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ARCHITECTURE AS A SCIENCE.*

(*With special relation to Construction, Engineering and Modern Requirements.*)

BY A. T. TAYLOR, M.R.I.B.A.

(*Continued from page* 67.)

The late Mr. Street has well said, "The best thing in Architecture is always that which combines the most sagacious use of the materials, the soundest construction and the most convenient adaptation to the requirments, with thoroughly good artistic character and proportion in the masses and in all the details, and some evidence of imagination in the design."

We see, therefore, that Architecture spans two hemispheres, that of mechanics and the industrial arts on the one hand, and the fine arts on the other. She has two expressions—prose and poetry. It is the former of these that we shall chiefly consider to-night.

As building was the forerunner of architecture, so the useful must ever take precedence of the ornamental.

It is an axiom, which may appear self-evident, but which is often forgotten, that a building should be perfectly suited for its purpose. No building, however beautiful, is architecturally perfect which ignores this. It is, therefore, and must be utterly wrong to set down exact copies of Pagan temples, or Moorish mosques, or mediæval castles, all of which were doubtless well suited for their time and for their purpose, but with our entirely altered circumstances, are now quite unsuitable.

This, however, is what was done not so very many years ago, and we have yet pitiable examples of the practice. Temples of rectangular shape, with studied invariable proportions, and balanced parts which required no windows (such light as they needed being received from the roof), and no chimneys, were made to do duty for modern churches and dwellings, and all sorts of devices were resorted to in order to concealt he windows, chimneys, and other necessary adjuncts to modern houses. The mediæval castle, with its machidolated battlements intended to protect defenders and present embrasures from which cannons could be fired or missles discharged, the overhanging spaces, down which molten lead could be poured on the besiegers below, and other features very necessary and desirable for the times in which they were built, are surely hardly suitable in our peaceful times, when the only projectiles flung from the housetops are frozen snow and ice, and the only warders "tuning their footsteps to a march" behind the battlements, are sundry predatory or amatory members of the feline tribe.

We have also in England and Scotland many examples of buildings sacrificed to a mania for external uniformity, regardless of convenience within, and I have often seen cases in which it has been necessary to enlarge the house by adding on a wing at one side, a screen wall, corresponding with this wing being placed on the other side for the sake of uniformity. The door and portico were fixed in the middle, and windows were ranged in solemn array on each side, no matter whether they were wanted or not, of exactly the same size and height. If there was a plain surface of wall, the most original idea which could occur to the builder was to put in a blank window, and paint on the cement the window frames, the glass, and even window blinds and red tassels, all so like life as to be very deceptive—a long way off.

From an utterly false idea of art everything had to be balanced by perfect similarity, somewhat after the manner of the old Scotch gardener who had a summer house at each end of a long walk in the garden, and having caught his master's son pulling apples had shut him up in one of the houses, where his father discovered him. On his going to the other house at the other end of the walk he found his other son in durance vile also, and asking if he also had been pulling the apples, the old gardener said "No; but he had put him in there for the sake of symmetry!"

It is true there must be a balance of parts in all good compositions, but this by no means needs to be by exact similarity. The old builders of our English, and especially of continental cathedrals and churches understood this, and if you will carefully examine them you will find that where, for example, there are two towers or spires at the one end, they are generally not only of

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*A lecture delivered before the Faculty of Applied Science, McGill University.

unequal height, but of a different design, preserving a perfect balance of harmony, but not a perfect identity that, wherever it was possible they rejoiced to vary their work. Thus it must ever be with all great souls who are not content to be mere machines: they must give expression to their great thoughts ever surging up in new forms, and cut and hew a way for their heaven-born ideas to get to the light of day.

In designing anything, the exterior should be the outcome of the internal arrangement, and should express such, and this is the only sensible mode of designing for us. If a window is wanted, put it in when and where it is wanted; if a chimney is required, run it up; if a balcony is desired, throw it out. You will not have a dull, dead uniformity, but you will thus have a sensible, living picturesque architecture.

In designing, the climatic requirements must be taken into consideration. This fundamental principle I pointed out in my first lecture. Underlying are the striking differences we found in the architecture of the different countries of the world, and the ignoring of these has produced much of the confusion of modern building.

Thus we find that in warm countries with much sunshine and little rain, porticoes and colonnades, deep recesses, where cool shadows may sleep, comparatively flat roofs are common features of the buildings, while in more northern and gloomier regions we find the high pitched roofs to throw off rain and snow quickly, and the absence of colonnades, except in the shape of porches and such like, where they were useful for shelter while waiting. It would puzzle "say" a New Zealander a hundred years after this if he had to judge of the climate from the buildings, to say what it had been. Should many of the buildings be standing then, which I very much doubt, he would see high pitched, low pitched, and flat roofs; open faced buildings with large, welcome-looking windows, side by side with morose, jealously-guarded, narrow-windowed bastiles; sham porticoed Greek temples, elbowing, fantastic, dutch, high-gabled fronts; cathedrals inspired by that lovely poem in stone at Salisbury, staring out of countenance, cathedrals built on the lines of Bramante's and Michael Angelo's great work at Rome.

Yet there is a good deal to be said for the peculiar requirements of a climate such as we have here, which combines an Italian Summer with almost an arctic Winter.

How are we to reconcile these two distinct climates, so as to make our buildings suit both? That is a problem which I hardly think has been satisfactorily worked out yet, but has to be faced before we can establish a truly national and good architecture.

Our buildings should be designed to suit the materials they are to be built with, whether stone, brick, terra cotta, wood or iron. This also was an important factor, as we found in shaping the ancient styles of architecture.

Where stone could be readily quarried in large masses, there we found an architecture developed in which large stones were essential. Such, for example, is the Greek. Build one of their temples with small stones or bricks, and you destroy at once a large part of its beauty.

It was essential to have the lintels in one piece, all the columns also were in large stones, and the ancient Egyptians had a clear understanding of the value of large monoliths in monumental architecture when they set up their remarkable monolithic obelisks, 60, 70, 80 feet high. These, with their hieroglyphic inscriptions, are striking and imposing because of their being in one stone. Had they been built up in twenty or thirty layers they would have been common-place.

The adaption of the arch by the Romans made building with small stones or bricks possible, but until they developed a style of their own, their imitations of the Greek were necessarily imperfect and unsatisfactory.

The Gothic is *par excellence* a small-stone style of architecture, and it is possible to build a cathedral with stones none of which need exceed the carrying strength of two or three men. The brick and terra cotta architecture of Italy, much of which is beautiful and suggestive, shows what can be done with the commonest materials, if only treated in a common-sense way, and if its own capabilities are recognised.

Red brick may be said to be the fashion just now, but it has more than fashion to recommend it. The question of colour in architecture I hope to refer to in my next lecture. The difficulty has been how to obtain a good brick which would stand the weather and frost, the average brick being soft and unreliable for external faces of walls. Where pressed bricks were desired the custom has been to obtain them from the States, but there is a very good pressed brick made here in Montreal which seems to answer all the requirements of the case, and they have the advantage of being much cheaper than those from America so that you have the gratification at the same time of fostering native industry.

Even wooden buildings can be made very beautiful, of which there are many examples in the chalets of Switzerland and in Norway, not to speak of Japanese and Chinese houses, and I must own to a feeling of great disappointment in travelling through Canada to see how utterly prosaic and devoid of all taste, or even attempt at architectural effect, the wooden houses of the farms, villages, and settlements are.

Even time, which lays her gentle finger upon and beautifies most things, seems to have despaired of beautifying a Canadian frame house, for they seem to get uglier if possible with age.

There is also a great field for effective construction in the combination of timber framing and brick and plaster; skilfully and artistically arranged and designed they give most beautiful results. There are many such buildings in all parts of England, some of them 200 and 300 years old, and they form as at Chester and elsewhere, some of the most interesting domestic antiquities we possess.

Terra cotta is also a valuable building material. It was in common use by the Romans, and there are many interesting examples of its use in various parts of Italy. If of good clay and hard burnt it stands the weather better than most stones, and is almost imperishable: it has also the advantage of being fireproof. It has of recent years been reintroduced, and one of our leading English architects, Mr. Waterhouse, has largely used it in many of his important buildings, notably in the new Natural History Museum at Kensington, a clever and striking building full of strength and energy with great fertility of design and freedom of execution.

One great advantage of the material is that you can get the artist-workman's own impress on the work, and another that within proper limits you can get a reduplication of any design with more econony than in stone.

Herein however, lies its danger. The facility of reproducing in any quantity a given design, whether it be a carved panel or a moulding, is apt to degenerate into machine work and lifelessness unless carefully watched.

It is beginning to be used in the States, where they are also making it, but with only partial success as yet. The results of my endeavours to use it here were not very encouraging, but doubtless, when they understand the manufacture of it better, the result will be more satisfactory.

I come now to an important material for constructional purposes and one which will in all probability come more and more into use, viz., *iron*. This is almost entirely a modern material as regards its use to any large extent in architectural or engineering construction. It was, you may say, entirely unknown for this purpose to the Greeks, the Romans, and the medæval builders, and the uses to which it was placed was in the shape of tie rods to tie the springings of arches together, which had in sufficient abutment as in many of the Italian Gothic buildings and monuments; or in the form of a chain to equalize the thrust or pressure as in the domes of St. Peters' at Rome and St. Paul's, London.

It is an interesting question to know what the builders of the great cathedrals and monuments of antiquity, would have made of iron, had they been as conversant with it, as we are.

The wrought iron of the mediæval ages and of even earlier times, is so lovely, in the uses to which they put it, as in gates, railways, grilles, screens, balconies, etc, that one would fain believe that they would have been able to shew good work with the other also.

It is in this material that engineering draws closest to architecture.

Before the era of iron, and the inauguration of railways, adoption of drainage schemes, water works, etc., all work such as bridges, buildings, etc., which we would now call more distinctively engineers' work, was designed by architects and was considered part of their work. Your Chairman will not, I am sure, feel aggrieved when I say that the engineer was unknown.

Those benefactors of their race had not yet risen upon the scene, as a special class.

But for the reasons I have named and partly owing to the apathy and conservatism of the architects of the time, the men who devoted themselves to the problems of the new forces then awakening, came to be designated by the name of engineers. Those of you who propose becoming engineers have a noble ancestry numbering many talented and great men. You are the heirs of noble achievements and the future of your profession has even brighter things in store. I suppose that the era of bridge-building in stone is over and that iron or steel will be the almost universal material. From an artistic point of view one regrets this, as to my mind there are no modern bridges so satisfactory in appearance as the well defined old stone bridges.

Waterloo Bridge over the Thames at London, not to speak of London Bridge itself—many of the bridges across the Seine at Paris, the Bridge of St. Angelo, at Rome, the Rialto at Venice, the Ponte Vecchio at Florence, What poetic associations around them! What apparent strength and dignity they have as linking shore to shore they span the turbulent river, as if rebuking the restless rush of the waters!

But all these I suppose must go, before the approach of iron, like the old three-deckers and ships of the line, before the iron-clads. The old stone bridge and the gallant ship with every sail set, were favorite subjects for painters, but who would sit down deliberately and paint an iron-clad or turret-ship, such as the "Devastation" or "Thunderer," or an iron bridge in all its gaunt ugliness. But this is a utilitarian age and the "almighty dollar" is the standard alike for judging men, buildings and bridges.

But with this dirge for the disuse of stone bridges I must freely confess that iron and steel are most valuable materials in architectural and engineering structures, and have made possible the bridging over of wide gulfs and raging torrents, and even seas that would otherwise have been impossible, and also the covering over of large interiors such as markets, railway stations and halls.

Unfortunately when it was first used its utility was all that was thought of, and its appearance was never considered, so that strange and ghastly abominations, speedily began to loom up and confront one in the streets and hang over the rivers like a nightmare, and engineer's architecture became a by-word and a reproach. Mr. Ruskin has lately been lecturing on the plague cloud of the 19th century and attributing it to the degeneracy in the morals and manners of the age. I think he might have included in the list of causes certain engineering monstrosities.

Of recent years, however, there have been great improvements, and when engineers have worked in conjunction with architects, the result has been much more successful, as for example the new St. Pancras Station, in London, the new railway station in Philadelphia and others.

It has begun to dawn on the minds of engineers a directors of railways and others, that a thing may be both ugly and dear, and that a bridge or roof designed on graceful lines with features pleasing to the eye, even without any ornamentation, may be constructed quite as strongly and economically, as one which acts as a constant irritant on a mind with refined instincts and tastes, and is a perpetual blot on the face of nature.

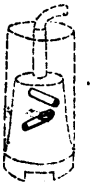
I believe there is more scope for the successful use of iron or steel in engineering works than in architectural. The engineer has been forced by his very circumstances to create new forms and is therefore untrammelled by old ideas and is free to superinduce on the constructive skeleton such features as may make it graceful and growing naturally out of the construction.

The great danger is that to save trouble the engineer will do pretty much as the architect has done, take stone or brick details and have them cast in iron or hammered out in wood work forgetting that the nature of the material must give the key to the shape of detail and mode of ornament and that instead of a genuine ferruginous ornamentation we may have simply a sham stone ornamentation, and we may even consider ourselves happy if it be not painted to imitate stone with the lines and joints of the sham masonry shewn on.

If this be so then there is an end of all hope of improvement on these lines.

To be continued.

BOILER EXPLOSIONS IN 1883.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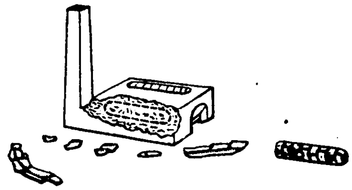
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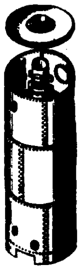
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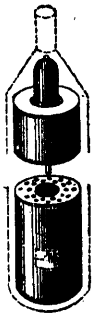
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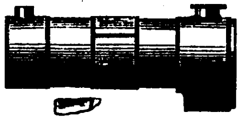
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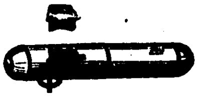
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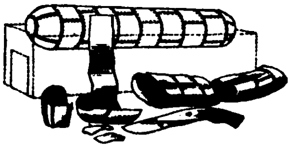
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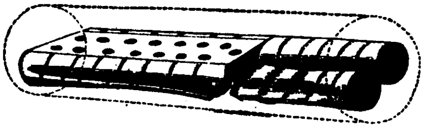
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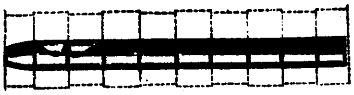
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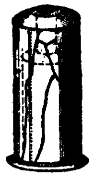
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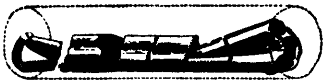
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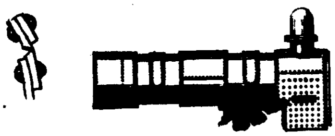
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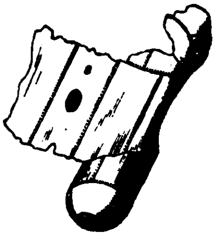
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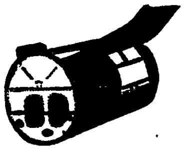
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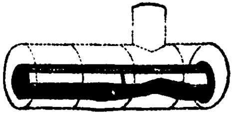
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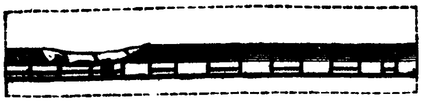
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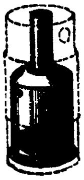
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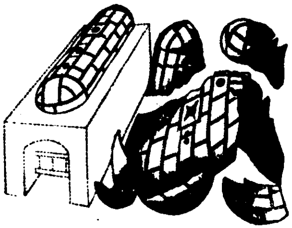
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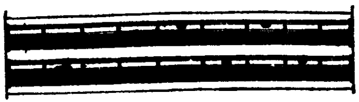
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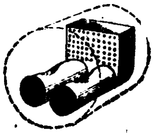
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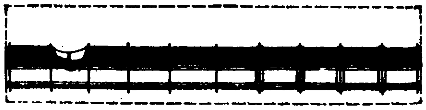
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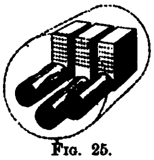
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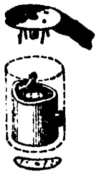
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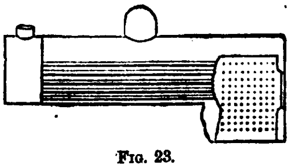
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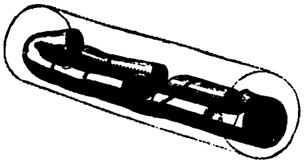
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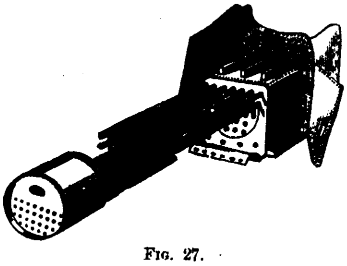
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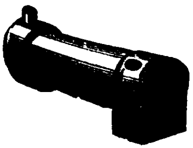
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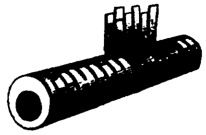
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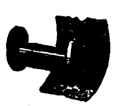
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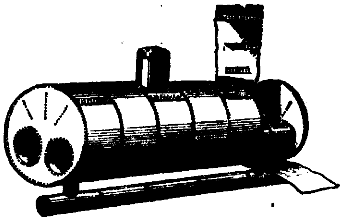
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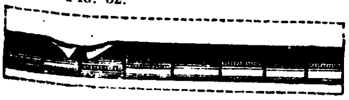
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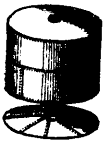
FIG. 37.

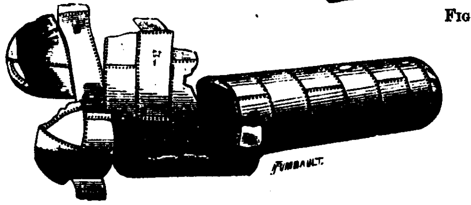
FIG. 38.

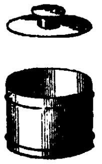
FIG. 39.


FIG. 40.

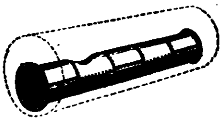
FIG. 41.

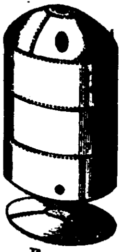
FIG. 42.

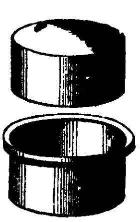
FIG. 43.

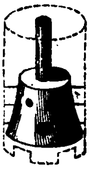
FIG. 44.

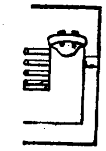
FIG. 45.

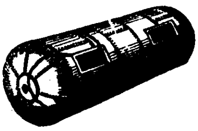
FIG. 46.

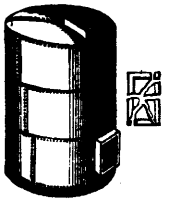
FIG. 47.

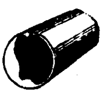
FIG. 48

BOILER EXPLOSIONS IN 1883.—(*Engineering.*)

LIKE our daily contemporaries, we publish from time to time returns of killed and wounded, the list of lives lost or damaged by the greed, carelessness, or incompetence of the makers, owners, and attendants of steam boilers. The information we now give we take from the annual report of Mr. E. B. Marten, the chief engineer to the Midland Steam Boiler Inspection and Assurance Company, whose admirable yearly summary just issued bears evidence that the long-continued efforts of the scientific press and the boiler companies are bearing fruit, though somewhat tradily. The number of lives lost during the year 1883 from the explosions of steam boilers was only 21, a great improvement upon the past, as will be seen by a glance at the subjoined Table, which gives the results, as regards injury to life and limb, of all the boiler explosions of the last eleven years:

Year.	Number of Explosions.	Number of Persons Killed.	Number of Persons Injured.
1873	78	57	85
1874	76	77	198
1875	68	81	142
1876	39	93	110
1877	54	54	75
1878	46	47	84
1879	30	38	53
1880	31	71	83
1881	33	41	51
1882	38	38	43
1883	39	21	41

The following is a copy of Mr. Marten's report:

These were 39 boilers explosions in the year 1883, and they caused the death of 21 and the injury of 41 other persons.

Of the 62 thus killed or injured, 1 was an owner, 4 were sons of owners, 1 was a manager, 9 were enginemen, 9 firemen, 28 labourers, 5 children, and 5 strangers not belonging to the works.

Several very slight steam boilers explosions, or explosions of somewhat similar vessels, are mentioned in an appendix, as not being sufficiently important to put in the records of boiler explosions as given in the past 22 years.

None of the boilers were under the care of this company.

The Exploded Boilers were used for the following Purposes:

	No.	Kd.	In
Steam tugs or boats	6	2	1
Small shops	5	1	12
	No.	Kd.	In.
Iron works	4	6	8
Collieries or mines	4	3	7
Farms	4	0	1
Contractors or builders	4	2	4
Mills	4	3	5
Chemical	1	0	0
Paper works	1	2	0
Tanyard	1	0	1
Soda water works	1	0	1
Quarries	3	0	0
Railways	1	2	1
Total	36	21	41

The causes of explosion are arranged under the following heads:

A. *Faults of Construction or Material which may be Detected before Starting or after Repair.*

	No.	Kd.	In.	No.	Kd.	In.
Weak tubes	2	2	4			
Weak ends	1	0	0			
Seam rips	2	0	10			
Bad joints	1	1	1			
Bad punching	1	0	2			
Bad stays	2	0	1			
				9	3	18

B. *Faults to be Detected by Periodical Inspection.*

	No.	Kd.	In.	No.	Kd.	In.
Internal corrosion	11	6	9			
External "	6	1	4			
				17	7	13

C. *Faults which could be Detected by Attendants.*

Shortness of water ..	7	10	9			
Deposit	1	g	0			
Over pressure, from valves out of order ..	4	1	1			
				12	11	10
Unknown, as vessel sunk				1	0	0
Total				39	21	41

The exploded boilers were of the following kinds, the causes of explosion being stated as in the summary under the heads A B C.

	Cornish or Lancashire.									
		No.	Kd.	In.	No.	Kd.	In.	No.	Kd.	In.
A	Weak tubes ..	2	2	4						
	Rigid ends ..	1	0	0						
	Seam-rips ..	1	0	8						
					4	2	12			
B	Internal corrosion	2	0	2						
	External corrosion	3	0	4						
					5	0	6			
C	Shortness of water	4	10	8						
	Deposit	1	0	0						
					6	10	8			
								15	12	26
	Plain Cylinders.									
		No.	Kd.	In.	No.	Kd.	In.	No.	Kd.	In.
A	Bad repair				1	0	2			
B	Internal corrosion	2	1	3						
	External corrosion	2	6	3						
					4	3	6			
								5	3	8
	Locomotive Multitubular.									
A	Bad stays ..				1	0	1			
B	Internal corrosion or furrow ..				2	2	1			
C	Over pressure ..				3	0	1			
								6	2	3
	Vertical or Crane.									
A	Bad joints ..	1	1	1						
	Bad punching ..	1	0	2						
	Bad stays ..	1	0	0						
					3	1	3			
B	Internal corrosion	2	0	0						
	External corrosion	2	1	0						
					4	1	0			
								7	2	3
	Marine—Ship, Tug, or Boat									
B	Internal corrosion	1	1	0						
	External corrosion	1	0	0						
					2	1	0			
C	Shortness of water	2	0	1						
	Over pressure	1	I	0						
	Unknown, sunk	1	0	0						
					4	1	1			
								6	2	1
	Total							39	21	41

Of the fatal cases, two were in Scotland where no inquests are hold, and, in the other ten cases, the verdict was accidental death, with certain recommendations as to better inspection.

The Board of Trade has made preliminary inquiries under the Boiler Explosions Act of 1882, in thirty-one of the cases mentioned in the records, also on twelve of the slight cases mentioned in the appendix.

As four cases were at collieries, the reports will appear under the Mines Department, while those on shipboard under the Marine Department.

The most fatal cases have been at iron works. The class of boiler most frequently failing has been Cornish or Lancashire, as might be expected, as there are more in porportion to any other kind. The cause of explosion most prevalent has been corrosion which could have been detected by inspection ; and also others which might have been prvented by more care by the attendant.

The models used in making the sketches for the annual records were lent during the year to scientific societies or gatherings of engineers, at Middlesbrough, Newcastle-on-Tyne, and Stoke-on-Trent, and addresses were given with simple experiments upon various matters bearing on the subject of boiler explosions. Some of the these addresses are printed with full illustrations, and from an addition to the introduction of vol. ii. of the records.

The general extension of the system of covering all risks by assurance has caused a demand for large sums to be assured on boilers, with comparative indifference on the part of those asking for it, as to securing that inspection which should accompany it. The long experience of twenty two years confirms the importance of that independent periodical inspection which is the primary object of this company to provide, and it is hoped that the perusal of these records will assist in showing the owners of boilers the importance of making prvoision for the proper carrying out of inspection, in the interest of both safety and economy.

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WIRE-GUN CONSTRUCTION.

BY MR. JAS. A. LONGRIDGE.

Before entering on the specific subject of the paper, the Author referred to a number of documents received by the Institution from the Ordnance Department, U. S. A. These were mostly translations from the works of Virgile, Rosset, and Clavarino,and related entirely to the Hoop-Constructions of Guns. The conclusions and formulas arrived at by these authorities completely bore out those of the Author's Paper of 1860, and the fundamental formulas, agreed with those derived by Lamé, Hart, and Rankine. The formulas, however, required modification in certain circumstances, when account was taken of the action of lateral forces, whether of tension or of compression.

In guns constructed on the Author's principle there was no strain on the core or coil in the direction of the axis of the gun, so that only the radial compression-force had to be considered ; it was shown that in no case was this very important, and that its effect vanished when the modulus of elasticity of the material of the gun was the same throughout. Virgile came to the conclusion that no part of the gun should be strained beyond its elastic limit, whether in tension or compression. Whilst agreeing with this as regarded tension, the Author came to a different conclusion as regarded compression. This from his own experience might be largely exceeded without detriment, and in this he agreed with Clavarino, and expressed the opinion, fully confirmed by experiment, that a compression of three times the elastic limit was perfectly admisable. Both Virgile and Clavarino attached great importance to the proper determination of the shrinkages, in this respect agreeing with the Author, who had always contended that Sir William Armstrong and the Woolwich authorities were wrong in assuming that if the actual shrinkages were in excess of those indicated by theory, the gun would shake itself right by repeated firing. This view the Author contested ; he pointed out that it would only be true if the excess strain caused a permanent set just equal to the original excess shrinkage ; that it often happened that the permanent set was greatly in excess of this, and in such case the gun was reduced to the condition of deficient shrinkage, and it might be of no shrinkage, and would then inevitably fail. The Author next referred to the failure of a 6·3-inch gun on board H.M.S. "Daring" on the 22nd February, 1883, resulting in the death of two men and the wounding of three others during target-practice. From calculations made by him, the Author concluded that the failure of this class of gun was certain, if the powder-pressure was not kept down to about 10 tons per square inch, the effect of which on the efficiency of the gun need not be stated. He thought it probably that, owing to the method of construction, this gun did not actually burst, but was torn asunder by the successive permanent sets loosening the hold of the hoops upon each other between the breech and the trunnion. After referring to Rosset's experiments on "Special Elasticity," or the extension of the "Elastic Limit" by stretching, the Author pointed out that inasmuch as this only took place when stretching was the effect of mechanical force, and not when it resulted from contraction in cooling, this property was not available in the ordinary method of gun-construction, though it had some effect on the behaviour of a gun under fire. After careful consideration the Author was forced to the conclusion that the construction of a perfect hooped-gun was beset with enormous practical difficulties, and that the present armament of the country was unreliable.

Turning to wire guns the Author remarked that there was a good deal of misconception on the subject. It was not that a material in the form of wire was much stronger than the same material in mass, and that the method of coiling it on was expeditious and convenient. This was true; but the essential feature of Wire-Gun Construction consisted is the facility it afforded of bringing the body of the gun into the proper state of varied initial tension, in order that, when the powder-pressure acted, every portion of the coil might be equally strained to a pre-determined tension. Thus the important question was to determine the proper tension with which to lay on the wire. It was maintained by some that the tension should be uniform, and by others that it was sufficient to lay the wire on with just enough strain to ensure close contact. The latter plan had been adopted by Dr, Woodbridge in the 10-inch gun constructed at Frankford Arsenal, in 1873, for the United States Government. After briefly describing that gun and its mode of construction, the Author pointed out the impossibility of its proving a success, being wrong both in principle and in practice.

The Author then proceeded to enunciate the problem, and to enumerate the variables on which it depended. By a series of diagrams he showed that by a proper formula it was possible to determine the exact laying-on tension of each coil of wire, so that when the powder-pressure acted, every wire should be uniformly strained to the allowed limit, which should always be kept well within the elastic limit of the wire. The diagrams also demonstrated the strains both of the coil and of the core, when under fire and when at rest. There were three sets of these diagrams, in the respective cases where the modulus of elasticity of the core was 4,500 tons, 9,000 tons, and 22,000 tons, that of the wire being 22,005 tons throughout; and they showed clearly the great advantage of a core of low modulus. In the next section the Author dealt with the case of laying-on the wire with uniform instead of varying tension, and by a series of diagrams he showed how very important it was to determine the proper amount of this tension if uniform. He also showed that for each individual gun there was one "particular" tension of laying-on which gave the best result, and that this particular tension might be found by the formulas. The formulas and diagrams also demonstrated the condition of the respective guns when under fire and when at rest. A further set of diagrams showed the serious error that had been made in Captain Schultz' 34-centimetre guns, if the account of its construction in the United States Ordnance Report was correct. Clavarino's hypothesis, that the strength of a gun was measured by the "extension" and not by the "tension" of the material was shown to be ill-grounded. Proceeding to the objections which had been made to wire-guns, namely, want of longitudinal strength, derangement of tensions by heating, and crushing the core by the compressive action of the coil, the Author pointed out that such objections had no validity, provided the gun was constructed properly. The next section of the Paper was devoted to a brief examination of the practice of "chambering." This was maintained to be only a device for reducing initial pressure of the powder gases to such an extent, that it would not overcome the inherent weakness of the guns of the present day. A comparison was made of two 14-inch guns, one with a large chamber, the other unchambered, and it was shown that whilst the two guns were equally strained by the explosion, the chambered gun, with 500 lbs of powder, imparted about 19,000 foot-tons of energy to the projectile; the unchambered gun, with 413 lbs., gave nearly 30,000 foot-tons. Some remarks were then made upon slow-burning powder, and it was maintained that it was a retrograde step as regarded ballistic effect, and was only called for by the weakness of the gun.

The principal inferences drawn from the investigations on which the Paper had been founded were three :—

First, the paramount importance of a proper, formula for the laying-on tension of the wire. Second, the advantage of a core of material of a low modulus of elasticity, such as cast iron. Third the advantage of a thin core. In an Appendix were given the principal formulas for the construction and the calculation of the strength of these guns, and a few examples of their application.

THE production of the Lake Superior copper-mines for 1883 was sixty millions pounds of copper.

TELEGRAPH OFFICES IN CANADA.—The total number of telegraph offices in Canada is 2,259, the highest number *pro rata* to the population of any country in the world.—*Electrician.*

ROADS AND STREETS.[*]

BY JAMES MOFFATT.

Roads are built for the purpose of affording quick, safe, and economic carriage, and in order to attain this, regard must be had first to their location, grade, cross-sections and cost.

Location.—In all old settled countries the opening of a new road is a tolerably easy work to an engineer, for not only can trustworthy maps of the district through which it is proposed to run the road be had, but even the general characteristics of each farm, such as nature of the surface, whether under cultivation, or wooded, or marshy, &c., are obtainable in the different Registry offices, so that he can make an approximate location before proceeding to any instrumental examination.

But in a new country it is a much more difficult matter; no maps that give anything but the most general information are obtainable, and unexpected difficulties are constantly arising as the work advances.

To surmount these, unless the surface of the country is very level as on the prairies of the North West, it is advisable to make a reconnaissance or rough survey of the district, noting all the features that are connected with road location, as streams—their size and easiest places for bridging, nature of their beds and banks, direction of flow, &c.; the hills and ridges—whether they form part of a range or not, their direction if they do, their height, &c.; the soil—its suitability for road-making, &c., and whether the country is wooded or not, &c.

Money spent liberally in these surveys is by no means thrown away. In the construction of the Canadian Pacific Railway some of the favoured routes through the Rocky Mountains were found quite impracticable when preliminary surveys were made.

Having thus obtained an approximate location of the road, it is then finally located and constructed by the ordinary methods of surveying; and here much of the future value of the road depends upon the work.

The road must be as straight as possible or the cost of building and keeping it in repair will be unnecessarily large, and carriage over it will be slower and consequently more expensive; but straightness must be sacrificed whenever a level road can be had instead of one with steep ascents and descents.

The grades should be no greater than can possibly be avoided, for travel over steep ascents and descents is slow, besides being attended with more or less danger, and smaller loads too must be taken or else additional tractive power supplied. It often happens that a road around such a place, though it may be more than twice as long, affords quicker and safer transit.

A rise or fall of one foot in 35 is generally considered as the maximum grade; down this a horse can trot rapidly with safety.

When the carriage over a road is greater in one direction than another, the descents may be made slightly steeper in this direction for the sake of economy.

Shape of the Road-bed. In Canada the majority of the roads and streets are 66 feet wide, and when traffic demands a greater width, they are usually made 99 feet wide. Avenues are commonly this latter width.

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[*] Summer Report in course of Civil Engineering, McGill University.

The road-bed itself is of different widths, varying from 16 and 17 feet in country roads, and 25 and 30 feet on principal thoroughfares, to 50 and even 60 feet where the traffic is great and where there is much pleasure driving.

Where the road runs down a long hill-side or mountain by zig-zags, it is usual to make it several feet wider at the curves connecting the straights.

This road-bed is hardened in many ways as will be afterwards seen in order to make the traction as light as possible. It is made in the centre of the road-allowance, so that the sidewalks and drains may be placed on either side when necessary.

FIG. 1.

Its shape is governed by the following requisites :—(1), it must wear down evenly; (2), it must not not wear concave and keep its centre a pool in wet weather; (3), it must permit the water to run off rapidly into the ditches at its sides; (4), and it must be of such a shape that vehicles will travel over it in all parts indifferently.

Taking these circnmstances into consideration the cross-section of a bed formed by two planes with their angle at the centre slightly rounded (Fig. 1) is the best.

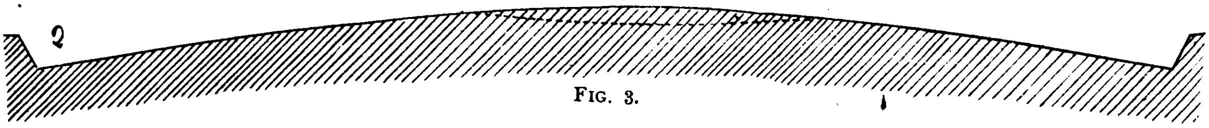


FIG. 3.

Another form, that of a convex curve, is often davocated (Fig. 2); but it does not meet any of the requisites of a good cross section, for vehicles will not leave the ridge as the sides are too steep, so the wear is consequently uneven, and as shown by the dotted linein the figure, it will retain water in its centre until it sinks into the road-bed, the very place where it is not wanted.

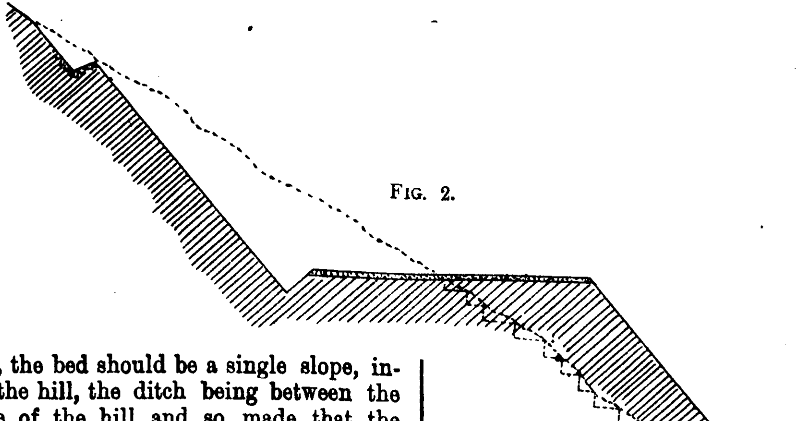


FIG. 2.

On a hill side, the bed should be a single slope, inclining towards the hill, the ditch being between the bed and the side of the hill, and so made that the water can be carried along the side of the road either to convenient places for making culverts, or for certain distances where culverts should be put in.

In this case the road-bed (Fig. 3) is usually made half in excavation and half in embankment, allowance being made for shrinkage in the latter.

To provide against sliding, it is well to cut the earth on which the embankment is made in steps, as in Fig.

An open trench at the top of the cutting should also be made for the purpose of intercepting the water and preventing it from washing down the earth on the slopes.

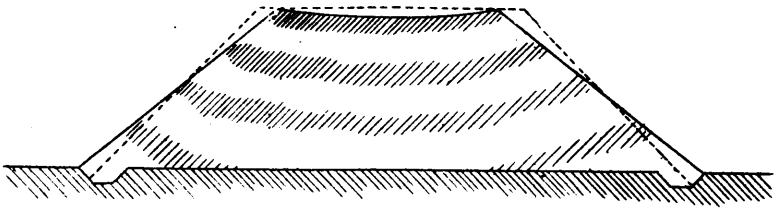
When the hill is very steep, the slopes of both cuttings and embankments should be revetted either with stone walls or timber.

Roads over marshes will be noticed under "corduroy roads." In all fillings it is usual to make the road-bed wider at the top and correspondingly narrower at the bottom, so that after the road becomes fully settled it comes to the required dimensions. (Fig. 4) explains this fully. Fillings are advantageously kept concave on the top, as the water gathers there and hastens the settling and hardening of the road materially, and the shape, too, tends to prevent slides.

In all cuttings, slopes of 1 in 2 will in most cases be found sufficient, but the deeper the cut the more gentle should the slope be. When the earth is very light and easily washed down by rains, all deep cuttings should have retaining walls at the foot of their slopes, sufficiently high to hold all the wash of a wet season When springs are disclosed in cuttings they should be tapped and carefully led off.

Drainage.—This is a very important subject in road building and too much attention cannot be paid to it. The side drains should not only be able to carry off all water that falls on the bed, but also cut off all surface

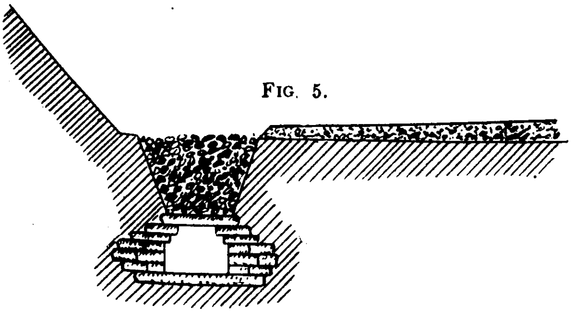
FIG. 4.



water from filtrating under it from the adjacent ground and rendering the substratum soft. In a fairly level country these drains should be about 3 ft. below the bottom of the road-covering; this depth with say two feet depth of road-covering would give 5 feet of side exposed to the drying effect of wind and sun, and will usually ensure a good dry road if water is not allowed to remain on the top.

Covered drains are necessary in cuttings where open side-drains would soon be filled by "wash." Fig. 5 shows an excellent method of constructing them.

FIG. 5.



Culverts for carrying the water from one side of the road to the other and for allowing small streams to pass under it are made in various ways. In the average Canadian road it is usual to make them of squared timber, with side of about 18 inches. Two or three sticks on each side, one on top of the other, form the two sides of the culvert, the width depending on the amount of water likely to pass through at the time of freshets. On these there are laid several sills, which support the roadway, made of planks 3 or 4 inches thick, and laid down at right angles to the direction of the road. The bottom is commonly covered with small stones to prevent any underwash.

Where timber is not in plentiful supply culverts are made of stone and should have a concrete floor to prevent underwash doing injury to the stone-work foundation and the road-bed. (Fig. 6.) In streets that are paved, gutters 3 inches in depth are sufficient to gather all water from the carriage-way and convey it to the drains and sewers of the city or town.

The plot and profile of the line, the establishment of grades and calculations of cuttings and fillings are made by the customary methods of surveying.

CLASSIFICATION OF ROADS.

EARTH ROADS, or as commonly called in Canada, mud roads, are the simplest kind and are the foundation of nearly all our thoroughfares. They are everywhere the pioneer roads, owing to their easiness of construction, for they are merely the natural surface of the ground with the smaller ridges cut down, and the hollows filled with the earth taken from them and the side ditches, if they ever have these.

In summer they are dusty, and in wet seasons they are very muddy, especially if there is any heavy traffic over them; but they are the easiest of all roads for driving on, a carriage running over them as smoothly and noiselessly as if on a carpet.

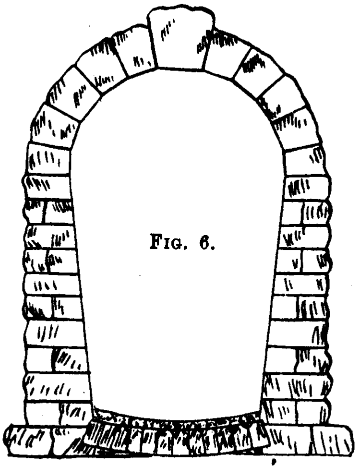


FIG. 6.

Their grades should be easy, not exceeding 1 in 30, and the surface should not slope less than 1 in 20 to ensure a dry road. The side ditches should be deep and large.

In sandy soils a top layer of pasty clay makes a great improvement, as the sand and clay two pack together and soon form a fairly solid bed. If the soil is a stiff clay the addition of a layer of sand will have a like beneficia leffect.

The ruts made in the fall and spring should be filled in with coarse gravel as soon as formed so that it will be pounded down and worked in with the mud before the road gets dry in the summer. By doing this carefully for a few years a very compact and solid bed is made.

CORDUROY ROADS.—When such a road as the one just described came to a marsh in early days, as it was useless to build it further the settlers had recourse to another primitive kind of road, a corduroy.

As Canadian swamps are usually well stocked with cedar, and pine, they felled these along the proposed road and towards it to lighten the work of hauling them, cut them into lengths of about 16 or 17 ft, lopped off all branches close to the trunk, and laid them down at right angles to the direction of the road on two others laid lengthways with it and partially sunk in the ground, so that those on top would not sink down into the soft ground unevenly, being careful to leave but the smallest spaces possible between them.

When they wished to improve the road they split some of the straightest trees into three or four pieces with triangular cross-sections and inserted these edge downwards in the open joints, placing them so that their top surfaces would be on the same level as the tops of the logs.

In some instances roads are built through country totally unfit for settlement, as pioneer waggon-roads for the advancement of railways.

The Canadian Pacific Railway, owing to its passing through such a country from Mattawa, westward through the districts of Nipissing and Algoma, has been compelled to build a road along its located line to forward supplies, &c., in order to have a greater number of miles of road under construction at the same time.

Nothing but a mud road is, of course, attempted, for as soon as the end of the iron reaches any spot on this road it is at once disused. Drainage is rarely attended to, owing to its being too expensive for the amount of use the road is put to. The road is built as near the located line as possible, in order for it to be convenient for future operations when the grading is being done, and as the most level ground is sought for for the railroad, it is to be expected that a large number of swamps and low-lying stretches of ground will have to be crossed. This is the case especially in Algoma. In one particular instance the line crosses a large spruce flat, about five miles long, and with no high ground in any reasonable distances on either side. The flat is plentifully timbered with large spruce, tamarac and balsam. In some places the water was two or three feet deep for half a mile at a stretch, when the location party went through early in the month of June.

To cross this cheaply, the following method might be tried, Fig. 1.

Clear the necessary width of road, trimming the branches, some that are tolerably straight, and throw them on the part where the road is to be made, at right angles to its direction, in order to form a bed to keep the logs from sinking much in the soft ground. On top of them lay logs, the same way as in preparing for a corduroy—that is, two logs laid in the direction of the road, trimmed, &c.,—an additional one in the centre would be a great advantage. On these lay the cross logs, notched, so as to prevent their rolling, one every eight feet would probably answer well, the number depending on the size of the logs. On top of these again lay another three in the same way as the first, and also notched to prevent rolling. Care should be taken that the odd numbered rows break joint with each other. If this raises the road-bed sufficiently, the cross-logs that form the roadway are then to be laid in the same way as in the ordinary corduroy road.

Where fair timber can be had, an additional thickness of two logs would raise the road high enough to make it dry where such a road could be built with any degree of cheapness.

The advantage of such a road is that it is cheap as regards labour, easy of construction, and least expensive in a very swampy piece of country. The timber, except, perhaps, some of that used in the roadway, is uninjured, and may be made into ties when the end of the iron reaches it.

As the country became more thickly populated these roads were covered with gravel and earth and were considered complete.

The opening in the woods caused by the filling of the trees has a very beneficial effect on the ground along the road, as the sun and wind getting at it dries it up considerably.

Military engineers build roads over wet and marshy ground in a somewhat similar manner to this, but instead of using timber, they use fascines or bundles of brushwood, 18 ft. long and 9 inches in diameter, securely fastened at 12 places with withes, spun yarn, wire or hoop iron, the two latter answering the purposes best.

They are laid crossways in one, two, and three layers according to the requirements of the place, the top row being always at right angles to the direction of the road.

The whole is covered with gravel sloped 1 in 30 from the centre. It makes an excellent road, easy and springy, and for these reasons valuable for the transport of artillery.

It might safely be used by civil engineers, for it is light and little liable to settle in wet ground, and not only for this reason but also on account of the difficulty earth would have in working up through it as it sank, especially if put down in three layers. It has also the advantage of using no valuable timber.

As the country, in its better sections, becomes settled, this method of road-making would be a very suitable one. Every bit of brush is suitable for making the fascines, and the hazel might be used for the bands.

Cutting and scattering this under brush over the road way has been tried along the Algoma Mills Branch of the Canadian Pacific Railway, but as no earth was put on top of it the natural consequence is that when the brush got dried out, a horse stepping on it makes it fly up in every direction. For a temporary road way the spreading of six or seven inches of earth over it would make it serviceable.

Plank Roads.—Plank roads were once somewhat in use in localities where lumber was cheap and gravel scarce, but are now seldom made. They were built alongside of earth roads for use in wet weather and were usually only about 8 ft. wide; the planks, which were 3 or 4 inches in thickness were laid on sleepers about 5 ft. apart and as in figure 8. The object of this arrangement was to prevent long ruts being made at the edge of planks and to assist vehicles in getting on the plank covering again after they had turned off, as of course one would always have to do from the narrowness of the road.

The sleepers should not be placed deep in the ground or they will form form serious hindrances to the drainage of the road. A good dimension would be 12″ x 3″ and laid flat.

However, it is not a successful kind of road; the planks twist and warp, and so get loose and displaced and render travel over them disagreeable and dangerous. A good gravel road will in time prove much more profitable in most localities.

Gravel Roads.—Gravel roads in Canada have been nearly all built on the top of mud ones, and have consequently good beds to begin upon. In choosing material, gravel that is coarse and varying in size from $\frac{1}{2}$ inch to $1\frac{1}{2}$ inches is best and should not be water-worn but should contain sufficient earthy matter to make the two bind well together. Gravel from lake shores and beds of rivers is not suitable for road-metàl, the pebbles have become rounded by the action of the water, and all the little roughnesses that would once have greatly assisted their consolidation in a road-bed, have been removed. Besides the sandy loam has been all washed away, so that it is quite unsuitable for road covering unless other materials are mixed with it.

Before using gravel dug from pits it should be screened through a sieve with wires $1\frac{1}{2}$ to $1\frac{3}{4}$ inches apart so as to clear it of all large pebbles, and then through a second one with wires $\frac{3}{4}$ ins. apart. Those pebbles which do not pass through the first must be broken if used; and the earthy matter which passes through the second sieve should not be used in making the roadbed at all, but will answer for side-walk coverings.

In applying the road metal, a layer of 4 inches of gravel should first be spread over the road bed and vehicles then be allowed to pass over it until it becomes almost consolidated; the ruts as fast as they open being filled in. A second layer should then be put on 3 or 4 inches in depth and treated in the same way as the first; and finally a third layer, but the aggregate thickness need not exceed 12 inches.

It should be packed each time with either a steam or horse roller, a light one of about 2 tons weight being used for the first layer so as not to pack it too well together and hinder the second one binding with it. For the other layers a heavy one of 6 tons and upwards in weight may be used.

If the gravel becomes too dry to pack well under the roller it should be moistened with water.

The side ditches should drain the road bed at least 15 inches below the bottom of the road covering.

Macadam Roads.—Macadam roads, so called from the name of the man who first introduced them, are made with broken stones.

From observing heavy vehicles pass over newly made gravel roads and noticing how the more or less rounded pebbles rolled and pushed one another about when under the wheels and that the road began to consolidate only after long traffic over it and after the pebbles began to get broken, he came to the conclusion that all the stones should be broken into angular fragments by hand and that no large stones should be used. He even went so far as not to allow any earthy matter to be mixed with them, but this when carefully tried on the roads of the New York Central Park proved to be a mistake, as the broken stones even under the weight of a 12 ton roller would not pack so much that they would not loosen under the action of wagon wheels and horses' feet.

French engineers consider that the cleanliness of the stone is unnecessary as the travelling over the road very soon pulverizes part of the stone and fills the interstices with dust, &c.

Some engineers think too that just enough calcareous matter should be added in advance as will fill up these vacancies.

The stone to be used should be very hard and tough; basalt and trap are perhaps the best. Limestone is good too where the traffic is not very heavy but is apt to wear and is dusty in dry and slippery in wet weather.

For the bottom layers softer metal may be used as it is not exposed to any grinding action.

According to Macadam, stones should be reduced to pieces not exceeding 6 oz. in weight, which corresponds to a cube of about 1-5-inch in side. The stones are broken either by hand hammers or by machines, the best known of which are made by Mr. Blake and can break from 3 to 7 cubic yards of stone per hour according to size of machine.

The thickness of the road covering need not exceed 10 or 11 inches, 5 to 9 being frequently sufficient. Macadam laid the metal metal down simply on the natural ground after the bed had been prepared by levelling, sloping, draining, &c., first a layer of 3 inches thickness, then travel was admitted or a roller used, ruts raked in when formed and when almost consolidated, a second layer was added of same thickness and proceeded with in same way and so on until the necessary thickness was reached.

The broken stones need not be spread over a greater width than 12 to 16 feet except near large cities; for roads little used 8 or 10 feet will be enough.

A binding layer of about an inch in thickness, of gravel or hard pan, is sometimes added when the last layer has become nearly consolidated.

Telford Roads.—Telford roads are only an improvement on Macadam ones. A foundation of "bottoming" of pieces of stone 4 to 7 inches in dimension being set on the bed by hand on the broadest edges and lengthwise across the road, the 7 inch ones in the centre, and the smaller ones towards the sides as in Fig. 9. Above this "bottoming" the road metal is spread as in Macadam roads.

The superiority of the Telford road over the Macadam depends on the following:—The smaller stones of the road metal get between the "bottoming" stones at the tops of their joints and act as wedges, tightening and making stiff this "bottoming" foundation, and so hindering heavy traffic making depressions or hollows in the road surface above.

REPAIRING OF GRAVEL, MACADAM AND TELFORD ROADS.—These roads must be constantly repaired to keep them in a good state for travelling on, as the very toughest metal soon gets ground into dust under heavy traffic, and as a rule they seldom are;—ruts are formed, into which all the rain that falls on the road runs, and lies until it soaks down into the road covering and bed, so that instead of being comparatively dry roads a little wet weather makes them muddy for days.

All these roads should be repaired during wet weather, if possible, the upper surface of the part to be mended being first slightly loosened with a pick, and the new layer then spread uniformly over it and carefully rolled otherwise, the new metal will not bind.

Street Pavements.—Street paving at present is a subject of much discussion, and to say what kind is really the best is a difficult matter. A good pavement must in the first place be durable, so that it will seldom require renewing and repairing, and must be capable of being taken up without injury for the purpose of putting in and repairing sewers, and water and gas pipes; it must give a firm foot-hold for horses and yet be smooth and easy for driving upon; it must be free from dust and noise; it must be able to carry off all

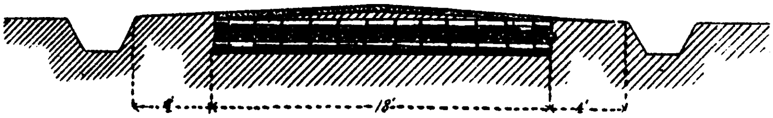


Fig. 7.

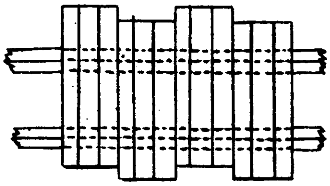


Fig. 8.

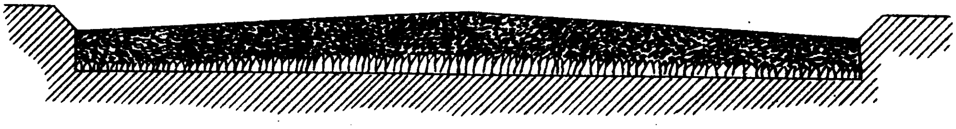


Fig. 9.

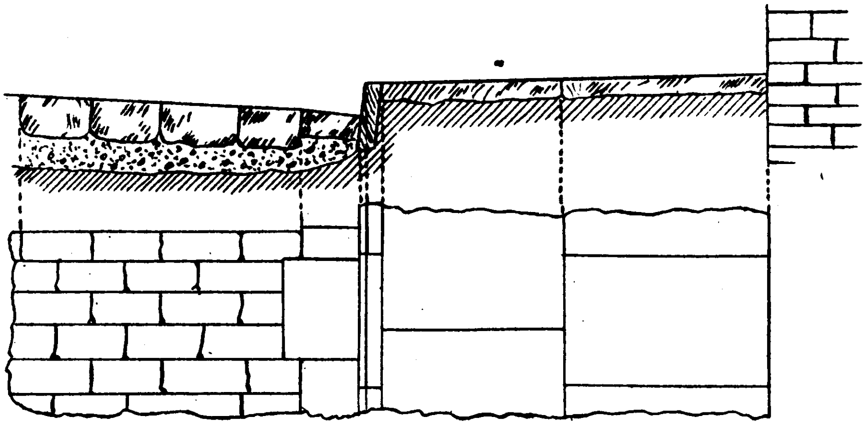


Fig. 10.

liquid refuse called sewage; and lastly it must be easily cleaned.

Foundations.—For all pavements good foundations are absolutely necessary, and the want of them is one of the most frequent causes of the failures of pavements. They should be made of some incompressible material and of sufficient thickness to keep the bottom of the pavement from the subsoil.

The chief foundations are those of sand, of broken stone, of pebbles, and of concrete.

For stone pavements, sand is one of the best, owing to its incompressibility, and is laid down on a well-pounded prepared bottom in a layer of about 4 inches in depth, then wetted thoroughly and pounded; two other layers may then be added in like manner, and the whole when well rammed should measure about 8 inches in depth.

Two additional inches of loose sand may then be spread over the whole so as to fill up the joints of the stones from beneath.

Broken-stone foundations are prepared in the same way as macadamized roads, and should not generally be less than 8 or 10 inches in depth. A few inches of clean gravel spread on the top completes the foundation.

Pebble or cobble stone foundations are used chiefly for dressed stone pavements to rest upon. They are set in a bed of sand a foot or so deep.

Concrete foundations should be composed of 1 part of Roman cement and 1 part of sand mixed together dry; the whole then mixed with 8 parts of broken stone using as little water as possible. Upon firm subsoils 6 or 7 inches properly rammed in one or two layers will be sufficient; other soils in proportion. In a few weeks it becomes strong and though it may crack a little, its superiority over all the others can scarcely be doubted.

Section of Street.—In cities and towns the road bed is usually the whole width of the street less the width of sidewalks and gutters. The road-way is separated from the sidewalks by a row of stones called the curb stones, set on their edges, their tops flush with the sidewalks, to allow the water to flow over them into the gutter. Their lower edges should be below the street pavement, to which they form an abutment. The gutters should extend from these curb stones some 15 or 16 inches, and this part should receive special care in paving. The slabs used for this should be 3 feet long at least, 15 or 16 inches wide and 6 inches thick; they are laid flat. (Fig. 10.)

Stone-block Pavements.—The material used in this pavement should be tough and hard, should not

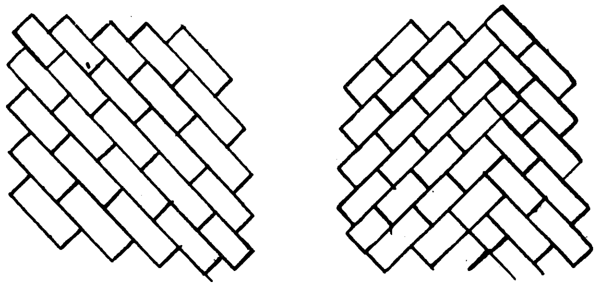


fig. a FIG. 11. *fig. b*

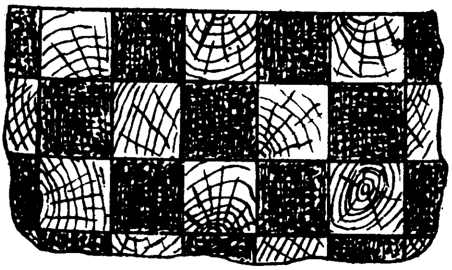


FIG. 12.

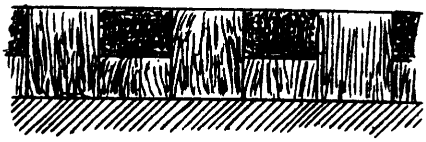


FIG. 13.

wear smooth, but always remain rough on the surface, so as to give foot-hold to horses, nor should it wear readily; and lastly the blocks should be of uniform depth else the less deep ones will settle more in the sand as there must necessarily be more loose sand under them to bring all flush.

Fig. 10 shows how sidewalks, gutters and pavements are connected.

A good size for the blocks is 3½ to 4½ in. broad, 9 to 12 or even 15 inches long and 8 or 10 inches in depth. Some engineers recommend cubes of 8 inches side as a good size. They must be packed closely in continuous courses, with their length across the street, and joints broken.

When the stones are laid, as in the plan above, with their courses at right angles to the direction of the street their edges are found to wear away owing to the shocks from the wheels, &c., so to prevent this they are laid frequently with their courses making an angle of 45° with the roadway as in either *a* or *b* (Fig. 11). When the street slopes if the V of figure *b* is placed with its point up the slope the flow of the water into the gutters is greatly assisted by the joints of this coursing.

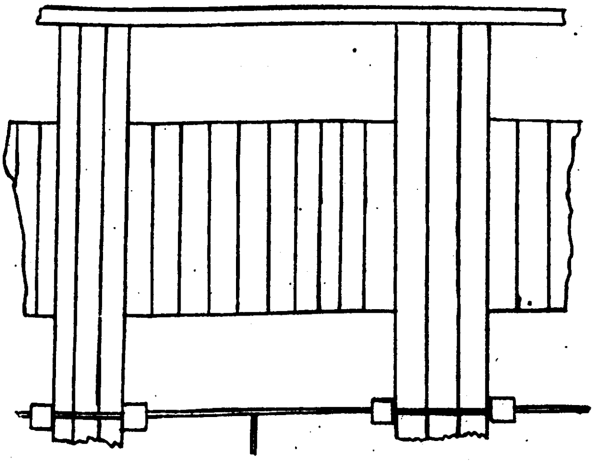


FIG. 14.

The stones are sometimes set firmly in a bed of stiff mortar cement and not disturbed until the mortar has set. Some builders advocate that the joints as well should be filled with mortar and this certainly would give a very compact road.

The blocks are set in contact with each other and a thin layer of sand poured over them and allowed to work well into the joints.

Lately in Toronto, Ont. in discussions as to the relative cost of the different pavements, it was estimated that stone-paving would cost the city $2.50 per yard when laid down; to this was added 50 cents per yard for replacing and repairing the surface stone once in its average life; so that the total cost of this pavement would be $3.00 per yard for 21 years, which was considered an average life.

In Buffalo, U. S., it is found to be cheaper still, being laid down for from $1.80 to $2.25 per yard.

The principal objection brought against it in Toronto was the noise vehicles made going over it, and this certainly is a serious one on streets where a large retail business is done, though it is no greater than is made going over macadamized roads. Certainly no pavement has been found yet that will stand immense traffic, preserve an even surface, be as durable and as economical as a first-class stone pavement.

WOODEN PAVEMENTS.—Wooden pavements are made of blocks of wood, set on end, with the grain vertical.

That they are slippery in wet weather, and that they do not last long are the principal objections to them. They soon decay owing to the water getting into the pores of the wood; various methods are adapted to prevent this, the principal ones are—Kayne's method, which saturates the wood with a solution of bichloride of mercury or a corrosive sublimate, (one pound in ten gallons of water); Burnetts', which uses a solution of chloride of zinc (one pound in ten gallons of water) absorbed in a vacuum; Renwick's, with coal tar;—Seely subjects the wood to a temperature above the boiling point of water and below 300 ° (F) while immersed in a bath of creosote oil, until the moisture is expelled; when thus expelled the hot oil is replaced by cold oil, which condenses the steam in the pores and forms a vacuum into which the oil goes. There are numerous other methods.

Yellow or white pine and cedar are the woods usually used; they must be free from sap and sound; none but picked wood should be used.

NICHOLSON PAVEMENT.—For this pavement the blocks are made between 3 and 4 inches wide, between 6 and 14 inches long and 6 ins. deep, the grain being in direction of the depth. The blocks for the gutter are sawed to a bevel so as to form a channel about 6 inches from the curbstones.

The foundation is made by excavating the subsoil to a depth of 9 inches and must be shaped to the same form it is intended to give the top surface of the pavement. A layer of clean sand is then put on, and a close flooring of pine boards (1 inch stuff) is laid on this and lengthwise with the street, the ends resting on the same kind of boards laid crossways as sills. These boards are tarred on both sides with hot coal-tar to preserve them, and upon them the blocks are laid, their lower ends being dipped into the tar just before being put down.

As each course of the blocks is laid across the street a baton of common pine 1 inch deep and $\frac{3}{4}$ inch thick is laid at the base of the blocks and nails driven through both baton and block into the floor. The spaces above these batons are then filled with a concrete of clean roofing gravel and hot coal tar thoroughly mixed and rammed down. Lastly, the surface of the pavement is coated with hot coal tar, one inch thick, and covered with fine sand and gravel.

A modification of this pavement consists in making all the blocks of the same dimensions on top, (4″ x 4″ is a good size,) but cutting just one-half of them 3 or 4 inches less in depth than the rest and setting them as in Fig. 13, fill in the spaces with coarse gravel and prepared coal tar or asphaltum, and the whole then covered as before with the coal-tar preparation and sand.

The most common kind of wood pavement in Canada is made with the best picked cedar blocks, about 10 inches in depth and 8 inches in diameter, bark stripped off, and usually left round, but occasionally hewn into a hexagonal shape. They are put down in the same manner as the blocks of the Nicholson pavement, the spaces between them being filled with gravel and hot coal tar as before, and the whole covered with tar and sand and gravel.

In Toronto, Ont., a great deal of this kind of pavement has been put down within the last three years, but as the road bed was not properly prepared, nor was the plank bedding put in, the consequence is that it shows hollows in places. At present Queen street east is being paved in this way and at least one block in every eight or ten has a hole through the centre or has dozy wood there.

That this pavement can stand but a very few years and that it is not a fair test of this method, must be apparent to every observer.

In Toronto it was estimated that this pavement would cost $1.20 per yard laid down, so that taking its average life at 7 years it would cost $3.50 per yard in 21 years without taking into consideration any cost of repairs. Hence a stone pavement would be 60 cents per yard plus cost per yard of repairing blocks cheaper than a block pavement in 21 years, and would have also the advantage of less stoppage of traffic on the street for laying down new and repairing old pavements.

But undoubtedly on a street over which there is no very heavy carriage a block pavement is the best as it is easier for driving on and less wearing on horses and vehicles.

On the whole a stone pavement is best for streets on which manufactories and wholesale houses are built and also on those over which heavy traffic is done, but for streets on which there is light and rapid driving the block pavement is most suited on account of its springiness and quietness.

ASPHALT PAVEMENTS.—Asphalt is a variety of bitumen generally found in a solid state. It is brownish-black in colour, opaque and too hard to be marked with the nail at ordinary temperatures; it has a smooth fracture and no odour unless heated.

It is prepared for use in road-making as follows: it it first broken into small piece, and then combined with bitumen or mineral tar, by heating the latter in an iron boiler, and adding the asphalt by degrees, taking care to stir them well together. The average proportion of the two is about one part by measure of bitumen to seven or eight of asphalt. Then eleven measures of this is mixed with nine of broken stone to form the bituminous concrete used to cover the road.

The foundation should be preferably concrete or broken stones laid in the same manner as for stone pavements. If the surface requires levelling, mortar is used prepared as follows: one measure of Rosendale cement paste, one of common lime paste, and seven or eight of coarse sharp sand; or Portland cement paste one, lime paste two, and sand ten or twelve.

The covering is spread, while hot, over the foundation 1½ ins. thick for the carriage way, and for sidewalks, ¾ ins. thick, in rectangular sections. Its surface is then sprinkled with sand and the surplus sand swept off, and the whole left to cool.

To repair this roadway, dissolve one part of bitumen in three of pitch oil and spread ten ounces of this over each square yard and sprinkle on it two pounds of powdered asphalt, and then on top of all the sand as before.

It has many merits. Among them may be mentioned: It produces no dust, and hence no mud; it is quite noiseless; it absorbs no noxious liquids, and, therefore, emits no foul vapours; and, lastly, it makes traction light, and does not get polished and slippery in wet weather.

Its cost, including the laying down of a concrete foundation, is from $2.75 to $3.00 per yard.

SIDEWALKS.

Sidewalks, for the accommodation of foot passengers, are built on both sides of the road-bed, and are paved with flagstone, wooden blocks, or some variety of concrete. They are given a pitch of about one in twenty towards the gutters.

Flagstones are laid down in a bed of sand or gravel, or in the middle of a bed of asphalt prepared in a similar way to that used for road beds. The flags are usually about 4 feet by 2½ or 3 feet, and four or five inches deep.

Wooden blocks are used, too, but chiefly for crossings, when they are placed within two rows of stones of same shape, and placed in the same way as curbstones, and given a curved form for the sake of keeping them dry.

Asphalt side-walks are made in the same way as the road-ways, the covering being, however, only ¾ inch thick.

Planks, two or three inches thick, of pine, hemlock, and cedar, are also much used, being laid with their length at right angles to the traffic.

In Montreal, Fig. 14 shows a favorite way of laying down plank sidewalks in those parts of the city away from business and much traffic.

It consists of a six feet wide sidewalk, with the planks in front of the gates sufficiently long to reach to the curbstone for the convenience of those getting in and out of vehicles. The remainder of the space not taken up by the planking is filled with either cinders or asphalt.

The great advantages in having wooden sidewalks are their being less wet in rainy weather—partly owing, perhaps, to their absorbing the water, however—and less slippery, and their being so much easier to walk on than stone. The only disadvantage is that they do not last, and require constant repairs after being down a few years.

This method of road-making may have to be used yet more than one might at first think. In Algoma there are miles of brulé, with scarcely a stick of timber standing, where nothing but small underbrush covers the ground, usually soft maple, cherry, poplar and hazel. The surface of the ground rolls but very little, making drainage a difficult matter, and, consequently, road-beds would be soft.

RAILWAY CURVES, &c.

Mr. A. A. Robinson, M. Am. Soc. C. E., stated that the location of the New Mexico Extension of the Atchison Topeka and Fe. Railroad was made with the standard of compensation based upon the theory that each degree of curvature was the equivalent in resistance to the movement of trains of 5,100 lbs per foot of ascent. After the construction it was found—first, that upon maximum gradients O. 6 per cent where in full train was 30 to 32 loaded cars, this compensation was hardly sufficient; second, upon maximum gradients of 1 13-100 per cent with full train of 18 to 20 cars it was fully sufficient; third, upon maximum gradients of 3·4 per cent with full train of 7 to 8 cars it was evidently greater than was needed. Mr. Robinson, considers that the resistance due to curvature is affected by so may conditions that it cannot be determined by a mathematical formula except for the particular conditions assumed in a special case. The speed of the train, the elevation of rail, the greater length of outer rail, the guage of the track as compared with that of the wheels all affect the question and the resultant of all the forces will be a function not only of the rate of curvature and of the gross tonnage of the train but also of the number of cars in the train. A train of 10 cars will produce a resistance greater than 10 times that of a single car. Upon a division of the railroad where a locomotives can pull 30 cars the rate of compensation should be greater than upon a division where engines can pull but 10 cars. In practice Mr. Robinson has adopted the following rules for compensation.

Rate of maximum grade 0.0 to 0.6 per 100 compensation 0.06 per 100
" " " " 0.6 " 1.6 " " " 0.05 " "
" " " " 1.6 " 3.0 " " " 0.04 " "

Mr. Wm. H. Searles, M. Am. So. C. E· discussed mathematically the nature and amount of the increase of resistance on curves due to the increase in number of cars upon a train and deduced a general formula for the total tractive force necessary to be applied at the head of a train of cars moving at a uniform velocity on a giving curve, and presented tables giving the coefficient for solving such formula in terms of the number of cars and the degree of curve. He also presented tables of resistances for given trains upon certain grades, and a summary of equivalent grades per station per degree for a given train upon various curves and grades. Also a table of resistances for a consolidation engine of 60 tons handling its maximum train on a 20 degree curve. He also expressed the opinion that widening the guage on curves was not an advantage as far as a 4 wheel truck is concerned.

Mr. Lewis Kuigman C. E. stated that on the Atlantic and Pacific Railroad the compensation 5·100 per degree was adopted for all curves; that 10 degree curves were the maximum, and that all curves were leased off at both ends by compounding gradually from the tangent to the full degree of curvature. This practice he considered of great value and of very slight additional expense. From careful observations upon the action of locomotives pulling trains upon curves, it is his opinion that the compensation should vary with the grade.

Mr. A. M. Wellington, M. Am. Soc. C. E said that the rule adopted by him was for the high grades the same as that of Mr. Morley, viz., 4-10 per degree of curvature, but that Mr. Morley increased this to 6·10 per degree on lower grades. The theory upon which this was done was formerly advocated by Mr. Wellington, but he now believes from further investigation both experimental and theoretical· that no sensible difference exists due to the longer trains which could be run upon the lower grades. No absolutely fixed rate of compensation ought to be made. Circumstances of location may make it inexpedient to adopt a rate of compensation which otherwise might be desirable. The rate of compensation of 1·10 per degree is higher than is ever necessary unless in certain cases at stations or where it may become a question whether to admit certain sharp curves at all. It is extremely probable that curve resistance is materially· greater, and more complete experiments cannot be secured than have already been made.

Mr. M. N. Forney, M. Am. Soc. C. E. referred to the fact that the conditions of rolling stock and of track were very important elements in any experiments that could be made

upon this subject. Different car builders made cars and trucks and wheels according to their individual notions. Engineers made the section of rail according to their individual notions. The actual condition of the rolling stock of the country was such that it was doubtful whether any experiments could be relied upon as determining results which could be applied generally.

Mr. Wellington expressed the opinion that while it was perfectly time that the condition of rolling stock was as stated by Mr. Forney, yet that experiments properly made could be relied upon to give fair average data.—(*In. Am. Soc. C. E.*)

SOUND-MILLS.—(*Nature.*)

AFTER the notable researches of Crookes on radiation, which culminated in the discovery of the radiometer, or light-mill, it was a natural transition of thought which suggested to several minds almost simultaneously the possibility of devising an apparatus which should rotate under the influence of sound-waves as does the radiometer under the influence of the rays of light and heat. Such instruments were indeed devised independently about six years ago by Lord Rayleigh, by Prof. Alfred M. Mayer of Hoboken, by Mr. Edison, the well-known inventor, by Prof. Mach of Prague, by Dr. A. Haberditzel of Vienna, and by Prof. V. Dvorák of the University of Agram (in Croatia). These researches, though of great scientific interest, have been somewhat overlooked in the rush of scientific inventions during the intervening years. During the course of the past year, however, Dr. Dvorák has given to the world, in the pages of the *Zeitschrift der Instrumentenkunde* (vol. iii. Heft 4), a detailed account of his experiments, together with figures of various pieces of apparatus hitherto undescribed. We propose to give a *résumé* of the principal points of Dvorák's researches.

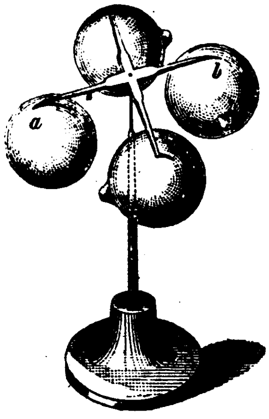


FIG. 1.

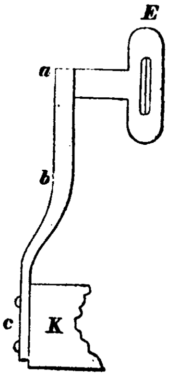


FIG. 2.

Four kinds of sound-mills are described by Dvorák, two of them depending on the repulsion of resonant-boxes or cases, and two others on different principles.

The first of these instruments is depicted in Fig. 1, and consists of a light wooden cross, balanced on a needle point, carrying four light resonators made of glass. These resonators are hollow balls of 4·4 cms. diameter, with an opening of 0·4 cm. at one side. They respond to the note g' (=392 vibrations). When the note g' is forcibly sounded by an appropriate tuning-fork, the air in each of the resonators vibrates in response, and the apparatus begins to rotate. As a resonator will respond when placed in any position with respect to the source of sound, it is clear that one single resonator properly balanced should rotate; and this is found to be the case, though, naturally, the action is more certain with four resonators than with one.

Before proceeding to the other forms of sound-mill devised by Dvorák, it may be well to explain briefly the cause of the phenomenon, and to describe Dvorák's particular method of exciting the appropriate sound Dvorák has pointed out, as indeed has been done elsewhere both by Lord Rayleigh and by Prof. A. M. Mayer, that, when sounds of great intensity are produced, the calculations which are usually only carried to the first order of approximation cease to be adequate, because now the amplitude of motion of the particles in the sound-wave is not infinitely small as compared with the lengths of the sound-waves themselves. Mathematical analysis shows that under these circumstances the mean of the pressures in the condensed part and in the rarefied part of the sound-wave is no longer equal to the undisturbed atmospheric pressure, but is always greater. Consequently at all nodal points in the vibrations of the air in tubes or resonant-boxes the pressure of the air is greater than elsewhere; and therefore any resonator closed at one side and open at the other is urged along bodily by the slight internal excess of pressure on the closed end. The apparatus, Fig. 1, therefore rotates by reaction, in the same way as Hero's primitive steam-engine rotated, though the reaction is due to a different cause.

To produce vibrations of sufficient intensity Dr. Dvorák employs heavy tuning-forks mounted on resonant-cases, and excited electrically. For this purpose he places between the prongs of the fork an electromagnet constructed on the following plan. Two plates of iron separated by a sheet of paper are used as a core. They are cut of such a breadth as to lie between the prongs without touching them. This core is overwound with insulated copper wire, as shown at E, Fig. 2, and the electromagnet is then mounted by a bent piece of wood, *abc*, upon the sounding-box, K, of the fork. The wires are connected in a circuit with a battery, and with the electromagnet of a self-exciting tuning-fork of the same note. Dr. Dvorák is extremely particular about the arrangements of the resonant-boxes of his tuning-forks. They must not touch the table, the arm *a b c* being clipped at about the point *b* in a firm support. Moreover the resonant-boxes themselves require to be specially tuned, for all are not equally good. Dr. Dvorák points out that, beside the tone of the fork, and the tone of the air column in the cavity of the box, there is also a tone proper to the wood of the box itself, which in most of the forks used in acoustic researches is too base, the wooden walls being too thin. To hear this tone the prongs of the fork should be damped by sticking a cork between them, and the cavity should be filled with cotton-wool, while the wooden box is gently struck with the knuckle, or with a cork hammer. It is important that the wood-tone should be tuned up to coincidence with the tone of the fork and with that of the air in the cavity. Dr. Dvorák himself used the box depicted further on in Fig. 6, in which drawing F is the socket into which the stem of the fork

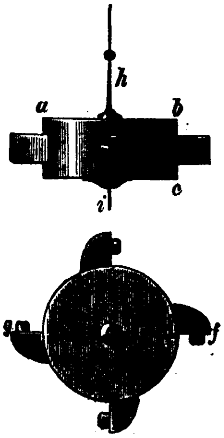


FIG. 3.

was screwed. The wood was tuned by planing it away at the top and bottom, while the air cavity was tuned by enlarging the circular opening in front. In the later researches the box stood on four feet made of india-rubber tubing. The note of the fork so mounted was very strong. At 40 cms. distance it would set the sound-mill in motion.

Dvorák's second apparatus, a "rotating resonator," consists of a short cylindrical box, constructed of stiff glazed paper, having four projections, shown in plan and elevation in Fig. 3, each of which bears at its side a short open tube of paper. It is, in fact, a resonator with four openings, arranged so that it can be hung upon a silk fibre. A fine needle projects also below to steady the motion during its rotation, which occurs whenever the apparatus is brought near to the sounding-fork. For the note *g′* the dimensions were: diameter, 7 cms.; height, 3·6 cms.; diameter of openings, 0·6 cm.

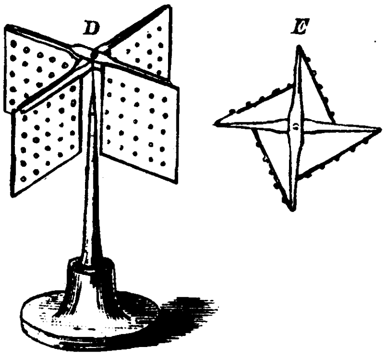


FIG. 4

The third apparatus is the "sound-radiometer" described by Dvorák before the Imperial Viennese Academy in 1881. Its cause of action is less readily explained, though its construction is even more simple. Its form is shown in Fig. 4, D; there being, as before, a light cross of wood, pivoted by a glass cap upon a vertical needle. To the four arms of the cross are cemented four pieces of fine white card, about 0·08 cm. thick, perforated with holes which are depressed conically at one side, and raised at the other. These holes may be made by punching the card upon a lead block with a steel perforating-punch of the form shown in Fig. 5, A, the dimensions of which are: $ab = 0{\cdot}38$ cm.; $cd = 0{\cdot}2$ cm. The holes should be from 0·6 to 0·65 cm. apart from one another. When a card so perforated is held in front of the opening of the resonant-box of the tuning-fork it is repelled if the smaller ends of the conical holes are toward the box; or is attracted if the wider openings are toward the box. A better, but less simple, way of perforating the cards is by the use of the conical steel punch shown in Fig. 5, B, and the matrix, Fig. 5, C. The angle of the cone is 55°, and the narrow projecting nose of steel is 0·2 cm. The card should be damped, laid on the matrix C, and the hole pierced by two or three blows upon the die. Dr. Dvorák prefers this plan: it throws up a high burr or edge behind the conical hole, and such perforations are more effective. The cards may be varnished, and are then mounted upon the cross. The rotations are more rapid if the cards are set on obliquely in the fashion shown in Fig. 4, E, the burred sides being outwards. Cards with twenty-five perforations so mounted rotate briskly when the "mill" is set in front of the resonant-box.

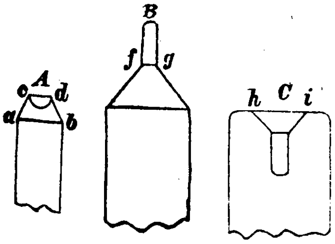


FIG. 5.

The fourth apparatus of Dvorák is called by him an "acoustic anemometer." It is shown in Fig. 6. This is merely a little "mill" of simple construction, the vanes being small pieces of stiff paper or card slightly curved. The sounding-box previously described is placed a little way from it, and between them is held an ordinary Helmholtz's resonator, with its wide mouth, *b*, turned toward the box, and its narrow opening, *a*, toward the mill. From what has been previously said it will be understood that the internal increase of pressure in the resonator at *a* has the effect of driving a jet of air gently against the sails of the mill, which consequently rotates. Dr. Dvorák also suggests that this two-aperture resonator may be replaced by one having but one aperture, as shown at R, with its open side, *l*, turned towards the mill. This resonator is formed of a glass ball cut away at one side and cemented to a glass plate having a small hole at the centre. It may be remarked that when the air ejected from the mouth of this resonator is examined by the method of mixing smoke with it, and then viewing it through slits cut in a rotating disk, the currents are seen to consist of a series of vortex-rings.

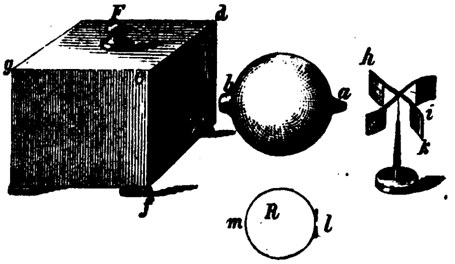


FIG. 6.

A second kind of "acoustic anemometer" may be made by taking a card pierced with 100 conical holes, as previously described, and placing this between the resonant-box and the "mill." The latter rotates in the wind which passes through the conical holes.

Space does not admit of a comparison being drawn between these instruments and those of Mayer, Mach, and others, which are very closely akin in their design and mode of action, interesting though such a comparison might be. Nor can we here compare the action of these instruments with the "phonomotor" with which Mr. Edison literally accomplished the feat of talking a hole through a deal board. But this remarkable machine was a purely mechanical toy, which converted the vibrations of the voice, by means of a very finely-cut ratchet-wheel, into a motion of rotation round an axis.

SILVANUS P. THOMPSON

LONDON SEWERS.—There are now about 2,300 miles of underground covered sewers, more than half of which have been constructed in the last twenty-seven years. They vary in diameter from 9 inches to 12 feet 6 inches. All the houses are connected with them, and refuse is removed through them by the water supplied to the houses flowing through the sewers after use, in an inoffensive and economical manner, to covered reservoirs on the banks of the Thames, 12 miles below London Bridge. The main intercepting scheme came into operation in 1870-71, and has been conducive to the health and longevity of the population.

GAS AND CALORIC ENGINES.*

BY PROF. FLEEMING JENKIN, LL.D., F.R.SS., L. & E., M. INST.C.E.

The lecturer began by defining what he meant by the efficiency of an engine, and stated that the steam-engine converted about 10 per cent. of the total heat generated by the coal into mechanical work, or, in other words, had an absolute efficiency of 10 per cent. It was his duty to compare hot-air and gas-engines with the results achieved by steam. The first important hot-air engine was that devised by Sir George Cayley, in 1807, which was fully described in his patent of 1837. A diagram of an engine, made by Buckett, was referred to as closely resembling Cayley's engine. Details were given of the theory of the Cayley-Buckett engine, which showed that the results so far were comparable with those obtained by steam, but that there was no great promise of improvement for the future. Gas-engines were next treated of, being also a form of internal combustion machine. The engine designed by Otto, and improved by Crossley, was described as one typical example, and the other chosen was that made by Thomson and Sterne according to Mr. Dugald Clerk's plan. The following points were named as those of chief interest:—the limitation to the higher and lower limits of temperature; the rate at which combustion proceeded inside the cylinder; whether dissociation was a sure course of the limit to the higher temperature; the loss of heat by the cooling of the walls of the cylinder, and the loss of heat in the residual products rejected. Experiments specially made by Messrs. Crossley were described, showing that a change in speed with a constant charge had caused an alteration in the maximum pressure and maximum temperature; but that this change did not extend between wide limits. A change in the richness of the mixture, produced a much greater change in pressure and temperature. A diagram was shown in which the pressure was almost uniform throughout the stroke, and another showing the modification produced in the indicator-diagram when the charge introduced is not allowed to mix with the residual products. All these diagrams tended to prove that gradual combustion certainly took place in these engines, and that the rate of combustion was under control.

A series of very interesting diagrams, illustrating experiments made by Mr. Clerk, was then explained, the rate of combustion in different mixtures of gas and air, and of hydrogen and air, being exhibited by a continuous curve. These experiments established, beyond a doubt, that the rate of combustion varied in proportion to the richness of the mixture, and that this rate was, in the poorer mixtures, such that a considerable portion of the stroke would be completed before the combustion was complete. In fact, Mr. Clerk's experiments and those of Messrs. Crossley nearly agreed, although these makers might differ in their explanation of the cause. The experiments further showed that whether dissociation acted as a limit to the temperature or not, practically the mean temperature of the contents of the cylinder in gas-engines at the beginning of the stroke seldom rose above 150° Centrigrade. The experiments of the makers further agreed in this:—that the loss by conduction through the walls of the cylinder was a little over 50 per cent., and that at the moment when the highest pressure was attained not much more than one-half of the total heat was developed, the rest being developed through the stroke. The lecturer pointed out that the true condition of the burning gases was one which it was extremely difficult to analyze or follow; that within the cylinder there must be an extremely hot kernel at a temperature greatly above the mean; that at the outside there must be a layer little above 150° Centigrade, and between these limits layers at all temperatures; that part of the gases must expand receiving heat, and part give it up. But it was interesting to find that the practical result of these complicated actions did not differ widely from the adiabatic curve, although, in point of fact, one-half of the heat was being given up by conduction. Passing from these theoretical considerations to the practical results, the lecturer found a similar agreement. Both makers produced engines giving 1 indicated H.P. for 20 cubic feet of gas. This result corresponded to one-third, or one-fourth, of the consumption recorded for the early gas-engines made by Lenoir. Moreover, they showed that from 16 to 24 per cent. of the whole heat generated was actually converted into indicated H.P., notwithstanding the enormous waste of one-half by conduction across the walls. In absolute heat efficiency, therefore, the gas-engine was already 100 per cent. better than the steam-engine. When, however, what might be termed the relative efficiency, was compared, that was to say:—the relation between the theoretical achievement which was possible, and the actual achievement, the steam-engine would be found nearly to have reached the limit of what was possible or probable, whereas the gas-engine was very imperfect, and therefore gave hopes of great improvement.

Taking the range of temperatures as the highest and lowest used in a gas-engine, the ideal efficiency might be spoken of as 77 per cent., but no real gas-engine could reach this figure because the heat was not wholly given at the higher nor wholly rejected at the lower temperature. If the indicator-diagram were treated as bounded by two adiabatic curves and two vertical lines, the theoretical efficiency of the gas-engine with the temperature described would be about 48 per cent., and one-half of this had been attained, the other half being accounted for by the cooling of the walls. The lecturer then passed on to consider what possible means might be suggested for improvement, and divided into two classes—those in which it was intended to lower the practical temperature of rejection, and those in which it was intended to diminish the loss by cooling. As regarded the first of these—increasing the pressure of compression produced good results by increasing the expansion; but the advance to be made in this direction was not expected to be great, as the pressures used were already large.

The lecturer next proceeded to describe the Stirling engine, invented in 1827, pointing out that Robert Stirling was the first inventor of the regenerator—a device which had not been fertile so far as heat-engines were concerned, but which, in the hands of the late Sir William Siemens, had greatly modified several of the important industries in the kingdom. He pointed out that it was a natural idea to modify the Stirling engine, which received its heat from outside into an engine which, like the Cayley-Buckett or gas-engines, received their heat inside, and explained in detail the difficulties that had been met with in several attempts to carry this idea into practical effect. The late Sir William Siemens had worked at the conception during the greater part of his life, and had he been spared a few years longer, there could be no doubt that complete success would have been attained. Professor Jenkin's experiments in the same direction had been chiefly directed to combating the difficulties introduced by the porosity of refractory materials, which was much greater than was usually supposed, even in the case of very dense fire-brick. These experiments had been given up temporarily, under the conviction that the complications involved in introducing internal combustion, whether by gas or coal, into a Stirling engine were such as to render small engines of this type impractical, but without any loss of faith that, for the larger types, they would ultimately be successful. Small engines of the Stirling type were actually in the market, made either by Bailey, Robinson or Rider. The results from these engines were as good as could be expected from their small size and the low pressure used. They could be made more efficient by raising the pressure, but the complication introduced would probably outweigh the advantage obtained in the saving of coal. The theoretical results to be obtained by the simple adoption of a regenerator, through which the mixture of gas and air passed on entering the cylinder, and repassed on leaving it, were then described, and seemed to show that this device might be serviceable in sensibly increasing the efficiency of engines, and finally some attempts were described by which it was hoped that the great conduction across the walls of the cylinder might be dimished. For this purpose, however, invention was required. In due time it would be forthcoming. In fact the most interesting point connected with gas-engines was this:—that while in the steam-engine, the limit of improvement had almost been reached, with the gas-engine, the theoretical efficiency was already double that of the steam-engine, and the cost of working comparable, especially when Dowson gas was used, and that in the case of the gas-engine it was possible to look forward to double and triple the efficiency which had so far been actually obtained.

Miscellaneous Notes.

PIPES MADE OF STEEL PLATES.—Pipes made of steel plate are coming into use in England for the conveyance of water under high pressure. The plates are coated with lead on both sides by immersion or otherwise, then rolled to form, rivetted, soldered the whole length, and covered with pitch. Of this

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* A lecture delivered before the Institution of Civil Engineers.

method it is said 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, and the strength of the pipe is much greater.—*The American Iron News, March, 1884.*

COMPRESSIBILITY OF LIQUIDS.—From a paper recently presented to the Academy of Sciences of Berlin by Mr. Guincke it appears that the compressibility of liquids, which is generally considered to be practically *nil*, may be shown under pressure of even less than one additional atmosphere. Mr. Guincke experimented with liquids contained in glass bulbs, with a capillary tube attached to them vertically; the bulbs were placed in the chamber of an air pump, and the decrease of volume resulting from increased pressure was observed, which method promised more exact indications than the opposite one of watching the expansion under diminished pressure. Water carefully freed from air by continuous boiling was compressed by 49 millionths of its original volume under a total pressure of two atmospheres. The following figures express the compressions of some liquids resulting from one millimetre additional pressure, also in millionths of the respective volumes; glycerine, .03; olive oil, .07; alcohol, .12. The observations, which extended over a large number of liquids, agreed well with one another of former, but not such extensive researches by M. Grassi. Within the limits of pressure of one additional atmosphere, the compression remains proportional to the pressure. The experiments further confirm the theory that a certain relation exists between compression and the co-efficient of refraction, but as yet they are not decisive enough, whether one or the other of the various ratios, which have been based upon theoretical calculations, is correct.

LONDON & PRESS; Sir Joseph Bazalgette in his address before the Inst.Civil Engineers (*Eng.*) then alluded to statistics respecting seventy-five foreign cities, which he had epitomized and tabulated for reference, and which enabled such a comparison to be drawn between some of the conditions existing in London and in other large cities, as would justify the assertion that London is without a rival as regards health, extent, and population. Of these cities, Paris contained a population of 2,240,000, occupying 77,000 houses, and covering an area of 30 square miles. The population was twice as dense as in London; its rateable value was £24,000,000, not quite one-third less than that of London. The water-supply was 82,000,000 gallons daily, or 36 gallons per head of the popnlation. Its sewers had cost upwards of £4,000.000, and the expense of their cleansing and maintenance amounted to £50,000 a year. The greater portion of the sewerage was removed out of the city in cans by carts. Paris was lighted by gas lamps equivalent to 44,000 lamps of one burner each, which consumed 770,000,000 cubic feet of gas, at a cost for gas of £130,000 or about 3*s.* 4*d.* per 1,000 cubic feet. The rapidity with which the population of most large cities had increased within the last forty years, had been much greater than the rate of increase of the population of the globe. Whilst the population of London, Paris, St. Petersburg, and Vienna had increased about 200 per cent., and that of Constantinople, Naples, Madrid, Rome, and Amsterdam, about 100 per cent., the population of the globe had increased only 40 per cent., the greatest increase having been in America, and the least in Asia. The rapid growth of cities was doubtless due to the development of civilization and of engineering science, which had stimulated manufacture and trade, and had turned those who were formerly agriculturists into artizans, obtaining more lucrative employment in large cities.

The ultimate object of all sanitary science was the comfort and convenience of the living, and the reduction of the death-rate. With respect to the latter, it had been reduced in London from 24·4 per 1,000 in the decade ending 1870 to 21·4 per 1,000 at the end of 1882. . In Baltimore the death-rate was 21·9 per 1,000; in New York 30·6; in St. Petersburg 35·2; in Cairo 37; and in Pekin about 50. If the London death-rate was raised to that of St. Petersburg, 55,000 more deaths would occur each year in excess of the present deaths. The rateable value of the cities per inhabitant afforded some indication of the cost, and therefore of the extent of accomodation, of the houses, as compared with the number of their occupants. The rateable value of Pekin was £2 8*s.* per inhabitant; of St. Petersburg, Amsterdam, and Calcutta, £3; of Vienna, £6; of London and Hamburg, £7; of Berlin, £7 14*s.*; of Paris, £10; and of Brussels, £11 8*s.*

THE EVOLUTION OF FLOWERS.

By GRANT ALLEN.

III.—*Integration Begins.*

Besides the true Alismas with which we have hitherto dealt, there are a few other Alisma-live plants in Britain, each of which helps us on a little way toward the development of the true lilies; and as it is better, where possible, not to travel beyond the limits of fairly well-known or easily-obtainable flowers, we may as well take these English species as the representatives of the various intermediate stages.

In a very few spots among the South-eastern counties there grows a rare water-side weed of wet ditches or pools, known to botanists as *Damasonium stellatum* or *Actinocarpus stellatus.* It is a South-European plant, which only just reaches our shores where they lie nearest to the Continent, and has never been able to spread itself further north or west against the adverse climate and the stout competition of our more northerly waterside weeds. Damasonium at first sight presents a great many points of resemblance to the water plantain; it has three small green sepals, three much larger white petals, six loose stamens, and a group of carpels in the bossy centre. Being fertilized by the same sort of flies as water-plantain, it has even the yellow spot at the base of the petals as in Alisma, whlch marks the way to the honey, and points back to the original yellowness of the whole petal. But when we come to look more closely into the flower, we see that it possesses twe distinct symptoms of advance in organization, each of which is very important in leading onward and upward in the direction of the true lilies. In the water plantain we saw that the carpels were very numerous, sometimes as many as thirty in a single flower; but in Damasonian thev are always six in number, that is to say, they are reduced to two whorls of three carpels each. The significance of this change is best seen if we put together four typical groups in ascending order of evolution, thus—

Water-plantain	3 sepals: 3 petals; 6 stamens (= twice 3); many carpels.
Damasonium	3 sepals; 3 petals; 6 stamens; 6 carpels (= twice 3).
Lily (tulip)	3 sepals; 4 petals: 6 stamens; 3 carpels (united).
Iris	3 sepals; 3 petals; 3 stamens: 3 carpels (united).

Thus it is clear that Damasonium has taken a step forward towards that reduction of parts which is so conspicuous a feature in the higher lily-like plants, and which, as we shall see hereafter, reaches a climax in those marvellous and highly-developed flowers, the orchids.

Again, in the water-plantain, we saw that each carpel contained only a single seed; but in Damasonium each carpel generally contains two. In fact, while in the true Alismas the carpels are many, small, and one-seeded, in Damasonium they are few, large, and two-seeded. This variation is a common mark of advance in the earlier stages of floral evolution; the carpels tend to grow fewer, bigger, and many-seeded. For example, in the buttercups, as in Alisma, they are numerous, small, and one-seeded; in the marsh-marigold they are reduced to five or ten (one or two whorls of five each), much larger and longer, and containing several seeds apiece.

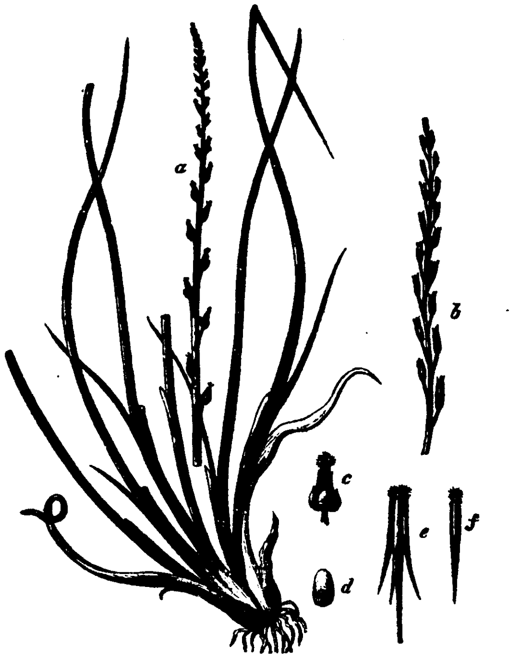
Now, what is the reason of this advance? Clearly, plants must derive some advantage from the change, or it would not constantly occur as a concomitant of higher development in various families. A little reflection will serve to show us what that advantage really is. In the primitive plants with one-seeded carpels, each seed has to be separately fertilised by a distinnt act of impregnation; for every stigma on to which an insect brushes pollen only one seed in the end gets set. This, of course, necessitates the production of a large number of carpels, and compels the plant to ensure, as far as possible, the separate impregnation of every one among them. Hence it becomes an advantage for the plant to produce fewer and larger carpels, each containing two or more ovules; because, in that case, each single act of impregnation suffices to fertilise two or more seeds. Accordingly, we find that as plants rise in the scale of evolution, they usually at first lessen the number of their separate carpels, while increasing the number of seeds in each. Later on, as we shall observe hereafter, the number of seeds also begins to decrease; but that is only when, by improved methods of fertilization, protection, and dispersion, and increased richness of the seeds themselves, the plant is able to dispense with the necessity for producing an immense number of seeds from each flower. Efficiency, in such cases, serves the species in place of quantity.

Another interesting peculiarity of Damasonium consists in the fact that all six of its carpels are not quite free and separate from one another throughout all its life, as is the case with those of the Alismas and the buttercups: they are joined together at the bottom on the inner side to the stem or axis of the flower. This is the first beginning of that tendency which finally produces the compact, three-celled ovary of the lilies, where the three carpels have coalesced altogether, though their original distinctness is still marked by the walls of separation which divide the three cells from one another. Among the buttercup group, the monkshood is in this respect the exact analogue of Damasonium, for its three carpels are also usually joined together slightly at the base. If the lilies, however, had been developed from an ancestor at precisely the same stage as Damasonium, they would, of course, have had six cells to the ovary, instead of three, as is actually the case. The carpels of Damasonium taper to a sharp point, and are arranged radially like a conventional star, whence it gets its second name—*stellatum*, or starlike, and its other title of Actinocarpus, or "ray-fruit." I believe this arrangement of the carpels has reference chiefly to the fertilisation, so as to allow the insect's head to touch each stigma in succession easily and certainly; but it also doubtless aids in dispersing the seed equally in all directions.

Damasonium stellatum.

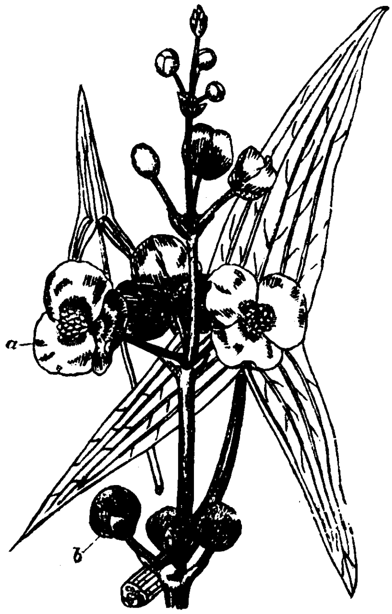
It is very seldom that we can trace the marks of evolution continuously along a single line. We must rather pick out here and there separate indications of its general tendency, each surviving step or link being oftener a mere analogy (or independent similar development) than an actual survival of the various stages in the pedigree of the higher kinds. This is very strikingly seen in the Alisma-like plants, where several species preserve different levels of development, not in all parts alike, but one part in one species and one part in another. For example, take our two British arrowgrasses (*Triglochin maritimum* and *T. palustre*). In one respect, both these plants approach closer to the lily type than even Damasonium, for they have their carpels united during the flowering stage around the axis, though they separate from it into distinct pieces when ripe. Yet in another respect they are still as primitive as Alisma, because they contain only one seed in each carpel. Let us look for a moment at these two curious and common, but inconspicuous, little plants.

The arrowgrasses are degenerate small Alisma-like weeds, growing among tall marsh plants and grasses, and compelled by their habitat to decline into the practice of wind-fertilisation. Hence, like all other wind-fertilised plants, they have no bright-coloured petals. All six perianth pieces (that is to say, sepals and petals alike) are simply green, and they are very small or almost scale-like. Colour is not here needed to attract insects, and so the plant dispenses with it altogether. There are six stamens, hanging rather looser than in Alisma, so as to shed the pollen to the wind, though much confined by the scales of the perianth; and the carpels have each a feathery stigma, protruding from the flower, so as easily to catch the pollen dropped by the stamens. This feathery state of the stigma is very common among wind-fertilised plants, as it exactly suits their habit of life. In fact, the arrowgrasses are Alismas which by degeneration have very nearly reached the same state as the true grasses; only, these latter are degenerate lilies, starting from a higher level in the evolutionary order. The head or spike of flowers in arrowgrass reminds one very closely of the common plantains (*Plantago*), which are degraded relatives of the veronicas, with closely similar habits.



Triglochin palustre.

Our two kinds of arrowgrass differ between themselves in the matter of carpels. The marine kind (*Triglochin maritimum*), which grows in salt marshes, is clearly the more primitive in type of the pair, for it has six carpels, like Damasonium, reduction having gone here only so far as to leave two whorls. In the flower there is thus a six-celled ovary, in the ripe fruit the cells divide as six distinct carpels. The fresh-water species (*T. palustre*), common everywhere on the border of streams, has only three, the reduction here having left but a single whorl. Thus this species, when in flower, closely resembles the true lilies, and is only distinguished from them when in fruit by the



Sagittaria sagittifolia.

Butomus umbellatus.

fact that its carpels separate from one another as they ripen, so bearing witness to their primitive distinctness in the original ancestor. Still, a great many things conspire to show us that this Triglochin is not really a predecessor of the true lilies, but only an analogue, that is to say, a plant which has independently developed to some extent in the same direction. The Flowering Rush (*Butomus*), which we shall examine hereafter, though less like the lilies in its ovary, stands really nearer to them in genealogical order, as we shall see by-and-bye; but I must defer the consideration of that plant, as well as of the pretty arrowhead, to our next paper. We shall then have finished with the British representatives of these earliest Alisma-like monocotyledons.

Before we finish with the simplest group of monocotyledons, the Alismas, and proceed to their more developed relations, the true lilies, we must stop awhile to examine a couple of divergent species which present some singular features of their own, showing them to be distinct lateral offsets from the primitive water-plantain ancestor.

The common arrowhead (*Sagittaria sagittifolia*) might fairly claim, for several reasons, to represent the original monocotyledon even more closely than Alisma, were it not for one particular, which I shall mention in due course. It is a pretty and stately perennial, with glossy green, arrow-shaped leaves, rising high out of the water, and bearing a tall bunch of large and striking snow-white flowers. As in Alisma, there are three outer green sepals and three inner and larger white petals. The stamens, instead of being only six in number, are very numerous; and as this is also the case in the buttercups, the simplest and most primitive dicotyledons, we may fairly accept it as a common sign of great antiquity. The carpels are also numerous, small, and one-seeded. All these points show the arrowhead to be at least as primitive in general type as the water-plantain, while the large number of the stamens and carpels seems to betoken a still earlier and simpler organization.

Why, then, should we not take the rare arrowhead rather than its commoner ally, the Alismas, as the best living representative of the general ancestor from whom the whole existing lily stock is ultimately descended? Simply for this reason: the Sagittarias have all distinct male and female flowers, while in the Alismas, as in the lilies and most other advanced monocotyledons, the stamens and pistils are both found together in the same blossoms. In the arrowhead, the upper flowers are usually males, that is to say, possess stamens alone, while the lower ones are females, with nothing in their middle but a group of very numerous carpels. The flowers, originally hermaphrodite (that is to say, with both stamens and carpels), have become differentiated into two distinct sexes, males above and females below, by the abortion or gradual disappearance of the carpels in one case and the stamens in the other.

Why is this? Well, the change is only one out of the many means commonly adopted by flowers to ensure cross-fertilisation. We may conclude that at some early time some very primitive Alisma-like plant showed some tendency to, produce more stamens on some of its blossoms, and more carpels on others. This is a tendency which often occurs in many plants, and as a familiar case we may take the strawberry, which everywhere, but especially in America, has a constant leaning towards the separation of its sexes not only on different flowers, but even on different plants. Now, whenever this tendency is set up, it is pretty sure to prove advantageous to the species (unless, indeed, it interferes with some other and better device for cross-fertilisation) because it renders it absolutely impossible that any blossom can be impregnated in the undesirable fashion with pollen from its own stamens. Accordingly, the arrowheads have kept this useful feature ever since, and so have successfully avoided self-fertilisation with its usual concomitant of degeneracy and final extinction. Their chief insect allies are flies of the same sort as those which visit the true Alismas.

Why, again, are the male flowers at the top, while the females are below? For this reason. The flies, like most other insects, always begin their visits to a spike of blossoms at the bottom and proceed slowly upward. In this way they arrive at the female flowers first, and dust them over with pollen from the plant they last visited. Then, as they rise towards the top, they reach the male flowers, and gather from them a fresh store of pollen, which they carry away to the next bunch. By such a simple device nature ensures the fertilization of each blossom, not merely from another flower, but also from another plant. That is cross-fertilization in its truest and purest form, and it produces the stoutest and healthiest seedlings of all.

Once more, why doesn't the pollen from the male flowers fall down and fertilize the females below? Would it not have been better to put the females on top, so as to avoid this chance? No, because the flowers open from below upward, and so the females ripen first. They will, therefore, in all probability, get impregnated before the stamens begin to shed their golden dust. But if they don't, then the pollen will fall upon them in due course; and this modified form of cross-fertilization from the flowers of the same stem is better far than no fertilizotian at all, and consequent absolute sterility.

Arrowhead, then, is clearly a close representative of a very primitive form; but it fails to be the closest representative, because in it the pistils of some flowers and the stamens of others have become abortive, and this could not have been the case in the ancestor of the fully hermaphrodite lilies and amaryllids. In short, arrowhead is a very slow but still specialized form.

Our last British Alismaceous plant is the beautiful rose-colored flowering rush (*Butomus umbellatus*), whose tall, straight stem and handsome umbel of large bright flowers rise so proudly above the ponds and backwaters of our southern counties. The flowering rush shows some distinct signs of advance in the same general direction as that taken independently by the lilies. The distinction between sepals and petals has here nearly died away, fer all sixth perianth pieces are nearly equally large and brightly coloured, and all equally take part in the attractive display. Nevertheless, if you look carefully you will see that the three outer ones still retain marks of their original character as sepals, for they are not quite so large or so petal-like in structure as the three inner, and they have acted as a covering to the true petals while in the bud. This similarity between petals and sepals is even more marked in the lilies, where the distinction of the two can scarcely ever be perceived in anything else save arrangement on the stem. The stamens are nine in number—three whorls of three each, and the carpels are six, as in the damasonium and the sea arrow grass. But in each carpel—and this is an important point—there are many seeds, instead of one or two only; and we shall find that a similar advance in such respect is almost universal in the lower lilies.

The large rose-coloured flowers of the Butomus attract bees and other higher insects, by whose aid they have no doubt been developed. These trustworthy allies enable it to get fertilized very securely, and so to lessen the number of its carpels to six. But each carpel contains many seeds, and so the plant can afford to do with comparatively few flowers, far fewer than the Alisma or the Triglochins. It has learnt to substitute efficiency for large numbers. This, also, is a step in advance in the direction of the true lilies.

Finally, observe the bracts or small leaves at the base of the bunch of flowers, put there to sheathe them from harm while they are young buds, and to protect them both from cold and from injurious insects. These bracts are the first indication of what is called a spathe, which becomes so important and conspicuous in several of the higher lily-like plants. Among the true lilies, we get it very marked in the garlics and onions. Among the Amaryllids it is almost equally noticeable in the narcissus and daffodil. Among the palms it assumes the form of a large sheet, completely enclosing the whole mass of blossoms. And last of all, in the very degraded arums, it forms the hood or sheath, which is all that can be seen externally of the flower, and within which the real blossoms cluster closely on a long spike or spadiz, almost entirely hidden within the large coloured apathe. It is interesting thus to note the first faint beginnings of what rises at last to be so very conspicuous and remarkable an organ. As it occurs in the flowering rush, the spathe is nothing more than three small thin bracts, that is to say, very reduced and simple stem-leaves.

(*To be continued.*)

COMPRESSED-AIR AND OTHER REFRIGERATING MACHINERY.

A PICTURE BY MR. A. C. KIRK, M. INST. C.E.

Glancing at the importance of refrigerating-machines, the Lecturer briefly traced their history from the first great step in 1845, by Dr. Gorrie, of New Orleans, who caused compressed and cooled air to expand in working a piston in a cylinder. He then showed that no really intelligent progress had taken place until the mechanical theory of heat had been fully developed, and proceeded to illustrate a very simple proposition, namely, that every refrigerating machine was only a thermodynamic engine in which the power was negative. The machine, instead of giving out power, must be supplied with power from an exterior source to work it. An engine which gave out power received heat at a higher and rejected a portion of it at a lower, temperature. When an engine absorbed heat at a low temperature and gave it out at a higher temperature, power must be applied to move it. In this case the engine became a refrigerating-machine. This was illustrated by taking the case of air-engines and steam-engines and showing how, under the above conditions, each of them passed into a refrigerating-machine.

The refrigerating-machine represented by the steam-engine, belonged to the type of which the other machine was a common example. Although the ammonia-machine belonged really to the same type, the absence of all apparatus to communicate motive power to it, as in the case of the ether machine, and the fact of its receiving energy directly as heat, rendered special notice of its indispensable. The Lecturer then proceeded to observe that the ammonia-machines resulted from the well-known experiments of Faraday, and he gave an account of the apparatus as constructed by Messrs. Mignon and Rouart. In this class of machines cold was produced by the evaporation of the volatile liquid employed in it—ether, ammonia, or other substance. In all these machines it was necessary to remove the vapour as fast as it was produced by the volatilisatian, or boiling, of the ether, ammonia or other liquid; and in order that the liquid might be condensed at the ordinary temperature, it was necessary to compress it to a higher pressure in a condenser. In the ether machine this was done by a piston working in a cylinder. In the ammonia-machine the same process was effected by the peculiar affinity ammonia had for water. When a solution of ammoniacal gas and water was heated, the ammonia was forcibly expelled into the condenser where it was liquefied, thence passing to the evaporator it boiled, and cooled whatever substance were exposed to it; and this vapour was intantly again compressed by bringing it into contact with cold water. The same change of temperature of the water from hot to cold performed a similar function to the piston, when it moved backwards and forwards in the cylinder of the ether-machine. In air-machines on the other hand, the air was compressed and cooled as far as the cooling water available would allow, after which it was permitted to do work on a piston in a cylinder, and in proportion to the amount of work it did, the greater cold it produced.

The Lecturer then proceeded to describe a machine of his own invention, which had been laid before the Institution in 1874. In this machine the theoretical conditions of a perfect air-engine were very nearly fulfilled. The regenerator—an invention of Dr. Stirling's—performed the same function that adiabatic expansion and compression preformed in Carnot's perfect air-engine. Indeed, Stirling's regenerator might, in theory, be held to furnish as perfect a cycle as Carnot's. He next showed that the application of the regenerator was limited to the case of dry air; otherwise temperatures below freezing it would get closed up by snow. He briefly alluded to a variation of the above machine, in which the cooling-water and the brine which had to be cooled were both injected directly into the compressed and expanding air. The brine in this case washed the regenerator, and prevented the formation of snow. The last type of refrigerating-machine alluded to was also an air-machine, but in this machine the air which acted as a cooling medium inside the machine was discharged directly into the chambers to be cooled. Tracing the history of these from the earlier attempts of Professor Piazzi Smyth, Professor Rankine, and Sir William Thompson, he observed that its first introduction on a practical and efficient scale was due to Mr. Coleman, who applied it to the cooling of chambers for the preservation of meat. The only question of practical difficulty attending this machine was the production of snow—a difficulty which had not been entirely overcome. The machines in use were of two kinds : one, in which the compressed air was cooled by the injection of water ; the other in which it was cooled by coming into contact with cold surfaces, like the surface of the condenser of steam-engine, He showed that in the latter case, when the machine had for a little time drawn air out of the chamber and cooled and returned it to the chamber, the store of moisture in the air would be exhausted and snow cease to be formed. He then descrbed, in some detail, the arrangement of one of Mr. Coleman's machines, working by injections, and observed that where injection was used the power required to compress the air was reduced. On the other hand, when it was not used less snow was produced ; and in docks and rivers the bringing of foul and tainted water into contact with the air which had to be passed over the meat was avoided. But where dry compression and cooling were adopted, it was necessary to use oil in the compressing cylinder. Noticing Mr. Lightfoot's invention, where moisture was deposited by a partial expansion, he showed the important part which the interchanger played in all these machines. By that means, instead of the compressed and cooled air entering the expanding-chamber, possibly at 90°, being cooled from that to—40°, and sent out of the chamber again at 39°, cooling might be made to commence almost from the temperature at which the air escaped from the chamber cooling the air previous to expansion. The effect of this was to reduce the amount of compression or expansion necessary, or, to put it in other words, to reduce the size of the machine, and consequently the power required to work it. The interchanger further played the important part of condensing a portion of the moisture contained in the compressed air and bringing the snow formed within manageable limits.

The Lecturer than noticed some of the applications of these machines, and first, ice-making. Detailing the result of his experiments, he showed that the essential condition of making hard and clean ice was that the surfaces of ice while freezing should not get nearer than within a few inches of each other, as, when the reverse happened, amorphous crystallization ceased, and by mutual attraction the crystals of ice shot like long spikes through the water to meet each other, and these spikes interlacing were the cause of spongy and rotten ice. He next illustrated the process of cooling paraffin, which was, as far as he knew, the first application of a refrigerating-machine to manufactures. Paraffin being a bad conductor of heat, had to be cooled in thin films ; this difficulty he overcame by making a drum revolve, which was kept cold by the machine, with its under surface dipping slightly into the solution of oil and paraffin intended to be cooled. A thin coating adhering to the drum, by the time it had made nearly a revolution, became sufficiently cool, and was then removed continuously by a scraper and ready to be taken to the press, so that the oil might be extracted, and the solid paraffin obtained from which the finest candles were made. Glancing at its important application to breweries, the last subject the Lecturer elucidated was the process of preserving meat by freezing it. The late Mr .Mort, of Sydney, gave much attention to this subject many years ago, but nothing practical came of it, at least so far as the importation on board ship went, until Mr. Coleman applied the direct method of cooling air. On long voyages from Australia, meat was frozen quite hard ; in fact, much of it was at a temperature many degrees below zero. Meat brought from America, however, did not require to be actually frozen. He showed that it was in every way preferable to use a small quantity of air, cooled to a very low temperature, than a very large quantity cooled to a less temperature, it led to the reduction of the space occupied on board ship, the size and friction of the machinery were diminished, and the very cold air, by its greater density, assisted to maintain the requisite circulation amongst the closely-packed cargo of meat with which the ship's hold was filled.

In conclusion, the Lecturer gave some statistics of the extent to which this meat-trade had grown during the last five years. By the use of Mr. Coleman's machine alone (he had not been able to find out how much had been imported by other machines), 563,568 quarters of beef and 113,633 carcases of mutton, had been imported from America. By various machines during the last four years there had been imported from Australia 3,159 carcases of beef and 138,664 carcases of mutton ; while from New Zealand in the last two years, 728 quarters of beef and 129,732 carcases of mutton, had been imported. In the months of January and February this year, there came from Australia and New Zealand 69,663 carcases of mutton. These figures might be taken to represent a gross value of nearly three millions and a half sterling, besides which a considerable quantity of meat had been imported from the River Plate. He pointed out that each machine had its own proper use in this country. For such purposes as making ice the ammonia-machines would perhaps be most largely used ; while abroad, where supplies of chemical substances were apt to fail, and were at all times very expensive, machines producing cold by the expansion of air would be found preferable. On the other hand, where water-power could be had, the air-machine and apparatus after the type of the ether-machines, were the only ones applicable. On board ship, the air-machine was the only suitable one.

A CORRESPONDENT sends the enclosed from the *Derry Standard* for explanation : A singular accident is reported to have happened in connection with the insulated electric rail on the Portrush Electric Tramway. A plough manreturning from work on Thursday stood upon the rail to mount his horse, and, on applying his hands to the back of the, animal, the brute fell dead, while the man was uninjured s though the current of electricity must have passed through his body to the horse.

CHIMNEY, &c.

PROCEEDINGS OF AM. SOC. S.E.

A paper by Hiram F. Mills, C. E. describing the construction of the Pacific Mills Chimney at Lawrence, Mass., was read by the Secretary at a meeting of the American Society of Civil Engineers. This chimney was built by Mr. Mills in 1873, and consists of an outside octagonal shell 222 feet high above the ground with a distinct interior core 8 feet 6 inches in diameter inside, extending one foot above the top of the outer shell and eleven feet below the ground. The chimney is founded 19 feet below the ground, upon coarse sand, the foundation being 35 feet square enclosed by pine sheet piling. The base is concrete, one foot thick, then rubble masonry of large pieces of granite in cement, this stone work being 7 feet high. Upon the stone work is placed the brick chimney, the outer shaft being at the base 20 feet wide, and at the top, under the projecting cornice of 11 feet 6 inches wide. This brick-work is 28 ft ins. in thickness at the base ; at 12 feet in height it becomes 24 inches, which continues 18 feet ; then 20 inches for 20 feet ; then 16 inches for 40 feet ; then 12 inches for 60 feet ; then 8 inches to the top. The inside core is 2 feet thick to a height of 27 feet and one foot thick for the remaining height of 154 feet. The top of the chimney is of cast iron plates ¾ inch thick. The horizontal flue entering the chimney is 7 feet 6 inches square. The vertical flue of the chimney is a cylinder 8 feet 6 inches in inside diameter, and 234 feet high with walls 20 inches thick for 20 feet, 16 inches thick for 17 feet, 12 inches thick for 52 feet and 8 inches thick for 145 feet. The foundations were laid in mortar, of Rosendale cement and sand ; the outer shell in mortar of Rasendole cement, lime and sand ; and the flue walls in mortar of lime and sand.

During the winter of 1873, the flue being 90 feet above the ground, boilers having 452 square feet of grate surface were connected with the chimney with satisfactory results. Between June and September, 1874, the chimney was finished.

The approximate weight of the chimney is 2,250 long tons, the number of bricks being about 550,000. The chimney is opposite the middle of a line of 28 boilers and 210 feet distant from them. It was designed to serve for boilers having 700 square feet of grate surface, burning about 13 tons of Anthraeite coal per square foot of grate surface per hour.

The chimney was struck by lightning in June, 1880, after which date a lightning rod was put up which consists of a seamless copper tube, 5-16th inch thick, one inch inside diameter, at the top of which are 7 points radiating from a ball 4 inches in diameter, the top of the central point being 8½ feet above the iron cap. The rod is attached to the chimney by brass castings, and is connected at the bottom to a 4-inch iron pipe extending 60 feet to a canal.

A description was then read of the chimney of the Merrimack Manufacturing Co. of Lowell, Mass., built under the direction of J. T. Baker, C.E., in 1882. This chimney is founded on a ledge of sand stone. The foundation, 30 feet in diameter, is built of granite blocks laid as they come from the quarry. At the surface of the ground there is a dressed granite base 2 feet 6 inches in height, laid in clear Portland cement, the remainder of the foundation being in Rosendale cement and sand. Upon this base is placed the brick-work consisting of three cylinders, the outside one 28 feet in diameter, 24 inches thick, the middle one 18 feet in diameter, 8 inches thick, the core 12 feet inside diameter and 16 inchus thick. The middle cylinder is carried up vertically 75 feet 6 inches; the outside ring has a batter 42-100th of an inch per foot to a height of 100 feet. At the height 75½ feet the middle ring connects with the exterior ring making the masonry at that point 36½ inches thick; it is then 20 inches thick for an additional height of 60 feet; 16 inches thick for 70 feet, and 12 inches thick thence to the enlargement for the chimney head. The core is uniformly 12 feet inside diameter to the top, the first 100 feet being 16 inches thick; then 12 inches thick for 60 feet; then 8 inches thick for 90 feet; and then 4 inches thick for 29½ feet to the top. It is entirely separate from the outside masonry except about the door-ways and openings for the flues. The core was laid in mortar of lime and sand; the outside shell in lime, cement and sand. On one side of the chimney is a ladder of wire extending from the ground to the top, and on the opposite side is a ¾-inch galvanized iron wire rope, both ladder and rope being connected with a copper ring having four spurs the central of which extends 8 feet above the top of the chimney. The bottom of both ladder and rope is connected with a 16 inch water pipe. Two wrought iron flues enter the chimney, one 5 feet by 6 feet, the other 5 feet by 11 feet. The chimney is constructed to provide for 15 sets of boilers only 12 now being in use. Each set has 103½ square feet of grate surface, and is rated at 300 horse power. The weight of the chimney is 3392 tons. 1,101,000 bricks were used, 6875 cubic feet of stone masonry. The cap weighs 18,600 pounds. The cost of the chimney was $18,500.

A description was then given by Dr. Charles E. Emery, M. Am. Soc. C.E. of the construction of the chimney built under his direction, of the Greenwich Street boiler house of the New York Steam Heating Company. This chimney was a creature of circumstances, it being necessary to place within a very limited area, a very large boiler capacity, viz., 16,000 horse power. This was done by making four stories of boilers—the chimney was therefore necessarily located with reference to these boilers, and the plan of the chimney was determined by the shape of the lot. The beach of the Hudson river was at some time at this locality, and the foundation of the chimney was placed in fine clear beach sand with some packets of coarser sand and a little stone. The foundation is one foot below high water. The chimney is 27 feet 10 inches in the clear inside, and 8 feet 4 inches wide. The height is 220 feet above high water—221 feet above the foundation—217 feet above the basement floor—201 feet above the grates of the lower tier of boilers, and 141 feet above the grates of the upper tier of boilers. The thickness of the walls on the interior of the building runs from 5 feet to 20 inches, and on the other side from 3 feet to 20 inches. The gases for each chimney are taken from 32 boilers of 250 horse power each. About 1,000 tons of coal will be burned daily. It is expected that elevator arrangements will be perfected to receive this amount of coal each night. More trouble is experienced with the ashes than with the coal. Ordinary grate bars have been used. Clearing is done once every six hours. We have used a new bar that turns on hinges and gives good results. We have not made many experiments with coal dust. We have to use a fuel which has some reserve power to provide for possible contingencies. We find coal is worth about what is charged for it.

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Abstract from Sir Jos. Bazalgette's Address before the Inst. of C. E. (*Eng.*)—In London, 5,800,000 tons of coal were consumed per annum, in addition to 2,000,000 tons used in the manufacture of gas. Bearing in mind that each ton of coal consumed generated 56,000 cubic feet of carbonic acid gas, and that in a pure atmosphere there were not more than 3½ parts of carbonic acid in 10,000 parts of air, the mode of dealing with this product became a subject of grave importance. But it was the imperfect combustion of coal which caused the more apparent annoyance of smoke and soot. The appliances and regulations to secure the effectual combustion of fuel, so as to prevent its waste and unnecessary contamination of the atmosphere, might be carried out in new cities at no great cost, although there must always be objection to the introduction in an old city of any improvement which rendered necessary some structural alreration in every house. Sir Joseph Bazalgette then referred at considerable length to the housing of the poor. Prior to introduction of the Artizans' and Labourers' Dwelling Act of 1875, twenty-eight associations had provided improved homes for 32,435 persons, at a cost of about £1,200,000, at an average rental of from 2*s.* to 2*s.* 9*d.* for one room to 4*s.* 6*d.* to 6*s.* 6*d.* for three rooms per week. The return realized upon the outlay varied from 2⅜ to 6¼ per cent. But these associations had the advantage of selecting vacant sites on favorable terms, whilst under the operation of the Artizans' Dwellings Act the houses on any unhealthy district for which the new buildings were substituted had to be purchased compulsorily, as well as the public-houses and shops mixed up with them, at a heavy cost, and then cleared, and new thoroughfares and sewers constructed. Twelve areas in different parts of London, embracing an aggregate area of 40 acres, in which the houses were overcrowded and unfit for human habitation, had been dealt with by the Metropolitan Board of Works, at a cost of £1,500,000, and some further areas by the Corporation. The cost of the new building had varied from 6*d.* to 8*d.* per cubic foot. The sites which had been cleared for their erection had been sold at from 2*s.* to 5*s.* per superficial foot. In the dormitories of poor-houses and prisons a breathing space of from 450 to 500 cubic feet, with proper ventilation, had been deemed requisite for a healthy man. The police requirement for common lodging-houses was 240 cubic feet per head, and 450 cubic feet were allowed to each policeman lodged at a station. The Poor-Law Board allowed 500 cubic feet per head in sick wards, and 300 cubic feet per head in dormitories. 500 cubic feet per head meant a room 8 feet high and 15¾ feet square for four adults, and this allowance per inhabitant had been generally made in carrying out the provisions of the Artizans' Dwellings Act; the doors and windows of the new buildings were also larger, the surrounding streets and open spaces wider than previously, and the ventilation was superior.

Steel Railroad Ties.—Experiments are about to be made with steel ties by the Chief Engineer of the Reading Railroad. The only noticeable difference in shape between the wooden and steel, is that the steel would be made hollow. They would be of great duration, lasting until rusted away, while the best oak ties lasts only some eight years. Among the advantages, it is claimed, they would lessen the wear and tear of the track. The road bed being of a more solid basis the train could attain a higher speed, running firmer and smoother. The expenditures will also be greatly lessened. Before long there must be some substitute for wooden ties as they are becoming more and more expensive every year.—*Sc. Am.*

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WILD BEES.—(*Knowledge.*)

By S. A. Butler, B.A., B.Sc.

(*Continued from page* 89.)

Sometimes there may be found on the bodies of bees a curious little orange-colored six-footed creature about one-tenth of an inch long. This is the young larva of a great, fat, lazy beetle, the Oil Beetle, so called from a nasty habit it has of causing drops of an oily fluid to exude from its joints whenever it is handled. The perfect beetle may frequently be seen lazily scrambling over the grass in our fields. It is a bluish-black, flabby creature, with an abdomen of proportions quite aldermanic. It is not easy to understand what the larvæ of these beetles can want on a bee's back; but in some instances, at any rate, on being carried to the nest, they fall to on the larva of their host, and enrich themselves at its expense.

The humble-bees, or dumbledors, which constitute the genus *Bombus* are subject to the parisitism of certain two-winged flies. The grubs of one of these live actually inside the bodies of the bees. Another is called *Volucella bombylans*; it is a beautiful creature, presenting a superficial resemblance to the bees in whose nests it lives; but the most curious fact about it is that its colour varies with the species on which it is parasitic. When it lives with a yellow-banded white-tailed bee, it is itself yellow-banded and white-tailed; but when the host has a red tail and no yellow band the fly also is furnished with a like colouration. The fly-grubs devour the bee-grubs, and sometimes almost clear out the nest. But the *Bombi* are subject to more insidious parasitism than even that of *Volucella*; certain *bees*, almost the exact counterparts of the *Bombi*, but differing in having no brush of hairs on their legs for the collection of pollen, live with them like the wasp-like cuckoo bees before-mentioned, and their grubs feed upon the store of nutriment laid up by the industrious hosts for their own progeny. Notwithstanding their "sponging" habits, these parasites live quite amicably with their hosts; who may, indeed, be unable to distinguish them from the legitimate owners of the nests.

Wild bees are either solitary or social. The solitary species live each in its own nest, while those that are social form larger or smaller communities, living in a single nest. Solitary bees may be, and often are, gregarious—that is, many burrows are found very near together, in the same bank, for example, but these are all separate abodes, and the inhabitants are all independent of one another. Amongst the solitary species there is, as I have already implied, a great diversity of habits. The burrows of the Plastering bees are adorned with layer upon layer of a most delicate membrane, something like gold-beater's skin, but much thinner; this is secreted by the insect itself, which uses its curiously-shaped tongue (Fig. 2) as a kind of trowel to plaster the secretion over the sides and end of its burrow. The Leaf-cutters (Fig. 7) line their nests with fragments of leaves, which they cut from various shrubs and trees. The cylindrical burrow having been prepared in sand, earth, or wood, as the case may be, the little labourer flies away to its chosen shrub—say a rosebush. It alights upon a leaf, and, fixing itself upon the edge, holds it with three legs on each side, and then with its mandibles begins to snip out an oval or semicircular cutting, biting its way backwards and holding on all the time to the piece, which is thus gradually detached. When the last bite is given, and the insect is about to fall with its prize, it spreads its wings and flies away in a "bee-line" to its home, where the leaf-cutting is duly deposited in a suitable position. Straight back again to the same plant the industrious creature flies, and in the same way makes another cutting, slightly altering the shape according to the requirements of the burrow. This is placed so as to lap slightly over the piece first placed in position, and then another and another is added, until the whole cell is made snug and comfortable for the reception of the egg and the food the young grub is to eat; then the cell is closed up with a number of circular leaf-cuttings, all obtained in the same way as before.

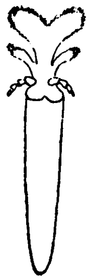

Fig. 2 *bis*.—Tongue of Plastering Bee.

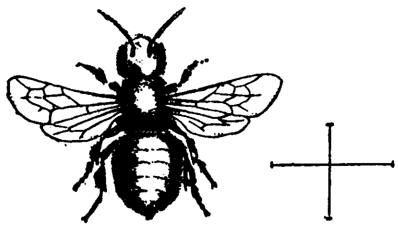

Fig. 7.—Megachile centuncularis. A Leaf-cutter Bee.

Like the Leaf-cutters, the Mason Bees are stoutly-built insects; their habits are very various, so much so, indeed, that they have been said to manifest greater diversity of instinct than any other group of bees. There is not that constancy in the choice of a situation for the construction of the nest that we find in most of the other groups. For example, the commonest species, *Osmia rufa*, exhibits a wonderful power of adapting itself to circumstances; in hilly country, or at the seaside, it often burrows in the sunny side of cliffs and in sandy banks, but in a cultivated district, especially when the soil is clayey, it will seek out some old willow tree and make its burrow in the decaying stump. Much more difficult situations are, however, not unfrequently chosen, *e.g.* the mortar of old walls. Nor does the insect always excavate its own burrow; it sometimes avails itself of some cleft or crevice already made; thus, its nests have been found in the lock of an out-house door and in a cavity in a flint used in the rockwork of a garden; but, most extraordinary of all, a nest was once formed in the tube of a fife that had been left in a garden arbour. When the fife was found, no less than fourteen cells had been made by the industrious little creature, and the fifteenth had been commenced; the bee had entered the fife at the lower end, and commenced its cells a little below the blow-hole. Some species form their nests in old snail shells, arranging the cells in different ways, as necessitated by the varying diameter of the whorls of the shell. Others, again, choose as a nidus the hollow straw-tubes in thatch, or a bramble stick from which the pith has been extracted. The cells are made of little particles of earth, stone, or other materials, agglutinated together by a gummy substance secreted by the insect itself. Both Leaf-cutters and Masons have the under surface of the abdomen densely clothed with pubescense, and with this brush of hairs they collect the pollen required for the support of their young.

The economy of the social bees is exceedingly interesting; the great buzzing, humble bees that are seen in the warm days of spring rifling the sallow blossoms, or calmly cutting their way through the air with self-satisfied hum, are the females, which have remained in a torpid state through the winter months, but have been revivified and brought forth from their retreats by the enlivening rays of the sun, as it daily mounts higher and higher in the heavens. The troubles of maternity are before them; and after they have made selection of a convenient cavity for the nest, a store of pollen has to be provided to meet the wants of the expected offspring. In addition to this, the parent bee constructs a number of receptacles called honey-pots, which she fills with a coarse kind of honey, the use of which is not certainly known. Then a few eggs are laid, which soon hatch, and the little creatures speedily pass through their metamorphoses; these are the neuters, or workers, and upon them now devolves the labour of enlarging the nest according to the needs of the community, as well as of providing for the wants of their future companions. It is not till the season is considerably advanced that young females appear, and these are followed after a time by the males. The females are often very much larger than either the males or the workers, and sometimes the latter are exceedingly diminutive, when compared with the mother of them all. Some of the Bombi construct their nests on the surface of the ground, and others at some depth underneath, and it is a remarkable fact that this difference of habit is accompanied by a difference of temperament in the insects, the underground builders being much more pugnacious and vindictive than those that build at the surface. The nests of the latter consist of piles of little bits of grass, moss, &c., collected with great assiduity, and arranged with considerable care and skill by the little artificers. Occasionally they will adapt birds' nests to their requirements, apparently turning out the real owner, sometimes even after its eggs have been laid. The number of bees constituting one community of course varies with the season, being greatest in the autumn, when all the sexes are found. At this time the nest of one of the carder bees has been found to contain about 120 specimens, of which about half were workers. In no case is the population anything like so dense as with the hive-bee. It may be as well to mention that honey-comb is not manufactured by any of our wild bees.

HYDRAULIC PROPULSION.

BY MR. SYDNEY WALKER BARNSBY, ASSOC. M. INST., C.E.*

The idea of propelling ships, by forcing water through the bottom or sides by means of pumps, was suggested in 1661, which was the date of the first patent upon the subject. The "Nautilus" and the "Waterwitch," built in 1866, attracted a good deal of public attention. The latter was an armoured gunboat built for the Admiralty at the Thames Ironworks, the machinery having been designed by Mr. Ruthven. This gunboat was driven by two water-jets discharged from nozzles at the sides level with the water, the diameter of each of which was 24 inches. The jets were supplied by a centrifugal pump, 14 feet in diameter. The quantity of water discharged per second was 5.2 tons at a velocity of 29 feet per second. When the engines were developing 760 indicated H. P. the vessel, which was of 1,161 tons displacement, attained a speed of 9·3 knots. The "Viper," a similar vessel, but driven by a screw-propeller, with a displacement of 1,180 tons, attained a speed of 9·58 knots, with 696 indicated H. P. Although this pointed to a considerable waste of power by the Hydraulic system, many people thought it had not received a fair trial; and Lord Dufferin's Committee on designs of ships of war in 1871, recommended that in view of its suitability for drafts of water so small as to preclude the use of screws, it should receive a more thorough trial. In 1878 an hydraulic torpedo vessel was built in Sweden for competition with a similar vessel propelled by twin screws. The vessels were 58 feet in length with 10 feet 9 inches beam, and of 20 to 21 tons displacement. The screws with 90 indicated H.P. drove the boat at a speed of 10 knots, while the turbine, with 78 indicated H.P., gave a speed of 8·12 knots per hour. The displacement co-efficients were 82 with the screw, 52·5 with the turbine. The Fleischer Hydromoter, built in Germany in 1879, also failed to compete with the screw in point of economy. In this vessel there was no centrifugal pump. The steam acted directly upon the water, forcing it out of vertical cylinders through nozzles in the bottom of the vessel, which could be turned in any direction. The motion was unpleasant owing to the intermittent action of the jets, and the speed obtained was small.

The advantages which the hydraulic system of propulsion presented might be enumerated as follows:—No impediment to speed under sail; no racing of the engines; power of reversing-motion in the hands of the officer on deck; full engine power for manœuvering; vessel capable of being made double-ended, and power of ramming much increased. The propeller was not liable to receive damage from running aground, and could not be fouled by floating obstructions; it was favourable for light draught, and the large pumping-power was available for keeping down leaks. The disadvantages were mainly these:—The difficulty of utilizing the full energy of the water entering the propeller; every particle of water acted upon must be carried in the ship; loss by friction of the water in the passages and by bends in the pipe.

In 1882, Messrs. Thornycroft was building at Chiswick twenty second-class torpedo boats for the Admiralty, and they were commissioned by their Lordships to fit one of them with a Ruthven propeller in competition with the screw. As the machinery was necessarily heavier, the hydraulic boat was given a little extra length. The dimensions of the screw-boats were: length 63 feet, beam 7 feet 6 inches, draught 3 feet 8½ inches, displacement 12·89 tons. In the hydraulic boat the length was increased to 66 feet 4 inches, the beam was 7 feet 6 inches, draught 2 feet 6 inches, and displacement 14.4 tons. The engines, which were compound and surface-condensing, had cylinders 8½ and 14½ inches in diameter, with 12 inches length of stroke. They drove a turbine 2 feet 6 inches in diameter at 428 revolutions per minute. The inlet to the pump was at the bottom of the vessel about amidships, and the discharges, 9 inches in diameter, were at the sides just above the water. In all previous hydraulic boats the water had been taken in through a hole in the bottom, in such a way that all its velocity relative to the ship was destroyed before it entered the pump. This velocity had to be restored by the pump, which involved a large waste of power. In the Thornycroft boat the bottom had been formed in such a manner that a large hole was presented to the water at right angles to the keel. The water flowed with unchecked velocity through the pump, and if the vessel was towed along the water was scooped up, flowed of its own accord through the pump, and fell out at the nozzles. The nozzles could be worked from the conning-tower, and made to discharge the water ahead, astern, or athwartships, thus driving the boat in either direction or stopping her. On trial the pump discharged one ton of water per second, at a velocity of 37¼ feet per second. The H.P. developed by the engines was 167. The speed obtained by the boat was 12·6 knots per hour. The engines in the screw-boat were considerably lighter. The cylinders were 8¼ and 13½ inches in diameter, with 8 inches length of stroke. They developed 170 indicated H. P. with 636 revolutions. The speed obtained was 17·3 knots perhour. The measure adopted for measuring the quantity of water discharged from the nozzles in the hydraulic boat was considerably more accurate than any hitherto employed. On the "Waterwitch," very imperfect measurements of the velocity of discharge were taken with a patent log placed in the jet. Measurements were made by the Author on the new boat by a thin plate 1-03125 inch square, attached to the end of a lever, and placed in the jet just where it left the nozzle. The pressure on the plate was recorded by a dynamometer. The apparatus was so arranged that the pressure could be measured at every part of the jet, and not in the centre only. The pressure varied greatly in different parts of the jet, the mean being nine-tenths of the pressure in the centre. From this the velocity of the water was estimated, and also the quantity discharged.

The efficiency of the jet was found to be 0·71 and of the pump 0·46. In the "Waterwitch" the efficiency of the jet was 0·5, and of the pump 0·47. In the Swedish hydraulic boat the efficiency of the jet was 0·5, and of the pump 0·55. The total efficiency or ratio of useful work in the jet to the actual work expended in producing it was—in the "Waterwitch," 0·18; in the Swedish boat 0·214; and in the Thornycroft boat 0·254. The displacements co-efficients at the maximum speeds were, in the Thornycroft screw-boat, 169; in the Thornycroft hydraulic boat, 72. The only fair comparison, however, between these two boats was at the same speed of 12·6 knots; the co-efficient of the screw was then 140—still nearly double that of the other boat. It must also be remembered that no comparison could fairly be drawn between the co-efficients of the Thornycroft hydraulic boat at 12·6 knots and the co-efficient of the "Waterwitch" at 9·3 knots which was 116. The speed of 9·3 knots was an easy one for a vessel 16·2 feet long, while 12·6 knots was a speed difficult of attainment by a boat only 66 feet long. If the latter had been designed to run at 8½ knots, its most economical speed, the co-efficient would have been 140 against the 116 of the "Waterwitch."

In conclusion, it was worthy of note that one of the greatest obstacles to the success of the jet-propeller, namely, the loss of energy of the water entering the propeller, had been overcome. It had been clearly foreseen by Mr. Thornycroft; and by adapting the bottom of the boat to meet it in the manner described, the efficiency of the jet had been raised from 0·5 to 0·71. Unfortunately this obstacle did not stand alone. What efficiency it was possible to get with a centrifugal pump delivering one ton of water per second, with a lift of 21½ feet and of limited weight and dimensions, the Author could not say; 46 per cent. seemed very low; had it reached 70 per cent. the total efficiency would have been 0·38 and the speed upwards of 15 knots. Perhaps this amount of success might yet be achieved for the hydraulic propeller, but it was not likely to be exceeded. The case at present stood somewhat thus:—In the screw-boat the efficiencies were—engine, 0·77; screw propeller, 0·65; total, 0·5. In the hydraulic boat—engine, 0·77; jet-propeller, 0·71; pump, 0·46; total 0·254. The jet, as a propeller, might be taken as a little better than a screw, but the loss in the pump was a dead loss, and represented about half the power. In other words, before a hydraulic-propelled boat could be made to compare favourably with one driven by a screw, the pump producing the jet must work without loss.

Miscellaneous Notes.

SUNSHINE RECORDERS.—It is singular that an important defect in a sunshine recorder now being brought prominently before the public appears to have escaped the attention of its makers. The card-holder has adjustment for any latitude, but it does not allow the sunshine to focus through the glass sphere for more than six hours on each side of the meridian. Now, in the latitude of London, in the middle of June, the sun rises about 3 hours 15 minutes a.m., and sets about 8 hours 15 minutes p.m. This sunshine recorder will not act before 6 a.m., nor after 6 p.m. Consequently no less than four and a half

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* A Lecture delivered before the Institution of Civil Engineers.

hours of possible sunshine cannot be recorded by this instrument. The defect will apply more or less to all the records of sunshine during the six months March 21st to September 22nd.

THE *Engineer* states that the world's average product of sulphur is about 280,000 tons, of an average value of 109.20 lire per ton = 30,793,000 lire, or over £1,200,000 sterling. Of this total, Sicily produces 242,000 tons. There is an export duty of 11 lire per ton on sulphur, and the average export is 216,000 tons. The Sicilian sulphur is mostly exported raw, as it comes from the kilns. It is of seven qualities, the values varying from 101 to 115 lire per ton. Except in the better-worked "solfare," the separation of the sulphur from the earths in which it is contained is still conducted in Sicily by means of kilns (calcuroni). which do not require any additional fuel, but which entail the consumption and loss of about one-third of the sulphur itself. About 18,000 hands are employed in the Sicilian "solfare," of whom about 14,000 work in the interior of the mines, including those employed in the transport of the ore to the surface. The sulphur in many mines is still carried to the surface on the backs of boys called "carusi," of whom there are about 3,500.

RAILWAY BUILDING ACROSS BRITISH NORTH AMERICA.—The annual report of the Canadian Minister of Railways, as presented to the Dominion Parliament, contains an interesting review of the progress made in the past year in the completion of the through connection over Canadian territory between the Atlantic and Pacific sea-boards. Of the 2,889 miles of Canadian Pacific main line or railway, 2,023 have been completed, and are now in operation. It appears that as compared with the estimate of distance of the through line made in the last report of the Minister, a saving of 100 miles has been effected by the change of route through the Rocky Mountains from the Yellow Head Pass to the Kicking Horse Pass, to the summit of which the track of the railway is now laid. The Government Chief Engineer of Canada, in his statement to the Minister of railways, reports that on a personal inspection of the whole line of the Canadian Pacific Railway, so far as it is completed, he found it to be "well and substantially built, the larger streams being spanned by strong iron bridges, resting upon abutments and piers of massive masonry, and the whole is being carried out in a manner fully up to the requirements."

Telephony.—The figures which we subjoin, says the *Pall Mall Gazette* of the 22nd inst., showing the number of messages sent through the United Telephone Company's London Exchange during the past week, are simply astounding, reaching as they do now to nearly 300,000 a week, or an increase of nearly 50,000 messages a week over the past month. Should this rapid rate of increase continue, this company will in the short period of four years from its formation be transmitting a greater number of messages than the whole Postal Telegraphs, not only in London, but in the United Kingdom.

		Calls.	Messages.	
Monday, March	10,	25,497	50,994	Number of subscribers, 3,293 at £20 a year, = £1,267 for one week.
Tuesday, "	11,	25,658	51,316	
Wednesday, "	12,	25,335	50,670	
Thursday, "	13,	26,011	52,022	
Friday, "	14,	36,284	52,568	
Saturday, "	15,	17,074	34,148	

291,718 for £1,267 or one penny per message.

Corresponding week in Feb. 249,202

Increase .... 42,526 a week.

London was at present supplied with water by eight independent companies. The aggregate supply was 140,000,000 gallons daily, of which from 15,000,000 to 18,000,000 were consumed outside the Metropolitan boundaries. The consumption within the Metropolis was at the rate of about 31 gallons per head daily. Nearly one-half of the water was obtained from the Thames, and the remainder from the River Lee, the New River, and other sources. The charges of the Water Companies for water were mostly based on the rateable value of the houses supplied, and not according to the quantity consumed. But inasmuch as the rateable value of houses in London had risen since 1855 from £4 per head to £7 per head of the population, and the consumption of water had remained the same, the price of water, as based upon the rateable value, was now 75 per cent. dearer than it was in 1855: and there was no reason to doubt that so long as the price remained a fixed charge upon the rateable value of the houses, the cost of water and the value of the property of the Water Companies would increase in a like ratio. The total capital employed by the Water Companies was about £13,200,000, or at the rate of 61·7*d*. per 1,000 gallons of water supplied. The net charge for water amounted to 7·3*d*. per 1,000 gallons, on which there was a net profit of 4·1*d*. When in 1880 it was proposed to purchase the London Water Companies, the arbitrator valued their interest at £33,000,000.

THE LIGHTING is after supply of Lonnon The lighting of the Metropolis was effected mainly by three Gas Companies, at a cost varying from 2*s* 10*d*. to 3*s*. 2*d*. per 1,000 cubic fect. More than 20,000,000,000 cubic feet of gas per annum were manufactured out of 2,000,000 tons of coal. It was distributed through 2,500 miles of pipes, varying from 3 inches to 4 feet in diameter, at a cost of about £3,000,000, or more than double the cost of the water-supply. The gas was required to have an illuminating power of 16 candles when consumed at the rate of 5 cubic feet per hour, to be entirely free from sulphuretted hydrogen, with a maximum of 4 grains of ammonia, and from 17 to 22 grains of sulphur, in 100 cubic feet of gas.

Electric lighting was rapidly advancing. When, in 1878, the Jablochkoff Company commenced lighting a portion of the Victoria Embankment, the charge for each lamp was 5*d*. per hour. This had been reduced by stages, and since June, 1881, forty lights on the Embankment, and ten on Waterloo Bridge had continued to be lighted at the rate of 1½*d*. per light per hour. In fact, twice the illuminating power was at present obtained on the Embankment by electric lighting for the same money if expended on gas. But it had been stated that the contract had not been profitable at the latter price. Incandescence lighting, though much more costly in production, was more economical in the regulation and distribution of the light.

Sir Joseph Bazalgette in his inaugural address before the Institution of Civil Engineers stated that in the United Kingdom alone there then existed 8,000 miles of railway, on which £286,000,000 had been expended. There were now upwards of 18,000 miles of railway, having an authorised capita exceeding £800,000,000, on which the gross annual receipts were £67,000,000, and the annual working expenditure £35,000,000. These railways carried 623,000,000 passengers annually, besides 500,000 season ticket holders, and 246,000,000 tons of minerals and general merchandise. Contrary to the anticipations of Telford and of Walker, the demand for engineers of a more highly educated and trained class, and the number of these, had continued rapidly to increase, notwithstanding competition was keen as in all other occupations in this country. The discovery of some of the latent energies in nature, and their application for the use of man, was tending still further to the development of engineering.

London is now without a rival as regards size and population, not only in the present. but as far as is known in the past history of the world. London, or the Metropolis, as defined by the Metropolis Management Act of 1855, contains at present nearly 4,000,000 people, covering an area of 117 square miles, upon which are built 500,000 houses. Its population is equal to that of the whole State of Holland, is greater than that of Scotland, and double that of Denmark. At the same rate of increase, by the end of the century, it would equal that of Ireland, as indeed Outer London now does. Its population has quadrupled since 1801, when it numbered 959,000; and it is now increasing at the rate of 70,000 per annum, equivalent to the addition to London every year of a city as large as Geneva or of Plymouth. The rateable value of property in London has grown from £6,000,000 in 1841 to £28,000,000 at presen, or nearly five-fold in forty-three years. But the traffic through London has risen even more rapidly. The arterial lines of thoroughfare, wide enough half a century ago, are now altogether insufficient. Thus, although the Strand and Cheapside have been relieved by the formation of a new route between Charing Cross and the Bank, along the Victoria Embankment and Queen Victoria Street, and Holborn has been relieved by a new route from Oxford Street to Shoreditch, and new and widened streets continue to be made through the City and other crowded localities, the old lines of thoroughfare still remain congested by the traffic. There now pass over the Metropolitan bridges daily 384,000 pedestrians and 75,000 vehicles, the annual increase being at the rate of 4½ per cent. and 13 per cent. respectively. The traffic on three Metropolitan railways has risen from 79,000,000 passengers in 1871 to 136,000,000 in 1881, or to 373,000 daily.

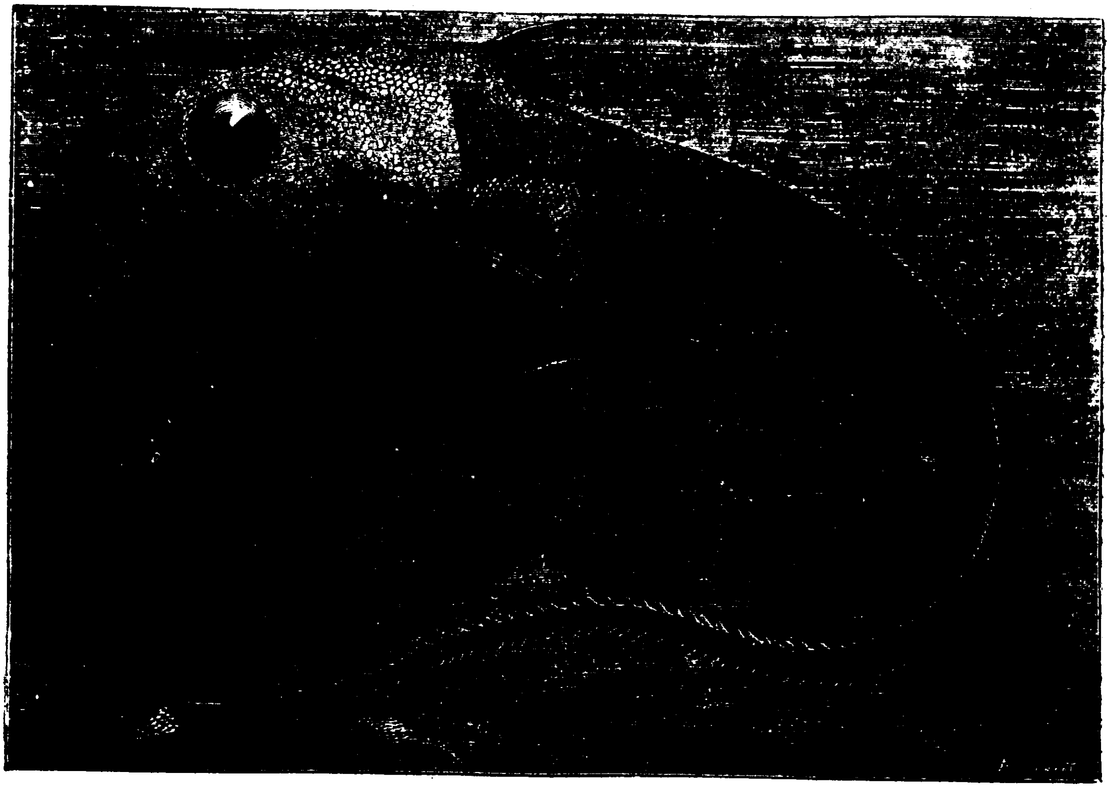

FIG. 1.—*Macrurus globiceps*, Vaill.

THE DEEP-SEA FISHES OF THE "TALISMAN."

Among the many wonderful animal forms collected during the voyage of the *Talisman* none surpass the fishes in interest. In the exhibition, now open at the Jardin des Plantes, Paris, of the various specimens collected during this voyage, the collection of fishes holds a chief place. During the cruises of the *Travailleur*, owing to the apparatus employed, the capture of a fish was a rare event, but by the employment of a kind of drag-net on board the *Talisman* the number both of species and individuals taken was quite surprising. Once, on July 29, in 16° 52' F. lat. and 27° 50' W. long., in one haul of the drag-net no less than 1081 fishes were taken from a depth of 450 metres. The chief surface fish noted in M. Filhol's very interesting papers, which are in course of publication in our French contemporary *La Nature* (to which journal we are indebted for the illustrations accompanying this notice), were the well-known shark (*Charcharias glaucus*) very common between the Senegal coast and the Cape de Verde Islands; its strange attendant fish, the so-colled pilot fish (*Naucrates ductor*), and the very curious and odd-looking fish of the Sargassum Sea, *Antennartus marmoratus*. It is noted that not only were the pilot fishes never molested by the sharks but that they constantly swam round them, sometimes even they were seen placing themselves against the shark's sides between their pectoral fins. Many observations were made on the strange Antennarius, the colour of whose body so closely approaches to that of the alga amidst which it lives that it enables these fish to approach almost unseen, and so quite easily take their prey. It is not, however, altogether unworthy of remark that this prey, consisting for the most part of small crustacea and mollusks, is also of the same general shade of colour as the mass of the weed, so that the assuming of this uniform dull tinge of colour must mean a heightened danger to some of these forms of life.

The great interest, however, of the fish captures of the *Talisman* centres in the remarkable forms taken from the depths of the sea, which were both considerable in the number of individuals and in the newness of the forms. The question of whether certain fish inhabit certain zones of depths was closely considered, and is answered in the affirmative. These zones are of very considerable depth, varying from 600 to over 3650 metres, and in bringing up specimens from such areas of great pressure these suffer immensely through the phenomena caused by the rapid decompression of the air, the more remarkable effects being dilatation of the swim bladder, the eyes being squeezed out of their orbits, and the scales clothing the body are shed. In some cases even the fish's body has become smashed into pieces. Notwithstanding all these phenomena, the area in depth of the distribution of many of the deep-sea fish is very considerable. Thus *Alepocephalus rostratus* is met with between a depth of 868 and that of 3650 metres; *Scopelus maderensis* between depths of 1090 and 3655 metres; *Lepioderma macrops*, between 1153 and 3655 metres; and *Macrurus affinis*, between 590 and 2220 metres. The explanation would seem to be not only that the organization of these fishes is such as enables them to support the enormous pressures at the greater depths of the ocean, but that in the course of their movements of ascent and descent they proceed very slowly so as gradually to get accustomed to the alterations in pressure. These fishes are all flesh eaters, with well developed dental systems; the absence of light prevents the growth of marine algæ in these depths, and as a general rule all the fish found below 150 metres are of necessity predatory. These deep-sea fishes, as Dr. Gunther reminds us, do not belong to any peculiar order, but are chiefly modified forms of surface types; some of these modifications being no doubt very extreme, but serving as indications not only of the struggle for existence, but also of the plasticness of the forms to adapt themselves to the extreme conditions under which they live. The most remark-

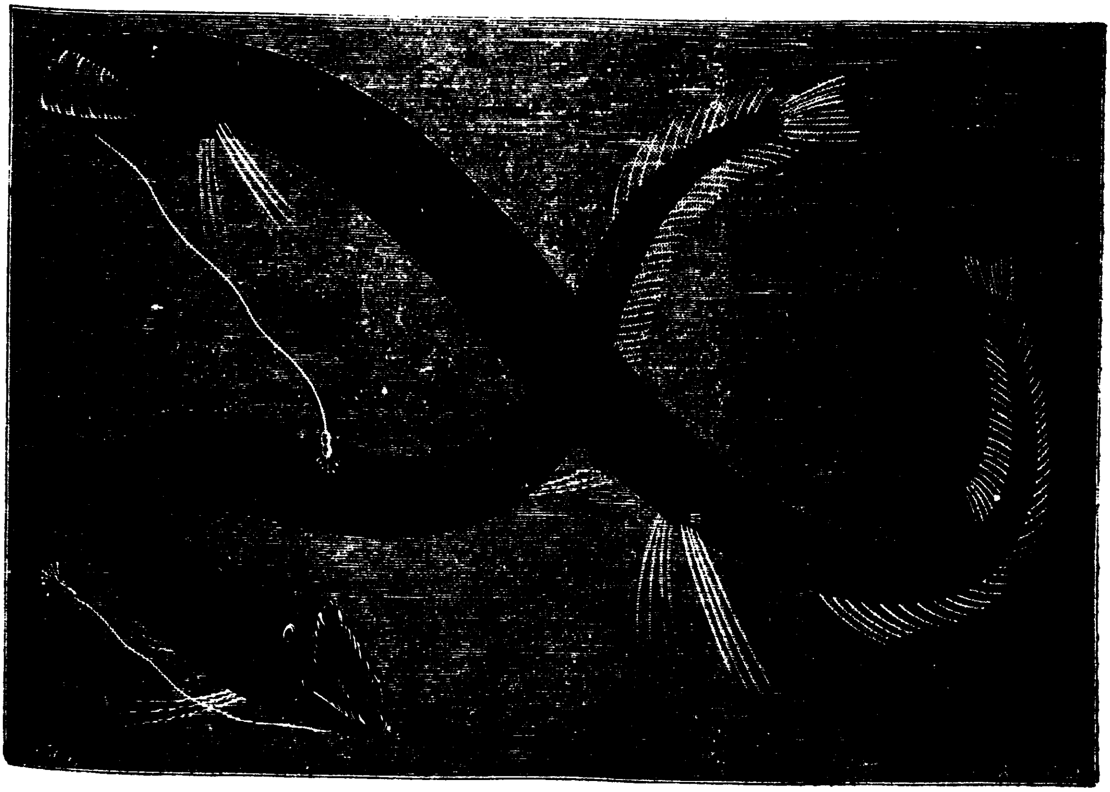

FIG. 2.—*Eustomias obscurus*, Vaill.

able phenomena in connection with their deep-sea life is doubtless the tremendous pressure which has to be borne. No one seems to doubt but that these deep-sea forms live as active a life as surface forms, indeed their very appearance seems to indicate a swiftness and energy of movement not to be surpassed by surface swimmers, and we may believe that the abyssal pressure has a great deal to do with keeping their feebly calcareous bones and delicate muscular system compact and in a condition for effective use. The placid state of the water at these depths must also be borne in mind—no storms affect them, and the extraordinary attenuation of some organs may be directly ascribed to this phenomenon. This *Macrurus globiceps* (Fig. 1), which forms one of a family of deep-sea Ganoids, known as living at depths of from 600 to 2200 metres, and occurring in considerable variety and great numbers over all our oceans, is a new species, described by M. L. Vaillant as found at a depth of between 1500 and 3000 metres. Its body, globular in front, will be seen to be very greatly attenuated behind.

In some of the deep-sea fishes peculiar organs, unknown for the most part among surface fishes, are to be found; these are sometimes "more or less numerous, round, showing mother-of-pearl coloured bodies embedded in the skin;" in some fish these are to be met with on the head, or near the eyes, or along the sides and back. Dr. Gunther informs us that of these strange bodies the following hypotheses are possible: (1) all these different organs are accessory eyes; (2) only those having a lense-like body in their interior are sensory, those with gland-like structure are not sensory but are phosphorescent; and (3) all are producers of light. Many serious objections can be urged against the first view. Some of the fish with immense eyes have these bodies, others without eyes want them, while as to glandular bodies being sense organs this is not yet scientifically realizable. One seems therefore justified in adopting the middle hypothesis, and though on first thought it seems strange that fish with large eyes should have accessory eyes, yet Dr. Gunther's supposition may be the true one—that there are light producers behind the lenses, and that these latter may act the part of "bull's-eyes" in a lantern. This form of "light organ" might constitute a very deadly trap for prey, one moment shining it might attract the curiosity of some simple fish, then extinguished the simple fish would fall an easy prey.

Long filamentous organs are to be met with showing apparently a brilliant type of phosphorescence. Among the many curious forms of development of these tactile organs to be met with, one of the most singular is that to be seen on a fish refeared by M. L. Vaillant to a new genus and species found at a depth of 2700 metres, and represented in Dreysan. In this form (*Eustomias obscurus*) the tactile organ takes the appearance ofa long filament, which is placed underneath the lower jaw, and which ends in an inflated and rayed knob-like phosphorescent mass.

Another peculiarity now well known in deep-sea fishes is the enormous development of the mouth and stomach of these fish. In the genus Melanocetus and in Chiafmodus the capacity of the stomach is such that it can contain prey twice the size of the fish which swallowed it, and perhaps the largest gape of jaws known is that of *Eurypharynx pelecanoides*. The greatest depth at which a fish was taken during the cruise of the *Talisman* was 4255 metres; the fish was *Bylhytes crassus*; but it will be remembered that during the *Challenger* expedition a specimen of *Bathyopts forax* was taken at a depth of 5000 metres.

We hope again to have the opportunity of referring to other of the deep-sea forms taken by the *Talisman*.

NOTES ON ELECTRICITY AND MAGNETISM.

BY PROF. W. GARNETT.

(*Continued from page* 87.)

If the air be at a positive potential and a conductor be surrounded by the air but placed in connection with the earth, the conductor will be at potential zero, and will be negatively electrified. In order to bring the conductor to the potential of the air, it must be placed on an insulating support and then deprived of its electrification.

If it were possible to remove the whole of the outer surface of the conductor, the induced electrification might be carried off with it and the conductor left unelectrified, and therefore at the potential of the air around it. On connecting the conductor with an electrometer the latter would not, however, attain the potential of the air unless the capacity of the conductor were very great compared with that of the electrometer.

If the conductor be insulated and connected with the electrometer, and if a very sharp point be attached to the conductor, electricity will pass off the point so long as there is any considerable charge induced upon the conductor that is, so long as the potential of the conductor differs considerably from that of the surrounding air; but unless it is extremely sharp the point will become inefficient before the potential of the conductor approaches very closely to that of the air.

If a burning match or gas flame be in communication with the conductor, the flame will form part of the conductor itself, and will be negatively electrified so long as the potential of the conductor is less than that of the air immediately surrounding the flame. But the negatively electrified flame is continually being dissipated into the air, carrying its negative electrification with it, and being replaced by another flame, as it were, which in turn becomes electrified at the expense of the conductor, and this process goes on until the conductor, and the quadrants of the electrometer connected with it, are raised to the same potential as the air which *immediately surrounds the flame.* In connection with his portable electrometer, Sir William Thompson employs a burning slow match to raise the potential of the plate of the instrument to that of the air in the neighbourhood.

Sir Wm. Thomson's water dropping collector, as employed for the determination of the potential of the air at fixed observatories, consists of a metal tank of water supported on an insulating stand and connected with one electrode of a quadrant electrometer, the other electrode of which is put to earth. A long tube, suspended by insulating strings, conveys the water from the tank to the point at which the potential of the air is to be measured. At this point the water is allowed to escape from a jet and break up into drops. If the potential of the tank is lower than that of the air at the point where the drops fall, each drop, being in connection with the conductor, will be negatively electrified, and in falling will carry off its negative electrification with it. This action will continue until the potential of the tank is equal to that of *the air immediately surrounding the drops at the point where they break away*, and when this is the case the drops will fall away unelectrified, and the potential of the tank will undergo no further change. The electrometer, therefore, will register the potential of the air at the point where the drops fall away from the jet; or if a continuous stream of water fall for some distance, the potential registered would be that of the air where the stream breaks up into drops. If the tank be originally at a higher potential than the air at the point where the drops fall, the drops will be positively electrified until the potential of the tank has been sufficiently reduced.

If a Leyden jar is so constructed that its inner or outer armatures (or coatings) can be removed by means of insulating handles, and if the jar be charged and then stripped of its armatures, the latter will be found to be almost unelectrified, but upon replacing them in their proper positions the jar can be discharged. If, instead of replacing the same armatures, a new pair of armatures were fitted to the jar, the discharge could be obtained with equal facility. This experiment indicates that the energy of the charged Leyden jar does not reside upon its armatures but upon or within the glass itself.

When a Leyden jar is charged to a very high potential, a spark will sometimes pass through the substance of the glass, destroying the jar and frequently pulverising the glass in the neighbourhood of the perforation. Before the glass can yield to the electric forces it is clear that it must be strained beyond its elastic limits and up to its ultimate strength. Hence we may conclude that before the jar is charged sufficiently for a spark to pass the glass must be in a state of strain. To produce this strain work must have been done, and the glass, like a bent spring, in relieving itself from this state of strain, is able to do an amount of work equivalent to that which has been done upon it (if its elasticity be perfect). We are thus led to regard the strained condition of the glass as the form which the energy of the charged Leyden jar assumes, and as all the electrified systems with which we are concerned in the study of electrostatics differ from a charged Leyden jar only in the nature of the dielectric and the forms and relative positions of the electrified surfaces, we naturally infer that the energy of all electrified systems is due to a state of strain of the dielectric or insulator, which separates the oppositely electrified surfaces. According to this view the conductors in an electrostatic system simply serve to bring the electric charges to their surfaces. The dielectric is the arena of all electrostatic phenomena.

Faraday supposed that the particles of a dielectric in an electric field are thrown into a state of polarization, each particle being electrified positively on one side and negatively on the other, and that in this way the electric force is communicated from point to point in the field. Maxwell showed that electric phenomena can be accounted for by supposing that there is a tension in the dielectric in the direction in which the electric force acts, accompanied by an equal pressure in every direction at right angles to the force, and that such a system of stresses is compatible with the equilibrium of the dielectric. The energy of the dielectric due to the state of strain into which it is thrown is the energy of the electrified system. The mechanism by which Maxwell supposed this state of strain to be brought about is consistent with Faraday's theory of polarization.

When a Leyden jar is charged we must regard the glass as thrown into a state of strain, being exposed to a tension in the direction of its thickness, and an equal and opposite pressure at right angles to this direction.

When the jar is discharged this state of strain is suddenly relieved, and the pent up energy appears in the discharge.

When a glass fibre is twisted and then released it is found that it does not immediately return to its original state, but having nearly regained its original condition in the first rebound it afterwards returns only very slowly, so that a very long time elapses before the glass is in exactly the same condition as it was before the strain. Other (imperfectly elastic) substances exhibit similar phenomena in a more or less marked degree. The same behaviour appears in the discharge of the Leyden jar. The glass does not at once return to its original condition, and restore in the first discharge the whole of the energy employed in charging the jar. But if, after the first discharge, the jar be left for a time, it will be found possible to obtain a second discharge (much smaller than the first) from it, and after another interval a third discharge, and so on, the discharges becoming successively feebler. This phenomenon is known as the "*residual charge*" of the Leyden jar.

All dielectrics do not allow of the transmission of electric force with equal facility. Thus, if two balls be charged so that they repel one another with a force of one dyne when separated by one centimetre in air, and if the balls be then placed in paraffin oil, the force between them will be considerably less than one dyne when they are at the same distance apart, and to obtain a repulsion of one dyne at a distance of one centimetre in paraffin oil the charges must be considerably increased. Hence, if we were to determine the unit of electricity by finding the amount which would repel an equal amount at a distance of one centimetre with a force of one dyne, and were to repeat our experiments in different media, each different dielectric would furnish a different unit, that obtained in air (or vacuum) being the least.

Since the forces between charges of electricity depend on the medium through which they act, it follows that the quantity of electricity required to raise a conductor to unit potential will depend on the nature of the dielectric which separates it from other conductors in the neighbourhood.

DEF. The ratio of the capacity of a condenser having any given substance for its dielectric to that of an otherwise precisely equal condenser having air for its dielectric is called the specific inductive capacity of the substance.

The letters S. I. C. are sometimes employed as an abbreviation for specific inductive capacity.

The measurement of the specific inductive capacity of a dielectric is a very difficult operation on account of the complications introduced by the phenomenon of "risual charge." The difficulty is greatest in substances which, like glass, are of very complex chemical constitution. To reduce as far as possible the errors arising from this cause attempts have been made to measure the capacities of condensers when they are charged and discharged successively many thousands of times in a second.

A NEW ILLUMINANT.—Lieutenant Dick, of the Russian army, is said to have discovered a new illuminating substance which is capable of imparting luminous properties to objects to which it is applied. It is in the form of a powder, and of three colours—green, yellow, and violet, the latter being the most powerful. Water in a glass vessel is by this means converted into an illuminating fluid. In a lecture recently delivered by the inventor at the Nicolai Engineering Academy, at St. Petersburg, he explained the application of the substance to military and industrial mining operations. The illuminating power lasts for eight hours, and the powder must then be renewed. The German Government is said to have been lately making experiments with Lieutenant Dick's invention.

PANCLASTITE.—(*Sc. Am.*)

The new explosives known as panclastite, which have attracted so much attention from engineers and chemists, from a group which has no connection with any other known explosives. They are possessd of peculiar properties and power, and merit a description. The combustive element of this new section of explosive bodies, which is the discovery of Mr. Eugene Turpin, is peroxide of nitrogen. The combustible body may be formed of different substances, such as sulphide of carbon, petroleum touene and xylene, benzoles, and vegetable and animal oils. Each of these substances gives a different explosive endowed with special properties. Another group is formed of a mixture of peroxide of nitrogen with nitrobenzine. This latter groupe gives products great stability. In fact, the combustible being already nitrated to saturation by nitric acid, the peroxide of nitrogen has no action upon it, and intervenes, merely as a combustive, by its simple admixture, to render it explosive. These compounds are specially adapted for military purposes.

In principle, panclastite for industrial purposes consists of two liquids, one soluble in the other, which are inert taken separately, but which it is only necessary to mix together to at once obtain, without any other operation, an explosive that is more powerful and more instantaneous than nitroglycerine.

Certain mixtures thus obtained resist shocks better in the liquid state than any other known explosives, even ordinary mining powder. Ordinary power explodes under the shock of an iron weight of six kilogrammes falling from a height of half a meter. Gun cotton and other products of the same section explode under the fall of the same weight from a height of a quarter of a meter. Seventy-five per cent dynamite explodes under the same weight falling 0.15 meter, and dynamite gum explodes under a fall of from 0.20 to 0.25 meter Pur nitroglycerine explodes under a fall of 9.10 to 0.15 meter. Panclastite in a liquid state does not explode under the shock of the same weight falling *four meters.* All these experiments were made under exactly the same conditions by means of apparatus constructed by Mr. Turpin, and one of which is shown in Fig. 1.

Certain compounds of panclastite are non-inflammable, while others are more or less inflammable, but never detonate throught fire alone, in an open vessel. All the inflammable compounds burn quietly in the open air. It requires a preliminary explosion to bring about one of panclastite, such, for instance, as that of a primer charged with fulmite of mercury. Certain of the compounds burn so quickly and with so brilliant a flame that Mr. Turpin has been led to devise a portable apparatus for optical telegraphy at night, in which the material is used as an illuminating agent. Panclastite, considered as an explosive, enjoys the peculiar and valuable property that its sensitiveness and power may be varied at will. All the experiments with it have been made with the mixture that is least sensitive in a liquid state.

But its sensitiveness may be made such that a hermetically closed vessel filled with the mixture will explode under its own weight in falling from a height of from one to two meters upon hard ground. One the contrary, the sensitiveness may be made so slight as to make it impossible to explode it under the influence of a primer charged with 3 grammes of fulminate of mercury. Finally, as with nitroglycerine, panclastite may be united with an active porous substance, such as powder, vandanite, etc. In such a case, it again loses its sensitiveness to shock.

When dynamite and panclastite are caused to explode in the open air upon leaden cylinders, it is found that the effects produced by panclastite are infinitely superior to those obtained with a larger quantity dynamite.

Fig. 2 shows the arrangement befoe the explosion. A is the leaden cylinder, B is a bottle plaeed upon it and containing the explosive, and C is the priming and fuse. Here the bottle represented as containing 10 grammes of panclastite.

Fig. 3 shows the leaden cylinders before and after the explosion. No. 1 represents the cylinders before the explosion, No. 2 the same cylinder crushed by the explosion of 20 grammes of dynamite gum, and No. 3 a cylinder crushed by the explosion of 10 grammes of panclastite. As may be seen, the effect produced by the new explosive is greatly superior to that given by dynamite, notwithstanding that the former be used in much less quantity.

Among other open air experiments that have been tried with it we may cite the following. An iron rail was placed upon an oak tie, and in the channel between the flange and lighted head, there was laid a cartridge containing 60 grammes of panclastite primed in the ordinary way. When the fuse was a violent explosion ensued and the rail was literally crushed into fine bits, the majority of which were driven deeply into the tie, tha latter itself having been broken.

Some of the fragments of the rail weighed but a few grammes. For these details and the engraving we are indebted to *La Nature*.

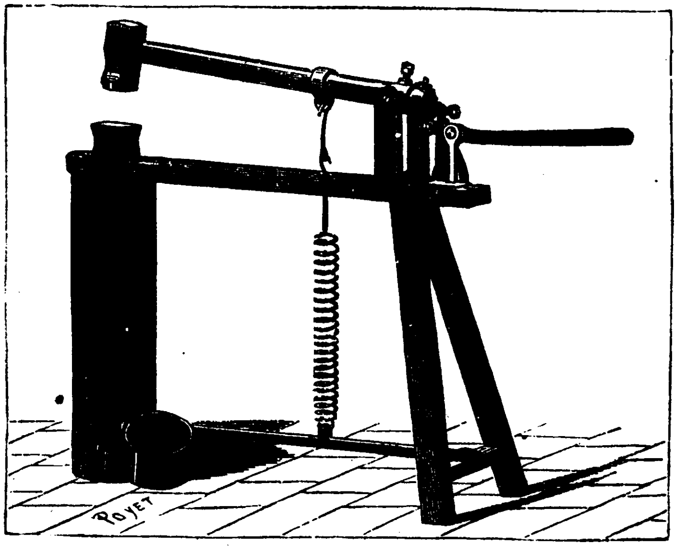

Fig. 1.—TURPIN'S PERCUSSION APPARATUS FOR EXPERIMENTING UPON EXPLOSIVES.

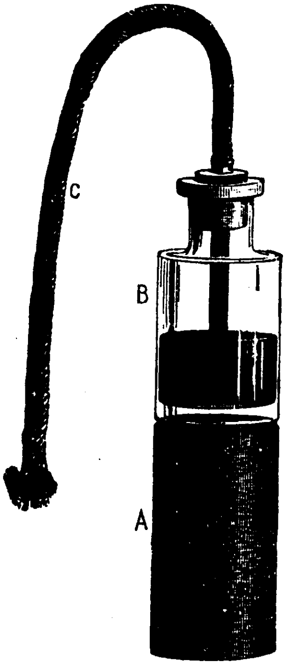

Fig. 2.—ARRANGEMENT FOR TESTING POWER OF EXPLOSIVES.

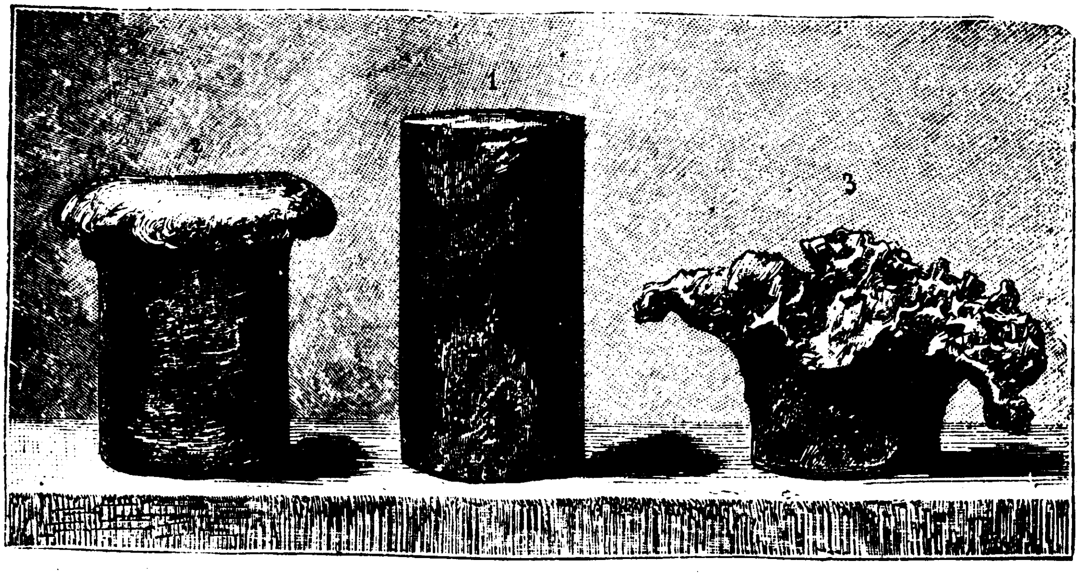

Fig. 3.—COMPARATIVE RESULTS GIVEN BY THE EXPLOSION OF DYNAMITE AND PANCLASTITE.