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Communications relating to the Editorial Department should be addressed to the Editor, Henry T. Bovey, 31 *McTavish Street, Montreal.*

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NEW BOOKS.

Conversion Tables, by Robert H. Thurston, A. M., C. E. (New York, John Wylie and Sons.)

The main portion of this very convenient volume is also printed as an appendix to Part I. of the *Materials of Engineering,* by the same author, and contains all Measures and Weights expressed according to the British, United States, and and Metric systems, as well as the most complete and most useful Tables of " conversion factors" yet published.

In the present work these Tables are prefaced by an excellent Essay on the requisites of a *perfect* system, and by a discussion as to the merits of that known as the metric for which Mr. Thurston claims many great advantages.

The Plasterer's Manual, by K. Cameron, (New York, W. T. Comstock,) The " Plasterers Manual,"is a neat little book which is designed to be used as a pocket guide. It contains a number of useful tables and receipts, *terse* descriptions of the various materials used in plastering, instructions for making mortars and the results of practice as to the best methods of performing the various descriptions of work. While there is much in the book of value to the experienced, it does not overlook the wants of the novice to whom the author gives the following advice : " Do not depend upon a book alone in learning a trade ; example and practice, as well as precept, are also required to master it thoroughly. It is therefore essential to place yourself under the instruction of an experienced workman, being careful to form an apprenticeship only with one whose work and reputation are excellent. An apprenticeship formed with any other would prove a damage rather than a help." Mr. Cameron's Manual would be a valuable guide to a young man in the selection of a master, because it points out very clearly what good work is. The remarks on the character of work and the value of workmen have the ring of good common sense.

" COVERED SERVICE-RESERVOIRS."

By Mr. William Morris, Mech. Inst., C.E.

(A paper read at the Institution of Civil Engineers.)

The Author alluded to the fact that covered reservoirs were used by the Romans, and other ancient people, for keeping water cool and pure for potable purposes, and showed that their use was by no means a recent refinement, although they had only lately been introduced in modern waterworks. It did not appear, from official returns, that covered reservoirs were used in London in 1850, when filtration had only been partially introduced. But it soon became evident that covered reservoirs were necessary for the storage of filtered water, and accordingly it was enacted by the Metropolis Water Act, 1852, which required all water (except water pumped from wells) to be filtered, that all reservoirs for filtered water within 5 miles of St. Paul's Cathedral should be covered. This enactment was more particularly intended to preserve the water from contact with the smoke of London ; but the objection to uncovered reservoirs was by no means confined to the neighbourhood of large towns, as owing to the rapid growth of vegetable and animal life in service reservoirs, the improvement from the filtration of the water was rapidly lost, especially during the summer. As examples, the Author referred to the uncovered reservoirs constructed at the cost of the Admiralty in Greenwich Park and on Woolwich Common for the protection, in case of fire, of the Greenwich Hospital, Royal Dockyard, and other Government establishments, which were partially used by the Kent Waterworks for the supply of their district. The Author then proceeded to describe the covered reservoirs at Plumstead and at Shooter's Hill, purchased by the Kent Company. These were covered by brick arches, springing from cast-iron girders. Then followed descriptions of different works, including the Chislehurst Reservoir, which was built of brick, covered with arches supported by cast-iron girders, and rendered internally with cement. The circular reservoir, purchased from the Dartford Local Board of Health, was covered with brick arches supported on nine wrought-iron joists radiating from the centre, where they were supported by a cast-iron column. The circular reservoir in Greenwich Park consisted in brick arches, resting on concentric rings of rolled wrought-iron, girders supported by piers. The filter-beds at Deptford were converted into covered reservoirs, consequent on the Kent Company abandoning the supply from the river Ravensbourne in favour of spring-water from the chalk, in which case the old filtering material was utilised in the construction of the concrete vaulting. The covering of a small reservoir at Plumstead with Bunnett's flooring was described, and the construction of a covered reservoir on Woolwich Common in lieu of the old one referred to, when relinquished by Government. This was an oblong reservoir 200 feet long by 100 feet wide ; the walls were of concrete, faced with brick ; the covering arches were of brick springing from rolled joists supported on brick piers. The above works were designed by the Author's father, the late Mr. W. R. Morris, M. Inst., C.E.

The Author then described the New Cross Reservoir, built under his direction in 1874, which was similar to that on Woolwich Common, except that the roof consisted of brick arches springing from the piers instead of rolled joists. He then gave a full description of a reservoir recently constructed by him at Farnborough, Kent, in which the outer walls were reduced to a minimum, by supporting the covering arches till their springing was level with the centre from which they were struck. This system was adopted for the end as well as for the side walls. An account was given of a slip which occurred during the construction of the reservoir, and of the means taken for making the work secure.

The East London Waterworks Company had at Hornsey Wood a fine brick reservoir which was capable of containing 5,000,000 gallons of water. The same Company had at Haggar Lane a reservoir capable of containing 1,500,000 gallons. This also was built of brick, the vaulting was supported by longitudinal walls, stiffened by transverse walls, so that the reservoir was divided into forty-nine sections, the walls of which were pierced with circular openings. The Kilburn Reservoir, capable of containing 6,000,000 gallons, was a fine brick structure, with vaulted roof, supported on cruciform piers, the outer walls were supported by buttresses against the pressure of the external earth. The Hampton Reservoir, capable of containing 2,750,000 gallons, was constructed entirely of concrete. This reservoir was built in clean sharp gravel, and the excavated ballast was admirably adapted for the concrete. The arches sprung from wrought-iron joists. The Barton-on-Trent Reservoir, built for the South Staffordshire Waterworks, had a capacity of 4,000,000 gallons; it was rectangular on plan, and was covered with brick arches springing from cast-iron girders, supported on cast iron columns; the walls were of concrete, faced with Staffordshire bricks.

The Author then referred to several service-reservoirs, of which he had the opportunity of learning some particulars during a recent tour. The Charlottenburg Reservoir of the Berlin Waterworks, with a capacity of 5,000,000 gallons, was built of brick, with walls sufficiently thick to resist the internal pressure of the water; the soil was fine loose sand, on which bitumenised paper was spread before laying down the concrete foundations. The Berlin filter-beds were covered with Bohemian vaulting, the foundation of which rested on gravel puddle. The reservoir at Breslau, capable of containing 900,000 gallons, was supported on a tower 150 feet high, and the tower contained the pumping-engines. The Author then described one of the Vienna reservoirs, and furnished some notes on the aqueduct which supplied that city. The waterworks of the city of Munich, which were in course of construction at the time of his visit, comprised a reservoir having a capacity of 8,800,000 gallons, the walls and floor were of concrete, the vaulting was semicircular, built with one ring of brick. The Author gave a sketch of the Frankfort Reservoir and some notes as to the water supply of the city. The reservoir and works of the Darmstadt Waterworks were noticed; the reservoir was of brick, built above ground, it was capable of containing 900,000 gallons; the water was pumped from six tube-wells, sunk in the sandy plain between the Odenwald mountains and the Rhine at Griesheim, about 5 miles from the city. The reservoir at Cologne, which consisted of a cast-iron tank, with a capacity of 800,000 gallons, was erected on a tower 100 feet high; the water supplied to the city was pumped from wells on the banks of the Rhine; but the spring-water was quite distinct from the Rhine water. The Dresden Reservoir was capable of holding 4,600,000 gallons of water. The Hanover Reservoir, with a capacity of 2,400,000 gallons, was of brick. It stood 30 feet above the ground-line, and the outside walls supported the full pressure of the water without the assistance of any embankment.

After some remarks on the marked preference of Germans for spring-water as compared with lake-water or river-water, the Author concluded the Paper with a sketch of his idea of a model service-reservoir. This was so arranged that the earth dug from the excavation was all utilised in forming the necessary embankment. The floor and the side-walls were of concrete, the piers, arches, and vaulting of brick. The vaulting was similar to that of the Farnborough Reservoir; but the ends of the vault were brought down with a curve of 12 feet 6 inches radius till they rested on correspondingly curved bays in the concrete end-walls. By this construction the thrust of the roof would be carried down to an abutment reaching against undisturbed ground, and the pressure of the water on the reservoir would not only be supported by the abutment, but be also counterbalanced by the weight of made-earth facing the embankment, which rested on the exterior arches of the reservoir, in addition to the pressure of the earth which would have to resist internal pressure if the walls were vertical. The Author held that the whole of the interior surface should be rendered in cement mortar.

◆

REPORT OF COMMISSION ON WIND PRESSURE ON RAILWAY STRUCTURES.

MEMBERS.—SIR JOHN HAWKSHAW, SIR W. G. ARMSTRONG,
W. H. BARLOW, PROFESSOR GEORGE G. STOKES,
COL. WM. HOLLAND.

The conclusions arrived at by the Commission were as follows:—

1.—That for railway bridges and viaducts a maximum wind pressure of 56-lbs. per square foot should be assumed for the purpose of calculation.

2.—That where the bridge or viaduct is formed of close girders, and the tops of such girders are as high as or higher than the top of the train passing over the bridge, the total wind pressure upon such bridge or viaduct should be ascertained by applying the full pressure of 56-lbs. per square foot to the entire vertical surface of one main girder only. But if the top of a train passing over the bridge is higher than the tops of the main girders, the total wind pressure upon such bridge or viaduct should be ascertained by applying the full pressure of 56-lbs. per square foot to the entire vertical surface from the bottom of the main girders to the top of the train passing over the bridge.

3.—That where the bridge or viaduct is of the lattice form or of open construction, the wind pressure upon the outer or windward girder should be ascertained by applying the full pressure of 56-lbs. per square foot, as if the girder were a close girder, from the level of the rails to the top of a train passing over such bridge or viaduct, and by applying in addition the full pressure of 56-lbs. per square foot to the ascertained vertical area of the surface of the ironwork of the same girder situated below the level of the rails or above the top of a train passing over such bridge or viaduct. The wind pressure upon the inner or leeward girder or girders should be ascertained by applying a pressure per square foot to the ascertained vertical area of surface of the ironwork of one girder only, situated below the level of the rails or above the top of a train passing over the said bridge or viaduct, according to the following scale, viz:—

a. If the surface area of the open space does not exceed two thirds of the whole area included within the outline of the girder, the pressure should be taken at 28-lbs. per square foot.

b. If the surface area of the open spaces lie between two-thirds and three-fourths of the whole area included within the outline of the girder, the pressure should be taken at 42 lbs. per square foot.

c If the surface area of the open spaces be greater than three-fourths of the whole area included within the outline of the girder, the pressure should be taken at the full pressure of 56-lbs. per square foot.

4.—That the pressure upon arches, and the piers of bridges and viaducts should be ascertained as nearly as possible in conformity with the rules above stated.

5.—That in order to ensure a proper margin of safety for bridges and viaducts in respect of the strain caused by wind pressure, they should be made of sufficient strength to withstand a strain of four times the amount due to the pressure calculated by the foregoing rules. And that, for cases where the tendency of the wind to overturn structures is counteracted by gravity alone, a factor of safety of 2 will be sufficient.

Where trains run between girders they will generally be sufficiently protected from the wind, the degree of protection afforded by the girders depending upon the extent to which the girders are open or close; where the girders are so open as to afford insufficient protection, or where trains run, as in some cases they may do, on the tops of girders, we assume that the engineer will provide a sufficient parapet, but we are indisposed to go further into detail on this subject, as it might tend to stereotype modes of construction which we think is undesirable.

In conclusion we beg to point out that the velocity of wind, like that of every other moving body, is more or less retarded by friction, and will be affected therefore by the character of the surfaces over which it has to pass, which may be rough, smooth, or irregular. It will follow, therefore, that other things being the same, greater velocities will be attained at higher altitudes than at low ones, the wind at higher altitudes being further removed from retardation by friction.

Though we are of opinion that no bridge or viaduct is likely to be built in such a situation as to expose it to wind pressures equal to those which have been occasionally indicated by the disc on the Bidston Observatory, yet even if that were possible, a bridge or viaduct constructed according to the rules we have given would not be subjected to strains nearly equal to its theoretical strength.

On the other hand, there will be many structures of small altitude or in sheltered situations which never can be exposed to the wind pressure we have assumed, and where the application of the rules we have given would require modification.

Some modification of the rules may also be required in the case of suspension or other bridges of very large span, but such cases will be of rare occurrence, and we recommend that they should be specially considered when they arise.

Additional clause proposed to be added by Sir W. S. Armstrong and Prof. G. G. Stokes.

The evidence before us does not enable us to judge as to the lateral extent of the extremely high pressures occasionally recorded by anemometers, and we think it desirable that experiments should be made to determine this question. If the lateral extent of exceptionally heavy gusts should prove to be very small, it would become a question whether some relaxation might not be permitted in the requirements of this Report.

Method of deducing the Maximum Pressure of the Wind during a storm from the maximum run of wind in any one hour during the same storm.

In order to deduce the maximum pressures from the maximum runs of the wind in any one hour it is necessary to have recourse to some good station where both of these sets of quantities have been measured. The station selected for the formation of such a table is the Bidston Observatory. This station is very suitable, both from the wide range of the velocities and pressure experienced, and from the care and order with which the observations have been recorded and published. The table has been formed from the published results of the Bidston observations from January 1st 1870, to December 31st 1877. The method of forming the table was as follows :—

As the object of the table was to deal with the higher velocities and pressures of the wind, no notice was taken of maximum hourly runs of the wind smaller than 35 miles in an hour. A first subsidiary table was then formed of all the maximum hourly runs of the wind lying between 35 and 45 miles in an hour with the maximum pressures corresponding. these were respectively added up and an average result obtained of a maximum pressure of 14·7 lbs per square foot for a maximum hourly run of the wind of 40 miles. A second subsidiary table was then formed of all the maximum hourly runs of the wind lying between 45 and 55 miles in an hour with the maximum pressure corresponding, and an average result obtained as before. A third subsidiary table was then formed of all the maximum hourly runs of the wind being between 55 and 65 miles in an hour with the maximum pressures corresponding. And so on to the highest velocities registered. The results obtained in this manner were as follows :—

Maximum Hourly run of the Wind in Miles.	Maximum Pressure in lbs. on the sq. ft.
40	14·7
50	23·7
60	33·9
70	48·0
80	65·5

On an examination of the above figures it is seen that the pressures are very near proportional to the figures of the velocities in every case, and that the simple formula $\frac{V^2}{100} = P$ will serve with tolerable accuracy as the basis for the computation of a table connecting the maximum run of the wind in miles in any one hour (V) with the maximum pressure in lbs. on the square foot (P) at any time during the storm to which (V) refers.

NOTE.—Since the erection of the first viaducts on high piles in France it has been customary to adopt the following wind pressures in the calculations :—150 kilogrammes per square metre when a train is supposed to pass over the viaduct without a risk of being thrown off the rails, 270 or 275 kilogrammes per square metre for the bridge or viaduct without any rolling load.

These figures correspond to about 30·8 lbs. per square foot in the first case, and 56·4 lbs. per square foot in the second case.

* * *

CHARCOAL AS A FUEL FOR METALLURGICAL PROCESSES.[‡]

By JOHN BIRKINBINE, PHILADELPHIA.

The great iron industry of the United States, and, in fact, of the world, was established with charcoal as fuel. Long before the value of mineral coal was recognized, the carbonization of wood was carried on in connection with various metallurgical processes, but at the present time we look upon establishments using charcoal as the remnant of a former greatness, and are apt to sympathize with the operators because they have no other fuel to depend upon. In the iron industry there are now a number of works consuming charcoal which are believed to exist only because some of our ancestors erected them in particular locations. With but few exceptions, however, these locations are found to be advantageous, both on account of a good wood supply and the existence of remarkable beds of iron ore Constructed at a time when transportation facilities were limited, a majority of such plants have no railroad connections, but some which have been remodelled and operated in the light of present knowledge are very successful ventures.

It is proper, in view of the prevalent opinion concerning the early abandonment of charcoal as a metallurgical fuel, that before the processes of manufacture are considered some idea as to the quantity consumed be obtained, for, while in many locations the denudation of forests fixes a limit to the manufacture of charcoal, and in other instances a wilful waste destroys what might be a permanent supply of wood, the amount and value of charcoal used is not generally appreciated.

Charcoal at present produces 18 per cent. of all the pig iron made in the country. In the year 1881, 638 838 net tons of pig iron and 84,606 net tons of blooms and billets, a total of 723,444 net tons, were made with this fuel, consuming about 1,000,000 net tons of it. Never in the history of the iron trade have so great quantities both of pig iron and blooms been made with charcoal as fuel, and it is probable that the product of 1882 will considerably exceed that of 1881. The world's yearly production of charcoal pig iron is nearly 2,000,000 gross tons.

If to the amount of this fuel used at iron works, we could add that consumed in the various smelting works of the silver and other metallurgical industries, the total annual consumption of charcoal in the United States would be found to approximate 2,000,000 net tons. This, therefore, establishes the importance of considering this fuel, so far as quantity is concerned, and the quality may now be investigated.

Analysts tell us that average wood is composed of 50 per cent of carbon, 20 per cent. of water, and 20 per cent. of hydrogen and oxygen, in proportions closely approximating those in which they form water. These even percentages are affected by small quantities of ash, and by special compounds differing in various woods.

The following analyses of wood and charcoal will be of interest.

Analyses of Dried Woods. By M. Eugene Chevandier.

WOODS.	COMPOSITION.				
	Carbon.	Hydro.	Oxygen.	Nitrogen.	Ash.
	Per Cent.	Per Cent.	Per Cent.	Per Cent.	Per Cent.
Beech	49.36	6.01	42.69	0.91	1.00
Oak	49.64	5.92	41.16	1.29	1.97
Birch	50.20	6.20	41.62	1.15	0.81
Poplar	49.37	6.21	41.60	0.96	1.86
Willow	49.96	5.96	39.56	0.96	3.37
Average	49.70	6.06	41.33	1.05	1.80

[‡] A paper read before the American Inst. of Mining Engineers.

DIAGRAMS ILLUSTRATING MR. KENNEDY'S LECTURE.

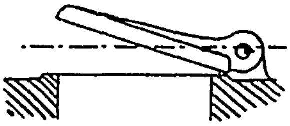


FIG. 1.

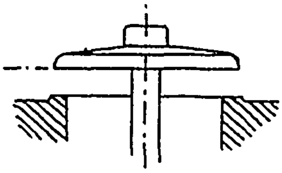


FIG. 2.

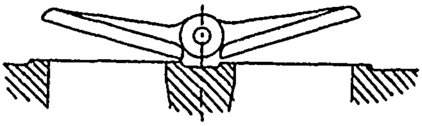
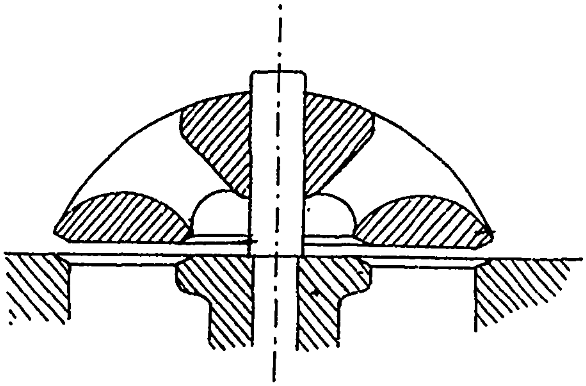
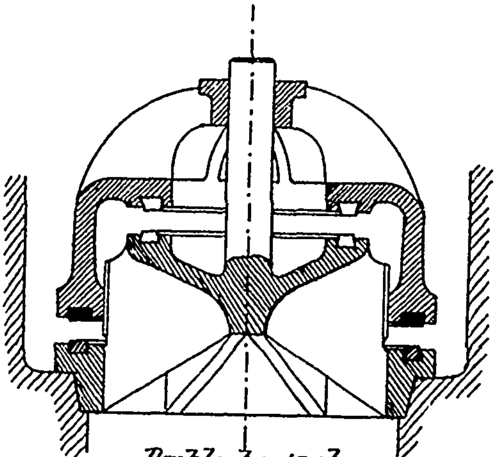


FIG. 3.



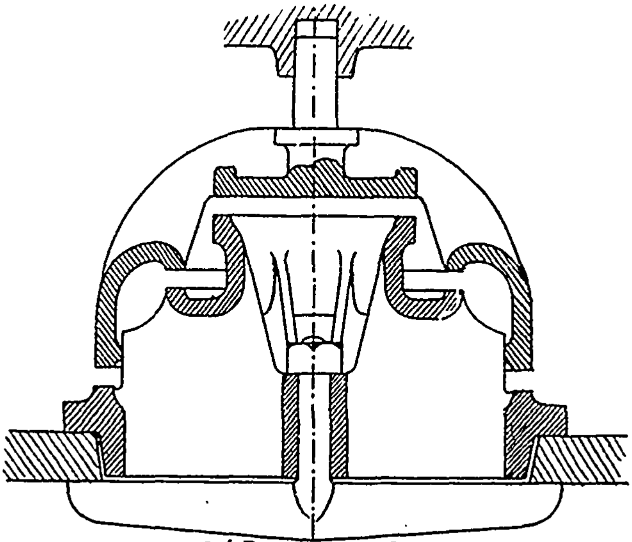
Annular Valve

FIG. 4.



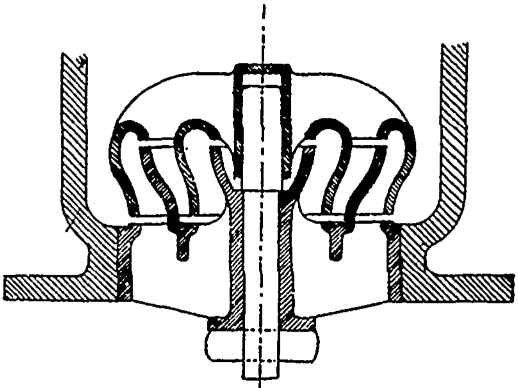
Double-beat valve

FIG. 5.



Triple-beat valve

FIG. 6.



Four-beat valve

FIG. 7.

DIAGRAMS ILLUSTRATING MR. KENNEDY'S LECTURE.

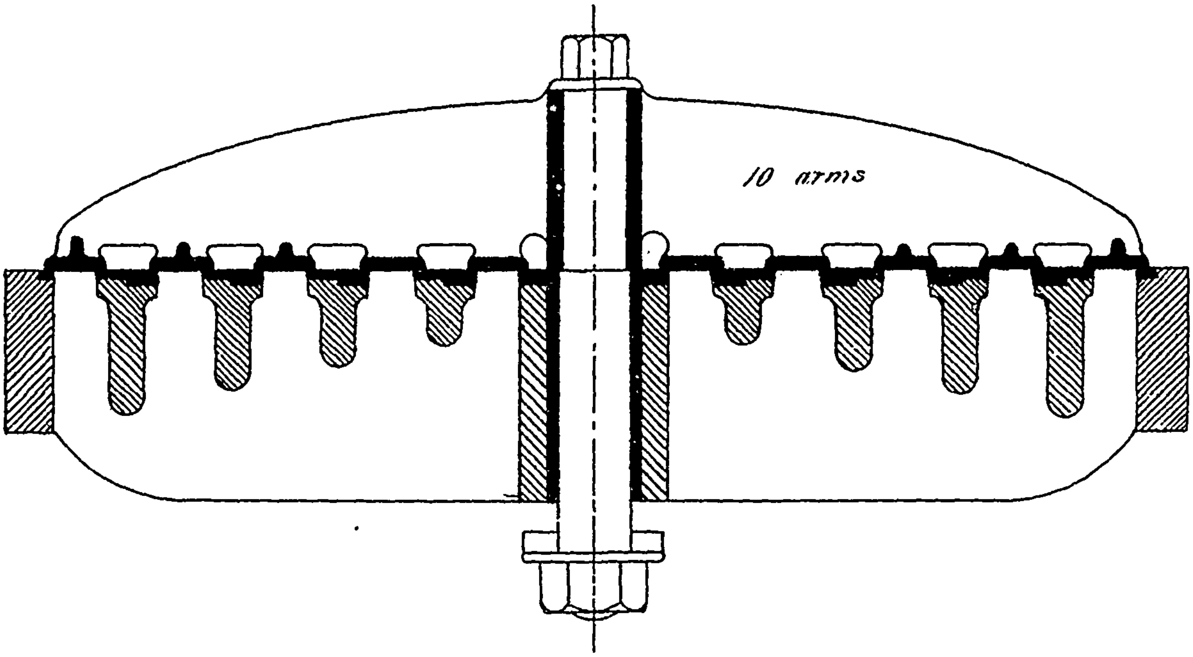


Fig. 8.

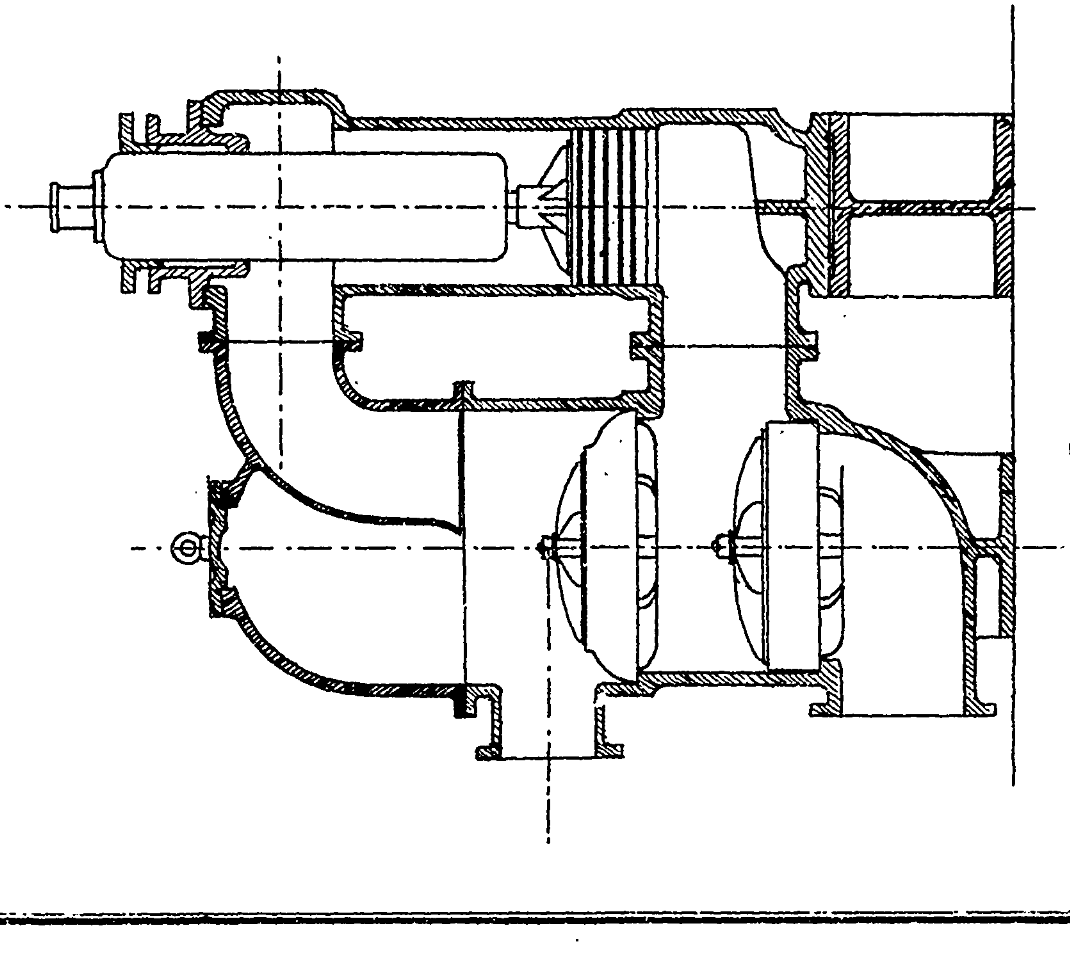


Fig. 9.

The following table, prepared by M. Violette, shows the proportion of water expelled from wood at gradually increasing temperatures:

TEMPERATURE.	Water Expelled from One Hundred Parts of Wood.			
	Oak.	Ash.	Elm.	Walnut.
257° Fahr.	15.26	14.78	15.32	15.56
302° Fahr.	17.93	16.19	17.02	17.43
347° Fahr.	32.13	21.22	36.94?	21.00
392° Fahr.	35.80	27.51	33.38	41.77?
437° Fahr.	44.31	33.38	40.56	36.56

The wood operated upon had been kept in store two years.

When wood, which has been strongly dried by means of artificial heat, is left exposed to the atmosphere, it reabsorbs about as much water as it contains in its air dried state. ‡

Temperature of Carbonization.		Composition of the solid product.				Carbon for a given weight of Wood.
		Carb.	Hyd.	Oxy., Nit., and Loss.	Ash.	
Centigrade.	Fah.,	P. C.	P. C.	P. C.	P. C.	P. C.
I. 150°	302° †	47.51	6.12	46.29	0.08	47.51
II. 200°	392° †	51,82	3.99	43.98	0.23	39.88
III. 250°	482°	65.59	4.81	28.97	0.63	32.98
IV. 300°	572°	73.24	4.25	21.96	0.57	24.61
V. 350°	662°	76.64	4.14	18.44	0.61	22.42
VI. 432°	810°	81.64	4.96	15.24	1.61	15.40
VII. 1023°	1873°	81.97	2.30	14.15	1.60	15.30
VIII. 1100°	2012°	83.29	1.70	13.79	1.22	15.32
IX. 1250°	2282°	88.14	1.42	9.26	1.20	15.80
X. 1300°	2372°	90.81	1.58	6,49	1.15	15.85
XI. 1500°	2732°	94.57	0.74	3.84	0.66	16.36
Melting point of platinum		96.52	0.62	0.94	1.95	14.47

A Table showing the composition of charcoal produced at various temperatures. By M. Violette.

Temperature Degrees at which Carbonization was effected.		Products of the decomposition of 100 parts by weight of wood by carbonization at different temperatures.				
		Composition of the solid matter or charcoal.			Comp. of the matter Volatilized.	
		Carb.	Gas. Elem H,O,N.	Ash.	Carb.	Gas. Elem H,O,N.
Centigrade.	Fah.					
I. 150°	302°	47.51	52.41	0.08		
II. 200°	392°	39.95	36.97	0.18	7.56	15.34
III. 270°	518°	26.17	10.65	0.32	21.34	41.52
IV. 350°	662°	22.73	6.75	0.18	24.78	45.56
V. 432°	810°	15.40	3.25	0.22	32.11	49 02
VI. 1029°	1873°	15.37	3.12	0.26	32.14	49.11
VII. 1100°	2012°	15.32	2.86	0.22	32.19	49.41
VIII. 1250°	2282°	15.81	1.91	0.22	31.70	50.36
IX. 1300°	2372°	15.86	1.40	0.20	31.65	50.89
X. 1500°	2732°	16.37	0.83	0.11	31.14	51.55
XI, Beyond 1500°, melting point of platinum.		1448	0.23	0.29	33.03	51.97

The wood experimented on was that of black alder or alder buckthorn, which furnishes a charcoal suitable for gunpowder. It was previously dried at 150° C.=302° F.

In carbonization, the water, oxygen, and hydrogen are driven off with some loss of carbon, the greater part of the carbon and the ash remaining; we therefore have a fuel which when anhydrous is practically pure carbon, the percentage of ash seldom reaching 2 per cent., but the open porous structure permits the absorption of considerable atmospheric moisture, and much of the charcoal as used in actual smelting or refining may be considered as containing

Carbon	90	per cent.
Ash, say	1	"
Water, say	9	"

The improved methods of manufacture, however, largely reduce the chances for absorbing moisture. In metallurgical processes the water in the charcoal is driven off in the first stages, and therefore it does not ordinarily affect the value of the fuel except where it is bought or charged by weight. No attempt will be made to discuss the relative merits of different fuels, as exhibited in their chemical composition, but some facts will be presented as to work done to demonstrate the character of the fuel under consideration.

In the very complete census report on the iron and steel industries for 1880, prepared by Mr. James M. Swank, the following statistics are given:

Pig iron produced in 1880.	Net tons.	Net tons.
With anthracite coal	1,112,755	
" bituminous coal	1,515,107	
" mixed anthracite and coke	713,912	
		3,341,774
" charcoal (cold blast)	79,613	
" " (hot blast)	355,405	
		435,018
Furnace castings		4,229
Total		3,781,021

Allowing a proportionate amount of castings to each kind of fuel, we can safely estimate the quantity of iron produced in blast-furnaces with mineral fuel at 3,345,450 net tons, and with charcoal at 435,571 net tons. The fuel consumption, in producing this metal, is stated as

2,615,182	net tons	anthracite coal,
1,051,753	" "	bituminous coal,
2,128,255	" "	coke,
5,795,190	" "	total mineral fuel, and
53,909,828	bushels	charcoal,

Estimating the charcoal at twenty pounds a bushel (a fair average), its weight would be 539,098 net tons.

This, therefore, gives as the average consumption per net ton of pig iron: 1.732 net tons of mineral fuel, 1,238 net tons of charcoal. When it is remembered that most of the charcoal blast furnaces are of small size, that many of them are poorly equipped, and that one-fifth of the iron produced with this fuel was made with cold blast, thus augmenting the quantity of fuel consumed, the value of charcoal as a fuel for producing iron is manifest.

In the same report the records of six consecutive weeks' work of eleven mineral coal and coke furnaces, and eleven charcoal furnaces show the following averages:

	Mineral fuel.	Charcoal.
Diameter of bosh, feet	17	10.5
Height, feet	70	47
Temperature of blast, degrees F	1035	770
Fuel per ton, pounds	2569	2203
Gross tons made per week	557	218
Burden per pound of fuel	2.23	2.506

The above were selected for their exceptionally good records.

While its value as a fuel, practically free from deleterious substances, is important, the physical structure of charcoal is probably of greater advantage. This will appear evident when the fact above mentioned is considered, viz., that charcoal as ordinarily charged does not contain over 90 per cent. of carbon.

(To be continued.)

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‡ *Vide* Combustion of Coal, Barr., p. 36.

† The products obtained at these temperatures cannot properly be termed charcoal.

WATER WORKS PUMPING MACHINERY.

By John Kennedy M. Inst. C.E.

The above is the title of a very able lecture recently delivered by John Kennedy, M. Inst. C. E., Chief Engineer of the Montreal Harbour Works, to the engineering classes of McGill University. Several of our leading engineers, Messrs. F. Shanly, W. B. Smellie, P. A. Peterson, L. Lesage, G. D. Ansley, showed the great interest they feel in the training of the younger members of the profession by being present, and kindly promised to give their help in continuing the lecturing system inaugurated during the last season. The lecturer commenced by stating that

Waterworks pumping machinery may be conveniently considered under these heads . 1. Pumps ; 2. Motive Power; 3. The Arrangement of these, with reference to each other and to their foundations.

Pumps for water works are almost exclusively reciprocating. Rotary pumps of various kinds have often been tried, but from their great tear and wear, leakage, waste of power, and cost of maintenance, they are unfit for constant use. An example worthy of notice as being near at hand, and as affording a full trial under favourable circumstances to one of the best forms of rotary pumps, was that at Ogdensburgh, N.Y. A set of three Holly rotaries was fitted up by the Holly Co. of Lockport about 15 years ago for the supply of the City at about 30 lbs. per inch for ordinary domestic use and about 80 to 100 lbs. for fires, but after a short time they were abandoned for the reasons stated, and reciprocating pumps substituted. The low first cost of rotary pumps has occasionally led to their use in water-works as reserves or fire auxiliaries, and they are well adapted to such use, but the desirability of having the reserve pumps of such kind as to be suited for regular use has almost universally led to the duplication of reciprocating pumps in preference to using rotary reserves.

Reciprocating pumps are conveniently classified as 1. piston, 2. plunger, 3. bucket-plunger. The piston, and the plunger are either single or double acting, and the bucket-plunger is single acting in feed, but double in delivery These types are sufficiently distinct in their ordinary forms and too well-known to need description, but they are sometimes so far varied in design as to be somewhat difficult to classify.

In dealing practically with pumps and especially with those of considerable size, and lifting 100 to 300 ft., as common in water-works, we soon find that the valves and the packing are the parts of chief importance and if these be right there is little else to give trouble.

Packing, strictly speaking, is some substance placed between the pump barrel and plunger, or between other stationary and moving parts to make a water-tight joint between them. Hemp and other soft substances compressed in a stuffing box, and metallic rings or sections, made elastic by springs. are most generally used. Instead of packing proper, bushings or similar devices, depending on the accuracy of their mechanical fit, are frequently used, and it will be convenient to consider both together. For single acting plungers and piston rods in which the packing is open to the air at one end, the old-fashioned hemp or flax, and common stuffing box is undoubtedly the best. The box should be capable of taking in 8in. to 12in. depth of yarn. and the packing should be loose enough to supply lubrication by a slight leakage of water.

For double acting plunger pumps, when the packing is more or less difficult of access and where leakage is of no importance, except as in Fig. 11, the loss of so much pumped water, the metallic bushing is frequently used, and is on the whole, to be preferred to packing. Clean water is a fair lubricator for two brass surfaces and for pumps of moderate size, brass plungers and brass bushings are therefore satisfactory. For large pumps where iron plungers are used for economy, brass or white metal bushings are used with good results. In all cases the bushings are made to be easily renewable; they are grooved with circumferential grooves to check the flow of water between them and the plunger. The depth of the bushing should manifestly bear some relation to the pressure of water and to the weight of plunger, in case it is a horizontal one and supported by the bushing—probably half to one diameter of the plunger is within the limits of ordinary practice for large pumps. For pistons, cupped leather, gutta percha, and various metallic and lignum-vitæ packings, made in sections and kept expanded by springs, in imitation of steam cylinder packings, have been often tried but without much success, and on the whole hemp or other fibrous packings is yet the most satisfactory for pump pistons. For the gland on the stuffing box there is in the piston a follower to press out the yarn and with this difference the packing of a piston and a plunger are alike.

The difficulty of access to pistons to tighten up or renew the packing has, in instances of good modern practice, led to the abandonment of packing and the substitution of deep pistons fitting accurately in the pump barrel and depending merely on their mechanical fit and on grooves cut round their circumference to prevent leakage, as in the case of bushings on plungers. The great 54 in. by 10 ft. pumps of the Chicago water-works and the new 30 in. by 4 ft. pumps of Hamilton, Ont., Fig. 9, are examples of vertical pistons or buckets, and the new Fairmount water-power pumps of Philadelphia are instances of horizontal pistons so treated. A depth of piston of half to three-quarters the diameter for vertical pumps and up to a full diameter for horizontal pumps is usual, and it is customary to make the periphery of the piston as a movable band or sleeve which can be easily changed when worn.

Pump valves.—The requisites in a valve are simply that it should let the water pass freely through it in one direction and entirely prevent it passing in the other. Perfection in action in these points together with durability constitute the excellence of a valve. Water may be retarded and the pump burdened by the valve being too small in area, thus increasing inertia and friction. Or the valve may be unduly heavy in proportion to its lifting area causing a material increase in pressure of water required to lift it; or the water-passages may be crooked and badly shaped. In all these cases the valve is faulty from not allowing the water to pass freely.

It may also be faulty from not closing quickly enough and thus allowing some water to return. This is a very serious evil not merely from the water wasted, but because of the shock produced by the sudden closing of the valve after the water above it has begun to move backward.

To obviate this shock is the great problem in valve designing and has led to almost infinite variety of forms. Time will not permit a description, however

DIAGRAMS ILLUSTRATING MR. KENNEDY'S LECTURE.

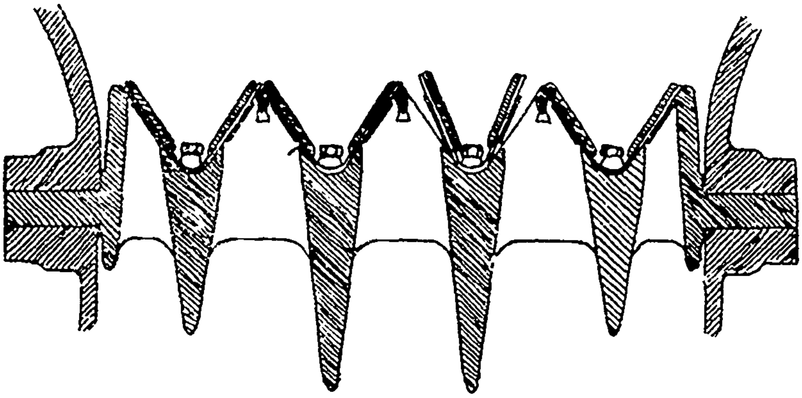


FIG. 10.

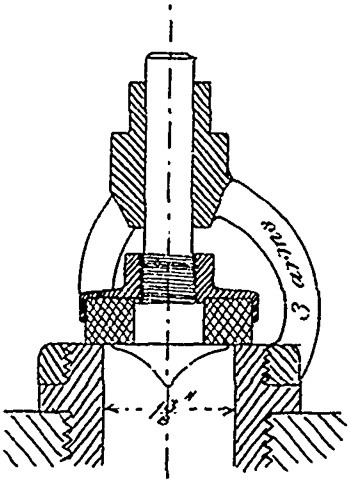
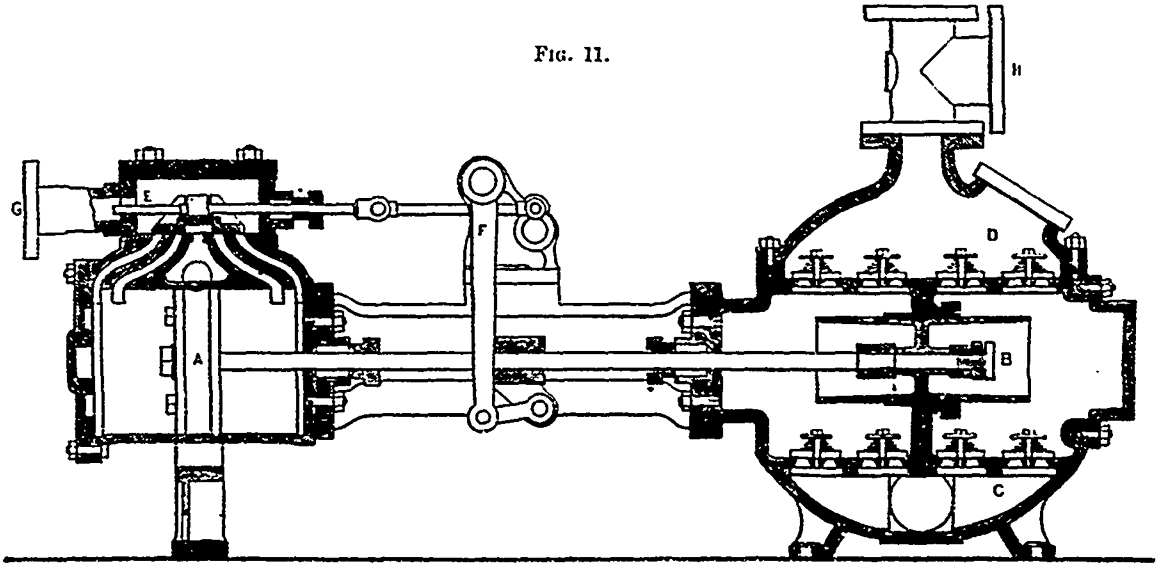


FIG. 12.

THE WORTHINGTON STEAM PUMP.

FIG. 11.



interesting it might be, but we may look at the types and trace the line of thought of the designers, and see what success has been attained.

Looking first at the old and still-used vertical hinged valve, we see at once that its weight hangs on the pivot, and has little effect in completing its closing. Obviously the way to improve it was to place the seat on a slope or make it entirely level, and this was done. But at best, a hinged valve can open at only one side and half open at its two ends. For instance a 4-in. square hinged valve would require a 2-in. lift to be fully open, but if (Fig. 1) opened equally all round (Fig. 2) only 1-in. would be required. If therefore a larger valve area be required without increase of lift, the only course is to increase the number of valves.

Circular and other valves having a parallel lift, obviously have four times the area of hinged valves of equal lifts, but in simple or single beat valves, the limit of area is also very soon reached.

To increase the effective, or discharging capacity of the parallel lift valve, without increasing its lift, an opening was made in its centre (Fig. 4), and it then became the annular valve with two beats on the same plane. A great improvement on this was the raising of the inner beat to a higher level, making the well-known Harvey & West's double beat valve, which not only secured, larger area, without increase of lift, but allowed of the reducing of the difference in the relative areas of the beats, and thus also of the weight or pressure of the valve on its beats. Carrying on the same principle, a step further produced the beat valve three and four, (Figs. 6 and 7). An example of the latter may be found at the Montreal Water-Works.

Pursuing in the same manner the line of thought which produced the simple annular valve and the grated flap-valve, brings us to a multiplicity of rings connected together and acting as one valve—an arrangement which obviously allows of the choosing of such size of opening and lift as the case requires, and then attaining the requisite area by merely multiplying the rings. Figs. 8 and 9 show examples in use at the Hamilton Water-Works designed by the author.

In all these examples the increase of valve area has been obtained by increasing the dimensions of the valve, but another method is to merely multiply the number of separate valves (Figs 10 and 12.) In order to pack the numerous valves into as small a space as possible—or rather into as small a diameter of pump barrel or chamber as possible—they have been arranged in superimposed rings and groups of many shapes.

(To be continued.)

THE ELECTRICAL TRANSMISSION AND STORAGE OF POWER.

BY DR. C. W. SIEMENS, F.R.S., M. INST. C.E.

The following is an abstract of a lecture delivered under the auspices of the Institution of Civil Engineers (London) on March the 15th:

Dr. Siemens, in opening the discourse, adverted to the object the Council had in view in organizing these occasional lectures, which were not to be lectures on general topics, but the outcome of such special study and practical experience as Members of the Institution had exceptional opportunities of acquiring in the course of their professional occupation. The subject to be dealt with during the present session was that of Electricity. Already Telegraphy had been brought forward by Mr. W. H. Preece, and Telephonic communication by Sir Frederick Bramwell.

Thus far Electricity had been introduced as the swift and subtle agency by which signals were produced either by mechanical means or by the human voice, and flashed almost instantaneously to distances which are limited, with regard to the former, by restrictions imposed ' the Globe. To Dr. Siemens has been assigned the task of introducing to their notice electric energy in a different aspect. Although still giving evidence of swiftness and precision, the effects he should dwell upon were no longer such as could be perceived only through the most delicate instruments human ingenuity could contrive, but were capable of rivalling the Steam Engine, compressed air, and the hydraulic accumulator, in the accomplishment of actual work.

In the early attempts at magneto-electric machines, it was shown that, so long as their effect depended upon the oxidation of zinc in a battery, no commercially useful results could have been anticipated. The thermo-battery, the discovery of Seebeck in 1822, was alluded to as a means of converting heat into electric energy in the most direct manner; but this conversion could not be an entire one, because the second law of thermodynamics, which prevented the realization as mechanical force of more than $\frac{1}{7}$th part of the heat energy produced in combustion under the boiler, applied equally to the thermo-electric battery, in which the heat, conducted from the hot points of juncture to the cold, constituted a formidable loss. The electromotive force of each thermo-electric element did not exceed 0.036 of a Volt, and 1,800 elements were therefore necessary to work an incandescent-lamp.

A most useful application of the thermo-electric battery for measuring radiant heat, the thermo-pile, was exhibited. By means of an ingenious modification of the Electrical Pyrometer, named the Bolometer, valuable researches in measuring solar radiations had been made by Professor Langley.

Faraday's great discovery of magneto-induction was next noticed, and the original instrument by which he had elicited the first electric spark before the members of the Royal Institution in 1831, was shown in operation. It was proved that although the individual current produced by magneto-induction was exceedingly small and momentary in action, it was capable of unlimited multiplication by mechanical arrangements of a simple kind, and that by such multiplication the powerful effects of the dynamo-machine of the present day were built up. One of the means for accomplishing such multiplication was the Siemens armature of 1856. Another step of importance was that involved in the Pacinotti ring, known in its practical application as the machine of Gramme. A third step, that of the self-exciting principle, was first communicated by Dr. Werner Siemens to the Berlin Academy, on the 17th January, 1867, and by the lecturer to the Royal Society on the 4th of the following month. This was read on the 14th of February, when the late Sir Charles Wheatstone also brought forward a Paper embodying the same principle. The lecturer's machine which was then exhibited, and which might be looked upon as the first of its kind, was shown in operation; it had done useful work for many years as a means of exciting steel magnets. A suggestion, contained in Sir Charles Wheatstone's Paper, that "a very remarkable increase of all the effects, accompanied by a diminution in the resistance of the machine, is observed when a cross wire is placed so as to divert a great portion of the current from the electro-magnet," and led the lecturer ' an investigation read before the Royal Society on the 4th of March, 1880, in which it was shown that by augmenting the resistance upon the electro-magnets 100-fold, valuable effects could be realized, as illustrated graphically by means of a diagram. The most important of these results consisted in this, that the electromotive force produced in a "shunt-wound machine," as it was called, increased with the external resistance whereby the great fluctuations formerly inseparable from electric-arc lighting could be obviated, and that, by the double means of exciting the electro-magnets, still greater uniformity of current was attainable.

The conditions upon which the working of a well conceived dynamo-machine must depend were next alluded to, and it was demonstrated that when losses by unnecessary wire-resistance, by Foucault-currents and by induced currents in the rotating armature were avoided, as much as 90 per cent, or even more, of the power communicated to the machine were realized in the form of electric energy, and that *vice versâ* the reconversion of electric into mechanical energy could be accomplished with similarly small loss. Thus, by means of two machines at a moderate distance apart, nearly 80 per cent. of the power imparted to the one machine could be again yielded in the mechanical form by the second, leaving out of consideration frictional losses, which latter need not be great considering that a dynamo-machine had only one moving part well balanced, and acted upon along its entire circumference by propelling force. Jacobi had proved, many years ago, that the maximum efficiency of a magneto-electric engine was obtained when

$$\frac{e}{E} \quad \frac{w}{W} = \frac{1}{2}$$

which law had been generally construed, by Verdet (Theorie Mechanique de la Chaleur) and others, to mean that one-half was the maximum theoretical efficiency obtainable in electric transmission of power, and that one-half of the current must be necessarily wasted or turned into heat. The lecturer could never be reconciled to a law necessitating such a waste of energy, and had maintained, without disputing the accuracy of Jacobi's law, that it had reference really to the condition of maximum work accomplished with a given machine whereas its efficiency must be governed by the equation

$$\frac{e}{E} \quad \frac{w}{W} \quad \text{nearly } 1$$

From this it followed that the maximum yield was obtained when two dynamo-machines (of similar construction) rotated nearly at the same speed, but that under these conditions the amount of force transmitted was a minimum. Practically the best condition of working consisted in giving to the primary machine such proportions as to produce a current of the same magnitude, but of 50 per cent. greater electro-motive force than the secondary; by adopting such an arrangement, as much as 50 per cent. of the power imparted to the primary could be practically received from the secondary machine at a distance of several miles. Professor Silvanus Thompson, in his recent Cantor Lectures, had shown an ingenious graphical method of proving these important fundamental laws.

The possibility of transmitting power electrically was so obvious that suggestions to that effect had been frequently made since the days of Volta, by Ritchie, Jacobi, Henry, Page, Hijorth and others; but it was only in recent years that such transmission had been rendered practically feasible.

Just six years ago, when delivering his presidential address to the Iron and Steel Institute, the lecturer had boldly suggested that "time will probably reveal to us effectual means of carrying power to great distances, but I cannot refrain from alluding to one which is, in my opinion, worthy of consideration, namely, the electrical conductor. Suppose water-power to be employed to give motion to a dynamo-electrical machine, a very powerful electrical current will be the result, which may be carried to a great distance, through a large metallic conductor, and then be made to impart motion to electro-magnetic engines, to ignore the carbon points of electric lamps, or to effect the separation of metals from their combinations. A copper rod 3 inches in diameter would be capable of transmitting 1,000 horse-power a distance of say 30 miles, an amount sufficient to supply one quarter of a million candle-power, which would suffice to illuminate a moderately sized town. This suggestion had been much criticised at the time, when it was still thought that electricity was incapable of being massed so as to deal with many horse-power of effect, and the sise of conductor he had proposed was also considered wholly inadequate. It would be interesting to test this early calculation by recent experience. Mr. Marcel Deprez had, it is well known, lately succeeded in transmitting as much as 3 H.P. to a distance of 40 kilometres (25 miles) through a pair of ordinary telegraph wires at 4^{mm} diameter. The results so obtained had been carefully noted by Mr. Tresca, and had been communicated a fortnight ago to the French Academy of Science. Taking the relative conductivity of iron wire employed by Deprez, and the 3-inch rod proposed by the lecturer, the amount of power that could be transmitted through the latter would be about 4,000 H.P. But Deprez had employed a motor-dynamo of 2,000 Volts, and was contented with a yield of 32 per cent. only of the power imparted to the primary machine, whereas he had calculated at the time upon an electro-motive force of 500 Volts, and upon a return of at least 40 per cent. of the energy imparted. He had been anxious, indeed, not to overstate the case, and if he were now asked what size of conductor he would recommend, he should say a 3-inch copper rod. In March, 1878, when delivering one of the Science Lectures at Glasgow, he said that a 2-inch rod could be made to accomplish the object proposed, because he had by that time conceived the possibility of employing a a current of at least 1,000 Volts. Sir William Thomson had at once accepted these views, and with the conceptive ingenuity peculiar to himself, had gone far beyond him, in showing before the Parliamentary Electric Light Committee of 1879, that through a copper wire of only ½-inch diameter, 21,000 H.P. might be conveyed to a distance of 300 miles with a current of an intensity of 80,000 Volts. The time might come when such a current could be dealt with, having a striking distance of about 2 feet in air, but then, probably, a very practical law enunciated by Sir William Thomson would be infringed. This was to the effect that electricity was conveyed at the cheapest rate through a conductor, the cost of which was such that the annual interest upon the money expended equalled the annual expenditure in producing the power to be conveyed. It appeared that Mr. Deprez had not followed this law in making his recent installations.

Sir William Armstrong was probably first to take practical advantage of these suggestions in lighting his house at Cragside during night time, and working his lathe and saw bench during the day, by power transmitted through a wire from a waterfall nearly a mile distant from his mansion. The lecturer had also accomplished the several objects of pumping water, cutting wood, hay, and swedes, of lighting his house, and of carrying on experiments in electro-horticulture from a common centre of steam power. The results had been most satisfactory. the whole of the management had been in the hands of a gardener and of labourers who were without previous knowledge of electricity, and the only repairs that had been found necessary were one renewal of the commutators, and an occasional change of metallic contact brushes.

An interesting application of electric transmission to cranes, by Dr. Hopkinson, was shown in operation.

Amongst the numerous other applications of the electrical transmission of power, that to electrical railways, first exhibited by Dr Werner Siemens, at the Berlin Exhibition of 1879, had created more than ordinary public attention. In it the current produced by a dynamo-machine, fixed at a convenient station and driven by a steam engine or other motor, was conveyed to a dynamo placed upon the moving car, through a central rail supported upon insulating-blocks of wood, the two working-rails serving to convey the return current. The line was 900 yards long, of 2-feet guage, and the moving car served its purpose of carrying twenty persons through the exhibition each trip. The success of this experiment soon led to the laying of the Lichterfelde line, in which both rails were placed upon insulating sleepers, so that the one served as the conveyance of the current from the power station to the moving car, and the other for completing the return circuit. This line had a guage of 3 feet 3 inches, was was 2,500 yards in length, and was worked by two dynamo-machines, developing an aggregate current of 9,000 Watts, equal to 12 H.P. It had now been in constant operation since the 16th of May, 1881, and had never failed in accomplishing its daily traffic. A line ½ a kilometer in length, but of 4 feet 8½ inch guage, was established by a lecturer at Paris in connection with the Electric Exhibition of 1881. In this case two suspended conductors in the form of hollow tubes with a longitudinal slit were adopted, the contact being made by metallic bolts drawn through these slit tubes, and connected with the dynamo-machine on the moving car by copper ropes passing through the roof. On this line 95,000 passengers were conveyed within the short period of three weeks.

An electric tramway, 6 miles in length, had just been completed, connecting Portrush with Bush Mills, in the north of Ireland, in the installation of which the lecturer was aided by Mr. Traill, as Engineer of the Company, by Mr. Alexander Siemens, and by Dr. E. Hopkinson, representing his firm. In this instance the two rails, 3 feet apart, were not insulated from the ground, but were joined electrically by means of copper staples and formed the return circuit, the current being conveyed to the car through a T iron placed upon short standards, and insulated by means of insulite caps. For the present the power was produced by a steam engine at Portrush, giving motion to a shunt-wound dynamo of 15,000 Watts 20 H.P., but arrangements were in progress to utilize a waterfall of ample power near Bush Mills, by means of three turbines of 10 H.P., each, now in course of erection. The working-speed of this line was restricted by the Board of Trade to 10 miles an hour, which was readily obtained, although the gradients of the line were decidedly unfavourable, including an incline of 2 miles in length at a gradient of 1 in 38. It was intended to extend the line 6 miles beyond

Bush Mills, in order to join it at Dervock station with the north of Ireland narrow-guage railway system.

The electric system of propulsion was, in the lecturer's opinion, sufficiently advanced to assure practical success under suitable circumstances —such as for suburban twramays, elevated lines, and above all lines through tunnels, such as the Metropolitan and District Railways. The advantages were that the weight of the engine so destructive of power and of the plant itself in starting and stopping, would be saved, and that perfect immunity from products of combustion would be insured. The limited experience at Lichterfelde, at Paris, and with another electric line of 765 yards in length, and 2 feet 2 inches guage, worked in connection with the Zaukerode Colliery since October, 1882, were extremely favourable to this mode of propulsion. The lecturer however did not advocate its prospective application in competition with the locomotive engine for main lines of railway. For tramways within populous districts, the insulated conductor involved a serious difficulty. It would be more advantageous under these circumstances to resort to secondary batteries, forming a store of electrical energy carried under the seats of the car itself, and working a dynamo-machine connected with the moving wheels by means of belts and chains.

The secondary battery was the only available means of propelling vessels by electrieal power and considering that these batteries might be made to serve the purpose of keel ballast, their weight, which was still considerable, would not be objectionable. The secondary battery was not an entirely new conception. The hydrogen gas battery suggested by Sir Wm. Grove in 1841, and which was shown in operation, realized in the most perfect manner the conception of storage, only that the power obtained from it was exceedingly slight. The lecturer, in working upon Sir William Grove's conception, had twenty-five years ago constructed a battery of considerable power in substituting porous carbon for plantinum, impregnating the same with a precipitate of lead peroxidized by a charging current. At that time little practical importance attached however to the subject, and even when Planté, in 1860, produced his secondary battery, composed of lead plates peroxidized by a charging current, little more than scientific curiosity was excited. It was only since the dynamo-machine had become an accomplished fact, that the importance of this mode of storing energy had become of practical importance, and great credit was due to Faure, to Sellon, and to Volckmar, for putting this valuable addition to practical science into available forms A question of great interest in connection with the secondary battery had reference to its permanence. A fear had been expressed by many that local action would soon destroy the fabric of which it was composed, and that the active surfaces would become coated with sulphate of lead preventing further action. It had, however, lately been proved in a paper read by Dr. Frankland before the Royal Society, corroborated by simultaneous investigations by Dr. Gladstone and Mr. Tribe, that the action of the secondary battery depended essentially upon the alternative composition and decomposition of sulphate of lead, which was therefore not an enemy, but the best friend to its continued action.

In conclusion, the lecturer referred to electric nomenclature, and to the means for measuring and recording the passage of electric energy. When he addressed the British Association at Southampton, he had ventured to suggest two electrical units additional to those addressed at the Electrical Congress in 1881, viz., the Watt and the Joule, in order to complete the chain of units connecting the electrical with mechanical energy and with the unit-quantity of heat. He was glad to find that this suggestion had met with favorable reception, especially that of the Watt, which was convenient for expressing in an intelligible manner the effective power of a dynamo-machine, and for giving a precise idea of the number of lights or effective power to be realized by its current, as well as of the engine power necessary to drive it. 746 Watts represented I H.P.

Finally, the Watt-meter, an instrument recently developed by this firm, was shown in operation. This consisted simply of a coil of thick conductor suspended by a torsion wire, and opposed laterally to a thick coil of wire of high resistance. The current to be measured flowed through both coils in parallel circuit, the one representing its quantity expressible in Ampères, and the other its potential expressible in Volts. Their joint attractive action expressed therefore Volt-Ampères or Watts, which were read off upon a scale of equal divisions.

The lecture was illustrated by experiments, and by numerous diagrams and tables of results. Measuring instruments by Professors Ayrton and Perry, by Mr. Edison and by Mr. Boys were also exhibited.

ABSTRACT OF MR. KENNEDY'S REPORT

ON THE DEEPENING OF THE SHIP CHANNEL BETWEEN MONTREAL AND QUEBEC AND THE DREDGING IN THE HARBOUR OF MONTREAL. (FIG. PAGE 108).

The places at which the largest quantities of work have been done during the year are: Cape la Roche, Lake St. Peter, Contrecœur Channel, and Pointe aux Trembles en haut.

The following are the chief details:

Cap la Roche.—At the close of 1881 a considerable part of the channel had been dredged to 20 feet, a small part to 23 feet 3 inches, and the remainder to an average of 22 feet at ordinary low water. During the past year the whole was deepened to an average of 22 feet and then passed over again to clear off loose shale and boulders, after which about three-fourths of the channel was tested to a clear depth of 21½ feet, and the remainder to a depth of 20 feet 9 inches at lowest water. The breadth of channel cut through the rock is 300 feet. At the lower end the boulders are cleared away on the south side so as to give a much wider entrance. Total shale rock and boulders lifted, 33,567 cubic yards, costing $32,314, or 96¼ cents per yard.

Lake St. Peter.—At the close of 1881, there remained to be dredged in the Lake about 1½ miles of the full breadth of the channel above No. 1 Light Ship, 1 8-10th miles of half the breadth just below No. 1 Light Ship, and 2 miles of of irregular cutting at No. 3 Light Ship and the Nicolet Traverse. The material in the shoals of the Traverse consisted almost entirely of sand and very tough clay, with many boulders, and the rock-working dredges were employed in its removal.

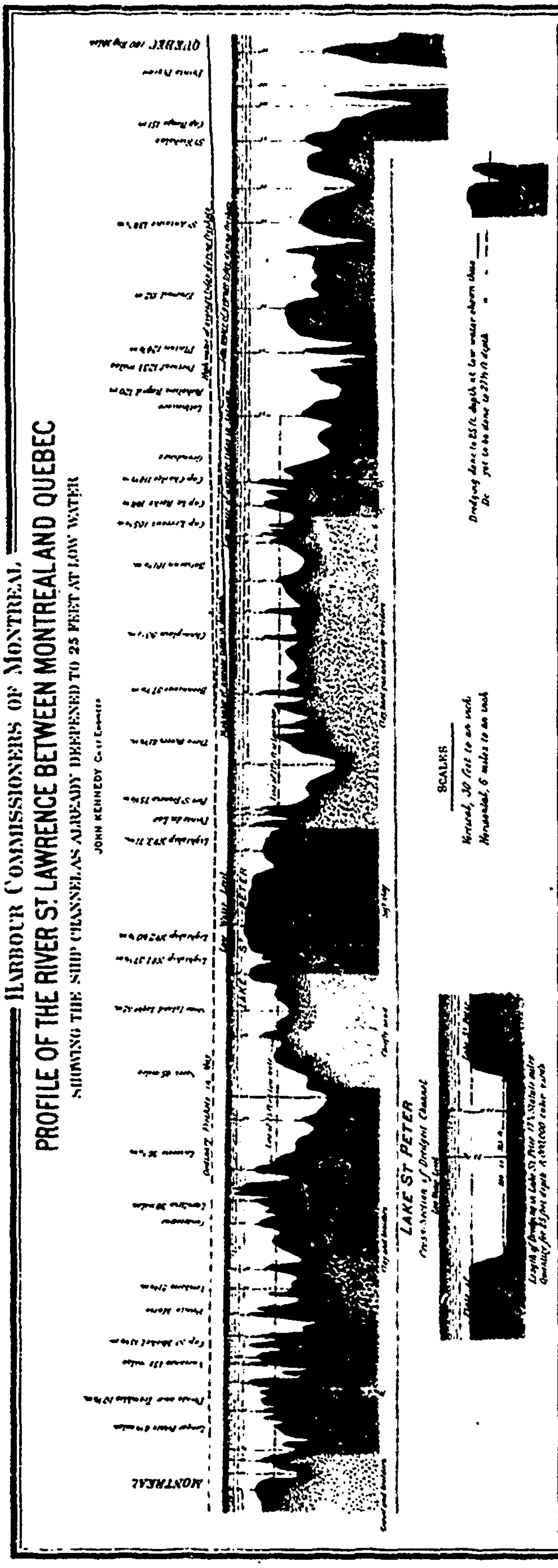
Dredging was commenced in the Lake at the opening of navigation with four dredges, and in order to push on as rapidly as possible, two of them were worked night and day up to the completion of the work in August. The extra expenses in preparation and in boarding the crews were very considerable, and on the other hand the weather proved so exceptionally stormy that the dredgers lost much time, and the work they accomplished was not greatly in excess of the rate of day work alone of ordinary years, so that the cost of that which was done was of course increased in inverse ratio.

The line of the finished channel is the same as that of the 20 ft. channel, with the exception of the bend at No. 3 Light Vessel and the line of the Nicolet Traverse, both of which were moved considerably to the north in order to economize work, and to secure more room for vessels which might be carried out of their course by cross currents. In the straight line above No. 1 Light-Ship and below the White Buoy, the breadth is 300 feet, in other straight parts above No. 3 Light-Ship it is 325 feet; in the Nicolet Traverse it is 450 feet, and at the bends connecting the straight lines it is generally 450 feet. In making the last cut for the 25 feet depth, the bottom of the long pools opposite Yamachiche and at No. 1 Light Ship was reached and their great value in reducing the quantity of dredging, and in furnishing safe anchorage and turning places for the largest vessels, will therefore not be available in future deepening.

The quantity dredged in the past year was 557,625 cubic yards, at a cost of $41,496, or an average of 7.44 cents per yard.

Contrecœur Channel.—The dredging has consisted largely of the removal of the tops of small isolated shoals and lumps found in testing and in cleaning up some places previously dredged. The breadth of the finished channel as it stands is 300 feet in the straight parts, and 450 feet at the bend in the middle of the main cut. The bend at the junction of the main cut with the wide water at the south side of the river is made by a curve of half a mile radius, but the currents are such thatit is felt to be too quick a turn for large vessels, and it is therefore much in need of being eased off to about one or 1¼ miles radius. Quantity dredged last year, 67,871 cubic yards, costing $11,886 or 17½ cents per yard.

Pointe aux-Trembles to *Longue Pointe.*—The dredged channel was extended up to deep water near Longue Pointe; the bend at the head of Ile Ste. Therese and the line of the Pointe-



aux-Trembles lights were finished, and the piece of rock dredging opposite the village was taken out and the channel generally was tested and completed. The minimum breadth in the straight dredging is 300 feet with an enlargement at the bend to 450 feet.

Quantity dredged, 102,074 cubic yards, clay and small boulders, costing $20,869, or 20.44 cents per yard, and 2,820 cubic yards rock and overhanging gravel and boulders costing $2,166, or 75.8 cents per yard.

Hochelaga.—Opposite the lower part of Hochelaga, or about a mile below the Hudon Cotton Mill, a neck of shoal, consisting entirely of large and small boulders, connects the shallow water of the north and south shores of the rivers, and through this a channel of 450 feet wide was made with dredges and stone lifters. Quantity of stones dredged and grappled 5,025 cubic yards, costing 6,620, or $1.31½ per yard.

Montreal.—The greater part of the main channel through the Harbour was tested and run over by dredges, and cleaned of boulders and small lumps. Quantity dredged, 80,912 cubic yards, costing $32,069, or 38.95 cents per yard.

Abstracts of the quantity dredged at each place and by each dredge, together with other information as to the work, will be found in the annexed tables.

COST OF DREDGING.—The cost of working the dredging plant for the past year has been increased over that of other recent years by further advances in the cost of labour, fuel and stores, and by night work on two of the dredges and their tugs. The quantity of work done in cubic yards is on the other hand much reduced from the fact that the dredging was for the most part merely cutting off tops of small isolated shoals, spread over great lengths at the margin of the larger shoals, which required that the dredge should pass over a large area of ground for sometimes only a few stones and scow loads of earth.

The total amount expended for the past year including repairs, outfit, fuel, wages, salaries, insurance, and every expense except interest and depreciation of plant, was, for the Ship Channel fleet proper, $151,223, and for the Montreal Harbour plant employed in the channel, $20,981, or in all $172,204. The quantities dredged are 861,837 cubic yards earth, etc., and 47,398 cubic yards rock and boulders, making an aggregate of 899,235 cubic yards.

The measurement of the quantity dredged is by tally of the scows, which, when filled level, hold 80 to 150 cubic yards, for the ordinary and large sizes respectively, but are reckoned at 60 and 120 cubic yards each, to allow for imperfect filling.

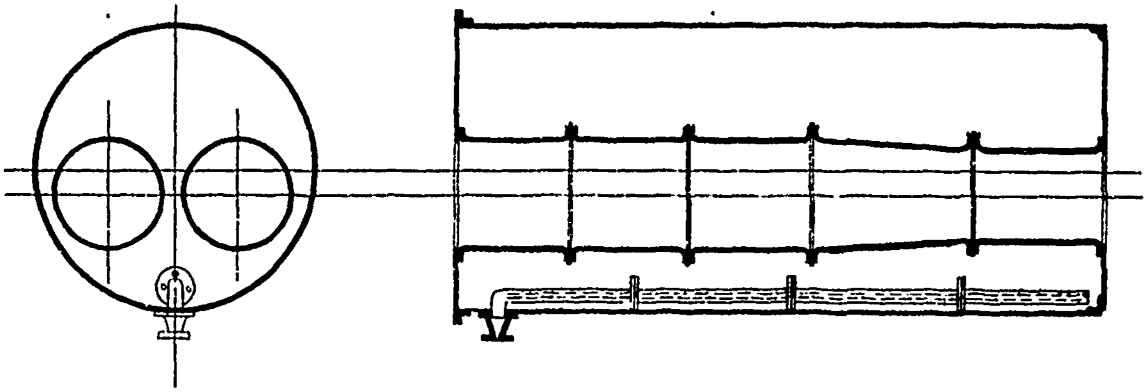
DREDGING PLANT.—The working plant employed consisted of the following essels:

Three Elevator Dredges for working rock..Nos. 10, 11 & 13.
Two " " for earth, &c..Nos. 3 & 9, small buckets.
Two " " " " ..Nos. 8 & 12, large buckets.
Three to four Spoon Dredges, during part of season.
One side-wheel Tug.
Eight to ten Screw Tugs.
Two stone-lifting Barges..............................Nos. 1 and 2.
Five Barges (coal tenders and smiths' shops.)
One boat for boarding night crews.
Eighteen hopper bottom scows.
Three to eight flat scows.

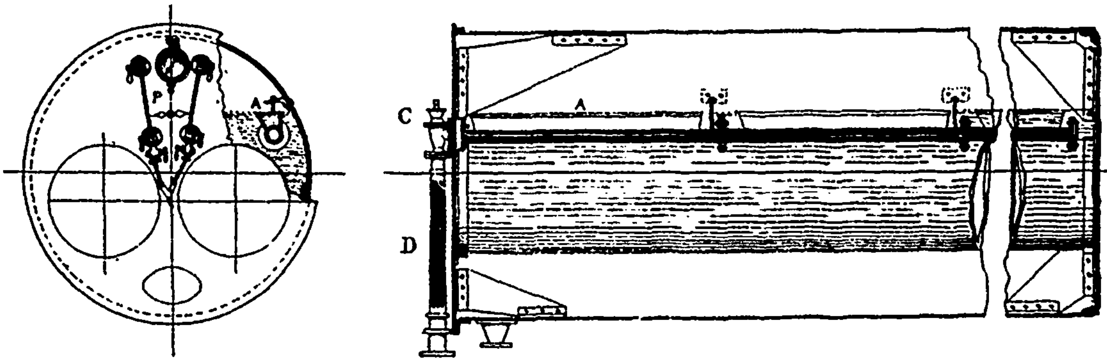
The elevator dredges, which constitute the Ship Channel fleet proper, commenced work at dates between April 19th and 24th, and continued work until dates between November 18th and 30th. Dredges 8 and 12, and stone-lifter No. 2, to expedite the work, were worked night and day from 29th April to 10th August, and from 15th May to 23rd September respectively, and the remainder of the plant was, as usual, worked during day only.

The number of days on duty, reckoning all except Sundays, from the date of leaving winter quarters to that of returning, and counting a night and a day on the night and day dredges as two days, was 180 to 191 days for the dredges which worked in day-time only, and 280 and 286 days for the two which worked for day and night; and the aggregate for the whole seven during the season was 1,504 days, or an average of 214 6-7th days each.

The nominal working hours during the long days of summer are 12 hours for the day dredges, and 11 hours per shift for the night and day dredges; but the actual dredging time is reduced by short days in autumn, early stoppages on Saturdays, time lost in storms, changing positions, accidents, repairs and delays of all kinds, so that the time during which the dredges were actually dredging was 10,339 hours, or an average of 6¾ hours per day for the whole season.



Sketch Showing Longitudinal Internal Pipe Connected to Blow-off Tap.



Sketch Showing Scum Apparatus.

RECOMMENDATIONS WITH REGARD TO TREATMENT OF SCALE AND DEPOSITS IN BOILERS.

By John Waugh.

A pure feed supply (not distilled) would *per se* insure clean internal surfaces, with, of course, a corresponding economy in the amount of fuel consumed, and the saving of Boiler cleaning, the cost of which is a secondary consideration.

This desideratum is, in some cases, not to be had; in others it is deemed too costly when a plentiful supply of an inferior kind is to be had for the raising, or from the adjacent streams.

In nineteen bad feed waters out of twenty, soda is the best neutralizing agent, and if properly applied, will not only assist in the removal of the scale already formed but will prevent its accumulating to any very injurious extent. It is in this latter capacity that common soda is the most efficacious.

The description of soda used is generally the washing crystal, and soda ash. Caustic soda should not be introduced into any boiler whilst at work and under the working pressure, but its application is invaluable where the water can be allowed to evaporate from the manhole for a week or longer before letting off for cleaning purposes; it is much more costly than common soda, but may be purchased wholesale for about 2d. per lb.

Where simple soda is used, it frequently happens that the soda is put in injudiciously, little or no benefit being derived from its use; in this way—After "boiler cleaning," a bucketful or two is thrown in before screwing down the manhole cover. After one day's working, the whole, or most of the soda put in, has passed away with the steam, or evaporated, having had very little time to do its work of dissolving the incrustation; this method has also an injurious effect on the cylinder and valve faces—the soda "eating up" the tallow and other lubricants, leaving the surfaces dry. In such cases the soda solution is too strong.

A method which has been adopted by many firms, for the prevention and removal of incrustation and which has been attended with very beneficial and satisfactory results, is as follows:—An injector, or, better still, a donkey pump, attached to a small tank or vessel, containing some 50 or 60 gallons of water (in which to mix and dissolve the soda) is laid down; when the soda is thoroughly dissolved in the tank it is injected into the boiler, after the engine has been stopped for the day, and when evaporation has ceased. During the night the soda is surely and slowly doing its beneficial work. In the morning, before anything is disturbed, (rousing the fires up, starting the engine, &c.) and before circulation has commenced, the blow out tap should be opened, and the water level in the boiler lowered ½ to ¾. This should be perseveringly attended to *daily*.

In Lancashire two flued, or other double furnaced boilers, an internal blow-off pipe 2 to 2½ inches diameter of *wrought iron*, is fitted, with manifest advantage, the whole length of the boiler. There should be perforations or slots on the under side, next the shell bottom $\frac{5}{16}$ to ⅜ broad; in the blow-out orifice a wrought iron bend or elbow pipe is inserted coupled or jointed to the longitudinal internal pipe. When made up with scale or deposit, the whole pipe can be drawn out through the mud-hole door, and thoroughly cleaned, which may be done by placing over a fire. For this reason wrought-iron is superior to cast-iron for an internal pipe, as with the latter metal, the scale can only be removed from the inside by boring. (*See sketch.*)

The quantity of soda to be put in varies with the size of boiler; 5 lbs. daily being sufficient for a boiler 28″0 by 7″0. This may be increased with boilers fed with corrosive water, the soda neutralizing the acids contained in the supply. Where Economisers are fitted the solution of soda should be passed through, and the blow-off tap, usually fitted, regularly used once or twice daily. The use of Scummer and the boiler blow-off taps should be left to the engineer in charge, being operations requiring greater care and caution than is usually supposed.

Soda is found after years of practical experience and observation to quite supersede any "celebrated anti-incrustator" and "Boiler Composition," and is more effective and reliable, much cheaper, and quite harmless to any boiler plate. "Boiler Composition," which answers well with some water, would aggravate an existing evil in others.

Blow-out taps are frequently met with which are from a variety of causes, inoperative and unsafe to use when steam is up. Amongst other defects is the absence of waste pipes and taps, connections to drains, in many cases made of two different metals, which after being opened, are liable to stick fast, from unequal expansion. Such taps should be replaced by modern brass plug taps—and regularly used.

A good Scummer is a valuable appendage to all Boilers fed with greasy or muddy water, from which deposits form rapidly on the plates to the serious detriment and efficiency of the Boiler. A sketch of this apparatus is shewn on page 109 and the following is an explanation of its action.

(A) is a trough passing along the entire length of Boiler on one side at the water level. When the water is at the level indicated by the fixed pointer (P) in front of the Boiler, the water is just over the trough, thus, by opening cock (C) the entire surface of the water is scummed, and is passed through down-pipe (D) to drain, ridding the Boiler of much that otherwise would settle and form a deposit upon the crown of furnaces and bottom of shell, impeding the free passage of heat and involving much labour in removal.

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BASIC FURNACE LININGS.

It appears, from a recent paper issued by Junghaug and Uelsmann, in *Dingler's Polytechnisches Journal*, that soda and potash carbonates are used instead of the corresponding chlorides of those metals, and that the durability of the lining is said to be increased by the addition of cryolite. The following modification of the usual method of preparing the lining has been found to answer admirably. The raw or calcined masses of lime, dolomite, or magnesite are ground and mixed with the flux; the mixture is then burnt to dust and worked up into bricks, the dust being rendered plastic with tar treated with 3 per cent of flux. When the flux is made up of alkaline carbonates, ground calcined phosphate or bone-black, with the addition of a few per cent of the alkaline carbonates, are used in the preparation of basic bricks, muffles, &c. André states that the basic masses are to be burnt at a high temperature, then pounded and ground, and the powder thus obtained is formed into bricks by the addition of freshly prepared lime sulphate. Two per cent of the lime sulphate suffices to form a plastic material. Borsig proposes to mix dolomitic limestone, either in a crude, calcined, or finely divided form, with from 2 to 2·5 per cent of crude boracic acid, or 3 per cent of fused and pounded borax. The mixture is used in a dry or wet condition for lining furnaces or for the preparation of bricks.

According to the Society of Mines of Horde, and the Rhenish Steel Works at Ruhrort, limestone, free from magnesia, containing not more than from 15 to 20 per cent of silicic acid, alumina, iron oxide, and manganese oxide may be used for the preparation of basic linings. The quantity of iron oxide present should not exceed 6 per cent. It was, further, found that phosphorus can be got away in the slag without the after blow, by the use of fluor-spar equivalent to one-tenth part of the tribasic lime phosphate formed. Instead of fluor spar, alkalies, alkaline earths, or cryolite may be used. The dephosphorization is also effected by blowing air into a reverberatory furnace having a basic hearth. Immediately before the introduction of the metal into the converter lined with basic bricks, it is recommended to add lime or a mixture of eight parts of lime and one of ferric oxide. The mass is heated and air blown in for from six to ten minutes, when the converter is emptied, and the metal treated with a mixture of from two to three parts of lime and one part of ferric oxide free from silicic acid. The quantity of flux in the first blowing amounts to twice the weight of silicium and phosphorus contained in the original charge while the quantity used in the second operation depends on the durability of the converter. The object of the addition of the second flux is to obtain a slag containing more than 36 per cent of lime and magnesia. The basic flux may be replaced partially or wholly by manganese ores, cryolite, fluor spar, and caustic or carbonated alkalies, while phosphorite or bone-black, mixed with clay or asphalt, is used as a lining. After the decarburation of the iron bath the exoxidation of the remaining phosphorus is effected by the introduction of oxidizing agents, as ferric and manganic oxcides, into the iron. This operation takes the place of the after-blow.

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PILE DRIVING BY DYNAMITE.

In the course of executing some municipal works at Buda-Pesth, the piles already driven were required to stand a greater load than had been originally contemplated. It was, therefore, necessary to test them, and drive still deeper those that yielded. On account of the expense of bringing a pile-driving machine successively over each pile for so little work, it was determined to try the effect of dynamite; and the city engineers applied to Colonel Prodanovic, of the Second Regiment of Austrian Engineers, to carry out the experiments.

According to the *Wochenschrift des Oesterreichischen Ingenieur und Architekten Vereins*, the piles were cut square, and a wrought-iron plate, 15 inches in diameter and 4⅝ inches thick, was placed on the top of each. On its centre, and immediately over that of the pile, was placed a charge of No. 2 dynamite, in the form of a cake, 6 inches in diameter and three-fourths inch thick, and weiging 17½ ounces avoirdupois. This was wrapped in parchment paper, covered with clay, and fired. The effect produced was found on an average to be equal to five blows from a 14¾-cwt. monkey falling from a height of 9 feet 10 inches. The iron plates stood from twenty to twenty-four explosions. The system is not considered applicable to a pile standing considerably out of the ground, but saves a great expense when piles already driven have to be sunk deeper. In this country gunpowder has been used for many years, particularly in Philadelphia, for pile driving, though employed generally to drive the monkey upward.—*Ex.*

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The Best Material for Joists.—It is claimed by many builders that wood joists, encased in plaster, are proof against any ordinary fire, and for many reasons are much preferred by them to the ordinary regulation fire proof iron joists. Strips are attached to the joists, over these strips iron are run, and on these the plaster is spread. The theory is that in any ordinary fire these joists thus treated will be fire proof, and only when the fire has reached such a fury that the building must go anyway will they be affected. Here comes in one of the advantages claimed for them. When a building is being burned by a furious fire the iron joists expand and crush out the walls, and do other damage. The wood joists would simply be burned up without injuring the walls at all.—*Lumberman.*

Preservation of Railway Ties.—A few interesting facts are published in the English journals, shewing the relative value of different methods of injecting railway ties. Upon the road from Hanover and Cologne to Minden, *fir* ties injected with chloride of zinc required a renewal of 21 per cent. in *eleven* years; *birch* ties injected with creosote required a renewal of 46 per cent. at the end of *twenty-two* years; *oak* ties injected with chloride of zinc required a renewal of about 21 per cent at the end of *seventeen* years; while the same kind of ties in their natural state required a renewal of at least 49 per cent. at the end of a like period. The conditions in each of these cases were very favourable for obtaining reliable proofs; the sub-soil of the road was good; the non-renewed ties shewed, when cut, that they were in a sufficiently good state of preservation.

Upon another line where the oak ties were not injected, it was necessary to renew the ties in the proportion of 74 per cent. at the end of *twelve* years; these same ties injected with chloride of zinc required a renewal of only 3·29 per cent. at the end of *seven* years, while such ties injected with creosote required a renewal of only 0·09 per cent. at the end of six years.

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A TUNNEL WHICH IS NOT A TUNNEL.

The curious phenomena of a tunnel so filling itself up as to resist all efforts to open it is reported from Virginia, Nevada. In Castle District, at a point about five miles north of that city, is a tunnel that may be called an ex-tunnel. It is a tunnel that remonstrates against being a tunnel. It was run about four years ago into the side of a steep hill, and was originally about forty feet in length. When in about fifteen feet, the tunnel cut into a soft, swelling clay, very difficult to man-age. After timbering and striving against the queer, spongy material until it had been penetrated some twenty-five feet, the miners gave up the fight, as they found it a losing game. Being left to its own devices, the tunnel proceeded to repair damages. It very plainly showed that it resented the whole business, as its first move was to push out all the timbers and dump them down the hill. It did not stop at that, but projected from the mouth of the tunnel a pith or stopper of clay the full size of the excavation. This came out horizontally some eight feet, as though to look about and see what had become of the miners, when it broke off and rolled down the slope. In this way it has been going on until there are hundreds of tons of clay at the foot of the hill. At first it required only about a week for a plug to come out and break off, then a month, and so on, till now the masses are ejected but three or four times a year, yet the motion continues, and to-day the tunnel has the better of the fight by about four feet.—*Ex.*

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New Method of Coupling Cars.—An invention for coupling and uncoupling railroad cars which seems likely to prevent the waste of life and limb now involved in carrying on railway work, was recently on exhibition in New York City. By the new method the coupling of cars is entirely automatic —they meet and are locked by their own motion. Uncoupling is done by a lever worked from the top of a freight car or from the side of a passenger car, and is effected in a moment. There is no need for any person to pass or stand between the cars, where so many have been crushed to death. Instead of the loose links, bolts and chains so generally used, there is a stout hook sliding into a socket, where it is caught by a crosspiece. This crosspiece is raised or lowered by a simple movement of the lever, and the cars thus coupled or separated at will. One or more cars may be dropped at any station, or left at a flying switch, without stopping or even slowing the train.

Improvement in Chimneys.—An American contemporary remarks · The best chimneys are made by inclosing hard baked glazed pipe in a thin wall of bricks. Such chimneys will not only draw better than those made in the usual way, but there will be less danger from "defective flues." A four inch wall of bricks between us and destruction by fire is a frail barrier, especially if the work is carelessly done or the mortar has crumbled from the joints. To build the chimneys with double or eight inch walls makes them very large, more expensive, and still not as good as when they contain the smooth round flues. To leave an air chamber between them for ventilating, is better than to open directly into the smoke flue, because it will not impair the draught for the fire, and there will be no danger of a sooty odour in the room when the circulation happens to be downward, as it will be occasionally. The outside chimney, if there is one, should have an extra air chamber between the very outer wall and the back of the fireplace to save heat, a precaution that removes to a great extent the common objection to such chimneys. A very large per cent. of fires comes from defective chimneys.

Wind Pressures.—It may interest some of our readers to know that the maximum force recorded during recent storms by our wind pressure plates at the Forth has been 20 lbs. per sq. ft., upon the small and light plate having an area of 2 sq. ft., and 12½ lbs. upon the large and heavy one, with an area of 300 sq. feet. The same ratio holds good down to pressures of 2 lbs. per square foot, and it appears pretty certain that the higher blasts are of such momentary duration and of such unequal distribution, that even a small sized railway bridge could never experience ordinary anemometer pressures. Other reasons for a reduced pressure on a large surface have been advanced by Dr. Siemens in a recent number of the *Comptes Rendus*. Nevertheless, in this instance of the Forth bridge we have assumed that a 56 lbs. hurricane will act simultaneously over the whole width of the Forth, with a resultant lateral pressure of no less than 8,000 tons upon the main spans. We have further assumed that the said hurricane might blow down one side of the Forth, while a dead calm prevailed on the other side, and have even provided for the twisting action upon the piers and superstructure due to a 56 lbs. hurricane blowing *up* the Forth one side, and *down* it on the other. To ascertain what lateral pressure a 56 lbs. hurricane would cause, we tested, both in air and in water currents, a large model of the bridge, with cross-bracing complete, and ascertained its equivalent in square feet of flat surface. Under any of the conditions of wind pressure enumerated above, combined with any distribution of the rolling load, the resultant stresses up superstructure, holding down bolts and piers will be far within the safe working limits as determined by our experiments upon the respective materials.—B. Baker in *Nature*.

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THE HEAT OF THE SUN.

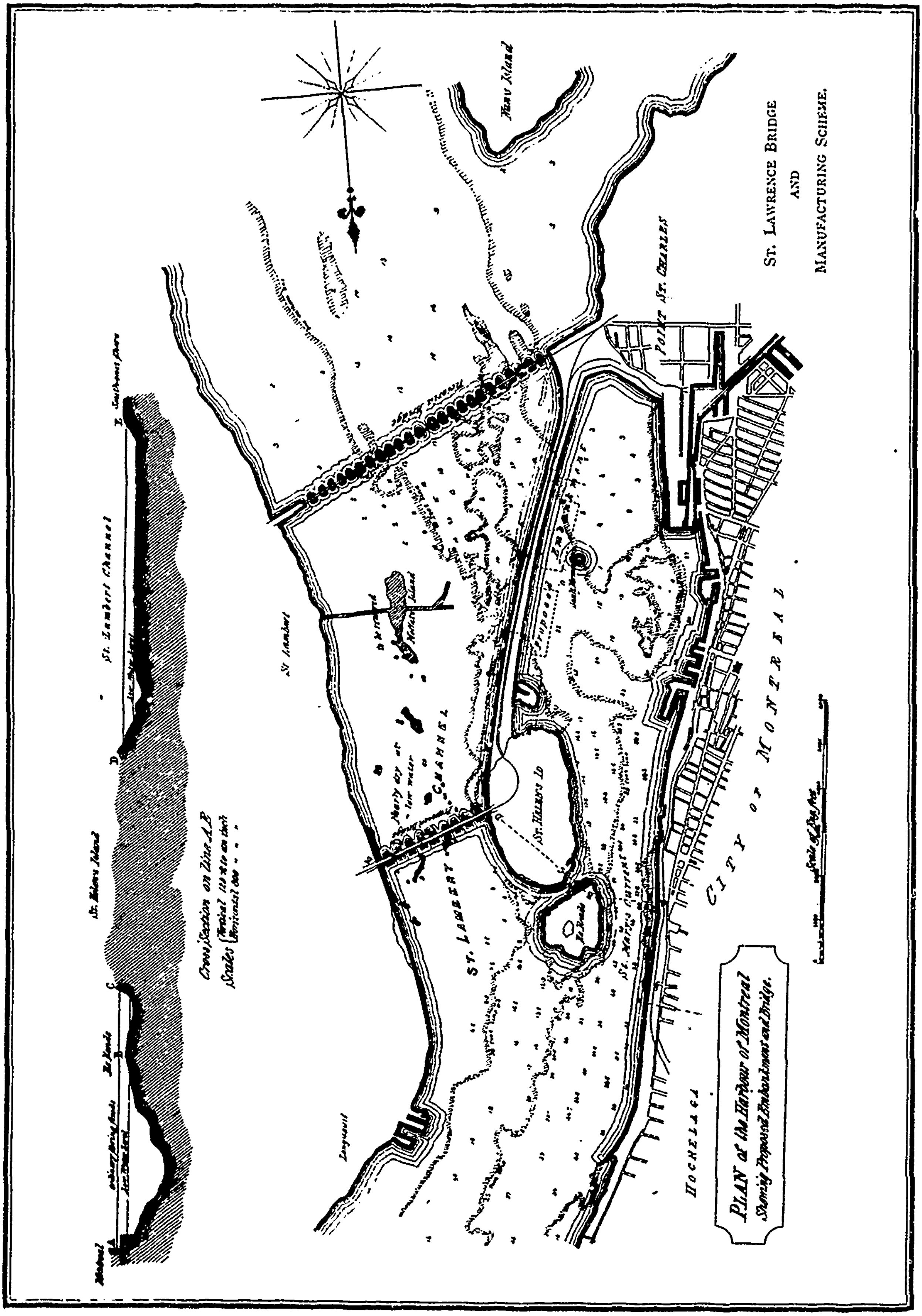
BY ERNEST H. COOK, B.SC. (LOND.), F.C.S.

When we consider the magnificence and beauty which under favourable conditions of the atmosphere the heavenly bodies exhibit, it is a matter of no surprise that the most brilliant and grandest of them all should have attracted and rivetted the attention of the earliest philosophers. Accordingly we find in the very first pages of the world's written history under the influence of an eastern sun, that those Chaldean Shepherd Astronomers speculated as to the constitution and position of the central luminary. As soon as the enormous distance of the sun was established and approximately fixed, speculations began to be made to attempt to account for the source of the enormous amount of heat which is given out by the sun. The first and most unscientific of these theories of the sun's heat, that of combustion, was propounded before any actual experiments had been made as to the exact amount of heat which is constantly given out. Thus attempting to explain and account for something which was not known, it is not to be wondered at that subsequent discovery and investigation have shown the utter inadequateness of this first assigned cause of the sun's heat.

Before we state and examine the various theories it is necessary for us to thoroughly understand and appreciate the vastness of the action we have to account for.

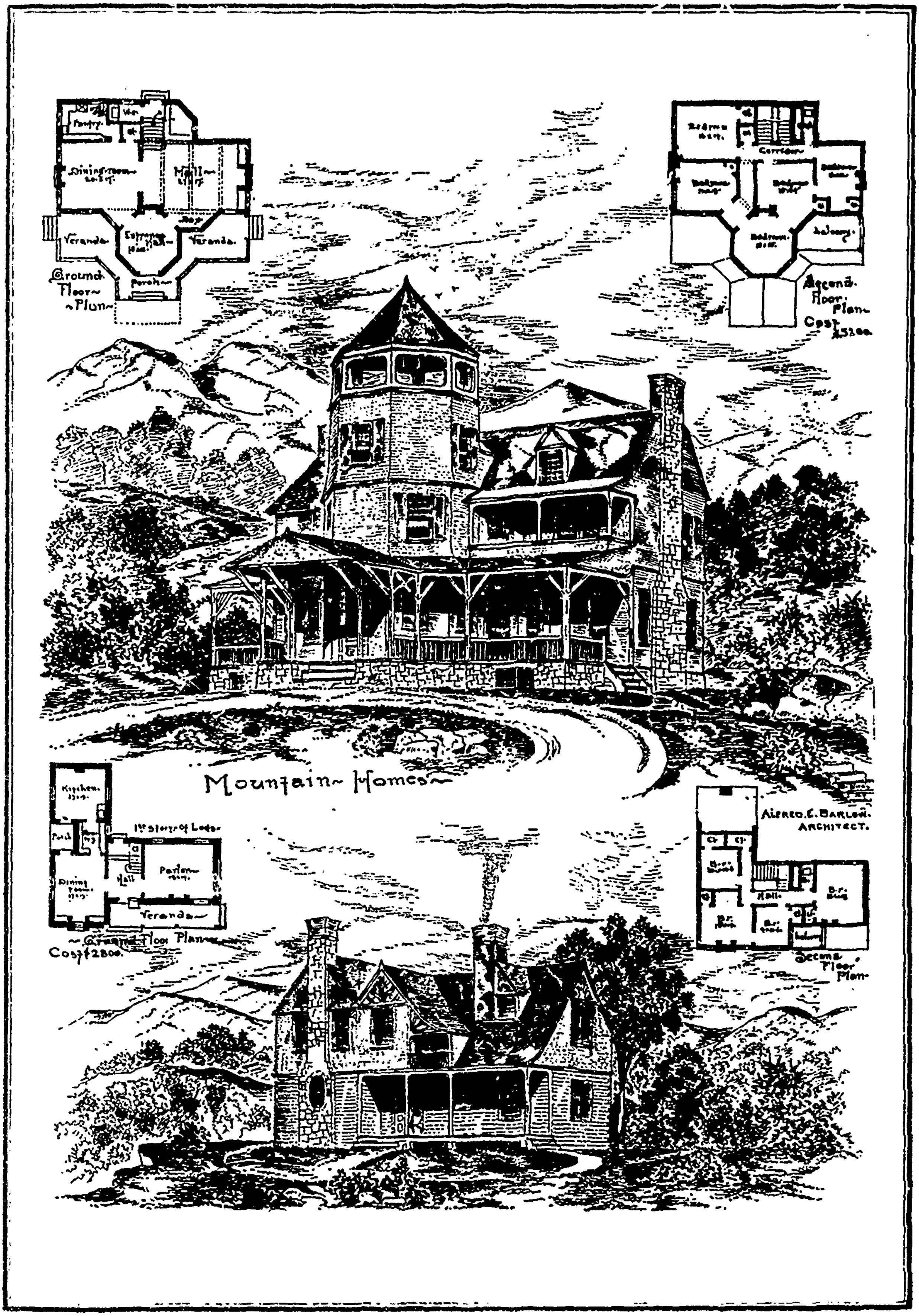
The distance which separates us from the sun has been determined with very great accuracy because of its importance to astronomers, this distance forming their unit of length. With tolerable accuracy we may take this as equal to 92,000,000 of miles. Although this distance is infinitely small when compared with the distance of many of the stars which are familiar to astronomers, it is yet so great compared with our ideas of distance that we can form no conception, of it however remote. Fortunately, however, we are now dealing, not with conceptions and imaginings, but with bare and unvarnished facts. Knowing the distance, knowing also the apparent magnitude, *i.e*, the observed diameter of the sun, it is easy to calculate his real diameter. This has been found to be approximately given by 880,000 miles. These distances being determined and the fact established that the planets revolve round the sun, it follows that there must be some force pulling these planets, emanating from the sun, which causes them to revolve around it. This force we know to be that of gravitation. Again the period which it takes the earth to revolve around the sun is given by the length of what is called a mean solar year. It is also known that the length of this mean solar year has not altered during the period of recorded astronomical observations.

It therefore follows that the force pulling the earth and keeping it in its orbit is just sufficient to do so and no more. For if the sun's force acting upon the earth were more than just sufficient to do this, the year would be gradually diminishing in length by an amount which would be proportionate to this excess of



ST. LAWRENCE BRIDGE AND MANUFACTURING SCHEME.

PLAN of the Harbour of Montreal Shewing Proposed Embankment and Bridge.


Pantry
Dining-room
Hall
Bay
Veranda
Entrance Hall
Veranda
Porch
Ground Floor Plan
Bedroom
Corridor
Bedroom
Bedroom
Bedroom
Bedroom
Balcony
Second Floor Plan
Cost $3200
Mountain Homes
Kitchen
Porch
Dining room
Hall
Parlor
1st Story of Lodge
Veranda
Ground Floor Plan
Cost $2800
Alfred E. Barlow. Architect.
Cl.
Cl.
Hall
B.R.
B.R.
B.R.
B.R.
Balcony
Second Floor Plan

force. In short the earth would be gradually approaching the sun. If, on the contrary the force were less than just sufficient to do this, the year would be gradually increasing in length, in short we should be receding from the sun. Observations extending over a great number of years prove that neither of these things is occurring. Now if we know the mass of a body which is moving in a certain orbit, if we know the radius of that orbit and also the velocity with which the body is moving, we can find by employing a formula well known to scientific men the force which is emanating from the centre, and which is just able to keep the body from moving out of that orbit. Calculating in this manner it has been deduced that the attraction which the sun exerts upon our globe is equal to that which would be exerted supposing it to consist of 360,000 earths rolled into one. Now we have just seen that the diameter of the sun is 880,000 miles, that of the earth is 8 000, thus the sun's diameter is about 110 times greater. The bulk or cubic capacity of the sun is therefore the cube of 110, or 1,331,000 times that of the earth. But the mass, calculated from the attraction which it exerts is only 360,000 times greater, consequently the materials of which the sun is composed must be much lighter than those which compose our earth. Speaking accurately and scientifically we should say that if the density of the earth be taken as unity that of the sun is only .250, or if. as experiment shows the specific gravity of the earth is equal to 5·2, then that of the sun is equal to 1·3. Having now fixed some of the physical constants of the centre of our planetary system, we have now to determine the amount of heat which is given out. In the first place, it is evident that we who live upon the earth must necessarily make our observations upon the earth, it is thus important that we should know what fraction of the total amount of heat emitted by the sun is absorbed by the earth. The radius of the earth's orbit, we have already seen, may be taken at 92,000,000 miles, the circumference of the approximate circle which is described around the sun is thus equal to 314,157 × 92,000,000 × 2 or about 578,000,000 miles. The diameter of the earth is about 8,000 miles consequently the earth occupies about the 73,000th part of the circumference of the approximate circle which it describes around the sun. But this refers only to one plane. Taking the area of the hollow shell surrounding the sun, at a distance of 92,000,000 miles as equal to 115,000,000,000,000,000 square miles and taking the earth as a flat plane 8,000 miles in diameter or 50,000,000 square miles in area, we find that the earth intercepts the 2,300,000,000th part of the total heat emitted by the sun. If then we find the quantity of heat received by the earth and multiply it by this last number, we shall obtain the actual amount of heat given out by the sun. By allowing the rays from the sun to fall perpendicularly upon a surface which is capable of warming a known quantity of mercury the heating power of the sun has been determined. Two series of observations on this point have been made, one at Paris by M. Pouillet with his pyrheliometer, and the other at the Cape of Good Hope by Sir John Herschell with his actinometer. The results are concordant and they give that the amount of heat received by the earth in one year would be capable of liquefying a layer of ice entirely surrounding the earth to a depth of a 100 feet. This then is the amount of heat which falls upon an area of 50,000,000 square miles, multiplying this by 2,300,000,000 we obtain the total amount of heat emitted by the sun. In speaking of the distance of the sun it was stated that we could form no idea of the vastness of the distance which separated us from him. And if it is impossible to form an idea of the distance it is also equally impossible to form an idea of the immense heat which he possesses. The highest temperatures which we can obtain are so cold compared to his temperature, that the comparison between an Arctic winter and an Equatorial summer is quite inadequate to represent the difference. Thus Prof. Tyndall says: —"The heat emitted by the sun, if used to melt a stratum of ice applied to the sun's surface, would liquefy it at the rate of 2,400 feet an hour. It would boil per hour 700,000 millions of cubic miles of ice-cold water." Another eminent writer upon this subject Sir John Herschell, says, "that the heat thrown out from *every square yard of the sun's surface* is equal to that which would be produced by burning on that square yard six tons of coal per hour. and keeping up constantly to that rate of consumption. And this, mind on each individual square yard of that enormous surface, which is 12,000 times that of the whole earth." In attempting to bring the imagination to to grasp such enormous numbers and statements, we are attempting a hopeless task, it recoils from such immensity much as a billiard ball recoils from the cushion upon which it strikes. But although thus unable to appreciate such facts the reasoning powers of many (I may perhaps say most) scientific men have from time to time employed themselves for the purpose of seeking a *cause*, which shall be a sufficient and a possible one, to account for the enormous expenditure of power an expenditure be it remembered which has been going on at least during historic times without the slightest diminution.

The theories which have been proposed from time to time, we will now examine taking them in order of their age, and impartially examine each.

THE COMBUSTION THEORY.

This is the oldest, simplest, and most unscientific of the whole. It cannot be ascribed to any author, and in fact it is probable that most thinkers upon the subject upon a first and superficial examination would propound such an explanation. Shortly expressed it says, that the sun is a fire, differing only from our terrestrial fires in magnitude and in the intensity of its combustion. Now as the substance which we use most extensively and which gives us more heat than any other common substance is carbon, it has been suggested that the sun consists of a mass of carbon in an active state of combustion. This then, is the first crude idea which was held respecting the combustion of the sun.

Before we allow ourselves to wonder at the authors for proposing so unsatisfactory an explanation, we must bear in mind the "nature of the environment" if I may so call it, in which they were placed. In the first place the distance of the sun was not thought so immense as it is now proved to be; secondly, the age of the earth was not considered so great as at present, consequently a less powerful cause had to be found;

and thirdly those wonderful discoveries of the spectroscope which have revealed to us the physical construction of the sun had not been made.

Now in order that combustion as we term it should go on there must be some substance with which the combustible body can combine. Here on our earth this body is known to be oxygen, and it is supposed that the same body exists in the sun, and by its combination with the carbon produces the heat which we find given out.

Again we know that one pound of pure carbon in burning so as to produce the greatest amount of heat combines with $2\frac{2}{3}$ lbs. of oxygen. Also one cubic mile of pure oxygen will weigh about 13,189,120,000 lbs. Also on every square yard of the sun's surface there is given out as much heat as would be produced by the burning of 6 tons of carbon per hour. (Herschell) Six tons of carbon will require 35,840 lbs. of oxygen, and such an amount of oxygen would be contained in a column one square yard base and 14,336 yards high. Thus in every hour the sun uses up a column of pure oxygen 8.3 miles high and of the density of the gas at the average atmospheric pressure here on the earth. But the attraction of the sun upon any body placed near it, is, in consequence of its mass very nearly thirty times as great as the attraction of the earth upon the same body.

We will thus reduce the height of this column this number of times and thus obtain that every hour there is used up a shell of about $\frac{3}{10}$ of a mile thick around the sun of pure oxygen. (This difference in attractive power is only mentioned to guard against misrepresentation and for the purpose of making the latter part of the argument more conclusive. The immense heat of the sun would probably expand gaseous bodies so much as to counterbalance the effect of the increase of gravitation. Moreover as we recede from the sun, the attractive force diminishes according to the well known law of the square of the distance). But if this is the amount used up in one hour it is easy to calculate the amount used up in any number of hours or years. We thus find that in 5,000 years the height of the atmosphere of pure oxygen consumed would be 13,240,000 miles high *assuming* the density, the same as that which it would have *at the surface of the sun.* If however we consider that, as pure oxygen is a most unlikely substance to exist in such quantity; that the solar atmosphere consists of the same materials as the terrestrial one, in fact that it is only part of the universal atmosphere :—an assumption which has been made and which is highly probable—then the height of the atmosphere required for a period of 5,000 years becomes 66,200,000 miles. This distance is much greater than the distance of the planet Mercury, and is about equal to that of Venus, from the Sun.

We therefore see that examining the theory in this way (which the author believes to be a novel one) we are called upon to assume the existence of a solar atmosphere extending up to the planet Venus and possessing a density thirty times as great as that of the earth at the sea level. And this immense volume is required for the comparatively short period of 5,000 years. Taking Croll's estimate of the age of the earth as 20,000,000 of years we must extend the atmosphere about 100 times as far as the orbit in which the most remote member of the planetary system revolves. It is needless to say that such a state of things is impossible, for the retardation which the planets would suffer would most assuredly have been discovered long before this ; and it is probable that owing to such retardation one or more of them would ere now have fallen into the sun.

I have selected this method of viewing the combustion theory because the conclusions drawn from it are so obviously impossible. It can however easily be shown that at the rate of burning necessary, a block of carbon of the size of the sun would be burnt out in about 5,000 years. We can also ask what becomes of the products of combustion ? Where is the carbonic anhydride stored away ? These and other questions, impossible to answer compel us to at once put aside the combustion theory as not only untenable, but impossible.

Many modifications (if we may so call them) of this theory have been proposed but they all fail to afford an adequate cause. Thus the suggestion has been made that the oxygen needed for combustion may be supplied from the material of the sun itself ; just as gun powder is supplied with oxygen from the nitre it contains. But even supposing him to consist of gun cotton, the substance which is better supplied with oxygen than any other, it is easily calculated that he would be burnt out and :—

> ". . . Wander darkling in th' eternal space
> Rayless and pathless,"

in less than eight thousand years.

These various suggestions, for we cannot call them theories we will not stop to consider. Ingenious and yet simple as many of them are, they one and all fail to rise to the magnitudes with which they have to deal. We pass on to the consideration of the next, and certainly the one held by many physicists.

(To be continued.)

THE SHAPES OF LEAVES.—(*Nature*)

BY GRANT ALLEN.

I.—General Principles.

The leaf is the essential and really active part of the ordinary vegetal organism ; it is at once the mouth, the stomach, the heart, the lungs, and the whole vital mechanism of the entire plant. Indeed, from the strictest biological point of view every leaf must be regarded as to some extent an individual organism by itself, and the tree or the herb must be looked upon as an aggregate or colony of such separate units bound together much in the same way as a group of coral polypes or the separate parts of a sponge in the animal world. It is curious, therefore, that so little attention, comparatively speaking, should have been given to the shapes of the foliage in various plants. "The causes which have led to the different forms of leaves," says Sir John Lubbock, "have been, so far as I know, explained in very few cases." Yet the origin of so many beautiful and varied natural shapes is surely worth a little consideration from the evolutionary botanist of the present day, the more so as the main principles which must guide him in his search after their causes are simple and patent to every inquirer.

The great function of a leaf is the absoption of carbonic acid from the air, and its deoxidation under the influence of sunlight. From the free carbon thus obtained, together with the hydrogen liberated from the water in the sap, the plant manufactures the hydro-carbons which form the mass of its various tissues. Vegetal life in the true or green plant consists merely in such deoxidation of carbonic acid and water, and rearrangement of their atoms in new forms, implying the reception of external energy ; and this external energy is supplied by sunlight. We have thus two main conditions affecting the shape and size of leaves: first, the nature and amount of the supply of carbonic acid; and second, the nature and amount of the supply of sunshine. But as leaves also aid and supplement the roots as absorbers of water, or even under certain circumstances perform that function almost entirely alone, a third and subordinate element also comes into play in many cases, namely, the nature and amount of the supply of watery vapour in the air.

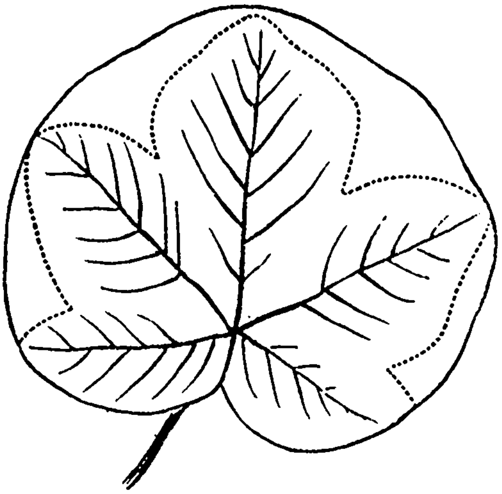


Fig. 1.

This last element, however, we may leave out of consideration for the present, confining our attention at the outset to the first two.

Carbonic acid is the true food of plants: water, one may say, is only their drink. The roots can almost always obtain a sufficient amount of moisture; and though no doubt there is sometimes a fierce struggle for this material between young plants, yet its effects are not usually so obvious or so lasting on the shape of the parts concerned. But for the carbon of which their tissues must be built up there exists a competition between plants as great and as evident as the competition between carnivores for the prey they pursue, or between herbivores for the grasses and fruits on which they subsist. The plant endeavours to get for itself as much as it can of this fundamental food stuff; and all its neighbours endeavour to frustrate and to forestall it in the struggle for aërial nutriment. Again, the carbon is of no use without a supply of sunlight in the right place to deoxidise it and render it available for the use of the plant. Hence these two points between them mainly govern the shapes of leaves. Natural selection insures in the long run the survival of those types of foliage which are best fitted for the performance of their functions as mouths and stomachs in the particular environments that each species affects. Accordingly, in the final result each plant tends to have its chlorophyll disposed in the most economical position for catching such sunlight as it can secure; and it tends to have its whole absorbent surface disposed in the most advantageous position for drinking in such particles of carbonic acid as may pass its way. The importance of the first element has always been fully recognised by botanists; but the importance of the second appears hitherto to have been too frequently overlooked.

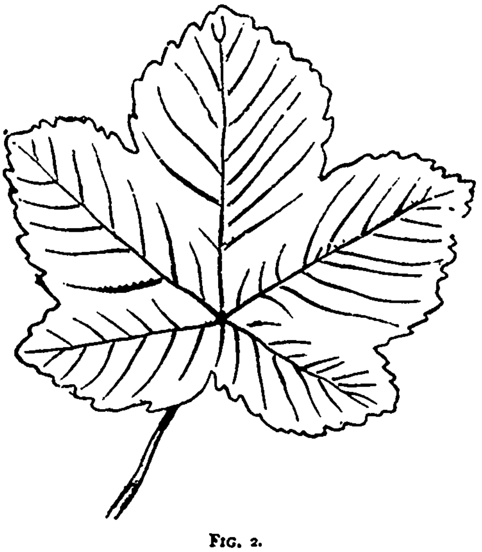


Fig. 2.

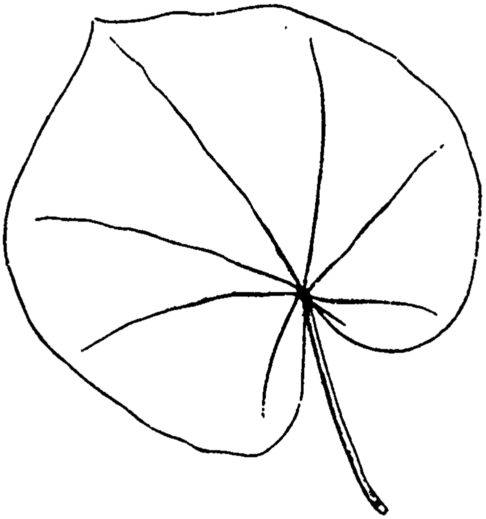


Fig 3.

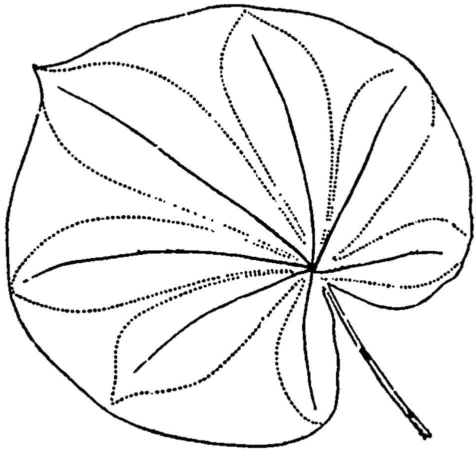


Fig. 4.

At the same time, the shape of the leaf in each species is not entirely determined by abstract considerations of fitness to the function to be performed: as elsewhere in the organic world, evolution is largely bound by hereditary forms and ancestral tendencies. Each plant inherits a certain general type of foliage from its ancestors; and it modifies that type so far as possible to suit the exigencies of its altered conditions. It cannot remake the leaf *de novo* at each change of habit or habitat: it can only remodel it in accordance with certain relatively fixed ancestral patterns. Hence, as a rule, each great group of plants—family, tribe, or genus—has a common type of leaf to which all its members more or less closely approximate. Occasionally, as among the composites, the diversity of types in a single family is very great; at other times, as among the peas and still more among the pinks, the type is fairly well preserved throughout. But, in spite of all apparent exceptions, and of numerous very divergent cases, there is a general tendency in most allied plants to conform more or less markedly to a certain general central and ideal form of leaf—the form from which all alike are hereditarily descended with various modifications. The actual shape in each case is not the ideally-best shape for the particular conditions; it is only the best possible adaptive modification of a pre-existing hereditary type.

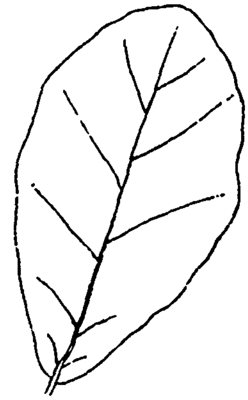


FIG. 5.

The point that is most common to leaves of different sorts in the same group is their vascular framework or ground-plan; in other words, their venation. This is the typical thing which tends most of all to reproduce itself, under all varieties of external configuration. The plant seems to build up first, as it were, its ancestral skeleton, and then, if it can afford material, to flesh it out with the intervening cellular tissue (not, of course, literally, for all the leaf buds out at once from a single knob). A glance at the accompanying diagrams will show how easily, by failure of growth in the intervals between the principal ribs, a simple primitive rounded leaf may be converted during the course of evolution into a lobed or compound one. In Fig. 1 we have such an ovate leaf, with digitate venation: the dotted line marks the chief intervals between the ribs, mainly filled by cellular tissue. In Fig. 2 we have the leaf of a sycamore, with the same venation, but with the intervals between the ribs unfilled. Here it will be noticed that the apex of the five main lobes corresponds in each case with the termination of a main rib; and the largest lobe answers to the midrib. Similarly, the apex of each minor serration answers to the termination of a secondary riblet. The type remains the same throughout; only in Fig. 1, material has been supplied to fill it all in, and in Fig. 2, only enough has been supplied to cover the immediate neighbourhood of the main veins.

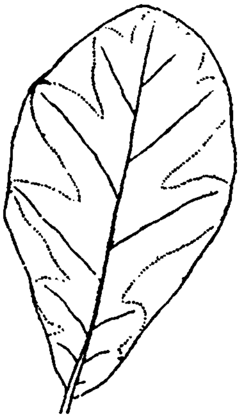


FIG. 6.

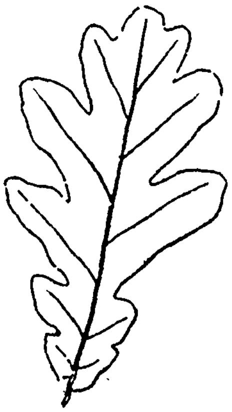


FIG. 7.

In Figs. 3 and 4 we get a further modification of a similar type. Here the cutting of the lobes goes so deep as to divide the entire blade into separate leaflets; and the result is the compound leaf of the horse-chestnut.

The same thing may also occur with pinnately-veined leaves. In Fig. 5 we get a typical leaf of this character, where the supply of carbonic acid and sunshine under the average circumstances of the plant is sufficient to allow of its having assumed a full and rounded specific form. Fig. 6 shows the less fully-veined tracts in such a type of foliage; and in Fig. 7, where the ordinary conditions do not favour full development, we get the familiar irregularly-lobed blade of the English oak. The diagrammatic representation in Fig. 8 suggests the steps by which a regularly pinnately-veined leaf, such as that of the common olive, may pass into a pinnatified and pinnatisect form by non-development of the mainly cellular tracts. We may thus get either a lobed leaf like the hawthorn, as

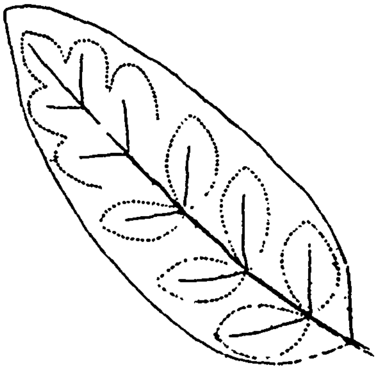


FIG. 8.

FIG. 9.

adumbrated at the summit of the diagram, or a compound leaf with pinnate leaflets like the commonest papilionaceous type, as shown in the lower portion. These examples will at once make clear the principle that with very slight changes in the real structural composition of a leaf we may have very great differences in the resulting outline. How the various underlying types of venation themselves are acquired or modified we must consider at a later stage: for the present we must take them for granted as relatively fixed generic or tribal characteristics.

It may be necessary to warn the reader in passing that comparatively little importance must be attached to the particular circumstances of each individual leaf. It is the average circumstances of the species which give rise to the specific type. True, each particular blade cannot grow at all except in so far as material is supplied to it during its growth from the older and more settled members of the complex plant-commonwealth, but even when such material is supplied to it, it will only grow to the extent and into the shape which natural selection has shown to be the best on the average for all its predecessors. For example, no plethora of available material would make the sycamore or the oak produce leaves like those represented in Figs. 1 and 5; it would only make them produce a greater number of normal leaves like those represented in Figs 2 and 7, since these embody the final result of all the past experience of the race—the residuum of countless generations of unsparing selection.

A single illustration of the way in which these general principles work can best be found, as a first example, in the foliage of the water-crowfoot (*Ranunculus aquatilis*, Fig. 9). This well-known plant, growing as it does in streams or pools, has two forms of leaf on the self-same branch, strikingly different from one another. The lower or submerged leaves, which wave freely to and fro in the water, are minutely subdivided into long, almost hair-like, filaments, the upper or floating leaves, which loll upon the surface of the stream, are full and rounded, though more or less indented at the edge into from three to six obovate lobes. Familiar as is this curious little English plant, the causes which give it its two types of leaves admirably illustrate the laws which we must employ as the general key to all the shapes of foliage throughout the vegetal kingdom.

First as to the submerged leaves. These organs, growing in the water under the surface, have not nearly so free access to carbonic acid as those which grow in the open air. For the proportion of carbonic acid held in solution by water is very small; and for this small amount there is a great competition among the various aquatic plants. As a rule, the cryptogamic flora of fresh waters consists of long streaming algæ or characeæ, which assume filamentous shapes, and wave about in the water so as to catch every passing particle of the precious gas. When flowering-plants like the water-crowfoot, take to inhabiting similar spots, their submerged leaves also tend to assume somewhat the same forms, and to move freely with every current in the pond or stream, so as to catch whatever fragments of carbon may happen to pass their way. In this case, there is no dearth of sunshine, no interference of other plants with the incidence of the light, the weaving thread-like form depends solely upon the comparative want of carbon in the surrounding medium. The leaves have acquired the shape which enables them best to lay hold on whatever carbon there may be in their neighbourhood, any other arrangement would involve a waste of chlorophyll—a misplacing of it in an unadvantageous position. Full round leaves would be useless under water, because there would not be work enough for them to do there.

On the other hand, when the leaves reach the surface, they have room to spread out unmolested into an area singularly free from competing foliage. Here, then, they plim out at once into a larger rounded type, as they can obtain abundant carbonic acid from the air around, and can catch the unimpeded sunlight on the surface of their pond. The two cases, as Lamarck long since remarked, are somewhat analogous to those of gills and lungs; for though in the one case it is oxygen that is required, and in the other case carbonic acid, yet inasmuch as both are gases dissolved in water, the parallelism on the whole is very close.

It is to be noted, however, that in both cases the central ranunculaceous type of leaf is faithfully preserved in the ground-plan or framework. This central type of leaf is found in a rounded form in the lesser celandine (*R. ficaria*), and in the radical leaves of the goldilocks (*R. auricomus*). It is more divided and cut, or (to put the same thing conversely) less filled out between the ribs in the common meadow buttercup (*R. acris*). But in the water-crowfoot, the floating leaves remain very close to the rounded form of lesser celandine, though a little more lobed at the edge; while in the submerged leaves, we get hardly anything more than an attenuated skeleton of the venation, still essentially keeping up the typical form, though in a somewhat exaggerated and minutely subdivided manner. When one compares these submerged leaves with the equally filiform and minutely dissected submerged foliage of the water-violet (*Hottonia palustris*) and the water-milfoil (*Myriophyllum spicatum*), one sees at once that the same effect has been obtained in the various cases by like modification of wholly unlike ancestral forms. While assuming extremely similar outer appearances, all these plants retain essentially diverse underlying ground-plans.

Furthermore, there are various minor forms or varieties of the water crowfoot in which minor peculiarities of like import may be observed. The form known as *R. fluitans* lives chiefly in rapidly-running streams, where none of its leaves can reach the surface; hence all its foliage is submerged, and deeply cut into very long, thin, parallel segments, which wave up and down in the rapids, and are admirably adapted to catch the floating particles of carbonic acid carried down by the water in its course. The variety known as *R. circinatus* grows mainly in deep still pools, where also its leaves cannot reach the top; and it has likewise submerged foliage with finely-cut segments, but the separate pieces are "shorter and more spreading," because this form is best adapted to catch the stray dispersed particles of carbonic acid in the quiet waters. The common type (*vulgaris* of Bentham) has both forms of leaves, floating and submerged, and grows mostly in shallow pools or slow streams. The type known as ivy-leaved crowfoot (*R. hederaceus*) creeps on mud or ooze, and has only the full three-lobed leaves. Finally it may be noted that even the particular position of individual leaves here counts for something; since nothing is commoner than to find one of the finely-cut submerged leaves with a few upper segments floating on the surface; and these upper segments begin to fill out at once into broader green tips thus giving the end of the leaf an odd, swollen, and bloated appearance.

(*Continued on page* 120.)

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THE PROGRESS OF TELEGRAPHY,

BY W. H. PREECE, F.R.S, M. Inst. C.E.

Telegraphy is the oldest practical application of Electricity. It grew about the railway system, and was rendered a practical agent by the foresight of Robert Stephenson, I. K. Brunel, Joseph Locke and G. P. Bidder, who were its godfathers in England. Electric currents are, as a rule, maintained for telegraphic purposes by the combustion of zinc, and in the innumerable forms of batteries, the conversion of zinc into sulphate of zinc is the root of the transformation of energy into that form which was utilized as electric currents. There are three forms of battery in use in the British Post-Office Telegraph system, and in the following numbers.—

Daniell....................	87,221	cells.
Leclanché	56,420	"
Bichromate.................	21,846	"

Every administration has its own adopted form, differing in design, but based on one or other of those types. Magneto-electricity is applied for some forms of apparatus, and dynamo machines are occasionally utilized to supplement batteries. The various terms, electro-motive force, resistance, induction, and current, though measurable in definite units, have not yet become household words, but, having been admitted into commercial, legal, and parliamentary lore, they will soon be as familiar as feet, gallons, or pounds.

Electric currents are conveyed from place to place either overground, underground, or submarine.

OVERGROUND.—Wooden poles preserved in creosote are employed in England, but iron poles are extensively used in the Colonies. The conducting wire is almost universally of iron, but copper wire is much used through smoky places where iron is liable to rapid decay. Phosphor-bronze wire is under trial, and is a very promising material, as it possesses the conductivity of copper with the strength of iron. The improvements made in the quality of iron wire have been very great, and it conducts now fully 50 per cent. better than it did a few years ago. Electric tests have had a marvellous effect upon the production of pure metallic conductors; copper has improved in a greater ratio than iron, and samples have been produced better even than the standard of purity. The insulators remain principally of porcelain, and their forms vary nearly with the number of individuals who use them; the only improvement of any value recently made is one which facilitates the very necessary process of cleansing.

UNDERGROUND.—Wires are almost invariably carried underground through towns. Copper wire, insulated with gutta-percha, encased in iron pipes, is the material used. There are 12,000 miles of underground wire in the United Kingdom. There is a great outcry for more underground work in England, owing to the destruction to open lines by gales and snowstorms; but underground telegraphs, wire for wire, cost at present about four times as much as overground lines, and their capacity for the conveyance of messages is only one-fourth; so that overground are, commercially, sixteen times better than underground wires. To lay the whole of the Post-Office system underground would mean an expenditure of about £20,000,000. Hence there is no desire to put wires underground except in towns. Besides snowstorms are few and far between, and their effects are much exaggerated. Of the numerous materials and compounds that have been resorted to for insulating purposes, gutta-percha remains the oldest and the best for underground purposes. It, like all other materials used for telegraphy, has been improved vastly through the searching power that the current gives the engineer.

SUBMARINE.—The past ten years has seen the globe covered with a network of cables. Submarine telegraphs have become a solid property. They are laid with facility and recovered with certainty, even in the deepest oceans. Thanks to such expeditions as that of H.M.S., "Challenger," the floor of the ocean is becoming more familiar than the surface of many continents. There are at present 80,000 miles of cable at work, and £30,000,000 have been embarked in their establishment. A fleet of twenty-nine ships is employed in laying, watching, and repairing the cables. The Atlantic is spanned by nine cables in working order. The type of cable has been but very little varied from the first made and laid between Dover and Calais; but the character of the materials, the quality of the copper and the gutta-percha, the breaking strain of the homogeneous iron wire, which has reached 90 tons to the square inch, and the machinery for laying, have received such great advances, that the Telegraph Construction and Maintenance Company laid a cable across the Atlantic last year in twelve days, without a hitch or stoppage.

Ideas are conveyed to the mind by electric signals, and, in telegraphy, these signals are produced at distant places by two simple electrical effects.—(1) that a magnetic needle tends to place itself at right-angles to a wire when an electric current passes through it; and, (2) that a piece of iron becomes a magnet when a current of electricity circulates around it. An innumerable quantity of tunes can be played on these two strings. Various companies were established at different times to work certain systems, but when the telegraphs were absorbed by the State, the fittest were selected to survive and their number consequently declined.

The A B C instrument is the simplest to read, for it indicates the letters of the alphabet, by causing a pointer to dwell opposite the desired letter. There are 4,398 in use. Its mechanism is, however, complicated and expensive, and it is being rapidly supplanted by the telephone. The needle instrument is the simplest in construction, but it requires training to work it. There are 3,791 employed by the Post-Office, and 15,702 among different railway companies. As a railway instrument it is the simplest, cheapest and most efficient ever devised. The Morse instrument, of which the Post-Office possesses 1,330, records its letters in ink, in dots and dashes on paper tape, and like the needle and A B C appeals to the consciousness through the eye, it also indicates the letters of the alphabet by sound, and thus utilises the organ of hearing. Sound-reading is gaining ground in England with great rapidity. There are now 2,000 sounders, while in 1869 there were none. In America scarcely any other instrument is used, but on the Continent of Europe there is scarcely one.

Acoustic reading attains great perfection in Bright's bell instrument, where beats of different sound replace the dot and dash of the Morse alphabet. Sound-reading is more rapid and more accurate than any system of visual signals or permanent record. In fact, no record is kept in England, for the paper tape is now destroyed as soon as it has been read. Errors are of course inherent to all systems of telegraphy. A telegraphist cannot see what he writes, nor hear what he says, and who is there that does not make mistakes, whose eye follows his pen, and whose ear takes in his own words? The Hughes Type-Instrument, which prints messages in bold Roman characters, is much used on the Continent; it is in fact recognised as the international instrument, but it has had to give way in England to a more rapid system of telegraphy. It is, however, solely employed for the Continental circuits by the Submarine Telegraph Company. All long cables are worked by Sir William Thompson's beautiful Siphon-Recorder.

In ordinary working only one message can be sent in one direction at one time; but by a simple and ingenious contrivance, by which the neutrality of opposite currents is utilized to convey signals, duplex telegraphy is rendered possible, so that two messages can be sent on the same wire at the same time; and, by a still further improvement, where currents of different strength are utilized, four messages are sent on one wire—two simultaneously in opposite directions—at the same time. There are in England 319 duplex and 13 quadruplex circuits at work.

The acme of efficiency in telegraphy is attained in the automatic system, in which manual labour is supplanted by mechanism in transmitting the messages. There are 71 circuits worked by these instruments, and 224 instruments in use, and a speed of working of 200 words per minute is easily maintained upon them. With the hand alone from 30 to 40 words per minute is the maximum rate attained, but by automatic means the limit is scarcely known. Since this system can be duplexed, and in many cases is so, 400 words per minute on one wire are easily sent. By the use of high-speed repeaters, the length of circuit for automatic working is scarcely limited; it would be easy to send 100 words per minute to India.

The growth of business since the telegraphs have been acquired by the State is enormous: 126,000 messages per week have grown to an average of 603,000; but the mileage of wire has not increased in anything like the same proportion, the excess of traffic having been provided for by the great improvements made in the working capacity of the apparatus. In 1873, the average number of messages per mile of wire was 147, it is now 256. It is in press work that the greatest increase has taken place: 5,000 words per day at the time of the Companies, have grown to 934,154 words per day now. 340,966,344 words of press matter were delivered in the year ending 31st March, 1882.

The development of railways has necessitated a corresponding increase in the telegraphs required to ensure the safety of the travelling public, and while 27,000 miles of wire in England, Scotland, and Wales were used for that purpose in 1869, at the end of Dec., 1882, the total had increased to 69,000 miles, equipped with 15,702 instruments, against 4,423 in 1869.

The growth of business is equally discernible in the great Cable Companies. In 1871, the number of messages dealt with by the Eastern Telegraph Company was 186,000; in 1881, it was 720,000 This growth is equally striking in all civilized countries, and even in Japan, 2,223,214 messages were despatched, of which 98 per cent. were in the native tongue. The mode of transacting the trade of the world has been revolutionised, and while wars have been rendered less possible, their conduct has been expedited, and their penalties alleviated. *Trans. Inst. C.E.*

AN enormous aerolite fell on February 16, a little before 3 p.m., in a ploughed field near Alfianello, between Cremona and Brescia, sinking more than one metre in the ground, and producing a rumbling noise, heard twenty kilometres off, and a reeling of the nearest houses as by an earthquake. Unhappily the ignorant country people, when the first freight passed, with mattocks and sticks smashed it and took away the pieces, so that Prof. Calderoni, who directly ran up from Cremona, could obtain only some little fragments for chemical analysis and for scientific cabinets.—*Nature*

A COMMUNICATION from Dr. Joule, F.R.S., was read at a recent meeting of the Manchester Literary and Philosophical Society, on the use of lime as a purifier of the products of combustion of coal gas. The slaked lime is placed in a vessel the bottom of which, about one foot diameter, is slightly domed and perforated with fine holes. The vessel is suspended about six inches above the burner. It is found that a stratum of four or five inches of lime is sufficient to remove the acid vapours so far as to prevent them from reddening litmus paper. The lime seems in many respects to present important advantages over the zinc previously recommended.

THE SHAPES OF LEAVES[1]

II.—*Extreme and Intermediate Types*

WHERE access to carbonic acid and sunlight is habitually unimpeded by the competition of other plants in any direction, the leaf of each species tends to assume a completely rounded form; the conditions are evenly distributed on every side of it. Such absolute freedom to assume the fullest foliar perfection is best found on the surface of the water. Hence most water-plants which have leaves lolling on the surface assume a more or less distinctly rounded shape, the venation and other details remaining in accordance with the ancestral habit. Foliage of this character is found in the water-lilies and many other aquatic plants. The little entire lenticular fronds of the common duckweed, *Lemna minor* (Fig. 10), which coats all our small ponds and ditches, form an excellent example of the type in question. Here the shape is almost orbicular; the edge is entire; and the smallness of each separate frond is due to the minuteness of the plant and the obvious necessities of its situation. In the waterlilies we get a similar example on a much larger scale, for these plants recline on broader and more permanent sheets of water, and draw nourishment from their large rhizome, sunk securely in the mud beneath, and annually accumulating a rich store of food-stuffs for the growing foliage.

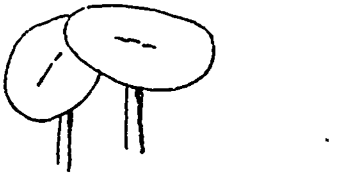

FIG. 10.—*Lemna minor.*

FIG. 11.—*Nelumbium speciosum.*

Mr. Herbert Spencer (by whose kind permission two accompanying diagrams are copied from "The Principles of Biology") points out a distinction between the shapes adopted by such plants, according to their relations to a central axis. In the sacred lotus, *Nelumbium speciosum* (Fig. 11), the leaves grow up on long and independent footstalks, without definite subordination to any such axis; and they therefore assume an almost perfectly symmetrical peltate form. In the *Victoria regia* (Fig. 12) the footstalks, though radiating almost horizontally from a centre, are long enough to keep the leaves quite remote from one another; and here they assume an almost symmetrically peltate shape, but with a bilateralness indicated by a long seam over the line of the footstalk. The leaves of our own white waterlily, *Nymphæa alba* (Fig. 13), are more closely clustered, and have less room to expand transversely than longitudinally; hence they are somewhat longer than broad, and have a cleft where the *Victoria regia* has only a seam. *Limnanthemum* shows the same type on a smaller scale.

Among land plants, the conditions under which leaves can fill out to the full rounded shape occur less frequently than among floating aquatic species; still, even here a very interesting set of gradations may be observed. The best example of all is that given by the common American May-apple, *Podophyllum peltatum*, where the separate radical leaves grow straight up from a stout rootstock on very thick and tall stalks, so as to overshadow all the other vegetation; and they assume a regular, circular, peltate form, exactly like a Japanese parasol. The radical leaves of our own English *Cotyledon umbilicus* (Fig. 14), springing from a perennial rootstock, for the most part on bare walls or unoccupied hedgerows, are able similarly to expand without interference, and catch carbonic acid and sunlight to their hearts' content. Hence they are orbicular and peltate, though they retain the characteristic crenate edge of most flat-leaved Crassulaceæ. But the upper leaves, springing from the flower-stalk, are more bilateral, as shown in the figure, though even these round out to a more or less orbicular form, owing to their exceptional access to air and light. The so-called garden nasturtium, *Tropæolum majus*, with leaves growing out at right angles into open space, has also peltate leaves, as has likewise the usually aquatic *Hydrocotyle*.

FIG. 12.—*Victoria regia.*

FIG. 13.—*Nymphæa alba.*

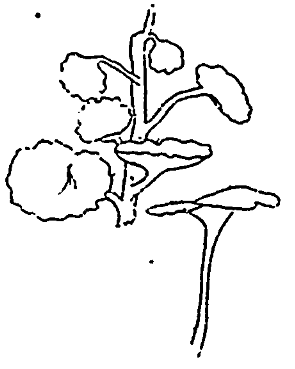

FIG. 14.—*Cotyledon umbilicus.*

When the plant sends up leaves from a rich buried rootstock, so tall as to overshadow the surrounding vegetation, but subordinated to a common centre, they usually assume the reniform shape. This type is particularly well seen in the various coltsfoots—for example, in *Tussilago farfara*, *T. petasites*, and *T. fragrans* (Fig. 15). Similar types occur in *Asarabacca*, and in the marsh marigold, *Caltha palustris*. Extremely similar to the leaf of *Caltha*, though on a smaller scale, is that of one true buttercup,

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[1] Continued from p. 115

Ranunculus ficaria, the lesser celandine, which produces its foliage in early spring from buried tubers, and so anticipates other plants, having the air all to itself for a couple of months, after which it gets overshadowed by later comers. The same type recurs pretty closely in the radical leaves of its allies, *R. auricomus* and *R. parviflorus*, as also somewhat more remotely in the ivy-leaved crowfoot, *R. hederaceus*, which creeps, unimpeded, over soft mud. Many early spring plants have lower or radical leaves at least of this reniform type, because they grow in comparatively unoccupied ground. As an example, take ground-ivy, *Nepeta glechoma* (Fig. 16). The violets represent a closely similar case. Many of these plants, however, produce later on, when foliage grows thicker, much more lanceolate leaves. In the burdocks, docks, &c., this type is persistent.

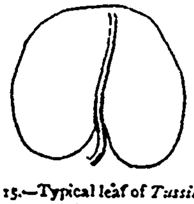


Fig. 15.—Typical leaf of *Tussilago* genus.

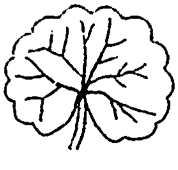


Fig. 16.—*Nepeta glecoma.*

On the other hand, where the distribution of carbonic acid is most scanty, or where the competition is fiercest, or where the competing plants are supplied with no reserve to enable them to send up shoots which overtop their competitors, immense subdivision into leaflets takes place, and these leaflets are often almost or quite filiform. The extent to which leaflets are subdivided depends upon the relative paucity of carbon in their environment; the general resulting form depends mainly upon the inherited type of venation. Among submerged aquatic plants, the filiform condition is habitual, because carbonic acid is so comparatively scarce in water. Among British species, the water violet, *Hottonia palustris*, is a good example. All terrestrial primroses have undivided foliage; but in *Hottonia* the leaves, still preserving the pinnate character of the venation, as in the common primrose, are cut into very deep segments, forming a close mass of narrow, linear, waving threads, more like a *Chara* than a flowering plant at a first glance. *Utricularia* shows the same result with a different ground-plan. In *Myriophyllum*, water milfoil, we have whorls of leaves each minutely subdivided into hair-like pinnate segments, and moving freely through their still ponds in search of stray carbon particles diffused in the water. *Hippuris* has the separate leaves undivided, but attains the same result by crowding its long, thin, linear blades in whorls of ten or twelve, so as closely to resemble an *Equisetum*. Our common *Ceratophyllum* looks at first sight much like water-milfoil, but here the whorled leaves, instead of being pinnately divided, are repeatedly forked into subulate or capillary segments, the result of a branching rather than of a pinnate venation. Other instances will occur at once to every botanist.


Fig. 17.—*Chærophyllum silvestre.*

On land we get very much the same condition of things in the fierce competition that goes on for the carbon of the air between the small matted undergrowth of every thicket and hedgerow. The common weedy plants, and especially the annuals or non-bulbous perennials, which grow under such conditions, cannot afford material to push broad leaves above their neighbours' heads, and they are therefore compelled to fight among themselves for every passing particle of carbon. Hence they are usually very minutely subdivided, though in a less waving and capillary manner than the submerged species; their leaflets are oftener flat, and definitely exposed on their upper surface to the sunlight. That essentially weedy family, the Umbellates, contains a great number of such highly segmented hedgerow leaves. Common wild chervil, *Chærophyllum silvestre* (Fig. 17), forms a familiar example: other cases are *C. temulum*, *Sison Amomum*, many *Carums*, *Œnanthes*, *Pimpinellas*, *Daucus*, *Caucalis*, &c., all of which belong by habit to greatly overgrown localities. Compare these with the free-growing, almost orbicular, radical leaves of *Astrantia* and *Sanicula*, in

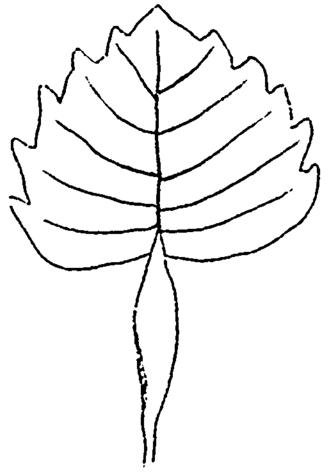


Fig. 18.—Floating leaf of *Trapa natans.*

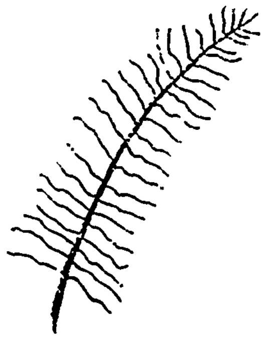


Fig. 19.—Submerged leaf of *Trapa natans.*

the same family; or with the still freer peltate leaves of *Hydrocotyle;* or again with the divided but more broadly segmented leaves of those tall open-field species, cowparsnip, *Heracleum sphondylium*, and Alexanders, *Smyrnium olusatrum,* which have only to compete against the grasses and clovers; or, finally, with the large waterside forms, *Apium graveoicus, Sium latifolium*, and *Angelica silvestris.* So, too, take the much segmented herb—Robert, *Geranium Robertianum*, of all our hedgerows, growing side by side with the like-minded chervils and carrots, and compare it with that persistent rounded geraniaceous type which recurs, not only in our English *G. Molle*, etc., but even in many exotic *Pelargoniums.* Among composites the crowded type is best exemplified by that thicket weed, milfoil, *Achillea millefolium*, with its infinite number of finely-cut pinnatifid segments; while in the taller but closely allied sneezewort, *Achillea ptarmica*, growing on high open pastures, we get the same general type in outline and venation, only retire save for one slight serrations along its edge. In tansy, *Tanacetum vulgare,* also a hedgerow plant, the same type as milfoil recurs on a far larger and handsomer scale. Compare these with coltsfoot and burdock, or even with the tall eupatory and the tufted close-packed daisy. Other good miscellaneous instances of the weedy type are fumitory, *Corydalis*, moschatel, the camomile group, etc.; while among larger cryptogams the majority of thicket ferns display an equally marked subdivision of the fronds and pinnæs It may be added that highly civilised countries like England are particularly rich in these subdivided types of foliage, owing to the predominance of hedgerows and of tall grasses.

As in the submerged plants, so in the matted terrestrial undergrowth, whorling of linear leaves may practically answer the same purpose as minute segmentation. Some plants solve the difficulty of catching straying stray carbon in the one way, and some solve it in the other. Each adopts the easiest modification of its own ancestral type. For example take the stellate tribe. Their tropical allies, the larger Rubiaceæ, have simple, usually entire, opposite leaves, with interpetiolar stipules. In the small, weedy, northern forms however, the interpetiolar stipules have grown out into linear leaf-like foliar organs, forming with the true leaves an apparent whorl of six members. Sometimes, too, the whorl is enlarged to as many as eight leaves, and sometimes reduced to four. These thick whorls of small leaves, always well turned outward to the sunlight, have become practically analogons in their action to minutely segmented leaflets, in our English *Galiums, Asperulas,* and *Sherardia G.* Two of them at least, *G. Mollugo* and *G aparine* are extremely common hedgerow plants. Compare them with the broad-leaved free-climbing *Rubia peregrina*, which has only four large members to each whorl.

Among monocotyledons, where (as will be afterwards explained) the type is given by the peculiarity of the cotyledon and governs the venation, minute subdivision is replaced in the matted undergrowth by single, linear, lanceolate blades, which answer the selfsame purpose in the long run. The grasses, sedges, and woodrushes are sufficient examples. Here the numerous leaves, all long and narrow, and all with long thin flower stems, strive to overtop one another, and run up side by side to a considerable height. They may be compared with the larged rich leaves of the bulbous lilies, tulips, amaryllids, and orchids. In both cases the type is the same, but the development is different. Plants that consort much with the grasses, as for example ribwort plaintain, though wholly unlike in type, are apt to be drawn up and assimilated to them, not merely, in general character, but even in venation and mode of fertilisation. Other grass-like dicotyledons are found among the *Polygonums, Armerias, Bupleurums,* pinks, etc., all under similar circumstances to those of the grasses themselves.

Intermediate types between these two extremes of entire obicularity and minute subnivision occur everywhere. Compare, from this point of view, the common meadow buttercups, which grows in fully occupied meadows, with *Caltha* and the lesser celandine. Compare, again, the mallows on the one hand with the peas on the other, or the docks with the crucifers. Throughout these intermediate, various stages can be easily observed For example, the South European water-chestnuts, *Trapa natans*, beautifully illustrates the gradations which have finally given us our own *Hippuris* and *Myriophyllum* from an Onagraceous or Saxifrage ancestor. It has a number of floating leaves (Fig. 18) supported by bladder-like petioles filled with air, and arranged radially round the stem. Hence, though large and spreading, they are distinctly bilateral, and they do not interfere with one another's food supply. But the submerged leaves (Fig. 19, very diagrammatic) are mere pinnate skeletons of the venations, waving about in the water below. Among monocotyledons, the *Potamegetons* show us some very instructive similar cases, altered in character by the peculiarities of the very persistent monocotyledonous foliar type. In the floating leaves of *P. natans* they come as near the waterlilies as a monocotyledon can reasonably expect to do; in *P. pictinatus*, the wholly submerged leaves look like long blades of grass, proceeding from the thread-like stems.

Less minutely subdivided than the hedgerow plants are a large class of somewhat weedy forms, well typified by our smaller English crucifers. These are often pinnately divided to a considerable extent, as in *Cardamine hirsuta* and *Senebiera didyma.* Compare them with the taller kinds, such as cabbage and charlock. Much the same type reappears in the lowly forms of Papilionaceæ, as for example in *Anthyllis, Astragalus, Ornithopus, Hippocrepis,* etc. On the other hand, in the tall climbing *Vicias,* and still more in *Lathyrus,* the leaflets, having more carbon, more sun and less competition, fill out rounder, and generally decrease in number, the upper ones being transformed into tendrils. But in the very grass-encumbered clover-like types, *Ononis, Medicago, Melilotus, Trigonella*, and, above all, *Trifolium* itself, the leaflets are dwarfed and reduced to three, the lower members being suppressed, and only the three terminal ones left, so as to raise them on a long footstalk up to the air and sunshine. Compare the very similar leaflets of wood-sorrel. Again, look at the various conditions under which the following Rosaceous plants grow: pear, blackthorn, strawberry, cinqufoil, silver-weed, great boonet, salad bureet, and compare some of them with clover, lady's-fingers, and *Hippocrepis.* The comparison tells its own tale at once.

Finally, we must briefly allude to a large class of tufted plants, usually with entire, ovate, obovate, or ovatelanceolate leaves, which grow in a rosette from a centre, and insure themselves a good supply of carbon and of light by keeping under all competitors with their close tufts. Of these, our common daisy forms an excellent example: notice the tight way it fits itself against the ground so as to prevent grass from growing beneath it. Another good case in point is *Plantago media:* compare form and habit with those of *P. major* and *P. Lanceolata.* To the same class, more or less, may be referred *Arabis thaliana* and many crucifers, London Pride, the common primrose, *Hieracium pilosella*, etc., and, with more pinnate, lyrate, or prickly leaves, the young thistles, and the radical foliage of many ligulate composites.

The shapes of leaves thus depend upon the average surrounding conditions, modifying a given ancestral type. How these ancestral types themselves were first developed we shall have to inquire in our next paper.

(To be continued.)

ELECTRIC DISCHARGE IN RAREFIED AIR.—Edlund continues his investigation of this subject. He connects the combs of a Holtz machine by means of a wire interrupted by a short air-space. The circuit contains in multiple arc a sensitive galvanometer, and a rarefied air-space, 5mm. long, between aluminium electrodes. The galvanometer is also shunted by a wire; and one junction of this shunt with the rest of the circuit is grounded. When the Holtz machine is worked, frequent sparks pass, and the galvanometer-needle finally attains a nearly constant deflection. The singular fact is observed, that this deflection is many times greater, when the galvanometer is shunted by the rarefied air-space, than when it is not so shunted. The explanation proposed is, that, after each spark from the Holtz machine passes through the rarefied-air space, a 'disjunction,' or reverse current, is set up by the e. m. f., which the discharge has generated at the surface of the electrodes. This current passes through the galvanometer in the same direction as the current from the machine.

Edlund's articles seem to be of value in calling particular attention to the long-recognized resistance at the surface of the electrodes in a discharge-tube, thus making it appear probable that the proper resistance of the rarefied air has been over-estimated, and so tending to remove the difficulty at present felt in regard to the height of auroras. Edlund's own conclusions--viz., that empty space, or rather the ether, is an excellent conductor—will probably be accepted by few—(*Phil. mag.*, Jan.) E. H. H.

Prof. Forbes has been experimenting with wires to determine the thickness required for carrying different electric currents without overheating, and announces as a result that, if you can carry a definite amount of current through a wire of a certain diameter without heating it over a temperature of 150 degrees, then, in order to carry a current twice as great without overheating, the wire used must be twice the diameter or four times the section. This is an important matter, if true, for the size of copper conductors is a very important element in the cost of a plant for electric lighting, and conductors liable to be overheated greatly increase the cost of the current, besides being dangerous.

Immediate Analysis of the Pozzuolanas and a rapid Method of Testing their Hydraulic Properties.—In a recent number of the *Comptes Rendus*, M. Ed. Landrin described a number of experiments shewing, (1) That the silica arising from the combinations in which it occurs in a pozzuolana is a variety of hydraulic silica at its maximum power. (2). That they give a rapid process of testing pozzuolanas, viz., attack with hydrochloric acid, and trial of the insolubles with lime-water. (3). That simultaneous experiments, made during the same period upon the pozzuolanas themselves, shew that there is no possible comparison between the action of pozzuolanas and of their insolubles on lime-water. It is likely, then, that the hydraulic silica is not isolated from the oxides in the pozzuolanas, as Girard de Candemberg thought, and that the regular and progressive hardening of hydraulic mortars with a base of pozzuolana is due to a very slow displacement of the bases combined with the hydraulic silica by the lime, a displacement instantaneously produced in the experiments, by treating the pozzuolanas, with hydrochloric acid.

Note on the study of longrain and the measures of schistosity in schistous rocks by means of their thermic properties by M. Jannettaz.

M. Jannettaz has never met with any exception to the law that heat is propagated along the plane of schistosity more easily than in a perpendicular direction. Do all the planes of schistosity then conduct heat equally well? The isothermal surface for schistose rocks, as for crystals, is an ellipsoid whose three principal planes are the plane of schistosity, containing the greatest and mean axis, and two planes perpendicular to each other and to the former, the one containing the greatest and least axis, the other the mean and least axis of ellipsoid. It may happen that the two axes in the plane of schistosity are equal, in which case the ellipsoid is a surface of revolution; it is also depressed and has its least axis perpendicular to the plane of schistosity. Very frequently, however, these two axes are unequal; what is their direction?

In visiting slate quarries it will be observed that the workmen everywhere avail themselves of a first division, generally with great ease, in the plane of schistosity, or plane of *first clearage*, in order to break up the rock into plates of large superficial area; then of a division less easily effected than the first, in a division called the *longrain*, *long*, or *fil*, according to the locality, and which may be designated the plane of *second clearage*, in order to cut up these plates in narrow bands. These bands are afterwards cut into small tablets by means of edge tools, to obtain slates of the required length.

The relation between these two planes of cleavage and the principal sections of the surface which measures the thermal conductivity is most simple. The line of intersection of these planes is parallel to the greatest axis and the plane of schistosity is perpendicular to the least axis of the isothermal surface. In other words, the greatest axis of this surface is parallel to the longrain or second clearage, and the least axis is perpendicular to the first clearage or plane of schistosity.

◆

A NEW COPPER-ZINC ALLOY.

Engineering says that Mr. Alexander Dick has succeeded in producing a new copper-zinc alloy which exhibits characteristics as essentially superior to brass as those of bronze are to gun metal. The advantages claimed for the new alloy, which has been named "delta metal," are great strength and toughness, and a capacity for being rolled, forged and drawn. It can be made as hard as mild steel, and when melted is very liquid, producing sound castings of close fine grain. The colour can be varied from that of yellow brass to rich gun metal; the surface takes a fine polish, and when exposed to the air tarnishes less than brass. These latter characteristics will meet with ready appreciation for cabinet work, harness fitting, etc. The metal when cast in sand has a breaking strain of 21 to 22 tons per square inch; when rolled or forged hot into rods, the breaking strain is 43 tons per square inch; and when drawn into wire of 22 B.W.G. of 67 tons per square inch.

◆

Gulf-Stream.—Commander Bartlett's recent measures on the coast-survey steamer Blake show that the current off Florida, where the channel is 48 miles wide, and the deepest point 439 fathoms, has a cross-section of 429,526,240 square feet; a velocity from one to five, averaging three miles an hour; a discharge of 51,000,000,000,000 gallons an hour; and a temperature varying from 78° to 83° at the surface, and from 57° to 44° at the bottom. Farther along our coast, the current flows over an even plateau, narrowing toward Cape Hatteras, about 400 fathoms deep, and suddenly dropping off to over 2,000 fathoms at its eastern edge. In the stronger parts of the stream, the bottom is swept clean, and consists of firm coral rock, hard enough to dent the brass cylinder of the sounding-apparatus. Where fine deposits occur, south of Charleston, they are of pteropod ooze, characteristic of the Caribbean and Gulf of Mexico; farther north, globigerina ooze becomes more common, as it is in the open north Atlantic. The division between these two deposits is considered the boundary of the cold, arctic current which follows down our shore from the north, passing under the Gulf-Stream off Hatteras, where the shallow plateau forces it out. No warm or cold bands or bifurcations were found in the surface-waters till off Hatteras, and no distinct "cold wall." Near shore the current was much influenced by winds. A brief description is given of the Siemens deep-sea thermometer, based on the variation of electrical resistance in metals with change of temperature. Measures made with this and with the Miller-Casella thermometer show almost absolute agreement, even at considerable depths.—(*Bull. Amer. geogr. soc., 1882*, 69.)

◆

OUR BODIES:" (*Knowledge*).

THE PROCESSES OR FUNCTIONS OF THE BODY.

BY DR. ANDREW WILSON, F.R.S.E., &c.

There is an animalcule, averaging in diameter the one-five-hundredth of an inch, or thereabouts, found in stagnant pools, called the *Amœba*. The name of the animalcule is derived from the Greek for "change." In appearance it is a mere speck of living jelly, which is ever changing its form—ever flowing, so to speak, from one shape to another. The living matter whereof the amœba consists is called *protoplasm*. This substance closely resembles the white of egg (or *albumen*)in its chemical composition. It is the one substance which seems to be inseparable from life; or to put it more exactly, life is nowhere known or heard of except as exhibited by some form or other of "protoplasm." Whatever may be the relation of protoplasm to life—a topic I need not discuss here—this much is assured, that life, as we know it, seems to require protoplasm or albuminous matter for its exhibition and mere existence. Protoplasm, in this way, becomes truly the "clay of the potter," woven by the powers that be into the wondrously varied warp and woof of living beings.

The Amœba, then, is a protoplasm speck. It takes in food particles by any part of its frame, and it appears capable of digesting them in any part of its body. There is no mouth, stomach, heart, breath organs, or nervous system. Yet the animalcule *lives*, and lives as perfectly in its own simple way as the man. There seems, indeed, a wide gulf betwixt humanity and the Amœba, but it is a gulf that is by no means impassable, when we consider that a community of likeness (in the essential nature of their living parts) and a sameness of function (in respect of the actions of life) characterize this lower form of life and the sphere of human hopes and fears. We shall have to refer hereafter to the Amœba as a type of a considerable number of actions which the physiologist studies in man, and it will serve a good purpose if we, therefore, bear the humble denizen of the pool, with its soft protoplasm body, clearly in mind.

Every living being—animal or plant, monad or man—performs three great functions in the course of its existence. The physiology of any animal or plant can be summed up in the expression, that the whole business of life, so to speak, consists of three great processes, which include many minor processes within their limits. There is, firstly, the function of *Nutrition*, whereby the animal or plant nourishes itself, digests food, and repairs its ever-recurring waste. Then, secondly, succeeds the process of *Innervation* or *Relation*. Through the exercise of this latter function, the living being brings itself into "relation" with the outer world by means of its nervous system. To the discussion of the functions of the nervous system, this second department of physiology is, therefore, devoted. But hosts of animals and plants die daily. Continually the units of a race perish and drop into the grave. Hence a third function—that of *Reproduction*—renews the *race*, just as "nutrition" renews the *individual*. New animals and plants are thus brought into the world to take the place of their fellows that have succumbed in the battle of life.

It is clear that whilst these three functions represent the collective type of the animal or plant, there must be many subdivisions of each action or duty. For example, the function of *nutrition* includes every action through which the *individual* body maintains its place in the world. Under this single head what subjects fail to be considered? The reply is—firstly, *foods*; then *digestion*—itself a comprehensive topic; then the *blood*, into which food is converted; next *circulation*, which distributes the blood to all the tissues of the body; and then comes *excretion*, or the getting rid of waste matters. This latter duty is performed by lungs, skin, and kidneys, so that the single word *excretion* stands for and implies the functions of breathing, of the skin, and of the kidneys respectively. Of the other two main functions of the body, the same remarks hold good. Each function is susceptible of division into a large number of lesser actions and details. The so-called "life," then, of a human being may, without any straining, either of physiological language, ideas, or facts, be described rather as a series of "lives," than as one life. And this latter contention becomes plainer when we reflect that in our blood, as well as in other fluids of our frames, there are "cells" or minute living particles, which certainly possess a power of motion independent of the body of which they form part, and which also exhibit a vitality that is not dependent upon the frame, through whose blood-vessels they perpetually travel.

For our present purpose, however, it must suffice that we regard the varied processes and actions of the body as existing in a close unity which lies on the surface of things. Health and a truly enjoyable life are only possible to us when this unity is maintained. Derangement of one function is apt to cause aberration of many functions; and we can only live a perfect and healthy life, physically, when every organ, part, and tissue co-operates with its neighbours in the maintainence of the whole bodily existence.

Our first consideration must be devoted to the consideration of the function of *nutrition*. It is only natural that we should first seek to know how our bodies are nourished. *Why* they are nourished we have already seen. Waste and wear are inseparable from existence. Every act of life means the wear and tear of the organ which works. Hence, it is to repair and renew the perennial waste which the living body undergoes, that *nutrition* devotes all its energies.

The means whereby we repair waste are largely summed up in the words *food* and *digestion*. *Food* is the material from which we derive the new matter for living upon, and *digestion* is one word for many processes whereby this food is converted into a fluid capable of being added to and poured into the *blood*. Digestion, then, is merely the line which connects the food and the blood. Through digestion we convert food or matter that is more or less unlike ourselves into ourselves.

The apparatus by which this action is effected is called the *digestive system*. Each collection of organs in a living body (the organs being devoted to the performance of a function) is called a "system." Heart and blood-vessels form a "system"—that of the *circulation*. Lungs, skin, and kidneys,—forming a kind of natural trio—constitute the system of *excretory organs*, which are devoted to getting rid of waste matters. And in the *digestive system*, we find a whole series of organs, which perform, each, an important part in the work of food-elaboration. Thus, there are the *mouth* and *teeth*; then come the *salivary glands* of the mouth. The stomach and intestines come next, the food passing through these parts. The *liver*, "sweetbread" (or *pancreas*), *gastric glands* of the stomach, and the glands of the intestine are all so many organs which discharge duties connected with the conversion of food into a fluid capable of being added to the blood.

But last of all it is possible to form a generalised idea of this complex system of digestive organs. We ought to think of any digestive system as merely *a longer or shorter tube* through which food passes, and in which food is subjected to the action of fluids thrown in upon it by certain glands (liver, sweetbread, etc). Such a simple idea—that of a tube with "glands" attached to its sides—perfectly describes the digestive system of any animal.

THE TRUNK AND LIMBS.

The *trunk* of the body (minus the *head* or skull, already described), consists of the spine, chest, and the "girdles" of the limbs. These "girdles" are the series of bones which attach the limbs to the trunk. Their composition we shall note presently.

The chest or *thorax* is formed by the spine and ribs behind, by the ribs at the sides, and by the ribs and their *cartilages* (or *gristly ends*), and breast-bone in front. The *ribs* number twelve pairs in man, and are attached behind to the twelve dorsal or back-vertebræ, each by a movable joint, which is utilised in the breathing movements. Occasionally thirteen pairs of ribs are developed in the human subject: The thirteenth pair in such a case is usually borne by the first lumbar vertebræ. Sometimes, however, we find a thirteenth rib attached to the seventh or last neck-vertebræ. These odd or extra ribs in man are, perhaps, best explained as survivals of the conditions of lower life, and as ancestral marks. The gorilla has normally thirteen pairs of ribs, and crocodiles have a whole series of neck-ribs. What is unusual in human anatomy, may thus be perfectly normal in lower existences. The first seven ribs are attached in front to the *sternum* or breast bone each by a *rib cartilage*. Each *cartilage* is simply a bar of gristle, of highly elastic nature. We can see that with the front of the chest thus rendered elastic, the movements of breathing should be readily accomplished. In a crowd, our ribs are never so readily broken, if we meet the pressure from before backwards, so that the cartilages of the ribs act as buffers. If, on the contrary, the same pressure were applied at the sides of the chest, the ribs would most likely be fractured. The eighth, ninth, and tenth pairs of ribs are attached in front to the cartilage of the seventh rib. The eleventh and twelfth ribs are often called *floating ribs*—a bad name, because they do not "float" in anything. We should call them "free" ribs, and thus express the fact that they are short, and that whilst springing from the spine behind, they are not attached to anything in front. The *sternum*, or breast bone, is a flat bone, shaped somewhat like a sword. It is broad above, and narrow below, where it ends in a piece of gristle. In old age, the cartilages of the ribs and breast-bone tend to become of bony nature. The ribs in old persons are thus more brittle and more readily broken than those of the young. Lime appears to be deposited in the rib cartilages in old age, and this fact, which is named a "degenerative process," is also represented in the bloodvessels as well as in the rib cartilages.

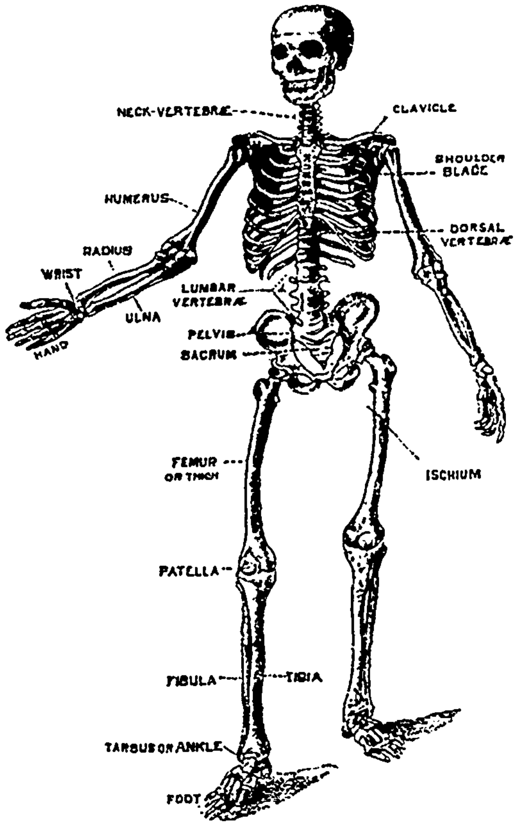
The *limbs* in Vertebrate or "backboned" animals never exceed four in number. They are always developed in pairs, and always possess an internal bony axis or skeleton, to which the *muscles* of the limb are attached. Vertebrate animals may have no limbs at all. Some fishes, *most* serpents (some snakes have small and rudimentary hind limbs), and a few lizards are limbless. Some fishes, such quadrupeds as the whales and sea cows, and a few lizards have only one pair of limbs.

Each limb, as already noted, is joined to the body or *trunk* by a series of bones forming the *limb girdle*. If we take this *girdle* into account, we shall find a limb to be composed of *six* parts. The *upper* (or *fore*) limb is attached to the trunk by the *shoulder* "girdle." In man, two bones form this "girdle." In a bird or reptile, we should find at least three distinct bones. One of these three bones, man possesses in a modified condition.

The *scapula*, or shoulder blade, is the first of the two shoulder bones. It is a triangular, flattened bone, lying on the back and upper part of the chest. Outside it has a strong ridge (the *spine* of the shoulder blade) for the attachment of muscles. To the outer side, there are seen two prominent projections. The spine of the bone ends in one of these, the *acromion process*, and to this process the collar bone of that side is attached. The other process is the *coracoid process*. This, in the bird or reptile, is a *distinct bone*, and forms, in fact, the chief support of the fore-limbs in these animals. The coracoid process overhangs a shallow, saucer-like space, called the *glenoid cavity*. Into this cavity the upper arm-bone (or *humerus*) fits, and thus forms the *shoulder-joint*.

The *clavicle* or *collar-bone* is the second of the shoulder-girdle bones. It is a narrow bone, shaped somewhat like the letter S. It rests by its inner end on the top of the breast-bone, and by its outer end is attached to the "acromion process" of the scapula. No collar-bones exist in hoofed animals (horse, cow, etc.), or in seals and whales. They are small in carnivorous animals, whilst bats, apes, and other animals possess them in perfect array.

The fore-limb of man consists (1) of a single bone, that of the upper arm, called the *humerus*; (2) of two bones forming the fore-arm, and called *radius* and *ulna*, (3) of eight small bones, forming the *carpus* or *wrist*, (4) of five bones (one for each finger) forming the *palm* or *metacarpus*; and (5) of the five *digits* or *fingers*. The fingers, with the exception of the thumb, are composed of three small bones called *phalanges*. The thumb has only two phalanges (as one may see by looking at it), and there are, therefore, fourteen phalanges in each hand.



Holding the arm with the palm of the hand forwards or upwards (when the limb is said to be in *supination*), the *radius* is that bone in the fore-arm which lies to the thumb-side, the *ulna*, its neighbour bone, lying to the little-finger side of the limb. This is the natural position of these bones in man, and the bones lie parallel, as just described, and as seen in the right arm of the skeleton we have depicted. Now, turn the palm downwards or backwards. This action, of extreme utility to man, is popularly supposed to be effected by a "turn of the wrist." This is not the case. In turning the palm backwards or downwards, the *radius* runs round and crosses the *ulna*, so that in this changed posture (known as *pronation*), the relations of the bones are altered. The bones should, therefore, always be described naturally, with the palm forwards and with the radius and ulna lying parallel. It is interesting to note that in many animals (cat, dog, and carnivora generally; elephant, &c.), the *prone* position, with the radius crossing the ulna (as in the left arm of the skeleton depicted above), is the fixed and natural state of the fore-arm.

Five is the greatest number of fingers developed in mammals. They may diminish in number to four (in the dog), three (rhinoceros), two (in sheep, camel, &c.), or one (in the horse). The thumb may be wanting, as in spider-monkeys; and birds want the fourth and fifth fingers. In whales, the number of the *phalanges* (or small bones of the fingers) may be much increased from their numbers in man's digits. In the third finger of a species of whale, as many as fourteen phalanges are found.

The *lower* (or *hind*) *limb* is attached to a *girdle* familiarly named the *haunch*. This haunch, or *pelvis*, consists (1) of part of the spine (*sacrum*), already described, behind, and (2) of two haunch-bones or *innominate bones*, which are united in front. The sacrum is, in fact, firmly wedged in between the two haunch-bones behind.

Each *innominate*, or *haunch-bone*, consists in reality of *three* bones. There is (1) the *ilium*, forming the expanded part of the haunch; (2) the *ischium*, upon which the body rests in sitting; and (3) the *pubis*, or front portion, which joins its neighbour of the opposite side. There is no trace in the adult of the threefold composition of the haunch-bones; but it is only about the twenty-fifth year of life that final union and firm ossification of the three bones take place. On the outer side of each haunch-bone is a deep cup. This is the *acetabulum*, in which the head of the thigh-bone rests to form the hip-joint.

The lower limb consists of (1) the *femur*, or thigh-bone, the longest bone in the body; which, below, joins (2) the leg, consisting of the *tibia* (or shin), which receives the lower end of the thigh-bone and the *fibula*, a long, slender bone lying to the *outside* of the leg; (3) the *tarsus*, or ankle, consisting of seven bones (one less than in the wrist; (4) the *metatarsus*, or "instep" and (5) the *digits*, or toes. The composition of the toes (of fourteen phalanges) is exactly that seen in the fingers.

There is a close correspondence to be noted between the skeleton of the fore and hind limbs. For we see that whilst humerus and thigh correspond, fore-arm and leg, wrist and ankle, and toes and fingers also show a marked resemblance. How these resemblances have arisen, is a difficult question to determine. Perhaps the shortest and safest fashion of solving it is to allege, what development seems to teach—namely, that the fore and hind limbs have been developed from a common type, and owe their divergences to the different uses which, in the economy of animal forms, they have come to subserve.

We must lastly note that the knee-cap, or *patella*, is not, properly speaking, a bone of the skeleton. It is not developed, as the other bones are, but is formed in the *tendon* or sinew of the great muscle of the front of the thigh. Such bones are called *sesamoid bones*. We find these bones developed in other situations, where the tendons or sinews exert great pressure on the parts over which they move.

POLITICAL INFLUENCE OF COMETS IN CHINA. — The frequency of the comets during the last two years, says *Nature*, has been regarded by the Chinese as a very threatening omen. In the tail, which they liken to a flaming sword, they see the emblem of a vengeance which will be poured out upon an unworthy nation. In consequence of the last comet, a decree has been promulgated in the name of the young Emperor, stating that the comet proves the negligence of the officials in informing the sovereign of the misfortunes of the people. A very stringent enquiry is ordered, and it is possible that it will be followed by a radical reform in the Chinese administration.

RAREFIED AIR AS A CONDUCTOR OF ELECTRICITY

Edlund continues his researches upon the subject. A number of experiments are described to show that the phenomena of the opposition to the passage of sparks from terminal to terminal in rarefied air cannot be explained by the theory that a vacuum does not conduct electricity. He carefully discusses the question of the contrary electro-motive force which is developed at the terminals. "It is not the resistance of the gas, but this electro-motive force, increasing with the rarefaction and connected with the electrodes, that presents an obstacle to the passage of the current. Everything is in favor of the hypothesis that vacuum opposes a very feeble resistance to the propagation of electricity." Without the employment of electrodes, one can excite an induction current in a Geissler tube, which is sufficient to produce light. This would be impossible if the highly rarefied gas or vacuum were an insulator —*Phil. Mag.*

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Mr. G. R. Howell, New York, in a recent paper before the Albany Inst., favored the open Polar Sea theory for the following reasons 1. Water-fowl go regularly each spring northward from Greenland for nesting. As the ice-barrier from 73° to 82° is too cold for birds to raise their young, their nesting place must be north of this barrier, and in a milder climate. 2. The occurrence of warm winds from the circumpolar regions, as verified by explorers in high latitudes. 3. The occurrence of furious gales during the long arctic winters, which would be unaccountable if the region for ten degrees around the pole were as cold as the zone of the ice-barrier, and therefore as calm as the equatorial belt.

The class-experiment commonly employed for demonstrating chemical decomposition consists in heating mercuric oxide, and showing that oxygen is given off while mercury remains behind. An easier and beautiful experiment may be performed with crystallized copper formate. This salt, when heated over gas-flame in a dry test-tube, readily decomposes; oxides of corbon are evolved, and a brilliant residue of metallic copper is left. The formate is easily prepared by boiling copper oxide with formic acid, and filtering, On cooling, fine blue crystals are deposited. Although this experiment involves no new facts, I believe its applicability to class-room purposes has been generally overlooked. *F. W. C. in Science.*

AN ASPHALT MORTAR.

The *Centralblatt der Bauverwaltung* describes a patented composition made at a factory in Stargard, Pomerania, which has for some years past been used with perfect success on the Berlin Stettin railway for wall copings, water-tables, and similar purposes requiring a water-proof coating. The material is composed of coal-tar, to which are added clay, asphalt, resin, litharge, and sand It is, in short, a kind of artificial asphalt, with the distinction that it is applied cold, like ordinary cement rendering. The tenacity of the material, when properly laid, and its freedom from liability to damage by the weather are proved by reference to an example in the coping of a wall which has been exposed for four years to the drainage of a slope 33 feet high. This coping is still perfectly sound, and has not required any repair since it was laid down. Other works have proved equally satisfactory. In applying this mortar, as it is termed, the space to be covered is first thoroughly dried, and after being well cleaned is primed with hot roofing varnish, the basis of which is also tar. The mortar is then laid on cold, to the thickness of about three eighths of an inch, with either wood or steel trowels, and is properly smoothed over. If the area covered is large, another coating of varnish is applied and rough sand strewn over the whole. The waterproof surface thus made is perfectly impregnable to rain or frost, and practically indestructible. The cost of the material laid is estimated at not more than 10 cents per square foot, and it is stated that this price can be reduced by at least two cents for large quantities put down by experienced workmen.

Steel Water Pipes—The Chameroy Co. makes pipes of steel plate for conveying water under high pressure. The steel plates are coated with lead on both sides by immersion or otherwise, then rolled to form, riveted, and soldered the whole length, and covered with pitch. The first cost of the steel is not much greater than that of iron, and the steel pipes possess considerable advantages over those of iron. The lead coating is superior on account of the fineness of grain in the steel; the resistance to tensile strain and internal pressure is 50 and 60 times, and the resistance to deformation longitudinally from 30 to 40 times greater, while the superior elasticity of the steel plate permits of the pipes receiving tolerable hard knocks without being permanently deformed. For equal thickness the steel tubes stand twice the internal pressure of the iron, and being both light and strong, they are admirably adapted for laying down temporarily and taking up again.—*Iron.*

Astronomical Applications of Photography.—Professor E. C. Pickering described some photographic work which is now being undertaken at the Harvard observatory. Experiments are being made with various lenses, and on their completion it is intended to take photographs from the whole visible heavens north of 30° south. It is possible, also, that a map will be published. Measurements of the photographic energy of all the brighter stars will be made, down to, perhaps, the seventh magnitude. Besides this, it is proposed to obtain measurements of the color of the stars, by using a large lens of heavy flint-glass, giving as much chromatic aberration as possible. In the centre a circular disk of glass will be placed, slightly thinner at one edge than at the other. The effect will be, that every star will have two images placed side by side. By adjusting the sensitive plate at a certain distance from the lens the blue rays will be brought to a focus; but, in the case of the image formed by the rim of the lens, the violet and ultra-violet rays will be spread over so large an area as to produce comparatively little effect, while in the other image they will have nearly full power. By placing another plate somewhat nearer the lens the violet rays will be focused. A third plate will enable us to focus the ultra-violet rays. By comparing, in each case, the image formed by the edge of the lens with that formed by the centre, a series of quantitative results can be obtained, which will vary according to the spectrum of the star measured. By this method any variation of color as well as of magnitude could at once be detected.—(*Amer. acad. arts sc.*; *meeting Feb.* 14.)

PROCEEDINGS OF SOCIETIES.

The Institution of Civil Engineers: Mr. Brunlees, in the chair. A paper was read on "the Productive Power and efficiency of Machine-Tools, and of other Labour-Saving Appliances, worked by Hydraulic Pressure," by Mr. Ralph Hart Tweddell, M. Inst. C.E.

The Author stated that he had occasion to design a machine, which was required to exert great pressure in a confined space at a considerable distance from any shafting. The machine had to be portable, and to be capable of doing a large amount of work efficiently without the intervention of skilled labour. Such conditions were of common occurrence, and in this instance all were successfully fulfilled by the employment of hydraulic pressure. The Paper was an amplification of the subject of the application of this power to actuating machine-tools, and other labour-saving appliances in engineering works, and was divided under three heads, namely, the introduction and development of hydraulic-pressure machine-tools; the productive power and efficiency of machine-tools generally, and the modes of increasing them; and the increased productive power and efficiency obtainable by the employment of hydraulic-pressure for working machine-tools and other labour-saving appliances. Reference was made to the unpublished experience existing on these questions.

Under the first head an illustration was afforded by a small portable hydraulic apparatus for fixing the ends of boiler-tubes in tube-plates, the pressure of water employed varying from 1 to 1¼ ton per square inch. Owing to the introduction of high steam-pressures, the scantlings of marine boilers had to be considerable increased, but the mechanical riveting-machines formerly in use were mostly inadequate to make steam-tight joints. In 1865 the Author designed a hydraulic riveting-plant to overcome the difficulty. It consisted of pumps, an accumulator, and a riveting-machine, and in operation was seven times more economical than hand-work; moreover its surplus power was available for hydraulic presses for "setting," or joggling, angle and tee-irons. In action it was found that the material was much less strained, and that the wear and tear of the moulds and dies was greatly reduced, besides which the machines were movable. Previous attempts to perform similar work by portable machines driven by steam had not been very successful. This, it was believed, was the first hydraulic-pressure riveting-machine which could readily be applied at different points and over considerable areas, and at the same time maintain an uninterrupted connection with the accumulator-pressure in the mains. The system had been extended to machinery of sufficient gap to span the deepest girders, the same hydraulic power which actuated the heavier machines being utilized for lifting them. The water driving these machines and their lifting apparatus was supplied under a pressure of 1,500lbs. per square inch. Amongst the first to employ them was the firm of Sir William Armstrong and Co. Several instances were then given of their application: for riveting *in situ* the lattice-girder bridge which carried Primrose Street over the Great Eastern Railway at Bishopgate Street Station; for riveting locomotive boilers; for fastening rivets in gun-carriages and in agricultural machinery; for railway waggon-work, and for riveting ships. The substitution of hydraulic machinery for punching and shearing metals had been more gradual, but it had proved economical, and had been employed for shearing the links of chain cables 3 inches in diameter, both sides at one time. To obtain the full advantages due to the application of hydraulic pressure to machine-tools, the system should be applied throughout the works. This had been first carried out completely at the French naval dockyard at Toulon for building iron and steel war ships. A similar plant had since been erected at the shipyard of the Gorges et Chantiers de la Loire, at Penhouet, near St. Nazaire, illustrations of which were given, as also of another machine at Brest, which was now being constructed from the Author's designs. Other applications of hydraulic pressure were then referred to, such as for forging and stamping. The Authors held that the successful carrying out of hydraulic forging would depend greatly on the skill brought to bear in making the dies and moulds.

As to the productive power and efficiency of machine-tools generally, and the mode of increasing them, the Author observed that the cost of manufacturing depended upon the productive power of the tools employed, and upon the possession of facilities for transporting the material to and from them. Ample lifting and transporting arrangements should be provided in all cases. At present a large amount of lifting was done by manual labour, in which there was room for great improvement. Owing to the necessity hitherto of using belting or gearing for working them, power-cranes had only been applied to machine-tools to a limited extent as a means for increasing their output The Author pointed out that by the adoption of portable hydraulic machine-tools a great saving in floor-space might be effected. The introduction of hydraulic capstans had practically annihilated space in docks and railway-yards, and as the hauling of a given weight on a good road required less power than lifting it, an extended application of such machinery to engine-works was to be anticipated. The suitability of this system to increasing the output of large engineering shops and ship-yards was evident, and safety in lifting was ensured in hydraulic cranes by the impossibility of workmen putting on them a greater load than they were calculated to bear.

On the third head, namely, the increased productive power and efficiency obtainable by the employment of hydraulic pressure for working machine-tools, the Author observed that so far as the prime mover was concerned, the power necessary in a hydraulic system to pump water into the accumulator was nearly always obtained from a steam-engine; but even at this early stage the hydraulic system, by the use of the accumulator, allowed of a considerable reduction in the size of the motor. A comparatively small prime mover running continually, stored up sufficient energy to meet any sudden demand from even the largest of the machines worked from it; while, on the other hand, the prime mover would have to be equal to this. This defect was to a small extent met by the use of fly-wheels, which were, however, objectionable from their liability to accidents, and from the strains to which the shafting was subjected. From 200 to 300 blows per minute had been obtained in hydraulic machines, and in machine-tools and cranes the accumulator acted as a perfect safety-valve. Then, for the transmission of power to points distant from the prime mover, hydraulic pressure was the most economical. By the use of hydraulic mains laid underground, all overhead shafting was dispensed with. Under the present system lines of shafting, to a great extent, regulated the position of the machines. In a recent case, 48,000 square feet were required with shafting, while 32,000 square feet only were necessary when arranged for hydraulic transmission. In this case the cost of all the roofing and flooring of a building 300 feet long, 53 feet wide, and 25 feet high was saved. A pipe of 1 inch bore could transmit nearly 6 5 h.-p. at a very moderate velocity of water, and a 2-inch pipe about 25 h.-p. All danger from the use of belts and pulleys was avoided, and when once laid in the ground it needed no further attention.

The next question was as to the suitability of hydraulic pressure to actuating the tools. It had already been employed for slotting and planing-machines, and its application to rotary machines might even become as economical as any other. The simplicity and fewness of parts in all hydraulic machine-tools was a source of great economy. In respect to the economical application of force through each individual machine when performing such an operation as punching, the machine was moving at its lowest speed, and friction was at a minimum when most work was being done. Again, hydraulic machines consumed no power except when actually doing work, while it was not unusual in a machine-shop to see all the shafting running in order to drive a small tool at its extremity. With hydraulic machines it was immaterial whether the machine was 2 feet or 2,000 feet from the accumulator, only the exact quantity of water necessary to perform the operation was consumed. In conclusion, the Author stated that apart from questions of economy attention might be directed to several of the advantages arising from the application of hydraulic power to special cases. In riveting-machinery it rendered it possible in one and the same machine to close the plates with a steady pressure, to fill the rivet-hole without forcing the metal of the rivets in between the plates, and to give the metal a sharp blow; not only could the heaviest machine be lifted, but the machines could be attached to their work. In punching and shearing machinery much greater accuracy was ensured from the perfect control of the moving punch or knife, whose descent could be arrested even after it had touched the plate. Steel plates were less injured when punched by steady hydraulic pressure. Hydraulic punching and shearing-machines required no foundations, and could be readily taken on board ship, thus saving much carrying to and fro of plates. It was often desirable to follow up the effects of a sharp blow by maintaining a continued steady pressure. This was illustrated by the Author, who described an "impact" accumulator, and pointed out the difference of effect of a number of light blows as compared with one heavy one in the case of hydraulic riveting. Similar conditions applied to forging. The indirect advantages due to the uniformity of all the work applied also to the flanging-machinery, and in fact to everything passing through dies and blocks. He thought that even small firms might find it advantageous to combine in the erection of a common pumping-station, and so to obtain many of the economical benefits due to carrying out operations on a large scale.

The second Paper read was on "Stamping and Welding under the Steam-Hammer," by Mr. Alexander McDonnell, M. Inst. C.E. It was observed that the making of iron forgings under the steam-hammer in moulds or dies of simple form had long been practised. They had commonly been of scrap or fagotted iron, were often roughly finished, and much heavier than necessary, requiring too much to be taken off by planing or shaping to finish them. Very few forgings had been produced of a complicated shape, or built up of several pieces, under the hammer when common bar-iron was used. The steam-hammer had always been employed for welding in completing the rings of waggon-wheels, and in stamping wheels according to the system of Mr. Arbel. So far as the Author was aware, little had been done to make smaller forgings, welding together several pieces. He thought sufficient care had not been taken in the drawing office to design forgings so that they could be stamped, and that proper precautions had not been observed by the manager of the works or the foreman-smith, to arrange the material, so that the welds should be made in the right way, the metal flowing in the right direction to fill the mould, and the grain of the iron placed so as to get the greatest strength. Stamping in moulds gave a uniformity and accuracy which afforded great advantages where large numbers of similar oblects were made. The Author had carried out the system of stamping and welding carriage and waggon iron-work for some years at the Inchicore Works of the Great Southern and Western Railway of Ireland. He contrasted the cost of stamped forgings as compared with forgings by hand, showing that for the more complicated forms, the former process was the cheaper. Although for some purposes the steam-hammer was necessary, he believed many forgings would be better made by hydraulic forging-presses. Finally, he explained the method of making stamped forgings, by giving a detailed account of the manner of forging a number of different articles, which had been selected as fair samples of forgings of carriage and waggon iron-work.

Meeting on Feb. 13th., Mr. Brunlees in the Chair. A paper read was on "The Design and Construction of Repairing-Slipways for Ships," by Mr. T. B. Lightfoot, M. Inst. C. E., and Mr. John Thompson.

After reference to the first introduction of cradles on roller by the late Mr. Morton, of Leith, in the year 1819, a description was given of a modern slipway, capable of dealing with vessels of about 2,500 tons gross weight, and up to 300 feet in length. Four sections were dealt with in detail, viz., the foundations, the ways, the cradle, and the hauling machinery, and allusion was made to the gradient, which had generally to be determined by a consideration of the amount and value of land at disposal, by the depth of water to be provided over the cradle, and sometimes by the natural slope of the ground.

The foundations were described as not being difficult or expensive, except in special cases, as the weight of the vessel and cradle was spread over such a large area as to reduce the pressure per unit to a very small amount. Piling was objected to unless the whole length of the way was thus supported, as it was important to obtain uniformity of bearing thoughout the entire length in order to avoid excessive local stresses. The cast-iron rails upon which the cradle travelled were then referred to, and the method of laying and fixing them on the timber-ways was explained.

With regard to the submerged portion of the ways which usually had to be put in place with the assistance of divers, various proposals for shortening the slip, and so decreasing the expense of construction were dealt with. These were first, making the cradle telescopic, so that when run out the several divisions close up, while as soon as hauling commenced they opened out to receive the vessel; and, secondly, enclosing the upper part of the slip within watertight walls, provided at the bottom with a pair of gates. Both these systems had been adopted by the Authors, but the latter were only applicable in cases where there was a sufficient rise and fall of tide. When diving had to be resorted to, the submerged portion of the ways was first of all framed together on land, and the rails laid. It was then floated out over its final position, and sunk by laying on a sufficient weight of stones, the ground having been previously prepared by dredging and levelling up with ballast.

The construction of the cradle was next mentioned. The timber used was generally American oak, put together in the form of three ribs, one at the centre and two at the sides, over the outer lines of rails. The ribs were braced together and mounted on strong cast-iron wheels with wrought-iron axles running in cast-iron carriages. Across the ribs were beams of wood or iron carrying sliding bilge-blocks worked from the vessel itself Ploughs, stays and pawl-gear were provided, as well as wrought-iron guides, for convenience in placing the vessel.

The hauling-up machinery was described as being now generally actuated by water-pressure, though in some cases, engines with gearing were use, especially in slipways for small vessels.

The Authors then detailed the working of a slipway, mentioning the preparation and running down of the cradle, which sometimes was permitted 90 to 40 feet over the end of the ways, and the floating on of the vessel, which was guided by hawsers from the quay or jetty, and by the cradle-guides. After hauling-up had commenced, the ship gradually settled down on the keel-blocks, and the sliding bilge-pieces being run in in, it was drawn out of the water seated on the cradle. In launching the process was reversed. Two instances were then given of methods by which more than one vessel could be taken on a single slipway at one time. The first was by means of hydraulic presses placed under the keel of the ship. which enabled the weight to be transferred from the cradle to blocks supported entirely on the ground, so that by providing the cradle with swinging arms, it could be run down out of the way and prepared for receivihg another vessel. In the second method (Thompson and Cooper's), two cradles travelled on distinct sets of rails, with slightly different inclinations, so that the vessel might be transferred from one to the other, according as the two cradles were simultaneously hauled up or lowered down.

Morton's hydraulic hauling-gear, in which the links had to be disconnected at the end of each upward stroke, in order to take out a length, and permit the ram to travel back and be reconnected, was then described; and after pointing out the serious loss of time occasioned by this operation, the Authors proceeded to show how, by improved gear, loss of time was avoided. With this apparatus there was no disconnecting of links, which merely travelled up and down the ways according as the rams were on their outward or inward stroke, connection with the cradle being made by pawls attached thereto, which geared with the links on their upward stroke, and slipped so soon as they were reversed. During the short time the links were stationary in reversal at top and bottom, water was accumulated under pressure, and given out when the rams travelled in one direction or the other.

Reference was made to Messrs. Hayward, Tyler and Co.'s hauling-gear also to that introduced by Messrs. Day and Summers, the former being objected to on account of its cost, and the latter from the difficulty in obtaining wire ropes sufficiently durable to work under the heavy strains to which they would be subjected in a large slipway. Formulas were given for calculating the practical dimensions of the hauling gear, and the expense of working a slipway was stated, both for Morton's system and for that of the Authors.

The average cost of construction of a slipway was very difficult to determine, but it was stated that a slipway to haul up vessels weighing 2,500 tons, with 850 feet of ways, hauling-machinery, links, and one timber side-jetty, would probable come to £25,000 without the land.

In conclusion, the Authors said they did not advocate the indiscriminate use of slipways, but the choice of their adoption or otherwise must be left to the Engineer, after a survey of the ground, and a careful consideration of his resources. They thought, however, that in many situations the slipway possessed advantages in regard to first cost and facility in execution which should specially recommend it to the capitalist; while, from a shipowner's point of view the better ventilation around the vessel when it was withdrawn from the water, the opportunity afforded for inspection, and the short time occupied in hauling up and and launching were very important features.

The paper dealt with only such methods as were generally in use, and did not attempt to describe arrangements and modifications which might be desirable in special cases. Reference was however, made to the combined floating-deck and slips as first carried out in 1851 at Philadelphia, the total cost of which was about £163,000.

AMERICAN SOCIETY OF CIVIL ENGINEERS.—7th March, 1883; Wm. H. Paine in the Chair:— FLOW OF WATER IN PIPES.—A paper on this subject was read by Hamilton Smith, jr. M. Am. Soc. C. E., of San Francisco. This paper gave the results of many experiments upon the discharge of water through circular pipes ranging from half an inch to four feet in diameter, and with velocities from one-sixth of one foot to twenty feet per second. Wednesday evening, March 21st. The death on March 8th was announced of James O. Morse, one of the earliest members, and who had been Secretary of the Society for 15 years, and Treasurer 21 years. An interesting collection of specimens of native wood was presented by John M. Goodwin, member of the Society. The subject of a continuance of tests of structural materials was considered. The Secretary made a statement of what had been done up to the present. Mr. O. Chanute, Chairman of a Committee on this subject, related the effort that had been made to secure larger appropriations from Congress: and the subject of the besth metod for conducting and continuing tests and of collating results so as to secure desirable information, was discussed.

Letters were read from General S. V. Benét, Chief of Ordnance, stating that the programme adopted for continuing tests of structural materials would be carried out on the Watertown testing machine to the extent of the very small amount appropriated by Congress, and the Circular from the Chief of Ordnance, embracing that programme was also read.

A resolution was adopted to the effect that it was the sense of the meeting that a Special Committee should be appointed by the Board of Direction, to prepare and promote such a programme of tests of structural materials, as to secure the best results possible from the Watertown Arsenal Experiments.

ENGINEERS' CLUB OF PHILADELPHIA.—Meeting on Feb. 17th., Henry G. Morris in the Chair. A paper by J. M. Stewart on the DELAWARE BREAKWATER HARBOR IMPROVEMENT was read.

The construction of the Delaware Breakwater was commenced in the year 1829, upon plans submitted by a Board of Commissioners, appointed by the Congress of the United States.

The project of the Board contemplated the construction, in the concavity of the Delaware Bay, just inside Cape Henlopen, of two massive works on the "pierres perdues" or rip-rap system, separated by an interval or "gap" of about one-quarter of a mile, the greater called, the "Breakwater," to be about twenty-six hundred feet long, and fourteen feet above low water, to afford safe anchorage during gales from the north and east; the other called the "Ice Breaker," to be about one-half the length of the greater work, and of the same height, to protect shipping against northwesterly gales and heavy drifting ice of the bay.

The stone used in the construction of these works was uncut and varied from one-quarter of a ton to seven tons in weight, the smaller constituting the bulk of the mass, the larger being used to cover the exterior slopes and to sustain the direct impact of the sea.

During ten years the progress of construction was such, that by 1839, eight hundred and thirty-five thousand tons had been deposited. From this time on, work was done irregularly, until 1869, when the works were completed as they stand at present.

The Breakwater is two thousand five hundred and fifty eight feet long on the top, the Ice Breaker thirteen hundred and fifty-nine feet. The average width of both is twenty-two feet on top, one hundred and sixty feet at the base, and each is about fourteen feet above mean low water.

The Breakwater Harbor for many years fulfilled, so far as its capacity enabled it, the design of its projectors in projecting the commerce of the country. But the growth of this commerce, particularly the last twenty-five years, has so far exceeded possible anticipation, as to practically exclude more than a fractional part from the intended shelter. At various times, therefore, projects looking to the enlargement of the projected area have been the subject of deliberation by officers and boards of engineers and the matter received renewed attention during the fiscal year just closed, from the reference by the Chief of Engineers of the U. S. A., to a report of Major Wm. Ludlow, Corps of Engineers, U.S.A., showing comparison of a recent survey with former ones, and not only was the protected area yearly diminishing relatively to the amount of shipping seeking shelter, but was also undergoing a positive and serious deterioration from a marked decrease in depth. In view of this deterioration, a board of engineers recommended as a possible remedy, the closure of the "Gap" existing between the Breakwater and adjoining Ice Breaker, which, it is believed, will, to a greater or less extent, check further deposits within the harbor and remove those existing on the shoals in its vicinity, and also increase the protected area of anchorage nearly fourfold.

It is proposed to close this "Gap" by means of a concrete superstructure resting upon a granite rip-rap foundation, described generally as follows:

A bridge of creosoted timber is first to be constructed completely across the "Gap," with bays of sixteen feet long. Each trestle is to be formed of three piles, the centre pile vertical, the others inclined, and forming with the cap a profile for the concrete work. A double railroad track is to be laid on the bridge for the transportation of material.

Upon the completion of the bridge, it is proposed to begin the deposit of the rip-rap (the granite used weighing not less than one ton, the average being three to the block), laying the same uniformly across the "Gap" to prevent scouring of the bottom, and to gradually raise the height of the rip rap to twelve feet below mean low water, with a width of forty-eight feet on top, and a side slope of one-half on one.

The concrete superstructure is to begin twelve feet below low water, with a base of twenty-four feet wide, height twenty-four feet, side slope of four on one and a width on top of twelve feet.

The concrete is to be built in blocks of the above cross-section and length of sixteen feet, corresponding to the length of the bays of the bridge. For this purpose the bays are to be enclosed with detachable aprons forming boxes, to be filled in succession, the boxes containing at each end a triangular reentrant, which, after the two adjoining boxes have been filled can be taken down and likewise filled, forming square plugs to bind together the larger blocks. To hold the said aprons in position, tie-rods will be used, passing through pipes, the the extremities of which will be flush with the exterior surface of the concrete.

The aprons and tie-rods used in the construction of each block can be removed and used again as soon as the mass shall have attained the requisite solidity.

The closing of the "Gap" between the Ice Breaker and Breakwater will be begun at once, and it is expected that the work will be completed in about five years.

Dr. H. M. Chance reported his experience with the Loiseau Fuel in domestic use. He found the ash low in weight, but high in bulk. His conclusion was that it is a good fuel for open grates and for manufacturing purposes.

March 3rd. Mr. Horace See described the S.S. "Mariposa" built for the Oceanic S. S. Co. of San Francisco, Cal., by the Wm. Cramp & Sons, S. and E. B. Co., of Philadelphia;

The Mariposa is of the following dimensions: Length, 330 feet; breadth, 41 feet; depth of hold, 26 feet; gross tonnage, about 3000 tons.

The vessel is of the three-deck type, with the addition of a flush hurricane deck, extending fore and aft and from side to side, the hull being carried up to meet it. On the hurricane deck forward, are located the social hall, pilot house and state-rooms for captain, 1st and 2nd officers, and aft, a small house for smoking-room.

The vessel will have two masts and one oval smoke-stack.

The grand saloon is located on the upper deck, forward of the machinery space, extending from side to side, with state-rooms for 100 first-class passengers arranged forward of it and amidships on both sides of the machinery. The principal wood used in the finish of the saloon will be oak, relieved with maple and mahogany. In place of the old-fashioned dead eye side light, square openings of liberal size are cut in the sides, provided with iron shutters on the outside and glazed sash on the inside. This arrangement will add vastly to the comfort of the passengers. The incandescent electric light will be fitted all over the ship.

The accommodations for officers and crew are to be on the upper deck aft of the machinery space.

Steam steering gear of approved make will be located in pilot house, with hand power attachment in reserve. Screw-gear will be placed aft for additional security. A steam windlass, with capstan, will be arranged forward and two steam capstans aft. A steam deck pump will be provided both forward and aft. There will be steam elevators in each of the main hatches for loading and unloading cargo.

The propelling machinery will be of the independent, compound, inverted, direct-acting, three-cylinder type, of about 3000 horse-power, with the high pressure cylinder 43 inch diameter, the two low pressure 61 inch diameter, and all 51 inch stroke of piston. An independent centrifugal pump will be used for circulating water through the condenser, and for freeing the ship in case of a large leak. The engines will be reversed by the steam gear made by this firm. The propeller will be built up, and made of charcoal iron. Steam of 90 pounds pressure will be supplied by two single ended boilers. For part use and emergencies at sea, a large donkey boiler will be placed on upper deck. For hoisting ashes an arrangement of steam gear, dispensing with any attendance above, designed by one of the owners, will be used. Steam pumps for feeding main boilers, for extinguishing fire, etc., will be located in machinery space.

The Secretary presented, for Prof. Mansfield Merriman, a description of a Graphic Solution of Cubic Equations.

Mr. Wm. P. Osler presented a table for Bolts, Nuts and Threads, prepared by M. H. C. Slaney, Gas Engineer and himself.

The Secretary presented tracings of device for holding transit pole vertically, and shelf for holding field instruments in vertical position while temporarily out of use in office, contributed to the Club by Mr. Charles E. Chandler, Civil Engineer, Norwich, Conn. The former consist of a bubble tube, framed at right angles to the rod, and the latter of a shelf notched out to admit the legs under the tripod head and provided with a slide in front to retain the instrument in place.

The Secretary read a communication from Mr. C. René, of Stettin, describing a process for the drying of wood, intended especially for the preparation of wood for musical instruments, but perhaps otherwise useful. It is described as follows:

The wooden boards are so arranged in a large iron kettle, that gases may freely circulate over their entire surface, and exposed, in the first place, for twelve hours to the drying effects of hot air; after this the kettle is closed, reheated by the apparatus below and the air exhausted, when the kettle is filled with the oxygen ozodized by electrical sparks passing continually between two points of platina, forming the end poles of two wire conducted through tubes of glass into the kettle. The ozone is said to act so energetically upon the heated wood that it consumes the destroying resinous, oily or other parts in from 12 to 24 hours.