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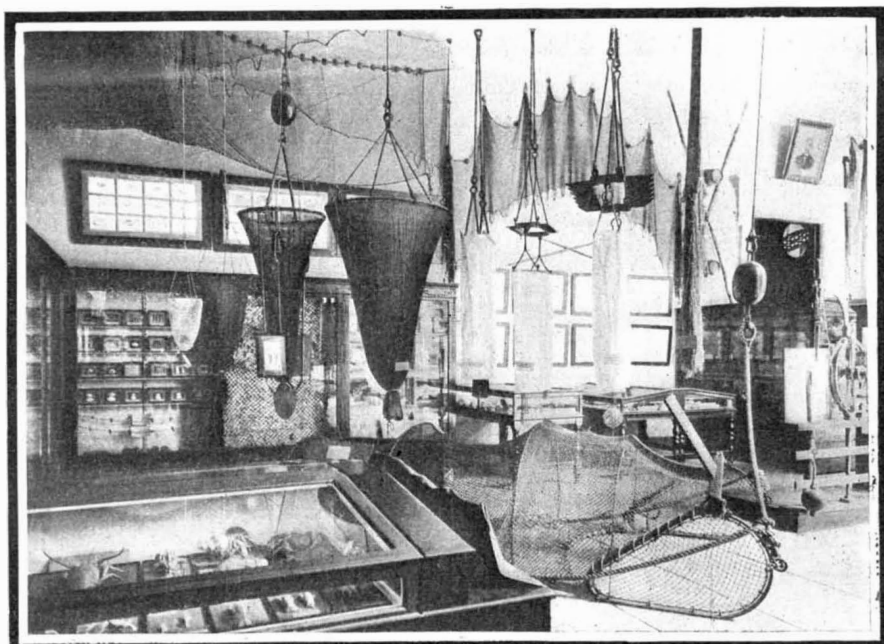
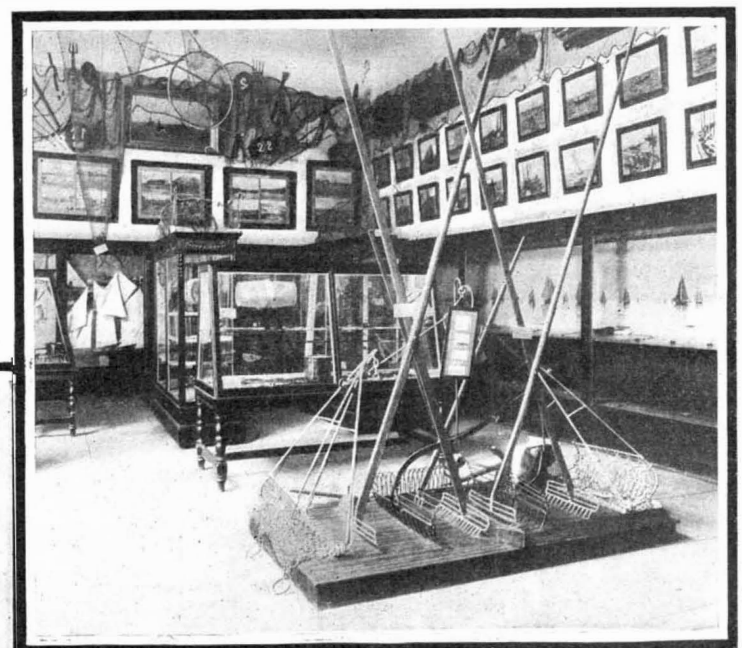
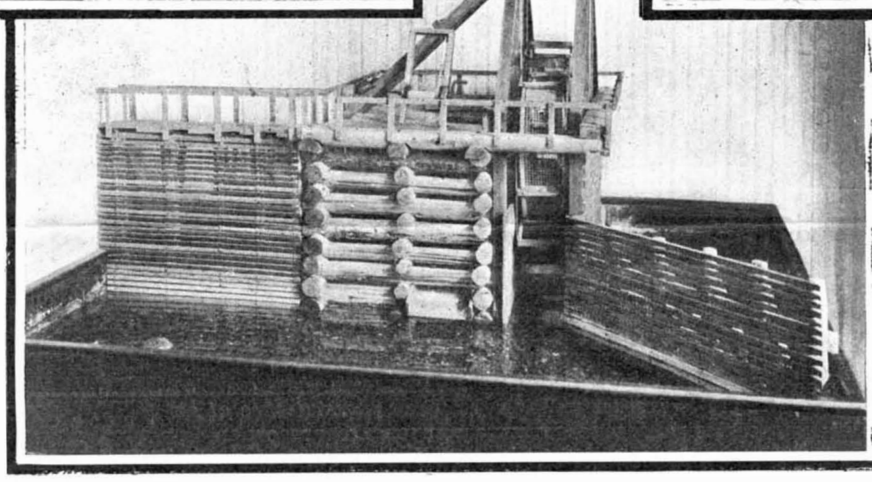


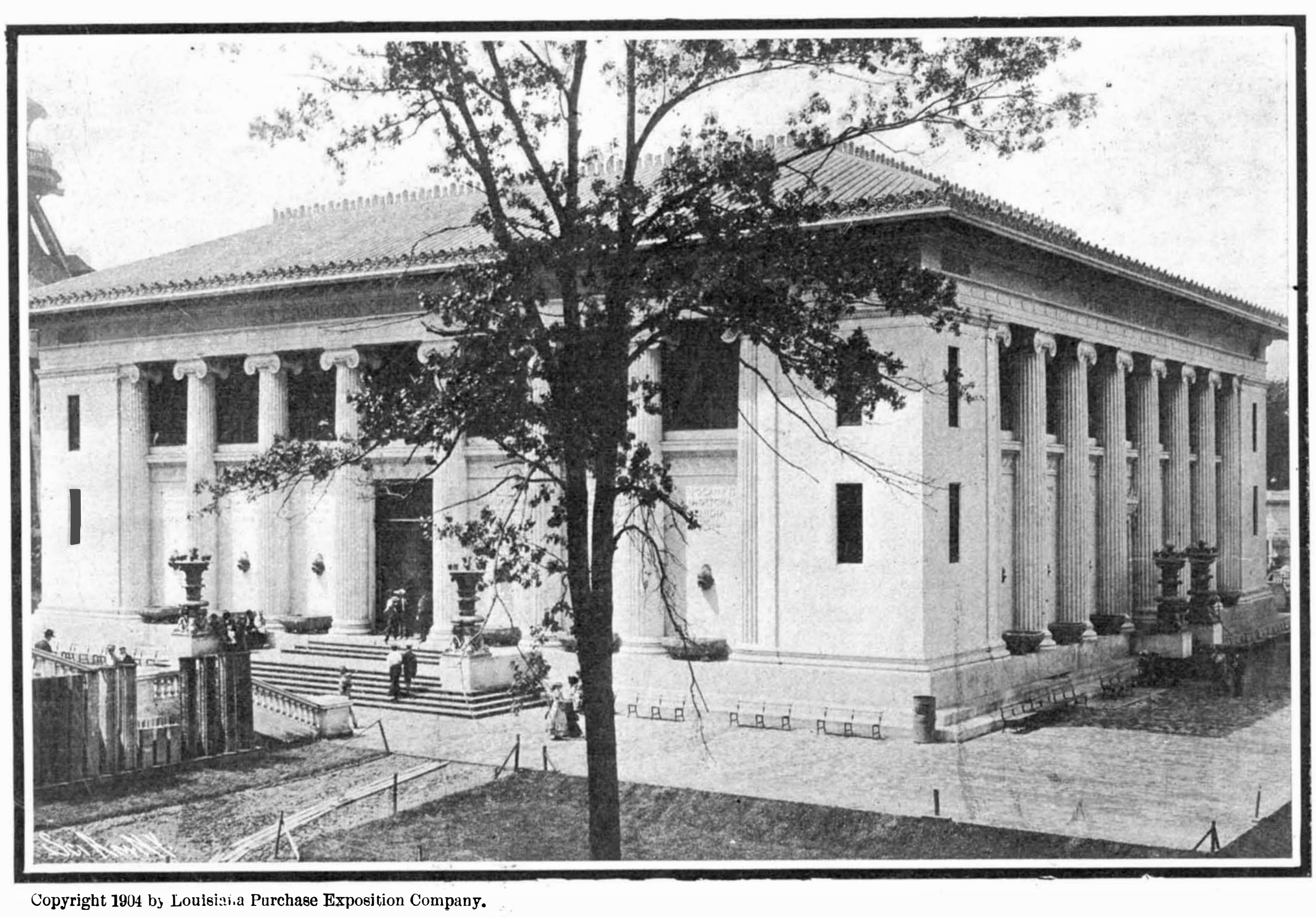
BEAM TRAWL FOR SECURING DEEP SEA SPECIMENS.



GROUP OF OYSTER TONGS AS USED ON THE ATLANTIC COAST.



MODEL OF A COLUMBIA RIVER SALMON WHEEL.



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FISHERIES BUILDING OF THE UNITED STATES GOVERNMENT AT THE ST. LOUIS FAIR.

THE UNITED STATES COMMISSION OF FISH AND FISHERIES BUILDING.

By Our St. Louis Correspondent.

The Fisheries Building is square in plan, measuring 136 feet by 136 feet, with an open court 74 feet square in the center. This court, in which is displayed the Case exhibit of the Fish Commission, is treated like a Pompeiian atrium. The large pool, 24 feet square, surrounded with twelve Doric columns 3 feet 10 inches in diameter, which support the roof, is situated in the center of the court. The roof is open above the pool, corresponding to the compluvium of a Roman house, while the pool beneath corresponds to the impluvium. The exterior of the building is classic like the main Government Building; but the traditions of Greece and Athens, rather than those of Rome, have been followed. The façades are ornamented by Ionic columns 4 feet in diameter and 36 feet high. These are engaged for three-quarters of their height, the upper quarter being free standing and supporting an open loggia. Between each pair of columns is a fountain playing into a large basin supported on the back of a turtle. Over the fountains and between the columns are placed the Latin names of the families and groups of fishes. Immediately behind these panels and somewhat lower are located the tanks containing the living fish. These aquariums are seen from the interior. The light coming from skylights placed in the floor of the loggia above referred to, and passing through the glass-front tanks into the grotto, gives a fine opportunity of viewing the fish in their native element.

The fisheries of the United States represent an investment of $76,000,000, which affords an income of more than $50,000,000 to the 200,000 persons employed therein. The present Bureau of Fisheries dates its existence from 1871, when it was established by Congress for the purpose of inquiring into the decline of the commercial fisheries, and finding if possible a means to remedy the evil. Up to the present time the Commission has hatched and distributed more than twelve billions of fish and eggs, three-fourths of this number being the output of the last ten years. The Pacific Coast salmon, which support the most extensive fishing industry of the world, have been rescued from danger of complete extermination. The shad, the most important fish of the Atlantic seaboard, owes its present abundance almost entirely to artificial measures, and it has been introduced on the Pacific Coast, where from California to Alaska it is now taken in large quantities. The striped bass, an eastern fish, has been transplanted with even greater success, the catch of shad on the Pacific Coast being more than 1,250,000 pounds, and of striped bass over 1,500,000 pounds. Lastly, the Great Lakes fisheries, affording an income of $2,600,000 annually, are maintain-

ed in their present flourishing condition only by artificial propagation.

The Fish Commission, in addition to the aquarium, shows the processes of hatching fish eggs by means of numerous forms of hatching appliances and accessories. On exhibition outside of the building also is a fully equipped Fish Commission car, which is open to visitors. Inside the building is shown a working model of the Columbia River salmon wheel, which consists of a succession of dip nets fastened to the periphery of a wheel, which is provided with paddles to revolve it automatically. The nets catch the salmon as they are running upstream to their spawning beds, each net, as it describes the upper half of its circular course, depositing its load in a compartment beside the wheel.

Models of the "Albatross" and "Fish Hawk," the largest vessels in the service of the Fish Commission, are located in the central aisles of the building. The Tanner sounding machine is exhibited, this instrument being used for physical research in depths not exceeding 500 fathoms. The most efficient contrivance for obtaining specimens from the bottom of the sea is the beam trawl, a large net attached to a wire frame or "shoes," which is lowered into the water and dragged upon the ocean floor. One of these trawls has been used by the "Albatross" at a depth of 4¾ miles. In addition to the beam trawl, and suspended from the ceiling above, are shown types of apparatus for collecting material from the surface, from the bottom, or from intermediate depths of the ocean. Limitations of space forbid any detailed reference to the work of the Commission in connection with the lobster, the sponge, and the oyster industries. The sponge experiments, which are still in progress, have been conducted with a view to establishing a commercially feasible method of rearing sponges.

The oyster is by far the most important single product of the United States fisheries, and oyster culture has become a necessity in order to keep up the supply. The natural beds on the North Atlantic Coast have long since given place to cultivated grounds, and the former seemingly inexhaustible fisheries of the Chesapeake and South Atlantic and Gulf coasts have declined until the valuable shellfish will soon be entirely dependent upon artificial methods. The exhibit illustrates the anatomy, growth, local and accidental variations, and other features of the life history of the oyster. Practically all of the economic marine animals are represented in this exhibit, which is one of the most complete and richly instructive in the whole exposition grounds.

PRACTICAL PRODUCTION OF BRONZE LEATHER.

All sorts of skins—sheepskins, goatskins, the skins of colts, and light calfskins—are adapted for the preparation of bronze leather. The Gerber-Kurier says that in this preparation the advantage lies not only in the use of the faultless skins, but that scarified skins and those of inferior quality may also be employed.

The dressing of the already tanned skin must be carried out with the greatest care, to prevent the appearance of spots and other faults. After the tanning the pelts are well washed, scraped, and dried, after that they are blanched. For coloring it is customary to employ methyl violet which has previously been dissolved in hot water, taking 100 grammes of the aniline color to 8 liters of water. If in the leather-dressing establishment a line of steam piping be convenient, it is advisable to boil up all the coloring dyes, rather than to simply dissolve them; for in this wise complete solution is effected, and greater or less particles of undissolved crystals, which often prove troublesome, are avoided. Where steam is used no special appliance is required for boiling up the dyes, for this may take place without inconvenience in the separate dye-vats. A length of steam hose and a brass nozzle with a valve is all that is needed. It may be as well to add here that the violet color for dyeing may be made cheaper than as above described. To 30 liters of pretty strong logwood decoction add 50 grammes of alum and 100 grammes of methyl violet. This compound is almost as strong as the pure violet solution, and instead of 8 liters we now have 30 liters of color.

The color is now applied and well worked in with a stiff brush, and the skins allowed to stand for a short time, sufficient to allow the dye to penetrate the pores, when it is fulled. As for the shade of the bronze, it may be made reddish, bluish, or brownish, according to taste.

For a reddish or brownish ground the skins are simply fulled in warm water, planished, fulled again, and then dyed. According to the color desired, the skins are treated with cotton-blue and methyl violet R, whereupon the application of the bronze follows.

The bronze is not dissolved in water but in alcohol, and it is usual to take 200 grammes of bronze to 1 liter of alcohol. By means of this mixture the peculiar component parts of the bronze are dissolved. For a fundamental or thorough solution a fortnight is required. All bronze mixtures are to be well shaken or agitated before using. Skins may be bronzed, however, without the use of the bronze colors, for it is well known that all the aniline dyes present a bronze appearance when highly concentrated, and this is particularly the case with the violet and red dyes. If, therefore, the violet be applied in very strong solutions, the effect will be much the same as when the regular bronze color is employed.

Bronze color on a brown ground is the most beautiful of all, and is used to the greatest advantage when it is desirable to cover up defects. Instead of warm clear water then in such a case, use a decoction of logwood to which a small quantity of alum has been added, and thus, during the fulling, impart to the skins a proper basic tint, which may, by the application of a little violet or bronze color, be converted into a most brilliant bronze. By no means is it to be forgotten that too much coloring matter will never produce the desired results, for here, as with the other colors, too much will bring out a greenish tint, nor will the gloss turn out so beautiful and clear. Next rinse the skins well in clean water, and air them in the wind, after which they may be dried with artificial heat. Ordinary as well as damaged skins that are not suitable for chevreaux (kid) and which it is desirable to provide with a very high polish, in order the more readily to conceal the defects in the grain, and other imperfections, are, after the drying, coated with a mixture, compounded according to the following simple formula: Stir well ½ liter of oxblood and ½ liter of unboiled milk in 10 liters of water, and with a soft sponge apply this to the surface of the skin. The blood has no damaging effect upon the color. Skins thus moistened must not be laid one upon another, but must be placed separately in a thoroughly well-warmed chamber to dry. From the drying chamber they are glossed, and may then be pressed into shagreen or pebbled. The thin light goatskins are worked into kid or chevreaux. Properly speaking, these are only imitation chevreaux (kid), for although they are truly goatskins, under the term chevreaux one understands only such skins as have been cured in alum and nourished with albumen and flour.

After drying, these skins are drawn over the perching stick with the round knife, then glossed, stretched, glossed again, and finally vigorously brushed upon the flesh side with a stiff brush. The brushing should be done preferably by hand, for the brushing machines commonly pull the skins out of all shape. After all, the brushing is only intended to give the flesh side more of a flaky appearance.

During the second glossing care must be had that the pressure is light, for the object is merely to bring the skin back into its proper shape, lost in the stretching; the glossing proper should have been accomplished during the first operation.

THE ACTION OF EXPLOSIVES.

It may be worth while to consider shortly the actual process by which an ordinary shot for the purpose of fracturing and displacing any rock or other material "in place" fulfills its function.

It will be remembered that in the discharge of an ordinary explosive two distinct results accompany its decomposition, and contribute to the amount of energy exerted by it, viz., (1) the formation of a volume of gas occupying some hundreds of times more space than the solid charge, and (2) the simultaneous development of a high temperature by which its expansive force is further multiplied. The dynamic value of an explosive depends, therefore, upon the proportion between the bulk of the original charge and the space which would be occupied by the resulting gases at normal outside pressures, and at the temperature of their combustion, that is to say, the space they would occupy were there no resistance beyond that of the general surrounding medium, whether atmosphere or otherwise. Hence the rock-breaking capacity of the same charge would be considerably modified according to whether it were employed in a vacuum—say outside the earth's atmosphere—or at the bottom of an ocean two miles deep. Similarly it would vary if the temperature of the surrounding medium were that of the sun's atmosphere or the absolute zero of space. Of course none of these extremes occurs in ordinary practice; but the variation within smaller limits is not to be disregarded. The useful energy of a charge exploded at the top of a mountain 15,000 feet high would be appreciably greater than if the same were used at the bottom of a harbor under 20 or 30 feet of water.

It is not always realized that what is commonly called an explosion is a process occupying a measurable and variable amount of time. No explosion is absolutely instantaneous; nor, on the other hand, is there any defined point of speed at which it might cease to be described as an explosion. There are plenty of illustrations of this fact. The curiously unstable compound known to chemists as iodide of ammonium (prepared by soaking iodine in an aqueous solution of ammonia gas and drying it) explodes by friction on being touched with a feather, and with such extreme rapidity that it may even be exploded by allowing a portion to drop upon a sheet of water—showing the speed of the explosion to be such that it is over before the powder has time even to absorb a particle of it. Contrasted with this is the time often occupied by the explosion of a mixture of gas and air accumulated in a mine or in a house, which may vary, according to its composition, from a fraction of a second down to a rate of combustion which could hardly be called explosive. From these considerations arises the importance of the question as to what speed of combustion gives the best effect in rock breaking; and here the element of heat plays an essential part.

It is obvious that a given number of heat units generated at the point of explosion almost simultaneously, and quickly dissipated around the same point, will do less expansive duty than the same number of units spread over a somewhat longer period, and thus able to maintain the temperature of the accompanying gas for an appreciable time. The degree of speed, or we might rather say the degree of slowness, of an explosion thus becomes an important item of adjustment with a view to obtain the highest useful effect. Practically every miner is aware of this—though perhaps only by rule of thumb—when he varies his grade of dynamite, or uses a certain proportion of black powder to assist its action.

The same theory applies (though perhaps less obviously) to the means employed to originate the explosion. It is very well known that many of the modern explosives, such as cordite or melinite, will burn off quietly on the application of an ordinary flame; and, in fact, cannot be made to explode without the use of a detonator or its equivalent. In this case the process is similar. The particles of explosive nearest to the source of heat are raised gradually to their point of combustion; and when this comes about, they in turn gradually raise the particles adjacent, so that the action proceeds with comparative slowness. But an application of the necessary heat to the first particle with such speed that none of it has time to disperse determines its explosion, which operates in like manner on the next, and throughout the mass. From this we may derive some assurance that accidental explosions—too often reckoned unaccountable—are actually due (however unlikely it may seem) to a sudden concentration of combustion heat at some one point from which it has no time to disperse. A slight slip of the knife during the objectionable act of slicing a stick of dynamite might suffice to bring this about, imperceptibly even to the unfortunate victim. This is not unfrequently done with the intent to enhance the strength of a shot by making it burn quicker, while the same operator adds with the other hand a modicum of black powder in order to make it burn slower!

It is admitted that the desideratum in speed must remain to some extent a matter of local experiment. Every shot has, in fact, to take its chances; for the reason that no man can see, at the bottom of a drill hole, what are the precise opportunities for the gas and heat of a given charge to disperse themselves. The practical question under this head is, therefore, what are the visible or ascertainable conditions by which the most effective speed and strength can be insured. The general quality and structure of the substance to be broken must of course be the main factor in determining how it is to be decided; and when the general principles governing these are sufficiently understood, the local conditions of each blast alone remain to be determined by the judgment of the operator. His mistakes will then be as few as can reasonably be expected.—O. H. Howarth in Mines and Minerals.

ARTIFICIAL STONE.*

The question which modern builders have had to face is, therefore, one turning more on the chemical composition of stones than on any other point; and, as reliable stone for town buildings has become more and more scarce and expensive, attention has, for over half a century, been turned to the study of the chemical composition of natural stone and the manufacture of a good artificial substitute. It also being evident, from centuries of observation, that silicate of lime had proved the best of all known cementing substances, special attempts have been, from 1832 till now, made to manufacture a silicate-of-lime stone. . . .

The inquiries and experiments made, have, I may here remark in passing, been not only in the direction of artificial stone, but also in that of washes for natural stone. Very few of these latter are, however, very effective and durable, or cheap. The principal one is silicate of soda; and lately Prof. Church's from six to twelve applications of barium hydrate—first in the form of spray, and then, after a few days, with a brush. This remedy appears effectual, but it must cost a great deal in labor and in scaffolding.

It not being, however, my intention to go deeply into this collateral subject, I will pass on to an account of the efforts made to provide good and cheap artificial stones.

Ranger's patents, dating as far back as 1832, mark the first step in the manufacture of artificial stone. His method was to mix sand or silicious material with caustic lime, slaking with hot water and ramming the plastic mass into mold boxes. Later, he used the aggregate hot, securing better combination by that means. There are, I understand, several large buildings now existing which were constructed with stone manufactured under Ranger's patents. His theory, and that of many who have followed him, was that the lime would combine chemically with the silica and form silicate of lime. Chemical authorities have, however, always been antagonistic to this view, and it is generally conceded now that caustic lime and sand merely mixed together with hot water, or even subjected to immersion in hot water for considerable time, do not combine chemically.

The Frear artificial stone, used for a time in the United States, was a mixture of hydraulic lime and sand, together with a certain portion of gum shellac. This latter ingredient was added for the purpose of hardening the block. Hydraulic pressure of fifteen to twenty-five tons was applied to the wet mixture when it had been deposited in the molds. In what manner the pressure was utilized and what was the exact

* Extracts from a paper by Mr. L. P. Ford, read before the Society of Arts and published in the Journal of that Society.

intensity per square foot, I have not been able to discover. The smaller blocks were ready for use in from three to four weeks. In this case, the hydraulic lime would contain a certain percentage of durable silicates, which would doubtless give to the stone considerable strength. The addition of the gum shellac, which accelerated the induration in the first instance, was probably the cause of the deterioration which ensued afterward; at any rate, the stone soon became decomposed, some authorities attributing it to the shellac, and some surmising that imperfect lime was the cause. Reid, already quoted, is very dubious as to the value of gum shellac, used with any matrix. Two other American processes may here be mentioned—Forster's and Van Deburgh's. In both instances, moist sand was used, but Forster used slaked, and Van Deburgh unslaked lime as the matrix. The sand was employed moist, the inventors being under the impression that every particle of moist sand would become evenly coated with lime paste, and no void spaces left. As a matter of fact, lime does not mix well with sand; under such circumstances, the moisture tends to make the lime "ball," and adhere in small lumps. To secure a perfect mixture, both sand and lime must be very dry. Van Deburgh further used steam to assist the slaking, and also agitated the mass for some time. Afterward the blocks were subjected to percussive pressure. Van Deburgh describes, also, various other methods of making stone. He mentions the use, as a matrix, of an alkaline silicate, and also proposes keeping the mixture *in vacuo* during the formative period to prevent the creation of carbonate of lime by combination between the carbonic acid of the air and the caustic lime, which action (he supposed) would interfere with the production of silicate of lime. Ordinary "water glass," silicate of soda or potash mixed with a suitable quantity of lime, should, under suitable conditions, form a silicate of lime, the soda or potash being rejected. The difficulty has always been to get rid of the rejected alkali, because so long as it remains in the stone, moisture will be attracted and induration retarded—60 or 70 days are required for the induration of stones made with alkaline silicates; and, unless the blocks have been carefully and frequently washed with clean water during that period, they will still effloresce, whenever they come in contact with moisture. It may be concluded that the difficulties and expense attending the manipulation of such mixtures were too great, as, apparently, none of those alternative processes were ever carried out on a practical scale.

A similar process was that of M. Sorel, a French chemist. The matrix in this case was calcined magnesian limestone, which was used in a manner substantially similar to that which Ranger adopted with ordinary lime. There is, however, great difficulty in calcining this class of stone, because a much higher temperature is required (1,700 deg. Fahr.) to drive off the carbonic acid of the carbonate of lime (which usually forms from 15 to 65 per cent of the bulk) than is necessary in the case of the carbonate of magnesia (700 deg. Fahr.). Consequently, if the magnesia is properly calcined, the carbonate of lime has to remain unaltered, and forms an inert proportion of the whole and a source of unreliability in the ultimate product. This difficulty alone would probably account for the permanent want of success which attended M. Sorel's efforts. Apart from this, however, it has been discovered that compounds of magnesium are not always to be relied on to withstand the action of either foul air or moist atmospheres or immersion in sea waters. All these inventors relied, to a great extent, in their practical operations, on the theory that silicate of lime or magnesia could be formed by merely mixing the materials together and treating them in the various ways described. The failure of their products discredited this theory for a time, and a number of so-called chemical (as contrasted with the above rather mechanical) processes were subsequently developed and attained a fair measure of success.

We now come to one of the ablest investigators of the subject, Frederick Ransome, whose earliest patent is dated 1855, and his latest 1875. Ransome's stone and slight modifications of it have been made until quite recently, and there are buildings in London and the country which testify to its enduring qualities. Ransome's method was to create a silicate of lime in a mass of sand or pulverized chalk, by first mixing the material with a soluble silicate, usually silicate of potash or soda, and then immersing the mass repeatedly in chloride of calcium or any other solution capable of decomposing the silicate. By this process silicate of lime is formed, and chloride of potassium or sodium is thrown off, giving rise for some time to an objectionable efflorescence, which must be washed off and will cease when the chemical interaction ends. Various improvements in this process have been patented, chiefly with the object of saving labor and securing better saturation of the blocks with the chloride solution. The blocks have been placed under vacuum and the solution introduced, either with or without pressure, and sometimes hot. Various forms of chambers have been devised in which to manipulate the mass economically, but apparently, although this product is excellent, these processes involved so much care in the preparation of materials that they failed commercially.

Sir H. Bessemer's and E. L. Ransome's patents in the United States of America describe the use of a vacuum-chamber to assist in drawing the cementing solution into the mass. And further modifications of the system known as silicating may be illustrated by a reference to another United States patent taken out by the same Mr. Ransome. In this case an attempt is made to avoid the expense involved in the direct use of the silicate of soda or potash as matrices, and also to improve the uniformity of the product. Silica, lime, chalk, hydraulic cement, and other lime substances, in a finely divided state, are saturated with a solution of caustic soda or potash, or of carbonate of soda or potash, the object being to create the silicates in the mass, instead of having to introduce them afterward.

Rudolph Zuber, in his German patent, describes an apparatus designed to extract the air from the component parts of the stone before mixing. He points out the difficulty of otherwise obtaining an absolutely solid mixture. Water, he says, contains a certain amount of air, and to drive this off he boiled it. The presence of air in artificial stone before consolidation is most detrimental to its strength and durability. "Hair cracks" are formed, and moisture, laden with elements of corrosion, is introduced into the body of the stone. In winter the moisture freezes and the block is split into fragments. These hair cracks also reduce the mechanical strength by lessening the cohesion of the mass.

Up to about 1885 little advantage seems to have been taken of the property of caustic lime to expand considerably when slaked. Fat limes expand from two to three and one-half times in bulk, and hydraulic limes from one to two times. Dr. Zernikow, in his German patent of 1885, describes the use of this property of lime, and he is really the pioneer of all the modern methods of making artificial stone. The lime and sand were mixed together dry and rammed into a strong mold box. They were then subjected to the action of steam or hot water for a considerable period. The first result of the contact with moisture was, of course, the slaking of the lime, and its efforts to expand being checked by the mold, they resulted in considerable consolidation of the mass. After the slaking was completed, the steam or hot water, it was claimed, slowly created silicate of lime in the block. A pressure of steam of only about three atmospheres or 45 pounds per square inch was used. The time occupied for the complete process was from four to seven days.

Owen, in 1894 and 1896, describes modifications of this procedure. He specified hydraulic lime, evidently because the fat limes were found unsuitable for a process which involves continuous immersion in water. Distilled water is also used to avoid the introduction of any air into the molds during the slaking period. The pressure (60 pounds per square inch) is kept up by means of a pump, instead of by steam (as in Zernikow's patent), and through a coil. In the earlier specification a claim is made that the hydraulic pressure external to the mold box will counterbalance the expansive force of the lime within. Since, however, the molds necessarily permit the water to enter for the purpose of slaking the lime, it is difficult to see how this can be the case. This process occupied about from sixty to seventy hours. Hydraulic lime, if of good quality, only expands to about twice its bulk when slaked. Consequently, the consolidation of the block will be less than in a case where a fat lime is used.

It was found that large blocks of artificial stone are liable to crack if dried and cooled too suddenly after manufacture, by the process just described. Drying and cooling devices were, therefore, protected by Bush in 1895, and by Owen, in the United States, in 1897. In another English specification in 1896, Prof. Thompson describes a process in which steam only is used as an amalgamating agent. He claims the formation of silicate of lime by simply subjecting the mixture of sand and caustic lime to the action of steam at a pressure of three to five atmospheres, but chemical authorities have decided that silicate of lime is not formed under such circumstances, and the extended experiments made by me have demonstrated that steam alone will not properly hydrate lime, and that the product is weak and unreliable. Further, to obtain the maximum slaking effect, it is essential that the lime be hydrated as quickly as possible. The water and plastic processes do not secure this perfectly, and the steam process occupies hours. I find that if the slaking takes place slowly, there is a tendency to solidification on the surface of the blocks before the centers have become hydrated.

Christian Heinzerling, in the German patent of 1897, improves on the method of Zernikow and Owen. The dry mixture of sand and lime is placed in a mold, and then the air is exhausted previous to the operation of slaking. He also specifies the use of carbonic-acid gas as an auxiliary amalgamating agent—presumably to create carbonate of lime as a matrix. This gas is introduced after the slaking has been completed, and is immediately preceded by the creation of a second vacuum around the mass. If the block is as solid as it should be, there will be little use in attempting to exhaust air from it, and the carbonic-acid gas will only be able to attack the skin.

Here ends my review of previous efforts to make large blocks of stone, but before I pass to my own work in that direction, I must add something about artificial stone bricks, otherwise called sand-lime bricks, for, when the Germans failed to make large stones, they gradually came down to producing these bricks, which have now become a most extensive industry all over the Continent, whence it is spreading to America and other places, and it is being inquired about even here. The English are generally slow to take up new things, but when we do, I think we soon outstrip the others. At any rate, in this case I, as an Englishman, am pleased to say that, not only have I mastered the long unsolved stone problem, but, also, that my son has produced a far finer sand-lime or stone-brick than any I have seen. How this came about constitutes, as some one writes, the "romance of the silicate-of-lime stone industry."

In 1894 I lent a sum of money on the silica mine in Wales, where my parent works now are; and in 1897 I was asked to take the mine over in the settlement of my mortgage. I did so. Then, believing I had got a very valuable material, I looked about for some use for it; tried, through experts, making Dinas fire-bricks, and failed; and then, hearing of Owen, who was making a silicate-of-lime stone at Woking, I sent an engineer and my son to see into it, found it was just the thing, as we thought, that would utilize my silica and lime quarries, and at once started experimentally. Succeeding very well on a small scale, I consented to my engineer erecting a large factory; but, when it was up, not one single stone could be produced of any size without cracks all over it. Being disgusted, I dismissed the engineer, went to Owen's, and found he had shut up from the same cause. I also traveled on the Continent, and found there, too, the same results. I then saw that if I went on, and overcame the difficulties, I should have something really needed all the world over, and I thought a couple of thousand pounds more would easily cover the cost. But instead of spending only that amount, I went on and on for nearly four years and spent altogether about £34,000. To do this I kept on realizing always at a loss, until I had to resort to mortgaging, and it was only when I was at the very end of my resources and did not know how to continue that I discovered the solution of the problem. After fully satisfying myself that I was right, I opened an exhibition here in London last year, and with some difficulty formed a syndicate, by the aid of which I have taken out patents in the principal countries of the world and followed up my discovery with great interest, for its reception all over the world has been most pleasing, and I trust now that I shall be able to depart this life some day leaving behind me an example of what can be done if one has a firm reliance on a loving and wise Creator, and does not mind enduring loss and hard work for the sake of serving one's fellow creatures.

The great value of the industry lies in the following points:

1. The stone itself is a production of a true silicate-of-lime stone—the old Roman mortar which has stood so many centuries.
2. It is not a concrete made with Portland cement, and is absolutely homogeneous throughout, and can, therefore, be cut up and used like—nay, better than—natural stone, which has layers, vents, flaws, etc.
3. It is better than natural stone, because few natural building-stones now used will resist the acids in the atmosphere, and this stone does.
4. Silica sand exists on over three-fourths of the earth's surface, and is, therefore, obtainable near building-sites, and thus an immense saving will ensue in carriage alone.
5. There are immense tracts of land where no natural building-stone is obtainable; and, therefore, where this is the case, the chance of obtaining stone by my process is a fact of immense importance.
6. In addition, the stone may be produced at about 3d. per cubic foot, a price at which natural stone cannot be quarried.
7. The carving qualities of the stone are splendid.
8. The crushing strength is three times greater than Portland stone, or less if desired.

The undoubted value of the stone is already being proved by the hearty testimony of architects and builders throughout this country and abroad, and by the many orders which are coming in.

As is usual, and I may say essential, for great success, my discovery is of the simplest possible, so that any ordinary mechanic, with a fair amount of brains, can learn and carry out the process, which is, shortly, this:

We use nothing else but ordinary silica sand (as most sands are) and common fat lime. The purer the sand, the purer and better the stone will be, and ordinarily we prefer not to have more than about 3 per cent of iron and 3 per cent of alumina and no other foreign matter. But I may say here that stone can be made by us out of almost any sand and quarry refuse, but it would not always be a pure silicate-of-lime stone. In some places that would not matter, but in large cities the purer the stone the longer it will endure.

The sand we grind and grade so as to get several grades, and the lime is reduced to a very fine powder. The two ingredients, in the proportion of about 92 per cent of sand to 8 per cent of lime, are mixed dry, and then run into a cylindrical mold, made in a special way, and this is the key to the process. The mold is closed, and placed in a boiler, from which the air is then exhausted, and into which water is immediately afterward allowed to enter and cover the mold. The temperature is gradually raised to about 350 deg. Fahr., and kept up for eight hours, when the process is complete. The boiler is allowed to cool, then opened, and the mold removed. When cool enough the mold is relieved of its contents, which can at once be used. I call the process absurdly simple; and yet it has cost, if we reckon the thousands each attempting inventor has spent since 1832, here and abroad, a couple of hundred thousand pounds, I suppose. The process is a close imitation of nature's methods, for in the bowels of the earth we find silica sand, alkalies, and a high temperature, with an enormous superincumbent pressure.

In conclusion, I will repeat a favorite assertion of

mine, already made, namely, that when civilization creates artificial conditions, simple natural things have to be replaced by artificial products.

THE SHRINKAGE AND WARPING OF TIMBER.

By Harold Busbridge, A.R.C.Sc., A.R.I.B.A., Mem. San. Inst.

It is well known that timber, in drying, is apt to

Fig. 1.

shrink, and it is commonly supposed that inferior timber is more liable to this defect than timber of good quality.

Although some woods shrink more than others, the fact remains that in all kinds of timber, some amount of shrinkage is bound to occur. All that can be done is to cut the timber in such a way that it can shrink freely without giving rise to splits, cracks, and that curvature of the pieces known as "warping."

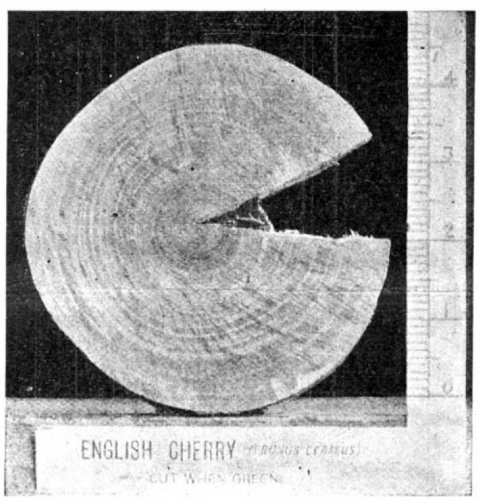


Fig. 2.

As soon as a tree is felled, its natural moisture begins to evaporate, and since evaporation can only take place from surfaces exposed to the air, the exterior of the log becomes much drier than the interior.

The driest parts of wood naturally shrink more than the other parts, hence the ends of logs and balks generally become full of cracks or shakes, owing to their getting dry more quickly than the interior. In order to avoid these end shakes as much as possible,

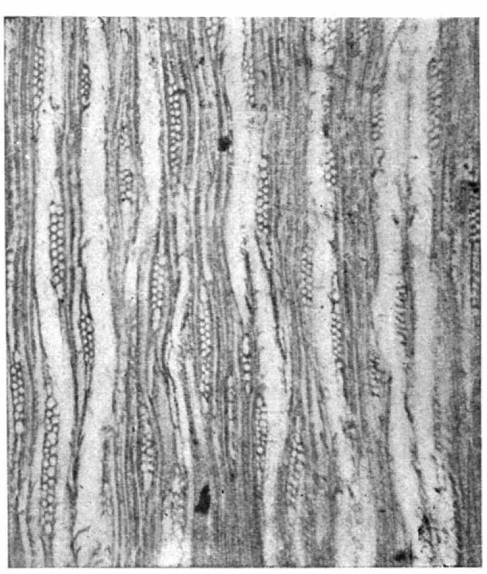


Fig. 3.—BOXWOOD, TRANSVERSE SECTION.

timber merchants often nail strips of wood across the ends of valuable boards of hardwood, as a protection from wind and sun. The evaporation of moisture being thus retarded, the shrinkage takes place more uniformly throughout the piece, and the tendency to cracking is reduced.

In order to obtain comparative results as to the behavior of the same wood when treated in different ways, a set of specimens was taken from a cherry tree of about twenty years' growth. Sections about 1¼ inch thick were sawn successively from the butt end of the tree, immediately after felling; and after being cut in various ways, as shown in the illustrations, were all placed together in a dry cupboard and allowed to shrink, warp or split, at will.

By taking their weight when first cut (in June) and comparing this with their weight when thoroughly air-dried about nine years after, it was found that the ratio of their weight when wet to the weight when dry was 1:63. It is probable that the driest wood exposed to air under ordinary conditions never contains less than 5 per cent of moisture; therefore on this assumption, it appears that the cherry wood in question originally contained at least 72 per cent of water.

The section shown in Fig. 1 was left with the bark upon it, and since evaporation could not take place from its outer surface so freely as from the section (No. 2) which was stripped, the radiating splits have not opened to so wide an angle. In No. 2 the whole of the shrinkage being collected into one angular split,

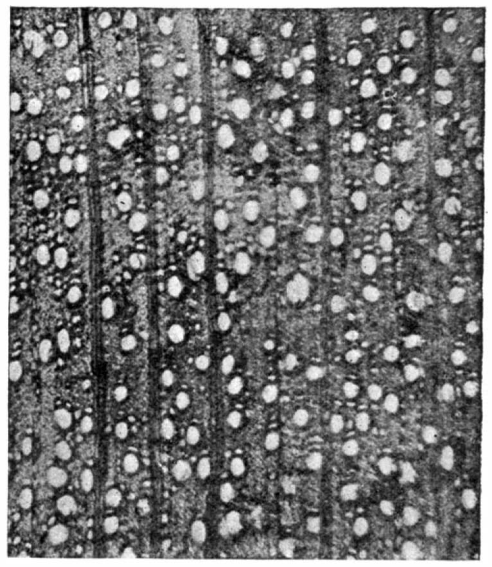


Fig. 4.—BOXWOOD, TANGENTIAL SECTION.

it is at once evident that the shrinkage in a tangential or circumferential direction is greater than that in a radial direction. It is well known that all woods shrink very slightly indeed in a longitudinal or axial direction, and from our observations it appears that the tangential is greatly in excess of the radial shrinkage. In seeking for an explanation of this, we are led to study the microscopic structure of wood.

We soon find that certain definite characteristics

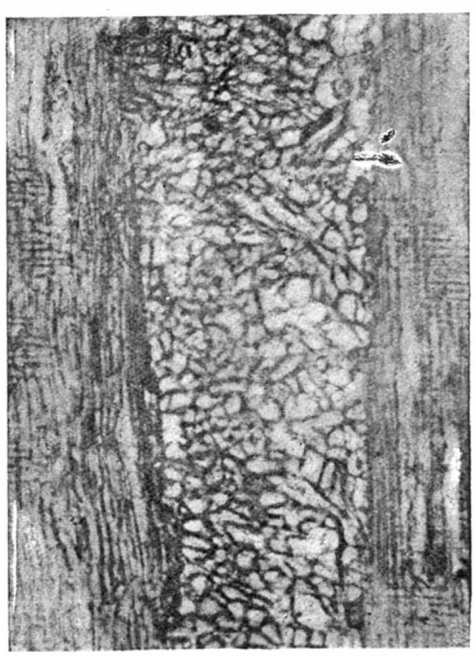


Fig. 5.—BOXWOOD, RADIAL SECTION.

mark the structure of all timbers, although each kind has its own peculiarities. Broadly speaking, the mass of all wood is chiefly made up of capillary vessels of various kinds, running in a vertical or axial direction; some large, but the greater number being small in diameter. The space occupied by the walls of these vessels bears but a small proportion to the air space inclosed by them; hence the large capacity for water which most soft woods possess. Besides the vertical members known as vessels, tracheides, and wood fibers, all woods exhibit groups of elements known as parenchymatous cells intersecting the former set, at intervals, in radial vertical planes. These are often visible to the naked eye, and form what are known in oak and other hardwoods as "medullary rays," the annual rings being formed by the vertical elements already referred to.

It appears that each individual cell, whether running in an axial or radial direction, has little or no tendency to alter its length in drying, but that all alike have a strong tendency to contract in diameter; although probably the different kinds of cells differ in degree as to their contraction, according to their size, and the relative thickness of their cell walls. Any given segment of wood, bounded by vertical planes radiating from the center of the tree, will therefore consist chiefly of vertical cells which have no tendency to change their length, but which will contract

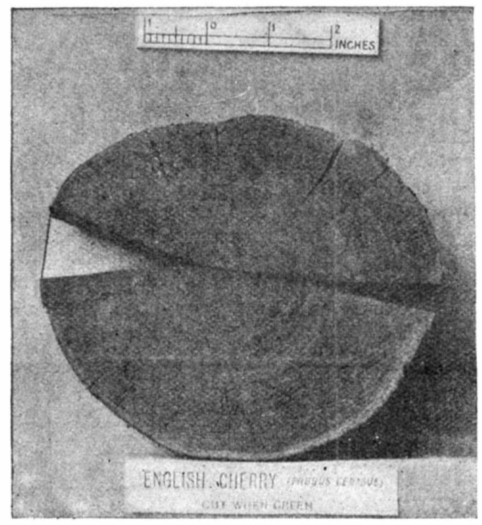


Fig. 6.

in diameter, either in a radial or tangential direction. It also contains a relatively small number of horizontal cells radiating from the axis, which resist any contraction in a radial direction, but which freely contract in a tangential direction.

It is evident, therefore, that, as with a lady's fan, change of dimension will take place most freely in a circumferential or tangential direction, and this affords a key to the interpretation of the forms assumed by the pieces of cherry wood here represented.

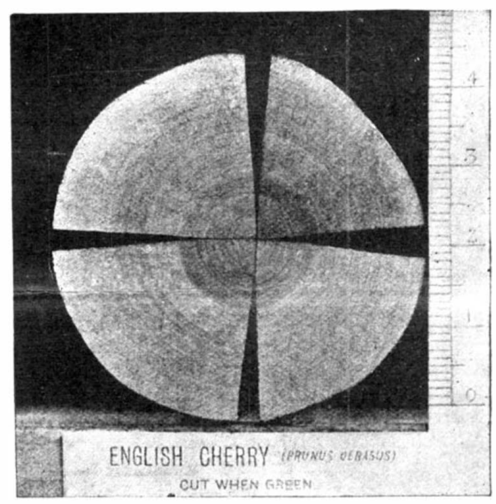


Fig. 7.

The three micro-sections of boxwood given in Figs. 3, 4, and 5 are fairly typical in character, and show clearly the structure of the medullary rays.

Fig. 6 shows that by sawing a log down the center immediately after felling, the radial splitting may be largely avoided; but that the two plane faces become convex in seasoning, this defect being less injurious to the timber than irregular splits.

Fig. 7 demonstrates that logs when "quartered" give timber which is still more free from splits than when halved, as the inevitable shrinkage can take place more easily.

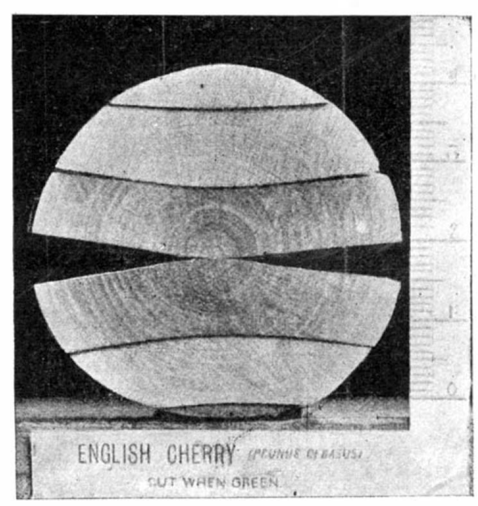


Fig. 8.

In Fig. 8 is seen the effect of cutting off planks or boards after halving the log. Here each plank must shrink more on that side farthest from the heart, and hence the result is a curved plank, having its concave side turned away from the center of the tree.

Fig. 9 is similar to the last, except that a piece was first cut containing the center of the log. This piece has both faces convex, and shows clearly that

the shrinkage near its edges, which contain the sapwood, is much greater than that around the center which consists of heartwood.

Fig. 10 exhibits the evils consequent upon the conversion of timber into balk, viz., that shakes generally run from near the center of one or more faces toward the heart. In this case, instead of getting several small shakes in each face, as is usual, the whole amount of shrinkage is collected into one large split.

Fig. 11 illustrates a method sometimes practised in cutting up large logs, so as to reduce the splitting and warping tendency to a minimum. Each piece has been able to shrink without restraint, hence there is little or no warping and splitting.—Technics.

ART AND ENGINEERING.*

It is unfortunate that the progress of the arts and sciences cannot be in a uniformly forward movement. The world of the engineer is rapidly progressive. The world of the architect, excepting for a few tremors or weak pulsations, has been dead since the sixteenth century. The art of the architect rests solely upon the traditions of the past. The science of the engineer has no tradition of yesterday which may not be cast into disrepute to-morrow. We have music than which the world knows no greater which is modern. We have literature of to-day. We have great paintings not yet dry on the easel. Sculpture is modern, but the last new great movement in architecture was in the sixteenth century. The architect and the engineer stand back to back. The architect has the ages for his vista; he sees the fifth century before Christ and the monuments of later epochs, but his vision is blinded and he sees no more after the sixteenth century. The engineer has his face turned the other way. His inspiration is the future. The past does not cloud his brain. May not the architect turn about face and move abreast with the engineer and live the life of his brother artists of the twentieth century rather than that of the earlier centuries which are in no way related to our life and time? The decorative and other artistic movements were never more plainly spread before us than now and never were there greater draftsmen than now. Nevertheless the art of the architect has never been more firmly rooted in tradition than during these days.

The modern movement in engineering has been along the line of rational economy. The Egyptian and Grecian structures of early centuries did not take economy into account. Their work was the erection of forms with respect to appearance alone. The definite factor of safety was a quality unknown to the builders of these centuries. The Grecian builder did the artistic thing. He made a column the proper size and form to be beautiful and was not embarrassed by mathematics or the materialistic spirit. The same condition existed with respect to the Roman construction though not to the same extent. The Byzantine work came much nearer being good engineering than anything which preceded it. Columns and arches were used more nearly in an engineering spirit. But late in the tenth century and during the eleventh and twelfth there was another period when form was again the first consideration and the engineer sat in the background. Walls were built heavy enough and thick enough to carry a load throughout their entire length when, in reality, the load was carried only on special points in that length. Columns were constructed with no serious regard for the economical disposition of material. The art element was dominant.

It is probable that during the thirteenth century the science of the engineer and the art of the architect were more nearly abreast than they have ever been since. Certainly the art of the builder was never so exalted as during the period. Certainly the science of the engineer and the art of the builder never joined hands more sincerely. Never in history have emotion and science expressed themselves with greater enthusiasm. There was a great and impelling reason for the sympathetic and hearty relation between the architect and the engineer. They were a people united in a declaration of independence. They were expressing their joy in the individual freedom of man which came as an illumination, as a new life, after the Dark Ages. They were the founders of a new democracy. It is certain that man never expressed himself in higher terms of exaltation than in the structures of that great period of the world's awakening. Through this motive the people were all united. Thus the engineer and the artist worked to a common purpose, and the work was great because the thought was great, because the struggle was great and the motive high. The dominant thought of our own time is materialistic, and hence the problem of uniting the interest of the engineer and the architect or artist is more complicated. The great work which had its origin in the thirteenth century only lasted during the continuance of the emotional impulse which created it. Within a hundred years it was on the wane, and in the fourteenth century had lost all the force of its initiative. During the fifteenth century in Italy and the sixteenth in France, the Renaissance developed—a period of the revival of learning, not the revival of soul; a period with a spirit of research, not one of creation, a spirit of imitation, far removed from that of invention; a spirit of resuscitation, not one of production.

The engineering work of the thirteenth century was controlled by the same spirit of economy in the disposition of material that we seek to attain in our modern utilitarian structures. I have in mind particularly, though not solely and distinctively, the ecclesiastical structures. These, by the way, were not constructed merely for religious uses. They were the great meeting-places for the people and utilitarian as well as spiritual in their functions. As used for religious ceremonies nothing could be more practical. The material part of the construction was arranged and proportioned by great engineers. The disposition

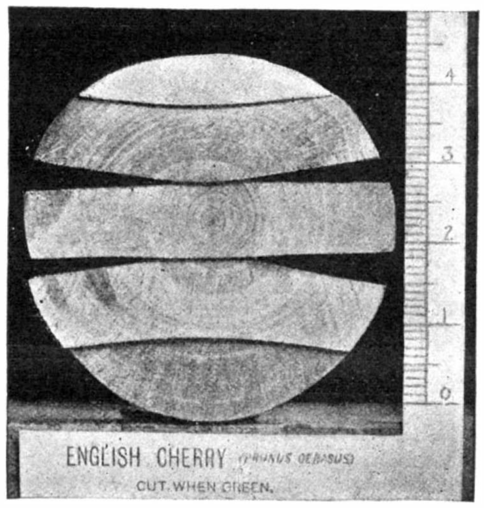


Fig. 9.

of material was controlled by economic considerations and the whole decorated profusely, elaborately, beautifully in the spirit of the times which created it. The engineer, the artist, and the craftsman operated from a common high impulse. Here was a condition contributing more successfully and more wonderfully to a union of art and engineering than the world has ever known before or since.

I wish to tarry a few moments longer with the thirteenth-century cathedral by reading the following quo-

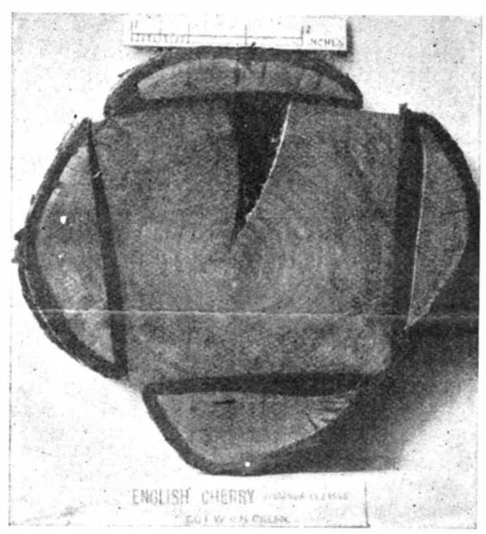


Fig. 10.

tation: "One great fact explaining the magnificence of these structures is that they were the work of a united community. The cathedral in any city belonged to every inhabitant thereof. Not only was there a most fervent religious spirit at the time of their erection, but there was but one form of faith. It was not necessary to build a dozen churches to accommodate a dozen different creeds. The cathedral was built large enough for the church-going population of a city or town, and the entire community contributed

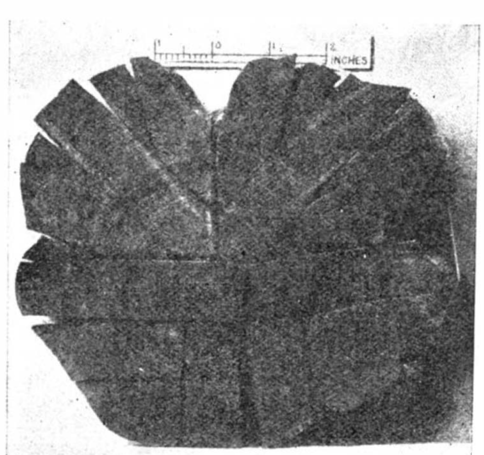


Fig. 11.

to its erection. Thus, the cathedral of the thirteenth century represented religious faith, political liberty, and the joy of artistic creation, a tremendous message nobly and fittingly and permanently expressed in enduring material."

While it is true that the artist and the engineer do not often get very close together and while this fact is lamentable, it is also true that they are more intimately allied in certain parts of the world than in others and for varying reasons. In France the engineer and the art builder come closer together than with us, for the reason that their architecture along its art side is much more highly developed and on the engineering side much less so. Thus their coming together is through both positive and negative channels. The French engineer has all the mediums and all of the combinations of structural engineering at hand that we know. His craftsmanship is certainly better than ours, but his planning, his mental processes, are much less free, much less inventive and much less ambitious than ours. The only fact contradictory to this proposition occurs in the construction of the Eiffel Tower. Here is one of the world's greatest and most beautiful monuments, an isolated expression in the history of modern civilization. It is essentially an engineering proposition, one involving no great difficulty, yet massive, courageous, and successful. This is probably true because form followed function.

From the mere standpoint of craftsmanship the Frenchman is far and away the best builder known to the modern world. No work is done so thoroughly, none so carefully or painstakingly, and none is done with the spirit of pride that we find in France. I speak of craftsmanship in its simple and ordinary application as related to fabrication and not as related to planning or engineering. The Frenchman is a much better builder than the American. He is greatly superior as an artist, but he is by no means the equal of the present generation of American engineers. The American has a faculty of uniting his nerve and his arithmetic that is not known to any other nation. The American engineer has his courage and his mathematics within the same skull. Is he not hazardous at times? we may ask. We answer that question by asking another. Is he not successful? We have recently taken up steel-concrete construction. Sure, we are tardy enough about it. Some of the French and German patents embodying general principles and certain details had long since expired before we took it up, but when we did we executed work more complicated, more courageous and more successful than has been accomplished through this medium in any of the European countries. A great Viennese review published a description of the Ingals building in Cincinnati, using the original text and language employed in the Engineering News. In commenting thereon it said: "The people of Germany and Austria have been pioneers in steel-concrete construction, but it has remained for the Americans to show us how to use it. They have shown their courage through the medium of their intelligence."

We all know that there were arc-lights on the Avenue de l'Opéra in Paris fully ten years before the arc-light was developed in this country, but we also know that it was so expensive to maintain (ten dollars per light for a few hours each night) that it was cut out and discarded several years before Brush made his light. To-day one will find many beautifully installed lighting-plants, not only in Paris but all over the world, employing American machinery. It is the American engineer who does things.

The cathedral was the characteristic, symbolic expression of the thirteenth century. The tall building, as we know it, is the symbolic expression characteristic of the nineteenth and twentieth centuries. In both examples form follows function. In that sense both are Gothic. It matters not if the tall office-building is clothed with the tattered garments of the sixteenth or the seventeenth century or from fragments and remains of the fifth century. The tall office-building, with its intelligent frame-work of steel, no matter how it may be masked, must be Gothic in spirit, if not in garment.

How can we expect to adequately characterize the great industrial progress of our time and the great engineering skill which has made this progress possible by the form, color, and detail of a classic period? How may we expect to symbolize our new life with cold, classic detail? Are we not as much entitled to a language for our architecture as for our painting, sculpture, music, and literature? The language of these arts is the language of our time. Not so the language of the art of architecture. Most of what we would call architecture is mere building. The architects are a trained body of conventionalists whose strongest impulse is to resist artistic progress. Inactivity deadens and dwarfs the human mind. These many years of conventional life have had a deadening and depressing effect upon the architectural mind. The architect's ornament, as well as his motives, have been a mere series of questions, a series of interlineations—scraps and selections from here, there and everywhere, with and without quotation marks, with and without credit, though, for the most part, the architect has never been ashamed to say: "Here is a quotation from the Erechtheum, or here another from the Colosseum, or yet another from the Mosque of St. Sophia," and so on down to the period of Francis I. Every effort to create, every effort to develop even new ornament, every effort to think in terms of our own time, develops strength, activity, and capacity.

When I decry the lack of vitality, the lack of spirit in the architecture of to-day and say that it has no to-morrow, that it has no growth, that its spirit is old, there are those who will say: How about l'Art Nouveau—the new art? What may it not do for architecture? L'Art Nouveau, as a new movement, has spread through France, Germany, Belgium, has invaded Italy and a manifestation of it is to be found in England. As we have not established a quarantine the disease has been felt by us as an infection only. We have developed nothing sporadic. It is, I believe, no more se-

* A paper by Mr. Louis H. Gibson, read before the Indianapolis Technical Club, Feb. 13, 1904.

rious than an architectural irritant. L'Art Nouveau is impossible of success with us. Primarily, because it is irrational. It is in no way related to the spirit or substance of our economies. It is entirely opposed to the spirit of modern engineering, and be it known that I believe the basic thought, the strong chord which will hold and control modern architecture, will be the logical functional operations of the engineering mind. It is economic, it is materialistic. L'Art Nouveau is none of these. L'Art Nouveau is undisciplined and riotous.

However irritating may be the general form and lack of functional interest which we find in the new architecture, there is yet hope in it. Signs of degeneration and decay in the world's architecture have always been first shown in its ornament. The integrity of large forms and general composition is preserved after ornament has shown signs of definite and chronic decay. Signs of life and hopes of a future are shown in the new and exceedingly beautiful ornament of this new art. The general structural and functional forms are bad enough, but the ornament and the color are often so superb that for a time one forgets the ugliness of the mass. Taken by itself, the ornament, pure and simple, which we find in the Art Nouveau movement is rarely and wonderfully beautiful.

Great architecture will come out of good engineering, good composition and beautiful ornament.

Without having my mind brought to the subject by recent events I wish to say, that for a long time I have had it in mind that a new, rational and functional art would be developed by the Japanese. While it is true that they have been influenced very largely in their art by those great artists, the Chinese, in the use of form and color, they are very highly developed not only as individual artists, but as craftsmen. They are yet much more highly developed along these lines than our race. On the other hand, the Jap is a hustler and we like him because he hustles in our way. He comes to our schools, reads our books, studies as we study, is in sympathy with our institutions, wears our clothes, combs his hair as we comb ours, and, most of all, thinks in our way. He does all this, returns home and preserves all of his racial characteristics. Withal he is an artist. May not this race, temperamentally so artistic and yet so expansive in their mental outlook, who are students all over the modern world, be able to unite modern engineering with new spirit? May they not be able to symbolize modern acquirement and material progress with modern engineering and the new art? Hitherto, our race has not been able to do this. Our engineering is modern. We make the pace, but we clothe it in the ancient garment.

I would regard an opportunity as lost, if I did not say here and now, in the strongest terms at my command, that there is no excuse for an ugly structure of any kind, be it a building, a bridge, a machine, or any other object in which material and labor are brought together. A bridge nearly always is beautiful. A locomotive is always beautiful, a machine tool is never ugly. This is true largely because form follows function. No one ever thinks of adding material or labor (which is merely another way of expressing expense) to any of the objects specifically mentioned for the sake of making them expressively beautiful. On the other hand, we never find ugliness among any of them. It is in building and other monumental work that ugliness, clumsiness, or lack of interest is so often dominant. In the building or the monument there is no excuse for ugliness. Good proportion costs no more than bad proportion. Harmony of color costs no more than inharmonious color. There is no more expense of time or material in a well-formed molding than in an ugly one. There is no more expense attached to grace than to clumsiness. Beauty is a condition of mind, a condition of heart, and not one of pocketbook. Clumsiness and crudeness come out of the crude and clumsy mind. It takes no more time or material and no more power to cast a beautiful piece of terra-cotta or brick or metal than one which the crude and clumsy mind. It takes no more time power, material, or skill to stick a beautiful molding through a woodworking machine than an ugly one. This general principle is true of every detail of every structure. Everything made by man might be beautiful without material consideration. The beautiful thing costs no more than the ugly thing. It is a question of mind and heart.

The mechanical engineer has a relation to art that is not appreciated by himself or understood by the public at large.

Some of us decry the use of machinery in the production of things artistic. It is affirmed by some that the artistic thought which is in the mind can only be expressed through the intervention of the tool which is in the hand. Certain grades of sculptural work and certain kinds of carving will always have to be done by hand. Yet it is true that many decorative motives can be produced and reproduced as well through the agency of the machine as through the agency of the hand. The influential factor is the impulse of the artistic mind which conceived the form which the machine produces. The machine is the great art democrat. It produces and reproduces art objects for the masses. It gives us color, printing, weaving, needlework, and many other forms of utilitarian and decorative objects. A form is artistic because it is beautiful and expressive and never because of its cost. We sometimes lose interest in a beautiful form because it is frequently reproduced. The Greek honeysuckle ornament has been used for twenty-five hundred years and its repetition has had no effect upon its beauty or its appreciation by the public. Its reproduction has been through the direct agency of the human hand, a hand often as mechanical and soulless as any device of the machine shop. If there were a thousand casts of Macmonnies's "Bacchante" each would be reproduced by mechanical means. Casting is essentially a mechanical process. Each of the thousand would be as beautiful as the one which exists. It is not necessary that someone's tired back should bend over the loom to produce the beautiful fabric. There should be more joy, more freedom in the wearing of the machine-made garment than one produced by an almost soulless human machine. The "Song of the Shirt" was written before the days of electricity and the sewing-machine. The machine will produce art forms conceived and planned by an artist, and it will produce beautiful objects at the same cost as ugly ones. Herein is the responsibility.

To produce art for everybody, the artist and the scientist, the artist and the engineer must sympathetically join hands. To the engineer belongs function and execution. To the artist belongs beautiful clothing and expression. Art, as engineers and architects know it, must be the decoration of functional form.

THE EVOLUTION OF THE HUMAN HAND.

By Prof. Robert MacDougall, New York University.

The succession of organic modifications which resulted in the formation of the human hand is part of the general process of evolution by which in the animal series the means of progression and of the taking of food were shaped by the environmental conditions under which life was carried on. Antecedent to the appearance of vertebrate limbs a series of manifold devices had originated by which the body could be transported from place to place and appropriate foodstuffs seized and carried to the mouth. These consisted of more or less permanent extensions of the body substances, naked or clothed in protective shields of denser material. In some types the limbs were created in the act of extension itself and were retracted by absorption and disappearance into the general body mass; in some they were formed of erectile tissues which could be protracted or withdrawn as occasion demanded; in some the whole body was thus contractile, and alternately elongated and shortened as the animal progressed; in some the organs of locomotion consisted of definitely formed limbs, which, while subject to loss by violence or even sudden shock, might be repeatedly and perfectly regenerated in the course of the individual life. In the forms to which they are molded and the mechanical principles upon which they depend, these organs of movement present the utmost variety, including ameboid extensions, flagellate cilia, pulsating bells, contractile stalks and bodies, suckered tentacles, swimming fins and tails, wings, and articulated legs. They appear as a great series of adaptive levels through which the evolution of this particular mechanism passed toward more highly integrated and developed types.

The functions of life which call into service the bodily limbs are chiefly two—locomotion, an activity which has arisen in connection with the search of food and flight from enemies; and prehension, which is concerned primarily with the grasping and tearing of food, but secondarily also with processes assistive of locomotion and other biological functions, such as sexual congress, the care of the body, burrowing, and climbing. Of these two functions, if we regard the vertebrate class only, the former is the more primitive. Upon the office of locomotion the prehensive and manipulative activities of the limb have been superposed as subsequent and more specialized adaptations. In vertebrates of less modified types the food is seized and manipulated by the mouth parts directly. Fish, reptiles, and birds feed in this way. In these as well as in mammalian forms which present relatively slight limb specialization, the mouth parts have in many cases undergone modifications which render them effective instruments for grasping, rending, digging, picking, and the like. Such adaptations are shown in the snouts of the mullet and pig; the beaks of the paddle-fish, the duck-billed otter, the humming-bird, and the secretary; the tusks of the boar, the horn of the rhinoceros, the proboscis of the tapir, the tongue of the chameleon and the trunk of the elephant. In all these cases the specialization of the limbs which accompanied such modifications of the mouth parts consists in an adaptation of the function of locomotion in connection with the particular conditions under which the life of the species is carried on; in consequence of which their general features have diverged very widely from those of manipulative organs.

The earliest form of locomotion which vertebrate limbs fulfilled was propulsion through the water. The problem to be solved did not include the support of the body, which was buoyed up by the dense medium in which the animal moved. The same dense medium afforded a sufficient resistance to allow of a relatively slow and weak movement on the part of the locomotive organs. The earliest vertebrate limbs, or the body extensions which foreshadowed them in times still earlier, needed neither the strength and rigidity of the terrestrial leg nor the expanse and velocity of stroke of the aerial wing.

If we conceive the progenitor of the limbed vertebrate to have progressed by means of an undulatory motion of the whole body, brought about by a peristaltic wave of contraction passing from front to rear of the animal, it is not difficult to infer the advantages which would accrue to those individuals in which a modification appeared in the form of flexible extension parallel to the longitudinal axis of the body, by the independent undulations of which progression became possible. The economy resulting from reduction of movement in the whole body mass would be accompanied by a decrease in the likelihood of attracting notice, a greater control of movements in taking food, and a more exact process of perception in adjusting the body to surrounding changes.

Though the series of limb forms is obscure in its earlier parts, the whole group is generally supposed to have its prototype in the lateral fold of the primitive fishes, in which locomotion took place through a wave-like movement passing backward along the length of the web. Out of this primitive lateral fold the various fin-formed limbs which characterize the aquatic progenitors of the land vertebrates arose by a series of modifications in which the following stages may be noted: In the undifferentiated swimming folds first developed a system of parallel rods extending from the body surface to the margin of the web, which probably both served the purpose of increasing the resistance of the locomotive organ and was accompanied by muscular and nervous developments which allowed greater definition and force in the reactions produced. Among these rods certain members outgrew the rest, a development which from mechanical causes alone would tend to survive a bilateral form. The number of such points of origin of increased growth in the rods was finally reduced to two on each side of the body, after a series of forms which we may conceive to have presented a diminishing series of rods, as the lamprey and shark present numbers of gill arches intermediate between those of the lancelet and the perch. With the definition of these fore and hind pairs of axial spines a concomitant modification of the adjacent members of the system of parallel rods took place, in consequence of which, first, a differentiation in size arose among them, those in proximity to the axial spine increasing, those remote from it decreasing in length; secondly, changes in the points of their attachment to the body occurred, the system of secondary rods moving from the median regions in either direction toward the axial spines; and finally, these accessory rods arranged themselves in a radial relation to the central rib, thus giving anterior and posterior fan-like extensions connected by the remnants of the degenerating fold and rods in the intermediate body regions.

Further differentiation of the axial and neighboring spines, in which the latter were progressively affiliated upon the former and there appeared a definite point of articulation of the whole system with the body mass, gave rise to the bipinnate fin, a roughly symmetrical organ in which the main spine occupies a central position and is flanked by a group of supplementary rods on either side. From this form structural modification proceeded, first, by the reduction and disappearance of the accessory spines on one side of the main axis, giving the unilateral fin; and, secondly, through a similar degeneration of those on the remaining side, by which the limb was reduced to a prong-like form represented in the lepidosiren. The limbs at this stage of development were in a condition which in general was more adapted to progression upon land than through the water, since the expansion upon which their propulsive action depended had ceased to be an element of importance, and all that was needed for terrestrial locomotion of a crude sort was a condition of sufficient rigidity in the limbs to allow of their use in dragging or pushing the body along, as the turtle does, but not necessarily of supporting its full weight as do the common quadrupeds. Before this final stage was reached, however, the animal had begun to practise land travel, using fins which were in the bipinnate condition as terrestrial limbs, as is the case with the Australian salmon, ceratodus.

From this primitive terrestrial vetebrate limb, through a series of cleavages of, or buddings from, its extremity, giving successively two, three, and four-toed forms, arose finally the five-toed generalized type of mammalian limb. The subsequent modifications of this organ, if we omit the divergent series of adaptations which gave rise to the pterosaurians and finally to the birds, present forms of specialization connected with the following modes of progression, namely, swimming, running, leaping, and climbing. The first, exhibited in different degrees by the whale and the dolphin, we may pass by, both because it follows a process of adaptation unlike that of the group of animals to which man belongs, and because the change may be regarded as degenerative, inasmuch as the animal returns to a medium which makes less demand upon the structural resistance of the organism than did that which was relinquished. Adaptation to running finds its extreme form in the hoofed animals, in which the body is poised upon the extremity of the limbs, thereby conserving their full length for the purpose of rapid movement by employing the utmost length of stride; and in which the number of functioning toes is progressively reduced until, as in the horse, only a single massive and horn-shod central digit forms the body of the so-called foot. In adaptation to leaping, which is presented both by animals which have passed through an arboreal stage, as the kangaroo, and by others which have always been terrestrial, like the hare and jerboa, the structural modifications consist primarily in an increase in the size and strength of the posterior limbs, with a concomitant degeneration of the fore limbs as they are less and less called upon to share in the function of supporting the body. Along with this primary modification goes a greater or less degree of specialization in the extremities of the limb, by which, as in the case of the running animals, one

or more of these take upon themselves the chief support of the body and the rest suffer functional atrophy. In the jerboa, for example, one toe only is thus degenerate, while in the kangaroo three are rudimentary.

It is with the modification of the five-toed limb for the purpose of climbing that we are here especially concerned, since it is in the arboreal group of animals only that the specialization of the fore limb in the form of a hand appears, and since it is to the adaptations fostered by this form of existence that man owes the early development of his own dextrous and accomplished manipulative organ. This modification consists, first, in the modeling of the extremities of the limbs to a form which made the act of grasping possible; secondly, in the separation of the whole system of limb terminations into two opposable groups, by which primarily a more perfect grasp was secured, and later the refined manipulation of objects was made possible; and finally, in the differentiation of hind and fore limbs, by which the former were made to provide secure and rapid locomotion and the latter were left free for specialization controlled by the sole condition of prehension and manipulation.

The first of these functions appears to be essentially connected with the habit of walking on the sole of the foot—plantigrade locomotion—and not on the knuckles or toes—digitigrade locomotion. Another method of climbing exists which is common to the rodents and the cats. In these animals the act of climbing depends upon the development of claws sufficiently long, strong, and sharp to be attached like hooks to the roughened surfaces upon which the animal climbs, and thus to support the body. In such forms the modification is of a superficial feature of the body structure and is probably a secondary function, the claws having been developed in connection with habits of seizing prey rather than of climbing. There is here no essential modification in the anatomical relations of the various parts of the limb, and it is inconceivable that any such subsequent development should be connected with this form of climbing organ as is presented in the limbs of the anthropoid apes and man.

In the plantigrade animal, on the other hand, the disposition of the limb is such that when the weight of the body is thrown upon it the toes tend to be thrust apart even when the foot is resting on a flat surface, and to be forced into a concave shape when pressed upon a rounded object. It is probable that a fair degree of development in the joints of the limbs had taken place in both flexion and separation before they were used for the purpose of climbing. But flexibility and separability of the digits form only the initial step in the process by which adaptation to an arboreal life was perfected. The second—and beyond all other changes important—modification consisted in the structural opposition of one digit to the remaining group. This differentiation occurs also in the lizards, e. g., the chameleon, and in the birds, under similar conditions of climbing and perching; but in connection with such specialization of the limbs in other regards and such modification of the body system as a whole that important service in the evolution of intelligence was precluded.

In the production of opposition changes took place in the hind limbs and most generally, since all species in which the thumb is opposed possess opposable great toes also—except in the single case of man—while many species occur in which opposition is presented by the hind limbs alone. In this adaptation of the foot to climbing three structural changes were effected—the parts of the limb became more flexible, the joints more widely separable, and the great toe, as has been said, opposed to the group formed by the remaining digits. All these are important features in rendering the limb a more efficient tool.

For the development of those peculiar functions which characterize the human hand, however, a further change in the use of the fore limb was necessary, by which it was relieved from participation in the support of the body and in primary locomotion. This relief must have taken place by a process which involved simultaneous changes in both fore and hind limbs. The support of the body, hitherto laid upon all four limbs, could not have been taken over at once in its final adequacy and security by the legs alone, unless we conceive of a spontaneous variation of improbably large extent. The animal at first raised itself hesitatingly upon its hind limbs, supporting its weight in part by the grasp of the hands upon higher portions of the trunk and branches, thus distributing the function as heretofore among the whole set of limbs, but in such a way that the fore limbs were adapted to their new specific use while performing their old generic function. The body, in this stage of development, was sustained in part by support from beneath and in part by suspension from above. Either of these factors may be conceived as appropriating a chief place in the locomotive function; and in different animal species these divergent directions of development are both presented, progression by swinging from limb to limb in the long-armed apes, and by the sole use of the legs in man.

It is probable that the progenitor of man, together with the whole group of anthropoid apes to which he belongs, maintained the quadrupedal position longer than those types which, like the Cebidæ, e. g., the teetees and Capuchin monkeys, present no opposition in the members of the fore limbs. If we conceive the semi-upright position to have been assumed at a time anterior to the development of opposition in the hind limb, say at the beginnings of aboreal existence, so that from the outset each pair of limbs was modified under different conditions of function, it will be found difficult to imagine the causes which under these unlike circumstances brought about a similar modification in each set of limbs. If, on the other hand, both fore and hind limbs were used to support the animal in a quadrupedal position upon the branch beneath it during the early period of arboreal life, it will be as difficult to imagine a reason why both sets of limbs should not present the same type of adaptation. The condition which predisposes to conservation of the phenomenon of opposition is support, not suspension; it is peculiarly a modification of the foot. All that is involved in successful adaptation to the function of suspension is the existence of sufficient elongation in the digits, flexibility in the joints and strength in the muscles—the development of a strong and supple member, but not necessarily one possessing an opposable thumb. Even a single series of joints may form an efficient instrument of suspension, as in the case of the prehensile tail of the monkey tribe. For support upon the rounded branch beneath, on the other hand, some sort of forking is almost the only modification which could give security, and in the man-like ape this has taken the form of an opposition between a single member and the rest of the group.

We may therefore conceive that the progenitors of the Capuchins and other parallel-fingered species soon after their adoption of the arboreal habit—or at least before the appearance of any important modification of the earlier structural relations of their limbs—took to a form of locomotion in which the body was partly supported from beneath by the hind limbs and partly steadied or suspended from above by the grasp of the fore limbs; so that the peculiar modification which the arboreal form of life contributed to the animal type was incorporated in the hind limbs alone. The anthropoid apes, on the contrary, which show this specialization in fore as well as hind limbs, we shall conceive to have persisted in the quadrupedal habit during a period the continuance of which was sufficiently protracted to allow of the appearance of similar modifications in all four limbs. Only subsequent to this process of adaptation should we imagine the progenitor of man to have arisen from the quadrupedal position and to have used the fore limbs for the secondary support of the body by grasping the upper branches.

In this new function the limb specialized by opposition had probably little advantage over the more primitive hand of the monkey, in so far as suspensional support was concerned. In respect to those other uses upon which the subsequent development of man in all kinds of mechanical skill depends, this new structural variation was of the highest significance. The monkey tribe gave up the habit of walking on all-fours too early and is suffering from the consequences to the present day.

This stage of development, however, represents a condition in which the factors of further evolution are confused and the various parts of the organism imperfectly adapted to the functions they are hereafter to perform. Hands and feet conform to the same architectural type. Both share in the unitary process of locomotion; the hands are capable of supporting the fore part of the body in moving, the feet are still prehensile organs. There is no exclusive functional specialization by which fore and hind limbs may be set off from each other. This subdivision of labor must come about through a development of the lower limbs by which they become capable of the sole support of the body at rest and in progress. In other words, the hands can not be released from their office of steadying and supporting the body until sufficient skeletal changes and muscular growth have taken place in the lower limbs to enable them to carry on the function of locomotion alone. The freeing of the hand for exclusively manipulative purposes thus depends upon the replacement of the semi-erect posture by a fully erect one, in which process the calf develops, the joints are straightened and the whole limb rotates upon its point of attachment to the body until the main axes of the two are parallel and each is vertical in position.

These changes could hardly have taken place during the continuance of an arboreal habit of life. The means of support afforded by the branches is too precarious, the form of locomotion which practical conditions impose upon the animal too restricted and interrupted to make the development of such a limb as the human leg possible. The need of supplementary support to which an unstable balance must give rise and the facility with which the arms can come to the aid of the legs as the animal makes its way from tree to tree are likewise factors which retard the development of efficient bipedal locomotion. The freeing of the hands may therefore be regarded as a concomitant of the return of man's progenitor to a terrestrial habitat, in which free, large, and continuous movements of locomotion were both possible and necessary. Only on the wide, open spaces of the ground can we conceive the ape-man to have become a swift and sustained runner, holding the body upright and the arms free.

At the same time with the changes in the leg already described the habit of traveling over the level surface of the ground would tend to produce a closer knitting of the ligaments of the foot and a greater compactness and rigidity in its general structure. The opposition of the great toe, no longer necessary to preserve the animal's equilibrium—since this is sufficiently secured in a lateral direction by the relation of the two legs—becomes a distinct impediment to land travel, owing to its interference with the movements of the fellow limb and its liability to injury by striking upon the objects among which the animal walks. With the further development of the foot, however, whether degenerative or other, we have not here to do.

As regards the special causes which led to the adoption of a terrestrial habitat in preference to the earlier arboreal life, it is probable that the change was intimately related to the development of the opposable thumb. The platyrrhine monkeys have the same type of foot as that possessed by the man-ape and do not progress predominately by swinging as do the long-armed apes. Anatomically, therefore, they differ from the progenitor of man chiefly in the fact that, unlike him, they have retained the parallel-fingered hand. In this differential feature resides their disability. The monkey form of hand is adequate for seizing and clinging to branches, but deficient in adaptability to all other mechanical purposes. For grasping and pulling, for digging and tearing, for handling stones and sticks the human hand with its opposable thumb is incomparably superior. Among the uses for which, in virtue of these capacities, it is especially fitted are the employment of weapons, the construction of means of defense from attacks by carnivorous beasts and later the use of tools.

The relinquishment of an aboreal habit involved the giving up of an important refuge and the assumption of a mode of life assailed by many new and grave dangers. The tree is a place of safety; it affords a secure retreat from some enemies and concealment from many others. A life amid its branches is compatible with a condition of weakness or defenselessness which would be fatal to the species under the circumstances of a ground habitat. To descend from the trees and venture that mode of life implies one of three possible resources: the animal must either be fleet of foot enough to distance his pursuers, or he must possess weapons of defense sufficient to repel attack successfully, or, finally, he must supply deficiencies in these regards through a cunning which enables him to escape his enemies by artifice. The apes are not swift of foot as compared with beasts of prey. They are poorly provided with natural weapons or means of defense. They have neither tusks nor claws, neither hoofs nor horns, neither great mass and strength nor impenetrable hides. If they are to take the aggressive or even to repel attack successfully it must be by the invention of artificial weapons whereby their deficiencies are made good; but as recourse to such instruments is a purely mental resort to obviate actual physical difficulties, it may be said that the ape-man met his difficulties in only one way, namely by cunning—escaping his enemy by retreat to strongholds of his own devising; meeting him, when battle was unavoidable, not with bare hands but with weapons, and taking his prey by traps and snares. But the schemes of his cunning brain could become practicable only as the result of a distinct mechanical constructiveness. Stones must be gathered and dropped or thrown with accuracy; clubs must be selected and wielded; traps must be put together after they have been devised. In all this the manipulative hand is essentially linked with the resourceful mind. With any other known type of limb the problem would have been insoluble. The specialization of the hand, therefore, with its opposable thumb and its wonderful adaptability to mechanical uses we may conclude to have been the single indispensable condition, so far as regards gross anatomical features, which determined the widely divergent subsequent fortunes of the monkey tribe and man-ape respectively.

For the principle of separation between this type and the rest of the anthropoid apes we must look to the different directions of development taken by the central nervous system in the two cases. Henceforth no important structural changes are to occur in the general features of the hand. Development is to take place chiefly through an increase in the facility and precision with which a variety of relatively simple movements are made, and the substitution, in ever increasing grades of complexity, of mechanical instruments for the use of the hand itself as a manipulative and constructive agent.—Popular Science Monthly.

The old water filters at Warrington, England, were formed with clay puddle bottoms and sides, the latter faced with bricks on edge, according to a paper by Mr. George Mitchell before the British Association of Water Works Engineers. Bitumen sheeting was used to secure watertightness, as a part of recent improvements, as this material was considered to be well adapted to bear the slight periodical movements of the banks, due to the varying amounts of moisture in the clay. A thin layer of fine concrete was then spread on the bottom and carefully smoothed over. The bitumen sheeting was laid on this and covered with a layer of fine concrete 5 inches thick, with a finishing coat of cement rendering. The sheeting on the slopes was protected by means of blue pressed Staffordshire bricks on edge, finished with a stone coping. Considerable difficulty was experienced in laying the bitumen sheeting owing to the pressure of the ground water during wet weather, and holes had to be cut in the sheeting to relieve this, the holes being made good and the paving completed after the brickwork had set, after which no further trouble was experienced. The floors of the filters are level longitudinally, but have a slight fall toward the main drains, which increase in section toward the outlet wells. The filtering material consists of 2 feet of sand, supported by gravel of an average depth of 10 inches, supported on a false bottom of perforated tiles laid on lines of brindle bricks. The

lines of bricks supporting the perforated tiles were laid flat rather than on edge, the depth of the filter being thereby slightly reduced.

ENGINES OF H. M. S. "PRINCE OF WALES."

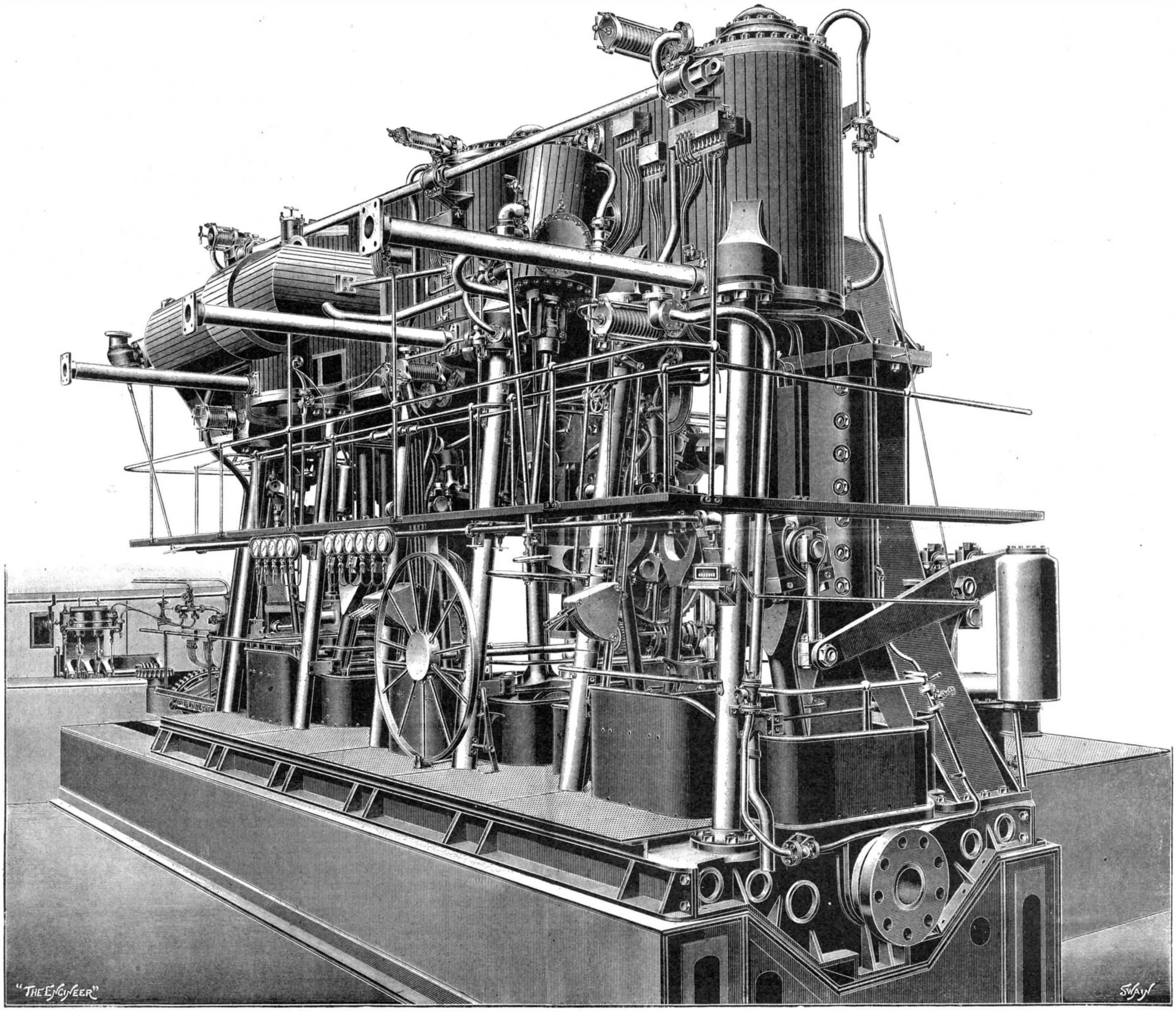
We illustrate one set of the propelling engines of H. M. S. "Prince of Wales," a first-class battleship of 15,000 tons displacement. These engines were built by Messrs. Scott & Co., Greenock Foundry. There are two similar sets of triple-expansion engines arranged in separate water-tight compartments, each engine being capable of developing 7,500 indicated horse-power, or a total of 15,000 indicated horse-power. Each set of engines has three cylinders, the diameters being, high-pressure 31½ inches, intermediate-pressure 51½ inches, and the low-pressure 84 inches, arranged in the usual manner, and all having a stroke of 51 inches. The cylinders are fitted with cast steel pistons and covers; the high and intermediate-pressure cylinders have forged steel liners, while that of the low-pressure cylinder is of hard, close-grained cast iron. All the cylinders are steam jacketed. The slide valves for the distribution of steam are of the piston type for the high and intermediate-pressure cylinders, and those for the low-pressure are of the flat, double-ported type, with a relieving ring at the back. The cranks are set at an angle of 120 deg. with each other. The crank shaft is made up of three interchangeable parts, the diameter being 17 inches external and 9 inches internal. The shafting throughout is hollow, and is made of forged steel. The back columns are of cast iron, and the framing of the engines of cast steel. The front columns are round and of forged steel polished. The propellers have a diameter of 17 feet 6 inches and 19 feet pitch, with detachable blades of manganese bronze. The exhaust steam of the main engines is condensed in four large gun-metal condensers, two in each engine-room, which have a total cooling surface of 16,000 square feet, and are so arranged that they can be used independently. There are also two auxiliary condensers, one in each engine-room, with a total cooling surface of 2,400 square feet, for condensing the exhaust from the auxiliary engines. The auxiliary machinery is of the usual type. An independent air and circulating pump is used for each auxiliary condenser, while the main air pump is worked in the usual way from the crosshead of the main engines.

The boilers are of the Belleville type, and were also made at Greenock, and they contain all the latest improvements. There are twenty in all, fifteen consisting of ten elements and five of nine elements, all with economizers arranged in their separate boiler-rooms. The working pressure is 300 pounds per square inch, reduced to 250 pounds at the main engines. The total heating surface is 37,040 square feet, and the grate area 1,170 square feet. Air is supplied to the furnaces by three large air-blowing engines. The stokeholds are ventilated by ten fans, two in each stokehold, driven by inclosed steam engines. The ventilation of the engine rooms is effected by two electric motor fans.

The machinery trials were successfully completed last December. The table gives the principal results.—Engineer.

Nature of trial.		Mean pressure in cylinders.						Mean I.H.P.		Total I.H.P.	Coal consumption per I.H.P. per hour.	Boiler pressure, lb. per sq. in.	Speed in knots per hour.
Power.	Hours.	High.	High.	Inter.	Inter.	Low.	Low.						
		P.	S.	P.	S.	P.	S.	P.	S.		lb.		
$\frac{1}{5}$	30	39.3	41.8	15.4	12.3	5.3	5.8	1583	1545	3,128	2.21	221	10.45
$\frac{3}{4}$	30	97.1	97.3	34.3	30.8	13.7	12.3	6038	5631	11,669	2.08	267	17.043
Full	8	105.7	105.8	41.4	38.8	17.5	17.9	7721	7643	15,364	2 02	286	17.87
½ power after opening out		69.3	74 6	27.7	27.0	10.8	9.4	4152	3983	8,135	—	248	14.6

Water consumption per I. H. P. per hour (all purposes) = 19.0 pounds—on full power trial.



7,500 INDICATED HORSE-POWER TRIPLE-EXPANSION ENGINES, H.M.S. "PRINCE OF WALES."

HISTORY OF CIVIL ENGINEERING.

It is so common to speak of civil engineering as of modern origin, even as the youngest of the professions, that its real age is recognized by only a few civil engineers. As a matter of fact, it should be regarded as a venerable profession. The beginnings of civil engineering are lost in prehistoric antiquity. If the engineering works completed in ancient Assyria and Egypt or in the ancient East Indian country could be described and the methods of their construction set forth, engineering literature would be enriched by additions of fascinating interest.

Exact methods of computation, efficient processes of construction and the magnitude of engineering works have been pushed forward with such amazing rapidity during the last half century that the accomplishments of the preceding three or four thousand years are entirely overlooked. Indeed, if one were to confine his attention to the engineering literature produced since the first locomotive was built, the impression would be gained that there was neither engineering science nor engineering construction prior to that period. Relatively speaking, of course, there was so little engineering before the advent of the locomotive that it is not much of an error to ignore it. In spite of that fact, however, there have been periods in the history of the world when really great engineering constructions were successfully designed and completed. This is particularly true of the old Roman period. The Romans were born engineers, although they did not apply that name to their great constructors. The name "architect" included not only those who would be classified under that designation to-day, but also those whom we should call engineers. Vitruvius belonged to that class. His treatise on architecture was largely a work on civil engineering. His book contains admirable ad-

vice regarding the design and construction of foundations, harbor works, public water supplies and other similar works. He even set forth some of the fundamental principles of the sanitation of water supplies. While his recognition of the conditions under which wholesome water is found are somewhat quaint, including the observation that the sources of potable water should not be "charged with the exhalations of the fenny animals," it is possible that his quotation indicates an obscure appreciation of the influence of pathogenic bacteria. Again he states, referring to the means of judging water: "If it be an open and running stream before we lay it on, the shape of the limbs of the inhabitants of the neighborhood should be looked to, and considered. If they are strongly formed, of fresh color, with sound legs and without blear eyes, the supply is of good quality." Such a method of determining the character of a proposed water supply would scarcely be considered conclusive at the present time, yet the distinction between good and bad water was recognized with absolute clearness, and the Romans established that distinction by means of the best lights at their command. The great masonry aqueducts, roads, and other engineering works are well known to all intelligent and well-read people. In a general way their engineering knowledge has been disclosed to us, but their methods of design and the details of the considerations on which their designs were based are practically lost, although we know absolutely that their modes of design must have been guided largely by quantitative considerations.

It is practically certain that the Romans did not establish out of hand the great body of engineering knowledge which they possessed, although there is little doubt that they greatly enlarged and developed whatever they may have acquired from others. Long before the Romans were engaged in any engineering construction of magnitude remarkable public works were serving the industrial operations of the teeming population which occupied the valleys of the Tigris and Euphrates. The full extent of these public works can never be known, but the ruins of the network of canals and their appurtenances demonstrate conclusively that the ancient Assyrians had developed water transportation to a remarkable extent. They were clearly familiar with the control of water in rivers and canals for useful purposes. It is equally clear that the construction of the arch as well as the construction of great buildings must have been known to them little or no less than 4,000 years before the Christian era. When these facts are coupled with the further knowledge of their extensive commerce at the same time with the coasts of Southern Asia, it is unquestionable that they had reached a high degree of excellence in a considerable field of engineering construction, even though they knew practically nothing of real engineering science.

The ruins of ancient Egypt, dating possibly as far back as 2,500 or 3,000 years before the Christian era, together with what is positively known regarding the ancient irrigation works in the valley of the Nile, demonstrate with equal certainty that the Egyptians were also at least fairly good engineers in their day. Tunneling, quarrying, river diversion by means of dams and auxiliary works and the construction of great masses of masonry were included among their successful engineering operations, nor is it at all improbable that other lines of engineering practice existed.

Mr. J. A. L. Waddell has made a strong plea for the study of engineering history in technical schools, and the plea is rational. There is a body of engineering history, if it were put in useful shape, which would be of at least much indirect value to the engineering student. While he would gain no additional knowledge of engineering science, he would find ancient experiences stimulating and broadening in their influences upon his professional judgment and cultivation. It is a field in which little has been done, but which if properly developed would round out in a most valuable manner the study of the great engineering advances of modern times.—The Engineering Record.

THE 5,000-HORSE-POWER THREE-PHASE TURBO-ALTERNATOR AT THE PORTA VOLTA ELECTRIC SUPPLY STATION OF MILAN.*

THE electric energy required by the city of Milan for light, power, and traction purposes is supplied by the Compagnia Generale Edison di Elettricita. The current is generated by two plants, one at Paderno on the river Adda, 32 kilometers distant from Milan, and the other at Porta Volta on the very outskirts of the town. The former (15,000 horse-power) is an hydro-electric plant, while the latter (14,000 horse-power) is steam-driven.

Both plants work parallel. The energy is transmitted at a tension of 14,500 volts from Paderno to Porta Volta, where the tension is reduced to 3,700 volts. The current supplied by both plants is controlled by a large switchboard, and subsequently supplied by numerous feeders to the town and surroundings.

As previously stated, the Porta Volta station is run by steam, i. e., by six reciprocating steam engines of a total output of 6,000 horse-power to drive the exciters and the generators, and two 3,000 and 5,000 horse-power steam turbines coupled direct to their three-phase alternators. The first of these two turbine units was supplied by Messrs. C. A. Parsons & Co., the second by Messrs. Brown, Boveri & Co., Ltd., of Baden (Switzerland).

In our general view of the turbine room, the furthest of the two sets is the 5,000-horse-power Brown-Boveri-Parsons turbo-generator already mentioned.

This turbo-alternator is designed to run at 1,260 R. P. M., its total length being 16.5 meters, while the width and maximum height are 2.5 meters.

The bedplate of the turbine is simply placed on four blocks of cement in which it is partially sunk; no holding-down bolts are required, as even in large-size turbines there is no tendency to "creep." This generating unit can be divided into three main parts, i. e., the high and low-pressure cylinders and the generator. The shafts of each of these parts are coupled together by means of elastic clutch couplings specially designed for the purpose.

Each cylinder contains a complete turbine set, with different sets of blades and grooved pistons or dummies, proportioned to the various stages of the expansions of the steam between the boiler and the condenser. The circulation of lubricating oil for the bearings is attained under pressure by means of a pump driven from the shaft of the turbine. Another oil pump driven by a steam motor is kept in reserve, and employed whenever the turbine has to be started. The oil consumption is very small as compared with that of steam engines, and scarcely attains, in the case of this 5,000-horse-power steam turbine, 0.200 kilogramme per hour. As no lubricant is used in the cylinders of the turbine, the exhaust steam is entirely free from oil and other impurities, and the condensed water can therefore be pumped again directly into the boiler without the usual trouble of filtering. The rapidity with which the turbine can be started is one of the many advantages that this type of prime mover possesses over ordinary steam engines, the warming up of the cylinders of the turbine not requiring more than ten to fifteen minutes.

The parallel running of the turbo-alternators with the steam-generators in the same station, and with the hydro-electric installation at Paderno, has been most satisfactory and easy to attain. The special design of the Brown-Boveri-Parsons turbo-generators is in itself very favorable to attain and insure good parallel running, this being due to the small coefficient of irregularity of the turbines, generally less than 1-300, and also to the special construction of the rotating magnet field, which is designed very similar to the rotor of an asynchronous motor, an arrangement which has many advantages, both from an electrical and mechanical point of view.

These turbines are entirely and promptly controlled by their governors. The steam passes from one end to the other of the turbine in a fraction of a second; the link motion of the throttle valve tells directly on the speed of the turbine.

Practice has shown that these steam turbines can be regulated in a way much superior and more accurately than reciprocating steam engines, which generally rotate several times before a change in the link motion makes itself felt in the speed of the machine. These turbo-alternators are for this reason specially suitable to work on circuits subject to sudden variations of load, as occurs on a traction system.

For the 3,000-kilowatt turbo-generator the constructors guaranteed for sudden variations of load, i. e., 25 per cent above and below, that the variation in speed would be only 1 per cent. When the machine, however, ran its official trials, the whole load was thrown off suddenly several times, and at different loads, with the following results:

Load in KW. thrown off suddenly.	Maximum increase in speed indicated by tachometer.	Duration of the oscillation wave of speed.
680	2.2 p. c.	....
950	3.1 p. c.	44 sec.
1,160	3.5 p. c.	50 sec.
1,380	4.4 p. c.	50 sec.
2,450	7.5 p. c.	70 sec.

It is plain that these tests of automatic speed regulation gave not only better results than were guaranteed, but also furnished ample proof that the type of governor employed was capable of having complete control over the speed of the turbine at any emergency.

After several months of steady running the official tests were taken. The turbo-generator was run six hours consecutively, on 3,364 kilowatts mean load, with a steam pressure of 12.5 atmospheres and 231.7 deg. C. superheat, and it was found that the turbine consumed 7.26 kilogrammes of steam per kilowatt, corresponding to 4.5 kilogrammes per I. H. P. This figure was determined by dividing the mean daily weight of steam admitted into the turbine through the load in kilowatts measured at the terminals of the alternator.

As the steam consumption guaranteed was about 11 per cent higher than the results obtained, we may say that the guarantee could not have been better fulfilled.

We must also add that the turbine would have run

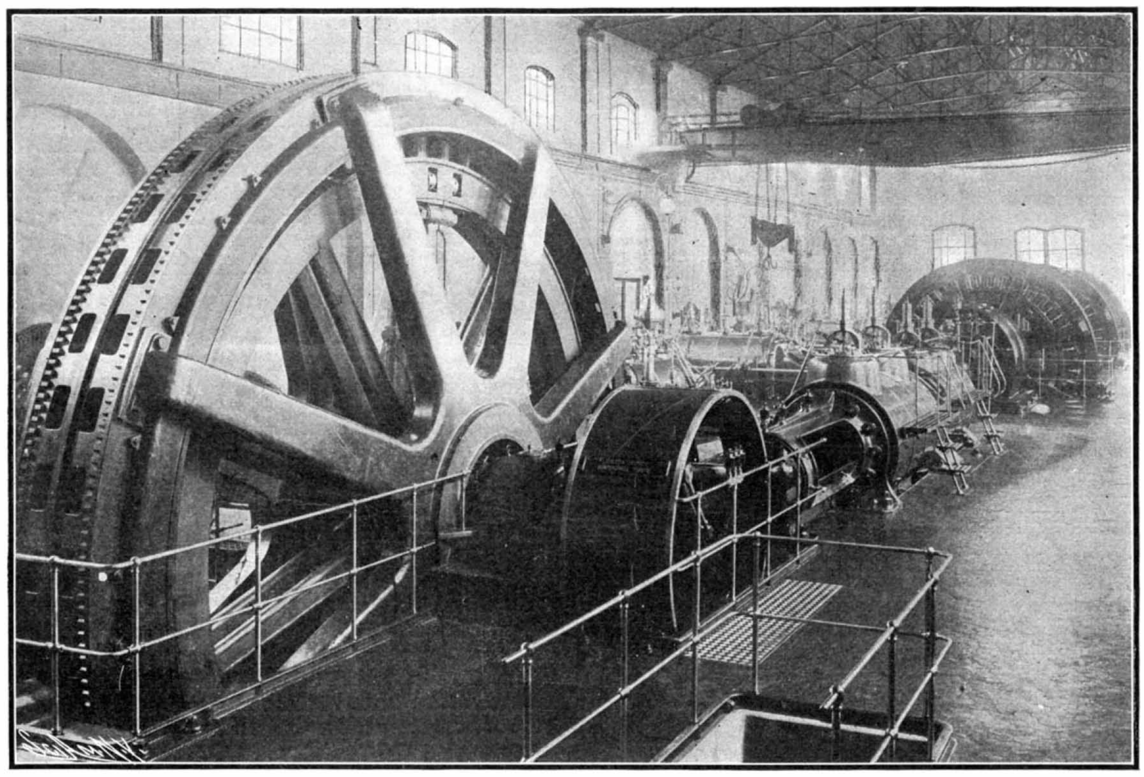


FIG. 1.—GENERAL VIEW OF GENERATOR ROOM AND 2,000-HORSE-POWER SULZER TANDEM COMPOUND ENGINE.

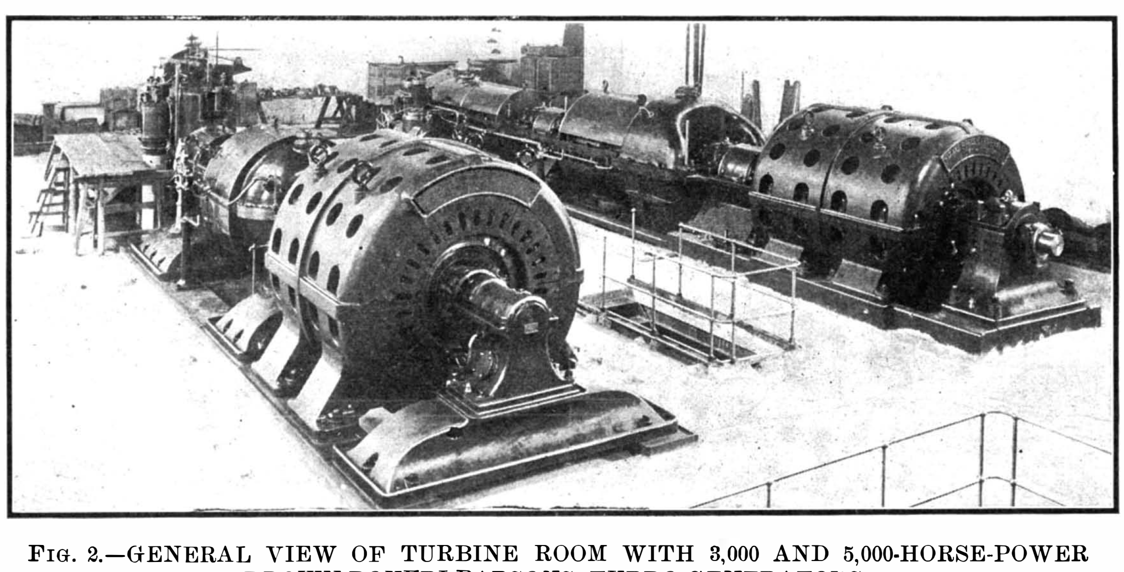


FIG. 2.—GENERAL VIEW OF TURBINE ROOM WITH 3,000 AND 5,000-HORSE-POWER BROWN-BOVERI-PARSONS TURBO-GENERATORS.

* Specially prepared for the SCIENTIFIC AMERICAN SUPPLEMENT.

under more favorable conditions, if it had been supplied with superheated steam at a temperature of 300 deg. C. superheat, in which case the steam consumption would not have exceeded 6.4 kilogrammes per kilowatt hour, i. e., 3.95 kilogrammes per I. H. P. These figures are obtained by comparing the results of the Milan turbine with those of a similar unit installed at the Frankfort Electricity Works.

THE WORK OF A GREAT ETHNOLOGIST.*

By Henry A. Balfour, M.A.

It has frequently been remarked, and not without some justification, that anthropology is an exceedingly diffuse science, and that it lacks the compactness and relatively well-defined field of enterprise enjoyed by most other sciences. This characteristic has even been employed by many as an argument against regarding anthropology as a subject of any considerable value for educational purposes, the suggested lack of cohesion being thought to militate against this science ever being allowed to occupy a similar position in the educational curricula and examination systems of this country as that to which the older sciences have for the most part been admitted. For my own part I cannot but consider the validity of this argument as open to question. The term anthropology, used in its unrestricted and, as I venture to think, proper sense, does, I readily admit, embrace a vast and varied field, and it inevitably overlaps, and even wanders far and at times freely into the domains of other sciences. How should it and how can it be otherwise? We, surely, would be guilty of grievously undervaluing and paying scant respect to our genus were we to imagine that the science devoted to its comprehensive study could be otherwise than far-reaching—call it diffuse if you will—and that it could be expected to avoid driving its roots deeply into other sciences whose chief practical interest lies, after all, in their adaptability to the service of man.

In admitting the partial justice of the accusation as regards diffuseness, anthropology, it seems to me, is really pleading guilty to the possession of an educational quality of which it may rather boast than feel ashamed. A science which is so far-reaching, and yet whose nucleus or focusing point is so well defined, seems of itself to furnish the materials in great part for a liberal education, if properly handled, and to lend itself to the preparation of the inevitable syllabuses, adapted to the different grades both of general education and of higher scholarship.

I readily admit that the word anthropology is unfortunately cumbersome; but it would seem to be inevitable, since no one has yet provided the science with a compact general name which may serve as an efficient substitute; and, since we must retain it, we may at least expect the word to work for its polysyllabic existence, by covering a wide area and serving as the most general term denoting the study of man in a wide and all-embracing sense.

It is not my purpose to discuss here the educational value of anthropology, but frankly and even gladly to admit that anthropology, in spite of its late recognition as a distinct science worthy of encouragement, has in recent years progressed with rapid strides, and has already reached a stage of developmental progress at which it is necessary to differentiate the several branches of study which are included under the general science, and to adopt a classification which is ever becoming more complex as the various divisions become unwieldy and require subdividing. An extensive terminology has been growing up for the purpose of assigning appropriate names to the already fairly numerous divisions of the main subject. Anthropology is passing through the developmental stages which have been followed by the older sciences, and is merely following normal routine in advancing from the simple to the complex. With the increase of knowledge the elements which together constitute a given science necessarily develop individually as well as collectively, and the original science loses its primitive unity by becoming an ever-increasing aggregation of sub-sciences. This process of subdivision or branching is inseparable from the life-history of an active and progressive science.

The genesis, growth, and maturity of Section H reflects to some extent the development of the study of anthropology. If we look back nearly sixty years, to a meeting of the association held in Cambridge in 1845, we see that ethnology was not mentioned at all in the programme and list of sections, though one ethnological paper does certainly figure among those of the zoological-botanical group. We may, however, assume that at this meeting a start was made, and give to Cambridge due credit for having a distinct claim to the parentage of Section H. For, in the following year, 1846, we find in the list of sections a definite sub-section of ethnology. Indeed, were we in doubt as to the parentage of the infant sub-section, there is circumstantial evidence clearly indicating this ancient university city, in the subtle influence apparently exercised upon the mind of the parent by overpowering leanings toward applied mathematics, as manifested by the interesting and otherwise unaccountable fact that the "sub-section of ethnology" was in that year humbly parasitic upon Section G, which was then, as now, devoted to "mechanics"!

From 1847 to 1850 the ethnological sub-section came under Section D (zoology, botany, and physiology). In 1851 ethnology appears in conjunction, and, apparently, on nearly equal terms with geography; and so it remained in the year 1862, when the association again had the privilege of meeting in Cambridge, that profound and ingenious student of man, Mr. Francis Galton, being president of the dual section. The geographico-ethnological combination lasted until 1868, after which, and until 1880, we find the prospective Section H replaced under the charge of Section D—biology (which included zoology, botany, anatomy, and physiology).

The steadily growing vitality of the study of man is very evident through all these years, from the list of papers read, and one may gather, from the way in which the sub-section was transferred from section to section, that the infant was rapidly outgrowing its nurses, and becoming a troublesome handful. Typographical signs of adolescence, coupled with a yearning for independence, appear in 1883, when, glancing at the list of sections, we see that, although anthropology is still a "department of biology," not only is it the only "department" specially announced under Section D, but the heading is printed in type of the same magnitude as that used for the section itself. The printer proved to be a good prophet; for in the following year, 1884, at the meeting in Montreal, the inevitable occurred, and anthropology blossomed out into the adult stage, and received the emancipation afforded by the assignment of an entire section to itself, the "Section H," which has, I venture to think, thoroughly justified its existence ever since.

It may be doubted whether we have as yet reached the limit of expansion. The time is likely to come when Section H will be the parent of one or more vigorous sub-sections, which, again, may repeat the developmental sequence, reaching at length maturity and discretion, and being perhaps allowed to set up for themselves as semi-independent sections. The original title of a section of the British Association may disappear entirely as such, after the sub-sections comprised under it have received their full emancipation. This has happened in the case of biology, which for some thirty years gave its name to Section D, but which finally gave way before the growth of its enterprising and very progressive offshoots (zoology, anthropology, physiology, and botany), which one after the other developed into independent sections. With this segregation of the various component elements of biology, the old generalized title ceased to appear on the list of the British Association. This, perhaps, will be the fate of the term "anthropology," as the growth of the subjects which have developed under the wing of this very comprehensive science gradually causes, for the sake of practical convenience, a number of subordinate titles to replace the time-honored and inclusive term. Should it thus happen, in response to the growth of the science, that this term is destined to follow the far wider term "biology" into a position of dignified ease, we shall be wise to bear continually in mind that anthropology is the main stem from which the various branches have sprung, and to whose nourishment and growth it should be the principal aim of their individual activities to contribute. In an age of ever-increasing specialization we may from time to time require a reminder of the fact that the true value of researches in the special fields of a science must be estimated by the degree to which their relationship to the whole can be and is rendered manifest. The work of specialists will necessarily lose half its value if there is a dearth of generalists who will gather together the threads and weave them into a substantial fabric, which shall show the importance of each individual piece of work to the progress of the science as a whole.

Once anthropology became recognized as a definite science, and one worthy of encouragement, the number of its devotees increased steadily and apace, and the range of its work widened rapidly. Indeed, it would appear as though there were an almost feverish desire to make up for time lost through the phenomenal tardiness of the discovery of a seemingly obvious fact, which is that "man" is in very truth a "proper study for mankind." Energy is not wanting, though this feverishness is kept in rigid subjection by the chilling and reducing effect of starvation for want of funds. The lack of adequate financial support is painfully apparent in Great Britain when we compare the conditions prevailing here with those obtaining in other countries.

I will not endeavor to cope with the many and varied aspects of anthropology and its complex ramifications, nor will I attempt to enumerate the many distinguished men of science to whose stimulating work we chiefly owe the progress already achieved in anthropology; the more prominent pioneers are well known to you, and several, I am glad to say, are yet with us. Their works remain as important landmarks in the developmental record of the science of man. I have, instead, selected as my principal theme one branch of the subject. My main object is to review, necessarily briefly, one of the factors which have played a part in stimulating scientific inquiry into the past and present conditions of man, and in furthering the development both of the scientific and the popular interests of anthropology. I wish to confine myself to the consideration of the contribution of one man toward the subject, a contribution which is the more valuable since it deals with wide principles, and thus affords a basis upon which a vast army of students may found valuable work. It amounted to the establishment of a particular school of research into the history of human culture, into which fresh workers are constantly being attracted, and which has stood the test of time through half a century.

It was about the middle of last century that an officer in her Majesty's army began to apply the lessons which he had learned in the course of some of his professional experimental work to studies pursued by him as a hobby in a far wider field of science. The story of the famous ethnographical collection of Col. Lane Fox is well known, and I need but briefly refer to it. During his investigations, conducted with a view to ascertaining the best methods whereby the service firearms might be improved, at a time when the old Tower musket was being finally discarded, he was forcibly struck by the extremely gradual changes whereby improvements were effected. He observed that every noteworthy advancement in the efficiency, not only of the whole weapon but also of every individual detail in its structure, was arrived at as a cumulative result of a succession of very slight modifications, each of which was but a trifling improvement upon the one immediately preceding it. Though noticing the unfailing regularity of this process of gradual evolution in the case of firearms, he was led to believe that the same principles must probably govern the development of the other arts, appliances, and ideas of mankind. With characteristic energy and scientific zeal Col. Lane Fox began at once, in the year 1851, to illustrate his views and to put them to a practical test. He forthwith commenced to make the ethnological collection with which his name will always be associated, and which rapidly grew to large proportions under his keen search for material which should illustrate and perhaps prove his theory of progress by evolution in the arts of mankind.

Although as a collector he was somewhat omnivorous, since every artefact product fell strictly within his range of inquiry, his collection, nevertheless, differed from the greater number of private ethnological collections, and even public ones of that day, inasmuch as it was built up systematically with a definite object in view. It is unnecessary for me to describe in detail the system which he adopted in arranging his collection. His principles are well known to ethnologists, either from the collection itself or from his writings, more especially from the series of lectures which he gave at the Royal United Service Institution, in the years 1867-69, upon "Primitive Warfare"; from his paper read before the Anthropological Institute in 1874 on "The Principles of Classification, as adopted in the arrangement of his Anthropological Collection," which was then exhibited at the Bethnal Green Museum; from that portion of the *catalogue raisonné* of his collection which was published in 1877; and from numerous other papers dealing with special illustrations of his theory. Suffice it to say that, in classifying his ethnological material, he adopted a principal system of groups into which objects of like form or function from all over the world were associated to form series, each of which illustrated as completely as possible the varieties under which a given art, industry, or appliance occurred. Within these main groups objects belonging to the same region were usually associated together in local sub-groups. And wherever among the implements or other objects exhibited in a given series there seemed to be suggested a sequence of ideas, shedding light upon the probable stages in the evolution of this particular class, these objects were specially brought into juxtaposition. This special grouping to illustrate sequence was particularly applied to objects from the same region as being, from their local relationships, calculated better to illustrate an actual continuity. As far as possible the seemingly more primitive and generalized forms—those simple types which usually approach most nearly to natural forms, or whose use is associated with primitive ideas—were placed at the beginning of each series, and the more complex and specialized forms were arranged toward the end.

The primary object of this method of classification by series was to demonstrate, either actually or hypothetically, the origin, development, and continuity of the material arts, and to illustrate the variations whereby the more complex and specialized forms belonging to the higher conditions of culture have been evolved by successive slight improvements from the simple, rudimentary, and generalized forms of a primitive culture.

The earlier stages in these sequence series were more especially the object of investigation, the later developments being in the greater number of cases omitted or merely suggested. It was necessary for Col. Lane Fox to restrict the extent of the series, any one of which, if developed to the full extent, would easily have filled a good-sized museum. The earlier stages, moreover, were less familiar, and presented fewer complications. The general principles of his theory were as adequately demonstrated by the ruder appliances of uncivilized races as by the more elaborate products of peoples of higher culture; and, moreover, there was doubtless a great attraction in attacking that end of the development series which offered a prospect at least of finality, inasmuch as there was always a chance of discovering the absolute origin of a given series. Hence the major part of his collection consisted in specimens procured from savage and barbaric races, among whom the more rudimentary forms of appliances are for the most part to be found.

The validity of the general views of Col. Lane Fox as to evolution in the material arts of man was rapidly accepted by a large number of ethnologists and others, who were convinced by the arguments offered and the very striking evidence displayed in their support. I have heard people object to the use of the term "evolu-

* Address before Anthropological Section of British Association for the Advancement of Science.

tion" in connection with the development of human arts. To me the word appears to be eminently appropriate, and I think it would be exceedingly difficult to find one which better expresses the succession of extremely minute variations by means of which progress has been effected. That the successive individual units of improvement, which when linked together form the chain of advancement, are exceedingly small is a fact which anyone can prove for himself if he will study in detail the growth of a modern so-called "invention." One reason why we are apt to overlook the greater number of stages in the growth of still living arts is that we are not as a rule privileged to watch behind the scenes. Of the numberless slight modifications, each but a trifling advance upon the last, it is but comparatively few which ever meet the eye of the public, which only sees the more important stages; those, that is to say, which present a sufficiently distinct advance upon that which has hitherto been in use to warrant their attracting attention, or, shall we say, having for a time a marketable value. The bulk of the links in the evolutionary chain disappear almost as soon as they are made, and are known to few, perhaps none, besides their inventors. Even where the history of some invention is recorded with the utmost care it is only the more prominent landmarks which receive notice; the multitude of trifling variations which have led up to them are not referred to, for, even if they be known, space forbids such elaborately detailed record. The smaller variations are, for the most part, utterly forgotten, their ephemeral existence and their slight individual influence upon the general progress being unrecorded at the time, and lost sight of almost at once. The immediately succeeding stage claims for the moment the attention, and it again in its turn becomes the stepping-stone upon which the next raises itself, and so on.

Before proceeding further, let me give as briefly as I can an example of a development series worked out, in the main, upon the general line of inquiry inaugurated by Col. Lane Fox. It is commonly accepted as a fact, which is borne out by tradition, both ancient and modern, that certain groups of stringed instruments of music must be referred for their origin to the bow of the archer. The actual historical record does not help us to come to a definite conclusion on this point, nor does the direct testimony of archæology, but from other sources very suggestive evidence is forthcoming. A comparative study of the musical instruments of modern savage and barbaric peoples makes it very clear to one that the greater portion of the probable chain of sequences which led from the simple bows to highly specialized instruments of the harp family may be reconstructed from types still existing in use among living peoples, most of the well-defined early stages being represented in Africa at the present day.* The native of Damaraland, who possesses no stringed instrument proper, is in the habit of temporarily converting his ordinary shooting-bow into a musical instrument. For this purpose he ties a small thong loopwise round the bow and bow-string, so as to divide the latter into two vibrating parts of unequal length. When lightly struck with a small stick the tense string emits a couple of notes, which satisfy this primitive musician's humble cravings for purely rhythmic sound. Among many other African tribes we find a slight advance, in the form of special rather slightly made bows constructed and used for musical purposes only. In order to increase the volume of sound, it is frequently the custom among some of the tribes to rest the bow against some hollow, resonant body, such as an inverted pot or hollow gourd. In many parts, again, we find that the instrument has been further improved by attaching a gourd to the bow, and thus providing it with a permanent resonating body. To achieve greater musical results, it would appear that somewhere in Africa (in the West, I suspect) two or more small bows were attached to a single gourd. I have so far been unable to trace this particular link in Africa itself, but curiously enough, this very form has been obtained from Guiana. It may be thought that I am applying a breaking strain to the chain of evidence when I endeavor to work an instrument from South America into an African developmental series. But, when we recall the fact that evidence of the existence of indigenous stringed instruments of music in the New World has yet to be produced, coupled with the certain knowledge that a considerable number of varieties of musical instruments, stringed and otherwise, accompanied the enforced migration of African natives during the days of the slave trade, and were thus established in use and perpetuated in many parts of the New World, including the north-east regions of South America, we may, I think, admit with some confidence that in this particular instance from Guiana to Guinea is no very far cry, and that the more than probable African origin of this instrument from South America gives it a perfect claim to take its place in the African sequence. I still anticipate that this type of instrument will be forthcoming from some hinterland region in West Africa. Were no evidence at all forthcoming of such a form, either in past or present, we should be almost compelled to infer that such a one had existed, as this stage in the sequence appears to be necessary to prevent a break in the continuity of forms leading to what is apparently the next important stage, represented by a type of instrument common in West Africa, having five little bows, each carrying its string, and all of which are fixed by their lower ends into a box-like wooden resonator. This method of attaching the bows to the now improved body of the instrument necessitates the lower attachment of the strings being transferred from the bows to the body, so that the bow-like form begins to disappear. The next improvement of which there is evidence from existing types consists in the substitution of a single, stouter, curved rod for the five little "bows," all the five strings being serially attached to the upper end of the rod, their lower ends to the body as before. This instrument is somewhat rare now, and it may well be a source of wonder to us that it has survived at all (unless it be to assist the ethnologist), since it is an almost aggressively inefficient form, owing to the row of strings brought into two different planes at right angles to one another. The structure of this rude instrument gives it a quaintly composite appearance, suggesting that it is a banjo at one end and a harp at the other. This is due to the strings remaining, as in the preceding form, attached to the resonating body in a line disposed transversely, while the substitution of a single rod for the five "bows" has necessitated the disposal of their upper attachments in a longitudinal series as regards the longer axis of the instrument. Inefficient though it be, this instrument occupies an important position in the apparent chain of evolution, leading as it does through some intermediate types to a form in which the difficulty as regards the strings is overcome by attaching their lower ends in a longitudinal series, and so bringing them into the same plane throughout their length. In this shape the instrument has assumed a harp-like form—a rude and not very effective one, it is true, but it is none the less definitely a member of the harp family. The modern varieties of this type extend across Africa from west to east, and the harps of ancient Egypt, Assyria, Greece, and India were assuredly elaborations of this primitive form. The Indian form, closely resembling that of ancient Egypt, still survives in Burma, while elsewhere we find a few apparently allied forms. In all these forms of the harp, from the rudest Central and West African types to the highly ornate and many-stringed examples of Egypt and the East, one point is especially noteworthy. This is the invariable absence of the fore-pillar, which in the modern harps of western Europe is so important, nay, essential, a structural feature. In spite of the skill and care exercised in the construction of some of the more elaborate forms, none were fitted with a fore-pillar, the result being that the frame across which the strings were stretched was always weak and disposed to yield more or less to the strain caused by the tension of the strings. This implied that, even when the strings were not unduly strained, the tightening up of one of them to raise its pitch necessarily caused a greater or less slackening of all the other strings, since the free end of the rod or "neck" would tend to be drawn slightly toward the body of the instrument under the increased tension. One can picture the soul-destroying agonies endured by two performers upon these harps when endeavoring, if they ever did so, to bring their refractory instruments into unison, while, as for the orchestral music of the old Assyrian days—well, perhaps we had better not attempt to picture that! The mere addition of a simple, strut-like support between the free end of the "neck" and the body would have obviated this difficulty and rendered the instrument relatively efficient and unyielding to varying tension. And yet, even in western Europe, this seemingly obvious and invaluable addition did not appear, as far as I can ascertain, until about the seventh or eighth century A. D.; and even then it seems to have been added somewhat half-heartedly, and a very long time had yet to elapse before the fore-pillar became an integral part of the framework and was allotted its due proportion in the general design.

I have purposely selected this particular series for my illustration, not because it is something new—indeed, it is already more or less familiar, and may be has even some merit in its lack of newness, since, in accordance with a popular dictum, it may urge a greater claim to be regarded as true—nor because it is specially striking, but rather for the reason that it illustrates suitably several of the points upon which I wish briefly to touch. Even in the severely condensed form in which I have been obliged to present this series of developments from bow to harp, there is, I think, demonstrated the practical application of several of the general principles upon which is based the theory whereby Col. Lane Fox sought to elucidate the phenomena of human progress.

A series of this kind serves, in the first place, to demonstrate that the absence of historical and archæological evidence of the actual continuity in development from simple to complex does not preclude investigations into the early history of any product of human ingenuity, nor prevent the formation of a suggestive and plausible if largely hypothetical series, illustrating the probable chain of sequences along which some highly specialized form may be traced link by link to its rudimentary prototypes, or even to its absolute origin, which in this particular instance is the ordinary shooting bow temporarily converted into a musical instrument. Where an actual chronological series is not forthcoming, a comparative study of such types as are available, even though they be modern examples, reveals the fact that, if classified according to their apparent morphological affinities, these types show a tendency to fall into line, the gap between the extreme forms—that is, the most simple and the most advanced—being filled by a succession of intermediate forms, more or less completely linked together, according to the number of varieties at our disposal. We are thus, at any rate, in possession of a sequence series. Is it unreasonable for us to conclude that this reflects, in great measure, the actual chronological sequence of variations through which in past times the evolutionary history of the instrument was effected from the earliest rudimentary form?

(To be concluded.)

* The Natural History of the Musical Bow, by H. Balfour: Clarendon Press, Oxford.

GERMAN MAPS.

A FAMOUS firm of map makers in Germany asserts that throughout its century of cartographic enterprise it has never used an atlas sheet in the compilation of any of its maps. In other words, it goes always to original sources for its material. It never trusts to the compilations and generalizations of geographic facts made by others. It takes only information at first hand, from the first rough route reconnoissance to the finished and scientific detailed survey; determines with trained critical sense its value for mapping, and uses it accordingly. Many of its maps, of course, require new editions in a year or two, but this is because new or more accurate facts have become accessible and not for the reason that the cartographers failed to use all the best material within reach when the map was made.

This firm has a geographical and map library that is supposed to be the most complete collection of the kind yet made. It includes all original map material and literary matter that will help the cartographer. It is collected in all languages and from all sources. The modest sketch map of the missionary traveler who first sets foot in an unknown region is treasured as well as the completed survey. The sketch is for the time the best thing obtainable; it is doubtless an approximation of the truth relating to some of the broader facts, and it is used until supplanted by something better. This great mass of material is not only classified and indexed, but also annotated, so that anything of the slightest helpfulness to the map maker is readily found.

Two other principles in the conduct of this business have helped to make the celebrity of its products. One is that the cartographer is also the geographer in making the map. He must combine the highest cartographic skill with geographic attainments that give him high rank in that line. The whole work is his—not only the mechanical execution, but also the geographic content. Like the sculptor who employs an assistant in fashioning his marble, so this map maker may have the services of a subordinate draftsman in some details, but he is responsible for the whole work and does most of it himself. The other principle is that time counts for nothing in the production of a map. There is no such thing as hurry. If a man wants months in which to turn out a map plate, he may have them if he says the best results require the time.

One of the latest maps from this house is an atlas sheet giving a general view of the Russian, Chinese, and Japanese empires. Covering so vast a territory on one sheet, the scale is necessarily very small. It is 1-20,000,000, or about 315 statute miles to an inch. It is of course impossible to give much detail on so small a scale, but the broader features of all phases of the geography of the whole northern and central region of Asia and Russia in Europe are given so clearly that they really force themselves upon the attention; and we know that this representation of the facts is up to date, for the figures 1904 are printed in a corner of the plate. We may give an illustration of the way in which facts are handled, confining ourselves to a few features of the hydrography.

Suppose it were possible that a man with ordinary experience in map reading knew nothing of the hydrography of this large part of the world. This small map alone would enable him to get a clear idea of it. He would find the very valleys in which the large and smaller streams rise, if the surveys have given us this information. He would see that on the long course of the Yangtse Kiang from the Tibetan highlands to its mouth there are four stretches, long and short, of the upper river that have not been traced; and these stretches are represented by broken lines, for the windings of the river, of course, cannot be shown; but he will see that the northern branch of the headwaters had been studied, and he will observe the little lake through which it runs and the mountains that feed it. He will also observe that the southern branch of the head streams is less known, though it has been proved to be divided into three streams.

He may take each river in the same way and he will be able to write correctly of the general features of the country through which it passes, of the causes that determine its course, of the differences of elevation above the sea of its upper, middle, and lower basin, and of the parts of it that have been explored and the parts that are still conjectural. Most maps show the great Brahmaputra as though it were entirely known, but this map shows three sections as still unexplored, One of them is where it bursts southward through the mountains to the plain of India. We know now that this mountain section is a part of the Brahmaputra, though the fact was long disputed. Marked logs set afloat on the Sangpo of Tibet have been picked up in the Brahmaputra of India, but owing to the hostility of the natives the mountain section has not yet been traced.

The brief allusions made here to the methods of one German house are by no means confined to it, for

other map producers of that country equal or have nearly attained to the same effective results.

Our own commercial map houses are making encouraging progress in the quality of their work, but the maps they give us will show better results if they set before them the highest standards as something to be finally attained. We have much to learn and many processes to revise before our ordinary map products become really good. One trouble is that those who order map plates usually want them in a great hurry; good or bad, they must be delivered in a few weeks. Then, many of our map makers have not learned how to generalize on their small atlas sheets the information contained on large-scale surveys; and the result is that they benefit little, for example, by the splendid topographic sheets issued by our government. There are not a few other weaknesses in our methods that help to give commonplace results, but some improvement is evident from year to year.

The public soon throws a book aside that is ignorant and untrustworthy. It would help map making along if the public were to reject every map sheet that demonstrates its unfitness by leading us constantly astray; and there are thousands of them, even in our schools, that do this very thing.—New York Sun.

THE BRITISH ADMIRALTY'S REPORT OF THE TUBULAR BOILER.

THE British Admiralty Committee, which has been engaged for the past four years upon the subject of cylindrical tubular boilers, has published its final report. Prolonged trials with various types of the latter class of steam generators have been carried out upon three vessels. In this report the committee reiterate the decision which they published in their interim report in May, 1902, the gist of which was published in the SCIENTIFIC AMERICAN, in which they expressed the opinion that it is undesirable to fit any more Belleville boilers in the navy. There is thus every probability of this type of water-tube boiler being entirely discarded. In their interim report the committee pronounced that there were four types of water-tube boilers which were sufficiently promising to justify their use in combination with cylindrical boilers. These were the Babcock & Wilcox, Dürr, Niclausse, and the Yarrow large tube. Since then severe and protracted experiments have been made with these four types, and now they announce that two of these boilers, the Babcock & Wilcox, and the Yarrow large tube, are satisfactory, and are suitable for use in large battleships and cruisers exclusive of combination with the cylindrical boilers. The committee has not discovered which of these two types is superior, as each has several particular advantages, and only long experience will determine which is the best all-round and serviceable boiler. The committee state that the up-keep of any type of water-tube boiler is heavier than that of cylindricals, but they state that they are of opinion that the two they have enumerated will prove less costly to maintain than any others that have been under their observation.

THE CONSTRUCTION OF AN INDICATING OR RECORDING TIN PLATE ANEROID BAROMETER.*

By N. MONROE HOPKINS, Ph.D.

HAVING designed and constructed a very successful aneroid barometer out of simple tin plates, for use in reading gas volumes, etc., in the physical and chemical laboratory, it occurred to the writer in view of the exceedingly simple construction, that others might be interested in such an instrument. The barometer finds equal use of course in the home as a forecaster of storm, if the principles upon which it is dependent are properly appreciated and understood. For a full discussion of the barometer and its place in weather forecasting the reader is referred to any good work on the barometer, or standard book on meteorology, the present article dealing only with the construction of the apparatus.

Fig. 1 shows the style of instrument first made by the writer, and which has proven exceedingly reliable. In this barometer twelve tin plates are used, forming six air-tight chambers made by soldering around the edges two of the plates, leaving a little puncture at the top as will be described in detail later. These six chambers when exhausted of the air which they contain, impart to a slender wooden pointer, thirty-six inches long, a movement over a scale of about twelve inches when the barometric pressure changes to a marked extent, as it does frequently upon the approach of a storm. In other words, when an ordinary mercury barometer falls two inches, the pointer of this particular instrument will travel about twelve inches over the scale. The instrument can be made even more sensitive than this by increasing the number of plates, or tin chambers in the chain, although six of these chambers or drums will prove amply sensitive for all practical purposes where an open scale is required, as in the case of reading gas volumes, and in weather forecasting. For such work as comparing and reducing gas volumes to a standard condition, it will be necessary to first compare and calibrate the aneroid with an ordinary mercury instrument.

Let us take up this particular barometer in detail, and set down the directions for its construction. The moving part consists of a brass lever of the shape indicated in the drawing, cut from brass ⅛ inch thick by means of a hack saw, and smoothed up with a flat file. The bearing upon which this lever turns is made by drilling a small hole in the center of its heavy end, which receives a short piece of tiny brass tubing, to be soldered in truly at right angles. At a distance of ¼ inch from this little bearing tube, a piece of ⅛-inch

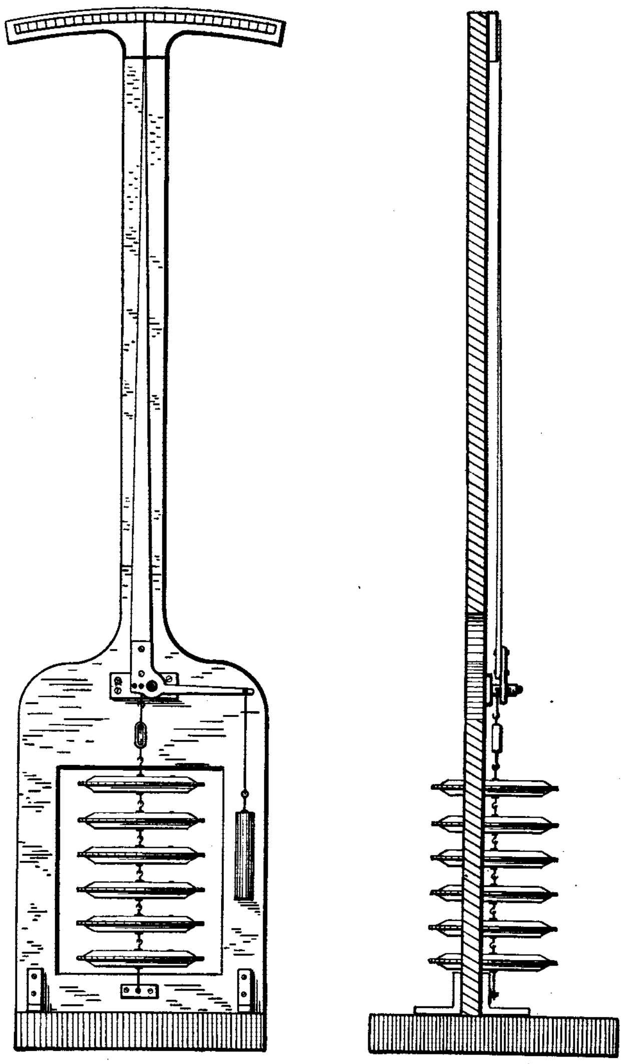


Fig. 1.—Front and Side Views of Sensitive Indicating Tin Plate Barometer. The Six Plates Hung in "Series" Produce a Movement in the Pointer of 12 Inches Over the Scale when the Barometric Pressure Changes from High to Low, as it Frequently does Before a Storm.

steel rod is tightly screwed in, from which the tin plate chambers hang. A second hole may be provided at a little greater distance and be equipped with threads also into which the little pin may be screwed in case it is wished to make the barometer less sensitive. At the extreme right of the lever, which is about five inches long, a small hole is drilled from which the weight hangs. This weight must be adjusted to the particular barometer for which it is intended, and should therefore consist of a brass tube with the lower end closed into which shot or melted lead may be poured until the instrument is properly

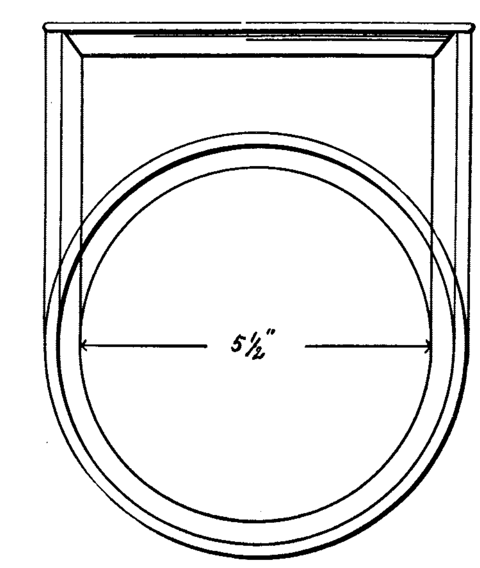


Fig. 2.—Diagram of Tin Plate Best Suited to the Construction of a Barometer.

balanced. As plates come in different thicknesses of tin, etc., no set rule can be given for determining this weight, and it must therefore be made by trial. The steel pin which enters and supports the lever from behind, comes out from a little brass plate at the back into which it is firmly screwed, the little brass plate being in turn screwed to the wooden support.

As this portion of the barometer is so very simple it will not be necessary to dwell upon it at length, except to state that a knife edge support, which is a little more elaborate, makes even a more sensitive and better instrument. An idea of this knife edge support can be had by a glance at the recording barometer. In this case, in place of the little sleeve bearing and steel rod, a knife edge and hard steel support are substituted, and the writer recommends this style of construction as being best.

The wooden pointer is made from ¼-inch pine tapered to a slender point both ways, that is to say in

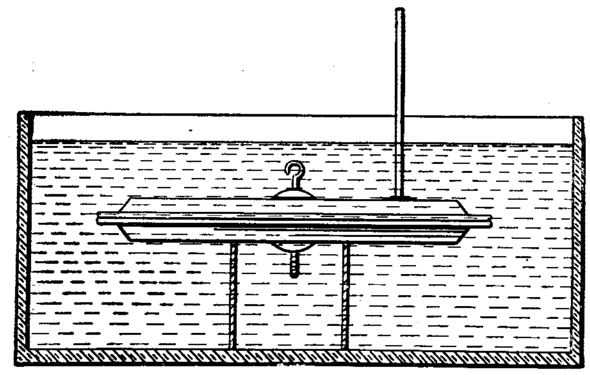


Fig. 3.—Method of Ascertaining Whether or Not a Tin Plate Chamber has been Hermetically Soldered.

breadth and thickness. It is attached to the upper lug of the little brass lever by brass bolts which pass right through the wood, securing it firmly to the brass on turning down the nuts.

The wooden frame and support may be cut from pine wood ⅞ inch thick and be mounted upon a heavy base board by means of screws and brass angles. This woodwork should be planed, sandpapered and neatly shellacked with orange shellac in alcohol, for appearance. The total height of this wooden upright should be fifty inches, and its width at the base eleven inches, with a rectangular opening at the bottom of at least seven by ten inches if six-inch plates are to be employed. Of course these directions are only general in character as the type of instrument and plan of making allow of considerable margin. Fig. 2 indicates an efficient shape of tin plate to buy, and is sold for making pies. The accompanying figure is drawn to scale, and represents the proportions of the plate used in the barometers described, although any plate closely approaching this should answer equally well.

These plates cost three cents apiece, so it will be seen that the principal part of the barometer is not very costly, and it is recommended that a few more plates than are actually needed be purchased for purposes of experiment in soldering, etc.

The first step in the making of the exhausted chambers from the plates consists in accurately finding the centers for the hooks, which are conveniently bought at hardware stores, and which are known as cup

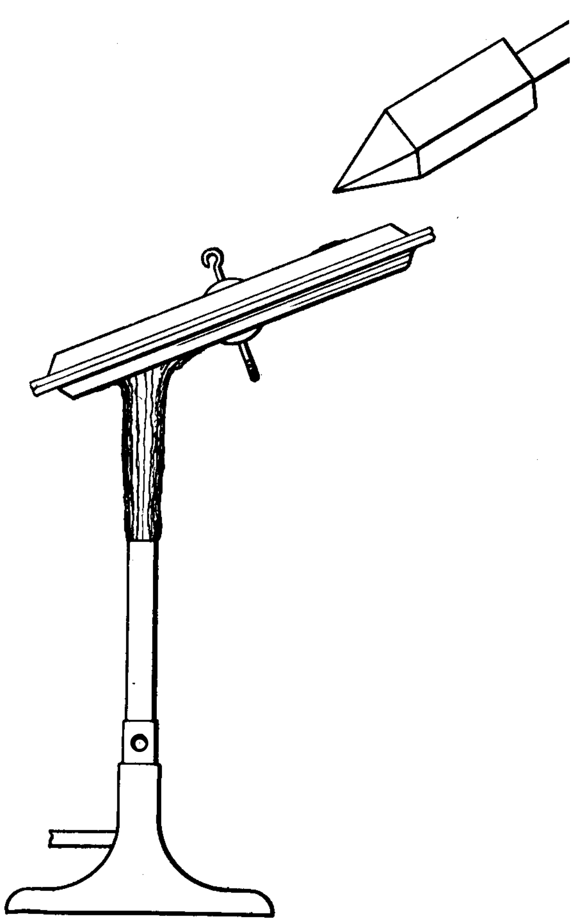


Fig. 4.—Scheme of Producing Vacuum and of Soldering up the Tin Plate Chamber.

hooks. The smaller size serves best for our purpose. These little hooks must be placed exactly in the centers of the plates, for otherwise the chambers would not hang horizontally, which would greatly mar the appearance of the furnished instrument. To get the centers of a number of plates it will pay to strike out from cardboard a disk with compasses of such a size as to fit closely into the plate. The center of the compass will then afford a place for the punch with which a small hole is made to receive the screw of the

* Specially prepared for the SCIENTIFIC AMERICAN SUPPLEMENT.

hook. These little hooks are screwed in as far as they will go, and are then carefully soldered airtight from the inside. It is also very important to cut off the projecting end of the screw, for it would defeat the object of the barometer to have them meet and touch within the chamber. Be absolutely sure the hooks are soldered in airtight before soldering the two plates

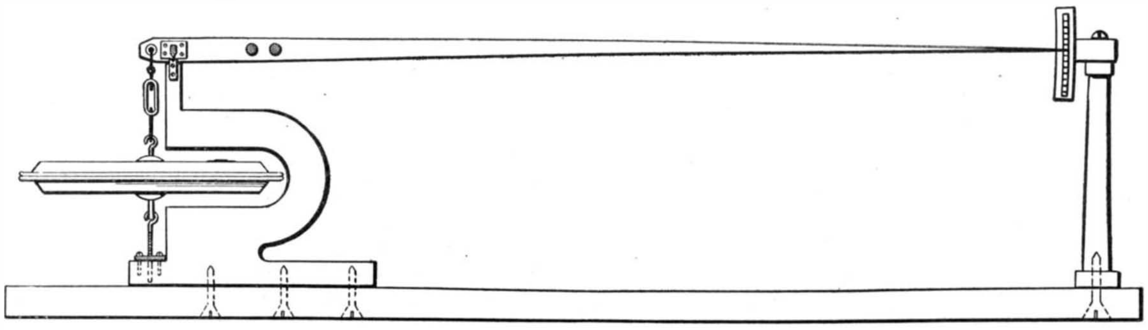


Fig. 5.—View of Simple Indicating Tin Plate Barometer. This Instrument is About as Sensitive as the Ordinary Mercury Barometer, and is Provided with a Scale About 3 Inches Long.

necessary for a chamber, around the edges, as it will be too late to do this neatly after the chamber is made with a leak about the hook.

Fig. 3 indicates how the plates forming the chamber are tested for tightness after being soldered around the edges. Do not attempt to solder these chambers without first making a small puncture in the upper plate for the expanding air to escape from under the heat of the soldering iron. If this is neglected, the

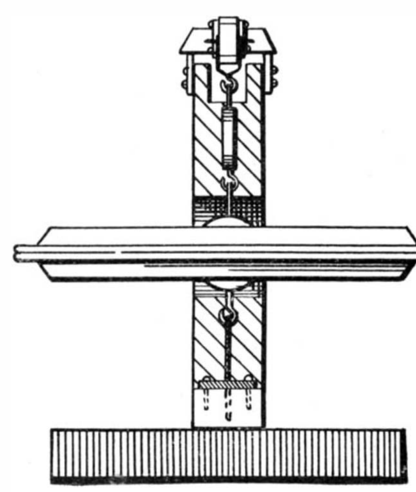


Fig. 6.—End View of Simple Indicating Tin Plate Barometer, Showing Knife Edges and the Method of Mounting.

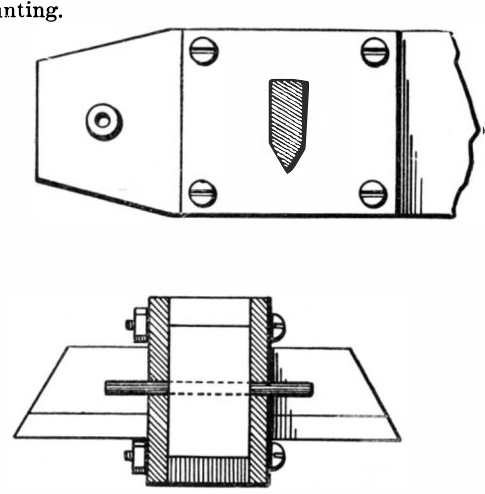


Fig. 7.—Detail of Knife Edge and the Method of Mounting in the Simple Tin Plate Barometer.

expanding air will blow through the fluid solder before it hardens, and leave minute holes. These little punctures if made with a punch must be smoothed down to the level of the plate, for they are to be covered with small disks of tin soldered on after exhausting. When the plate has been as carefully soldered as possible, and after a minute inspection, it is immersed in a vessel of water as shown, and an air pressure put upon the inside by means of a small blow

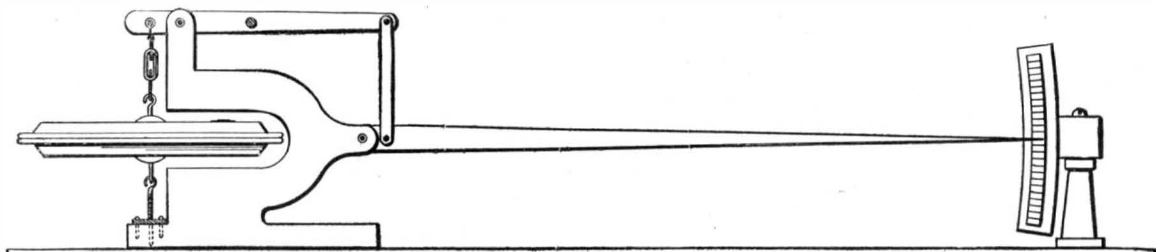


Fig. 8.—View of Single Tin Plate Barometer Made Sensitive by the Use of Multiplying Lever. The Pointer Moves Over a Scale About 12 Inches Long with Extreme Conditions of Barometric Pressure.

pipe provided with a rubber terminal to insure an airtight connection. If any bubbles appear around the edge, the entire success of the barometer depends upon their being detected, and the openings closed. Remember that these chambers are the all-important part of the barometer, and must be made absolutely airtight.

Fig. 4 illustrates the final step in the making of the air-tight chambers. The little puncture is treated with a solution of zinc chloride after brightening up with a file, and is tinned with solder. A little tin disk about the size of a dime is cut out as a cover and is also treated with the soldering salt and tinned. The chamber, with the little hole uncovered, is now rotated above the flame of a Bunsen burner or alcohol lamp and heated up as hot as possible without melting the solder on the edge. This is done to expand and drive out the contained air, when the little tin disk is slid over the puncture, and carefully soldered

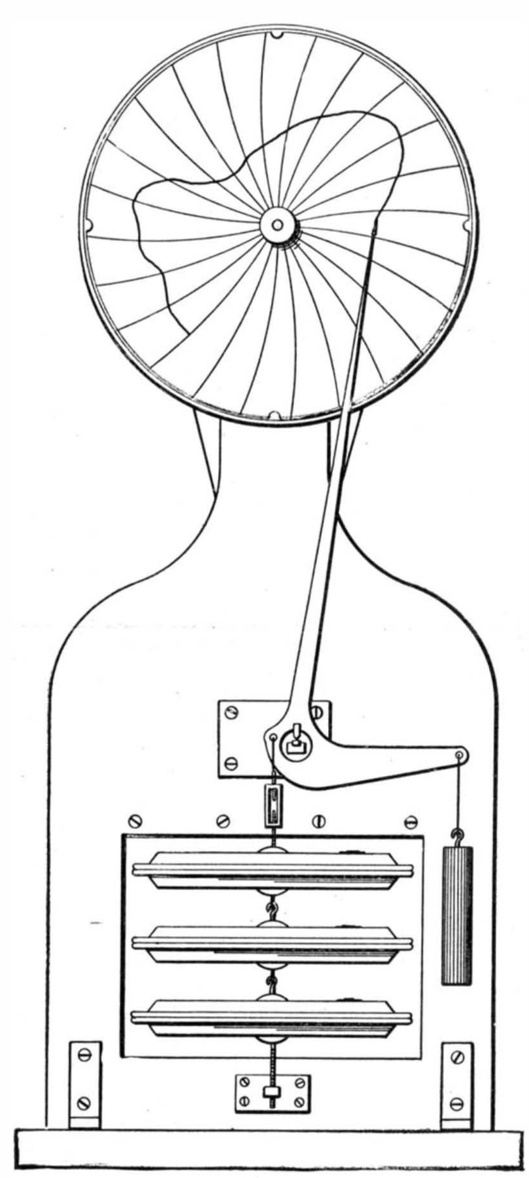


Fig. 9.—Front View of Recording Tin Plate Barometer. The Three Plates in "Series" Produce a Bold Movement Over the Revolving Scale and Leave a Permanent Record of the Atmospheric Pressure.

on airtight. While the little cover is being soldered on, the chamber is still kept heated. When the little cover has been properly placed and the surrounding solder has had time to solidify, the chamber may be withdrawn from the flame and allowed to cool. It will be noticed in a few minutes, if the chamber has been closed perfectly airtight, that the tops and bottoms of each chamber take on a slightly concave shape from the pressure of the atmosphere without. It will be argued that the vacuum within, as a result of this process, will not be very high, but it serves admirably the purpose. The writer has made a much higher vacuum by putting about a teaspoonful of water within the chamber, and boiling it off, and soldering up the little puncture while the steam is issuing. With this plan the steam drives out practically all the air, and when the steam condenses upon cooling, it leaves a very perfect vacuum. There are two objections to this method. In the first place the tin chambers are likely to be crushed out of shape by the great pres-

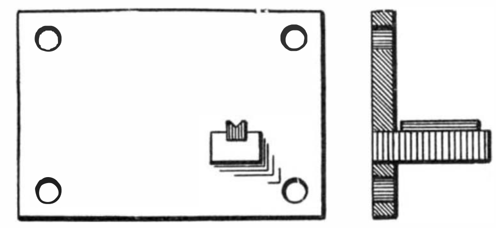


Fig. 10.—Detail of Knife Edge Support for the Recording Tin Plate Barometer.

sure of the atmosphere, as was the case in about four chambers out of five treated in this manner, and secondly the chambers are left with a little water on the inside, which in time will go through the tin and rust out the under iron, and in time might eat right through the chamber and put it out of commission. The objection to leaving a little air behind in the chamber, as must be the case with heating simply to

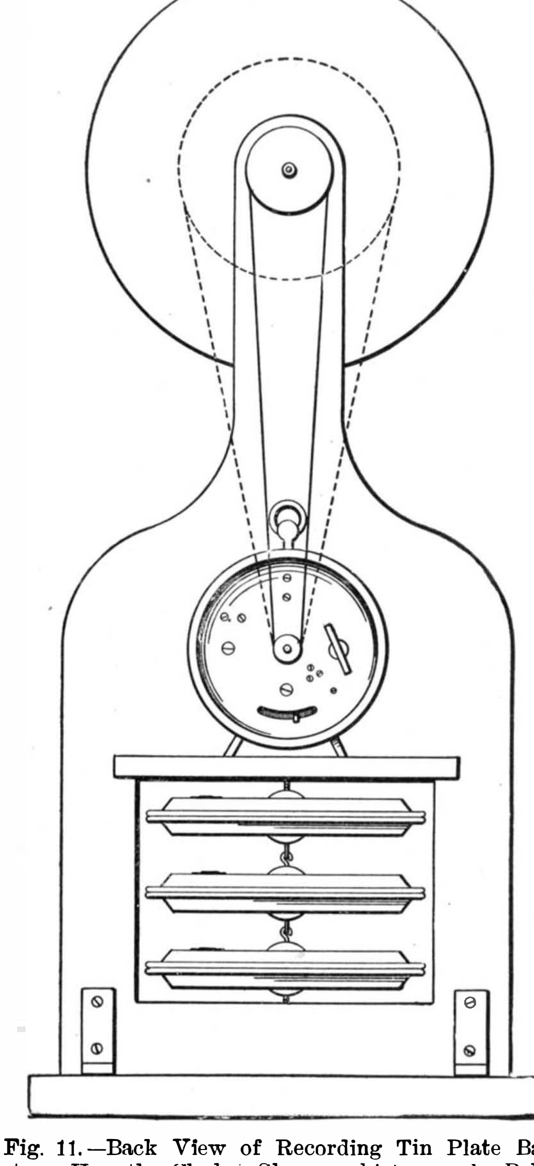


Fig. 11.—Back View of Recording Tin Plate Barometer. Here the Clock is Shown, which may be Belted to Drive the Revolving Disk at Any Predetermined Rate from One Revolution per Day to One Revolution per Month.

expand it, lies in the fact that the barometer will have a slight temperature error, but this has proven so small that it may for all practical purposes be neglected. All barometers have this small temperature error due to one cause or another, but fortunately it is so small as to be of no great moment.

It only remains to hang six such completed chambers in series in the recess made by cutting out the center of the supporting frame, as indicated in the first illustration. The bottom plate is attached to a pin in a little brass block, and the hook of the upper plate is attached to a small turn-buckle, by means of which the pointer is brought to the center of the scale after attaching the counterweight. Fig. 5 illustrates a much simpler form of indicating barometer using only a single chamber. This instrument, of course, is much less sensitive, that is, has a much shorter swing to its pointer. The support for the chamber may be cut from heavy brass or wood, and is attached to a suitable baseboard. The pointer can be made any convenient length, only the longer the pointer, of course, the greater the range. The instrument illustrated is made entirely of wood with the exception of the tin chamber. Fig. 6 shows an end view of this barometer, making the method of supporting the knife edge clear. The wooden support is notched out, and two metal plates are screwed to either side upon

which the knife edge rests. As pointed out in the description of the sensitive six-chamber barometer, the use of a knife edge support is by far the best, although a simple pin passing through will serve the purpose. When a simple pin support is employed, the index lags a trifle, and it is necessary to tap the barometer gently to get its true reading, for the friction of the common pin bearing causes the pointer to stick to a small extent. Fig. 7 illustrates the detail of the knife edge and the plan of mounting it. The knife edge is easily filed from a piece of good steel, and may be tempered by heating, and cooling suddenly in water or oil after shaping and sharpening. It is soldered truly into an opening in a small brass plate, which is bolted through the wooden pointer to a second brass plate also cut out to receive the knife. The two little shaded circular disks on the pointer to the right of the knife edge support are two small lead weights which run right through the pointer to act as a balance. Two or more may be required, but they must be added by trial after the completion of the barometer.

Fig. 8 illustrates a similar, simple single-chamber barometer, but provided with a multiplying lever to give a greater throw to the pointer. This instrument is provided with common pin bearings, as can be seen, but it may, of course, be equipped with knife edges if one is willing to undertake the additional work. A more elaborate system of compound levers may of course be added, thus increasing the range.

Fig. 9 illustrates a recording barometer easily made upon the same general plan, only in place of the usual scale a revolving plate is employed. This barometer may be made with any number of chambers, but for ink records three chambers appear to give the best results. The lever must be mounted upon a good knife edge, for there will be a little friction at the pen, which is so adjusted as to just touch the paper upon the revolving disk, and it is desirable to reduce all friction as much as possible. The amateur can learn more about weather forecasting by the use of such a recording instrument than in any other practical way, for it leaves the story behind for filing away with notes. Fig. 10 shows the detail of the support for the knife edge. It consists of a little piece of hard steel with a shallow groove filed into its upper side to receive the little hardened knife. The knife in the present instrument is truly soldered into the brass lever within an opening, as shown in Fig. 9. The support is soldered into the little plate near the lower right-hand corner in order that the plate may be in the center of the support. This makes the barometer look better balanced. Fig. 11 shows this recording barometer from the back, and illustrates the little shelf upon which the driving clock is placed. This clock is provided with a small wooden pulley with a groove into which is snapped a rather wide rubber band. This is done to provide a good friction surface for the driving belt. The revolving disk is equipped with a similar rubber band over which a belt of waxed string passes. The disk, which must be mounted upon a delicate bearing, insuring as much freedom from friction as possible, may be driven at any predetermined rate by simply varying the diameter of the large pulley. In the drawing the solid line represents the disk rigged for rapid turning, and the dotted line represents it for slow motion. The clock as here depicted is only a common twenty-four-hour timepiece, but it will be seen that any good eight-day clock may be substituted and the instrument may be elaborated in many other ways. The little pen at the top simply consists of a little piece of bent tin designed to hold a few drops of non-drying, glycerine recording ink. Now for a few words of final advice to those who have not had experience with barometers. When this instrument is properly completed and set up for observations (this statement applies to all the barometers described here) some of the readings will appear to the novice as being very erratic. It will take perhaps several weeks to get well acquainted with the meaning of the indications. Do not expect to become an infallible weather bureau at once! The writer also strongly advises the making of a common, straight-tube mercury barometer with which to compare the behavior of the aneroid. To do this procure from any dealer in chemical and physical glassware a thick glass tube about one-quarter inch internal diameter, and close one end by fusing in a blast lamp. Fill this with mercury as solidly as possible, that is as free from air bubbles as possible, and invert in a small vessel of mercury. The tube should be firmly supported in some way, and should be provided with two little paper collars which may be slid up and down, serving as indicators of minimum depression and maximum elevation. If the tin plate aneroid has been carefully made according to the directions herein given, the pointer will follow the motions of the mercury in the tube, only to a much more marked extent. By making such a comparison with a tube of mercury, the maker of the aneroid will be assured that his instrument is properly detecting and indicating or recording the true barometric conditions. The appearance of the barometer is greatly increased by nickel plating the chambers.

Unnumbered native Ohioans, not to speak of hundreds of thousands of residents of this State who have come from foreign lands and other States of the American Union, must have wondered why a fertile and productive tract in northern Ohio, a district which in no way hints the ravages of fire, should be called the "Firelands." Among all the vicissitudes of Ohio's early history great conflagrations were notable for their absence. No such terrible forest fires swept this State as ravaged large areas in Michigan and Wisconsin seventy or eighty years later. The fires to which the name refers raged in Connecticut, not Ohio, and they were the work of British and Tory soldiers, instead of the result of accidents or natural causes. In 1781, when the long struggle for independence was nearly ended, Benedict Arnold commanded an expedition which ravaged the Connecticut coast of Long Island Sound. He burned New London and other towns and left behind misery and destitution, as well as a more bitter hatred than he had earned before that outrage upon his native State. This and other cruel and senseless attacks upon Connecticut towns left so strong a feeling of sympathy and injustice behind that in disposing of Connecticut's rights in lands now forming part of Ohio, 781 square miles in the extreme western edge of the Western Reserve were set apart to be donated to sufferers by the British raids. Five ranges of townships running north and south were included in this tract. Sandusky Bay and Lake Erie extend so far southward at this point that the five ranges of townships contained only about 500,000 acres of land. The tract measured some 27 miles by 30. The Connecticut sufferers from the torch of the enemy lived chiefly in New London, Norwalk, and Fairfield, and it was from those towns that many of the settlers of the "Firelands" came to build in the Ohio wilderness settlements bearing the same names and having like civic ideals and character. —Dayton Herald.

SNAILERIES.

THE rearing of snails as a food-product is by no means a new industry, and it is to-day carried on in various European countries, especially in France and Italy. Many species are regarded as edible, but the large white snail (*Helix pomatia*) seems to be the snail that is generally preferred. The Romans reared this species in enormous quantities in gardens or inclosures, banked or surrounded with ashes and sawdust, so that the snails could not get out, feeding them on bran and sodden wine. The snaileries are said by Pliny to have been invented by Fulvius Herpinus some time before the civil wars between Cæsar and Pompey; and from another Latin author, Varro, we learn all about snail-stews and how to make them. It is from the Roman period that snails as delicacies have descended to us. According to Varro, the Romans also grew their snails so large that the shells of some would hold ten quarts!

Besides rearing these wonderful snails in *cochlearia*, they also drew supplies from Capri, Sicily, and the Balearic Isles, as we learn that from these places came the snails that were most prized in the Roman market. The Romans further acclimatized this gasteropod, and spread their taste for it, in all the provinces they conquered, Gaul or France retaining the taste to this day.

The *Helix pomatia* is in England an introduced and not a native snail, and is called the Roman snail, because it is generally supposed to have been brought here by the Romans, though tradition has it that it was first introduced by monks into Cambridgeshire, and also that it was introduced into Surrey—where it is known as the Italian snail—by one of the Countesses of Arundel. The *Helix pomatia*, however, whether introduced or not, is now found from Finland to Lombardy.

All edible snails are nocturnal hermaphrodites, and belong to a family which are distinguished into three groups: sea, fresh-water, and land snails. Our interest at present lies with the last-named. Besides *Helix pomatia*, the other snails that are used as food are *Helix aspersa* (the common garden-snail) and *Helix nemoralis* (the wood-snail). In the Midi of France they prefer *Helix vermiculata*, *H. aperta*, and *H. pisana;* in Italy they eat *H. lucorum;* and the edible snail in Mexico is *H. buffoniana*. In the United States edible snails are frequently to be seen exposed for sale; but they are not raised in that country, and those on sale have been shipped to America alive from Europe. In Vienna, again, during Lent there is a large snail-market, the snails coming in barrels from Swabia. The great center for the consumption of snails, however, is Paris and some of the French provinces. There is, indeed, a very large trade in this commodity in France, the large white snail being in special demand in Paris, while the garden and wood snails are in common use among poorer consumers in all parts of France. Snails are a recognized dish in French menus, and the *maitre d'hotel* can serve you snails *à la Cettoise*, or *Marseillaise*, or *Parisienne;* or *Bourguignonne*, or *Bordelaise*, all being excellent ways of disguising the snail. For example, if we take the last-named, *Bordelaise*, it is simply a combination of snails, red wine, butter, and garlic. Frenchmen also take snails medicinally for phthisis and catarrhal troubles, preference being given to preparations made from or with raw and uncooked snails. Under the name of *hélicine*, a powder is also sold in France which is said to have absorbed the juice of the snail.

It must be confessed that snails by themselves make a very insipid dish, but this is relieved by the strong condiments that are generally used; yet owing to their glutinous nature, snails still remain a difficult morsel to digest—that is, if the condiments used do not excite the secretion of gastric juice. They should generally be consumed immediately after they are gathered, after having been purged of all noxious vegetable substances that they may contain. Instances of poisoning have been known to occur when the snails were picked off henbane, belladonna, and other plants of like nature; but accidents of this kind are avoided when snails so gathered are first subjected, as is the usual custom, to a lengthened period of fasting before being used.

The production of snails in France is now not equal to the demand, and large quantities are yearly imported from Italy, Switzerland, and Germany. During the Paris Exhibition of 1900 there was such a scarcity of snails in the Paris market that at one time prices rose as high as fifty-five francs per thousand. The wholesale trade in snails in Paris is carried on in Pavilions Nos. 9 and 11 of the Halles Centrales, and here from sixty to eighty millions of snails are received yearly. Commercially, only two kinds of snails are known, the one called *gros blanc* (large white) or *escargot de Bourgogne*, and the other *petit gris* (the small gray).

In this snail market there are two seasons, called respectively *coureurs* and *bouchés*. In the first period, which extends from 15th April to the end of May, *gros blanc* sells at from eight to ten francs per thousand, and *petit gris* from two to three francs. The second period is divided into two; the first, called *voilés*, extends from 1st September to 15th October, the price for *gros blanc* ranging from twelve to fourteen francs, and for *petit gris* about four francs; the second is the *bouchés* proper, extending from 15th October to April, and in it prices average about eight francs for *gros blanc* and five francs for *petit gris* per thousand.

The snails that are sold in the period of *bouchés* have generally been kept in snaileries (*escargotières*), where at the first frost they inter themselves about ten to fifteen centimeters deep, and secrete a slime, which, mixed with the earth, forms a cement. The snails sold during the *voilés* period are those which have not been placed in preserves after being picked up, but have been simply shut up in pens, where through want of nourishment or from unnatural conditions they have only formed at the entrance to the shell a simple veil of slime.

Snails, as has already been noted, are nocturnal in their habits, moving about and eating during the night, especially so during the rains of spring. In the period known as *coureurs* they are gathered on dewy mornings or after heavy showers; consequently when there is a wet spring enormous quantities come to hand in the markets of Paris. It may be added that they are "moist goods" to handle, and therefore become easily heated, and deteriorate in three or four days. It is during this season that they are sold in the streets of Paris from small carts. The snails that are dispatched to the Halles Centrales are packed in cases, baskets, or sacks containing from five hundred to two thousand each, the cases being pierced with holes for aeration. With respect to the snails that come to hand in the *voilés* and *bouchés* period, these are generally sold by private contract to grocers, pork-butchers, wine-sellers and restaurant-keepers, who prepare them and sell them to consumers.

Independently of Italy, Switzerland, and Germany, the Parisian supplies of *gros blanc* are principally drawn from Somme, Aisne, Sarthe, Seine-Inférieure, Limousin, Savoy, and Auvergne. The snail crop or harvest in these regions principally comes in as *coureurs*, but an important quantity is also received as *bouchés*. The supplies of *petit gris* are drawn from Manche, Calvados, Pas-de-Calais, Charente, Vaucluse, and Deux-Sèvres, and come almost entirely as *bouchés*, being forwarded in cases or baskets or in kegs.

The collecting of the snails is carried on in the provinces all day long by men, women, and children, who with iron hooks search for them at the foot of thorn-hedges and under ivy, and in winter in old walls. If lucky, a good searcher will collect from one thousand to fifteen hundred snails. These are paid for according to their weight, about a thousand snails averaging ten kilogrammes, and the payment varies with the prices current in the Paris market, but it usually ranges from twenty to forty centimes per kilo. This work, therefore, cannot be said to be well paid. The result of allowing children to collect them has been that they pick up and bring in snails that are unsalable, and as these are thrown away, broken, or in other ways made useless, the snail-population of the country, through the loss of immature young, is rapidly decreasing.

Generally the slack time in the snail market is during May and June, when the collectors endeavor to restrict their collections so as to place more on the market in August and September. In some cases, instead of being sent to market the snails gathered are held in reserve by being kept in snail preserves or gardens. The size of these snaileries, or, as the French term them, *parcs à escargots* (snails' pens), varies greatly according to the number of snails they are intended to stock. In these pens are a number of shelters about two meters long and one meter broad, and each of them looks like a wooden roof laid on a bed of soil having a slight slant. They are so placed that round about each of them food for the snails may be grown, and every morning the keeper has to pick up and replace the snails that have wandered about during the night in search of food.

Snail gathering and preserving does not seem to be at all profitable, and curiously enough we now find many French authorities expressing the opinion that snails, as an edible commodity, trade a good deal on their ancient fame. Only last year, according to Le Journal d'Agriculture Pratique, the ques-

tion was put, "*L'élevage de l'escargot est il possible économiquement?*" and to it the answer was given, "*Nous répondrons sans hésiter; Non.*" It is possible, therefore, that snails will some day be a lost or exceedingly rare commodity so far as French cooks and gourmands are concerned. Undoubtedly the edible snail is getting very rare in certain parts of France, and it is possible that there may come a period when a few edible snails will be kept and exhibited at the Jardin des Plantes in Paris as unique specimens of an animal which through man's gastronomic voracity has disappeared. The loss will not be felt in England.—Chambers's Journal.

INFLUENCE OF TEMPERING ON THE ELECTRIC RESISTANCE OF STEEL.*

In previous researches I have shown that the electric resistance of steels with 0.85 per cent of carbon, attained after tempering a value one and a half times greater. M. Barus found that for hard steels this resistance could be more than tripled, but he gives neither the compositions of the steels which he studied nor the temperature of the tempering; he indicates only their source. There was such a disagreement, that new experiments seemed to me necessary.

I must state that steels of the same production as those of M. Barus have given me a proportion of carbon of 1.16 per cent, that means essentially superior to that of the steels which I employed. I have discovered that tempered at 950 deg. C., they attained a triple resistance. I had not in my first researches passed beyond a temperature of 750 deg. C., which is that employed industrially for hard steel for tools; their quality is the better, the lower the temperature at which they have been tempered.

Influence of the Temperature on the Tempering.—The first point to elucidate was the influence of the temperature. I present two series of experiments relating to steels having 0.84 and 1.13 per cent of carbon.

Steel with 0.84 per cent of carbon—Resistance at 15 deg. C. = 16.

Temperature	710° C.	740° C.	810° C.	850° C.	1000° C.
R. after tempering / R. before tempering	1	1.3	2.1	2.2	2 2

Steel with 1.13 of carbon—Resistance at 15 deg. C. = 18.

Temperature	710° C.	740° C.	810° C.	850° C.	950° C.
R. after tempering / R. before tempering	1	1.3	1.6	2.1	3

These results show first that tempering does not modify the electric resistance of steels, except when it has been effected above the temperature of recalescence (710 deg. C.); the condition is therefore the same as for the changing of mechanical properties. The electric resistance increases afterward with the temperature to a value which is the higher as the steel is richer in carbon. The increase of resistance which the iron experiences through the presence of the carbon in the tempering, is on an average 45 microhms per 1 per cent of the weight of carbon, or 7 microhms for one atom in a hundred of the same body. This is precisely the increase which I have found previously for silicium.

It is known through the researches of M. Osmond that the carbon during the tempering is distributed in a homogeneous manner in the metal, the tempered steel being really a solid solution of iron carbide Fe_3C in the iron in excess. This influence of the homogeneous mixture on the electric resistance appears to be general; the impurities, which, in the state of traces, increase so much the resistance of certain other metals, are here found also in the state of solid solution or isomorphous mixture, like traces of silver in copper or of copper in silver.

Influence of the Presence of Other Bodies besides Carbon.—I will give here two series of measures, one made on tungsten-steels, and the other on chromium-steels.

Tungsten-steels.†

Chemical composition.

	I.	II.	III.	IV.
Carbon	0.6	0.55	0.76	1.11
Tungsten	5	2.9	2.7	2.7
Silicium	0.02	0.2	0.3	0.32
Manganese	0.3	0.4	0.44	0.38
Resistance at 15 deg.	21	18	18.5	20

Resistance after and before tempering.

I.	II.	III.	IV.
760° C. 1	750° C. 1.2	730° C. 1.4	720° C. 1
800° C. 1.4	800° C. 1.4	780° C. 1.6	730° C. 1.3
850° C. 1.5	1,100° C. 1.8	850° C. 1:7	850° C. 1.4
1,100° C. 1.8	......	1,100° C. 2	1,100° C. 2.2

Chromium-steels.

Chemical composition.

	I.	II.	III.
Carbon	0.5	0.82	1.07
Chromium	2.5	2.8	2.4
Silicium	0.27	0.27	0.36
Manganese	0.23	0.21	0.21
Resistance at 15 deg.	19.5	21.5	24

Resistance after and before tempering.

740° C. 1.0	780° C. 1.3	730° C. 1.3
800° C. 1.3	1,100° C. 3.1	850° C. 1.5
820° C. 1.5	——	1,100° C. 3
1,100° C. 2.1	——	——

It will be remarked how different the influence of tungsten is from that of chromium. At elevated temperatures, the latter metal raises the increase of resistance, which tempering would have produced on steel containing carbon alone, while tungsten diminishes it. I am inclined to think that chromium, a metal similar to iron, remains after tempering, at least partly, in a state of isomorphous mixture, as is always the case with nickel and manganese. Nothing like this is produced with tungsten, the compounds of which, as well before as after tempering, remain isolated in the mass.

* From the French of Prof. H. Le Chatelier. Communication presented to the Academie des Sciences.

† A steel of 7 per cent of tungsten employed for the manufacture of certain lathe tools, which are not tempered, has presented a specific resistance of 24.5 microhms, and after being tempered at 800 degrees C. of 35.50 microhms.

ENGINEERING NOTES.

The saving in condensation effected with the best form of mica covering is nearly 88 per cent; that is, calling the loss of heat with bare pipes 100, the loss when wrapped with mica packing would be 12. Asbestos covering seems to be considerably inferior to mica, and cements are less desirable than either, for covering exposed steam pipes.

There are still in use in Versailles, France, cast-iron water pipes which were laid down at various dates from 1664 to 1688. Some of these pipes are 20 inches in diameter and the remainder 12.75 inches. They were cast in lengths of 40 inches and coupled by flanges and bolts. The 20-inch pipes average about 1⅜ inch thick and the smaller pipes ⅞ inch. The only repairs still found necessary consist in replacing, from time to time, bolts which rust through, but even this is not often necessary.

Tests on automatic stokers for locomotive boilers by a committee of the American Railway Master Mechanics' Association show that there is a saving of fuel of not less than 7 per cent when using the stokers as compared with the work done by good hand labor. The present type of stoker will throw about 3,000 pounds of coal per hour. A modern type of passenger engine, with 46 square feet of grate surface and burning 200 pounds of coal per square foot of grate per hour, will require about 9,200 pounds of coal per hour. The stoker, as it is built at present, will not accommodate such a fire-box, but the committee see no reason why the speed cannot be increased and the size of the trough so enlarged that a larger amount of coal will reach the fire-box each stroke.

The number of locomotives in use on the railways of the United States on June 30, 1903, was 48,371, an increase of 2,646 as compared with 1902. These locomotives were classified as follows: Passenger, 10,507; freight, 25,444; and switching, 7,058. The total number of cars in service was 1,753,389, an increase of 113,204 over 1902. The rolling stock was classified as follows: Passenger, 38,140 cars; freight, 1,653,782 cars; and the remainder, 61,467 cars. These latter were employed directly by the railroads in their own service. Of the total number of locomotives and cars in the service of the railroads—which was 1,797,260—1,462,259 were equipped with train brakes, and 1,770,558 were equipped with automatic couplers.

At the recent convention of the American Railway Master Mechanics' Association, among the committee reports that came up for discussion was one on piston valves for locomotives. Tests had been made on both slide and piston valves to ascertain which were the least given to leakage. The conclusions derived from these tests do not seem to favor either type of valve. The best piston valve shows a leakage of 268.56 pounds per hour, and the best slide valve 348 pounds per hour. The worst case of leakage with piston valves was 2,880 pounds per hour, and of slide valves 2,610 pounds per hour. On most roads piston valves are not given the same attention as slide valves, both when fitting up new valves and care of them when in service. If both kinds of valves were given equal attention, it is the belief of the committee that the piston valve would be the better as regards leakage around the packing rings.

A concrete-steel covered reservoir belonging to the waterworks of Antwerp, Belgium, is noteworthy for the provisions to prevent failure of the lining when the basin is empty and it is subjected to the pressure of ground water. The reservoir is about 203 x 134 feet in plan and is filled with water to a depth of nearly 10 feet. The bottom of the excavated site was filled with about twelve inches of broken bricks in which lines of drain tile were laid; these drains run to a sump to which a pump is connected, so that the ground-water can be drawn down when necessary. The bed of brickbats was smoothed over with a thin layer of 1:2:4 Portland cement concrete as a support for overlapping sheets of expanded metal, which were carried into the walls. On top of the expanded metal rows of 8.8-inch I-beams were laid across the bottom every 7.5 feet. Concrete was then filled up to the level of the top flanges of these beams. A second layer of overlapping expanded metal was spread on the concrete, to take up the stresses due to ground-water acting on the outside of the empty reservoir. On top of these sheets pairs of light angles were laid 10.2 feet apart at right angles to the I-beams. Finally the concrete floor was brought to a total thickness of 12 inches. The walls are of concrete 8 inches thick, and are also provided with two layers of expanded metal. They inclose I-beam columns spaced every 3.7 feet in the end walls and 5.1 feet in the sides. The roof is carried by 323 columns each 7.2 inches square and having a steel I-beam in its center. These posts are connected by Golding system concrete-steel arches in lines parallel with the long sides of the reservoir. The roof itself is a 5.6-inch slab of concrete with expanded metal near its lower surface.

ELECTRICAL NOTES.

After having shown the erratic manner in which the amount of alternate-current electrolysis varies with the frequency, A. Brochet and J. Petit have investigated the influence of the current density, using nickel electrodes and a potassium cyanide electrolyte. The efficiency-frequency curves have a very different aspect according to the current density employed. At low-current densities they are nearly hyperbolic, with the axes as asymptotes, the amount of electrolysis increasing as the frequency decreases. But from about 7 amperes per square decimeter the concavity of the curves is reversed, and the efficiency increases with the period, up to about 60 periods per second. The efficiency-current curves show a steep rise below 2 amperes, and then a fall which is very abrupt at 5 periods per second, and barely perceptible at 100 periods per second. These curves present the curious anomaly that the efficiency tends toward zero as the frequency diminishes and the current-density increases. If this were carried to the limit, there should be no electrolysis when the frequency becomes zero and the current therefore continues. As a matter of fact, the efficiency is then never lower than 80 per cent.

R. J. Strutt has endeavored to determine the rate of loss of a charged body which gives off α-rays only. Such a body is a rod of bismuth made active by a deposit of "radio-tellurium." This was attached to an electroscope and charged in a vacuum. At pressures of from 300 millimeters down to 2 millimeters, the rate of leak was found to be nearly proportional to the pressure, in accordance with the results of previous observers. But when the pressure was lowered beyond that the rate of leak diminished more and more slowly, apparently reaching a limit. Exhaustion was continued until the vacuum was so high that a discharge could not be forced through the Röntgen tube attached. Even then a considerable leakage was observed from the charged system. This leak was the same whether the charge was positive or negative. It is certain, therefore, that the current carried by the α-rays must be small in comparison with it. The nature of this conduction in high vacua is a difficult problem. It is very repugnant to modern ideas to believe that the current is carried independently of moving ions. As these cannot be derived from the gas, the only alternative seems to be that they are derived from the material of the radio-active substance, being torn away from it by the issuing α particle.

Crookes compared the disintegration of a large number of metals used as cathodes in gases at low pressure by means of a rotating switch which connected alternately four cathodes in the same exhausted tube with an induction coil. In each of the experiments one of the cathodes was gold, which was chosen as the standard. Palladium and gold had the highest rates of disintegration, and iron, aluminium, and magnesium the lowest. Granquist obtained somewhat different results, and latterly L. Holborn and L. W. Austin have made some new experiments, using grease instead of mercury to make the connections airtight, since they found that the smallest quantity of mercury leads to instant amalgamation of the cathodes tested. They obtained curves of remarkable regularity connecting the loss of weight with the cathode fall. The curves for the various metals all intersect at 495 volts, where the disintegration is nearly zero. They are straight lines, of various inclinations showing that above the point mentioned the disintegration is directly proportional to the cathode fall. The steepness of the line has a simple relation to the atomic weight. It is necessary to distinguish two groups of metals, to the first of which belongs silver, platinum, iridium, copper, and nickel, to the second another form of silver, bismuth, palladium, antimony and rhodium. The members of each group disintegrate in equivalent proportions at the same potential, when for the individual metals valencies are assumed which are recognized in chemistry.

P. E. Shaw and C. A. B. Garrett used both the boom apparatus and the balance apparatus in coherence experiments designed with a view to decide between the rival theories of the coherer. These theories are: (1) Lodge's fusion theory; (2) Branly's theory of a modification of the medium; (3) Auerbach's theory of adhesion brought about by mechanical shock; and (4) the ionic theory, according to which either a film condensed from the atmospheric gases or else an oxide film is ionized by the passage of the discharge. The authors show that for coherence to take place there must be some gap between the surfaces. This gap provides the large resistance so that enough heat is developed by the passage of the waves to fuse the surfaces. The last theory can be proved experimentally to be correct, for it is possible after cleaning the surfaces to bring them together with such slight pressure that the current passing is small. Coherence occurs even when no film existed previously, provided there is a gap between the surfaces. When coherence is broken, the surfaces part with a snap which sounds in the telephone like the sundering of a solid body, and when the surfaces are pressed together again, the ends of the bridge are found and can be easily pressed back flat. These facts show that coherence is a solid effect and dispose of the ionization theory and also of Branly's theory. The fact that the bridge has about the tenacity of the solid metal also supports the fusion theory. Again, the heat developed at the contact is ample to fuse the metal. Hence there is no simple adhesion, and only the fusion theory is left, and it is in accord with all the facts known.

TRADE NOTES AND RECIPES.

A Simple Remedy Against Rust.—Probably very few mechanics and watchmakers are aware that "ink-gum" (Faber's—German, *Tintengummi*) is a splendid preparation for removing rust, proving itself particularly valuable in cases where surfaces or sharp edges are to be kept intact, or in pieces that have already been fitted where no more than the least possible may be removed from the surface. It is unfortunately one of the evils attending all of our abradants and grinding agents that a part of the object is removed with the defacing rust, thus rendering it smaller.

Quite different is it with this gum. It attacks only the rust and slips over the polished surface as if it were not present, wherein it differs from the regular anti-rust gum in common use, which attacks all parts of the object indifferently. Of course, it will not be expected that rust spots of long standing will be removed, particularly if they have eaten well into the substance; its application is to be confined to slightly rusted steel parts upon which it is not advisable to use more vigorous agents.—Schweizerische Uhrmacher Zeitung.

Something New in Incandescent Mantles.—It is well known that incandescent mantles made from thorium oxide and cerium oxide are far from durable; the various additions of aluminium oxide, beryllium oxide, silicium dioxide, and others confer greater stability upon the network, it is true, but alas! at the expense of the light-emitting power.

When made up according to the following process, not only may a stable network be obtained, but also one which possesses a high power of light emission with the use of thorium and cerium in combination with fluorhydric acid.

An aqueous concentrated solution of thorium is compounded with fluorhydric acid, heated a short time and to it added a combination of cerium dissolved in water by means of some organic substance such as cerium oxalate; this compound gives good results. The formula is as follows: 59.4 grammes of thorium nitrate, 1 gramme cerium oxalate, 0.8 gramme fluorhydric acid, 3 grammes pyro-catechin—this latter to dissolve the cerium oxalate—and 135 grammes of water.

The textile material is thoroughly impregnated with this solution after the prevailing methods and then calcined.—Translated from Neue Erfindungen und Erfahrungen.

Practical Process for Softening and Cementing Celluloid.—If celluloid is to be warmed only sufficiently to be able to bend it, then a bath in boiling water will do. In steam at 120 deg. C., however, it becomes so soft that it may be easily kneaded like dough, so that one may even imbed in it metal, wood or any similar material. If it be intended to soften it to solubility, the celluloid must then be scraped fine and macerated in 90 per cent alcohol, whereupon it takes on the character of cement and may be used to join broken pieces of celluloid together. Solutions of celluloid may be prepared: 1. With 5 grammes of celluloid in 16 grammes each of amylacetate, acetone, and sulphuric ether. 2. With 10 grammes of celluloid in 30 grammes each of sulphuric ether, acetone, amylacetate, and 4 grammes camphor. 3. With 5 grammes celluloid in 50 grammes alcohol and 5 grammes camphor. 4. With 5 grammes celluloid in 50 grammes amylacetate. 5. With 5 grammes celluloid in 25 grammes amylacetate and 25 grammes acetone.

It is often desirable to soften celluloid so that it will not break when hammered. Dipping it in water warmed to 40 deg. C. will suffice for this. Any factory will furnish soft celluloid if ordered in sufficiently large quantities to pay.—Pharmaceutische Zeitung.

To Color Copper Chocolate by Oxidation.—While attaching one of the silver-plated feet to a copper tankard, a spot appeared upon the body of the pot. An effort was made to remove this chocolate colored spot, as well as others which came out on the cover, but without success. "Now, how was this oxide caused?" asks a correspondent of the Journal der Goldschmiedekunst, which proceeds to answer the query as follows. It would be better to return the pot to the factory and have it reoxidized, but if the repairer wishes to do it we give here a tried formula as well as the process.

Take about a tablespoonful of crystallized verdigris and dissolve it in ¼ liter of boiling water. Take also a piece of sal-ammoniac about the size of a nut and dissolve it likewise in ¼ liter of water. Now pour the two solutions together and add ¼ liter of wine vinegar. Boil them well together and filter. Of the filtrate now take about a wineglassful and just before using it add to it a teaspoonful of ammonium sulphide. The copper object to be colored must be perfectly clean and polished. The solution may be applied with a hair brush and dried in a warm oven. To assure the sticking of the oxidizing fluid, a sort of binder must be added and for this purpose a little rouge will do. The liquid should be very evenly applied and dried slowly.

After each application of the liquid it must be seen to that the old coat, which has dried in, is completely dissolved in the new, otherwise spots will arise. Six or even ten coats being thus applied, the pot may be washed in warm water and dried. Heat the article now slowly, whereupon it becomes considerably darker. If the required color has not yet been reached, the painting process must be repeated and the object again heated until the tint is reached.—Pharmaceutische Zeitung.

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