle of one of these ten.

When, and in what order, and by what kind of fishermen these various methods were first conceived and brought into use, we do not know. If we should trace their development from the beginning, we must draw upon our imagination, for they are old devices; so old that history affords but little information as to their first conception. We know that certain birds and animals are expert fish catchers, and we may imagine that the first fisherman imitated the salmon-catching bear, taking his piscatorial food from the water without other implements than those provided by nature in his strong arms and nimble fingers.

But it is an accepted fact that no fisherman was ever quite satisfied with his achievements, and we may assume that the primitive fish catcher soon began to look with covetous eye on the gamier fish; that he was sorely exasperated to see the finest specimens elude his grasp and swim with tantalizing dignity into the depths beyond his reach. Possibly it was one of these earliest fishermen who originally told how "the biggest fish got away," and it may have been the significant exchange of glances among the aboriginal cronies which fired him with a determination to capture that biggest fish by fair means or foul in order to maintain his reputation for veracity.

What sort of an implement would be devised under such circumstances? Probably a spear, and it is not unlikely that for a long period of time after the introduction of this device our pioneer fishermen were to be seen furtively stealing about the banks of streams and the shores of the sea and lakes, practicing the "gentle art" by jabbing these cruel instruments into the flesh of their victims, or, when not thus engaged, devising improvements in the shape, style and quality of their tackle—employing their time very much as fishermen do in the nineteenth century.

The snare has been referred to, not because it is now of any importance, but because it is a means of taking fish different from any other. It is one of the crude devices which would naturally suggest itself to a man without implements of any kind, who should see fine old fish lying between the rocks just beyond his reach. The nearest sapling would supply him with a pole, some twisted grass or bark fiber with cord to form a loop, careful adjustment of this to the tapering end of the pole, a little cautious manipulation of the tackle, the loop encircles the fish, is tightened by a sudden pull, and the victim landed flopping on the bank. We know from personal experience that nature has produced fish stupid enough to be taken in that manner.

Along with spear and the snare, some sort of a hook may have been devised, but we imagine that it was in the form of a gaff, and that the fishing industry was in a more advanced condition before the fishhook, as we now know it, came into use.

The habit of many slow-moving fishes to rest lazily on the gravelly beds of shallow rivers, and of others to congregate at the headwaters of streams in spawning season, and of still others to take temporary shelter in quiet nooks behind the rocks while ascending rapids, must have suggested the use of the dip net—first made, we may suppose, of woven grass, attached to a bent sapling, afterward of leathern thongs or some stout vegetable fiber twisted into cord of suitable size and knotted into meshes.

All these methods contemplated the capture of such fish as might be found in shallow water and in plain sight of the fisherman. Then we imagine arose the genius who first conceived the idea of luring the fish out of the safe places and inviting him to destruction by the offer of tempting food. We may suppose that bait was first used to attract the fish within the range of the spear, and that afterward, as the result of another inspiration, it was attached to a hook which the victim might take into his mouth. This was a tremendous advance in the development of fishing methods. Surely the catches increased enormously and intelligence of the new device must have spread rapidly among the tribes. We may confidently believe that at this time some of the old men, seeing the jubilant and heavily laden fishermen returning day after day from the fishing grounds, originated the remark which has been handed down through the ages and which, in its simplest form, runs about like this: "If this thing keeps on, the good fish will be caught out of the water in about three years." Yet notwithstanding the dire predictions of disaster, there was probably no appreciable diminution in the supply of fish, and the ingenuity of the fishermen continued to exercise itself in de-

* See "Experimental Researches on Alternate Current Transformers," by J. A. Fleming. "Proceedings of the Institution of Electrical Engineers," November, 1892.

vising ways and means to still further augment the catch. It occurred to some one to apply the lure, or bait, in combination with the dip net; that is, to set a baited net of similar shape in the water resting on the bottom, to be suddenly raised when a number of fish had collected above the netting and were busily dissecting the food.

The time came when the possibility of capturing by one operation a large number of those fish which periodically visit the coasts and rivers in immense schools attracted the studious attention of the ambitious fisherman. These fish would not go to the bottom to feed on bait deposited in his dip net. Then, instead of spreading the net beneath them, why not throw it over them? This clever idea resulted in the device known as the case net, which, from all the references to fishing nets in ancient writings, we believe to have been one of the earliest devices used by those to whom fishing was a means of livelihood. Yet it is not by any means one of the simplest devices, for the successful application of it requires great skill.

Another fisherman who seems to have lived before people began to record important events devised the sweep seine. This form of apparatus may have been adopted either as a means of stopping and encircling large numbers of school fish passing along the coast, or as a method of capturing such fish as might be feeding upon the grounds easily swept or dragged by a net of its character.

It was perhaps observed by some of the earlier seine fishermen that the immense schools of fish journeying along the coasts at certain times and seasons were often below the surface and invisible, and that they were intermittent, passing at unexpected hours, when the fishermen were telling yarns or were asleep in their bunks; and from this observation the idea of the appliance which is known as the pound, or weir, may have originated. There is a belief current among our fishermen that the pound is of recent origin, but it is said that the American Indian used such a device, constructed of poles and brush, before the advent of the white man, and if that is true, who can tell for how long a period this apparatus may have been employed? The belief that an aperture could be made opening into the pound which would not also be freely used by the fish as a means of exit, must have been founded upon a considerable knowledge of the nature of fish, and surely it was one of the distinctly original ideas in the history of fishing methods. It has been utilized in the construction of innumerable minor nets, among which are included a great variety of fykes and pots, although in the pot the idea of the funnel is applied in combination with the lure, and not with the leader; that is, the fish are attracted to it by the bait, not driven in by obstructions to their natural progress.

In the net we have referred to are found pretty effectual means for the capture of all fish which swim near to the land, either in the sea or in the rivers. For those which inhabit waters of great depth the gill net, quite distinct from all other nets, was devised and brought into extensive use. In this net the fish is not surrounded and dragged to shore, nor lured by the use of bait, nor drawn from his course and led into captivity; he is required merely to run his head blindly into the meshes, which are composed of the finest twine or thread it is practicable to use, in order that they may be as nearly as possible invisible.

A method differing from all others referred to is found in the use of the trammel net. Like the gill net, the trammel may be stationary or allowed to drift with the current, but, unlike the gill net, it is so constructed as to catch fish varying in size.

The shore fisheries thus being provided with most effective apparatus, and the gill net devised for the high-swimming ocean fish, there still remained for the attention of the net fishermen those fish which inhabit deep waters, but do not rise far above the bottom. The beam trawl met this particular long-felt want. It is, however, an apparatus more familiar to the fishermen of Europe than us. There the beam trawl fisheries equal in importance those of any other method, while here such experiments as have been made with them have proved unprofitable, and their use in the commercial fisheries is so limited as to hardly warrant consideration.

Now, if our attempt to account for the introduction of the various forms of fishing apparatus seems too fanciful, and does not accord with established facts, we are anxious to be enlightened by any one who knows better. The interesting fact is that all of the distinctive methods known at this time are of ancient origin; and it is a fact less scarcely noteworthy that every one of the appliances referred to, except the shore (and perhaps we should apologize for mentioning this device at all), is employed to some extent in the commercial fisheries of the United States even to this day.

The principle of the spear is applied in the whale and the swordfish fisheries. The spear in its simplest form is a common device successfully employed in fresh water lakes in winter fishing through the ice, and in taking eels from the muddy beds of the shallow creeks and harbors along the seacoast.

The dip net in its original form yields profit to the Indian fishermen on certain salmon rivers on the Pacific coast. The finest whitefish served at the hotels in Sault Ste. Marie are taken by the same primitive device by the native Indian fishermen, whose birch canoes may be seen at almost any time far out in the foaming rapids, manned by two men, one poling the canoe steadily up the stream, the other standing in the bow, dexterously scooping the fish from the quiet pools behind the boulders and rocks.

In South Carolina also this form of net is used to capture shad in very much the same way as the Pacific coast fishermen take the salmon; that is, by continually plunging the net at random into the swift-running current, from a position on the bank of the stream in such a way that one or more of the large numbers of fish passing upward to the spawning grounds may run into it.

The Columbia River salmon wheel is an application of the dip net principle, and the dip net used in combination with bait you may find in all parts of the country. Scores of them are in operation all summer long from docks about Chicago, supplying anglers with fine strings of perch for exhibition purposes at reasonable prices. The hook we all know is more extensively employed than any other device in the commercial fisheries, notably in the cod fisheries. The cast net is

found in common use along the Southern coast, more especially in Florida and the Gulf States. Seines, pounds and gill nets are three forms of apparatus of paramount importance to American fisheries.

The trammel net is used chiefly in the great rivers flowing into the Gulf of Mexico. It forms one of the most important means of capture in the market fisheries of the Mississippi. The fyke is used in the same section of the country, perhaps more extensively than in any other part, but this net is to be found on all seacoasts and in the lakes and rivers.

The beam trawl, as we have intimated, has not been employed profitably here, but its use is known, and the same principle is applied in the oyster dredge. It is not our purpose, however, to discuss the methods employed in the shellfish fisheries.

Having referred generally to the various kinds of nets used in American waters, and supposing that all here present are familiar with the principles employed in their construction, it may nevertheless be proper to describe those which are of most importance. Seining has been applied in America, as we believe it has nowhere else, to the offshore deep-sea fisheries, by means of contrivances for pursuing the net. In the mackerel, menhaden and salmon fisheries the purse seine is most extensively used.

The menhaden purse seine is from 150 to 200 fathoms in length and from 50 to 75 in depth. It is hung to double lines at the top and bottom, one right and the other left laid. The top line is fitted with corks sufficient in number to sustain the weight of the seine and float at the surface. At intervals along the bottom of the net iron or brass rings about three and a half inches in diameter and a little less than a pound in weight are attached to the hanging line. The purse line—Russia bolt rope, one and three-quarters inches in circumference—is passed through these rings. Two seine boats are used in operating the net, half of which is stowed in each boat. The boats are towed behind a fishing steamer, while cruising about in the waters where menhaden are known to be, until a school of fish is sighted at the surface, when they are manned and put off.

Having reached a proper position near the school of fish, the boats are rowed around it in a circle, starting in opposite directions, the seine being paid out as they proceed. When the fish are surrounded the crew of one boat enters the other, and all hands proceed to purse the seine—that is, to close the circle formed by the lower edge of the net by means of the purse lines and rings, as the mouth of a bag would be closed by a puckering string. The pursing is accomplished with the aid of a heavy, beet-shaped leaden weight dropped over the side of the boat, and having two blocks attached on opposite sides, through which runs the pursing line to the boat davits above. But it is quite impossible to describe this operation intelligently without the aid of a sketch or model. When the seine has been pursed it is hauled aboard the boats until the fish are gathered into the bunt, when the steamer comes alongside and the fish are taken aboard by means of a bucket and derrick rigged on deck for the purpose.

This illustrates the principle of the purse seine. The difference in methods of application in the other fisheries is chiefly confined to the boats and vessels employed. A seine fashioned on this principle is said to have been operated off the coast of Rhode Island as early as the year 1826. It was a small net, and apparently was not a marked success, as nothing more seems to have been heard of purse seines until about 1860, since which time they have been in general use.

The pound, introduced into the commercial fisheries in Connecticut about the year 1850, and soon afterward adopted by the New England fishermen, has come to be very generally employed. On the Great Lakes it is found in the form which is perhaps most effective where the use of a tunnel is practicable. The leader of the lake pound is from fifty to seventy-five rods in length, the two heart webs each nine rods in length, the pot thirty feet square, and the tunnel running from the end of the heart into the pot is of a length proportioned to the depth of water. The tunnel at the mouth is thirty feet wide, and of the same depth as the hearts, tapering to about three feet square at the small end, which extends eight or ten feet into the pot. The netting is hung in Manila rope one-half inch in diameter. All the parts are held in position by poles driven into the bottom of the lake. The nets are set in the water varying from fifteen to seventy-five feet deep, and in a few cases they have been made to set from ninety to a hundred feet deep. The upper lines of the leader and heart are even with the surface of the water. The pot extends three or four feet above the surface. In some minor particulars, such as the size of the lines, the opening in the tunnel, etc., the construction of the nets in some fisheries may differ slightly from the description we have given.

In the ocean pound, which has to contend with stronger currents and with floating seaweeds, the tunnel does not seem to be practicable. In its stead a second small heart is sometimes constructed, the converging point extending into the pot, leaving an opening from two to ten feet wide between the poles.

In the weir, extensively used along the coast of the Eastern States, we have the same principle differently applied—round pots or bowls take the place of the ordinary square pot and the net being held in position by poles, together with an elaborate system of guy ropes and anchors.

It is not practicable to give here more than these general particulars regarding the pound. The details of its construction vary in a hundred ways, according to the nature of the fishing grounds and the ideas and whims of the fishermen.

Gill nets are employed in the fisheries in great variety. In the large rivers flowing to the ocean gill nets are used for the capture of those fish which ascend to the headwaters in the spawning season. These river drift nets are employed chiefly for the capture of shad and salmon, and the methods of operation in taking the two kinds of fish are much alike. The nets fitted with corks, buoys and bottom weights are stretched across the river and allowed to drift with the current, following one another at frequent intervals. Drifting or floating gill nets have been used from the earliest times in the ocean fisheries for the capture of mackerel and herring.

Gill net fishing on the great lakes is a very different operation. Here the nets are only four feet in depth.

They are hung to light cotton lines, heavily weighted with cedar floats to keep them in an upright position, and sunk to the bottom in water of any depth varying from ten to seventy-five fathoms. In the larger fisheries they are operated from steam fishing boats, each boat having an outfit of nets which, if fastened together and all set at one time, would stretch to a continuous length of from twenty to thirty miles. Gill nets of different proportions, but operated in a similar way, are employed in the cod fisheries of the seacoast States.

The mullet and shad gill net fisheries of the Southern States have in recent years become very important, and from Florida to Maine the gill net is used to some extent for nearly all varieties of high-swimming marketable fish.

In the first half of this century the American fisheries, so far as they were carried on by the use of nets, were limited in extent. Gill nets and sweep seines were the principal means of capture employed, and were operated along the Atlantic coast extensively enough to supply the local markets with fishery products, but, except in the New England States, they were not of great importance. During the latter half of the century the development of net fisheries, encouraged by the growth and spread of population, with the consequent extension of markets and by the perfection of transportation facilities, has been marvelously rapid. Gill nets stretch their interminable lengths throughout all the waters inhabited by edible fish—in the oceans east and west, in the rivers flowing into them, and in the great fresh water lakes. Sweep seines, although for the most part abandoned in the great New England fisheries, find profitable employment in other localities, where they are better adapted to the fishing grounds. They are found in large numbers of great size on the Pacific coast. They form practically the only means of capture in the important net fisheries of the Gulf of Mexico. The capacity of the modern sweep seine is greater than the earlier fishermen would have believed possible. In the bays of North Carolina the seine sweeps several miles of fishing ground at one operation, being paid out of the deck of the steamboat and hauled by steam power stationed on the land. The purse seine steamers cruise about in the inexhaustible field afforded by the deep waters of the ocean. Wherever you may view a great expanse of water the black poles of the pounds, traps and weirs attest the universal presence of these appliances. In its special field of operations the trammel net is numerously employed. Fykes, pots, small seines and traps of multifarious form abound everywhere.

If it is true that during this period of remarkable expansion of the commercial fisheries no entirely new principle has been introduced in methods of capture, it is also true that the elaboration and application of old methods have been sufficiently progressive, and the observation of these changes is within the special province of the net and twine manufacturer, who views the whole field of operations and who is compelled to adapt his business to every new condition. Fishermen now living recall the time when half a dozen sizes of hemp twine of a rather ordinary quality sufficed for the requirements of all the American fisheries. In the year 1893 there were between eighty and ninety different kinds and sizes of twine in constant use as material for netting, and the variety is increased to more than a hundred kinds and sizes if we include such as are used for gill net hanging lines.

Previous to 1840 it had not occurred to any one apparently to supply the fishermen with ready made nets. In the twelve months of the present year the netting manufacturer, whose business extends through all the fishing districts, will have been called upon to supply more than three hundred distinct varieties of netting; that is, as many kinds as can be made up by the use of every conceivable size of mesh, duplicated in from two to thirty different sizes of twine. More than thirty sizes of mesh and forty kinds of twine are required for the gill net fisheries alone, the meshes varying from one and three-quarters inches (extended measurement) to thirteen inches, and the twines from the size of a single horsehair to thirty-six thread cotton, which is nearly one-eighth inch in diameter. Of the great variety in sizes and twines referred to, all but a few are made of cotton, no hemp twine being used in our fisheries, and linen only where the yarn must be spun to extreme fineness, as in the gill net fisheries of the Great Lakes.

The substitution of cotton for hemp twines in the American fisheries was a matter of considerable importance, for its results were far reaching, affecting the great fisheries of European countries hardly less than those of our own. The incident which led to this important step is here related:

Some time in the year 1844 a fisherman, known to history as Mr. McCarthy, while away an hour in a small store in Boston, where he bought his fishery supplies, expressed an opinion that somebody in this country might turn an honest penny by getting up a twine especially designed for nets and better adapted to the purpose than the imported hemp twine then used. This proposition was discussed in the presence of Mr. James S. Shepard, who was then engaged in the manufacture of cotton yarns at Canton, Mass., and he very soon afterward submitted to Mr. McCarthy, the fisherman, a cotton twine, which the latter made into gill nets and submitted in turn to the herring family of fishes for a final verdict. It was pronounced a satisfactory twine by Mr. McCarthy and was at once adopted by the fishermen, but candor compels us to say that the fishermen of the present day would not accept it as a gift. The best that can be said of it is that it was an improvement upon the hemp twine.

Soon afterward the popularity of cotton twines for both gill net and seine fishing induced Mr. Shepard to devote his whole time to their manufacture and improvement. The product of his factory was taken by the proprietors of the store we have alluded to, who for some years had been supplying fishermen in a small way with nets made by hand knitters in and around Boston. This concern was the nucleus of the present American Net and Twine Company, and included Mr. Shepard in its membership a few years after the events narrated.

Aside from the introduction of the new twines, methods of manufacture did not undergo any considerable change for some years; seines and gill nets continued to be the chief form of apparatus, and the netting was made by hand, women and girls being em-

ployed to do the work. The variety and sizes of the twine and mesh were very small. The fishing industry was attaining considerable proportions, however, and the use of cotton twines stimulated a demand for them which induced other yarn manufacturers to engage in their production.

In the year 1858 the net and twine company referred to imported the first netting machine used in the country. It was a hand power Scotch machine, the only kind then in existence. The Scotch machine was not, and we believe it never has been, adapted to the manufacture of heavy netting, so that after its importation all netting, except that composed of fine twines, continued to be made by hand. For light netting, however, the company built in their own factory several machines of the Scotch pattern.

The limitations of this netting machine led the Net and Twine Company to expend a considerable sum of their money in attempting to develop two or three inventions designed to overcome the difficulty of knitting heavy twines, but none of them proved satisfactory. In 1862 a newly invented machine, quite different in principle and well adapted to heavy work, was put in operation. Some years afterward an ingenious native of the State of Connecticut, Mr. Squire, invented a machine for knitting fine threads which possesses many advantages over the Scotch machine.

The larger netting companies are using the Scotch machine, which has been improved somewhat in construction, and the one hundred and sixty-two power machine, and the company we have spoken of use also the machine of American invention in the manufacture of fine thread netting. They have purchased the rights of the inventor.

The extensive introduction of these different machines was, of course, a process of gradual accomplishment, and while it was taking place the fisheries were undergoing that wonderful expansion which we have little more than indicated in this paper. Without the machines it would not be possible to produce the great variety of twine and netting used, and it is true, no doubt, that the ability of the netting factories to supply everything imaginable has induced the fishermen to adopt a great many sizes of mesh and twine which would not otherwise be considered necessary. — The Fishing Gazette.

GOLD EXTRACTION PROCESSES.

By T. K. ROSE, in Science Progress.

FROM very early times the ancients were attracted by the beautiful color, the brilliant luster and the indestructibility of gold, and spared no pains in the endeavor to acquire it. In the code of Menes, who reigned in Egypt some 2,000 years before the time of Moses, the ratio of value between gold and silver is mentioned, one part of gold being declared equal in value to two and a half parts of silver, and it is, therefore, clear that the extraction of both metals from the deposits containing them must have been carried on before that time. It is indeed probable that gold was the first metal observed and collected, since it occurs in fragments of all sizes in loose sand, and the operations of collecting the larger pieces and melting them together are so simple. Among the rock carvings of Upper Egypt there are several illustrative of the art of washing auriferous sands by stirring and working them up by the hand in hollowed-out stone basins, and subsequently melting the gold in simple furnaces with the aid of mouth blowpipes. The earliest of these carvings is supposed to date back to about 2,500 B. C. However, in ancient times, gold appears to have been mainly derived from India, and that country continued to supply most of the gold used in Europe until the discovery of America by Columbus.

In order to collect alluvial gold, the sands were washed down over smooth sloping rocks by means of running water, and the particles of gold, sinking to the bottom of the stream by reason of their high density, were entangled and caught by the hair on raw hides spread on the rocks. Among the hides used were sheepskins, and hence originated the form of the legend of the Golden Fleece. Stripped of its heroic dress this legend of course described a piratical expedition to win gold which was being obtained from streams with the help of sheepskins by the inhabitants of what is now Armenia. Similar expeditions have not been unknown in much later times, and the method of obtaining gold by washing river sands is still practiced with improvements in matters of detail in many parts of the world. Hides are even now occasionally employed to catch the gold, but sheep's wool when used is generally in the form of blankets.

The use of mercury as an aid in the collection of gold contained in river sands or in crushed rock is also of great antiquity. The earliest mention of quicksilver itself appears to occur in the works of Theophrastus, about B. C. 300; but Diodorus of Sicily, who saw gold being extracted from quartz in Upper Egypt in the time of Julius Caesar, does not refer to its use.* Only a few years later, however, Vitruvius,† about B. C. 13, described the manner in which, by the help of quicksilver, gold was recovered from cloth in which it had been interwoven, and in Pliny's time the separation of gold from its impurities generally by the same means was well known.‡ It is probable that this knowledge was never afterward entirely lost, although the references to it in the middle ages are very scanty. For example, Geber§ in the eighth century was aware that mercury would dissolve considerable quantities of gold and silver, but not earthy materials, and Theophilus the monk,|| in the eleventh century, carefully described the method of washing the sands of the Rhine on wooden tables, the final operation consisting in treating the concentrates with quicksilver for the removal of the gold. Biringuccio¶ was taught the secret of this use of mercury in Italy some time before 1540 in return for the present of a valuable diamond ring, and it is clear that the so-called invention of the amalga-

mation process in Mexico by the Spaniards in 1557 was only the introduction or adaptation of a process already well known in Europe.

The existing methods of washing auriferous sands all depend on two principles—the great density of gold when compared with that of the siliceous material with which it is associated and, as Baron Born expressed it over 100 years ago, the “elective affinity” of mercury for gold when mixed with impurities. The ease with which gold amalgam can be collected in spite of its being less dense than gold is of course due to the fact that it is miscible in all proportions with mercury, so that under proper conditions large globules of liquid alloy are formed by the running together of smaller particles, and the former are readily caught in suitable crevices.

A large number of implements of varied form and efficiency are used in different parts of the world to apply these principles. In operations on a small scale the batea, the trough and the miner's pan are chiefly used. In South America, in West Africa, and in parts of China, the batea is used, a wooden vessel having the shape of a very short reversed cone. When held in the hands and filled with gravel and water, a peculiar gyratory motion imparted to it results in the collection of the gold in the apex of the cone, and the light material can then be readily washed away.

A small wooden trough, twelve or fifteen inches long, is used for the same purpose in the far East by the Chinese, the Tonquins, the Annamites, the Malays and others, the water being made to flow up and down until the gold has settled to the bottom. The miner's pan, a flat-bottomed iron vessel with sloping sides, was first used by the California pioneers, but has now become the favorite implement of Europeans for prospecting in all parts of the world. In early days in Australia and California millions of ounces of gold were obtained from the river gravels by its use, but apart from its value in prospecting, it is at most a rough and ready means of treating small quantities of rich material, and is only suitable to individual effort.

In combined efforts to treat larger quantities of sand, the machines all consist essentially of a slightly inclined trough, through which a stream of water is made to convey the auriferous sand, mercury being usually sprinkled on at short intervals of time. If the trough is long enough, and the stream of water not too rapid, the gold and mercury sink, and, uniting, are swept along together, until arrested by some inequality of the bottom.

Crevices and “riffles” or obstructions of various kinds are arranged to catch the amalgam. The simplest contrivances are transverse slats of wood nailed to the bottom of the trough or sluice. In Siberia square “pigeonhole” depressions have been continuously used for more than fifty years. In California, the sluice is paved with square blocks of wood placed an inch or more apart, or with large rounded stones, or ordinary iron rails between which are plenty of crevices where the amalgam can lodge. To catch light spangles of gold, blankets are spread, the loose fibers of which become charged with pyrites and gold, and in New Zealand plush is a favorite gold catcher.

When a “clean up” is desired, a stream of clear water is run through the sluice, the riffles are taken up, the mercury and amalgam washed down and allowed to accumulate at some convenient spot, and then ladled out and squeezed in bags of canvas or leather as in the days of Pliny, who describes the process as follows: “Ut et ipsum [i. e., argentum vivum] ab auro discedat in pellis subactas effunditur, per quas sudoris vice defluens purum relinquit aurum.” The excess of mercury being thus filtered off, the pasty amalgam, containing about one-third of gold, is retorted.

The methods of conveying the auriferous material to the sluices vary with the scale of the operations and the other conditions. When rocking cradles or the smaller sluices are used, the gravel is shoveled into them. In Siberia, where the valleys are shallow and the inclination of the ground small, the gravel is carried in carts up an inclined plane to an elevated wooden platform whence the sluice starts. In California, where the gulches are deep, the fall of the ground rapid, and the auriferous deposits of great thickness, the banks of gravel are attacked by jets of water of tremendous power, and the earth washed down and carried through the sluices without being touched by hand, the so-called “hydraulic method.” When the gravel beds are below the general level of the country they are raised by the “hydraulic elevator,” a jet of water, under a head of as much as 400 or 500 feet, carrying water, sand, and boulders alike up a pipe inclined at some 60 degrees to the horizon, so as to deliver them all at the head of the sluice, the vertical lift being sometimes over 40 feet.

One of the main difficulties in the hydraulic process is in the disposal of the tailings, which are usually discharged into a river or into the sea. The enormous amount of loose sand and gravel delivered from the hydraulic mines into the Yuba and Feather rivers, California, prior to 1880, filled up their beds to such an extent that in rainy weather disastrous floods ensued, and much valuable agricultural land was buried beneath sterile drift deposits and rendered worthless. The farmers thereupon took action against the mining companies and obtained a perpetual injunction forbidding the discharge of tailings into these rivers. The result has been to stop the use of the hydraulic method in these important districts, and an apparently irreparable blow was inflicted on gold-winning industry in California.

In every country as soon as the richest of the placer beds have been worked out, efforts are made to extract the gold from quartz veins. The quartz must of course be crushed, and the crushed material has in the past been generally treated similarly to the auriferous sands occurring naturally. Thus, according to the account given by Diodorus Siculus, already referred to, the quartz was reduced to coarse powder by pounding it in stone mortars, then finely ground in handmills resembling the flour mills of the present day, and finally washed down over inclined planks with water, when the lighter material was carried away and the heavy gold retained on the wood. Hollowed out stone mortars suitable for the first of these operations have been found in many parts of the world, including Wales, Central America, the Pyrenees, and Transylvania. The stamp mill has no doubt been evolved from the pestle and mortar, but was not used for crushing ores

until about the year 1519, when the process of wet stamping and sifting was introduced by Paul Grommestetter, in Joachimsthal, the two operations, however, being at first kept distinct.

Agricola has given an exact description of the treatment of auriferous quartz in Germany in 1556,* from which it appears that the methods in use at that time were strikingly similar to those still employed in Transylvania and the Tyrol, which were among the districts of which he wrote. Doubtless in these districts the methods have been handed down from generation to generation with little change, while in other countries where they were introduced hundreds of years later the changes have been rapid and striking. In those points in which the older Tyrolean practice differed from the modern one it resembled the procedure of the old Egyptians. The wooden stamps, shod with hard stone or iron, were arranged in sets of three, and raised by cams to fall by gravity when released. The rock was shoveled dry into the mortar, and coarsely crushed by the blows of the stamps.

Next it was ground as fine as flour in a stone mill supplied with water, and carried by the stream of water into the uppermost of three wooden tubs, whence it overflowed in succession into the other two. Revolving mechanical stirrers furnished with six paddles kept in agitation the contents of the tubs, and “separate even very minute flakes of gold from the crushed ore. These flakes, settling to the bottom, are drawn to itself and cleansed by the quicksilver (lying in the tubs), but the water carries off the dross.”† Agricola here expounds the theory of amalgamation still adhered to in Austria, where mercury is regarded merely as a useful means of collecting particles of gold which have already been separated from the crushed ore by their great density. The Tyrolean bowls still in use at Vorospatack in Hungary and in a few retired valleys in the Eastern Alps do not differ essentially from the tubs drawn and described by Agricola; and, although wet crushing by the stamps has been introduced, the mortar is not usually furnished with screens.

Elsewhere, the changes in stamp battery amalgamation since Agricola wrote his treatise have been many and great. One of the first was the addition of screens in the side of the mortar, so that the two operations of crushing and sifting were united. In 1767 M. Jars saw these in use in the Hartz,‡ though even then only a single screen of brass wire twelve inches square delivered the product of three stamps, and in several other districts of Germany screens had not been adopted. The most important improvement however has undoubtedly been the introduction of the amalgamated copper plate for catching gold, the complement of the practice of charging mercury with the ore into the battery and so combining the operations of crushing and amalgamation. No mention of either this practice or the use of copper plates appears to have been made before stamp batteries began to work in California in 1850, although they had very likely been used in Georgia for some time previously.

The use of the copper plate was probably suggested by the experience in Mexico and South America of the working of the Cazo process, in which it is well known that amalgam tended to adhere to the copper sides of the vessel unless the proportion of mercury to gold and silver present was less than four to one. Thus Baron Born wrote in 1786:§ “In new kettles . . . the inside becomes wholly and so perfectly silvered that it never can be cleaned. . . . The silvery coat is daily increased by slow and gradual apposition, and the crusts of amalgama, accumulating on the bottom and sides of the vessels, become gradually so thick that on emptying them they often fall off by their own weight as silver plates, which, when dry, show the laminated texture of their daily augmentation.”

The knowledge of this behavior of amalgam in the Cazo process must have been common to many who were engaged in exploiting the quartz veins of the West soon after their discovery, and the speedy application of this knowledge is exactly what might be expected from those sturdy pioneers. Nevertheless, the exact date and locality of the introduction of the copper plate remains a matter for conjecture.

The copper plates fixed on the battery in the early fifties were about four inches wide and as long as the mortar, and were placed one on the “feed” side and one on the discharge side just underneath the screens. It was soon found that the plates worked better from the start if mercury was rubbed on them before they were placed in position, and this has now been invariably done for many years. Crushed ore, stones, water, and amalgam are flung violently against the plates and the amalgam is retained in great part.

The scouring action of the pulp on the plates is, however, always great, and becomes more violent in proportion as the stamps are larger. These are now as much as 1,100 and even 1,250 lb. in weight in the Transvaal—an enormous mass when compared with the 750 lb. stamp of a few years ago and the 120 lb. stamp of the last century. With this increase in weight, it has become desirable to modify the use of the copper plate. The plate on the feed side, long ago condemned by many, is accordingly being discarded more and more, and that below the screens is curved away in such a manner that it cannot be struck directly by the splash from the stamp, while slots in cast steel plates lining the mortar have been devised for the purpose of catching amalgam.

After leaving the mortar the pulp was treated forty years ago mainly by passing it over inclined tables covered with blankets, much in the same way as Jason may have seen the golden sands worked in Asia Minor. The sands accumulating on the blankets were washed off at intervals and ground in mills with mercury. In addition, the ore was frequently passed over or through baths of mercury (as is still done in many Australian mills) and concentrated in various ways. Amalgamated copper plates over which the pulp flowed were tried, but in Western America were at first almost everywhere rejected,|| probably owing to the great depth of the stream of ore and water made to flow over them. When this mistake began to be rectified, some twenty-

* Agricola. De Re Metallica, p. 233. Basel, 1556.

† Agricola, loc. cit.

‡ Voyages Metallurgiques, vol. ii, p. 309. Paris, 1780.

§ Baron Ingo Born's New Process of Amalgamation, p. 122, translated by Raspe. London, 1791.

|| See Nevada and California Processes of Silver and Gold Extraction, p. 61, by G. Kustel. San Francisco, 1863.

* Diodor., iii, 13. A full translation is given by B. H. Brough in his Cantor Lectures on Mine Surveying. Jour. Soc. Arts, 1892.

† Vit., lib. vii, cap. 8.

‡ Nat. Hist., lib. xxx, cap. vi, sect. 32. Quoted in full in Percy's Metallurgy of Silver and Gold, p. 559.

§ Salmon's Geber, cap. 47.

|| Theophilus, lib. iii, cap. 49.

¶ De la Pirotechnia. Venetia, 1540. Lib. ix, cap. xi, fol. 142.