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During the absence in England of the Editor, Professor Henry T. Bovey, communications, &c., relating to the Editorial Department should be addressed to R. W. BOODLE, 21 *McGill College Avenue, Montreal.*

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NEW BOOK.

The Materials of Engineering. Part II. "Iron and Steel," by Robert H. Thurston, A.M.,C.E. (New York, John Wiley & Sons, 1883.)

The second part of Mr. Thurston's "Materials of Engineering" proves to be, as the first led us to expect, a work of the greatest value to all engineers and students busied in this department of science. It is clearly printed and fully illustrated with cuts of different processes, machines, &c. The work serves as an admirable compendium of information upon this branch of the materials of engineers. Thus after an opening chapter upon the qualities of metals of somewhat an elementary character, and a sketch of the history and principles of metallurgic work, the student is led on to iron and steel in manufacture, and to suggestive remarks upon the effects of time and temperature upon the metals. The work concludes with a practical chapter upon Specification, Tests and Inspection. This is in every way a good book, and we are glad to be able to recommend it highly to the public. The author not only makes constant references to the works of recognized authorities like Weyrauch, Rankine, Molesworth, Egloston, &c., but has made excellent use of the Transactions of different engineering and scientific societies, chiefly American and French. This we consider to be an excellent point. Nowhere is improvement in detail and manipulation more constant than among engineers, and to keep abreast of the times it is necessary to read widely among the miscellaneous periodicals, registering recent results that have not yet found their way into the works of recognized authorities. With regard to iron and steel, this task has been admirably done by Mr. Thurston.

Upon Factors of Safety, p. 340, &c., Mr. Thurston has some capital remarks to which we would refer our readers. By way of illustration, we quote the following paragraph from them: "The factors of safety adopted for iron and steel are lower than those usually admissible for construction in other materials, in consequence of the fact that the elastic limit and the elastic resilience, or shock-resisting power of the former seem to increase, up to a limit, with strain; while the latter gradually yield under comparatively low stresses, as will be seen hereafter. In common practice, the factor of safety covers not only risks of injury by accidental excessive stresses, but deterioration with time, uncertainty as the character of uninspected material and sometimes equally great uncertainty as to the absolute correctness of the formulas and the constants used in the calculations. As inspection becomes more efficient and trustworthy; as our knowledge of the effect of prolonged and of intermitted stress becomes more certain and complete; as our formulas are improved and rationalized, and as their empirically determined constants are more exactly obtained, the factor of safety is gradually reduced, and will finally become a minimum when the engineer acquires the ability to assume with confidence the conditions to be estimated upon, and to say with precision how his materials will continuously carry their loads."

We reserve some thoughts and criticisms suggested by the work before us to a future Number.

THE HEAT OF THE SUN.

BY ERNEST H. COOK, B.SC. (LOND.), F.C.S.

(*Concluded from page* 101.)

With such a preliminary assertion Dr. Siemens proceeds to formulate the fundamental assumption that all space is filled with highly rarefied gaseous bodies, including hydrogen, oxygen, nitrogen, carbon, and their compounds. The planetary bodies scattered in such an atmosphere would attract to themselves atmospheres varying in density, according to the varying density of the planet. But this attraction would be, to a certain extent, selective, and consequently, such atmospheres would consist of the heavier and, therefore, less diffusible gases, while the lighter would remain in space. In space, therefore, there would be a vast preponderance of hydrogen, and the higher hydrocarbons. But again, the planetary system as a whole, will attract the rarefied gases existing in stellar space, thus we shall have existing in space what may be called three classes of atmospheres : inter-stellar, interplanetary, and planetary. Each of these will vary in density, the first according to the distances of the stars, the second according to the mass of the particular system as a whole, and the third according to the mass of the attracting planet. In support of this view, the molecular theory of gases is brought in, the evidence afforded by the analysis of gases occluded by meteorolites, which have fallen upon the earth, and the teachings of spectrum anaylsis. Each of these is in itself a perfectly sound and practically unanswerable argument in favor of the existence of a universal atmosphere.

In regard to the idea that if such atmospheres did exist, the central body of each system would attract to itself the heavier gases, whereas the revelations of spectrum analysis shows a prevalence of Hydrogen, Dr. Siemens remarks that it can be shown that at such a temperature as the sun possesses, no Carbon Dioxide or Carbon Monoxide could exist, and, in fact, supposes with Lockyer, that the metalloids can also have no existence. But he says that "outside the photosphere, there must be regions where these gases would accumulate, were *it not for a certain counter-balancing* action."

This counter-balancing action is provided for by the high rotative velocity of the sun, which is equal to about 125 miles per second, or, at the sun's equator, nearly $4\frac{1}{2}$ times that of the earth. Such a movement must cause an equatorial rise of the solar atmosphere. La Place has, however, calculated that owing to this cause, the height of the solar equatorial atmosphere could not possibly exceed $\frac{9}{20}$ths of the distance of Mercury. This calculation is, however, vitiated by his assumption of the emptiness of stellar space. If we suppose this action to go on in an unlimited medium, then a fan-like effect is exercised upon that medium, resulting in a movement outwards at the the equator, and a drawing in towards the poles.

The sun, therefore, upon this hypothesis is supposed to have around his equator, a disc of matter rapidly leaving him, and at the poles matter approaching him.

In this way, Dr. Siemens says enormous quantities of hydrogen, hydro-carbon, and oxygens are supposed to be drawn towards the polar surfaces of the sun. During their gradual approach, they will pass from their condition of extreme attenuation and extreme cold, to that of compression accompanied with rise of temperature, until on approaching the photosphere, they burst into flame, giving rise to a great development of heat, and a temperature commensurate with their point of dissociation at the solar density. The result of their combustion will be aqueous-vapor and carbonic anhydride or oxide, according to the sufficiency or insufficiency of oxygen present. These products of combustion will come under the influence of centrifugal force, and move towards the equator, where they will be projected into space. As they recede from the sun, they gradually lose their heat, and become more and more rarefied, until they obtain the extreme state of rarefaction, which they possess in interplanetary space. Here, it is supposed the inverse action to that which occurs in the sun, takes place. The now highly rarefied aqueous-vapor and carbonic anhydride absorbs some of the radiations which the sun is constantly pouring out, and it is supposed that at the extremely low pressure to which they are subjected, they are dissociated—oxygen, hydrogen and hydro-carbons being produced. These are in turn again drawn into the polar surfaces by the fan-like action produced by the solar rotation. Thus, we see that a continuous circulation of matter occurs, the same element alternately forming a portion of the coldest portion of interplanetary space, and the hottest portion of the central luminary.

Such in outline are the chief points of this latest theory of solar action. There are some other secondary points, which are rendered necessary in consequence of the known constitution of the sun. For example, we know that the solar atmosphere contains large quantities of the vapor of certain metallic bodies. These are supposed to constitute an inner atmospheric shell which is not affected, in consequence of its density by the centrifugal force caused by rotation. This force, in fact, only affects the higher materials, chiefly hydrogen constituting the circulating atmosphere. At the surface of contact between the two, however, "intermixture induced by friction may sometimes *occur, giving rise to those vortices and explosive* effects which are revealed to us by the telescope.... Some of the denser vapors would probably get intermixed and carried away mechanically by the lighter gases, and give rise to that cosmic dust, which is observed to fall upon our earth in not inappreciable quantities." Then again solar observation has revealed to us the undoubted fact that the quantity of solar heat varies from time to time, and that the condition of the photosphere, as indicated to us by the sun-spots, also varies. These are supposed to be accounted for by the circumstance that as the whole solar system is moving through space at a velocity of 150,000,000 annually. It appears possible that the condition of the gaseous fuel supplying the sun, may vary according *to its state* of previous decomposition, in which other heavenly bodies may have taken part.

Since its first publication, this theory has been subjected to a considerable amount of criticism, chiefly by French philosophers. Some of this may be considered as favorable, while some is decidedly hostile.

Most, however, of the notices which I have seen, agree with Dr. Siemens on some points, and disagree on others. *To this class, the present writer feels* compelled to ally himself. The idea of a universal atmosphere dating, as Dr. Sterry Hunt has shown, as far back as Newton, seems perfectly reasonable and probablé, and there are other considerations than those Dr. Siemens has brought forward, which strongly support it. Moreover the constitution of such an atmosphere would be such as we require for the purposes of this theory. It is in the subsequent portions of the arguments that we are inclined to differ.

Firstly, there is the question of dissociation. The hydrogen and carbon compounds, combine, we are told, with oxygen, producing intense heat, and the products of combustion move towards the solar equator and are projected into space. The *point here is, is it* not at variance with all terrestrial teaching, that such compounds can exist at such temperatures? Assuming that combination such as supposed really does take place, it seems to me, that subsequent dissociation must occur. This, it will be noticed, is just what Dr. Siemens requires, but he supposes it to occur far out in space, and if instead of this, it occurs close up to the sun, as here supposed, his argument about the conservation of the solar rays by this absorption, is untenable. In fact, the author of the theory himself says this, for he quotes Lockyer's idea, that at solar temperatures no metalloid can exist, and yet further on, he supposes the energy kept up by the production of carbonic anhydride and carbonic oxide, which can be demonstrably shown incapable of existence.

The prime cause of the movement of the atmosphere is the rotation of the sun upon its axes. But all the planets rotate also, and as they are all immersed in the atmosphere, we shall have the same action occuring in their case. Thus we ought to find an aerial current flowing constantly in the northern hemisphere from the north-east (allowing for the gradually increasing velocity of rotation), and in the Southern hemisphere from the south-east. In short, exactly in the same direction as the "Trade Winds." But these currents would occur in the higher regions of the atmosphere where the "Return Trades" are prevalent, and to these they would be exactly opposed.

The inner atmosphere of the sun is supposed to contain the metallic vapours. Supposing that dissociation does not occur and that combination does, we are still in a difficulty, for we have, at the bounding surfaces at any rate, a large mass of oxygen, in contact with hydrogen and vapors of the metals. Now, with which of these will this oxygen combine? The whole of the teachings of Chemistry tell us, not with the hydrogen, but with the metals for, as is well known, all the metals (with one or two exceptions) decompose water. It therefore seems, that instead of water being a product of the combination, metallic oxides, especially those of sodium and potassium, which have the most powerful affinity for Oxygen will be produced. Thus, owing to the action of chemical affinity, supposing it to occur, we should have produced not water and carbonic dioxide, but metallic oxides, either entirely or in combination with these.

Again it is supposed, that in consequence of the weight of the materials composing the inner atmosphere, they are not affected by the fan-like action, but only by that of gravitation. Now, this assumption of itself is difficult of acceptance, inasmuch as any force which affects one body, must also effect the other, even though they may differ in density. It is simply a question of degree, and if owing to centrifugal force hydrogen is projected x miles into space, then sodium vapor, which is 23 times as heavy, will be projected $\frac{x}{23}$ miles. And here another consideration comes in. We are told carbon dioxide and water are produced, drawn towards the equatorial regions, and there expelled into space. Also we know that large quantities of sodium, potassium, magnesium and lithium exist in the sun, forming, let us suppose with Dr. Siemens, the inner atmosphere. They, we are told, are not projected into space, because they are of greater density. But this is not the case. The specific gravity of carbon dioxide and of water, compared to hydrogen, is 22 and 9 respectively, while lithium vapour has a density of 7, magnesium of 24, and sodium of 23. While if we can imagine these metals to combine with oxygen, the density of lithic oxide is 15, of magnesic oxide 20, and of sodic oxide 31. According then to this view, the various products of combustion would be projected to the following proportionate distances:

Aqueous Vapor	$3\frac{4}{9}$
Lithic Oxide	$2\frac{1}{15}$
Magnesic Oxide	$1\frac{11}{20}$
Calcic Oxide	$1\frac{8}{28}$
Sodic Oxide	1

Similar reasoning will apply if we assume dissociation to occur, and consequently the composition of the stellar atmosphere must be far more complicated than Dr. Siemens supposes, and the existence of this inner metallic atmosphere is very problematical. I will only refer to one other point. The researches of spectroscopy and the revelations of the telescope have revealed to us undoubtedly the fact that our sun is only one of an innumerable number. A theory to be complete must thus account for the action of all. Moreover, Dr. Huggins has shown that the fixed stars may be divided into classes, according to the spectra which they emit.

Thus we have all gradations, from the spectrum of a white or bluish-white star, like Sirius, up to that of a reddish star, like Arcturus. Now, if we have the same atmosphere supplying all, and the same cause producing motion, it is difficult to see how these differences are to be accounted for. For, it must be remembered that Dr. Huggins' idea of different ages will not apply, the supposed cause producing their energy being independent of time.

In the foregoing, I have endeavord to present unprejudiced, if brief, views of the chief theories which have been proposed from time to time, to account for solar energy. The subject is a very fascinating one, requiring strict attention in order to prevent the imagination running wild when dealing with such actions and magnitudes. If it is the reader's opinion that it has thus run wild, I must respectfully ask his indulgence, and plead the nature of the subject as an excuse.

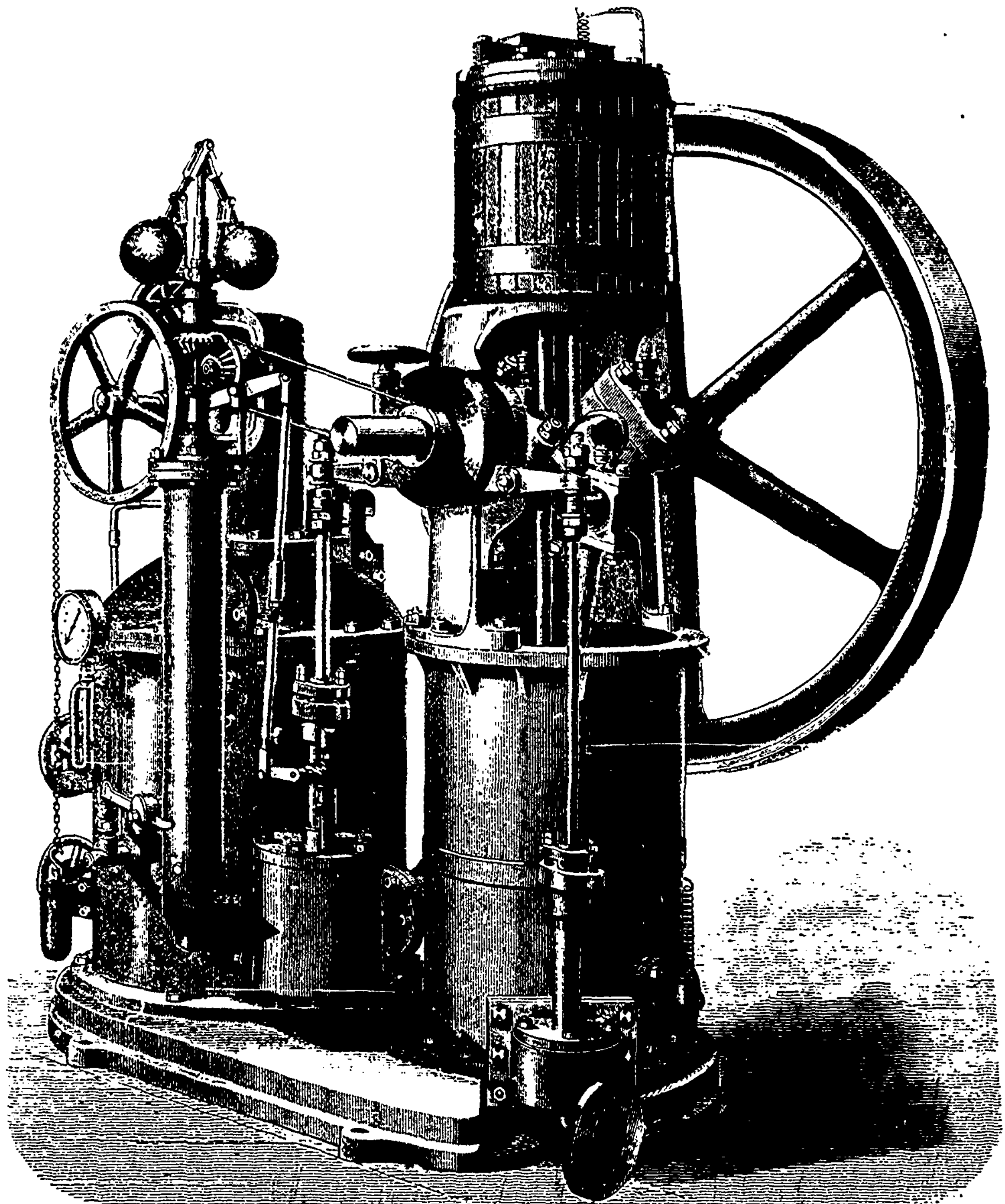
IMPROVED CALORIC ENGINE.

(*See page* 196.)

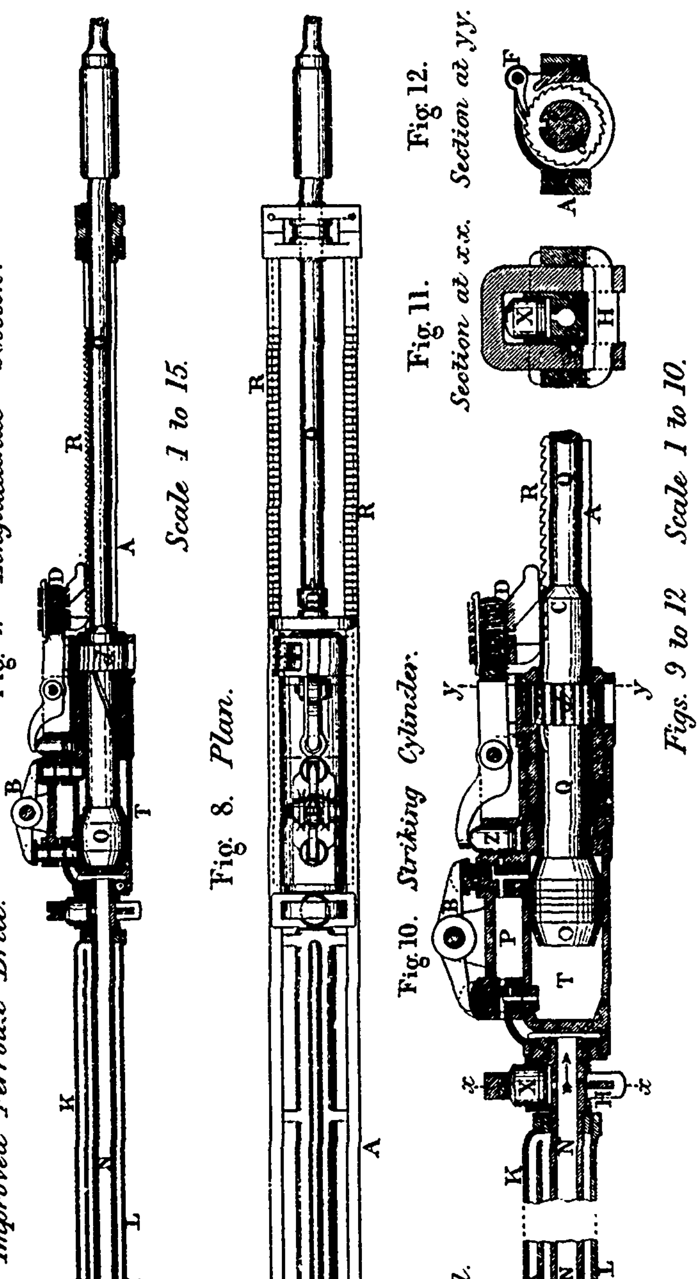
The Caloric Engine and Siren Fog Signals Company, of London, have been occupied in producing caloric engines suitable for general purposes, and our illustration, which we find in *Engineering*, shows the most recent design. This engine is of two horse power nominal, or 3¼ actual horse power.

It consists essentially of three parts, viz., a pump for supplying compressed atmospheric air; a generator or retort into which the air is forced and there heated, and a cylinder into which the heated air is expanded for the purpose of operating the piston. The generator comprises a cylindrical firebrick lining of smaller diameter than the casing, so that an annular space is left between the two, and a set of grate bars upon which the fuel is burned.

After a fire has been lighted in the generator, the air is, in the first instance, supplied by a hand pump or (in the case of small engines) by turning the fly wheel until the necessary pressure is created, when the engine commences to work, and the air pump at the top delivers at each upstroke of the piston a charge of air into a valve casing, where, by means of a hollow cylindrical valve, it is divided into two streams, one entering into the annular space above referred to, whence it descends and passes through the grate bars and the fuel, the other stream being delivered directly into the spaces above the fire. The air passing through the incandescent fuel forms, in the first instance, carbonic acid and ultimately carbonic oxide, so that the space above the fire may be considered as a combustion chamber, containing carbonic oxide and nitrogen. The oxygen of the air delivered into this space enters into immediate combination with the carbonic oxide, and produces an intense heat with a consequent increase of pressure.



IMPROVED CALORIC ENGINE.



St GOTHARD TUNNEL.

Improved Ferroux Drill. Fig. 7. Longitudinal Section.

Scale 1 to 15.

Fig. 8. Plan.

Fig. 9. Rear End.

Fig. 10. Striking Cylinder.

Fig. 11. Section at x.x.

Fig. 12. Section at y.y.

Figs. 9 to 12 Scale 1 to 10.

The governor alters the position of the cylindrical valve according to the load on the engine, so that the proportion of air sent through the fire and into the space above is varied, and also the consumption of fuel, according to the amount of work being done by the engine.

In engines of larger size than the one we illustrate the governor is made to perform four functions, viz. 1, it determines what quantity of air is to be delivered to the bottom of the fire; 2, what quantity above fire; 3, what quantity of air is to be rejected altogether, and 4, at what point of the piston's stroke the supply of motive fluid is to be "cut off." One great impediment to the successful operation of a caloric engine, working at such a high temperature, has been the undue heating of the connections and seating of the valve, which commands the communication between the generator and the working cylinder. This difficulty is now overcome by surrounding the parts with an air chamber, which forms practically a part of the main pipe for conveying the compressed air from the pump to the generator, so that for every stroke of the pump there is a current of cold air around the valve. The piston, which, as is usual in caloric engines, is provided with a shield or guard, has rings of the Ramsbottom kind, which are found to answer well.

The illustration shows a single cylinder engine, which is very satisfactory for ordinary purposes, but where great regularity and steadiness of working is essential, these engines are constructed with two cylinders, the cranks being placed at right angles. From a test made with a twelve horse power double cylinder caloric engine the following results are stated to have been obtained. Indicated horse power of cylinders, 41·24, power of air pumps, 21·04, net indicated horse power, 20 2. Tested by the dynamometer the effective horse power was 14·39. The consumption of ordinary gas coke was 36·56 pounds per hour, which equals 1·8 pounds per indicated horse power, and 2 54 pounds per effective horse power. The difference between the indicated and effective power shows a considerable margin for friction, but it must be remembered that the cylinders are necessarily larger than those of a steam engine of same power.

Scientific American.

THE ROCKLAND SLATE QUARRY,

MELBOURNE, P.Q.*

By Ernest McC. Macy, *McGill University.*

This quarry is situated in the township of Melbourne (Eastern Townships), about seven miles and a half from the village of Melbourne, and a few rods away from a large creek running from Brompton Lake to the St. Francis river. This creek, which affords excellent water-power for the machinery at the quarry, and also for mills lower down, runs through a deep gulley with pretty steep banks, and the quarry is opened on the top of the right bank. The vein of slate lies next to the Serpentine rock, on the east of it, and in a nearly perpendicular position, running in the direction north-east and south-west. All these strata on the east of the Green Mountains lean to the south east, and those on the other side (west) lean to the opposite direction. The vein extends a long distance, quarries being opened on it in this province, at Melbourne (on Mr Walton's estate), on Mr. Steele's place and at Danville, and in Vermont, at Montpelier, Norfield and Brattleborough.

The Danville quarry produces school-slates for which the Rockland stuff is too hard, and it has lately been much improved, and opened upon a larger scale than formerly. The supply of slate there is very large and of the best quality, colour, and texture, for writing-slates and the finer uses to which slate is put. The colour of the Rockland slate is a blue black, and its strength is unsurpassed. Lying to the east of it, there is a vein of green slate on which a quarry was partially opened some years ago, but there is no other colour known to be in this locality. At Acton, about twenty miles to the west, red and purple slates have been found; but this kinds are not well adapted for roofing, as they do not split thin enough, but they are used for tiles and mantels. Another deposit has been found to the east near Sherbrooke, but it is not good enough to warrant its working well. The Rockland vein is the largest and thickest deposit of good workable slate that has been found on this continent. It consists of three strata of slate, separated by beds of flint from ten to fifteen feet in thickness, and the three veins combined are about three hundred feet thick. The stratum furthest to the west, lying next to the Serpentine rock, has been worked right through and the second, which is a rather better quality, has been opened up. The slate probably extends to a depth of three or four thousand feet below the surface, and as the Company own a mile of the vein, the supply may be said to be practically inexhaustible. It is worked in benches made by natural joints in the rock, and the depth is about one hundred and twenty-five feet to the first, and about fifty feet more to the second bench, making a total depth of about a hundred and seventy-five feet.

The pit is about four hundred feet long, and of a rectangular oblong shape. There are two tunnels, one at each bench, running through the bank, the one at the first bench having been intended for taking out the rubbish, but it was found to be more economical to raise it to the surface with derricks and dump it down the outside, as the bank is almost perpendicular. For this purpose short tramways are laid, slightly inclined, from the pit to the dump so that the trucks, which are pushed by men, run down easily to the dump when loaded and are pushed up again without much difficulty when empty. The tunnel at the second bench was made for the purpose of drainage. The slate-mill and derricks are worked by a water wheel about forty rods from the mill, the power being conveyed by means of a wire rope, and it therefore costs nothing except keeping the machinery in running order. In the mill they make tiles, billiard-beds, mantels, wash-tubs, sinks, cisterns, paste-boards, and everything that slate is used for, and a few years ago they made a number of large slabs for lining the interior of burial-vaults. The mantel stuff is sold to manufacturers who finish, and marbleize it, imitating all kinds of marble to such perfection, that it can scarcely be distinguished from the original marble, and the various kinds of wood are imitated in the same manner. The slate for mantels, tubs, etc., is sawed to the proper size by circular saws, then planed to the required thickness, and finally polished with wet sand. The slabs, that have to be joined, are grooved, bolted with iron bolts, and cemented. There are, I think, about fifty or sixty men employed in the pit and slate mill, and at the derricks, and also at making the roofing slates. Those who work at making slates, etc., are paid by the piece, and get more or less according to the amount of good slate which is brought up in the day, while those who work in the pit, and on the derricks, are paid of course by the day. The roofing slates are made of eighteen different sizes, from twelve to twenty four inches in

* Summer Report in the Engineering Department, McGill University.

length, and are sold by the square, or the amount necessary to cover ten square feet on a roof, weighing about five hundred and fifty pounds. Up to the present time the slate has been drawn by teams to the Grand Trunk railway station at Richmond, a distance of about seven and a half, or eight miles, and they draw from seven to thirteen square at a load, according to the state of the roads; but the Missisquoi valley railway is likely to be completed next year and, as it will run close to the quarry, the slate can be shipped directly, without the trouble and expense of drawing, which is very heavy work. The men have been getting from twenty-five to forty cents a square for drawing, but the distance is too great to draw more than one load in the day. The pit is getting so wide that the old boom-derricks will not reach far enough now, so they are going to introduce travelling derricks, which consist of a wire rope two inches in diameter, stretching across the pit, with a carriage travelling on it. The carriage can be run out to any distance from the bank, and the rope let down, and the carriage drawn back to the bank, when the slate or rubbish is raised up to the top of the pit. They have also lately introduced steam-drills, and other improvements. The slate is shipped to England, Australia, the West Indies, and the United States, but the demand for it in Canada is very small, and the Rockland quarry alone could more than supply the Dominion. The very many uses which are now being made of slate, make the quarrying and finishing of it a most important industry, and one which ought to excite interest and attention from everybody. Letting alone its great importance as a roofing material there are dozens of other uses for which it is admirably adapted and for which it would be far more durable and convenient, than the materials which are more commonly used, and therefore cheaper in the long run.

UNDERGROUND SIGNALLING IN MINES.

The necessity for a good system of signals in mines, says the *Mining Journal*, now engages attention. The old method of signalling with knocker line or bells is considered inapplicable for great depth and extensive works. The telephone has been tried but given up, and signalling by electricity is being reconsidered, and although at first the arrangements were found defective in detail one eminent mining engineer now states that he has found no difficulty in arranging signals for an indefinite number of roads, by having a pointer attached to them or a pendulum to show which bell was sounded. In some instances it has been found advantageous to have one battery and two separate wires where there has been a number of stations, and one bell has been found sufficient for any number of off-shoots. It has been suggested that the wires might be injured by a fall of stone or mineral, but the wires are generally placed in the roads, so that the stone, etc., would be hardly likely to touch them, and therefore there is no danger to be apprehended in that direction; but even were the wire damaged it could be easily repaired. The Sax system has also been adopted in the North of England, and a similar arrangement has long been in use at the Mickley mines in Northumberland. In the early introduction of electric signals, and in those noticed, difficulties were met with, but these have now disappeared, and electric signal bells are admitted to be the best and cheapest that can be adopted for underground working.

AN American paper gives the following :—The United States burns about 322,000,000 dols. worth of wood every year. Railroads burn 5,000,000 dols. worth. Brick and tile factories burn 4,000,000 dols. Mining operations consume, as fuel, 3,500,000 dols. worth. Steamboats burn about 2,000,000 dols. worth

ON THE ST. GOTHARD TUNNEL.

BY HERR E. WENDELSTEIN, OF LUCERNE.

(*Concluded from Page* 171.)

4. BORING MACHINES.

Several different types of rock drill were employed more or less at the St. Gothard Tunnel. Amongst these may be mentioned the Ferroux, the Mackean and Seguin, the Dubois and François, the Turrettini, the Burleigh, etc. *The Ferroux drill* was the first to be employed, having been invented in 1873 specially to work in this tunnel. In 1875 the original was superseded by a simpler form devised by the inventor, and this improved drill did the greater part of the work from henceforward. As space will not allow of a description of all the varieties used, attention will be confined to this drill as the most successful example.

The improved Ferroux drill is shown in Figs. 7 and 8, page 197, with details enlarged in Figs. 9 to 12. It is about half the weight of the older form, and less expensive. L, Fig. 7, is the main feeding cylinder, in which work the piston M, fixed to a hollow piston-rod N. The outer end of this rod is connected to the larger or working cylinder T. In the latter, enlarged in Fig. 10, works the striking piston O, which is prolonged into the piston-rod Q, carrying at its further end the chisel or bit. The piston O is conical at each end. At either end of the cylinder T are sockets at right angles to it, and in these work the small plug-valves *aa*, which operate the entrance and exhaust of the air. These plugs are raised and lowered by the piston O, which as it reciprocates brings its conical ends under each of the plugs alternately, and so lifts it. The plug which is raised acts through the lever B to depress the other, and thus opens the other end of the cylinder to the outer air, whilst itself opening a passage from the compressed air in the chamber P to its own end of the cylinder. The piston is thus driven back to the other end, where the same operation recurs, and thus the reciprocation is carried on. The compressed air enters the feeding cylinder L, Fig. 9, from the supply-pipe through the stop-cock I, and passes to the air-chest P, Fig. 10, through the interior of the hollow piston-rod N. At the same time, by pressing against the end of the piston M, Fig. 9, the air forces the rod N, with the working cylinder T attached to it, forwards towards the rock to be drilled. Along the top of the bearers A, Fig. 10, which carry the machine, is a rack R. When the hole has been deepened by a distance equal to the interval of the teeth of this rack, the conical shoulder C of the rod Q has advanced so far as to raise the fork D, which has two pawls engaging in the teeth of the rack. When these are raised clear of the rack, the striking cylinder T advances by the length of one tooth; and this goes on until the cylinder has advanced the whole length of the rack. A plug Z, having the compressed air below it, operates to keep the fork D down upon the rack, and to bring it down again the moment it is released by the piston-rod.

To prevent the striking cylinder from moving backwards in the opposite direction, a small cylinder X, Fig. 10, is provided at its rear end, and is open to the compressed air. In this cylinder is a plug, which presses upwards against a stirrup, carrying at its lower part the cross-piece H, Fig. 11. This cross-piece engages with two racks on the under side of the bearers A, and having their teeth in the opposite direction to that of the racks on the upper side. Whilst this piece H is engaged with the rack, no backward motion is possible; but it can be released at any time, to bring back the drill, by pushing down the stirrup.

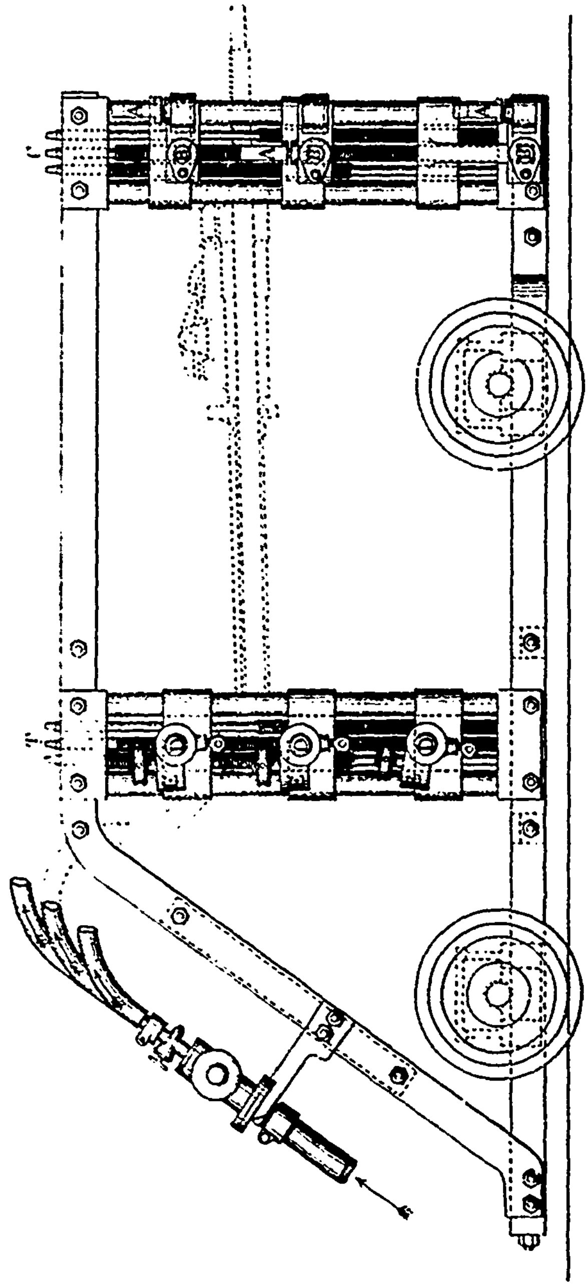
The rotation of the rod Q, which carries the drill, is given by an inclined groove in the enlarged part of the rod. Into this groove, shown in section in Fig. 12, fits a projection *c* from the ratchet-wheel *d*. As the striking rod Q advances towards the rock, the groove in it compels the wheel *d* to turn in the direction of the teeth. When the rod comes back for another stroke, the wheel is prevented from returning by the pawl F, and therefore the piston-rod itself is compelled to turn.

To bring the machine back when the hole is finished, the cock I is closed and the cock J is opened, Fig. 9. The air then escapes from behind the piston M through the chamber P into the atmosphere, while it enters through the pipe K into the annular space on the front of the piston M, and pushes it, with the striking cylinder and piston, back to the rear end of the cylinder L.

The weight of the machine is about 180 kilograms, or 397 lbs. and the gross quantity of compressed air used per stroke is

Fig. 13. ST GOTHARD TUNNEL.

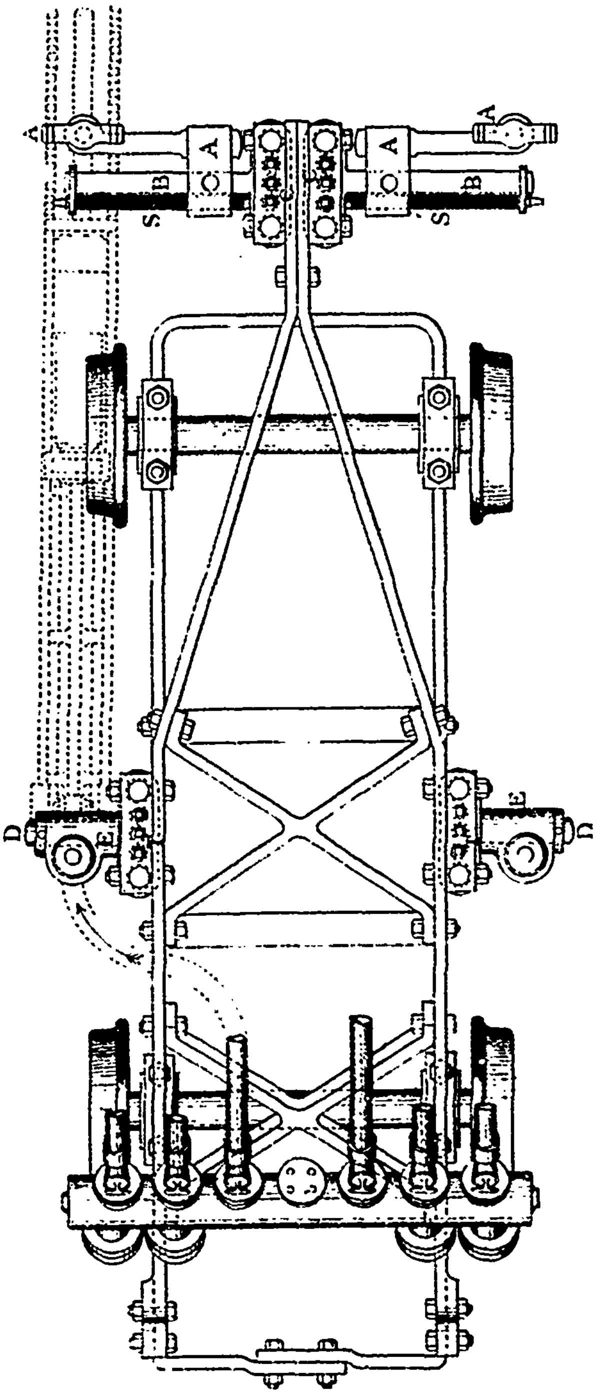
Elevation of Drill-Carriage.



Scale 1 to 20.

ST GOTHARD TUNNEL.

Fig. 14. *Plan of Drill-Carriage.*



Scale 1 to 20.

1·40 litres (85 cub. in.). The advantages claimed for it are diminished weight and cost, reduction in the number of parts, ease of maintenance, and durability.

The drill is connected with the carriage by means of a pin passing through the plate Y, Figs. 7 and 8. This carriage, which weighs about 2,400 kilograms (2·4 tons), is shown in Figs. 13 to 15, pp. 200-4. It is so arranged that, in a heading only 2·60 metres wide (8½ ft), the débris can be removed without shifting the carriage, as there is room for a small tramway, 0·30 metre gauge (11·8 in.), to be laid beside the carriage. The débris is filled into small trucks running on the tramway, and from these into the tipping wagons behind the carriage.

The carriage is arranged for six drills working together. These are placed three on each side, one above the other, the middle one being shown dotted in Fig. 13, page 300 ; and are mounted in sockets carried upon arms which can be moved by means of screws ; the workmen standing at the side are able to manage these with facility. In order that the drills may be directed to any point in the face and at any angle, the sockets at the front end AA are made capable of sliding laterally along the arms BB, Figs. 14 and 15, so as to traverse inwards or outwards as required. The movement is given by screws S lying parallel to the arms. The arms are raised or lowered as a whole by means of the vertical screws C. The arms in rear DD, Figs 13 and 14, can also be raised or lowered by the vertical screws T ; and the sockets EE on the arms can swivel round them, so as to incline the drills at the required angle to the vertical.

5. REMOVAL OF SPOIL.

The rock, after being blasted, was loaded into wagons, and hauled out of the tunnel by small locomotives worked by compressed air. At the face of the heading the rock was first loaded into small tip wagons, which were run back on the narrow-gauge tramway already described, past the drilling machines, and then tipped into the ballast wagons on a lower level. The locomotives, shown in Figs. 16 and 17, pp. 204-5, were built by Schneider & Co. of Creusot. The frames, springs, wheels, cylinders, cranks, reversing gear, etc., are all similar to ordinary locomotives. On the frame is mounted a cylindrical reservoir A containing the air under pressure. The pressure of course diminished during the journey. From the reservoir the air passes through an automatic expander R, where it is expanded down to the cylinder pressure, which is always kept the same. Between the expander and the cylinders it passes through a small reservoir B, which acts as a heater, and at the same time prevents shocks to the valves when the engine is started or stopped. The pressure in the main reservoir A is limited only by the power of the air-compressors, and the tightness of the joints in the pipes. In practice it reached 14 atms. (206 lbs. per sq. in.). By a special arrangement the compressors could be supplied with air already compressed to 7 atms., at times when the efficiency would have been too low, if compressing direct to 14 atms.

The expander R, shown enlarged in Fig. 18, page 204, is composed of a vertical cylinder AA, communicating by a pipe Z with the main reservoir, and partly surrounded by a jacket B. This jacket is filled with the partially expanded air, which can pass into it through two series of holes, *aa* and *bb*. From the jacket it passes to the engine cylinders through the pipe Y. At the lower end of the cylinder, next to the holes *bb*, there is a solid cover ; the upper end communicates with the atmosphere. Within the cylinder works a piston-rod H, carrying two pistons. Of these the upper one is of the ordinary form, but the lower is prolonged into a trunk, pierced with holes *cc*. The stroke is such that the bottom of the trunk never covers the holes *bb*, so that the bottom end of the cylinder below the trunk is always in communication with the jacket. The upper end of the piston-rod carries a plate K, and a spiral spring N holds this plate apart from another plate L, whose distance from the cylinder can be regulated by means of the screw M. This plate L being fixed, the spring tends to keep the trunk at the bottom of its stroke, and so to keep the holes *cc* opposite the holes *aa*, as shown in Fig. 18. If compressed air now enters through the pipe Z, it passes through these holes into the jacket B, and thence through the holes *bb* into the space beneath the trunk, where, its pressure being greater than the atmosphere, it tends to push the trunk upwards against the pressure of the spring. If the pressure be greater than the total resistance, the trunk rises, the holes *cc* become blind with those *aa*, and the air ceases to pass into the jacket. Now suppose the pipe Y to be opened, so that the air in the jacket escapes to the engine. Then the upward pressure on the bottom the trunk diminishes, the trunk descends, and the holes *cc* become partly open to those *aa*. The result of these two tendencies is that the area of the holes *cc* which is open to *aa* is kept of such magnitude as will cause the pressure of air in the jacket to balance exactly the reaction of the spring. The trunk is thus kept in equilibrium, and the pressure at which the air passes to Y is kept constant. *Its amount can be varied if necessary* by screwing up the spring.

The heating apparatus is on the Mékarski system. The heater B, Figs. 16 and 17, pp. 204-5, holds 390 litres (13·77 cub. ft.), and is fitted with *pipes and gauge-cocks for showing* the water-level in the interior—glass gauge-tubes not being applicable on account of the severe shaking and shocks to which the engine is exposed. The heater and the pipes leading to it are clothed with wood and felt. The mixture of compressed air and water passes out of the main reservoir through a pipe P, furnished with a cock and passing to the bottom of the heater, where, in order to devide the air into thin jets, it terminates in a rose. These jets are heated by the hot water, and the air then rises to the top of the heater, whence it is conveyed to the expander R. From this it passes to a pipe S running between the main frames, and dividing into two branches, which lead to each of the working cylinders.

To charge the engine, the cock between the main reservoir A and the heater B is closed, and the inlet pipe of the heater is coupled to a pipe leading from a fixed boiler. There are two outlet pipes from this boiler, one in the steam space and one in the water space, so as to *give steam or water as required*. The lower is first coupled to the heater, which is then filled with water up to the required level. This pipe is then shut off and the heater coupled to the other, and filled with steam up to the desired pressure. During the same time the main reservoir A has been coupled to a pipe leading from the compressed-air mains, and has thus been recharged with compressed-air. When the charging is completed the inlets are closed, and the cock between the main reservoir and the heater is opened : the engine is then ready for working. The pressures are ascertained by three gauges, one on the main reservoir, one on the heater, and one on the pipe leading to the working cylinders.

The principal dimensions &c. of the engines are given below.

Capacity of the large reservoir	7·600 c.m.	268 c.ft.
Internal diam. of do	1·700 m.	5·58 ft.
Length of do	3·550 m.	11·64 ft.
Thickness of steel shell plate	0·015 m.	0·59 in.
Thickness of the dished ends	0·017 m.	0·67 in.
Capacity of the heater	0·390 c.m.	13·77 c.ft
Internal diam. of do	0·800 m.	2·62 ft.
Length of do	0·880 m.	2·89 ft.
Thickness of steel do	0·012 m.	0·47 in.
Diam. of cylinder	0·204 m.	8·03 in.
Stroke of cylinder	0·360 m.	14·17 in.
Diam. of tread of wheels	0·760 m.	2·49 ft.
Volume swept through by piston in each stroke	0·0117 c.m.	0·413 c.ft
Volume swept through by both pistons per metre forward	0·0196 c.m.	0·692 c.ft
Absolute initial pressure of compressed-air in the principal reservoir	12 kg.p.sq.cm.	171lbs.p.s.in
Constant absolute pressure on entering the cylinders	4 kg.p.sq.cm.	57lbs.p.s.in.
Extreme length of engine from buffer to buffer	5·000 m.	16·40 ft
Weight of engine (about)	7 400 tonnes.	7·4 tons.

6. COST.

The cost of the tunnel cannot be given with any great exactness, but the total cost may be taken as follows :—

(1) Blasting of tunnel, making of water-courses, &c.	41,700,000fr
(2) Masonry, etc., inside the tunnel	13,300,000 "
(3) do outside "	600,000 "
Total	55,600,000 "

To this must be added the cost of various extra works, of the preliminary work of triangulation &c., of repairing of damages, of ballasting and laying the line of materials, signals, telegraphs, &c., which together may be taken at 2,000,000 frs. This makes the total cost of the tunnel about 58,000,000 frs. or for a length of 14,890 metres 3,900 francs per metre (£140 per yard), or in round numbers £250,000 per mile. With regard to special items, the cost of blasting was on the average about 46 fr. per cb. m. (28s per cb. yd.). The cost of walling per cb. m. may be taken as follows:—

Wages	13	francs.
Hewing and transport of stone, and selection and transport of rubble for packing	48	"
Hydraulic mortar and cement	6	"
Centres, scoffolding, &c	3	"
Superintendence, &c	6	"
Total	76	"

[Say 46s per cubic yard]

This however is rather the contract price than the actual cost, the latter was much reduced by using the rock blasted on the spot to make the masonry. Again, for the greater part of the length this masonry was merely a lining put for security, the rock being amply strong enough to stand without it.

GENERAL CONCLUSIONS.

In conclusion, the points connected with the construction of this tunnel, which seem particularly to call for notice and comment may be stated as follows:—

(1) The advantage in such cases of constructing a long tunnel at a comparatively low level, instead of a shorter tunnel at a higher level.

(2) The proper position of the leading heading in the section, and the proper mode of completing the full section from it.

(3) The best construction and arrangement of the turbines and air-compressors, to utilise a comparatively small quantity of water at a very high pressure and velocity.

(4) The best construction and arrangement of the drilling machines.

(5) The best means of keeping a long heading cool, in view of the very great loss of efficiency which is found to result from too high a temperature.

It is only on the first two of these points that any remark will be made on the present occasion.

With regard to the first of these points, the superior limit to the level at which such a tunnel should be made has been shown above to be fixed by considerations of climate. The interior limit to its position is determined on the one hand by the length, as influencing the time and cost of construction, and on the other hand by the height of the overlying strata above the tunnel, as influencing the heat within the heading. From observations made at the St. Gothard and elsewhere we may assume that the limit of temperature at which men can work at all in a tunnel is 50° C. (122° F.) in dry air, and 40° C. (104° F.) in air saturated with moisture. The observations at Mont Cenis and the St. Gothard also go to fix the relation between the depth below the surface and the internal temperature. At the St. Gothard the average increase appeared to be 2° C. per 100 metres vertical height (or say 1·1° F. per 100 ft. vertical height). The form of the overlying mountain, and the nature of the rock, have of course also an influence on the temperature. The amount of water to be expected is a matter on which it is generally impossible to speak with any certainty; but a long tunnel will always be more or less wet. Many modes have been suggested for drying and cooling the air within the heading, but there is little to be said practically as to their efficiency. The air used for ventilation is found to have little influence in either direction. These considerations have a practical bearing, for example, on the proposed Simplon Tunnel, which is to be nearly 12 miles long and only 2,300 ft above the sea. In this case the temperature of the rock would be about 47° C. [116° F.) according to the rule given above, as determined for the St Gothard by Dr. Stapff. If the tunnel were raised to a level of 2,600 ft. with a length of 10 miles, the temperature would be about 40° C. [104° F.]; while if it were raised to a level of 3,600 ft. with a length of 7½ miles, the conditions would be about the same as in the St Gothard tunnel. It follows that the longest of these projected tunnels could not be made in the same way as was practised at the St Gothard, and some improved method would have to be sought for.

As to the second point, *i.e.* the actual mode of driving the tunnel, the results obtained at the St. Gothard are of great interest. In the improvement of the drilling machines, and the employment of dynamite, that tunnel had a great advantage over the Mont Cenis; and accordingly the progress of the first heading was much more rapid. On the other hand the completion of the tunnel lagged much further behind. At the Mont Cenis the tunnel was open for traffic 9 months after the junction of the headings, whilst the interval was 22 months at the St. Gothard. There arises therefore a question how the improved rate of progress, which has been achieved for the heading, may be extended to the work of completion.

Whilst in the Mont Cenis tunnel the leading heading was driven along the bottom of the section, M. Favre adopted the opposite course at the St. Gothard, and drove the heading along the top. In 1874 this method was sharply criticised by Professor Rziha and others; and although the discussion led to no very definite result, the Arlberg tunnel is being driven by means of a bottom heading. These works have been two years in progress; the rate of advance in the heading is half as great again as at the St. Gothard, and the completed work follows as closely behind it as it did at the Mont Cenis. Herr Bridel, chief engineer of the St. Gothard Railway, and formerly a supporter of the Belgian or top-heading method, has written a report comparing the two methods (top heading and botton heading) under the three following heads:—

1. Influence of each method on the rapid completion of lengths already pierced by the heading.
2. Influence on the power of keeping back the pressure of soft rock.
3. Influence on the cost of construction.

His results are as follows.

Completion of Tunnel —With regard to the first head, it is very important, where drilling machines are used in the enlargement of the heading, to have as many points of attack as possible, so that the workmen may not be too much crowded together. With a bottom heading this is attained by adopting what is called the English system, in which openings are commenced in the sides and roof of the heading at a number of different places, corresponding to the rate at which the heading itself advances. It is obvious that the spoil from the furthest of these openings can be carried past the others without difficulty; which would not be possible in the case of a top heading, where the opening would have to be made in the floor and not in the roof. The bottom heading was adopted at the Mont Cenis tunnel, and also at the Arlberg tunnel; and in the latter, in spite of the much more rapid advance of the heading, the completed tunnel on 31st July, 1882, was only 1090 yds. behind the face of the heading on the West side, and 750 yds. on the East side. The same system, with slight modifications, was adopted at the Laveno tunnel 1·9 mile long. Here the junction of the headings took place 368 days after the commencement, giving an average advance for the two ends together of 8·15 metres (26·7 ft.) per day. In the last month the advance was 37·7 ft. per day. Top headings were here carried forward at the same time as the bottom headings, and their junction took place two months after that of the latter. Openings were made at short intervals from the one to the other, and the spoil from the top heading was thrown down through these into wagons below. The completion and walling of the section did not lag behind; and the tunnel was open for traffic 4½ months after the junction of the bottom headings, and only 16½ months from the commencement of the work.

On the other hand, in the case of the St. Gothard Tunnel, the whole length under construction in October 1877 (a time when the works were in an exceptionally regular condition) was 2750 metres (say 3000 yds.); which may be compared with 1260 yards in the case of the Arlberg tunnel. Even theoretically, the length under construction with the method adopted at the St. Gothard can never be less than 2600 yards. Assuming a maximum progress of 165 yards per month, it follows that the tunnel cannot be completed until 15·8 months after the junction of the headings. As a matter of fact the actual interval was over 21 months. In the Arlberg tunnel on the other hand the completion map be expected to follow within 5 months from the junction of the headings.

ST GOTHARD TUNNEL.

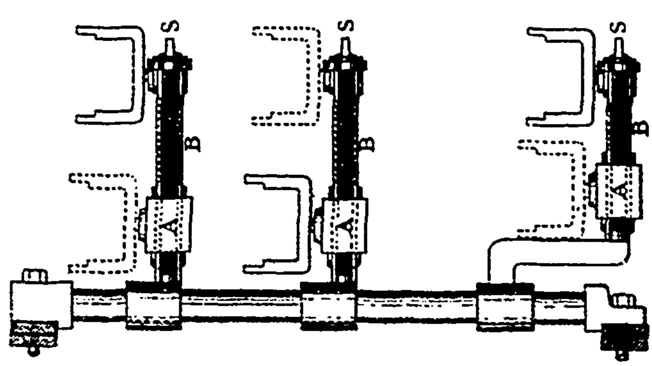


Fig. 15. Half Elevation of Drill Carriage. Scale 1 to 16.

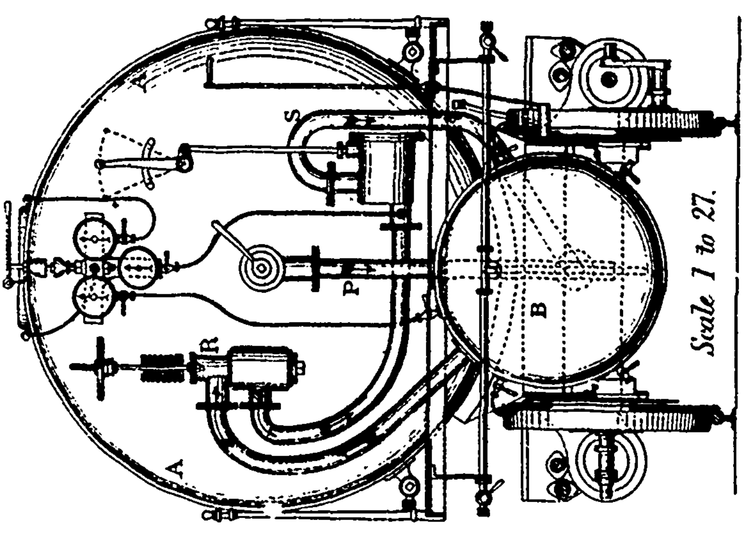


Fig. 17. End Elevation of Air Locomotive. Scale 1 to 27.

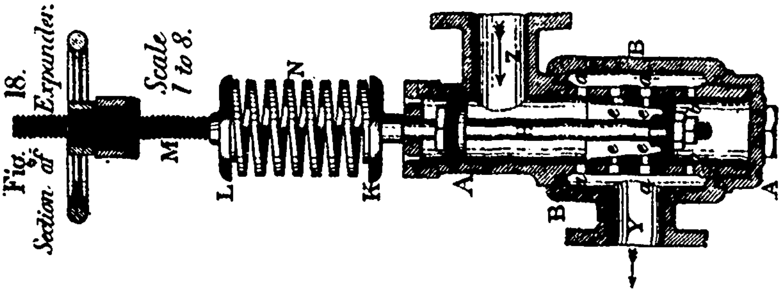
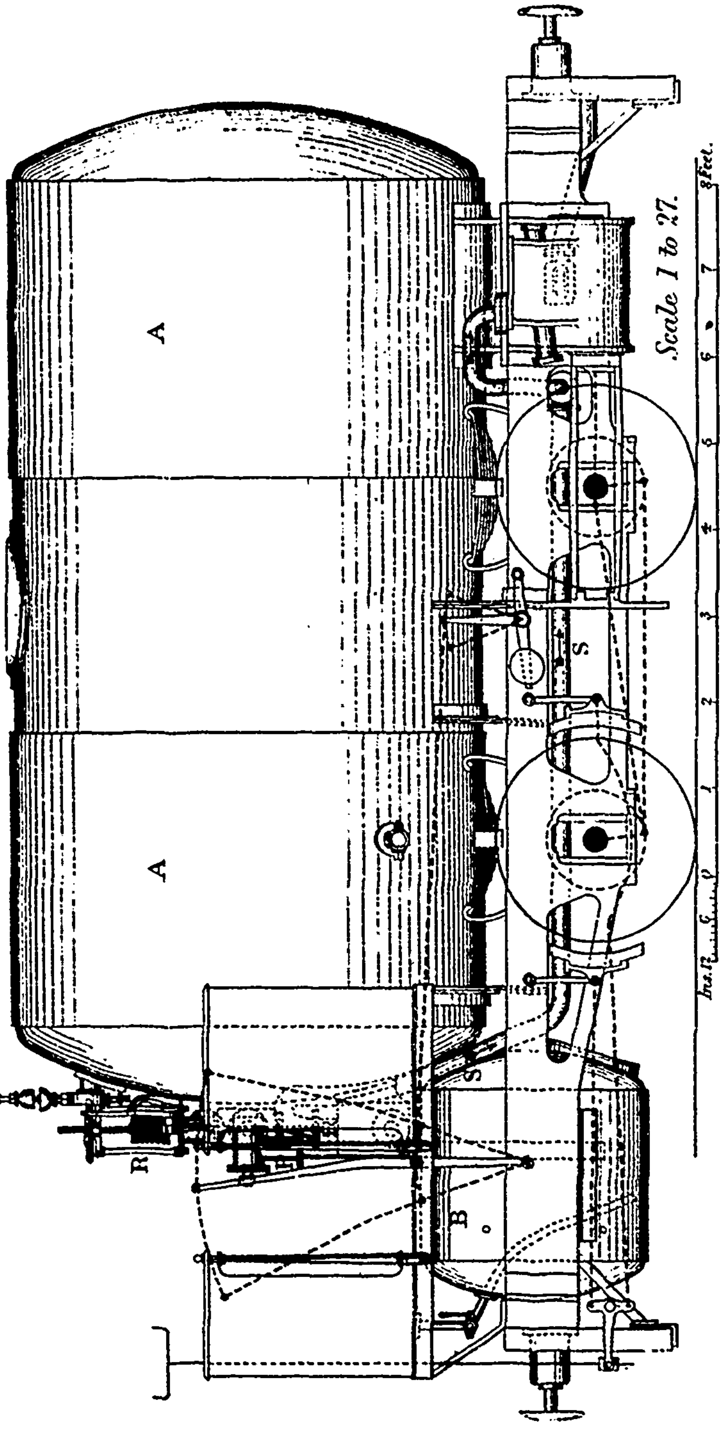


Fig. 18. Section of Expander. Scale 1 to 8.

ST GOTHARD TUNNEL.

Fig. 16. *Side Elevation of Air Locomotive.*



On the whole it would seem that the method of driving a top heading is not the best for any tunnel where machine drills are used for the rapid completion of the work.

Pressure of Rock.—Where the rock is of a gravelly nature, so that it exercises great pressure, but is not itself compressible both theory and practice show that if the Belgian method be adopted, and the arch put in without abutments, a sinking and crushing in of the arch cannot be prevented. The same is yet more certain where the rock is of a clayey or plastic nature, as has been shown on the line from Foggia to Naples, and also in the "pressure length" of the St. Gothard tunnel. Here it was found in many places impossible to complete the arch at all on the Belgian method, it was absolutely necessary to begin with the abutments and invert. In wet earth the Belgian method is clearly quite inapplicable.

Herr Bridel has drawn the following conclusions on this subject:—

a. The Belgian method is not safe where there is great pressure, and especially where the rock is plastic.

b. Even where all possible precautions are taken, the work is extremely difficult, slow, and expensive, and the success always doubtful.

c. With a top heading, the English method of completing the tunnel is possible indeed but exceedingly costly, difficult, and slow.

d. With a bottom heading, this method is capable of any amount of development, and renders possible a much more rapid advance.

e. In a long tunnel it is impossible to tell whether plastic strata, or others exercising great pressure, will be met with, through which it would be necessary to drive a bottom heading. But it is exceedingly difficult to pass from working by a top heading to working by a bottom heading.

All the above conclusions point to the superiority of the bottom-heading system.

Cost of Construction.—The experience gained on this head leads to the following conclusions, as drawn up by Herr Bridel:—

a. With forced working (*i.e.* where the progress is to be as rapid as possible), when the conditions as to ventilation and drying the tunnel are the same, the general cost of blasting is nearly the same whether the leading heading is at the top or at the bottom.

b. The drying and ample ventilation of the working places are however much more difficult with a top heading than with a bottom heading, so that the latter system is really superior in these respects.

c. The removal, loading, and transport of the spoil is done much more easily, quickly, and cheaply with the bottom heading than with the top heading.

d. The formation of drains, and the laying of roads and of air and waterpipes, are extensive and costly works with a top heading, but are a small matter with a bottom heading.

It follows that, where rapid progress is necessary, the bottom-heading system is to be preferred to the other.

At the Arlberg tunnel the contract price at 3 to 4 kilometres from each portal (which is about the average distance at the St. Gothard), and where walling is thinnest, is as follows.—

	Ft. per metre.
Bottom or leading heading	374
Top heading, following it..................	242
Completion, except masonry to trains........	1430
Masonry to drains........................	57
Total......	2103
Add 3½ per cent. for extras....................	73
Add interest on cost of plant, &c., supplied by the railway company (taking this as the same as at the St Gothard)...........................	470
Grand Total.......................2646	
(say £96 per yard.)	

On the other hand the contract price at the St. Gothard tunnel was as follows:—

	Fr. per metre.
Total except masonry....	2800
Masonry, minimum thickness. .	830
Total........	3630
(say £132 per yard.)	

There is thus a difference in favour of the Arlberg tunnel of 984 fr. per metre (£36 per yard). This difference is certainly more that can be accounted for by the somewhat harder character of the rock at the St. Gothard: and thus confirms the conclusion that, at least with force working, the bottom-heading system is the cheaper of the two

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THE DESIGN AND CONSTRUCTION OF BRIDGES.

(*See page 208.*)

The structure shown in our illustration page, represents the bridge constructed at Grenoble, over the Isere, by M. Berthier engineer-in-chief. As will be seen, it comprises three arches, segments of circles. The centre arch has an opening of 25·10 m., and a rise of 3.30m., the side arches are each 23·10m. span, and 3m. rise. These arcs correspond to an angle in the centre of 60°; in other words, the chord is equal to the radius or side of the inscribed hexagon. Many engineers rightly consider this proportion of arc as the most graceful. M. Debauve, whose description we are quoting, says, the thickness of the keystone of the middle vault is 1·20m., and that of the side vaults 1·10m. The fronts of the "pierres de taille" (ashlar voussoirs) are dressed to spring from a skewback, the masonry is formed in steps, and the front portions of the piers or cut-waters are also of ashlar masonry. The filling of the spandrel is in masonry covered by a layer, and the infiltrated water which collects is carried to the centre of piers, where it percolates through a heap of rubble or stones before being discharged by the inclined pipe seen in the section. The longitudinal and transverse sections illustrate the construction of the spandrel, and show the filling and masonry through the axis of the pier. The piers and quay walls have a slight batter, the former one of $\frac{1}{25}$ and the latter of $\frac{1}{15}$. The width between the parapets is 12 metres, and there is a slight set-off from the arch-face to the tympana. The widths of roadway and footways and parapets are figured in the cross section; the footways have gutters. The convex contour of the bridge is favourable to the carrying off of the water, and also to the architectural effect. The plan and elevation show that the bridge is turned by quarter circles or quadrants into the approaches or quays, which angles are rounded off by a corbelling of masonry a plan favourable for the easy passage of traffic. We give a plan of the end of bridge showing this arrangement We also give a plan and side view of the "organeaux," or rings, for mooring vessels. These are fixed in the piers. All bridges built on navigable rivers ought to be provided with these appliances, which are placed at different heights The piers, as will be seen, are built on a mass of beton submerged in an inclosure of piling. The scouring of the river is prevented by the rubble aprons seen in the section The bed of foundation is an incompressible gravel.

Our other illustration shows the railway bridge of Plessis-les-Tours, over the Loire. We only give one arch and pier of this fine structure which is composed of 15 arches of elliptical shape of 24 metres span each, and of 7 10m rise or versed sine, separated by piers of 3 metres in width, and terminated by abutments of 8 metres. The width of the bridge is 8 metres between the parapets. The thickness of the keystone is 1.20m., and the line of extrados springs from the summit of the head of the pier, which gives, at this part, a joint of 1·50m. for the vault. The small discharging or relief vaults have only a thickness of 0·70m. at the keystone. A dotted line on the elevation shows the backing. The foundations consist of masses of beton inclosed by piles and planks. The conveyance of the water which passes through the ballast, and which arrives at the surface of the masonry, is effected by a covering or layer, which is shaped to the profile shown in the sections, or inclined from the axis of pier to the summit of vault, where the discharge takes place. By this means, the surface drainage is carried to the summit of each vault, where they are met by vertical pipes, the superior orifice of which is protected by a head or rose covered by a mass of stones, forming a filter. The covering of the vault is composed of three layers, the lowest of concrete, the intervening of cement, and the upper of asphalte. Between the covering and masonry in the spandrels of bridge, the vaults have been filled with a very thin beton or rubble, which constitutes an incompressible material.

The parapets are built in terracotta, which, M Debauve observes, is less costly than ashlar, and is preferable to iron railings. The "voussoirs des têtes" are alternately in two or three pieces, but the keystone is formed of a single block, the front of which is cut diamondwise; and as will be noticed in the cross-section, the two keystones are connected by a rod of iron, which does not injure the solidity of the vault. The simple and elegant profile of the arches and the piers will commend the design to all bridge builders. The piers batter to a pleasing proportion, and are faced with courses 0·20 in height, and crowned by a capping of ashlar. The abutments have this moulding carried through to the banks at the same level, thus connecting in effect the piers and the abutments.

The total cost of the bridge was 1,345,000fr. for 438 metres. Our readers will be enabled to study for themselves the details of these two excellent examples of bridges, as all the dimensions are given, and the several radii of the arches in the last described structure are indicated. We are no less charmed with the scientific distribution of material and construction. than with the graceful elegance and simplicity in the lines and profiles of these two bridges. Our own London Bridge over the Thames only is comparable with these in the extreme simplicity and elegance of proportions between the opening and solids.

The two designs are instructive also as showing two distinct modes of reducing the weight on the foundations. In the first instance we see a backing of rubble masonry over the vault, the filling being of lighter material; in the latter case the weight is discharged by a small arch over the pier, and a considerable saving of solid masonry is effected. The designer of a bridge must use his own judgment as to which plan it is desirable for him to adopt. The main consideration should be the nature of the foundation or bed of the river. If this is at all doubtful, or if the formation is of a compressible soil, or if of rock full of cracks, the less weight on the foundation the better; if it is unyielding, the designer may adopt bold proportions for his openings. Perhaps no better foundation for a pier of a bridge can be found than that shown in our sections. Here we have no bearing piles supporting the pier, but a solid mass of concrete "in a shell," in the one case 5·03 m. deep and 6·40 m. wide, extending throughout the whole length of the pier. This mass of beton is supported while in the process of setting by the piles, and further protected from the scouring action of the river by stones thrown in all round.

In treating of foundations, a writer in the 9th edition of the "Encyclopædia Britannica" makes some very apt remarks, and as our purpose is now to give practical information with respect to the site and foundations of bridges, we may here refer to these observations in the course of our remarks. As regards site, the engineer must satisfy himself by borings at convenient distances. A solid rock is, of course the best if homogeneous, but if cracks are found, it cannot be relied upon, and is inferior to such formations as uniform gravel, chalk, and some kinds of sand and clay. A squeezable foundation is the worst, as it would allow of subsidence when the piers were loaded. Even more objectionable than a compressible foundation is one of unequal bearing power. When softer materials are found they should be removed, and the inequalities filled up with concrete.

Referring more particularly now to foundations under water, the action of the scour is one of the chief difficulties in the way of a lasting foundation against which the engineer has to contend. We may allude in passing to the subsidence of Waterloo bridge over the Thames as an instance of this. Little did its engineer, Rennie, think that in little more than half a century symptoms of failure of the foundations from this cause would have shown themselves. Many other bridges have failed by the gradual undermining of the piers, and we may have to say something about the action in a future article.

There are several methds adopted in the laying of foundations of bridges to which we may briefly refer. We have naturally first to speak of the system of cofferdams, and for the benefit of our younger readers we may say the cofferdam consists of a double row of sheet piles tied together by wales and cross beams inclosing a vertical wall of clay puddle. Its width is determined by the pressure or head of water, and sometimes it equals the head unless inside strutting can be adopted, from side to side of the inclosed area. The *Cours de Ponts*, as used at the school of *Ponts et Chaussées*, remarks that a cofferdam need not be made of greater thickness than from 4ft. to 6ft. The water being pumped out, the necessary excavations can then be proceeded with.

Another system of laying foundations is by making caissons: these may be of timber or wrought-iron plates bolted together in sections and sunk. One mode was by driving piles, cutting them off level at a certain depth, and then sinking a caisson or box filled with masonry on the proposed site. As the scour of the river has been found to injure this method of procedure, it has been generally abandoned. Another and preferable form of caisson is to construct it of wrought-iron plates ½in. to ⅝in. thick in circular segments or rings, bolted together so as to form sections of a manageable diameter and depth. The lower section is made with a cutting edge to penetrate the soil. These sections are sometimes sunk between guide piles, and the joints made watertight. After being sunk by their own and additional weight the ground within is excavated and the water kept down by chain and bucket or other kind of pump. Sometimes mechanical dredgers are used. Sometimes a frame is floated to the site of pier and then sunk, the inside soil is then excavated or concrete is shot within it, which sets undisturbed. These hollow timber frames without a bottom are particularly adapted for bridge pier building. They can be made watertight after being lowered, and can be used in water from 5ft. to 20ft. of depth. This mode of laying foundations will be effectual wherever a good rocky bed is found. When the frame is in position, it is allowed to remain as a protection for the concrete, and in such a case should be surrounded by a rubble embankment or "toe." The same plan has been used by the French engineers in the bridges we have described, and is called "concrete in a shell." This mode depends on the valuable property of hydraulic concrete of setting into a solid mass under water. The area of site is inclosed by piling or a shell of timber or iron. The soil inside is dredged out by a mechanical excavator until the foundation is reached, and concrete or beton is then shot or run in from a height of about 10ft. and rammed in layers. The rubble stones heaped up outside protect the shell or casing of piles against the scour of the current.—*The Building News.*

Japanese napkins folded in the shape of fans and put in glasses at each end of the top shelf on the sideboard are light and ornamental.

EXPERIMENTS ON AMERICAN WOODS.

BY PROF. S. P. SHARPLES, BOSTON, MASS.

(*Read at the Boston Meeting, February, 1883.*)

Under the act providing for the taking of the Tenth Census the superintendent was authorized to appoint experts to inquire into special industries. Under this act Professor Charles S. Sargent was appointed to gather statistics in relation to the forest industries.

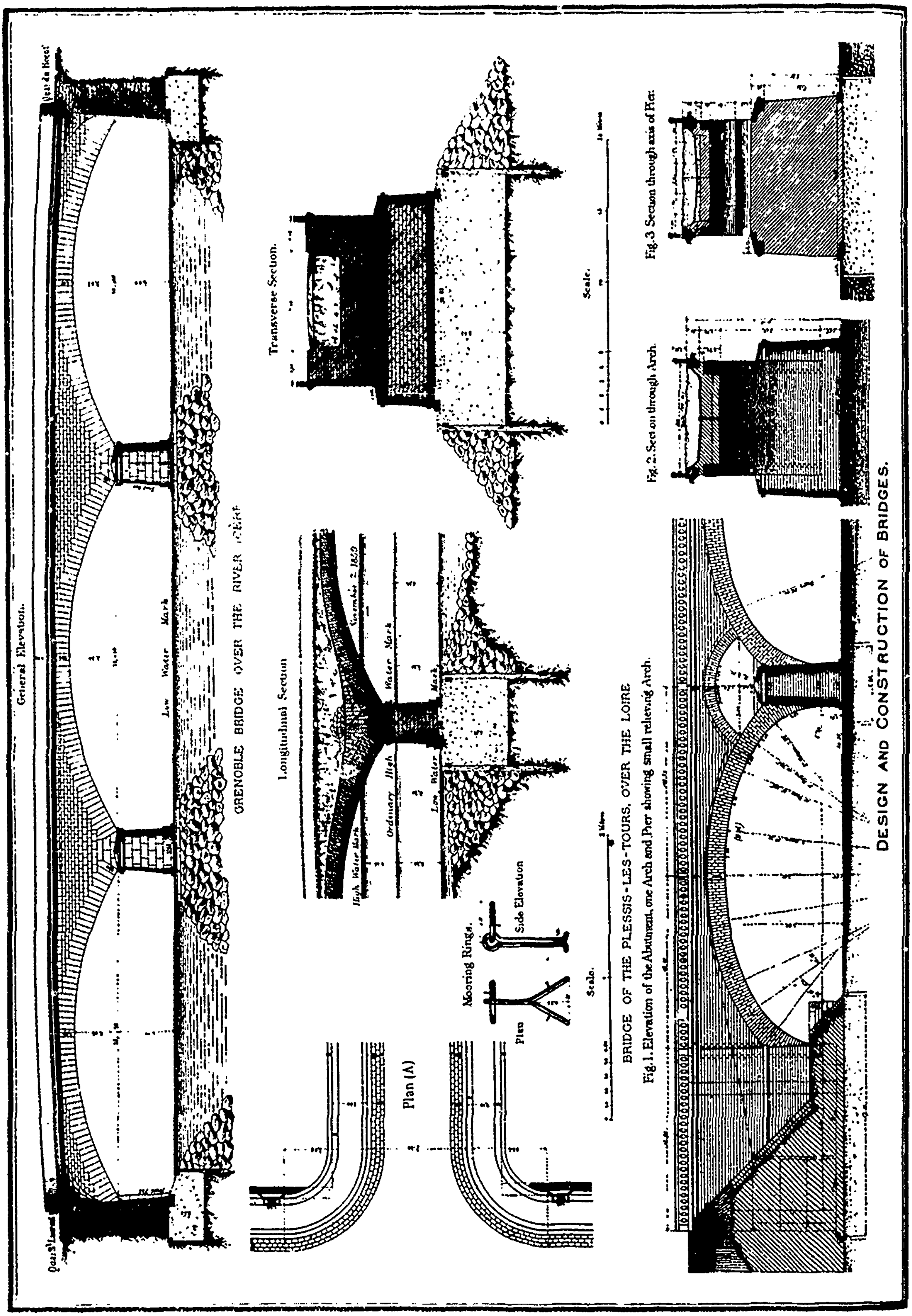
As chief of the Department of Forestry of the Tenth Census he has been busily engaged in this work since the Fall of 1869. Soon after his appointment he became convinced that it would be desirable to make an examination of the fuel-value of the various woods of the United States, and this work was placed in my hands.

At the same time I made the suggestion that while we had the opportunity, it would be well to test also the strength of these woods. The suggestion was adapted and Professor Sargent at once set his agents to work in various parts of the country to collect specimens of all the trees growing in their localities, employing as a rule botanists who were familiar with the flora of the region in which they were at work. The result of this work was the collection of over thirteen hundred specimens of wood, comprising over four hundred species and varieties, nearly one hundred of which had not before been described as trees existing in the United States.

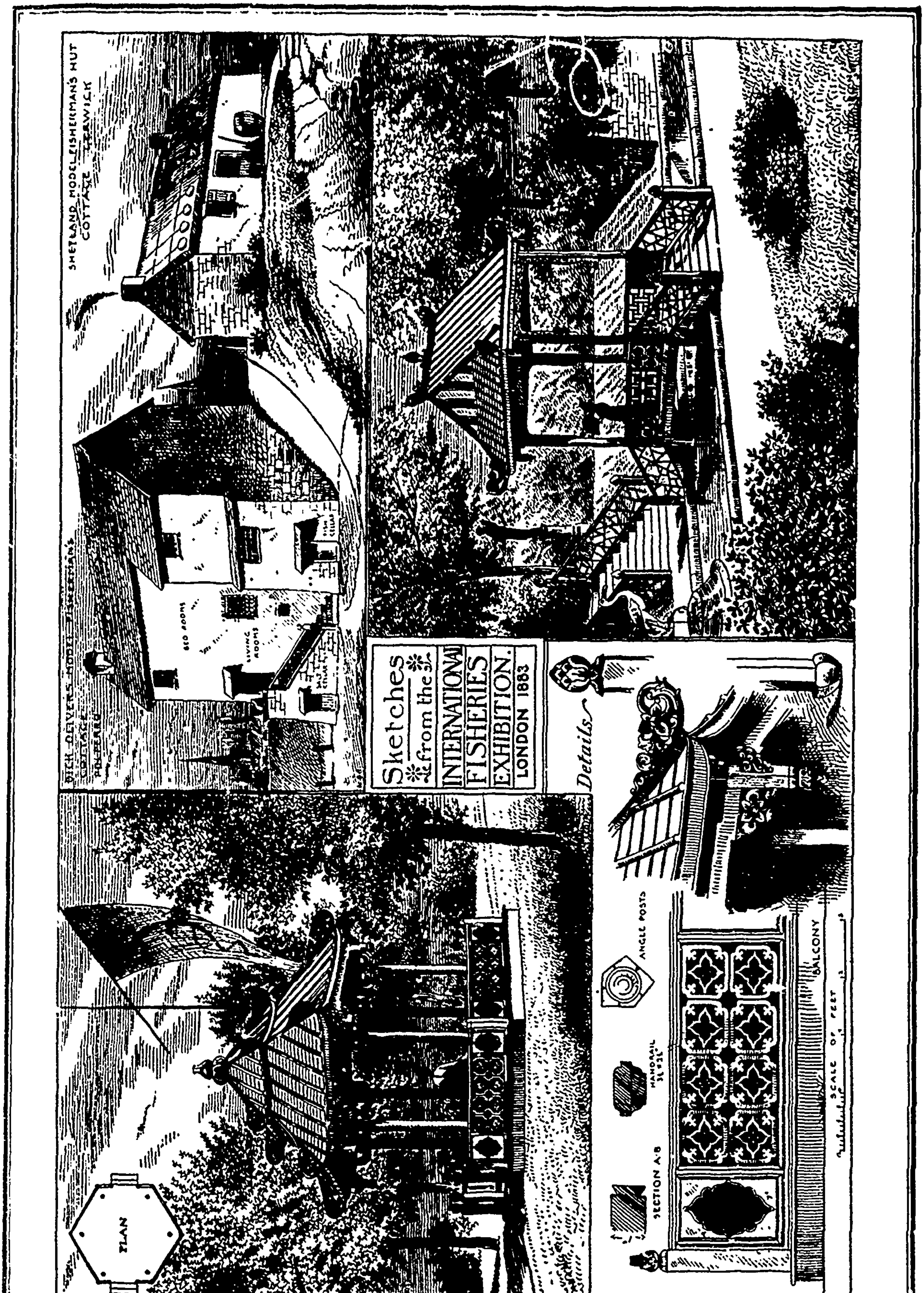
The ash and specific gravity of every specimen in this collection has been determined, in most cases in duplicate. About 2,600 ash and 2,000 specific gravities have been determined, about 325 species were further tested for transverse strength and resistance to crushing. In this series about 1,800 specimens were tested. As each of these was tested in three different ways, it made in all about 3,900 tests. The specific gravity of each specimen in this last series was also determined, thus making in all about 10,600 tests that were made on the specimens. Many of these tests, however, included not only a single test, but often a series of tests that required at least ten entries on the final report, as I shall explain further in this paper.

In addition to to the tests already spoken of, 70 tests were of the carbon and hydrogen in a number of specimens.

These tests have already, so far as the results of the ash and specific gravity of the dry wood is concerned, been published in *Forestry Bulletin* No. 22. The carbon and hydrogen deter-



DESIGN AND CONSTRUCTION OF BRIDGES.


Sketches from the International Fisheries Exhibition. London 1883
Details
PLAN
SECTION A.B
HANDRAIL
ANGLE POSTS
BALCONY
SCALE OF FEET
BED ROOMS
LIVING ROOMS

minations are to be found in *Bulletin* No. 18, while the tannin in the bark of a few of the most promising trees is found in *Bulletin* No. 24.

A *Bulletin* shortly to be published is to give the deflections under various loads of the woods tested in this manner, and the weight under which they failed, together with the force necessary to crush in the direction of the fibre pieces, whose length was equal to eight diameters. In addition to the tables published in the *Bulletins*, the final report will give the force necessary to indent the wood.

This series of tests is felt to be incomplete in many ways, and with the experience that has been gained in the work could doubtless be improved. A brief description of the methods used may be of interest.

Each specimen as soon as received was given a number, and this number has been constantly repeated in all the work done on that specimen, it is designated in the report as the office number, and wherever met with always refers to the same tree.

After numbering, the sticks were at once sawed into bars five centimeters square. These pieces were then seasoned by air-drying. During the first winter they were kept in a room warmed by a stove to about 70° F. After that they were removed to a timber-loft at Watertown Arsenal, where they were kept until they were dressed for the final tests.

Two blocks of fifteen centimeters in length were taken from each specimen and dried rapidly with steam-heat until they had lost most of their moisture. From these pieces blocks of exactly 11 centimeters in length and about thirty-five millimeters square, were dressed out. These were then placed in an oven which was maintained at a constant temperature of 100° until the blocks were perfectly dry. After they had ceased to lose weight, they were carefully measured with a micrometer caliper and then weighed. From the measurement and weight it was easy to calculate the specific gravity.

The ends removed from these blocks were used for determining the ash. They weighed from 10 to 20 grammes and thus gave quite appreciable amounts of ashes. The ash was determined by drying the wood in the same manner as the specific gravity blocks, then carefully burning in a platinum dish in a muffle-furnace heated by gas. The heat was so regulated as to burn the ash perfectly white without melting it. In most cases the ash was left in the exact shape that it occupied in the wood. It was judged best to report the ash exactly as found, and not to attempt to make any correction, on account of carbon dioxide that might have been lost from the calcic carbonate present.

From these results, the approximate fuel-value was calculated, assuming that equal weights of all woods have the same fuel-value. This value is supposed to be given more correctly by taking as the weight of the wood, not the specific gravity, but the weight of a cubic decimeter, minus the ash contained in it. The ash evidently adds nothing to the fuel-value, while it does add to the weight. This assumption, which is the one which is generally made, is not strictly true, but it is near enough for all practical purposes. It is founded on experiments made by Count Rumford and Marcus Bull.

The carbon and hydrogen determinations were made by burning fine sawdust in a platinum boat in a current of oxygen and collecting the products in the usual way. These analyses were calculated on the dry wood. The determinations may be conveniently divided into two classes—those of the coniferous woods and the non-coniferous.

The coniferous woods examined, with two exceptions, gave larger amounts of carbon than the hard woods. These two exceptions were the common white cedar or *arbor vitæ* of the north, and the black spruce or *picea alba*, neither of which would be selected as valuable fuel. The average composition of twenty-nine specimen of coniferous woods examined was carbon, 53.21; hydrogen, 6.45; ash, .32; specific gravity, .5624. Fuel-value by weight, 4488.3; by volume, 2524.2.

For the non-coniferous woods the average results were carbon, 49.53; hydrogen, 6 33; Ash, .66; specific gravity, .6951. Fuel values by weight, 3993.9; by volume, 2776.1. These latter values agree very closely with those given in the books, as the results of the analyses of European woods. It is rather singular that with the exception of fir, no coniferous woods have been reported on in Europe.

Forty-one determinations of non-coniferous woods were made. After the long sticks of wood had become thoroughly seasoned they were dressed out to the exact size of four centimeters square, and were sawed as near as possible to the length of 11 decimeters. They were then tested on the Watertown machine. In testing, the stick was placed in a perpendicular position resting on supports that were exactly one meter apart. The force was then applied at the centre of the length by means of an iron bearing, which had a length a little greater than the width of the stick and a radius of 12.5 millimeters. The weights were slowly applied, 50 kilograms at a time, after each weight was added, the deflection was noted. After 200 kilograms had been added, the weights were removed and the set read; the weights were again applied, the reading again taken at 200 kilograms, and then at every 50 kilograms until the stick was broken, the breaking weight being noted. In making the report, the coefficients of elasticity for the weights, 50 and 100, have been calculated; also the modulus of rupture.

So far I can only give the most general results in regard to these tests. In the first place we have not been able to establish any general law in regard to the direction in which a stick is the strongest, that is, parallel or perpendicular to the annual rings.

The results have shown, however, that it is by no means necessary to break two sticks to show which is the strongest, provided they are of the same kind of wood. The weak stick will show the largest deflections from the start. The strongest stick found was a specimen of locust, but following closely after it were specimens of hickory and southern pine. Ash was found to stand well up to a certain point, and then it gave away suddenly and without warning, generally shattering badly. The California red-wood was another that shattered very much. White oak was found to be inferior in strength to several other oaks, and to Southern pine, the average breaking weight of 40 specimens being 386 kilograms, while the average breaking weight of 8 specimens of *quercus prinoides* or the cow oak of the South was 528 kilograms.

The average of 27 specimens of *pinus australis* was 490 kilograms. The average of 36 specimens of the Douglas fir from the Pacific coast was 374 kilograms, and of six specimens of the Western larch was 523 kilograms.

13 specimens of white pine (*pinus strobus*) gave 274 kilograms.

11 specimens of beech gave an average of 454 kilograms.

16 specimens of *carya sulcato* averaged 464 kilograms.

20 specimens of *carya alba* averaged 512 kilograms.

24 specimens of white ash averaged 378 kilograms.

8 specimens of locust averaged 513 kilograms.

The next series of tests which were made, consisted in taking specimens of the same size, square as before, and 32 centimeter long, and compressing them in the direction of their fibres. Here again both locust and the Southern pine stood up well.

9 specimen of locust stood an average weight of 11,206 kilograms.

5 specimens of the Western larch stood an average of 10,660 kilograms.

35 specimens of white oak stood an average of 8183 kilograms.

24 specimens of *pinus australis* stood an average of 10,498 kilograms.

The third series of tests was to find the force necessary to indent the wood at right angles to the grain. These tests are not finished yet, and I have made no examination of the results.

They are made on blocks 4 centimeters square and 16 centimeters long, the bearing of such a size that it makes an impression on the block which extends from side to side of the block and is the same length; or, in other words, is 4 centimeters square.

In closing this paper I wish to express my thanks to Col. Laidley for valuable suggestions made during the progress of the work, and to Mr. Howard for the able manner in which he has executed the tests. These tests have been made at the joint expense of the War Department and the Census Bureau, the machine having been put at our service by order of the Secretary of War.

The tests will all probably be published in the annual report of the testing machine, calculated in feet and pounds.

DISCOVERY OF A PLANET.—Another small planet (No. 233) was discovered by M. Borrelly at Marseilles on May the 11th, and observed by M. Bigourdan at the Paris Observatory on the following night. It was of the eleventh magnitude.

OUR BODIES.

By Dr. Andrew Wilson, F.R.S.E., &c.

THE BODY'S INCOME AND EXPENDITURE.

In the course of our previous studies we have seen that the work of the body is perpetually associated with waste. Work and waste bear, in fact, a very well defined relation to each other and of necessity, the function of nourishment, whereby repair of this waste is effected, must in turn relate itself to both processes. Work is impossible without the energy (or power of performing it); we derive from our food, and the bodily waste is merely one indication of the extent to which that energy has been applied in carrying out the acts of life. A human body, as the result of its work, then, is perpetually breaking down, in a chemical sense, into various waste products. Of these products so much *heat* may be regarded as waste matter, seeing that it is given off from the body, and is thus lost to it. *Water* forms a second product of extreme importance, as also does, thirdly, the gas named *carbonic acid*. A fourth kind of waste is represented by the substance known as *urea*; and, fifthly, we can detect *ammonia* amongst the waste materials of our frames. To these we may add *organic matters* of various kinds, consisting of the actual worn-out cells and particles of the body; and *minerals*, whereof a considerable quantity is excreted or given off by the skin and kidneys especially.

The work of excreting or removing these waste matters from the blood, into which they have been poured as the result of the tissue-waste, falls chiefly upon the *lungs, skin* and *kidneys*. These organs form, in fact, a kind of physiological trio, engaged in the same kind of work, and capable of mutually aiding each other in its performance. The same products are excreted by all three organs, but in different proportions. The practical benefit of this knowledge is seen in the treatment of many diseases. For when the lungs are disordered in any way, the physician can compel the skin and kidneys to take up so much of the lungs' work, by giving medicines which stimulate the skin and kidneys respectively. When the kidneys similarly suffer disorder, skin and lungs come to their assistance. The mere fact that skin and lungs co-operate perfectly and invariably during exercise is sufficient to impress upon us the close interdependence which exists between the organs.

When we endeavour to sum up the income and expenditure of the body in a kind of physiological balance-sheet, we are met by the consideration that whilst the work of repair, or the facts of bodily income, are plainly enough to be discerned, the sources of loss or expenditure are not so readily noted. We know that *food*—solid and liquid—is converted into our own substance, and that the *oxygen* of the air also forms part of our dietary, since it is necessary for the maintenance of heat, and for other vital purposes. But the sources of loss are not so apparent as the means and ways of gain; hence we must firstly see where and how the bodily income is spent. A little consideration will show us that there must be a considerable amount of loss incurred through the action of what may be called the ordinary "wear and tear" of life. All the organs and tissues must wear and lose their substance in the discharge of their duties. In such an organ as the stomach, daily engaged in the important work of digestion, or the liver, which is perpetually engaged in its labour of manufacturing bile, there must be constant loss of substance. Again, there is actual waste of muscular substance in every movement of life, from the winking of an eyelid, or the stroke of the heart, to the blacksmith's energetic labours, hammer on anvil. Much of the bodily waste (water, heat, carbonic acid, etc.) must therefore arise from this source. A second source of waste is that incurred in the production of heat and of movement in our bodies. We are perpetually losing and giving off heat, yet the normal temperature of our bodies (about 100° Fahr.) requires to be maintained. Such an amount of heat cannot be generated without expenditure of force, or without the presence of *ash*, so to speak, which *ash* makes its appearance in the form of certain of the waste products already mentioned. As regards bodily *motion*, we have already noted the immense expenditure which muscular action entails upon us.

Other and more subtle forms of waste make demands upon our stores of energy, and necessitate bodily wear and tear as an equivalent. The thoughts that originate in the brain, the expression of nerve-force to which they give rise, its conveyance by the nerves, are, each and all, so many sources of waste and bodily expenditure. Even *growth* itself, the digestion of food, the propulsion of blood through the body, and all other processes of nourishment, necessitate an outlay of the store of strength we possess. It is thus perfectly true, in one sense that life is a process in which we burn the candle at both ends. The very acts whereby we build up our frames anew and nourish our bodies, whilst repairing these frames, at the same time draw from them the strength and energy we owe to previous acts of nourishment.

Summing up the sources of *income* of our bodies, we may discover, firstly, that in *solid food*, *water*, and *oxygen* we may be said to place our physiological trust. An adult consumes every day about 8,000 grains of solids, about 35,000 grains weight of water, and about 13,000 grains weight of oxygen. Nearly 8½ lb. of matter, calculating roughly, represent the daily income. Daily expenditure practically shows a similar amount, for supposing growth has ceased, then income and loss will, in health, be as nearly as may be adjusted; and if our means of research were more delicate, they would probably be found, in health, exactly to correspond. From the lungs we give off, per day, carbonic acid gas, water, and organic matters equal to 20,000 grains. The skin gets rid, in the same time, of nearly 12,000 grains weight of water, minerals, gases, etc. The kidneys excrete about 24,000 grains of waste (water, urea, minerals, etc.), and from the intestine the digestive waste given off may be estimated at about 2,800 grains weight. It follows that with about 8½ lbs. of material income, and the same amount of material expenditure, a man will deal with about 3,000 lbs. weight of matter per annum; and we cannot regard the amount as excessive, if we consider, even for a moment, the immense amount of work which his body performs upon that material, and the results of its conversion into bodily power. It has been calculated, indeed, that the daily force expended by an adult in maintaining his temperature, or heat, in the work of heart, lungs, &c., and in his muscular acts, may be set down at 3,400 foot-tons. In other words, the daily life of man, summed up in one huge lift, would be capable of raising 3,400 tons one foot high. *Knowledge*.

Mats and rugs for halls are polar white bear, leopard, and tiger skins mounted in black furs, the edging being extremely deep.

A PREHISTORIC CEMETERY.

By Joseph F. James,

CUSTODIAN CINCINNATI SOCIETY OF NATURAL HISTORY.

(*See page 212.*)

About ten miles from Cincinnati, along the Little Miami River, is a locality which has long been known to the country people as the "Pottery-Field." The ground was strewed with fragments of pottery, bones, arrow-points, and other remains of like character, and the place was generally considered to be the site of an ancient work-shop. The primitive forest still occupies the locality, and is made up of oak, beech, elm, maple, walnut, etc. All around are found numerous mounds or tumuli, most of them small. A few of these were opened by Mr. Florian Gianque, in 1876, and some interesting things found. But, in 1878, Dr. Charles Metz and other gentlemen interested in archæology commenced a systematic exploration of the country thereabout, and so much has been found that we are enabled to form some idea of the habits, and get a glimpse into the life, of the people who once lived in the immediate vicinity of the city of Cincinnati.

During the four years that the excavations have been carried on, between six hundred and fifty and seven hundred skeletons have been brought to light. Many of them are in an advanced state of decay, and crumble to piece on the slightest touch, while others, again, are in a very good state of preservation. It can, therefore, hardly be inferred that, because some of the skeletons are much decayed, they are necessarily very old; for, though we have well-preserved remains of bones from Babylon, Nineveh, and Egypt, which are certainly twenty-five hundred or three thousand years old, still the cases are exceptional in which they are found in good condition after the lapse of many years. Different kinds of soil and differences in climate have much to do with the matter: for, in a dry and equable climate, bones may resist for a long time the influences which would cause their decay, while, in a moist climate, and with sudden and extreme changes of temperature, such as we have here, any bone, unless buried in peat, or subject constantly to heavy pressure, so as to become partially fossilized, is liable to soon decay.

An examination of the skulls found in the cemetery, as it is called, as well as the other parts of the skeleton shows some

A PREHISTORIC CEMETERY.

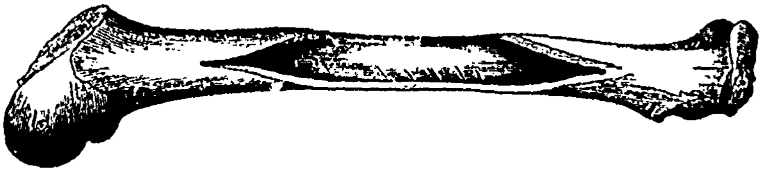


Fig. 1.

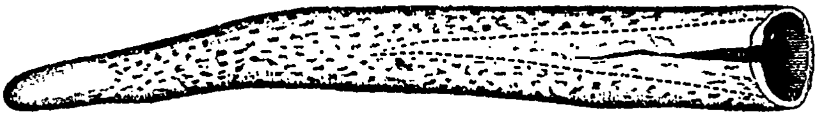


Fig. 3.

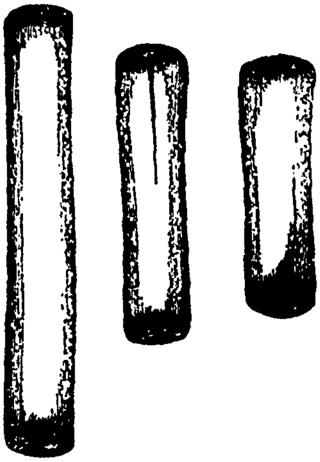


Fig. 2.

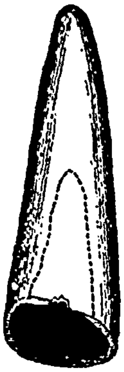


Fig. 4.

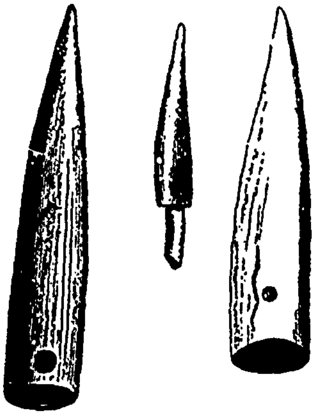


Fig. 5.

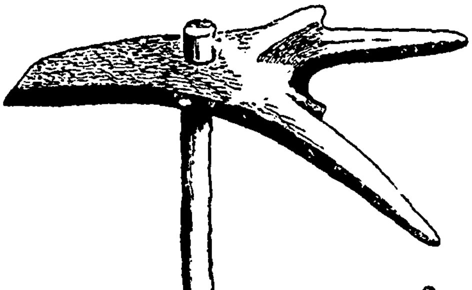


Fig. 7.

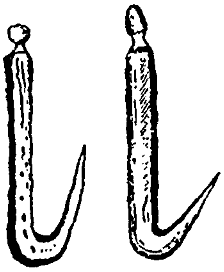


Fig. 9.

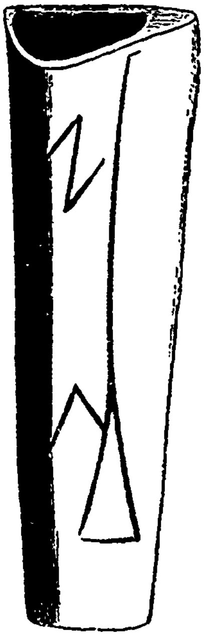


Fig. 8.

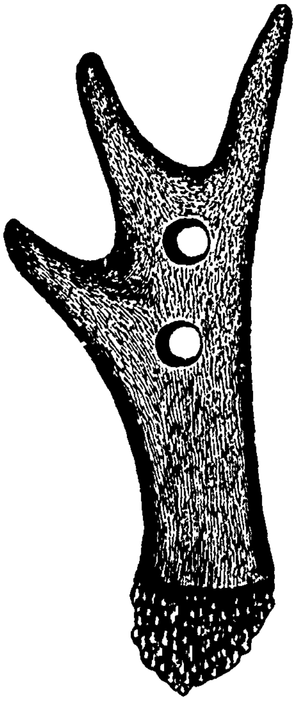


Fig. 6.

A PREHISTORIC CEMETERY.

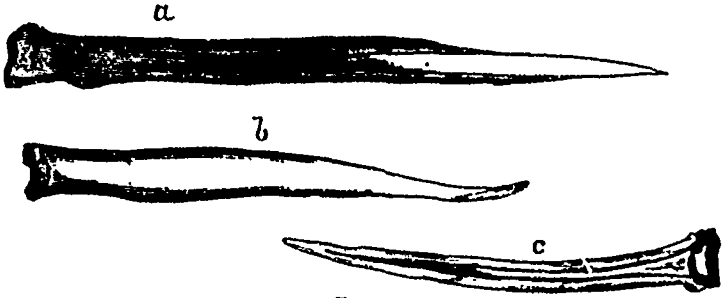


FIG. 10.

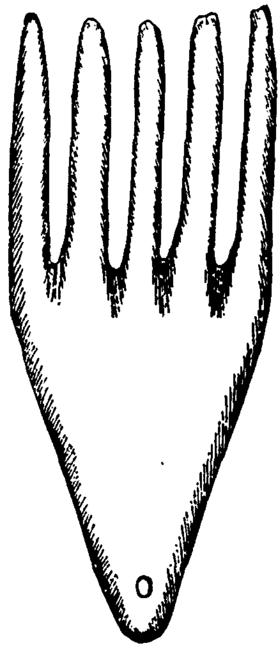


FIG. 11.

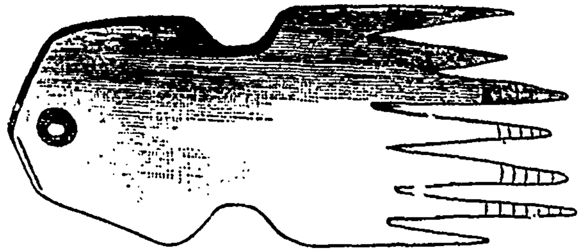


FIG. 12.

FIG. 13.

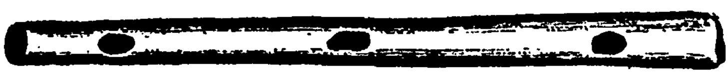


FIG. 14.

FIG. 15.

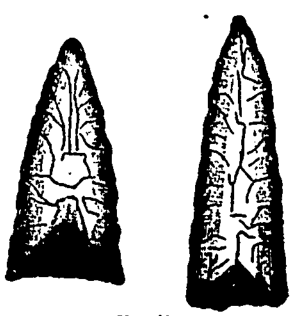


FIG. 16.

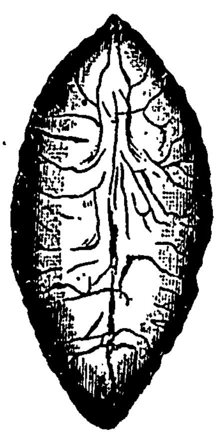


FIG. 17.

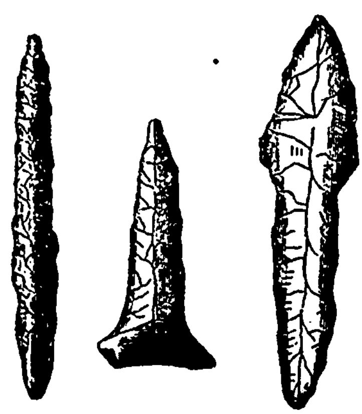


FIG. 18.

interesting facts In a paper by Dr. F. W. Langdon * is given a table of measurements of the crania which shows that the brachycephalous skulls (those with an index of breadth of ·800 and over) † are largely in the majority, there being fifty-two out of seventy-two of this character. None of them, however, exhibit any signs of the flattening of the frontal bone, which is such a characteristic feature of the Natchez and other Southern races of Indians. The Caribs of the West Indies and the Chinooks of Oregon both flattened the heads of their children in infancy; and the skulls of the ancient Peruvians and the figures on the monuments at Palenque show a remarkable flattening of the frontal. This is generally considered to have been the natural form of the skull, to have been the type of beauty cultivated by the Peruvians, Central Americans, Toltecs, etc., and not to have been produced altogether by compression. The peculiar form of the skull became hereditary, and children were born with this (to us) deformity.

Various forms of diseased bones are found among the human remains. One of these is a peculiar anchylosis of the spinous and articular processes of some of the vertebræ, the *bodies* remaining free. § It is supposed to have been the vertebral column of a female dwarf, the skeleton of which presented several other points of interest. Among the crania are several which have been fractured by some blunt implement, and the fracture has been partially or completely healed. Two other very interesting specimens are among the human bones. One is the eleventh dorsal vertebra, in which is imbedded for a quarter of an inch one of the small flint-points called war-arrows. The other specimen is a sacrum in which there is imbedded a similar point. This last was found in a pit with twenty-two skeletons, * and doubtless belonged to an individual killed with the others in a battle, all of the killed having been buried together. These specimens show with what force the people could send their arrows. Both had entered from the front of the body, passed through it, and were only stopped by the vertebral column. Some of the long bones exhibit various excrescences which have been referred to syphilitic diseases, and which show that the people here buried were afflicted with that fearful scourge which, as some one has expressed it, "turned Europe into a charnel-house."

But the bones of an extinct race of men, interesting though they may be, can tell us but little of their domestic habits, and it is to the implements found here that we turn with greatest interest. These are so abundant, and often of such a peculiar character, that we have much to speculate upon. First of all is the remarkable circumstance of finding so many implements of bone, the abundance of which has generally been thought to be a proof of a low grade of civilization. But probably their abundance or their rarity has been regulated also by the age of the deposit, for, the older the deposit, the less likely it is that the bone relics have resisted the action of time.

Many of the remains are of a peculiar character, unlike anything found elsewhere, and speculations in regard to their origin and use are rife. Still other relics are strikingly like some found elsewhere, not particularly in this country, but in Europe, as will be shown further on.

Among the most curious and anomalous of all are certain peculiarly grooved bones, as represented in Fig. 1 * They are usually made of the leg-bones of the deer or elk. But few of the specimens are perfect, the majority having been broken by use and wearing away of the bone. The groove is often highly polished, though scratches running the long way are visible. These scratches were made in the manufacture or use of the instrument or tool, but what its use was no one has been able satisfactorily to determine. Archæologists are puzzled, and pronounce them to be unique. It has been supposed by nearly every one that they were used in dressing skins, but no such scratches as are observed could be made in that operation. Some have suggested that perhaps they were made to serve some purpose of ornamentation, but neither is this explanation probable. It seems to me that the groove has been the result of rubbing, for the purpose of polishing certain other relics found here. There have been found numbers of peculiar cylindrical pieces of bone and horn, like Fig. 2, as unlike anything found elsewhere as the grooved bones; and it seems probable that these cylinders of bone have been rubbed and polished in the grooved bones. We find that the different sized cylinders fit well into the different-sized grooves, and certainly constant rubbing would both round off and polish the cylinders, and leave scratches in the groove. It has been a matter of speculation, also, to determine the use of these cylinders. Some have said that they were used in playing a game; but it is more likely that they were made into a belt for the waist, or a necklace, thongs being woven between them, first round one, then the next, and so on. None of them show any signs or attempts at boring from end to end.*

Deer and elk horns enter largely into the manufacture of many of the relics. Among others are what are known as bone arrow or spear points, shown in Fig. 3 and 4. They are invariably made from the sharp points of horn, the piece being first cut off, and then a hole driven into the blunt end with a flint. Marks made by the drill are still distinctly seen in the holes. The points were fastened to wooden shafts inserted in the holes. Now, strange though it may seem, relics of an exactly similar make and of exactly the same sort of material are found thousands of miles away. Dr. F. Keller, in his elaborate book on the "Lake-Dwellers of Europe," gives figures † of these implements found in the Swiss lake-dwellings, and Fig. 5 is taken from his book. It is immediately seen that the relics from the two localities are identical, with the exception of the small hole drilled into the side. In Fig. 5 one of the arrow-points has a portion of the shaft still fastened in the hole.

Large pieces of deer and elk-horn, with the prongs polished by constant use, have probably been employed as digging implements. Smaller pieces of the flat part of the horn, with two or three prongs, like Fig. 6, have circular holes drilled into them, and were probably used for loosening the ground in agricultural labors. Here also we have similar pieces found in Switzerland, and Fig. 7 is copied from Dr. Keller's book, before mentioned.* The same idea has evidently actuated the makers of both these articles. Still other implements of horn are known as skin-dressers. These are made of the broad bases of deer-horn, sometimes six or eight inches long and four inches wide. They are polished at the broad end by constant use, so that they look like ivory. Occasionally one is found with a hole bored in it, but such are exceptional, and were perhaps used for another purpose. Here, again we find relics of a similar character in Switzerland, as figured by D. Keller.†

Bone beads are also found with the other relics. These vary in length from one to three inches, and are often very highly polished. Fig. 8 is a large one, and has some peculiar zigzag markings on it, the significance of which is not known. Bone fish-hooks, as represented in Fig. 9, show the race to have lived by the product of the Little Miami River as well as by the chase. Bone harpoons, similar in make to those still in use by the Esquimaux,* show further that they derived sustenance from the river, while Fig. 10 shows a needle made of a fish-spine (*c*) with a large hole in one end, a deer-bone (*b*), used perhaps as an awl, and a turkey-bone (*a*), also used as an awl.

Besides the useful articles of bone that have been mentioned there are others used more for ornament. The beads have already been referred to. A peculiarly-shaped piece of elk-horn, with five teeth and a perforated handle, has been found and has been called a comb. Fig. 11 † represents it, and a striking resemblance between it and one from the Swiss lake-dwellings (Fig. 12‡) may be noticed. Another piece, the use of which is not known, but which is supposed to have been perhaps some sort of flute or whistle, is shown in Fig. 13. It is a hollow piece of bone, with six holes of different sizes made in one side,

* "Journal of the Cincinnati Society of Natural History," vol. iv, pp. 237, *et seq.*

† The long diameter being taken in 100.

§ For a figure of this and various other diseased bones, see article of "Journal of the Cincinnati Society of Natural History," vol. iv, pp. 241-257.

* Ibid., vol. iv, p. 252.

* Copied from "Journal of the Cincinnati Society of Natural History," vol. iii., plate I. Most of the figures herein given are made from specimens in the collection of the Cincinnati Society of Natural History.

* Since this was written, Dr. Phené, of England, suggests that they were used as currency, and it is very possible that this was the case.

† See plates 45, 62, 89, and 91 for these figures. The ones here given are copied from Figs. 25 and 28 on plate 62, and Fig. 6 on plate 91.

* See plate 13, Fig. 2.

† See plate 13, Fig. 14.

* Lubbock, "Prehistoric Times," p. 504, Fig, 219.

† Copied from the "Journal of the Cincinnati Society of Natural History," vol. iii., p. 132.

‡ Keller, "Lake-Dwellings," plate 28, Fig. 8.

and marks of another where the relic has been broken. How much longer it was we can not tell. In Fig. 14 we have still another tube, with only three holes, placed farther apart than in the preceding, and oblong instead of round; and in Keller* there is figured almost an exact counterpart, except that the centre hole is placed a little below the level of the other two. This last is called a weaver's shuttle, and, if our relic may be similarly named, we have evidence that weaving was another occupation of his people. And other facts are at hand to show that they did weave. Among the stone relics is one of those peculiar oblong pieces of polished plate which have sometimes gone by the name of "gorgets." These pieces have one to three holes drilled through them, supposed to have been made to carry the object by. Still another and more probable purpose, however, is for weaving, the holes being use to regulate the size of the thread. But all doubt vanishes when it is found that some "ash-pits," in which most of the relics have been found, contain pieces of coarse matting. This has been carbonized, so that it can not now be ascertained of what material it was made. Enough, however, remains to show that the fibers running one way are secured by twisted cords running across, and woven in and out between and around them.

As is very well known, the copper mines of Lake Superior were extensively worked at an early day, and articles made of the copper are found all through the valleys of the Mississippi and Ohio Rivers. The present cemetery is no exception, for fragments of copper are quite common. The pieces are mostly small, however, and do not seem to have been in very general use. In all probability the metal was highly prized, and used simply for personal adornment. The most of the pieces are simply coiled or rolled, and Fig. 15 represents common shapes. These two pieces still have the remains of a leather thong in them, shown; that they had been used like beads. Another piece is a sort of copper bell, made of a single piece of metal, with a hole in the side, a handle, and a small piece of copper inside, which rattles when the bell is shaken. Still another large piece is like a cross with two arms, the use or purpose of it being entirely unknown. Objects like it have occasionally been found elsewhere. Squier and Davis* have figured a similar piece, but of silver, which they refer to the French Jesuits; and Professor Putman figures another,† which differs in having only one arm. He considers it an ornament, "made in its present form simply because it is an easy design to execute, and one of natural conception." We must beg leave to differ from him in this latter point, for, if the design is one of natural conception, why do we make a point when it is found? Why are the forms like it not more numerous, and why does not the ornamental pottery have innumerable examples of it in the ornamentation?

Beads made of pieces of fresh-water and marine shells are found among the other remains. Sometimes pieces are cut from the mussel-shell, rubbed round, and then a hole bored. Sometimes specimens of *Melania* or *Paludina* had holes bored near the aperture, and were then used as beads. The beads made of marine shell show that some system of barter or commerce existed with the Atlantic Ocean or the Gulf. Quantities of shells, of species of the genus *Unio*, "fresh-water oysters," are found. They go to show that shell-fish formed an article of diet of the race. And not only did they eat the animal, but they made good use of many of the shells. Many of them have been ground off at the edge, and were used as spoons or ladles, while others have holes punched in the valves, and were probably used for hoes in their agricultural operations. An examination of many of these shells show no difference between the many individuals of the same species now found in the river. Still, a change could hardly be expected in the inhabitants of any locality, without a change in the conditions of life, and there is no evidence of a change in conditions since the shells were taken from the river.

The flint pieces, of various shapes, are quite numerous, and many of them beautifully worked. In Fig. 16 are shown some of the war arrow-points, and they are so abundant that one is almost inclined to believe the people who made them were not so peaceable as has been supposed. I Fig. 17 is shown one of the "leaf-shaped" flints, some of which are beautifully worked; while, in Fig. 18 are some of the drills use in boring holes in bones or shells. There is one thing to be noticed among the flint pieces. It is said that, in war, arrows like those in Fig. 16 were exclusively used, while, in hunting, points which were notched at the broad or lower end were used. Now, the peculiarity noticed is the *scarcity of points* of the latter character. For, out of 316 worked flints, selected from some thousands, there are but four which are notched at the lower ends. One of two things is to be inferred. Either that the race was more warlike than agricultural, and used horn arrows in hunting instead of the notched ones; or else they were manufacturers of war-points for other tribes, and lived peaceably by hunting, fishing, and agricultural labors. All that we know could be interpreted more in favor of the first view than of the second, for, while we are sure they were agricultural to a certain extent, this fact would not be opposed to an argument for their warlike character. The Southern Indians, within the historic period, were at war all the time, and still raised quantities of maize.*

The fact of the race of people here buried raising maize is established by finding, in some pits, quantities of it completely carbonized. Corn seems to have often been placed in pots and buried with the bodies, to serve, perhaps, as food for the journey to the spirit-land. Another of their agricultural labors was that of raising tobacco; for, in common with nearly all the other North American races, they were smokers. Numbers of pipes, of various styles and materials, are found here. Some of them are of the red clay known as Catlinite, others of ordinary limestone. In Fig. 19 is shown a pipe carved out of hard limestone. It is very highly polished, and considerable skill is exhibited in the carving of the head. It is evidently meant for a wolf, and the teeth, though interlocking in a peculiar way, are still tolerably true to nature in having the long canines.†

The stone implements are much the same as those found in various parts of the country. There seems, however, to be a remarkable paucity of grooved axes, there having been but two found so far. There are numbers of the ungrooved "celts," as well as of sling-stones, blunt at each end, but with a groove in the middle by which to fasten the handle. Some of these stones were also probably used as sinkers for nets in fishing, and are very similar to those found in Swiss lakes, as noticed by Dr. Keller. Rubbing-stones for polishing celts, hammers, anvils, pestles, and corn-pounders, are also abundant. Some pieces of a coarse, gritty sandstone have shallow grooves worn into them, which are supposed to have been used in rubbing down some of the bone or flint implements. Other pieces, with similar grooves, but made of close-grained sandstone, were probably used to straighten the shafts of the arrows. The shaft, at first wet and green, was rubbed up and down in the groove, and all the bends or twists thus taken out. Stones like these have been used by the Indians of the historic period.

Reference was made in the early part of this article to the name of the "Pottery-Field," given to the burying-ground. It may be inferred from the name that pieces of pottery were abundant, and the number of vessels taken out fully confirms the appropriateness of the name. These are all of one general shape and character. The material is a clay mixed with finely-powdered sheels, and was baked in the sun. Nearly all the vessels are furnished with four handles, and are generally devoid of any ornamentation. Some have salamander-shaped handles, and the few that are ornamental have simply cross-lines and stripes with lines running round the vessel near the top, and perhaps a few dots. Though some of them are very well formed, they do not show any great advance in art.

Among the most interesting remains of any race of people, are the rude beginnings of art they have left behind them; and, though the people under consideration did not have, as far as we know, any written language, they have left a few memorials of their artistic feelings in the shape of some carvings on bone, and a few inscribed stones. The most interesting of these are here figured. Fig. 20 represents, on a piece of limestone, the head and forelegs of some curious animal. What is meant is hard to imagine. The teeth are marvellous,

* *Loc. cit.*, Plate 41, Fig. 9.

* "Ancient Monuments of the Mississippi Valley," p. 208.

† "Eleventh Annual Report of the Peabody Museum of Archæology and Ethnology," p. 307.

* Jones, "Antiquity of the Southern Indians," p. 7. "When, in 1730, the whites interposed their good offices to bring about a pacification between the Tuscaroras and the Cherokees, the latter responded: 'We cannot live without war; should we make peace with the Tuscaroras, with whom we are at war, we must immediately look out for some others with whom we can be engaged in our beloved occupation. For notice of agricultural labors, see Jones, pp. 296 to 320.

† Many other forms of pipes from this locality are given in the "Journal of the Cincinnati Society of Natural History," vol. iii, Nos. 1, 2, and 3.

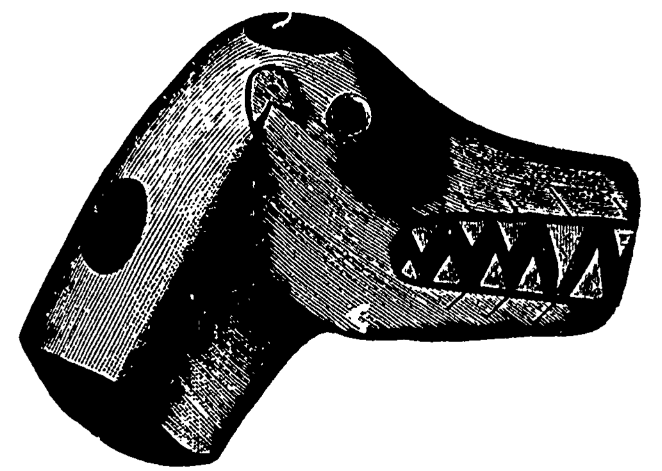


Fig. 19.

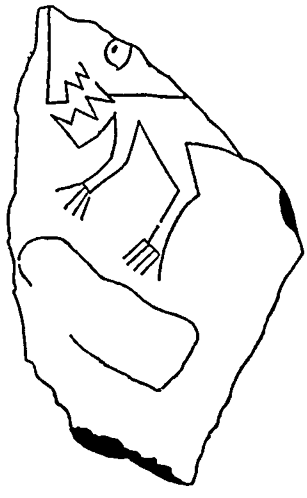


Fig. 20.

but still, in their arrangement, are like the teeth of the wolf-pipe in Fig. 19. Fig. 21 is a portion of a bone having peculiar marks cut on it. The marks are the same on both sides, but the meaning intended to be conveyed is beyond the interpreting powers of the writer, nor does he know of any explanation having been attempted.

From the remains here described, and from others found in the cemetery, for such the locality undoubtedly was, we can form some idea of the habits of the people. They were warlike yet agricultural, hunters as well as fishermen. They killed the bear, deer, elk, beaver, raccoon, and other animals of the forest, for the remains of all are quite abundant. They ate the shell-fish of the Little Miami River, and caught fish with hooks and nets. They raised corn, as well as tobacco, in quantities. They wove matting, made fish-nets, and perhaps blankets. They ornamented themselves with necklaces of bone and shell beads, bear and beaver teeth. They dressed in skins, prepared with horn and stone implements. They painted their bodies, as cakes of paint testify. They had commercial intercourse, or some system of barter, with Lake Superior and the Gulf, or the Atlantic. They were frequently embroiled in wars with neighboring tribes. They could hardly have been far advanced in civilization, if bone implements instead of stone is any indication. They had not written language, but yet left some record of their existence in the shape of carved bones and inscribed stones. Finally, if the burial of vessels containing food for the dead be any indication, they had some idea of a future life. Much further than this in their history we can not go.

The attention of the reader has been repeatedly called to the similarity between the implements found in this "Cincinnati" cemetery and those found in the Swiss lakes. No one could claim that, because of this similarity and almost identity of forms, the two races of people ever had intercourse with each other. But the fact is interesting as showing how, in two countries, thousands of miles apart, and separated by a period of hundreds of years in time, there were made, with the same materials, the same forms of weapons and implements. The resemblance is no argument for a common origin, but simply shows that nearly the same grade of civilization may be developed spontaneously in two widely separated countries.

It now becomes an interesting matter of speculation to discover the age of the cemetery. It has been referred to the age of the mound-builders, but, if so, it is a most remarkable fact, unless we consider the modern Indians as the lineal descendants of the mound-builders, which is quite probable. Heretofore but three or four authentic skulls of the mound-builders have been found in any sort of preservation, while here we have a great many taken from a small area. Further, if we are to refer the cemetery to the mound-builders race, we must admit that the race disappeared within a very recent period. On a level bank near the Little Miami River is a circular excavation about forty feet in diameter and seven feet deep. "An old settler relates that fifty years ago remains of stakes or palisades could be seen surrounding the excavation." * These have since disappeared, but their being there shows within how recent a period the ground was abandoned. Then the age of the forest trees growing on the ground argues against any very great antiquity. The largest trees measured are a walnut fifteen and a half feet in circumference, an oak twelve feet, an oak and a maple each nine and a half feet in circumference, † equal to about five, four, and three feet in diameter respectively. Now, the average growth of fourteen different species of trees is about .12 of an inch a year, or one foot radius (two feet diameter) in ninety-eight years.‡ Taking this average, a tree five feet in diameter would be two hundred and forty-five years old; one four feet in diameter, one hundred and ninety-six years old; and one three feet in diameter, one hundred and forty-seven years old; or, in round numbers, two hundred and fifty, two hundred, and one hundred and fifty years respectively.

There is no evidence to show that there was any growth of forest on this ground, after its abandonment by the former residents, previous to the one now covering it. The roots of living trees having trunks two and three feet in diameter have been found penetrating the crania of skeletons found here, a

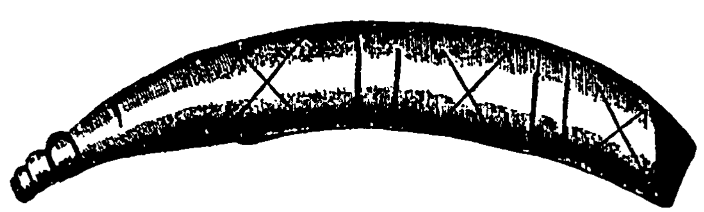


Fig. 21.

* "Prehistoric Monuments of the Little Miami Valley," by Dr. Charles Metz. "Journal of the Cincinnati Society of Natural History," vol. i, p. 123.

† Ibid., vol. iii, p. 44.

‡ See table by Dr. A. Lapham, of age of trees in Wisconsin, given in "Prehistoric Races of the United States," p. 374.

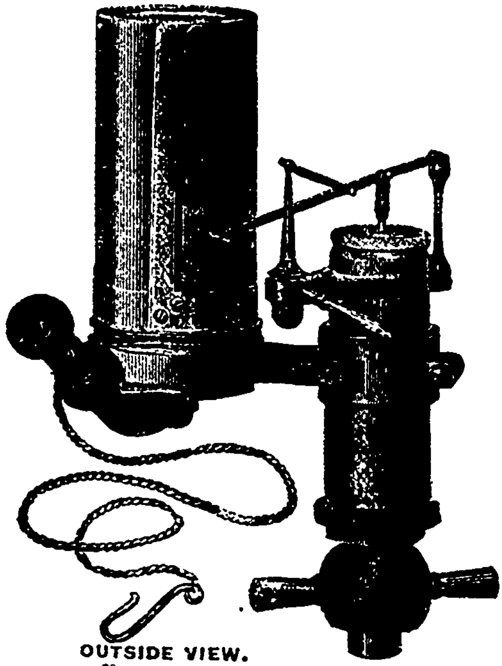
tolerably sure indication of a first growth. Notwithstanding the assertions of many people to the contrary, the process of covering land with dense forest is by no means a slow one. A field allowed to go without being cultivated becomes in a few years covered with a new growth of saplings. Mr. Robert Ridgway, in a late paper, after referring to the cutting off of timber, and also to its encroachment on prairie land in Illinois, says: "The growth of this new forest is so rapid that extensive woods near Mount Carmel (Illinois), consisting chiefly of oaks and hickories (averaging more than eighty feet high, one to nearly two feet in diameter), were open prairie within the memory of some of the present owners of the land." * Taking this fact into consideration, and remembering that the largest tree found on the ground was not over two hundred and fifty years old, the time of the abandonment of the cemetery can not be more than three hundred years ago. This would take it back to less than one hundred years after the discovery of America by Columbus. The present State of Ohio was then probably occupied by a tribe of Indians known as the Eries, who were totally exterminated in 1656, and it is possible we have in this cemetery one of the burial places of this tribe of Indians.

Catlinite pipes were unknown to the mound-builders, yet some made of this material are found in this cemetery. Hogs rooting in the ground find sufficient nutriment in the bones to eat them greedily, and probably there would be fewer bone implements found if they had not been buried in ash-pits. Everything, therefore, tends to show the comparatively recent date of this cemetery, and I would state, as a reasonable conclusion, that the remains are those of a tribe of Indians, perhaps the Eries, and were deposited not more than three hundred and perhaps only two hundred and fifty years ago. — *Popular Science Monthly.*

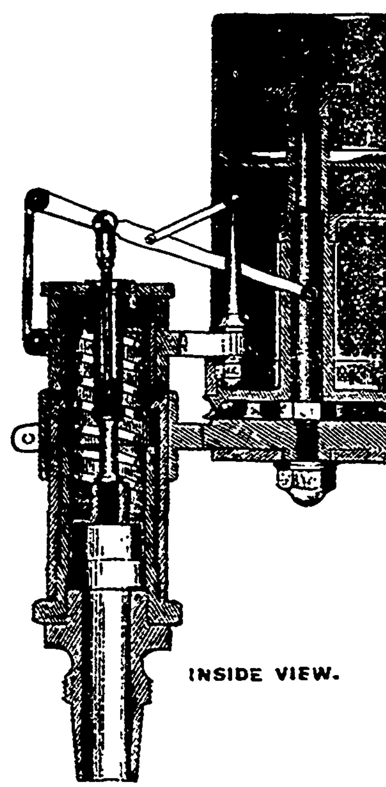
THE THOMPSON IMPROVED INDICATOR.

The Richards Indicator, for many years an important adjunct of the steam engine, has been found to require several important changes in order to adapt it to the high-speed engines which have come into general use during the past few years. The changes consisted for the most part in the reduction of the number and weight of the moving parts, thereby reducing to a minimum the vibration which is necessarily introduced by the rapid movements of the modern engine making from one to three hundred revolutions per minute; and were worked out, a few years ago, by Mr. J. W. Thompson, who, at the same time, made provision for working the instrument with pressures as great as five hundred pounds to the inch. It should be added that the Thompson Indicator will work equally well when attached to low-speed engines, and is therefore gradually superseding the older forms of indicators which give very uncertain results for engines making more than about eighty revolutions per minute.

The American Steam Gauge Co., of Boston., the manufacturers of the Thompson Indicator, have recently presented one of these instruments with several accessories (including an Amsler Planimeter for measuring the diagrams,) to *McGill College*. The collection forms a most important addition to the Museum of the Faculty of Applied Science.



OUTSIDE VIEW.
30



INSIDE VIEW.

SULPHUR IN PARIS.—M. Daubrée has drawn attention to the occurrence of sulphur in the recent excavations in Paris for public works. The crystallization of the sulphur is evident to the eye, and under the microscope the crystals are seen to be octahedral. In some places the sulphur is in sufficient quantity to pay for extracting. M. Daubrée supposes it to be formed by organic matters, such as manure, leather, bones, and vegetables, acting on the sulphate of lime.

* "Notes on the Native Trees of the Lower Wabash and White River Valleys in Illinois and Indiana," printed in "Proceedings of the United States Museum," 1882, p. 54.

Inventions.

A New Refining Process.—At a recent meeting of the Société de l'industrie minerale, M. Thiollier communicated the details of a method of refining pig, and finishing iron and steel, by the action of damp hydrogen. To assure himself that the well-known laboratory experiment may be carried out on a large scale, he has erected experimental works near Paris, having four furnaces with cast-iron retorts capable of treating about one ton at a time The retorts are coated inside and out with a vitrifiable substance to prevent oxidation, and loss of gas through the pores of the metal. Hydrogen is introduced through small metal tubes , and, in order to prevent all danger of explosion, the air in the retort is displaced by carbonic acid gas before the hydrogen is allowed to enter After being annealed for a few hours in an atmosphere of hydrogen at a dark-red to cherry-red heat, malleable cast iron acquires all the properties of steel. Coarse steels may be changed into fine tool steel. On wrought iron the action is slower. The cost is estimated at two francs per 100 kilos of poor-quality iron.

Artificial Fuel.—The process of Mr. E. F. Loiseau for making artificial fuel from coal-dust is in successful operation in Philadelphia, where from 80 to 300 tons, according to size of the lumps, are made daily.

The process of manufacture may be briefly outlined as follows:—

The coal-dust is fed into hoppers, together with about eight per cent. of bituminous slack, from which it passes through a series of four cylindrical revolving drums, in which it is thoroughly dried. From these it is carried to a receptacle situated near the press. The dust, still at a temperature of about 140° F., is then thrown into the mixing apparatus, in which it is thoroughly stirred by revolving shafts with blades, while the proper quantity of pitch and coal-tar is added from a reservoir in which it is maintained at a temperature of 180° by steam heat. The pitch is mixed with a certain quantity of coal-tar to give it the proper toughness. When thoroughly mixed with the melted pitch, the mass is plastic, and can readily be moulded into any desired shape. It is then carried to the press, where it is delivered between rolls having moulds upon their surfaces, from which the egg-shaped lumps are discharged. When discharged from the press, the lumps are quite hot, and have to be cooled by jets of water.

As thus prepared, the fuel is compact and very hard. Formerly clay was used as a cementing material, but now no incombustible or ash-producing material is required. The fuel is said to be even superior to the natural coal ; and this opinion is borne out by an analysis which gave the following results :—

	Chestnut anthracite.	Loiseau fuel.
Carbon	73.40	82.01
Hydrogen	3.09	2.56
Moistures	0.44	2.41
Ash	17.95	10.47
Nitrogen and oxygen by difference	5.12	2.55
Theortical calorific power, British thermal units	12,339.50	13,853.00
Equivalent to the evaporation, from and at 212°, of lbs. water	21.76 lbs.	14,33 lbs.

The Exhaust Steam Injector.—Mr L. J. Groves read a paper before the Institution of engineers and shipbuilders in Scotland, March, 20, describing the exhaust steam-injector. It resembles the feed-water injector of Henri Giffard both in principle and in its general construction. It forces the feed-water into the boiler by the action of the exhaust-steam at nearly atmospheric pressure, at the same time heating considerably the water passing through the instrument. It differs from the usual forms of Giffard injector in having the "mixing" or "combining" nozzle split in such a manner that it lies open when the apparatus is not working, but closes up to form the standard form of nozzle when the instrument starts into operation. The steam-nozzle is much larger than that of the common instrument, and has a central spindle, of cone shape, to direct and concentrate the jet. The instrument starts automatically when the engine starts. It draws cold water, and forces it into a high-pressure boiler at a temperature of 190° F. (88° C.) On a locomotive it has forced feed-water into the boiler at a temperature of 277° F. (136° C.), against a steam pressure of ten atmospheres.

A New Projectile.—Mr. J. D. Cable of Pittsburg, Pa., has applied for letters patent for a shell which, as a destructive weapon, is claimed to be unequalled. It is a nitro-glycerine bomb, and is described as follows : A heavy conical shell is first cast, and so arranged that one end is much heavier than the other. One end is closed with a tightly-fitting cap screwed after charging. The interior of the shell is divided into three compartments, each separated by a heavy plate-glass cap. The division furthest from the open end is filled with sulphuric acid, the next with glycerine and the outer one with nitric acid, these three elements being the component parts of nitro-glycerine. A small opening through the center of the cap fitting the open end of the projectile admits a steel rod, to each end of which is firmly attached a small circular piece of metal, the inner end resting against the first glass cap. The outer cap is then screwed on and the projectile is ready for service. According to the principle of gravitation the heavy end naturally strikes the ground first, the steel rod is driven through the plate-glass partitions, the chemicals are mingled and a nitro-glycerine discharge take place The inventor claims that if such a projectile should strike a vessel it would have a disastrous effect, and as a means of reducing intrenchments it would be serviceable beyond measure.

The Power of a Steamship.—The Oregon, of the Guion line, is to be the most powerful and the fastest of the trans-atlantic passenger-steamers. Her displacement is about 11,000 tons. Her engines have three cylinders, and are of 13,000 horse-power. The boilers contains 74 furnaces, consume about 300 tons of coal per day, evaporate 2,700 tons of water, require 6,000 tons of air to support the combustion, or a volume of nearly 175,000,000 cubic feet, and the power developed is sufficient to raise about 200,000 tons one foot high per minute. The ship will make 20 nautical miles (knots) per hour, against an estimated resistance of 94 tons, or twenty times the resistance overcome by the most powerful locomotive. The Atlantic will be crossed in six days in good weather.

Zinc Coating for Iron.—Attention has been drawn to MM. Neugean and Delaite's process of protecting iron against rust. A very fine powder of metallic zinc is mixed with oil and a siccative, and applied to the iron by means of an ordinary brush. In many cases one coat is sufficient ; two coats are at any rate guaranteed to secure a protection against the corrosive action of the atmosphere as well as of sea water. The zinc coating gives the iron a steel-grey appearance, and it does not interfere with subsequent painting. MM. Neugean and Delaite received a diploma at the Paris Electric Exhibition of 1881, and now recommend their process for iron structures, bridges, lamp-posts, &c., and also for iron ships. If this process really affords the protection it claims, nothing need be said in recommendation of it, since it can hardly be surpassed in simplicity and cheapness, and is capable of application in cases where galvanizing, the Bower-Barff, and similar processes would hardly be practicable. A good mixture, of which only the necessary quantity ought to be prepared, consists of 8 parts by weight of zinc, 71 of oil, and 2 of a siccative.

The framework of a curious hall chair is composed entirely of elk horns mounted in silver. The back and seat are of embossed leather, and the bordering is studded with brass nails.

Educational.

ADMISSION TO STUDY FOR THE PROFESSIONS.

The following letter addressed by Dr. Heneker to William White, Esq., as Batonnier of the Quebec Bar, in regard to the preliminary examinations for admission to the study of the professions, having been laid before the Protestant Committee of the Council of Public Instruction, it was unanimously resolved :—

"That the letter read by Dr. Heneker be adopted by this Committee as expressing its views, and be printed in the *Record*, and for general circulation."

(*Copy.*) SHERBROOKE, 29th June, 1883.

William White, Esq., Sherbrooke.

MY DEAR SIR,—I am not about to address you officially for I am not authorized to do so, yet I know you are so much interested in the question of education in this Province that, I cannot but feel (occupying as you do the highly honourable and important position of Batonnier of the Quebec Bar,) that you ought to be made aware of the desires of the Protestant Committee of the Council of Public Instruction in the matter of the examination of candidates for the admission to study the professions in this Province.

I wish, at once, to state that the Protestant Committee do not in any way desire to interfere with the education of Roman Catholics. The two Committees of the Council of Public Instruction have the same object in view, but they work on different lines.

The Protestant educational system may be classified into three grades, viz., Common Schools, High Schools and Universities. With the limited means at the disposal of the Committee they are endeavouring gradually to raise the tone of the High Schools. The Common Schools demand a great deal of thoughtful care in their administration, but hitherto they have been almost exclusively under the control of the Superintendent of Public Instruction: and the Universities, although receiving grants of public money, lie beyond the inspecting power of the Committee. Regular returns of their work and numbers are sent periodically to the Government,and they are worthy of the great confidence reposed in them by the public. But the High Schools or Academies, as they are called in country parts, have been in a most unsatisfactory condition. The Committee have laboured earnestly to raise their tone and to fit them for the work which the country demands of them. I do not wish to trouble you with an account of their shortcomings and of the efforts of the Protestant Committee to improve them. Suffice it to say that the aim of the Committee is to make the Academies the means whereby young men may prepare themselves for the study of the professions and for entering the Universities by giving them the ground work of a liberal education, such as may qualify them for public life, no matter what a man's special calling may be. One of the most serious difficulties the Committee has to encounter arises from the powers possessed by the several professional bodies to examine candidates for the permission to enter on professional study. This is a very different thing from the professional examination itself for admission to practice. With this latter the Committee have no wish to interfere; it is entirely outside of their province. But as to the admission to study, they feel that the best preparation a young man can have is a broad liberal education without " cram," such as will draw out the faculties and cultivate thought and observation. This style of training is equally applicable and useful to the intending student of Law, of Medicine, of Engineering and other professions, including even Divinity.

Under the present system there is no uniformity of plan or subject, no trained body of Examiners, and in the uncertainty which prevails, students are led to search previous sets of questions and to prepare themselves by a system of "Cram."

But further there is a great practical difficulty in the fact that no Academy teacher can give attention to students preparing for different professions, and at the same time attend to ordinary school work. Under such a demand any educational system will break down. The plan of the Committee is to have an Examining Board of trained teachers of experience, who may be appointed by the Government on the recommendation of the Committee with, if necessary, the concurrence of the professional bodies. Some such plan would meet the requirements of the case, provided the subjects taught in the Academies and High Schools formed the ground work of the examinations, and it would be of course open at any time to the professional bodies to recommend certain objects of study. The co-operation of the professional bodies would be welcomed by the Committee and would greatly strengthen their hands.

The adoption of some such system would give a higher tone to education and secure a higher class of teachers, and the evils of the "cram" system would be avoided. The Committee moreover insist very strongly on the absolute necessity of recognizing the University Degree as in itself a qualification for the entrance on the study of a profession. The two Protestant Universities, McGill and Bishop's College, are working to increase the quality of the degree. They are united on the subjects for matriculation in Arts, and although there are subsequent differences, so as to satisfy different classes of minds, yet both are earnest to require good work from their students. If the professional bodies will not accept men who have devoted three or four years of their strength to the study of Arts and Science, not in technicalities but on broad fundamental grounds, there would seem to be very little room for Universities at all in the Province of Quebec.

Commending these few observations to your kind notice and attention,

I am, my dear Sir, very truly yours,

R. W. HENEKER.

THE FLORA OF ANCIENT EGYPT. (*Nature.*)

BY DR. G. SCHWEINFURTH.

The discovery made by Emil Brugsch Bey on July 6, 1881, of the vault of a king of the twentieth dynasty, is of the greatest importance to botany, in consequence of the large number in species of plants contained in the offerings and funeral repasts and in the wreaths which adorned the illustrious dead. Among them are several which were not known to belong to ancient Egypt. I have begun the study of the remains of these plants taken from the breasts of the most celebrated kings of Egypt and of such inestimable value to science. Deputed by Mr. Maspero to arrange these relics for the Egyptological Museum of Boulak, I have classified them according to the high personages for whom they were intended. On the eight cardboards which I have the honour to send you in the name of Mr. Maspero, you have a part of the funeral wreaths belonging to Ramses II., Amenhotep I., and Aahmes I.

The wreaths of Ramses II. were renewed towards the end of the twentieth dynasty (1100 or 1200 B.C.), or at the time of the twenty-first dynasty (1000 B.C.). The king of that period, according to records inscribed on the coffins and translated by Mr. Maspero, caused a new coffin to be made for the great Ramses, the one in which he had first been placed having been accidentally destroyed. In this new coffin were several yards of wreaths, which Mr. Maspero handed to me. I have examined them all and ascertained their composition.

The wreaths of Ramses II. are formed of the leaves of *Mimusop Schimperi*, Hochst., either folded or torn in two and stitched together, and serving as clasps for the sepals and petals of *Nymphæa cærulea*, Savi, and *Nymphæa Lotus*, Hook., the whole strung on strips of the leaves of the date palm. Besides the wreaths, there were in the coffin at the side of the body, and fastened between the bands encircling the mummy, whole flowers of *Nymphæa cærulea* on stalks eighteen or twenty inches long. The water-lilies thus scattered separately on the mummy were all of the blue-flowered species. An examination of these entire flowers and the sepals and petals in the wreaths, whether of the white or of the blue-flowered species, leaves no doubt whatever respecting their identity with the living plants so common in ditches at the present day, especially in Lower Egypt, where they blossom from July to November.

The *Nymphæa cærulea*, Savi, which figures on all the ancient monuments of Egypt and among the offerings painted on the walls of the temples is often recognisable from the blue colour of its petals. In the temple of Ramses II. at Abydos the colour is remarkably well preserved, and besides there is always a leaf associated with each cluster of flowers, clearly demonstrating by its entire (not toothed) margin that the species represented is *N. cærulea* and not *N. Lotus*. The latter, whose sepals and petals occur abundantly in the wreaths taken from the coffins of Ramses II. and Amenhotep I., has not been found by me on the ancient monuments, though Unger records an instance at Beni Hassan where the white flower could be recognised. With regard to the question to which of the species the old name Lotus properly belongs, I have been able to ascertain the following facts. No design on the ancient monuments is referable to *Nelumbium*; neither the fruits nor the leaves, so easily characterised, are recognisable. Further, no remains of *Nelumbium* have been found either in the coffins or among the offerings and funeral repasts deposited in the vaults of the Pharaohs. The Lotus was not referred to *Nelumbium* until a very much later epoch. This plant has not been found among the wild plants of any part of Africa. It is eminently Asiatic, and was perhaps not introduced into Egypt before the Persian invasion. At the time of Ramadus it was probably cultivated every-

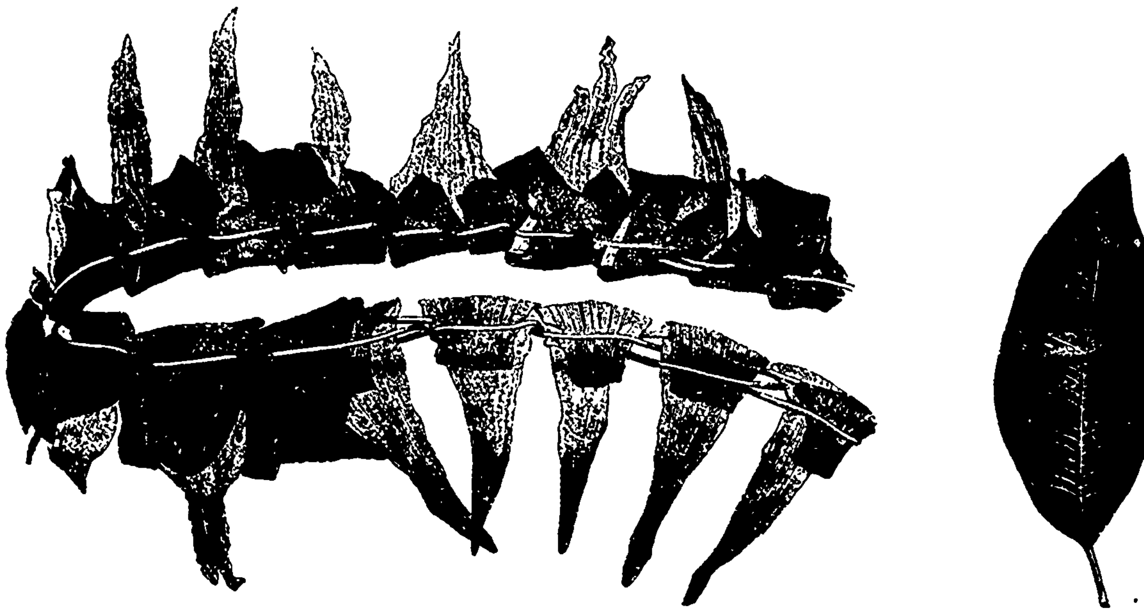


Fig. 1.—Portion of a Funeral Wreath from the tomb of Ramses II. (1000 to 1200 B.C.), composed of the folded leaves of *Mimusops Schimperi* and the petals of *Nymphæa cærulea*, Savi, stitched together with strips of the leaves of the Date Palm. A separate leaf of *Mimusops Schimperi*.

where in Egypt, for we often find it in the mosaics, sculptures, &c., of that period, associated with papyrus and animals characteristic of the Nile, and easily recognised by its fruit.

The most ancient writer who treats of the Egyptian Lotus in such a way as to leave no doubt that he meant the *Nelumbium*, and not a species of *Nymphæa*, is Herodotus (lib. ii. cap. 92); after him Theophrastus ("Hist. Plant." lib. iv.), and then Strabo, while Pliny (lib. xiii.) clearly alludes to a *Nymphæa* in a comparison of the fruit with the capsule of a poppy.

The *Mimusops* was evidently a sacred tree to the ancient Egyptians. The fruits, or the stones of the fruits, which had been eaten, are often found in the funeral repasts in the vaults; and the leaves not only occur in the wreaths of the ancient empire but likewise in those of later times, even down to the Græco-Roman epoch, as specimens in the Leyden Museum testify.

The fruit of *Mimusops* found in Egyptian tombs[1] exactly resembles—except that the stones are a little thicker—that of *M. Kummel*, Bruce, a species spread throughout Abyssinia and the region of the Upper Nile; yet no species of the genus is found wild in Egypt. The leaves forming the wreaths in question should belong to the same species as the fruits found in the tombs. Nevertheless, in comparing them with numerous specimens of *Mimusops Kummel*, I did not meet with the perfect identity one would have expected from the resemblance of the fruits. In Central Africa, and especially in Abyssinia, an allied species, *M. Schimperi*, exists, the leaves of which are much more like those of the wreaths. A longer, and especially a slenderer, weaker petiole, and a more acute, less abruptly acuminate blade characterise these leaves. With regard to the fruit of *M. Schimperi*, I have not had an opportunity of studying it. Moreover the two species under consideration are not sufficiently established as distinct species. But an anatomical character came to my aid. Dr. Westermaier of Berlin has ascertained that the leaves of *Mimusops Schimperi* and of *M. Elengi*, L., have a double layer of epidermal cells, a character they possess in common with the leaves from the ancient tombs; whereas in the leaves of *M. Kummel* there is only a single epidermal layer of cells.

[1] The ancient fruits, however, have usually a thicker stone, the three angles of which appear to be more prominent than in that of *M. Kummel*, Bruce.

Should this distinctive character be constant in the two African species, there is a double reason for naming the ancient *Mimusops M. Schimperi.* The fruit of *M. Elengi* is very distinct from that found in the tombs. I think it very likely that this species, of which we so often find the fruits and leaves in the tombs of the ancient Egyptians, may be the *Persea* of the old authors, which modern botanists have erroneously referred to *Balanites* and *Diospyros mespiliformis.*[1] The latter has not hitherto been found in the ancient tombs; neither does it occur depicted on the monuments. Diodorus (i. p. 34) has transmitted to us a valuable tradition concerning the *Persea.* He states that it was introduced into Egypt with the first colonists coming from Ethiopia, which clearly implies that the ancient authors regarded it as having been introduced from the regions of the Upper Nile and not as belonging to the indigenous flora. *Balanites,* however, grows wild in the valleys of the Eastern Thebaid and on the borders of the Red Sea, and in Nubia this shrub is of general dispersion. True its fruit has been found in the funeral repasts in the tombs, yet that of the *Mimusops* has been found much more frequently, and, in support of my hypothesis, the thick leaves of the *Balanites* are always wanting in the wreaths.

According to Theophrastus, the *Persea* had a black wood, and he compares the flowers with those of the apple-tree. I do not know the wood of the *Mimusops* sufficiently, but with regard to the flowers it must be admitted that no ancient authors ever made a more unmistakable comparison, while the flowers of the *Balanites* have nothing in common with those of the apple. Pliny (lib. xiii. p. 9) does not speak of the *Persea,* but of the *Persica,* and the only surprising thing in it is that he treats it as indigenous in Egypt. He mentions, too, the peculiarity of the Egyptian variety of the peach-tree, which consists in its persistent foliage. Even now in the middle of winter we see the peach-trees in blossom while still carrying their leaves. The same author (lib. xv. p. 13) expressly points out the difference between the *Persica* and the *Persea.* On Egyptian monuments we often see a tree diagrammatically represented, though the distichous, elliptical, acute leaves are evident. This tree, sacred to Hathor or Isis, and often drawn with these divinities, probably represent the *Mimusops* in question. The fruit of *Mimusops Kummel,* of Central Africa, resembles in appearance as well as in taste that of the wild rose; and it may be that under cultivation a still more palatable fruit could be obtained. Indeed, the fruit of specimens of this species collected in Abyssinia appears to be much more pulpy.

All the wreaths of the find at Deir-el-Bahari are of one and the same pattern. The leaves are folded lengthwise in the middle,[1] then folded again in the contrary direction over a string or strip about ⅛ in. wide, of a leaf of the date-palm. In the fold of each leaf, single flowers, or parts of flowers (sepals and petals), are inserted in

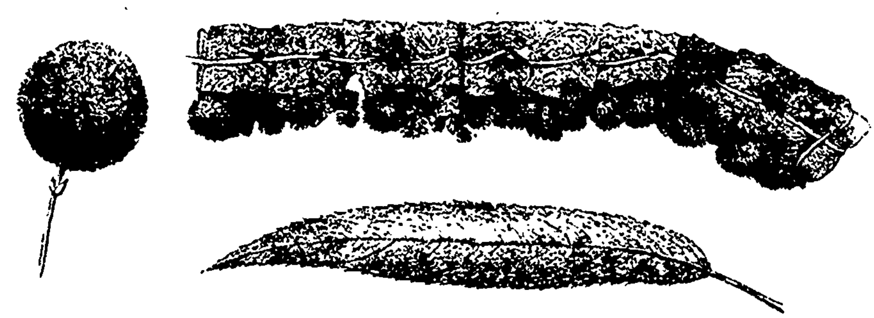


Fig. 2.—Portion of a Funeral Wreath from the tomb of Amenhotep I. (1300 to 1700 B.C.), composed of the folded leaves of *Salix safsaf* and the flower-heads of *Acacia Nilotica* strung together with strips of the leaves of the Date Palm. A separate leaf of the *Salix* (the teeth represented too sharp) and a flower-head of the *Acacia.*

such a manner that they are fixed in the leaf as in a pair of pincers. Then with a finer strip of the date-leaf than the central one, they are stitched through and securely fastened together in long rows side by side, and all pointing in the same direction. These wreaths are arranged in semicircles on the breast of the mummy, so that their disposition is like one sees in the necklaces of the present day. Their thinness rendered them suitable for using in large numbers, and sometimes they occur in several layers one above the other, filling up the limited space between the mummy and the lid of the coffin.

It is probable that it is to this kind of wreath that Pliny alludes (lib. xxi. p. 2) as the "so-called Egyptian wreaths," of which Plutarch and Athenius praised the beauty. Unfortunately these wreaths, which, with ordinary care, might have been removed entire from the mummy when the coffin was first opened, were broken and reduced to powder in several places. The specimens I send you attached to cardboard are the most perfect that I could procure after those selected for the Museum of Boulak. On placing them in boiling or cold water, according to the species, the leaves, &c., recover their original flexibility, especially in *Nymphæa cærulea;* and with proper precaution one succeeds in spreading them out and drying them again effectually. The fragility of these objects is only due to the extreme state of dryness they have reached during the thirty to thirty-five centuries they have lain in the tombs. It is at the same time the principal factor in their wonderful preservation.

The wreaths of the other kings of this vault I have at present only partially examined. From their general appearance, however, as well as from the flowers and leaves of which they are composed, which also indicate a different season[2] of the year, one would be justified in attributing them to a different period from that during which the wreaths of Ramses II. were renewed. If they really date from the time when the bodies of the kings of the eighteenth dynasty were first deposited in the vault, we have here to do with specimens four or five centuries older than the wreaths of Ramses II. In any case these objects are at least contemporaneous with the time commonly assigned to the Trojan war, if not several centuries more ancient.

The wreaths of Amenhotep I. (who was found during

[1] Kunth took the stones of *Mimusops* found by Passalacqua to be this plant.

[It may be mentioned that Kunth published his determinations of the remains found by Passalacqua in the *Annales des Sciences Naturelles,* viii. (1826) p. 418. Unfortunately it is not known to what period they belonged. Among them were seeds of a palm, *Areca (?) Passalacquæ,* Kunth, which was subsequently identified by Unger with *Hyphæne Argun,* Mart., a palm which inhabits some of the valleys of the Nubian desert in the bend of the Nile between Korosko and Abou Hammed.—W. B. H.]

[1] Or when they were too large they were torn in two.

[2] The records to which I have alluded indicate the day and the month; and these flowers will one day serve to fix the season with which the month of that epoch coincides. The Carthamus could only be had from the end of March to the middle of May; the Water-lilies from July to November; while the young leaves of Salix indicate the spring. The Acacia and Sesbania flower at all seasons.

Miscellaneous.

An Old Storage Battery Patent.—Electricians are interested at present in the discovery in the Patent Office of a patent issued February 6, 1861, to C. Kilchof, a New-Yorker, for an electric battery, which presents all the features of the storage batteries in use at the present day—lead plates immersed in acidulated water, which becomes coated with the oxide of lead. The principle appears to be the same as that of the Plante (French) storage battery, and the storage batteries now in market must hereafter rely upon peculiarities of construction instead of comprehensive claims.

Still Another New Thermometer.—Prof. Tait announces that by means of pure iridium and ruthenium he has been enabled to construct a standard thermo-electric thermometer, capable of reproduction anywhere, and which would afford a perfectly definite standard for the comparison and measurement of high temperatures, for which at present no proper instrument exists.

Hall effect.—Dr. E. H. Hall finds that the values of the "rotational coefficients" given by him at the York meeting of the British association for zinc, aluminum, copper, brass, and lead, are confirmed by later experiments. On trying the effect of change of temperature, only a negative result was obtained with gold; with iron, the increase was two-thirds of one per cent., with a rise of 1 °C. The coefficient, with change in the strength of the field from 1,000 to 7,500 absolute units, seemed to increase; but, of this, Dr Hall does not feel sufficient confidence to publish his results. The object of another experiment was to determine whether any part of the rotational effect could be made permanent. For this purpose a thin piece of very hard steel spring was used as the plate. The direction of the equipotential lines was permanently changed by the action of the magnet. This change was in the same direction as the temporary effect due to the magnet's action, and perhaps equal to two per cent. of this.

Radiation and Absorption of Rock Salt.—Herr C. Baur has made some observations on this subject. His results do not agree with those of Melloni and Magnus. Melloni considered that heat, radiated *from rock-salt*, was not absorbed by plates of rock-salt, any more than heat radiated from other substances. Magnus found that rock-salt plates absorbed heat radiated from rock-salt much more than that radiated from other substances. He believed that the radiation from perfectly pure rock-salt would be completely absorbed by a plate of the same substance, and that the apparent exceptions to this law were due to impurities in the radiating plate. Herr Baur concludes from his experiments that, 1. Rock-salt absorbs its own radiations better than those from any other body; 2. The absorption increases as the difference of temperature between the radiating and absorbing plates decreases, 3. The absorption is probably complete when both plates are at the same temperature. Magnus' exceptions were probably not due to impurities, but to a difference of temperature of the two plates.

Earth-worms and Fertility.—According to Hensen, earth-worms increase the fertility of the soil by forming burrows through which the roots of plants can descend into the subsoil This applies chiefly to *Lumbricus terrestris* while *L. communis* is confined chiefly or entirely to the surface-soil The tap-roots of many plants, he thinks may be able to force their own way through the hard subsoil; but the more slender side-roots descend chiefly through worm burrows, or other channels, such as those left by old decayed roots. By excavating in frozen ground, he was able to trace roots downward through worm-burrows, and to observe that the layer of excrements with which the latter were lined was covered with a delicate network of root hairs proceeding from the root in the interior. An important function of these roots Hensen believes to be, to supply the plant with water from the moist subsoil; and this is particularly important in the case of quick-growing annuals, like the cereals, which must develop their root-system rapidly, and frequently have to withstand prolonged dry weather It is plain that no new material can be added to the soil by earth-worms; but they effect the fixation of vegetable matters in the soil by drawing into their burrows leaves, and other loose fragments of vegetation: they hasten their decomposition, and distribute them through the various layers of the soil.

Magnetization of Iron and Steel by Rupture.—At a recent meeting of the Society of Physical and Natural Sciences at Karlsruhe, Germany, Mr. Bissingar dwelt at some length upon the phenomenon of magnetization of iron and steel when broken in the testing machine. The phenomenon is ascribed not to the elongation of the bar, but to the actual fracture, and both parts are converted into two magnets of sensibly equal power. The shock and vibration of the metal on breaking, is in all probability the cause of magnetization. In testing bars for tensile strength, *the south pole is formed at the upper end* of the bar, and it has been found that the different iron objects near the machine at the moment of rupture are also magnetized, but to a less degree.

An interesting discovery.—According to a French paper, the *Echo du Nord*, a number of coal mines in the north of France are about to be visited by a band of explorers of great distinction. Messages were recently sent from the place in question to the Academy of Sciences, in Paris, and to the authorities at the British Museum, *inviting delegates from each* of the bodies to pay a visit to the subterranean passages, where an uncommon discovery is said to have been made. The paper in question relates how, in excavating a new passage, the miners came across some extraordinary fossils, proving the presence there, at some remote period, of human beings, as well as of animals and fishes. The passage in question led, as it appears, into two caverns, the mouths of which have long been closed up, and in the first of these were discovered five perfect fossils—one of a man, two of women and two of children, besides several weapons and utensils of petrified wood and stone. The second cavern, discovered some time later, contained no less than eleven fossil bodies, described as being of large dimensions, a quantity of miscellaneous objects, and some precious stones. In addition to this, it is ascertained that the walls of the cave were covered with rude sketches representing the combats of men with gigantic animals, *from which it* would appear that the human race, while battling for existence with the aid of stones axes against the monsters of the field and forest, were still acquainted with *the graphic arts*, and anxious to perpetuate their deeds of early heroism. The bones and bodies themselves have now been removed to the neighboring towns of Lens and Lille.

PROCEEDINGS OF SOCIETIES.

Engineers' Club of Philadelphia · President Henry G Morris in the Chair, Mr. C G. Darrach exhibited two profiles from Tiffin, Ohio, to Lake Station on the southern bend of Lake Michigan The surveys were made for the Baltimore and Ohio short line to Chicago. One via Napoleon and the other via Defiance, Ohio.

The Defiance line (run by Mr. Darrach), was but 1½ miles longer than an air line.

About 240 miles of surveys were run and the profile and maps plotted in 60 working days, with a party of 8 men.

The Secretary presented a communication from Col. James Worrall with regard to the Panama Canal. Col. Worrall says·

"You may remember in my paper on the Panama project, I alluded to a catch-water dam on the Chagres and compared it to the Schuylkill, endeavouring to convey an idea of its difficulty. By the enclosed slip from the New York *Times*, I see they have abandoned the idea of a dam.—What next will they abandon? If they come to quicksand they will abandon the whole thing, at least as a canal *à niveau*.

"They can get across that neck of land *with locks*, but it will be many a long day before they get a level trench dug through the Andes even at the Panama Gap."

The Institution of Civil Engineers.—At the Meeting on the 8th of April, Mr. Brunlees, President, in the Chair, the Paper read was "On the Diamond Fields and Mines of South Africa."

The Author commenced by stating that Kimberley was situated in Griqualand West, about 700 miles north-east from Table Bay, and 450 miles inland from Port Elizabeth and Natal on the East Coast. Lines of railway were in course of construction from Table Bay and Port Elizabeth to Kimberley, and were about half completed. In Griqualand there were several diamond mines, the principal of which were Kimberley, De Beer's, Du Toit's Pan and Bultfontein.

In the Orange Free States there were also two mines, viz., Jagersfontein and Koffreyfontein, the first of which produced fine white stones. The mines were all divided into claims, the greatest number of which were to be found in the Du Toit's Pan mine. Bultfontein came next.

The deepest and most regularly worked was the Kimberley mine. The next deepest was De Beer's, which, however, was very unevenly worked. Then followed Du Toit's Pan and Bultfontein. The Du Toit's Pan mine ranked next in importance to Kimberley mine. Diamonds were first discovered in 1867 by Mr. O'Reilly, a trader and hunter, who visited a colonist named Van Niekirk, residing in Griqua. The first diamond, on being sent to the authorities, was valued at £500. Considerable excitement was caused throughout the colony, and the natives commenced to look for diamonds, and many were found, among which was one of 83½ carats, valued at £15,000. In 1868, many enterprising colonists made their way up the Vaal River, and were successful in finding a good number of diamonds The centre of the river-diggings on the Transvaal side was Klipdrift, and on the opposite side Pniel. In all there were fourteen river-diggings.

Du Toit's Pan and Bultfontein mines were discovered in 1870 at a distance of 24 miles from the river-diggings. The diggers took possession of these places. Licences were granted giving the first diggers a right to work. In 1871, De Beer's and Kimberleys mines were discovered, and, in 1872, Mr. Spalding's great diamond of 282½ carats was found at the river-diggings.

The mines were of irregular shape, and were surrounded by reef. The top reef was a loose shale, and had given great trouble from the frequent slips. Below this were strata of trachytic breccia and augite the formation was then seamy to an unknown depth.

Within the reef, the surface soil was red, and of a sandy nature. The next stratum was of a loose yellow gravelly lime, and the third blue, of a hard slately nature. This was the real diamantiferous soil. Large stones had been found in the "yellow," but the working of this generally did not pay. Kimberley mine, however had paid very well all through. The method of working in deep ground was determined by roadways running north and south. The soil was hauled up to these roadways, and taken to the sorting tables. The roadways decaying shortly after exposure to the atmosphere, a system of hand windlass was adopted, which worked very well for a time until horse-whims were introduced in 1873. The depth of the mines increasing, horse-whims had to give way to steam-engines in 1876.

The first diggers treated on an average 10 loads per day each party. At the present time, the least taken out by any engine, when fully employed, was 250 loads per day. The cost of working, with present appliances, the first 100 feet in depth, was 3s. 6d. per load; the second 100 feet (mostly blue) 5s., the third 100 feet 8s., and the fourth 100 feet 11s. Through scarcity of water a system of dry sorting had to be resorted to for several years, but it was superseded by the introduction of washing-machinery, which was now generally employed.

At the commencement, through inexperience, many serious mistakes were made. When the first diggers reached the bottom of the red sand, they thought no diamonds would be found in the next stratum. When, however, diamonds were found in the second stratum, the diggers had again to remove the *debris*, and so also when the "blue" was reached. Some of the claims in the Du Toit's Pan and Bultfontein mines were irregular in shape. The other mines, however, had been properly and regularly laid out. One or two shafts had been sunk and connected with the mines by underground galleries. These galleries were convenient in the case of falls of reef. Labour, at first, was cheap; but from 20s. per month, wages rose to 30s. per week, and food. The yellow soil offered no difficulty in working, being loose and broken, but the blue soil required blasting.

Several methods were adopted for extracting the soil and carrying it from the mine before steam was introduced. The cost of wood for heating purposes was a serious item, but good coal had now been found at 160 miles from Kimberley, costing £13 per ton, another serious item of expense was the transport over natural roads only, costing from £18 to £30 per ton.

The machinery designed by the Author for this industry was described. A 16 H.-P. direct-acting winding-engine was introduced for hauling up loads at the rate of about 1,000 feet per minute, and a 25 H. P. geared-engine, for hauling up heavier loads, at the rate of from 600 to 700 feet per minute.

Water was dear, and water-heaters were fitted to each engine, by which 33 per cent. of the water was again used, thus saving one-third. The boilers were as the locomotive type, mostly of steel, to save weight, and thus reduce the cost of transit. The fire-boxes were also made of steel of very soft and ductile quality. A semi-portable engine was made for driving the wash-mill. The engine was so arranged that it might be removed from the boiler and placed separately. The boiler was made to work at a pressure of 140 lbs. per square inch. Automatic cut-off gear was fixed to each engine, and the governors were provided with a spiral spring for adjusting the speed. A screen, or cylinder wash-mill and elevator, were used for dealing with the diamantiferous soil, and were described. Standing wires were fixed at the back of the machinery, and passed over a frame fixed at the top of the mine, the end in the mine being secured to strong wooden posts. After the blue soil had been blasted and collected into trucks, it was placed in tubs, which ascended the standing wires. It was then emptied into the depositing-box. The yellow soil might be put into the wash-mill direct, also that portion of the blue which had passed through the screen fixed over the depositing-box. The remainder of the blue, which was spread out to a thickness of 4 or 6 inches on the depositing-ground some distance from the mine to dry, was delivered into the upper part of the screen. The return-water from the elevator, with a portion of fresh water, was also discharged at this point, and operations were thus greatly facilitated, the soil becoming thoroughly saturated, and passing more easily down the shoots. The large pieces which would not drop through the meshes of the screen were discharged into trucks at the lower end and carried away. The smaller pieces with water, in the form of sludge, fell through into a shoot, and thence were conveyed into the wash-mill pan, and there kept in constant rotating motion by agitators. The diamonds, and other pieces of high specific gravity, sank to the deepest part of the pan, and the remainder of the sludge was forced over the inner ledge to the elevator. The sludge was then lifted, and thrown upon an inclined screen and down the shoot over the side of the bank. The residue left in the pan at the end of the day's work was passed through a pulsator, in which, by the force of water, the mud and lighter particles were carried away, leaving behind the diamonds, agates, garnets, and other heavy stones. It was the practice occasionally to put a few inferior stones in the soil, to test the efficiency of the machinery.

In 1881 the Author paid a visit to Kimberley, and found the industry a large one. The Post-office return showed the value of diamonds passed through the office in one year to be £3,685,000. Illicit diamond traffic had hitherto been a source of great trouble at the Fields. It was a question whether this industry would ever cease; in any case there was no doubt but that it would last for over a century. It was believed that the main bed of diamonds had not yet been reached, and that the mines in operation were merely shafts leading to it. Now that the waterworks were finished, with a bountiful supply of water, coupled with the great boon of railways to the Fields, and the advantage of a law recently passed for the prevention of illicit buying, a great and prosperous future was in store for the Diamond Fields.

The Determination of Copper in Steel, by Magnus Troilius Chemist to the Midvale Steel Company, Philadelphia. Read at the Boston Meeting, February, 1883.

The following is a very rapid method for determining copper in steel. I have found it to give results very closely agreeing with those obtained by galvanic precipitation of the copper.

Five grams of steel are dissolved in a mixture of 100 c.c. of water and 100 c.c. of sulphuric acid. When all is dissolved, add 2 c.c. of a concentrated solution of hyposulphite of soda and stir well. After 15 minutes boiling, all the copper is down as black sub-sulphite of copper (Cu_2S) and the solution regains its greenish color. Filter rapidly, wash a few times with hot water, pierce the filter, and wash the precipitate back into the beaker, in which it was made.

Dissolve in a little aqua regia and evaporate with about 2 c.c. of *sulphuric acid, until white fumes appear. Dilute with water, heat* to near boiling and add excess of ammonia (sp.gr. 0.96). Allow to settle in a warm place, filter and wash with hot water containing some ammonia. From the filtrate evaporate the excess of ammonia, add a little dilute sulphuric acid till it is slightly acid, and precipitate the copper as before with a few drops of hyposulphite of soda. Filter on a washed filter-paper, wash with hot water, place the wet filter in a weighed porcelain crucible, ignite and weigh as oxide of copper (CuO).

When an ordinary Bunsen burner is used, care should be taken not to let the crucible come into contact with the inner cone of the flame.

Engineers' Club of Philadelphia.—Record of regular meeting, April, 21st 1883: President Henry G. Morris in the Chair, 22 members and 2 visitors present. Mr. Percival Roberts, Jr., exhibited a turning from a cast steel roll. The dimensions of the roll, which was cast from open hearth steel, were about 30 inches by 5 feet 6 inches. The turning is 4 inches wide by 12 inches long, 1-32 inch thick, showing the roll to be very homogeneous and very tough for cast steel. A communication from Mr. E. H. Talbott, Secretary National Exposition of Railway Appliances, requesting the cooperation of the Club in the proposed Department of Engineering Exhibits, was presented and discussed.

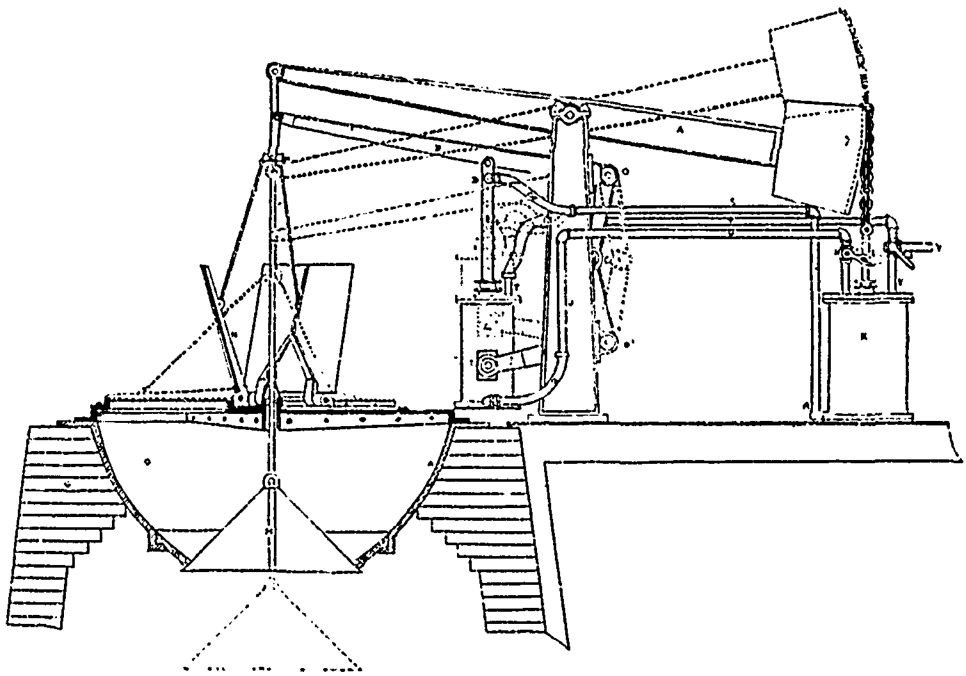
Record of Regular Meeting, May 5th, 1883.—President Henry G. Morris in the Chair: 22 members and 2 visitors present. Mr. T. M. Cleemann was enabled to show, through the courtesy of Mr. W. W. Evans, of New York, a map and profile of the Southern Pacific Railroad in California, showing where it crosses the dried up bed of a lake, being below the surface of the Pacific Ocean for 58 miles, and attaining a depth below said surface of 266 feet. At this point it skirts a deposit of salt from 6 to 24 inches in thickness. He also showed a number of photographs of the Tehachapi Pass on the same railroad near San Fernando. In order to attain the summit with a sufficiently reduced grade, the line was "developed," advantage being taken of a conical hill to wind about it in the form of a helix, crossing itself and continuing on its way with several meanderings. The St. Gothard Railroad has several such helices, but they are cut in the solid rock. A similar location was made about 18 years ago in the Southern Pennsylvania Railroad, but it was not built. Another piece of interesting location was also exhibited, namely, the mountain division of the Western North Carolina Railroad, which shows great skill in fitting a line to the country. Mr. George S. Strong described a new method of manufacture of corrugated boiler tubes. Mr. E. F. Loiseau gave a sketch of the progress and condition of the manufacture of artificial fuels. Mr. R. H. Sanders described a derrick used for hoisting material from a slate quarry by means of cable and bucket, and Mr. T. M. Cleemann noted a similar method pursued in the construction of a viaduct in Peru, 252 feet high, when the pieces were conveyed by a traveller to the pier. Mr. C. G. Darrach continued his remarks with regard to the relative quality of water at the top and bottom of deep reservoirs, and discussed methods of meeting the difficulty encountered in the accumulation of impurities below the surface.

THE AUTOMATIC GAS SEAL.

The tendency of improvements in blast furnaces has been almost exclusively in the direction of increased capacity. The marked success attained has naturally resulted in a very keen competition so that, in the future, economy in fuel, repairs, etc., will of necessity be the most important object to be sought by the iron smelters.

The automatic gas seal, shown in the accompanying illustration, is an invention of which the prime object is economy. It consists in a covering for the feeding hopper of a blast furnace, which covering has two or more openings (the number is determined by the size of the furnace), provided with lids N N hinged near the center. The lids are opened and closed by the movement of the lever arm B O C, which is pivoted at O. The moving power is derived from a cylinder connected to the arm B O at D and supported on trunnions in the fork of the lever F O1 G. The latter is pivoted at O1, and connected with B O C at C by a pin and slot.

In connecting and supporting the cylinder in the above manner its weight acts as a counterbalance to the lips, and action and reaction, that is, the upward thrust on the piston as well as the downward pressure on the bottom of the cylinder, both become effective in raising the lids, in consequence of which a much smaller cylinder will operate the seal than would be possible by any other arrangement. Furthermore, it is out of the way and easily got at. The illustration represents a design in which the blast is the motive force. The cylinder is eighteen by thirty inches, and cylinder K is twenty



THE AUTOMATIC GAS SEAL.

four by thirty-six inches. If steam be employed, which on the whole is preferable, the diameters may be reduced from eighteen to six inches and from thirty-four to eight inches, respectively.

The operation of the automatic gas seal is as follows. Supposing the hopper to be charged, the valve J is turned so as to admit the blast through T G I into the cylinder, where its action is upward on the cylinder head and downward on the piston, causing B O to descend and the seal to be closed. At this instant the port hole in the hollow piston rod will have entered the cylinder, thus establishing communication through D C S R with cylinder K. The blast in entering raises the piston, this allowing the bell H to lower and the contents of the hopper to be discharged into the furnace. The apparatus has now taken the position shown by the dotted lines. The bottom of the hopper is open, but the top is completely closed, thus preventing any gas from escaping. Reversing the valve J the air enters through Y into K, causing the piston to descend and the bell to be brought to its seat. At this moment the pin I will have opened the valve H, allowing the air to pass through H U L G to the cylinder, where its action and reaction causes the lids to be raised, leaving the hopper open to receive another charge.

The automatic gas seal requires no extra labor to manipulate it, it can neither be neglected nor misplaced, consequently the furnace is never open to the atmosphere and no gas is permitted to escape.

The advantages of a gas seal on a blast furnace are manifold, and its economical value much more far reaching than would appear at first sight. First and most apparent is the saving of the gas which ordinarily escapes while lowering the bell. The amount of gas thus actually lost varies with the relative number of charges and the time required in discharging, but will in no case figure less than equivalent to one ton of coal per 100 *tons of iron.*

There is also an indirect loss of fuel. First, in the furnace itself, due to the dilation of the gaseous contents and the loss of sensible heat carried off by the volumes of escaping gases. Second, when, while lowering the bell, the gas escapes at the top of the furnace, there is an inrush of cold air into the combustion chambers of the hot blast stoves and under the boilers. This has a cooling effect which undoubtedly causes as great a loss of fuel as the escaping gas itself, which would increase the fuel economy due to the gas seal to two tons per 100 tons of iron made. The items of fuel which are saved by a gas seal, although small per ton of iron, will amount to several times the cost of a seal in a single blast. It is, furthermore, not to be over-looked that a device which completely shuts off the gas and, requires no extra labor must be a boon to the "top filler," who is ordinarily more or less exposed to the noxious gases.

All these advantages, however, are of small significance compared with the great office of the gas seal to reduce repairs. First, the furnace itself, since the bell and lipring are scarcely ever worn out, but always burned or warped by overheating caused by the ignition of the escaping gas, it follows that when the hopper is provided with a seal which renders ignition impossible they may last an indefinite length of time. Furnace managers know that the most careful attendant can not always prevent the gas from lighting, and that it is only in rare and exceptional cases that a bell and lipring last through a whole blast; but, on the contrary, not unfrequently have to be replaced several times, the expense of each renewal by far exceeding the cost of a seal. Second, repairs in the hot blast stoves. The iron pipes may become warped by overheating, and can even be melted down by too strong a fire, but are invariably oxidized (burned) by the currents of uncombined oxygen impinging upon their hot surfaces while the gas ceases to flow.

The frequent failures of the iron pipes, the attendant delays and consequent heavy expense have induced not a few of the most experienced furnace managers to condemn the iron stoves and erect fire brick stoves at great cost, where a few hundred dollars invested in gas seals might have helped them over the difficulty.

Last, but not least, are the boiler repairs. The frequent explosions, numerous narrow escapes, and countless minor "give outs" in furnace boilers have in nine cases out of ten been traced to the continued strain caused by the expansion and contraction due to the intermittent flow of gas. This item is *of the most vital importance, since it is not only a source of* much annoyance and expense, but may result in fatal accidents. The deleterious effects of the change of temperature, and of the shocks caused by the sudden ignition of the re-entering gases on the walls of the hot blast and boilers walls, is also an item worthy of consideration.

Thus, considering the advantages of the gas seal in all its bearings, it is evident that it is destined to become a factor of no small import in the economy of iron smelting.

Mr. Ed. A. Uehling, of Sharpsville, Pa., is the patentee.—*American Inventor.*