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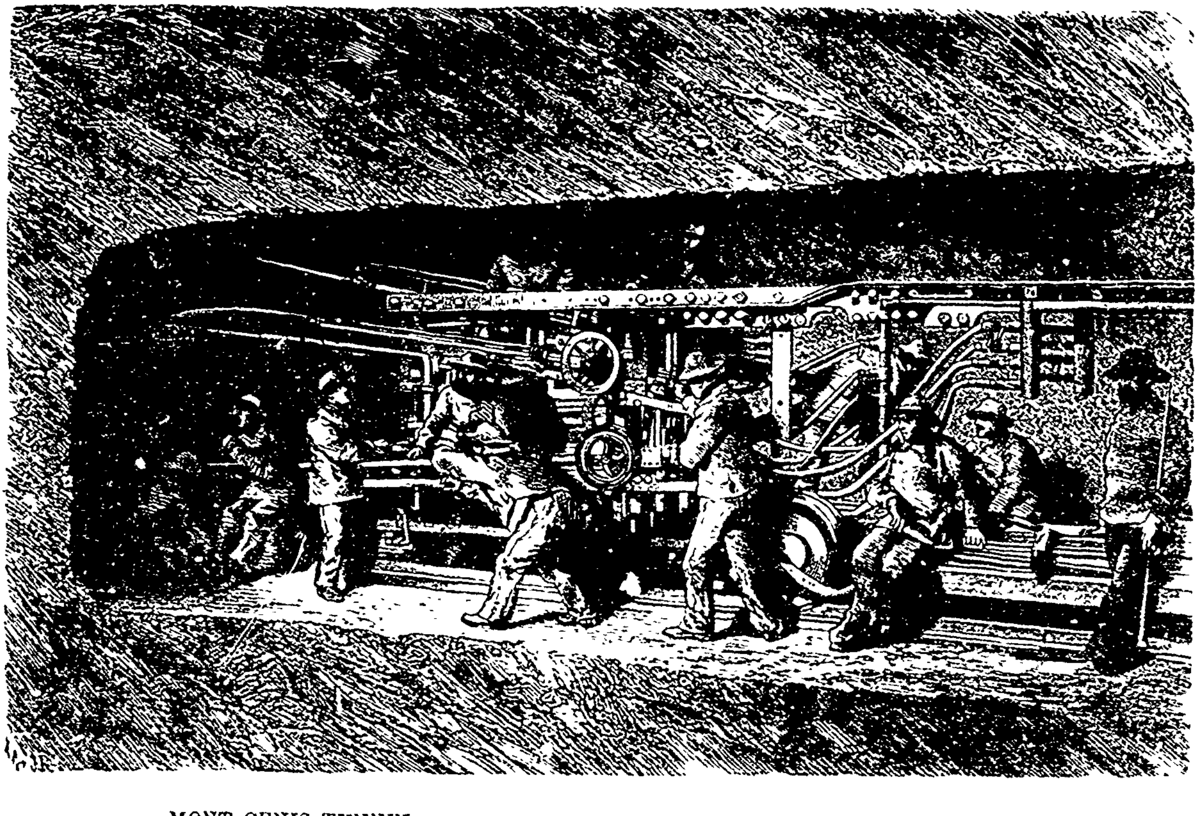

MONT CENIS TUNNEL.

Towards the close of 1870, when France and Germany were in the midst of bloody strife, that great triumph of modern engineering—the tunneling of Mont Cenis—was accomplished.

All travelers between France and Italy were obliged to leave the railway at Susa and endure a long and tedious ride of six hours in the stage-coach over the mountain pass. The highway is considered one of the best built roads in Europe, and well it might, costing upward of 12,000,000 francs. During summer the view of the surrounding mountain peaks is grand beyond description, but to be forced to ride for hours through the snow, or encounter an avalanche, intimidated many from employing that route In 1863, during the boring of the tunnel, the French built a railroad, using a part of the public road, this shortened the journey some three hours. It was a curious sight to see the trains zig-zagging up the mountain side.

Count Cavour, the great Italian Statesman, in 1857, demonstrated the feasibility of connecting Savoy, which was then Italian territory, and Piedmont, by means of a railroad through the Alps, and was the first to propose the tunnel. Mont Cenis was selected as the most direct line between Turin and Geneva (Switzerland) The little town of Bardoneche was chosen as the terminus on the Italian, or south side, thence through in a straight line to Modano, a small village of Savoy.

Of course they went but slowly on at first, the Italian Government having to bear all the expense, but soon after, when Savoy had been ceded to France and Napoleon commenced to bore at the Modane terminus, the work went more rapidly forward. For thirteen years, night and day, the work progressed and the opposite gangs were steadily approaching each other. For the first five years, the work moved forward tardily enough—being at the rate of 1,643 feet per annum. The rock is of the hardest species of gneiss, and hand-drilling was consequently exceedingly arduous. 1862, however, marks a new era in the history of this enterprise, for Sommeiller, a French savant, invented one of the most wonderful machines of modern times. It is especially adapted for the purpose, for, being put into action by pneumatic power, the dangerous boiler and the air destroying fire, were rendered useless. Immediately the work took a fresh start and was pushed forward at the rate of 4,200 feet per year.

This gigantic drilling apparatus was worked entirely by compressed air which was forced through pipes by a series of turbine wheels, driven by steam power at the entrance of the tunnel. The wonderful adaptability of this style of machines for working in close confined quarters, is shown in the fact, that the same air, after serving as the motive power, passed into the atmosphere and afforded breathing material for the working men. Water to clean the drills was also forced into the machine by pumps erected in the valleys at either end of the tunnel, and as the tunnel lengthened, a new section of the pipes was inserted, to keep pace. To render moving the drill easy, the connecting pipes were of flexible India-rubber.

When the holes had been drilled about thirty inches deep, the machine was drawn back upon the tracks, which were laid as rapidly as the work progressed, not only for this purpose, but also for the transportation of the detached rock. Now the blasters filled each drill with a pound, more or less, of powder; the men drew back, and soon a thunder-like noise would resound, scattering the rock and shaking the mountain to the summit. To those who dwelt near the opening of the tunnel the sound would resemble distant cannon. Immediately the air valves are opened, and soon all the smoke and dust is blown out of the tunnel into the open air. Soon all the detached stone is cleared away and the work proceeds as before.

Sommeiller lived to see his invention accomplish the work in about half the time it had been calculated at the outset would have been required. The most sanguine had removed the completion twenty-four years ahead, but the inventor finished the work within thirteen years. He was amongst the first to pass through the tunnel, end to end, by rail, but did not long survive the severe exposure he had undergone during the work. He died the following summer.

The tunnel is a fraction less than eight miles in length, 41,815 feet. And to give an idea of the labor it required, we will give a few figures. For every foot of stone taken out it was necessary to drill from thirty-five to forty holes, and to loosen the stone from thirty to thirty-five pounds of powder were used; thus making in all something like 1,580,970 holes drilled, and requiring no less than 1,489,892 pounds of powder.

From the entrance, on the French side, the bore ascends at the rate of sixty feet to the 1,000, until about half way, then level to the other end. So exact had been the calculation, that when the workmen met, four miles from the starting point, they found that there had not been an inch of deviation from the straight line. What wondrous skill so to guide, that two lines shall exactly meet at the centre of a mountain nearly 10,000 feet in height!

We can hardly imagine the moment of intense joy that thrilled the workmen on the 28th December, when at early dawn they heard, though dimly, each other working on either side of the fast waning rocky partition.

How they must have redoubled their energy and with what strong enthusiasm, they, flushed with the expectant victory, pressed on with their work. Never did men feel more filled with the importance of their work than they. For many long and laborious years they had gradually worked toward one another, and now their labours were soon to terminate in perfect success.

Quickly a messenger was sent from the Italian workmen, to go over the mountain and tell their French co-workers to prepare a huge blast, and touch it off at exactly twelve, noon, and the Italians would do the same.

The hour came, and with it a tremendous blast which shattered the last remaining rock, and united the ends of this stupendous master work.—*Cal. Ill Press.*

ON AN IMPROVED FORM OF ANEROID FOR DETERMINING HEIGHTS, &c.*

By R. L. Rogers Field, B.A., C.E.

The author begins by stating that the object aimed at in designing this improved form of aneroid was to simplify the correct determination of altitudes in cases such as ordinarily occur in England, and that the instrument is therefore arranged to suit moderate elevations, say of 2,000 ft. and under, and is not intended for considerable elevations.

Before proceeding to describe this instrument he briefly recapitulates the general principles on which the measurement of heights by a mercurial barometer depends, and for this purpose he refers to the mercurial barometer as the original source from which the graduations on the aneroid are obtained. If an observation taken at one station is compared with that taken at a higher one the difference of the readings of the barometer will give the height of mercury which balances the column of air between the two stations, so that knowing the relative weight of air and mercury we can determine the height of the column of air, or in other words, the vertical height between the two stations. The relative weights of air and of mercury are variable, being affected by the gradual reduction of the pressure of the air as we ascend, and also by variations of temperature; the accurate determination of their relative weights is the principle which lies at the basis of the various formulæ that have been proposed for barometrical measurement of altitudes, although the problem cannot be stated in such a simple form as this.

The preceding general principles apply to the aneroid equally with a mercurial barometer. A good aneroid is always graduated by direct comparison with a standard mercurial barometer, so that the readings of the aneroid represent those of a mercurial barometer, and the better the aneroid the more accurate this representation will be. A well constructed aneroid, however, differs from a mercurial barometer by being compensated to a certain extent for the effect of the temperature on the instrument itself, so that this need not be taken into account, more especially as the effect of temperature on the instrument only becomes important when the temperatures of the stations differ considerably, which they will not do in moderate elevations.

The conditions, therefore, which have to be taken into account in the present case, are, (1) the pressure of the atmosphere, and (2) the temperature of the air.

Various formulæ are given by different authorities for determining the altitude readings of the barometer, but they do not differ much for small altitudes, though this is far from being the case with great altitudes. The table which is adopted in graduating the present aneroid is that given by the Astronomer Royal in the "Proceedings of the Meteorological Society," vol. iii., page 406, and gives results which lie between those of the other authorities.

Aneroids constructed for the determination of elevation by readings from an altitude scale consist of two classes, one in which the altitude scale is fixed, and the other in which it is movable at random. The first class of aneroid with a fixed scale is accurate in principle, but the scale only allows for one of the conditions which have to be taken into account, viz., the varying pressure of the atmosphere, and the other condition, or temperature of the atmosphere has to be allowed for by calculation. The second class of aneroid, that with a movable scale, is radically wrong in principle as ordinarily used, inasmuch as the movable scale must be graduated from one fixed position of the zero, and when the zero is shifted at random according to the position of the hand of the instrument, the scale necessarily becomes inaccurate.

In the improved aneroid the scale of altitudes is movable, but instead of being shifted at random according to the position of the hand of the instrument, it is moved into certain fixed

* British Association, Section G.

positions, according to the temperature of the atmosphere, so that the shifting of the scale answers the same purpose as if the original scale were altered to suit the various temperatures of the atmosphere. The aneroid is graduated for inches in the usual way on the face, but the graduation only extends from 31 in. to 27 in. so as to preserve an open scale. The outer movable scale is graduated in feet for altitudes, and the graduation is laid down by fixing the zero opposite 31 in. This is the normal position of the scale, and it is then correct for a temperature of 50 deg. For temperatures below 50 deg. the zero of the scale is moved below 31 in. and for temperatures above 50 deg the zero of the scale is moved above 31 in.; the exact position of the zero for different temperatures has been determined partly by calculation, and partly by trial, and marked on the rim of the aneroid. In order to ensure the altitude scale not being shifted after it has once been set in its proper position, there is a special contrivance for locking it in the various positions. The altitudes are, in all cases, determined by taking two readings, one at each station, and then subtracting the reading at the lower station from that at the upper.

The movable scale requires to be set for temperatures before taking any observation, and not shifted during the progress of the observations. This will practically not give any inconvenience in the case of moderate altitudes, as small variations of temperature will not appreciably affect the result, and so long as the temperature does not vary during the course of the observations more than 6 deg. or 8 deg. from that at which the instrument is set, the result may be accepted as practically correct.

In conclusion the author states that the principle of allowing for the variations of temperatures of the atmosphere by shifting the altitude scale does not profess to be theoretically accurate, but simply sufficiently accurate for practical purposes In order to satisfy himself that this was the case, the author carefully tested the aneroid by comparing the readings obtained for different temperatures from the shifted scale with the correct readings as given by calculations from the normal position of the scale, and found that the maximum error was 8 ft. and the average error is under 3 ft., errors which are practically inappreciable.

The instrument was constructed by Mr. Cassella, of Holborn Bars, London.

MEYN'S PATENT BOILER.

The Actien Gesellschaft der Hollerschen Carlshutte, near Rendsburg, have at work in the German Boiler House of the Exhibition, two of J. C. Meyn's patent high-pressure boilers, of which we present engravings on page 198. These boilers are vertical, and of a very novel construction, and it will be seen from the experiments of which the results are given below, that they possess very considerable steaming powers.

Meyn's boiler consists externally of two cylinders, of which the upper is the smaller. The furnace is half internal and half external, and it will be seen that it requires but little building. It is made in this way because sufficient grate surface cannot be obtained on this system with an entirely internal furnace. The grate is 6 ft. 8 in. by 2 ft. 4 in., and has a surface, therefore, of 16.1 square feet. It has no bridge, but communicates directly through a short vertical flue, of which the upper opening is 2 ft. 1 in. diameter, with a central combustion chamber. This chamber is 5 ft 7½ in. diameter inside and 2 ft. 8 in. deep at the sides. Its roof is somewhat dished, and is stayed to the upper part of the boiler by ties as shown. The combustion chamber is traversed by 76 flattened vertical water tubes, which form one of the principal features in the boiler, and Fig. 2, shows their position in the cross section. They are wrought-iron welded tubes, with horizontal channels across their sides – the arrangement of which is shown to a larger scale in Figs. 4, 5 and 6. Through these tubes the water circulates from the lower part of the boiler, and between them the flame must pass. From the roof of the combustion chamber a double ring of tubes leads up to the upper part of the lower shell, the upper cylindrical shell being of such a diameter that it stands inside these rings of tubes. This upper shell is inclosed in a smokebox of the same diameter as the lower shell, and made of sheet iron. The ordinary water level is two-thirds up the height of the upper tubes, as shown on the drawing. The upper shell, therefore serves, as a steam dome of large capacity, and has apparently been really effectual in preventing priming. The steam is led away from the top of the boiler through a pipe which forms a triple ring round it in the smokebox before it is allowed to go into the air.

These boilers are mach ne-rivetted throughout, and if their rivetting is at all as good as that of some specimens (cut in half and planed) exhibited by the Carlshutte Company, it must be unusually excellent. The Company make their own rivets, and make them, we notice, with exceptionally large heads. The horizontal seams in the boiler are all single rivetted butt joints, and the vertical seams, plain single rivetted joints, but these latter would be better arranged to break joint than placed as at present in one continuous line down the side of the boiler. Proper attention has been paid to making the different parts easily accessible for cleaning and repairs, and they are more easily to be got at than is generally the case in similar somewhat complicated boilers. The usual working pressure is 60 lb. per square inch above atmospheric pressure Meyn's boilers are used, among other things, for heating with the flame and gases from puddling furnaces, but under those circumstances there is in general such a superabundance of heat that it can seldom be necessary to use such a complicated boiler in order to economise it.

The principal dimensions of the two boilers exhibited at Vienna are as follows:

	ft. in.
Length of the lower shell	8 4
Diameter "	6 3
Length of upper shell	6 5
Diameter "	4 4
Total height of boiler	14 9
Number of flat water tubes	74
Total surface of tubes	96 sq. ft.
Number of round tubes	66
Diameter of tubes	2.48 in.
Surface of tubes (to water line)	80 sq ft.
Total surface in boiler to water-line	275 "
" " above water-line	155 "
Total heating surface in boiler	430 " (40 sq. m.)
Length of grate	6 ft. 8 in.
Width "	2 " 4 "
Grate surface	16.1 sq. ft.

A number of experiments have been made with Meyn's boiler by engineers and others who use it, and from those published we select the following, which seem to have been made with care and completeness at the Essen Cast Steel Works, in Rhenish Prussia. The boiler tested was one with 34.5 square metres (371 square feet) total heating surface, of which 10.9 square metres (117 square feet) was above the water line The grate surface was 1.54 square metres (16.57 square feet). We have reduced the evaporation given to the corresponding evaporation from and at 100 deg. centigrade (212 Fahr.), which affords a better means of comparison than evaporation from 0 deg. and 100 deg which is the form given in the original table. The analysis of the fuel used was as follows

Carbon	81.34
Hydrogen uncombined	3.45
" in combination	0.74
Oxygen and Nitrogen	5.89
Sulphur	0.64
Water	2.00
Ash	5.94
	100.00

One pound of the coal to which the above analysis refers can evaporate theoretically 14.35 lb. of water from and at 100 deg. centigrade. The temperature of the gases in the chimney in the immediate neighbourhood of the smokebox was 215 deg. to 240 deg. centigrade (419 deg to 464 deg. Fahr.), and the ashes were from 14 to 15 per cent. of the weight of the fuel. It is due to the inventor to say that these experiments were made by the boiler users at his request and quite independently of him or of the boiler makers, and we see no reason to doubt their accuracy. The results which we have arranged in the adjoining table are not those most favourable to the boiler, but those which seemed, on the whole, the most complete. With a better fuel, a better evaporation should, and no doubt would be obtained. The boiler seems to be very free from priming, which is only what its exceptionally large steam room would lead us to expect. The weakest point about it will probably be the upper end of the round flame tubes, which are only a small distance above the water level. We have always found that tubes, the fastening of which is exposed on one side to flame, and on the other to very wet steam, are very apt to give trouble by leaking.

Table Showing Results Obtained with Meyn's High-Pressure Boiler

No of Experiment.	Kilos of Water evaporated from and at 100 deg C. by 1 kilo of coal *	Coal consumed per minute.	Coal consumed per minute.	Water evaporated per minute.	Water evaporated per minute.	Kilos of Coal used per square metre of heating surface per hour.	Kilos of Water evaporated per square metre of heating surface per hour.	Pounds of Coal used per square foot heating surface per hour.	Pounds of Water evaporated per square foot heating surface per hour.	Kilos of Coal per square metre of grate surface per hour.	Pounds of Coal per square foot grate surface per hour.	Percentage of useful effect of coal to total theoretical heat of its combustion.
		kil.	lb.	kilos	lb.							
1	9 168	2 15	4 73	16 61	36 54	3 7	29 0	754	5 91	83 7	17 07	64 1
2	8 565	2 41	5 36	18 17	39 97	4 2	31 7	856	6 46	95 0	19 38	61.8
3	8 211	2 80	6 16	19 32	42 50	4 9	33 7	999	6 87	109 1	22 25	57.2
4	8 030	2 94	6 46	19 81	43 64	5 1	34 6	1 040	7 05	114 7	23 39	[illegible]
5	7 746	3 27	7 19	21 90	46 80	5 7	37 2	1 162	7 58	127 5	26 01	53.9
6	7 413	4 28	9 41	26 80	58 96	7 5	46 3	1 530	9 54	166 9	34 04	51 8

* This column is, of course, the same as if pounds were substituted for kilogrammes

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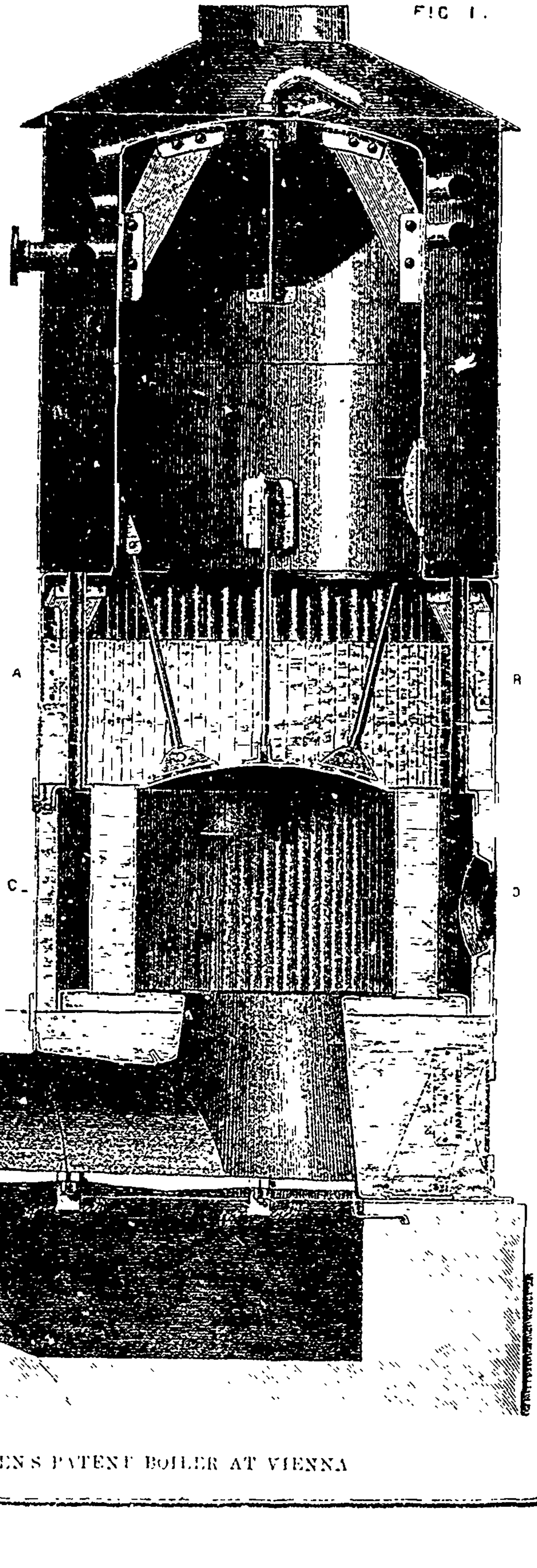
INVESTIGATIONS of a very interesting character, made by an experienced house painter in Paris to ascertain whether emanations from certain paints containing such substances as white lead, zinc white, linseed oil essence of turpentine, coal oil, &c., are injurious to health, show some noteworthy results. He caused the insides of some boxes to be painted, and within them he placed wire cages containing rabbits, which were not in contact with the paint, but only subject to the influence of the emanations from it The rabbits suffered while the paint was fresh, especially when it contained coal oil, but none of them died Living in apartments recently painted, and which emit the odour of oil of turpentine is not, therefore, permanently injurious to health. Some other tests were made for the purpose of obtaining deposits of these emanations from the fresh paintings of houses Instead of rabbits, plates containing a small quantity of water were placed in the boxes, and, after the water had evaporated from the plates, there were found some remarkable crystallisations like needles, consisting of combinations in which the oils employed formed the principal part. These crystalline combinations were obtained even when linseed was used.

INSTRUCTIONS TO ENGINEERS AND FIREMEN.

By R. ARMSTRONG, C.E., in *Van Nostrand's Magazine.*

1. Engineers and firemen who would keep steam with economy, should do with as little stoking or stirring of the fire as possible, if any. In order to do so, they should see before starting that the furnace is properly constructed for the purpose, and large enough for the quantity of steam required. The fire-grate should have about 1 sq. ft of effective fire-bar surface for each nominal horse-power of the engine, or for each cubic foot of water required to be boiled away per hour. The fire-bars may be from ½ to ¾in. thick on the face, with ¼ to ½in. draught spaces

FIG. 1.



MEYEN'S PATENT BOILER AT VIENNA

FIG. 4

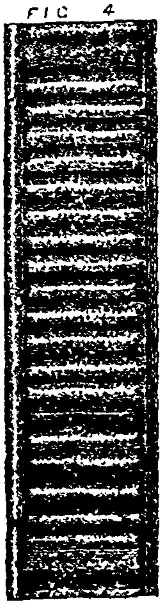


FIG. 2.

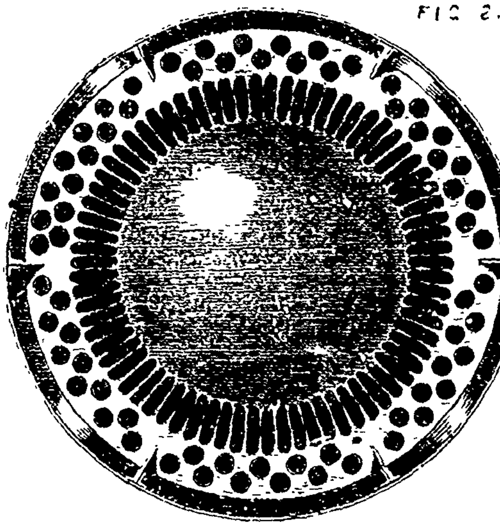


FIG. 3

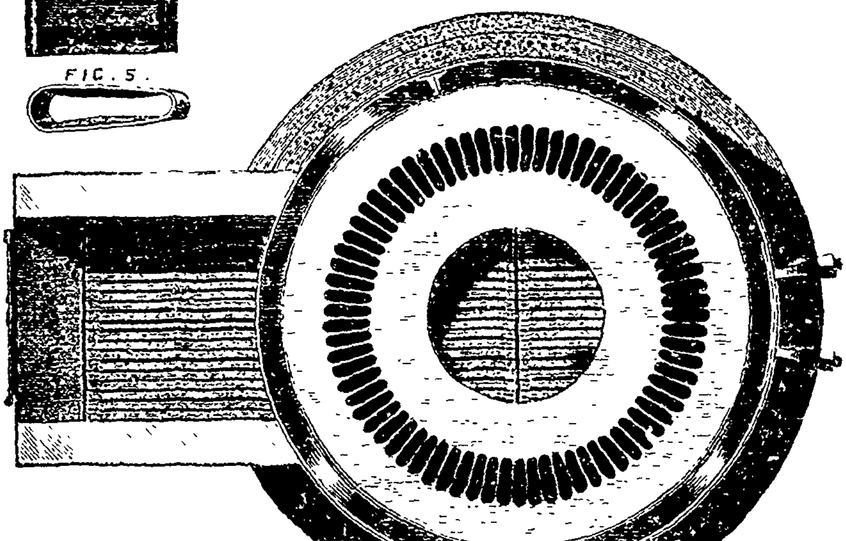
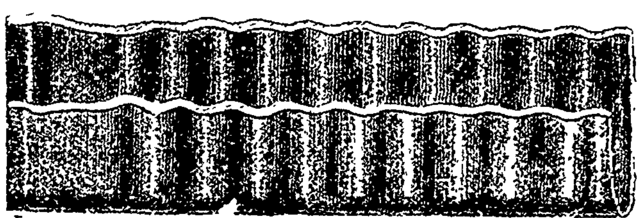


FIG. 5.

FIG. 6.



MEYEN'S PATENT BOILER

between them, and with joggles to keep them asunder nearly the whole depth of the bar. The boiler should have, at least, 8 or 10 sq. ft. of heating surface per horse, and the chimney should be of sufficient *capacity to create* a draught into the furnace equal to the pressure of a column of water $\frac{3}{8}$ to $\frac{5}{8}$in. deep, when the damper is set wide open.

2. In firing, spread the large and small coals (equally mixed) on all parts of the grate, thicker at the back of the grate near the bridge than at the front, because the draught *is* there the strongest, and the coals burn away the quickest.

3. The fire should never be less than about 3 or 4in thick in the middle of its length, 2 or 3in. in front, and 6 or 8in. at the back of the grate. In no case should the fire exceed double the depth here stated; and never more than two-*thirds* of the fire-grate should be entirely covered with fresh coals at one time.

4. If a regularly uniform supply of steam *is required*, and *the* damper quite up, the quantity of fuel on the grate may be gradually increased; but when an increasing quantity of steam is wanted, the average thickness or quantity of fuel on the grate must not then be increased, but ought rather to be diminished, and supplied by smaller quantities at a *time*, and more frequently. So soon, however, as the supply of steam exceeds the demand, the coal must again be supplied by larger quantities at a time, regularly increasing the quantity of fuel in the grate as before. On the other hand, when a diminished supply of steam is required, close the damper a little, and take the opportunity of *levelling the fire or cleaning* the fire-bars, doing one-half of the grate at a time.

5. A steam-engine furnace worked in this way will make very little smoke; or, if any, it may be prevented when desirable by opening the fire-door 2 or 3in. for 1 or 2min. after each firing, bearing in mind that the production of steam is commonly lessened by doing so, but so is the consumption of the fuel.

6. Stokers should understand that they are not to make a business of "stoking," but to leave it off entirely, excepting only when preparing to clear out the grate from clinkers and rubbish, which requires to be done generally three or four times a day with average qualities of coal, convenient times being chosen for the purpose when there is the least demand for steam.

7. A fireman's business is, first, to see, before the *fire-door is opened, that no coal is left* in the heap ready for going on bigger than a man's fist, and that very small coal or slack is wetted, at least damp, as well as a little water always in the ash-pit. *Then* begin by charging into the *farther end of the* furnace, reaching to about one-third the length of the grate from the bridge, as rapidly as possible, from a dozen to twenty or thirty spadefuls of coals, until they form a bank reaching nearly or quite up to the top of the bridge, and then shut the

fire-door, until the other fires, if there are any, are served in the same way.

8. In firing up, throw the coals over the rest of the grate by scattering them evenly from side to side, but thinner at the front, near the dead plate, than at the middle or back. In this manner keep the fuel moderately thick and level across the bars, but always thicker at the back than the front, not by pushing the fire in, but by throwing the coals on exactly where they are wanted.

9. Never for a moment leave any portion of the bars uncovered, which must be prevented by throwing or pitching a spadeful of coals right into any hollow or thin place that appears; and always remember that three or four spadefuls thrown quickly one on the top of the other, will make no more smoke than one, and generally less. But all depends on doing it quickly; that being the main, if not the only, point in which freedom from smoke and economy of fuel agree. Some firemen only put on three spadefuls, while another can put on four, and make 20 per cent. more steam in the same time by doing it.

10. In replenishing the fire, take every opportunity of keeping up the bank of fuel at the bridge, by re-charging it, one side at a time. Whenever this bank is burnt entirely through or low, and also when the fire is in a low state generally, take the rake and draw back the half-burnt fuel 12 or 18 inches from the bridge, and re-charge fresh coal into its place, upon the bare fire-bars as at first.

11. An engine-fire tended in this way will consume its own smoke without difficulty, simply by admitting a very moderate supply of air (which for safety to the boiler should be heated) at the bridge, this being a more certain and economical mode of prevention than that of diluting the smoke by the admission of much cold air at the fire-doors.

12. It may be set down as an axiom that a steam-engine chimney cannot be too large, if only provided with a damper, although ninety-nine in one hundred, at the present time, are decidedly too small. They are unable to create a sufficient draught of the air through the furnace, consequently a smoky flame is produced, instead of a flame with little or no smoke.

13. Want of chimney draught is a defect which no smoke-consuming furnace in the world can remedy, whether using hot air or cold, unless by the application of an artificial blast, which commonly costs as much to work as the heat it creates is worth.

14. It being impossible to consume smoke without great heat, which requires a good draught, and difficult to get a good draught without a large chimney, I here set down a table of chimney proportions, which have been practically proved to answer well with the inferior steam coal of the manufacturing and Midland districts for many years past. It is true that somewhat smaller dimensions might serve where the extravagant use of Newcastle coal is still continued, as in London; but even here those dimensions and proportions ought to be adhered to, because of the constant tendency to increase the engine and boiler power, while the same brick chimney remains. For similar reasons I commence with a chimney suitable for a 10-horse boiler, although a 5, or even a 2-horse engine only, may be required.

Height of Chimney.	Inside Diameter at Top.	Nominal Horse-power of Boiler.
20 yards	1ft. 6in.	10
25 "	1 8	12
30 "	1 10	16
33 "	2 0	20
35 "	2 6	30
40 "	3 0	50
40 "	3 6	70
40 "	4 0	90
45 "	4 6	120
50 "	5 0	160
55 "	5 6	200
60 "	6 0	250

15. A common low-pressure condensing engine is usually overloaded when it has less than 25 circular inches in the cylinder for each nominal horse power; and a high-pressure non-condensing engine ought to have from 10 to 12½, and to be worked at double the effective pressure, at the least, of the former—say 30 to 40lb. per square inch in the boiler.

RECENT SEWAGE NEWS.

The following *résumé* of news concerning the sewage question will be of interest to our readers, not only in itself, as news, but from the fact that the question is now being practically taken up in Canada. The Hochelaga sewage farm near Montreal has begun to attract some attention and the directors of that undertaking seem to have begun to experience some of the difficulties inseparable from these undertakings. The able and lucid account which follows is from the columns of *Engineering*:

"Hydra-headed, the sewage question is constantly cropping up, and September has been prolific in accounts of the doings and non-doings of those who profess to afford a solution of this difficult question. We are at a loss to ascertain which of two important subjects—this and the coal question—is of the most value to the community at large. On either side much is to be, and has been, said, yet but little done. Our position is, therefore, not that of a judge, but to state all those facts which, having been ascertained carefully, can be placed before our readers for their decision.

In the past month we have had several items of fresh intelligence, either pointing towards improvements of old processes, or suggesting new plans. At the meeting of the British Association at Bradford, we find that the treatment of sewage by precipitation methods is declared to be an entire failure. On the other hand, we learn that the Native Guano Company, the patentees of the A B C process, has been favourably reported on at Leeds, and its rival, the Phosphate Sewage Company, has recently issued a circular, in which an absolute confidence in its ultimate results, both manurial and purifying is asserted.

A new scheme has lately been propagated for draining a large area west of Teddington and partially east (in a direct line towards the Thames), of all the sewage products of the district, proposing, at the cost of some two millions, to convey the sewage to the Thames below Crossness, which is at present the position of outflow for the sewage of so-called South London. Practically we may call this the west outer circle of our present metropolitan sewage arrangement. It will embrace numerous towns, villages, hamlets, &c., which now, more or less, discharge their sewage into the Thames. The difficulty that has to be contended with is one almost entirely of an engineering character. In other words, the "levels" are such that pumping is inevitable to relieve these districts of the dangerous nuisance to which they are now subjected.

We have frequently urged a combination of all the existing sewage schemes as most probably leading to a solution of the whole sewage question. It is evident, however, that our efforts have been, and are likely to be, in vain. Irrigationists, chemical precipitationists, and the advocates of each form of earth-closet system, still maintain their individual superiority, and expect to defeat all their opponents. As an example of the present position, the following abbreviated reports of each advocate is given as issued in September.

We take, first, the report of the effects of the A B C process at Leeds. In previous issues we have described and criticised the operations of the company at Leeds, Leamington, and Crossness. It was shown that the manure produced at Leamington was generally attended with good results when applied to suitable soils. We have before us a report of experiments recently made by a sub-committee of the Streets and Sewerage Committee of Leeds, giving the comparative results that attended the use of various manures applied to parcels of land in the neighbourhood of that borough. At their last annual report they expressed themselves as quite satisfied with the effluent water produced by the A B C process. But the manurial question was not settled, and this—as we have on many occasions pointed out—is a most important item in the commercial value of any plan of dealing with raw sewages.

The Leeds authorities took six patches of land, each consisting of half an acre, to make what we may properly designate reliable experiments on the value of the manure produced by their work at Knostrop, where they treat a portion of the Leeds sewage by the A B C process. It appears that they employed six different dressings on an equal number of half-acre patches, namely, of street sweepings, which at Leeds are pretty good, considering the imperfect scavengering of the borough; of stable manure; of Peruvian guano; of "native manure," which, so far as we can learn, is a mixture of the native guano from the Knostrop Works, incorporated with the midden refuse; "native guano" *pur et simple*—that is, the product of the Knostrop Works; and sewage mud, which may be considered as the natural precipitate of the sewage generally. The pecuniary cost and product of all and each of these experiments, which have been just concluded, were as follows:

Manure Employed.	Cost Per Patch for Dressing.	Value of Crop per Each Patch.
	£ s. d.	£ s. d.
Street sweepings..........	4 3 6	2 13 10
Stable manure.............	2 8 0	3 1 2
Peruvian guano...........	1 12 10	2 16 7
Native manure............	1 11 10	2 6 4
Native guano..............	1 11 10	2 16 7½
Sewage mud..............	1 18 10	2 8 0
Total............	13 6 10	16 2 6½

It hence follows that 13*l*. was in round numbers, expended on three acres to obtain a return of about 16*l*., or about 81*l*. for each 100*l*. of produce.

The results so obtained are somewhat anomalous. The Committee, who have had the management of these trials, and whose impartiality is undoubted, have resolved to make sure on future projects. The advocates of the A B C process maintain that their manure is not a stimulant simply, but that its effects are lasting. We have every reason to believe that there is a foundation for this idea as our own experiments have verified it. The Committee at Leeds therefore proposed to leave each plot exactly as it is this season, to test the permanent value of each kind of manure they have employed.

It is somewhat remarkable that the native guano destroys indigenous weeds, and encourages the growth of grain, and especially of dandelion, while sewage proper destroys the latter, and encourages the growth of a heterogeneous class of weeds. Our experience on this point has been respectively derived from a year's inspection (two seasons) of native guano at Leamington, and sewage at Barking. In regard to the universality of the latter, we lay ourselves under correction, simply stating that by the term "weeds" we mean such products of a grass-field as the generality of farmers object to for green food and hay produce. It appears that the experience of the Leeds authorities, in respect to the native guano, agrees with this opinion, and this is the more remarkable on account of the great difference which subsists between the so-called weeds of this Warwickshire and of the West Riding of Yorkshire. We have already urged on our readers, in our "Notes on Sewage," the importance of studying the "botanical" conditions of the sewage question. Mr. Hope, the great advocate of irrigation, is well aware of the importance of this point in regard to his model farm.

From these remarks it is evident that neither chemical, botanical, nor physical conditions are to be taken separately as an indication of the value of any special mode of treating sewage, for taking all the results of sewage treatment, with the same chemical element or compounds present, whether at Croydon, Barking, Rugby, Leamington, Warwick, Leeds, &c., the practical deductions are not uniform. In other words, a general law of produce should follow the presence of a certain amount of nitrogenous and carbonaceous matter in a given amount of diluent, whether that be water, clay, sand, or any other comparatively inert material. The anomaly thus arising, however, is not inexplicable, for it is evident that, while the same manure may be applied to different soils, or the same soil be treated by different manures, the results must be affected by the varying conditions of the two sets of experiments.

We have already pointed out that the manurial value of any deposit effected by the A B C process depends essentially on the kind of sewage treated. The same remarks hold good in regard to every process employed for the utilisation of sewage. We state this to prevent any circumlocution in our further observations.

We next remark on a circular recently issued by the Phosphate Sewage Company, which, as is well known, is the chief rival of the Native Guano Company, excepting, however, the General Sewage Company, working under Dr. Anderson's patent. The distinction between these two processes is easily stated. The Phosphate Company treat a natural phosphate of alumina by means of sulphuric acid, by which they obtain a certain amount of phosphoric acid, phosphate of lime, sulphate of alumina, and sulphate of lime, the lime salts being produced by the addition of "milk of lime," added while the treated phosphate of alumina is passing into the sewage. In our last volume, on page 46, we gave a full description of the process just referred to, and we also, in that article, drew attention to the difficulties in which the company found itself placed in February last. By the circular recently issued to the shareholders we learn that the company have nearly completed their experiments at Barking, which, to our knowledge, have been in progress over a year. It is a pity that public companies are formed simply to try experiments, when the prospectuses on which they are based usually state that such experiment had long previously insured entire and permanent success.

The Phosphate Company, like others, has had to contend with the difficulty of drying the residual product, which, generally speaking, is very intractable. Numerous sewage-drying machines have been proposed, but we learn that the practical suggestions of Mr Henry Morgan have solved this difficulty. A public trial, which is shortly to take place at the Barking Works, will afford an opportunity of judging of the amount of success thus stated to have been arrived at. But a peculiar difficulty has been encountered by the company. It was originally formed to work the natural phosphate of alumina obtained from the island of Alto-Vela. The San Domingo authorities, however, ignored the concession which had been granted, and consequently the company's supply of material was stopped. We learn by their circular that they have now on hand about 18,000 tons of the phosphate, worth about 60,000*l*; and that they have taken proceedings in Chancery to recover the sum of 65,000*l*, which had been paid for the now forfeited concession. Failing a further supply from Alto-Vela, they anticipate no difficulty in getting a similar phosphate from other sources.

Next on our list of sewage news is the report of the Sewage Committee of the British Association. We are not surprised that the committee prefer irrigation as the solution, and the only one, of the question. At each of the recent meetings of that body, and of the Social Science Congress, irrigation has been alone considered as effective. For all practical purposes none of the chemical processes yet introduced has shown any results approximating financially and chemically to those obtained by the direct application of sewage to land, as shown in the Barking and Croydon farms. Until it is shown that similar or better results can be obtained by other means, the advocates of irrigation are justified in claiming the nearest approach to success for their plan. Having visited all the sewage farms in England repeatedly, at the different seasons of the year, we have come to the conclusion that their success is entirely dependent on proper management. In ordinary farming precisely the same results hold good. The chief difficulty to be contended with in establishing a universal system of irrigation will be that of obtaining suitable land in each place where the system is to be adopted. The present success of the existing sewage farms is essentially dependent on the accidental circumstance that such land was readily available in the district to which the sewage was to be employed. The great point is to have both in the surface and subsoil great powers of absorption, so that the water may be rapidly filtered away, leaving the manurial portions of the sewage ready for assimilisation by the radicles of the plant. It is evident, therefore, that a stiff clay land is utterly unfit for sewage irrigation.

Last in our list of reports is that of Dr. J. Whitmore, the Medical Officer of Health for Marylebone. It will be remembered that only a short time ago the outbreak of typhoid fever in the parish, traced to the use of a certain supply of milk, lead to the assertion that cows fed on sewage grass had their milk so affected as to produce such disease. This, however, cannot be associated with the Marylebone epidemic, except so far as the milk was concerned, for the cows supplying this did not touch sewage-grass. Dr. Whitmore then states how he traced the evil to one farm. The company from which the milk was obtained, possesses eight farms. Dr. Whitmore, with Dr. Corfield and Mr. Chalmers Morton, visited these, and seven were pronounced as generally satisfactory. 'At the eighth farm, however, the condition of things which then existed (middle of August) coupled with some antecedent facts which had come to our knowledge, demonstrated beyond the possibility of any reasonable doubt that the fountain and origin of the epidemic had been at last found out. The farm, known as Chilton Grove Farm, is situated some few miles from Thame, in Oxfordshire.' Having examined into the cause of death of persons resident on the farm, and traced it to typhoid fever, Dr. Whitmore remarks, "The farmhouse and buildings are placed on a slope, the privy, which is a mere open pit, being placed at the highest point, and at the lowest, the well." They discovered that the leakage from the privy had little to obstruct it in its passage to the latter, and this impurity was still further increased by adjacent manure heaps and pig-styes. The cans used to hold the milk were daily washed with this water, and Dr. Whitmore considers that a small portion of the liquid being left in the cans was sufficient to infect the milk afterwards sent away in them. The supply from the farm was instantly stopped, and one cause of the Marylebone epidemic was as quickly removed.

We forbear to make any further observation on the reports of which we have given a *résumé*. Our object is to place before our readers the latest phases of the sewage question. It will be seen that the present situation is eminently [illegible] difficulty, requiring all the aid that science and daily experience can give to so important a subject.

AMERICAN LIGHTHOUSES.

Last year the Lighthouse Board of the United States had under charge 179 sea and lake coast lights, 394 river and harbour lights, 22 light ships, and 33 fog signals operated by steam or hot-air engines, besides large numbers of unlighted beacons and buoys. Naturally the great diversity of the conditions under which the American lighthouses have to be erected, and the fact that the great extent of coast has necessitated the division of the work of superintendence into thirteen districts, each with its own engineer, have led to considerable variety of design, and we propose in this, and some succeeding numbers, to illustrate some of the types of lighthouses lately erected by the Board, or now in course of construction. This month we publish on page 203, two of these designs from the columns of *Engineering*, the upper figure showing the Race Rock lighthouse, and the lower figure that at "Thimble Shoal," Hampton Roads, Virginia.

The Race Rock lighthouse, at the eastern entrance to Long Island Sound, is one belonging to the third district, of which Colonel I. C. Woodruff is engineer. The general design of the structure is shown by the engraving, and we need merely add here that the foundation consists of about ten thousand tons of "riprap" stones, weighing from three to five tons each. The foundation was completed in November, 1871.

The "Thimble Shoal" lighthouse is in the fifth district, of which the engineer is Major Peter C. Hains. This light has been erected to take the place of the Willoughby Spit lightship, and it is situated on the shoalest point at the entrance to Hampton Roads. A start was made with this lighthouse in May, 1872, and on the [illegible]th of June of that year the platform from which the screwing of the piles into the shoal was carried on, was completed. The shoal proved to be very hard, consisting of fine compact sand, but by the 1st of August, 1872, the last pile was planted. The light is of the fourth order, and the general design of the structure is very neat. We may add here that the chairman of the Engineering Committee of the United States Lighthouse Board, is general Barnard, and the engineer secretary, Major George H. Elliot.

The use of the sheath of the hop-stalk in the manufacture of paper, a French invention we recently mentioned, is about to be practically tested in this country, a company being in course of formation to work the process.

FACTS ABOUT THE EAST RIVER BRIDGE.

(From the *American Artisan.*)

As the piers of the great East River Bridge, at New York, continue to rise, even the unprofessional beholder can, to a certain extent, begin to picture to himself the immensity of the work. The three towers on the Eastern pier, have made such progress, that they now mount far above any of the neighbouring structures, yet they lack seventy feet of completion. It is hoped that this pier will be raised to its full height within the present year. The western pier is also considerably advanced, and is being pushed as rapidly as the nature of the work will permit. Except when delayed by the setting of iron stays and staples for braces and guys, the great stones go up at the rate of 100 per day, or one in six minutes. One can, especially if he is somewhat acquainted with the plan and drawings, form an approximate idea of the appearance of the stupendous work, when the great cable shall be stretched from pier to pier, supporting the bridge — the only viaduct between two of the largest cities on the continent.

We often hear the question asked by non-professionals and sometimes by men of some engineering ability, whether it is practicable to build a suspension bridge of such an immense span. And, indeed it is not remarkable that, to those who have not carefully considered the subject, a single span of 1,595 feet, considerably more than a quarter of a mile, subject to the action of the wind, and the vibrations incident to travel and transportation, should seem impracticable. The first impression is that such a structure could not be made to sustain its own weight, without even considering the extraneous strain to which it must be subjected.

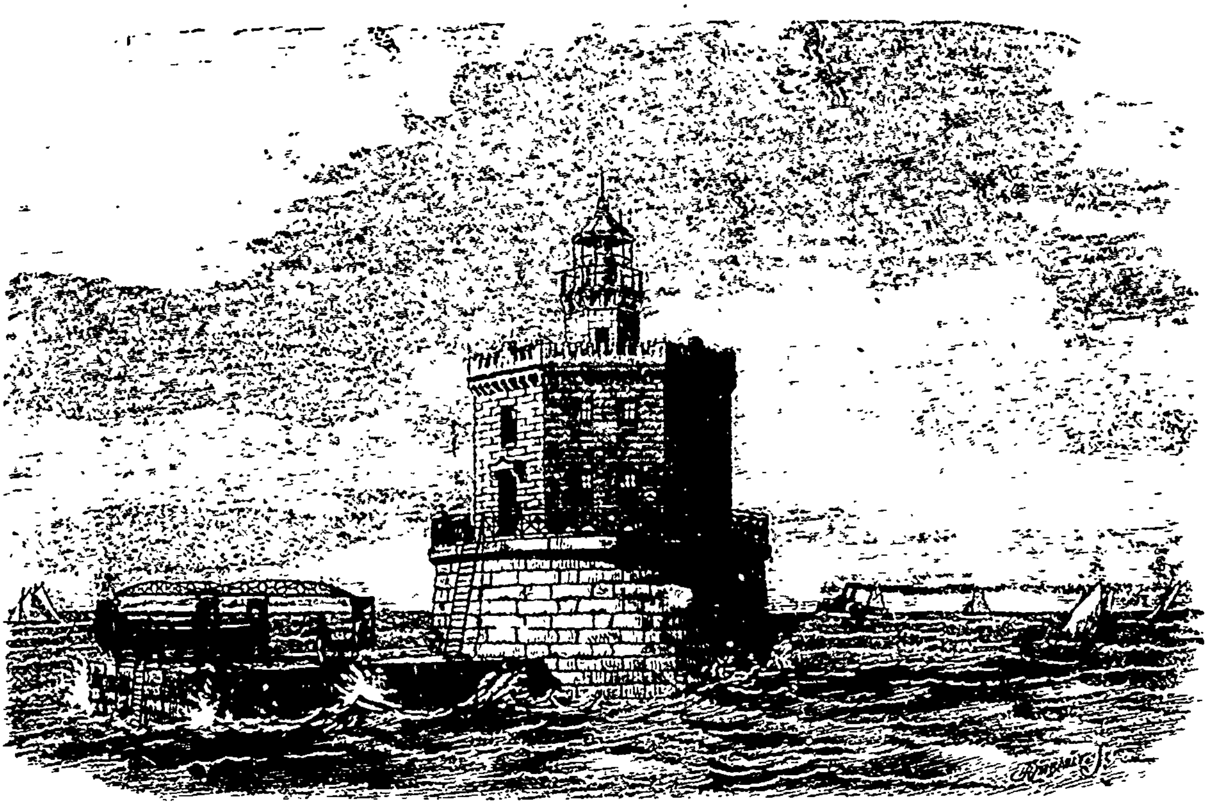
But a consideration of the conditions soon dissipates these fears for the final success of the enterprise, and the safety of the structure.

First, notice that the curve in which the cables will hang is such as to preclude anything like the sort of leverage which makes the strain upon a tubular, trestle-work, or other rigid bridge, increase so rapidly with the span, or which causes the great strain upon a long taut line when a weight is suspended at or near its centre. The strain increases very little, if any, by reason of the span, except as the greater span necessitates increased quantity of material, increased surface for action of the wind, and increased weight passing to and fro upon the structure. The action of the wind is the severest test, and is most carefully provided against.

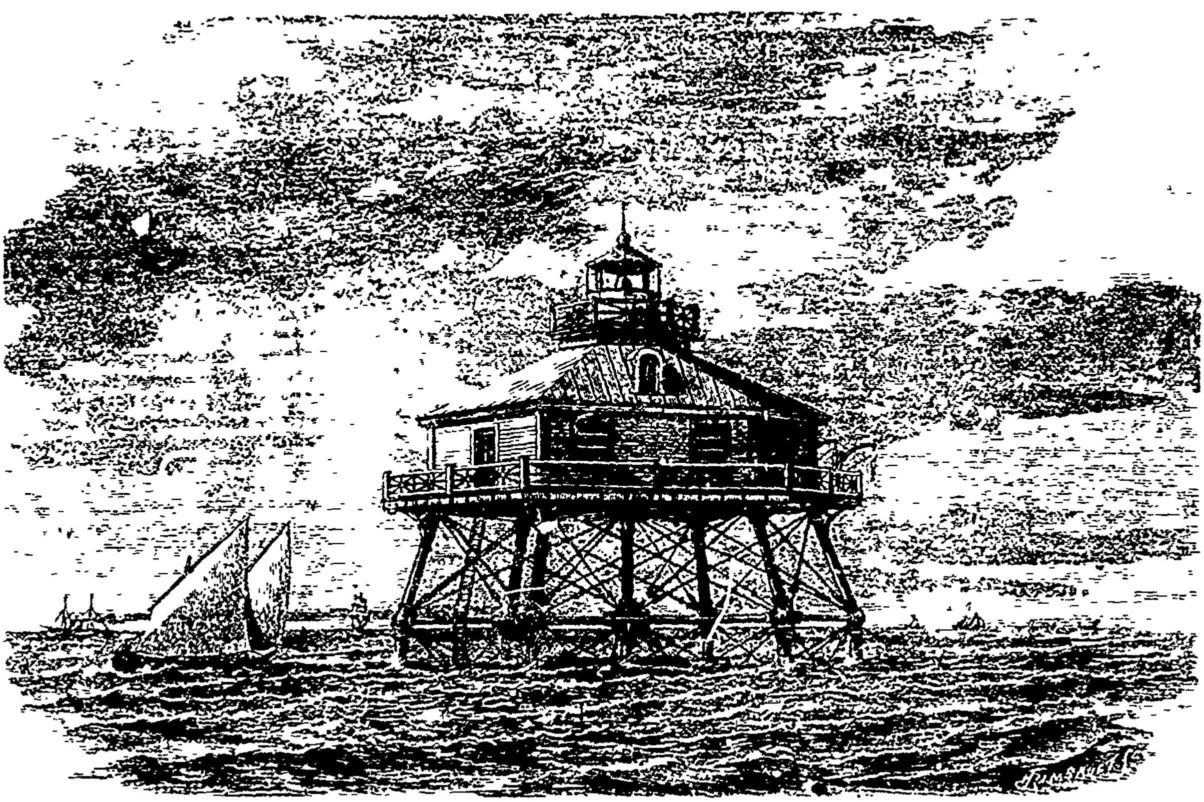
The tensile strength of steel, as given in the books, is 80,000 lbs. to the inch of cross-section. The weight of a bar of steel, having such a cross-section for a span of 1,595 feet at 3⅓ lbs. to the linear foot, is 5,316½ lbs., or about one-fifth of its ultimate tenacity. But the tensile strength of iron or steel in bars or links, is far less than the strength of the same weight of material in wires laid up into a cable. Capt. Eads found a very great difference in the tensile strength of steel, a difference depending largely upon the size of the rod or bar tested. Thus a bar of five and a half inches in diameter, was found to possess a strength of only 20,000 lbs. per inch, one-fourth the strength given in the books; the strength per inch increased as the size of the bar diminished, so that while the inch bar endured 80,000 lbs., number seven wire withstood a strain equal to 160,000 lbs. per inch, number eight wire, 220,000, and number fifteen wire, 360,000 lbs., or more than three times the ultimate tensile strength of bars or rods, as given by the best authorities.

The weight of each of the four cables is to be about 400 lbs. to the linear foot. The same weight of material in bar or links, would give a tensible strength of about 4,800 tons, while the strength of a cable of number eight wire would be 11,000 tons, making the total ultimate strength of the four cables, 44,000 tons. The construction of the bridge will be such that the point of the greatest strain from the action of the wind, that is, the centre of the bridge, will have the whole strength of these tremendous cables concentrated there, and the structure will be as safe and durable as any bridge in the world.

Our illustration on page 206, of the Brooklyn caisson, is from *Engineering*.



LIGHT-HOUSE AT RACE ROCK; EASTERN ENTRANCE TO LONG ISLAND SOUND.



LIGHT-HOUSE AT "THE THIMBLE SHOAL," HAMPTON ROADS, VIRGINIA.

QUALITATIVE ANALYSIS FOR AMATEURS.— V.

By E. J. Hallock, A.M., in the *Boston Journal of Chemistry*.

(Continued from page 181.)

Group Third, (continued.)

Dissolve some iron filings, or wire, in dilute sulphuric acid, and allow the solutions to crystallise. The green crystals formed are ferrous sulphate, or protosulphate of iron, $FeSO^4$. In an acid solution of this sulphydric acid forms no precipitate, but with ammonic sulphide a black precipitate is formed, soluble in dilute hydrochloric acid. After dissolving this precipitate in hydrochloric acid, the hydrated protoxide of iron is precipitated from it by boiling with caustic soda (NaHO), or caustic potassa. To another portion of the original solution add caustic soda, and the same result is produced. To a third portion, quite dilute, add a drop of red prussiate of potash solution (potassic ferricyanide), and a dark blue precipitate, known as Turnbull's blue, is formed. The yellow prussiate of potash gives, with fresh solution of a pure protoxide salt of iron, only a white precipitate which, however, turns blue in the air.

Dissolve some more iron filings, or clean piano wire, in hydrochloric acid, adding a few drops of nitric acid, to oxidise the iron. When dissolved, evaporate to dryness and dissolve in water. When H^2S is passed through this solution of the sesqui-chloride of iron, it is decomposed by it, and the iron is reduced to a protochloride. The turbidity is due to finely divided sulphur. This reducing action of sulphydric acid is represented by the formula, $Fe^2Cl^6 + H^2S = 2FeCl^2 + 2HCl + S$.

Ammonic sulphate produce[8] a black precipitate as before, soluble in acids. Caustic soda and ammonia give brown precipitates. If none of the proto salts are present, ferricyanide of potassium will not produce any blue colour, which tests always serve to determine between the two classes of iron salts. Yellow prussiate of potash, of ferro-cyanide of potassium ($K^4Fe Cy^6$), produces, even in dilute solutions, a precipitate of Prussian blue. One drop of perchloride of iron in a quart of water will yield with potassic sulphocyanide (KCyS) a red coloured solution. This is the most delicate test for iron.

Manganese is a rare metal, but its compounds resemble iron in some respects. It frequently occurs in the form of pyrolusite, or black oxide of manganese. When this is dissolved in hydrochloric acid, chlorine is abundantly given off. Ammonic sulphide produces a flesh-coloured precipitate, soluble in acids. From acid solutions it is precipitated by caustic soda. When fused in the borax bead it imparts to the latter an amethyst red colour. Manganese is used in making glass, both to produce glass of that colour, and to neutralise the green imparted by iron. Fused with sodic carbonate and nitre a green mass is formed, which is readily changed by oxidising agents into a rose pink or purple, whence it is called chameleon mineral.

Zinc is readily soluble in sulphuric acid, forming a crystallisable sulphate. In alkaline solutions H^2S forms a white precipitate in acid solutions none is formed. Ammonic sulphide yields a white precipitate, soluble in acids; caustic soda produces a precipitate soluble in an excess of the precipitant, so that this distinguishes it from iron, manganese, and chromium. The blow pipe test for zinc was given under the head of tin, and contrasted with the tin reaction.

Chromium forms a dirty-green precipitate with ammonic sulphide, soluble in acids Caustic soda produces a precipitate soluble in excess, but reprecipitated on continued boiling. With any salt of lead, chromium compounds give a yellow precipitate, as mentioned in Group First.

Alum gives with ammonic sulphide a white gelatinous precipitate, soluble in dilute acids. Caustic soda and potash produce white precipitates also, but the precipitates dissolve in an excess of the alkali. Sal-ammoniac precipitates aluminum even from the potash or soda solution.

Uranium is one of the rare metals little used in the arts, except by photographers in their intensifiers. It belongs to the third group, because it gives a precipitate with ammonic sulphide. This precipitate is of a brownish-black colour, soluble in acids. Like iron, chromium, and magnesium, it yields a precipitate with caustic soda, but this precipitate is soluble in carbonate of ammonium. With ferrocyanide of potassium it gives a reddish brown precipitate somewhat resembling that with copper. Like iron, it gives a red colour with sulphocyanide of potassium or ammonium; but the metal is so rare that this will not easily confound it with iron.

Separation of Metals of Group Third.

The metals of this group are all precipitated, as we have seen, by ammonic sulphide. By treating the filtered and washed precipitate with dilute hydrochloric acid, we can dissolve all the metals except cabalt and nickel. In the insoluble residue, then, we must seek for them, by the methods described. The filtrate is boiled in a porcelain dish for some time with caustic soda, for the purpose of not only precipitating the oxides of the metals, but also to redissolve zinc and alumina, which we found would dissolve in an excess of precipitant. On filtering, we shall find only these two metals in the filtrate; divide the filtrate into two parts, to one portion add sulphydric acid, which is able to precipitate zinc from an alkaline solution; to the second portion add ammonic chloride, which precipitates alumina as a hydrated oxide The residue from boiling with caustic soda is first treated with ammonic carbonate to dissolve the uranium, whose presence is farther proved by adding an excess of acetic acid, and then some ferrocyanide of potassium. The portion which is insoluble in ammonic carbonate contains, of course, iron, chromium, and manganese.

(To be continued)

Cape Breton Coal Trade.—The shipping season for 1873 has about come to its close, says the North Sidney "Herald" We have had a remarkably fine fall for business operations, in spite of occasional storms of considerable severity, which have caused great damage, but more at a distance than in our immediate vicinity. The aggregate shipments of our great staple from Sidney and outports are in excess of a half million of tons. As nearly as we can approximate at the present, of this quantity the Sydney Mines have shipped over 100,000 tons, the International Mines 70,000 tons, the Glasgow and Cape Breton Mines 60,000 tons, the Victoria Mines 10,000 tons, the Caledonia Mines 75,000 tons, the Little Glace Bay Mines 60,000, the Lingan Mines 30,000 tons, the Block House Mines 44,000 tons and the Gourie Mines 55,000 tons.

THE ANGLE OF WOOD-CUTTERS.

(From the *Cabinet Maker.*)

While the operators of wood machines are not expected to construct their own cutter-heads, it is expected that they will furnish plans and instructions to others as to how they should be made; and as the angles at which the cutters act is an important matter in the making of machines, it deserves some notice here.

The views given on the subject and examples shown are not based upon theoretical inference so much as upon practical experiment. There are some very obscure conditions connected with the action of wood-cutters; if they moved as slowly as metal-cutting tools, we could observe and note the process of their action, but when in motion they are practically invisible, and nothing can be determined except by comparative experiments.

A general object among wood workmen seems to be to get as low or acute an angle for cutters as possible, regardless of the particular uses to which they are applied, and then to prevent slivering, or pulling out the wood, by means of caps. There are, of course, exceptions to this rule, especially with small cutter-heads, as in the case of shaping machines, but exceptions are generally necessary from the form of constructing the cutter-head rather than the result of any plans that have reference to the work. Never trouble with or attempt to use caps on the cutters of power machines; they are expensive, inefficient to perform the intended purpose, and, besides, unnecessary.

Any kind of wood, including boxwood, rosewood, soft wood, or green wood of all descriptions can be worked without caps, or chip breakers, as they are sometimes called, simply by giving the edges a proper angle, and attending to other conditions to be noted.

In planing veneers by hand it has long been demonstrated that the plane iron requires a much higher angle than for other work. It is also known that scraping tools with blunt edges are the only tools that can be used in turning hard woods or ivory; in fact, with all hand tools, the principle of varying angles adapted to the work seems to be well-known and generally applied, but when we come to power tools we find planers and moulding machines made with their cutters at a constant angle, usually as acute as possible.

In determining the angle of cutters the following propositions are laid down:

1st. In cutting clean pine for surfacing, matching, or moulding, the angle of the cutters can be as low as practicable to clear a good washer and holding bolt with a standard head.

2nd. An acute angle requires a thin edge, and a thin edge cannot at the same time be a hard one, nor for that reason, a sharp one, except in working soft clean lumber.

3rd. An edge may be hard, and kept sharp, as the angle is obtuse and the bevel short.

4th. In cutting thin shavings the operation is altogether cross cutting, and a sharp edge is more important than a thin one.

5th. As the angle of cutters becomes more obtuse, or higher, the shape of the edge approaches nearer to having the same profile as the work, and the cutters for molded forms are cheaper and more easily made and kept in order than if at a low angle.

It is becoming of late years a common thing for planer men to grind a short bevel on the under side of the knives for working hard or cross-grained lumber, which is substantially the same thing as changing the angle of the cutters and making the bevel shorter. It is an excellent plan, as it would be impossible to change the cylinders when a machine has a variety of work to do, but by having some extra knives ground at different bevels, it becomes an easy matter to change them, and one that will pay well for the trouble, especially if the knives are tempered harder as the bevel becomes more obtuse.

It will be found in practice that a set of knives that are hardened to a very pale straw-colour, and with a bevel ground on the face side, just enough to keep the edge from breaking out, will run twice as long and do smoother work on walnut, ash, or oak wood, and will not pull out the stuff where it is knotty or cross-grained.

It has also become a common practice in some parts of the country to turn the matcher cutters of flooring machines upside down, that is, to turn the grinding bevel to the lumber, this is an effort in the same direction; a slow change from the necessities of practice, instead of from inference, as it might be. This way of getting an obtuse angle is going a little farther than is recommended here, but to halve the matter by grinding on both sides will be found an advantage in matching hard wood, including yellow pine. The plan is an old one. The Knowles' matching heads, introduced about 1850, had this idea fully carried out by having the bevel on the inside of the cutters; they were always considered as being capable of working any kind of lumber without tearing, and without clips or pressure pads, yet, for some strange reason, the plan was not carried out in the common matcher heads, probably from their being too expensive. We will notice one more fact bearing on this matter—that of machines for making wave moulding; such mouldings are cut smooth, and in part at an acute angle against the grain. These mouldings are not, as a rule, torn or spoiled in working, yet the whole secret of their manufacture, often a matter of curiosity, is nothing more than to set the cutters at right angles to the face of the moulding. The feed movement is given to the wood, and the reciprocating motion to the cutters which act as scrapers.

In the Jardin d'Acclimation is a foal, the produce of an Arab horse and a Morocco mule. The foal, a female, is healthy, vigorous, and well formed, and as no such hybrid has ever been known before—in fact, rather, has been deemed impossible—the young "mare" is regarded as a phenomenon. This may "make" for the Darwinians.

SCIENTIFIC NEWS.

[We should be glad to receive scientific news, suitable to this part of our paper, from any of our correspondents.]

A new voltaic battery of economical construction has been contrived by M. Gaiffe. He uses a rod of lead and a plate of zinc. The former rests on a layer of red lead in the bottom of the containing vessel. The exciting liquid is a 10 per cent. solution of ammonium chloride. The electro-motive force is about one-third that of a Bunsen cell.

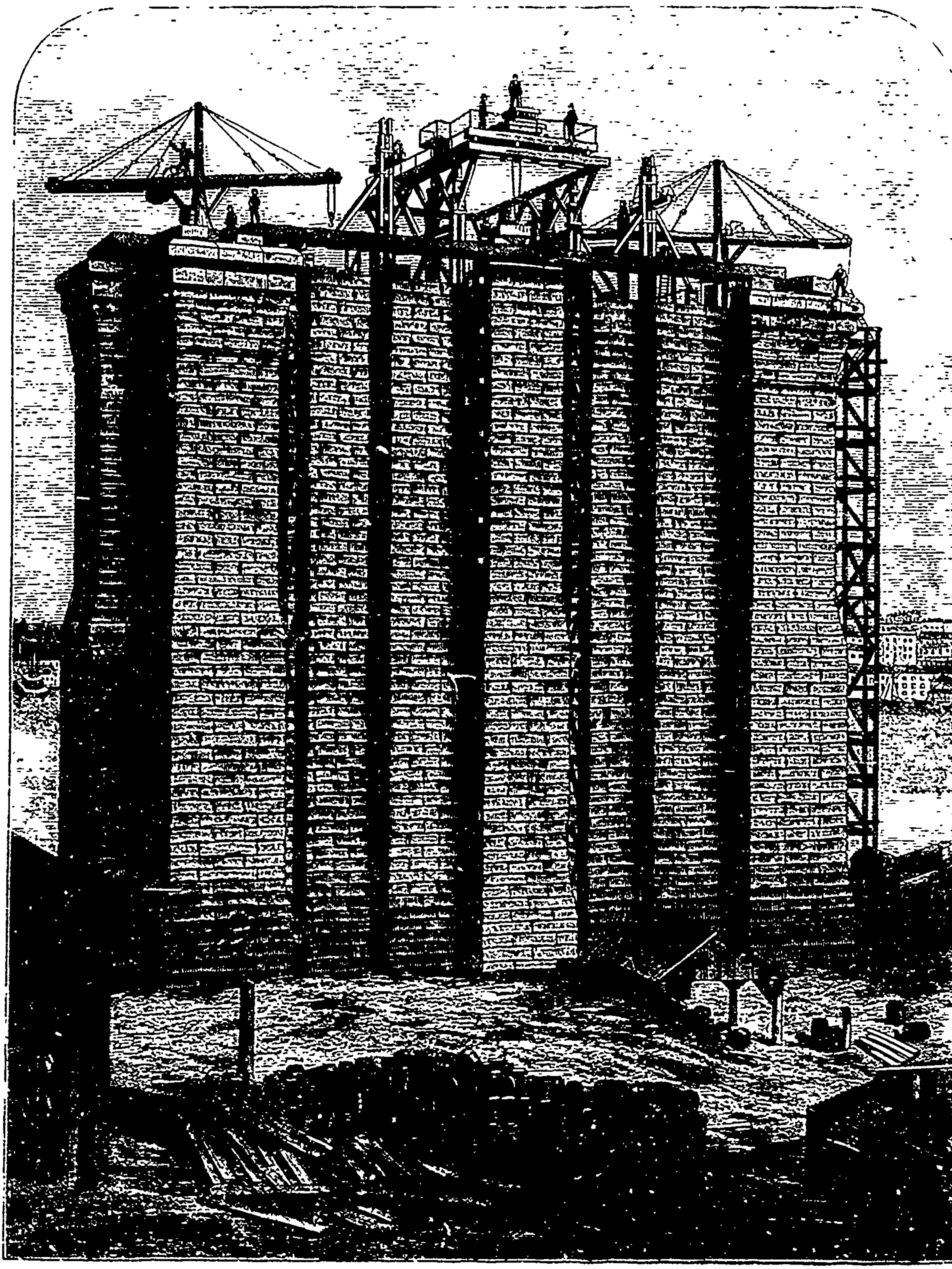
In the *Chronique de la Société d'Acclimation*, M. Ruimet states that by feeding silk-worms on vine leaves he has obtained silk of a fine red colour; and that by giving the worms lettuce leaves, they have produced cocoons of an emerald green colour. M. Delidon de St. Gilles, of Vendée, has also, by feeding silk-worms—during the last twenty days of the larva period—on vine, lettuce, and nettle leaves, obtained green, yellow and violet cocoons.

In a new work entitled *Telescope and Microscope*, recently published in France, the following method of obtaining a lens for a cheap microscope is ascribed to an experiment of Sir Humphry Davy. The process consists of igniting one end of a wheat or hay straw and allowing the entire spear to consume gradually. The cinder is then heated in the blue flame of a burner; and from the silex contained a solid globule of glass is formed, said to be well suited for microscopic purposes.

The new telescope manufactured by Alvin Clark & Sons, of Cambridgeport, Mass., for the U. S. Naval Observatory, has been successfully completed and will be sent to Washington without delay. The instrument is, we believe, the largest refracting telescope in the world, having an object glass twenty-seven and a half inches in diameter, and twenty-six inch aperture, with a focus of thirty feet.

In a recent note on photo-lithography to the Chemical Society of Paris, M. Paul suggests the use of albumen instead of gelatine, as giving better results. The paper is covered with a layer of albumen and concentrated solution of bichromate of potash. After drying, a hard and smooth surface is obtained. After sufficient insulation under the negative, the paper is covered with lithographic ink, then immersed in cold water to dissolve the unaltered albumen, which is then removed with a fine sponge. One thus obtains a very distinct image suitable for transferring to stone.

In the French world of industry and science a great sensation has been produced by an alleged discovery, the importance of which, if it turns out to be true, it is at present impossible to calculate, nor the effect it may have on the sugar trade of the future. It is asserted that the French engineer, M. Jouglet, has succeeded in making artificially beet root sugar, which, however, is not real beet root sugar, but a composition of chemical sugar, if we may be allowed to use such a term. Already has the eminent M. Berthelot succeeded in making alcohol by a synthetic process; but the new discovery is of much more practical value, as it affects a commodity of such general use. Provided the accounts published in the French papers are not exaggerated, although such exaggeration is very likely, this new discovery may possibly bring about a change in the manufacture of sugar, for it is announced that by the new process sugar can be made not costing more than 5 fr. per 100 kilogrammes, or one farthing per pound; and that in order to make it, it is only necessary to bring together certain common articles, which, after being liberated from the coarser elements with which they are combined, are known to have a chemical affinity to each other, and produce a sugar said to be equal to that made from cane-juice or beet root. Henceforward then, the manufacture of sugar would be placed in the hands of the maker of chemicals. It is added that the discoverer, M. Jouglet, has already sold his invention to a company for the sum of 1,200,000 francs, who intend to work the invention.



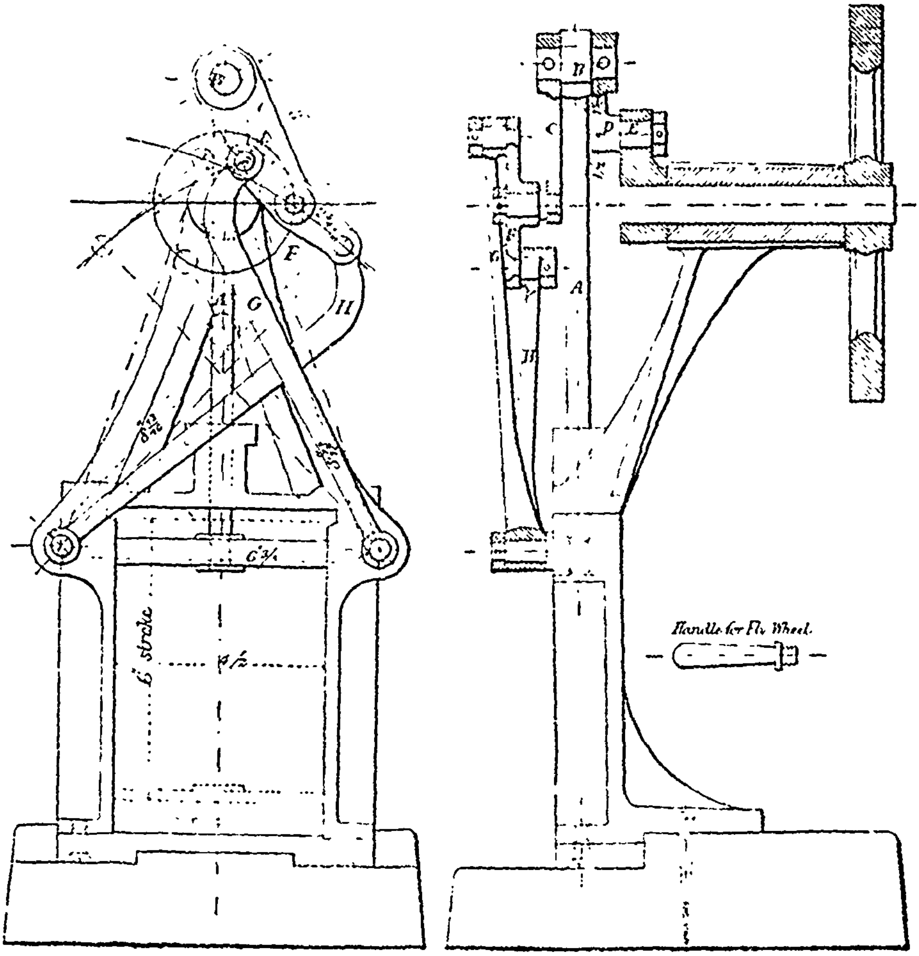
THE EAST RIVER BRIDGE, NEW YORK; THE BROOKLYN CAISSON.

(FOR DESCRIPTION SEE PAGE 202)

PARALLEL MOTION.

The Imperial Technical School of Moscow exhibits at Vienna an interesting collection of its educational appliances and also a number of specimens—on a more or less extended scale—of the actual work of its pupils in wood and iron. One of these is an ingenious parallel motion made by the pupils. Of this we present an engraving. In the Exhibition the motion is attached to a working model with a cylinder some 3 in. or 4 in. in diameter; our illustration, however, shows it as part of a sectional model, which makes its construction somewhat clearer. The motion is one of those in which the stroke of the crank is only equal to half that of the piston. The piston rod *a* has in its head a pin *b* to which are pinned two levers, *c* and *d*, with their centre lines in the same plane. The length of *c* is equal to half the stroke of the piston, and is twice the length of *d*, which carries at its other end the crank pin *e*. The lever *c* is connected by a pin with the centre of a link *f*, the extremities of which are compelled to move in arcs of circles by two radius rods *g* and *h*. The position taken up by the levers and links when the piston is in the same position in reference to the bottom of its stroke to that in which the full lines show it in reference to the top of its stroke, is shown by dotted lines. The motion is of little or no practical use, for we can scarcely imagine circumstances under which it would be more advantageous to use such a complicated system of levers, with so many joints to be lubricated and so many pins to wear, than a sound guide of some kind, but at the same time the arrangement is very ingenious, and in this respect reflects great credit on its designer.

The motion was worked out and practically constructed by Mr. Maleschoff, assistant in the Imperial Technical school of Moscow, the outline design, embodying its principle, was furnished by Akademiker Schebychef, honorary associate of the school.—*Engineering.*



PARALLEL MOTION, AT THE VIENNA EXHIBITION.

MORE ABOUT PHOSPHOR BRONZE.

We have, on several occasions, made mention of this new alloy, noticing such general facts as have reached us regarding it. We add to this information the following statement, extracted from the *Journal of the Society of Arts* Speaking of the inventions exhibited in the department of recent Scientific Investigations and New Discoveries in the Annual International Exhibition at London, now holding, it says:

"Foremost among the notabilities of the group on the present occasion stands a large case of implements and castings (4,829 of the catalogue), contributed by the Phosphor Bronze Company, of Cannon Street. The metal of which the articles are made is a new kind of bronze, patented by Messrs Montefiore & Kunzel, and is composed of varying proportions of copper, tin, and phosphorus. The alloy is capable of being made tough and malleable, or hard, at will, according to the proportion of the several ingredients It is rendered so liquid in the molten state by the addition of the phosporus that it forms very clean castings The purposes to which it is proposed to put the bronze are well illustrated in the numerous objects shown, which comprise heavy bearings of machinery, cogged wheels, guns, and cartridge cases, wire, tuyeres for blast-furnaces, and ornamental castings of various kinds; tools and appliances, such as hammers, knives, scissors, hinges, locks, keys, bells, netting, and sieves, are constructed of it for powder magazines, on account of the impossibility of their yielding sparks The bronze is in somewhat extensive use in these forms in the Government Powder Mill at Waltham Several railway companies are employing it for the bearing parts of machinery exposed to great strain. Messrs. Merryweather have drawn upon it for their fire-engines Messrs. Mackean have had rock drills and pinions made of it Messrs. Brotherhood & Hardingham have adopted it in some parts of their large three-cylinder steam-engines, and Messrs. Thorneycroft, of Wolverhampton, use it for pit ropes, a purpose to which its constructors consider it especially adapted, on account of its immunity from corrosion by damp They also propose to apply it, instead of copper, for the sheathing of sea-going ships."

The Union Pacific Road is building a snow plow to be driven by five locomotives. They expect it will go through a drift twenty feet deep.

MECHANICS' MAGAZINE.

MONTREAL, OCTOBER, 1873.

ILLUSTRATIONS :

CONTENTS:

CANADIAN MEAT IN ENGLAND.

Canadian enterprize, aided by our large mercantile marine, is gradually opening up a new, and, as it promises, very important branch of our commerce. We allude to the exportation of frozen meat to England. The amount shipped has not yet been very great, but the results of the experiments have been very satisfactory and there is no doubt as to the practicability of taking any quantity of frozen meat across in ordinary steamships. Our climate, which is certainly, in some respects, a draw back to our rapid progress will, in this case, become of material assistance. It is stated that meat thoroughly frozen here may be conveyed with perfect safety to Liverpool in winter without the use of ice at all, by merely observing the precaution of keeping it in a cool part of the ship; and in summer the difficulty would be, it is said, but little greater. The Liverpool *Albion* comments thus on a recent shipment :—

" The bringing of meat, when packed in ice, presents no difficulty; but when preserved in that way it does not remain good sufficiently long to meet the exigencies probably of a slow market. In reference to the inspection, it may be at once stated that the meat was considered by Mr. Lloyd, and others, to be in a faultless condition. It was as plump, red, and fresh as the most recently killed meat. The carcases of beef and mutton, however, presented one feature which was very apparent to all, and probably particularly painful to the professional feelings of Mr. Lloyd. The butchering is of the most abominably slovenly character possible, and suggests the idea that the animals had been hurriedly killed, say on 'the Wallaby track' by 'poor Roger,' and not the veritable Wapping butcher, Arthur Orton. The beef appears to be somewhat deficient in fat over the rib, though the weight of suet appended to the carcase shows that the general accumulation of fat has been well up to the British idea of a good average. The specimens of mutton are not weighty, but rather of that light description peculiar to Welsh mutton. The meat, however, is plump and fat. The turkeys are not by any means the largest that may be found in Canada, and weigh only about 16 lbs. each. One of the wild turkeys, however, is a very fine bird, and is almost as heavy as the domestic biped. Some notion of the savoury morsel that may be obtained from a dish of wild turkey may be formed from the fact that these birds feed on no less dainty fare than celery. It may be mentioned that the Duke of Manchester takes considerable interest in the introduction of Canadian meat into England. The Duke was a passenger on board the "Scandinavian," on her second last homeward voyage, and he had some of the beef which was then imported sent to him. Since then Captain Smith has had a letter from his Grace, in which he says that 'the Canadian meat was excellent.' The meat which is the subject of the present trial has been brought from Richmond, one of the Eastern Townships in the Province of Quebec."

With reference to the cutting up of the meat, that is a difficulty which must gradually disappear. Good meat, well cut up and well packed, with a brand on the package to distinguish it, would soon command such a price as would lead to vast improvement in this matter. The Australians are wide awake to the value of this commerce and, in spite of the vastly greater difficulties they have to contend with, they are determined not to lose the chance of establishing a trade, without a struggle. An attempt was recently made to transport a cargo of fresh meat from Australia to England. Their plan was to freeze the meat solid, and then to keep it in that state by surrounding the vessels in which it was packed with ice and salt. But the passage across the tropics was too severe a trial. The voyage was one of seventy-nine days and by the thirty-fourth the greater portion of the meat had to be thrown away. The experiment will, however, be repeated, under different conditions. It is claimed that the problem of sending fresh meat from Montreal to Liverpool was successfully solved, as long ago as eight years when a shipment was made *viâ* Portland. The meat in spite of fourteen days delay between Montreal and Portland, arrived sweet and found a ready market.

BOILER TESTS.

The Government of the United States will, during the months of September and October expend the sum of $100,000 in a series of boiler trials. The trials will take place at Sandy Hook and at Pittsburg. The boilers used will be of the best material and well built and will be placed in the positions they generally occupy. These experiments will, doubtless, be of great interest and we shall duly record the results. The trials will have reference to explosions caused by :

First.—Gradual increase of steam pressure.

Second.—Those caused by low water and over heating of the plates of the boiler.

Third.—Those caused by deposit of sediment, or incrustation on the inner surface exposed to the fire.

Fourth.—Those caused by the generation of explosive gases within the boiler.

Fifth.—Those caused by electrical action.

Sixth.—Those caused by the percussive action of the water in case of rupture of boiler in the steam chamber, Clark and Colburn theory

Seventh.—Those caused by the water being deprived of its air.

Eight.—Those caused by the spheroidal condition of the water.

Ninth.—Those caused by the repulsion of the water from the fire surface or plates.

REVIEWS.

The Carpenter and Joiner, Stair-Builder and Hand-Railer. By Robert Riddell. Edinburgh: Thomas C. Jack, India Buildings. Montreal, Dawson Bros.

This is a very comprehensive and beautifully got up work whose object is to aid and assist the workman by what is claimed to be "the most simple and perfect system of construction that has yet appeared in the English language, containing nothing either borrowed or pilfered Every idea advanced being entirely new and original." The treatment of the whole subject is truly scientific, but so simplified by explanations and illustrations as to constitute this a work almost indispensable to all classes of carpenters and joiners The subject of staircase construction is treated in a specially exhaustive manner. The present edition also contains important improvements on the subject of construction of the Mansard roof. The work is profusely illustrated and contains also a series of very useful card-board models.

UNIVERSAL PATENT LAWS.

The argument of George Haseltine, M. A., LL. D., Member of the firm of Haseltine, Lake, and Co, the eminent patent solicitors, Southampton-buildings, London, in favour of the first resolution adopted at the Vienna Patent Congress.

The resolution under consideration, Mr. President, will be affirmed by the vote of every English and American member of this congress. These members have noted the marvellous results of efficient patent laws in the industrial progress of their respective nations, and they require no word-logic to convince them of the policy or the justice of "special legislation for the protection of inventions." The thousands of modern inventions in this grand "palace of industry" have, with few exceptions, originated in States possessing liberal patent systems, and these inventions are in themselves eloquent advocates of the policy of patent legislation. In the absence of patent laws we may safely assert the Vienna Exhibition would be shorn of its chief attractions, if, indeed, this exhibition had been among the possibilities of our generation.—That a liberal patent system stimulates the inventive genius of a nation is proved by the "logic of events," which have afforded forcible illustrations to the debaters of this resolution. The dreams of fortune rather than the dreams of fame inspire the inventive fraternity, and the States that offer the highest prizes obtain the most and the best inventions. The inventors of America have during this century produced more valuable inventions than the inventors of all Europe, and within a decade a hundred thousand patents have been granted to her own citizens for new inventions. The equitable patent laws which are the pride of her legislation, have made America literally the "home of inventions."—A liberal patent system is even more essential to the practical introduction than to the creation of inventions. Capital is devoid of sentiment, and, as a rule, seeks investment where the prospects are brightest for a substantial return. The history of industrial civilisation, and the testimony of the most eminent of living inventors, prove that few important inventions would have been perfected without the aid of patent laws. Inventions which under liberal patent systems are developed by capitalists for the immediate benefit and the ultimate free use of the public would be practised in secret, or long remain undeveloped theories Mr. Henry Bessemer testified before the Select Committee of the British Parliament that he should have been unable to perfect his steel process, which absorbed a fortune, without the protection of patent laws, and without such protection this valuable invention would have been lost to the world. The worthy president of this congress (Dr. C. W. Siemens, F.R.S.) gave similar evidence in favour of patent protection before the same committee, and also stated that he was attracted to England by the superiority of her patent system over that of his native country. These eminent inventors, even while enjoying patent privileges, have added immensely to the wealth of the nations which protected their rights, and the history of "modern steel" affords a striking illustration of the mutuality of interests between patentees and the public. —A thousand memorable instances of the value of inventions to a nation are chronicled in the world's industrial records. The invention of Henry Cort has contributed, it is estimated, eight hundred millions sterling to the present wealth of Great Britain, and the invention of Eli Whitney half as much to the wealth of America.—The justice of "special legislation for the protection of inventions," even if such legislation were impolitic for a nation, will be generally conceded by the members of this congress. Inventors acquire their rights by virtue of creation, and their equitable title is superior to all legal enactments. The productions of the intellect belong to the highest class of possessions, as they may be enjoyed exclusively by their authors without depriving other members of society of what was designed for the common inheritance of mankind. The possession of more than a proportionate share of land deprives others of their natural rights, and the title to the houses we occupy is tainted by the natural claims of our houseless and less fortunate neighbours. The confiscation of invention-rights cannot be justified by any reasons that would not justify the equal distribution of all material possessions. Intellectual productions, then, demand the highest consideration of the legislator, who may regulate the privileges of inventors, but cannot justly deprive them of the fruits of their labour without adequate compensation. The peculiar nature of these possessions renders "special legislation" necessary for their most beneficial enjoyment, and in view of this legislation we concede the justice of the limitation of the term of use and other restrictions, the specific character of which cannot, however, be discussed in this connection.—The true basis of all legislation is universal justice, and fortunately for the objects of this congress, exact justice to inventors of all nations accords with the highest natural interests There is no antagonism in these matters between policy and justice, and the more complete the justice to the individual, without regard to State boundaries, the greater the ultimate advantage to the nation. The statesmen of America have recognised this principle in their patent legislation, and have sought the public interest through equal justice to the inventors of all nationalities. The merits of this legislation is appreciated by the people, and the opponents of the patent laws, among a population of forty millions, might be seated in this hall, no one of whom has been honoured by a seat in the national legislature. The recognition of the "rights of invention" is an indispensable condition of the assimilation of the patent laws of nations, and to secure this recognition is the first duty of the friends of patentees.—The patent system of Great Britain, which has existed for over two centuries, originated in Royal favouritism and States necessities, and justice to inventors is an incident rather than a purpose of her legislation—the right of actual inventors being still placed on a level with the rights of mere "importers" of inventions to whom patents were granted. The practical effect of this system has been to stimulate the production and importation of inventions but its mercenary inspiration has lowered the standard of British patent legislation, imposing unreasonable charges and vexatious restrictions upon patentees, and creating an influential party in favour of the entire abolition of the patent laws. The British nation is more indebted to its judges than to its legislators for the justice or the advantages of the present patent system.—The attitude of Prussia upon the question of patent-rights, even if free trade in inventions contribute to material prosperity, is humiliating to her people and unworthy a great nation; and failing to secure this result her policy equally outrages public interests and individual rights. The Prussian patent laws, in principle superior to the English, and hardly inferior to the American laws, have been rendered inoperative by a despicable administration, and the nation seems content with pirating inventions which other nations have originated when any special inducement offers for this species of naturalisation. This system has demoralised native ingenuity, and no great invention of modern times can be claimed by Prussia, who has been chief sufferer by her illiberal policy. The State educates her sons for inventors, and leaves them to starve or to live upon the patent rewards of other nations. In scientific attainments, and love of investigation the Germans have no superiors, and the records of the English and American patent offices prove that the natives of Prussia, when in more congenial lands, are not less inventive than men of other nationalities.—The opposition of some of our German friends to this resolution was, in view of their home experience, anticipated, nor do the advocates of patent laws deny the existence of valid objections to local patent systems. The most perfect of these systems will, especially in free trade countries, create cases of individual hardship, and may, for a season, retard the progress of a specific branch of industry. These objections, however, may be removed by equitable legislation, and assimilation of the patent laws of the leading commercial nations.—The British patent system, which has produced most beneficial results, and whose abolition would be one of the greatest calamities that could befall the nation, has received the unmerited condemnation of some of its most eminent jurists and statesmen. These adverse opinions are more generally entertained in Continental States, and the assimilation of the patent laws upon an equitable basis may become a necessity of their existence. This assimilation, which will conciliate the opposition, is in unison with the spirit of our times—it will tend to unite nations in bonds of universal brotherhood, and will secure to inventors a more adequate reward for their labours. The influence of modern inventions upon the political relations of States has fortunately rendered possible the assimilation of the various patent laws ; and it is the true mission of this congress to publicly inaugurate the coveted reform by enunciating essential principles that may form the basis of a general system. The real work must be done elsewhere, but we may by wise council accelerate the movement, and do more for the material interests of nations than any congress of modern times. The price of every great and beneficent reform is continued agitation, which in time creates public opinion—the supreme ruler in all liberal Governments. The press, the educator and the organ of this opinion, by the aid of the electric telegraph, whose existence is due to patent legislation, and whose capacity has been duplexed during the past year by an American patentee (M. J. B. Stearns, C. E.), has directed the attention of the civilised world to the objects of this conference, and upon the press we must depend for the ultimate success of our plans —The proposition to assimilate these laws is by no means a new invention, for which we are entitled to letters patent, though the honour, when success is secured, will be accorded to this congress. This assimilation was proposed seventeen years ago by the able manager of the British Patent Office (Mr. Bennett Woodcroft, F. R. S), whose proposals then made to the Royal Commissioners are now submitted for your consideration by the sanction of their eminent author. This gentleman, whose absence from our deliberation is for various reasons to be regretted, not only proposed, but acted, and in 1856 visited the chief European States to arrange plans for an assimilation of the patent sytems, and his suggestions were favourably received by the authorities. The assimilation has been recommended by the Select Committee of the British Parliament, and the most earnest advocate of patent abolition on that committee (Mr. R. A. Macfie, M. P.) has become a believer in assimilated or uniform patent systems, and was the first to urge upon British ministers the desirability of immediate action to secure such a reform The reason of his absence to-day has been made known to you by our worthy vice-president (Mr. T. Webster, Q C.), through whom he has presented to this congress his instructive work on the patent laws. This movement may count few friends in official circles, and few believers among the people, but the times are favourable to success.—The President of the United States has accredited to this congress an official representative (Hon. J. M. Thatcher), and other nations have expressed a readiness to join in the movement. The British Government has taken the first step towards assimilation by the collection and publication of the patent laws and regulations of the various nations, and it is believed that even Prussia will not decline concerted action. The success of the Vienna Patent Congress, Mr. President, if not the fate of patent reformation, depends upon a decisive vote in favour of this cardinal resolution. The influence of such a decision upon the amendment and assimilation of the patent laws of nations can hardly be over-estimated, and is sure to result in practical legislation. The harvest may be for others to reap, but by paying the price of reform we may reasonably hope that in our generation liberal patent systems, uniform in principle, will become co-extensive with civilisation.

Work has been commenced on the Port Dover and Lake Huron Railway, in the vicinity of Simcoe.

ON THE TORSIONAL RESISTANCE OF MATERIAL.

By Prof. R. H. Thurston.

(From the *Journal of the Franklin Institute.*)

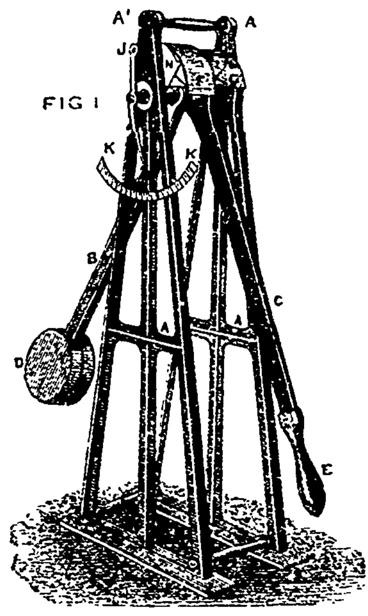
While the classes of the Stevens Institute of Technology were recently engaged in their revision of coefficients, as given by various authorities on strength of materials, the difficulty of determining how far the differences noted were due to errors of observation, and how far to variation in the quality of the materials used, suggested to the writer the advisability of obtaining an apparatus which should make its own record. This could readily be done by so constructing it that a curve might be automatically registered at each test, which should represent all circumstances of experiment.

Such an automatic registry would evidently yield more reliable and instructive information in regard to the circumstances of distortion and fracture than could any system of personal observation.

Representing the magnitude of the distorting stress at every instant, and under every degree of distortion of the material, up to the limit of elasticity or even to the point of rupture, and exhibiting also the corresponding alteration of form at every point, the pencilled curve would be a record from which might be deduced the coefficients of elasticity, strength, and resilience, as well as the laws governing the relations of the distorting forces to the resistance of the material.

A simple but effective machine was therefore designed and constructed, which accomplishes satisfactorily the desired result, and this machine, as planned by the writer and constructed by Messrs. Hawkins & Wales, instrument makers to the Institute, is shown in Fig. 1.

FIG 1



As here arranged, it is intended for experiments on the torsion of materials. Its modifications, for the purpose of experimenting upon transverse strength, will be described in a subsequent paper, in which will be given the results of that series of experiments.

In the figure, the frame A, A, A', A', supports two suspended arms C, E, B, D, which swing about independent axes in the same line. The arm B, carries at its extremity a weight D, and the arm C, has a handle E, by which it is moved. The axes of these arms are designed as shown in Fig. 2, each having a rectangular recess at L, and at M, which receive each an end of the test piece, which is squared to fit, as shown in Figs. 3 and 4

The frame A', A', carries a guide curve F, of such form that its ordinates are proportional to the twisting moments exerted by the weighted arm B, D, while swinging through the arc to which the corresponding abscissæ are proportional. A pencil holder I bears against this guide curve, and, being carried by the weighted arm, is thrown forward, as that arm swings out under the action of the force producing torsion, which force is transmitted through the test piece.

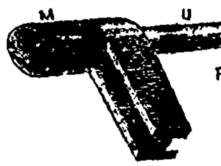
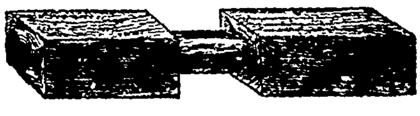


FIG. 2.

FIG. 3

FIG. 4.



The arm C, E, carries a table G, and the pencil I, therefore, traces upon the paper which is clamped upon it, a curve, the ordinates of which are proportional to the torsional moments, while its abscissæ represent the relative motion of the two arms, and, consequently, the amount of torsion to which the test piece has been subjected.

The curves thus described, of which the accompanying plate exhibits a number, present, in a very legible and convenient, as well as reliable form, all the results of the experiments, of which they are the respective records.

The pointer J, traversing the arc K, K, is arranged as a maximum hand, and affords a useful check upon the automatic record of maximum strength.

The plate represents the results of average experiments made upon a considerable number of varieties of wood, the test pieces of the form shown in Fig. 3, being used. The diameter of the neck of each piece was seven-eighths of an inch.

This diameter happened to be that the best adapted to use in this machine. A larger size was found frequently to yield by the destruction of lateral cohesion, the square head peeling, leaving a prolongation of the cylindrical portion, instead of twisting off in the neck. This size is convenient, also, in consequence of the fact that the coefficient of ultimate strength for the standard diameter of one inch is obtained, with a close approximation to exactness, by simply multiplying the twisting moment for each piece by 1 5.

These curves exhibit the relative stiffness, strength, and resilience of the woods tested very perfectly. The inclination of the straight line, forming the first portion of each diagram, from the vertical is a measure of stiffness, the height of the maximum ordinate indicates the ultimate strength, the point at which deviation from this straight line commences determines the limit of elasticity, and the area included within each diagram is proportional to the torsional resilience of the test piece.

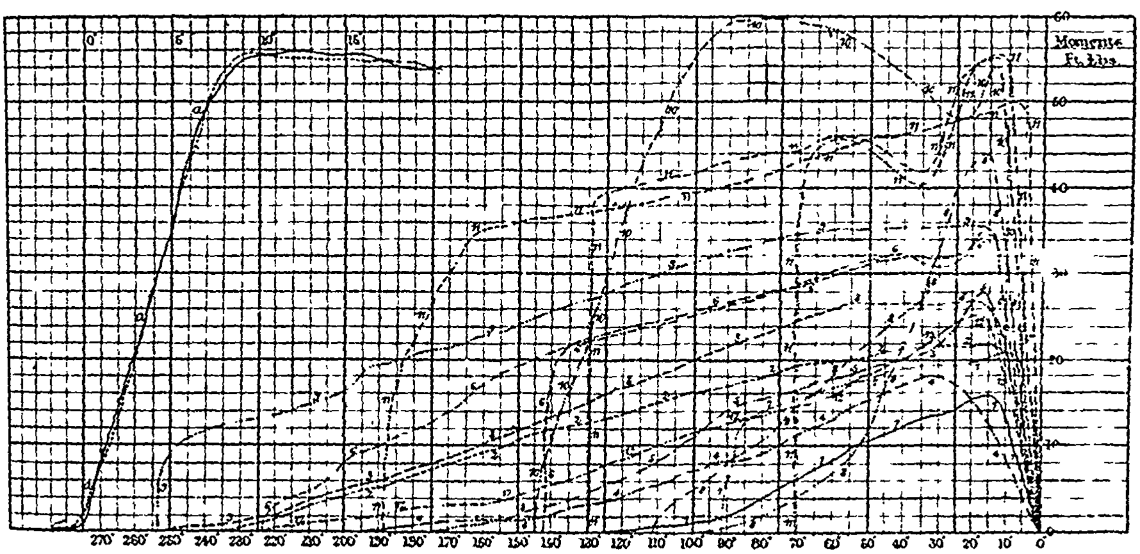
The fact that the commencement is, in each case, almost a perfectly straight line is well exhibited in the curve a, a, a, of locust, where the horizontal scale is purposely magnified; this justifies the usual assumption that, up to the limit of elasticity, Hooke's law is correct, and that the angle of torsion is proportional to the twisting moment.

The short curve of small radius, noticed at the foot of the straight portion of each line, is produced by the slight yielding of the test piece by crushing where it is grasped by the machine, which yielding continues until a firm hold has been secured.

It will be observed that, in most cases, the torsional resistance increases with the total angle of torsion up to a maximum, then, passing the limit of elasticity, it drops off more or less rapidly, returning finally to zero. In the brittle woods the fall takes place suddenly, while, in the tougher and more elastic varieties, the resistance decreases very slowly, in some cases vanishing only after the test piece has been twisted through a very large angle.

In the case of black walnut 6, 6, 6, locust 11, 11, 11, and in a still more remarkable manner, in that of hickory 10, 10, 10, a striking peculiarity is exhibited which is one of the most interesting and unanticipated developments of this series of experiments. In these curves the resistance increases with the amount of torsion, until a maximum is reached; the line then drops to a point considerably below and thence again rises and passes another maximum, which, in the case of hickory, is only reached after a torsion of 75 deg. The resisting moment there becomes considerably greater than at the limit of elasticity.

This striking peculiarity was shown, by carefully repeated experiments, to be due to the fact that, in those woods in which it was noticed, the lateral cohesion seemed much less in proportion to the longitudinal strength than in other varieties. Watching the process of yielding under stress, it could be seen, by close observation, that, in the examples now re-



ferred to, the first maximum was passed at the instant when, the lateral cohesion of the fibres being overcome, they slipped upon each other, and the bundle of, then, loose fibres yielding readily, the curve dropped until, by lateral crowding, further movement was checked, and the resistance again rose until the second maximum was reached. Here yielding again commenced, this time by the breaking of the fibres under longitudinal stress—under that component of torsional stress which takes a direction parallel with that of the fibres in their new position In these cases rupture seems never to occur by true shearing in the transverse plane. The fibres part, one after another, the exterior ones breaking first, under a tensile stress.

The following varieties of wood have been subjected to torsional fracture, and the curves obtained are shown in the diagram which illustrates this article:

1. White pine (Pinus Strobus).
2. S. yellow pine (Pinus Australis), sap wood.
3. " " " " heart wood.
4. Black spruce (Abies Nigra).
5. Ash (Fraxinus Americana).
6. Black walnut (Juglans Nigra).
7. Red cedar (Jumperis Virginianus).
8. Spanish mahogany (Suretenia Mahoganie).
9. White oak (Quercus Alba).
10. Hickory (Juglans Alba).
11. Locust (Robinia pseudo-acacia).
12 Chestnut (Castanea Esca).

The curves, the fac-similes of which are given in the diagram, exhibit well the relative values of the material tested for the various purposes to which they may be applied.

White pine, 1, 1, 1, yields quite rapidly as the torsional moment increases, and the considerable inclination of the line from the vertical indicates its deficiency in stiffness. It soon reaches the limit of elasticity and the diagram exhibits the maximum strength of the test piece 15½ foot pounds. Passing the limit of elasticity and the maximum moment of resistance almost simultaneously, its resisting power decreases rapidly, and with tolerable uniformity, until at "a total angle of torsion" of 130 degrees, it is twisted completely off. The area comprised within the curve is comparatively small and it is thus shown to have little resilience.

Yellow pine, in accordance with our already well-established ideas of its properties, is found by an examination of its curve, 2, 2, 2, 3, 3, 3, to have much greater stiffness, strength and resilience. The sap wood 2, 2, 2, is equally stiff, in the examples tested, with the heart wood 3, 3, 3, 3, but sooner passes its limit of elasticity, the former circumstance being quite opposed to the preconceived ideas of the writer. Notwithstanding the comparatively low position occupied by the pines in our list, they are excellent materials, the yellow varieties particularly, for general purposes. Our comparison is made with specimens of eq l size, and the important fact of the exceptional lightness of these words is now here brought to our notice by these tests.

Spruce, 4, 4, 4, 4, is less stiff than white pine even, but possesses greater strength and resilience, its moment of resistance reaching 18 ft. pounds, and twisting through a total angle of 200 deg.

Ash, 5, 5, 5, 5, seems to be weaker and less tough than is generally supposed; it is possible that the specimens tested were over seasoned. Its most strikir peculiarity is its very rapid loss of strength after passing its limit of elasticity.

Black walnut, 6, 6, 6, 6, of the excellent quality and good condition as regards seasoning of the samples tried, is very stiff, strong, and resilient, and is but little inferior to oak. Its resisting moment reaches 35 foot pounds, and one specimen reaches a total angle of torsion of 220 deg.

Red cedar, 7, 7, 7, 7, is stiff, but brittle, and loses all power of resistance after twisting through an angle of 92 deg. A torsional moment of 20 foot pounds only produces a total angle of torsion of 5 deg.

Spanish mahogany, 8, 8, 8, 8, is very stiff and strong. It is deficient in toughness and resilience, losing its power of resistance very rapidly after passing the limit of elasticity.

White oak, 9, 9, 9, 9, has less torsional strength than either good mahogany, locust or hickory, but it is remarkable for its wonderful toughness. It passes its elasticity at 15 deg but loses its resisting power very slowly indeed. We find the latter almost unimpaired until it has been subjected to a torsion of 70 deg.; it only yielded completely at 253 deg.

Millwrights are evidently perfectly correct in holding this wood in high esteem for strength, toughness and power of resisting heavy shocks and strains.

Hickory, 10, 10, 10, 10, exhibits in its curve, the remarkable pair of maxima already alluded to, and has, apparently, the highest ultimate torsional strength, combined with unusual stiffness and considerable resilience. Its moment of resistance to torsion reaches a maximum of 58 foot pounds

Locust, 11, 11, 11, 11, has greater stiffness than any other wood on our list, and stands next to hickory in strength; it is also very resilient Three diagrams are given each of which possesses its own peculiarities. One specimen is only twisted through a total angle of 40 deg. by a torsional moment of 43 foot pounds.

When more than one curve is given for the same wood, it is a fact worth noticing that the stiffness and ultimate strength are usually very nearly equal, and that the difference between the several specimens becomes marked, if at all, in their degree of toughness. In the formula for torsional strength, Pa, Cd_3, the curves give, values of C, as follows·

1. White pine	25	7. Red cedar	32
2. Yellow pine sap	35	8. Spanish mahogany ...	65
3. " heart...	40	9. Oak	53
4. Spruce	30	10. Hickory............	85
5. Ash...............	43	11. Locust	80
6. Black walnut.......	55	12. Chestnut	35

Determining relative stiffness by obtaining values of the ratio of twisting moment to the total angle of torsion, we obtain the following:

1. White pine	1.00	7. Red cedar...........	4.00
2. Yellow pine sap...	2.25	8. Spanish mahogany ..	3.00
3. " heart.	2.25	9. Oak.................	2.53
4. Spruce	0 67	10. Hickory	4.15
5. Ash...............	1.87	11. Locust	5.50
6. Black walnut......	2.63	12. Chestnut	1.60

Taking the well-established value for oak as a standard, we deduce the following values for the coefficient to be used in the formula:

$$0. = \frac{2Pa}{Gnr4} = \frac{\text{Total Angle of Torsion.}}{\text{Length of Part Twisted.}}$$

1. White pine.......	220,000	7. Red cedar	890,000
2. Yellow pine sap ..	495,000	8. Spanish mahogany	660,000
3. " heart .	495,000	9. Oak...............	570,000
4. Spruce...........	211,000	10. Hickory..........	910,000
5. Ash	410,000	11. Locust	1,225,000
6. Black walnut	582,000	12. Chestnut	355,000

Finally, by measuring the areas of the several curves, we deduce the following values for relative resilience, white pine being taken as the standard.

The work done in twisting off these specimens is found to have relative values as follows:

1. White pine..........	1.00	7. Red cedar	1.00
2. Yellow pine, sap......	3 01	8. Spanish maho...	2.25; 1.0[illegible]
3 " heart.....	3.87	9. Oak	6.[illegible]
4. Spruce.....	1.50	10. Hickory	6.[illegible]
5. Ash	2.25	11 Locust....	7.65; 5.85; 3.[illegible]
6. Black walnut....	5.00; 3.95	12 Chestnut............	2.[illegible]

The values of coefficients, as given, will be checked by additional experiments upon test pieces of the form shown in Fig. 4, carefully turned to a diameter of ¾ in., and of a length in the neck, of 1 in.

Coefficients for metals will also be given in a later communication.

A New York railroad company has recently instituted a system of paying its *employés* with interest bearing checks called "saving bank checks." Attached to each check are four coupons, one payable at the end of each quarter, the interest being at the rate of eight per cent., and the ultimate payment being guaranteed by a special deposit of the company's first mortgage bonds.

INCOMBUSTIBLE PAPER AND FIREPROOF INK.

An invention has been recently patented in this country which, if it will only stand the test, should have a wide field of usefulness A really incombustible paper, without a fireproof ink, would be a very valuable article in many businesses, and for many purposes of every-day life, but if it can be supplemented by a fireproof ink, its value will be enhanced tenfold. Such a discovery Mr. G. W. Halfpenny believes he has made, and has accordingly secured his rights by obtaining the Great Seal We gather from his specification not that paper prepared by his process is absolutely indestructible by fire of any degree of fierceness, but that, under such circumstances as fires in houses, factories, or other buildings, it is "ordinarily incombustible." The inventor prepares his paper, in the usual manner, from a pulp consisting of vegetable fibre, asbestos, alum, and borax, in, or about in the following proportions :—Vegetable fibre, 1 part ; asbestos, 2 parts ; borax, 1-10th part ; and alum, 2-10ths of a part. The vegetable fibres are minutely divided, and treated in the manner usual in the production of ordinary paper ; the asbestos is also divided as much as possible, and the two are then intimately mixed with the alum and borax in a sufficient quantity of water to make a pulp of the requisite consistency, which is then made into paper by any of the well-known processes. The proportions given are not rigid, but may be varied to suit the quality and nature of the desired product, and also to suit the different qualities of the raw materials. Thus the inventor says he has made incombustible paper in which the proportions of the ingredients varied from 50 to 70 parts of asbestos, and from 30 to 50 parts of flax or other vegetable fibre, with only 2½ per cent. each of alum and borax. He proposes to use in some cases silicate of soda, in order to insure hardness and coherence in the substance of the paper after it has been acted upon by fire. In order, we presume, to obtain a paper of great strength and flexibility, the sheets may be made of linen or other woven fabric, and coated on both sides with the incombustible paper.

The fireproof ink used in writing or printing on the incombustible paper is made of the following substances in, or about in the proportions given, in apothecaries' weight :—Graphite, 22 drachms ; copal or other resinous gum, 12 grains ; sulphate of iron, 2 drachms ; tincture of nutgalls, 2 drachms ; and sulphate of indigo, 8 drachms. These materials are mixed together and boiled in water, the graphite of course being reduced to an impalpable powder. This ink, which besides being fireproof is said to be insoluble in water, under ordinary circumstances is black ; but when coloured inks are desired, the graphite is replaced by an earthy or mineral pigment of the desired colour.

Another portion of this invention consists in the application of the incombustible paper pulp to the manufacture of covers for books and of wrappers or envelopes for parcels and packages. The inventor also utilises talc for this purpose, singly or in combination, with his incombustible millboard or ordinary boards Thus the "back" of the book may consist of a number of slips of talc overlapping one another, secured to and supported by a piece of incombustible paper.—*English Mechanic.*

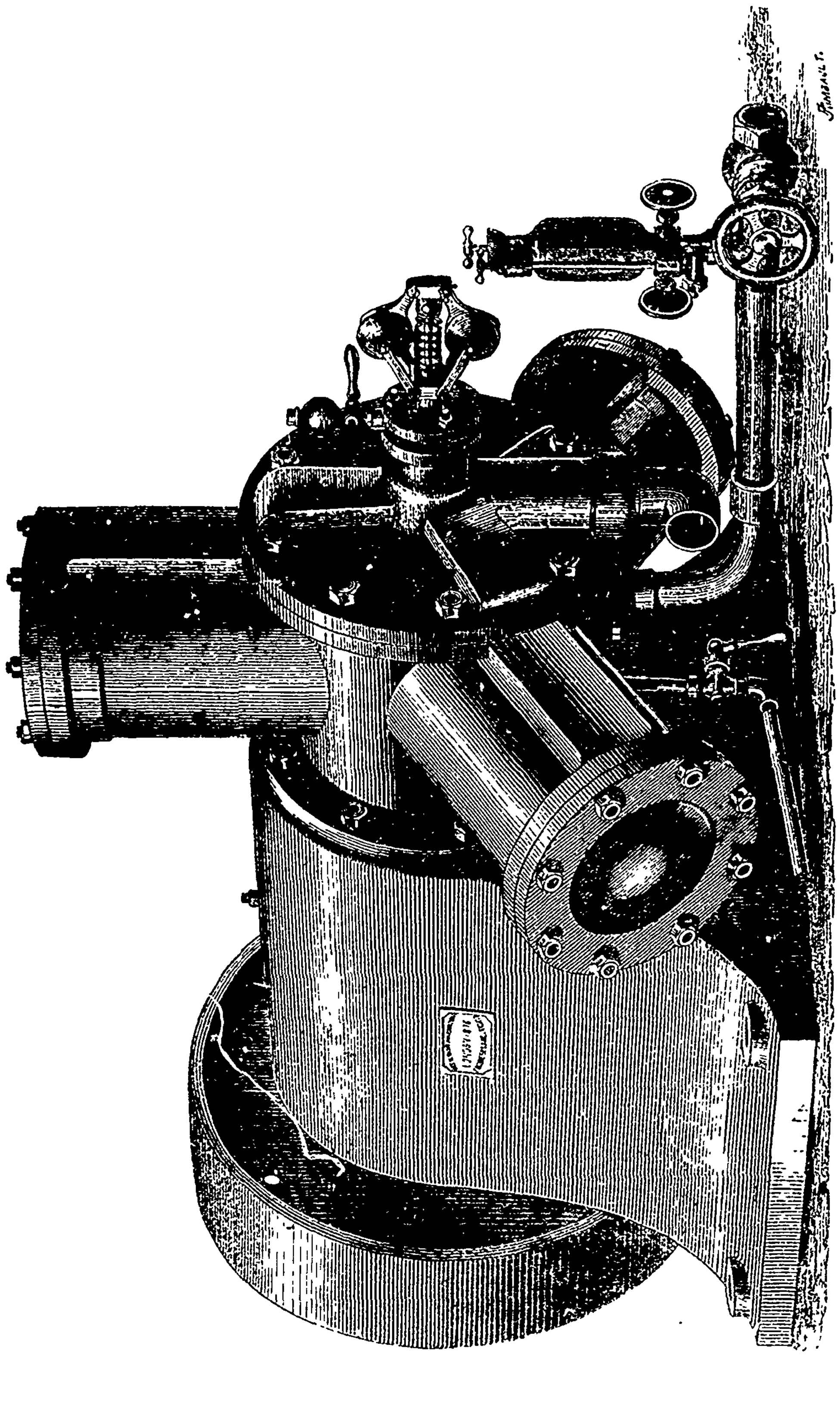
PROFESSOR JAMES DANA has written in the *American Journal of Science and Art* the following on the condition of the earth's interior. It seems now to be demonstrated by astronomical and physical arguments—arguments that are independent, it should be noted, of direct geological observation — that the interior of our globe is essentially solid. The condition of the earth's interior here recognised is, as many readers will have observed, that suggested long ago by Professor W. Hopkins—the author who first offered (1839) a mathematical argument in favour of the earth's either having a very thick crust or being solid throughout. In a paper on "Theories of Elevation and Earthquakes," in 1847, Professor Hopkins argues that the central mass of the earth became solid in consequence of the pressure whenever the temperature within reached a limit that permitted it ; that crusting at surface from cooling commenced afterward ; and that between the regions of interior and exterior solidification there long remained a viscous layer, which, in the progress of time, was gradually contracted by the union of the solid nucleus to the thickening shell. The possibility of solidification at centre from pressure, in the face of a temperature too high for consolidation from cooling, has not been experimentally demonstrated. Yet a number of facts favour the principle It has been urged that since the solidification of rocks is attended by contraction, that is, by increase of density, and since pressure tends to produce this greater density, therefore pressure may bring about the condition of the solid. The fact that ice, which has less density than water, changes to water under pressure, has been appealed to in support of the conclusion. The pressure to which the material within the earth is subjected is so great that experiment can never imitate it, or directly test its effect. Beneath only 150 miles of liquid rock it would be not less than one million of pounds to the square inch. Less than this may have been sufficient to produce crystallisation, and so give rigidity to the viscous rock material, or at least so after the cooling the earth has undergone. The rigidity of slowly solidified rock is beyond that of glass or steel—or the degree which, according to Sir Wm. Thomson, must exist in order that the earth should be as completely free as it is from tidal movements in its mass. According to the above the solid part of the globe consists, as regards origin, of three parts : the central mass, consolidated by pressure—the solidification centrifugal, or from the centre outward ; the crust proper, consolidated by cooling — the solidification centripetal, or from the surface inward ; the outer crust, or superficial coatings — the supercrust — made chiefly by the working over and elaborating of the material of the surface through external agencies, aided by the ever-acting lateral force from contraction, and including all terranes from the Archæan upward.

THE following has reference to testing lubricants for machinery :—To determine the viscosity a tube of about 15 mm. diameter and 10 centimetres long should be taken and drawn out at one end so as to afford an orifice of about 1½ mm. On filling this tube up to a mark with the different oils and noting the time occupied in emptying, the relative viscosity may be found. The temperature should be kept as nearly constant as possible at 15 deg. Water takes 9 sec. ; linseed oil, 88 sec. ; colza oil, 142 sec. ; olive oil, 135 sec. To test the length of time during which the lubricants will remain fluid, Nesmith's plan is recommended A weighed quantity of the lubricant is placed on a sheet of iron some two metres in length, which is set with a slight inclination The distance which the oil will run before it gums, and the length of time it takes to become gummy, afford means of estimating the value of the lubricants in this respect. It is also well to test the lubricants to discover whether any of the acid used in purifying is left in them, in which case they will etch the surface of metals upon which they may be placed, and as also to their liability to become rancid.

THREE CYLINDER ENGINE AT VIENNA.

Among the numerous steam engines exhibited at Vienna, few are deserving of more attention on account of the special nature of their construction than that which forms the subject of the present notice, namely, the three-cylinder engine of Messrs. Brotherhood & Hardingham, of 56, Compton-street, Goswell-road. The accompanying engraving from *Engineering* shows a perspective view of one of these engines as adapted for ordinary purposes. The details, however, will be best understood by a reference to the views on page 215, where the engine is shown as arranged for driving direct one of Boulton and Imray's helical pumps. Both these arrangements are to be seen at Messrs. Brotherhood & Hardingham's stand in the Vienna Exhibition. Fig. 1 shews a vertical section of the engine and pump, Fig. 2 an elevation, and Fig. 3 a plan, and Fig 4 being a horizontal section of the engine The construction of the helical pump will be found fully illustrated at page 215. We shall now confine our present remarks to the engine, which replaces the ordinary single cylinder type in use when we illustrated the pump.

In the new engine three cylinders are arranged at angles of 120 deg. with each other, around a central chamber, with which they communicate, the whole being cast in one piece.



THREE-CYLINDER ENGINE, AT THE VIENNA EXHIBITION.

CONSTRUCTED BY MESSRS. BROTHERHOOD AND HARDINGHAM, ENGINEERS, LONDON.

Fig. 1.

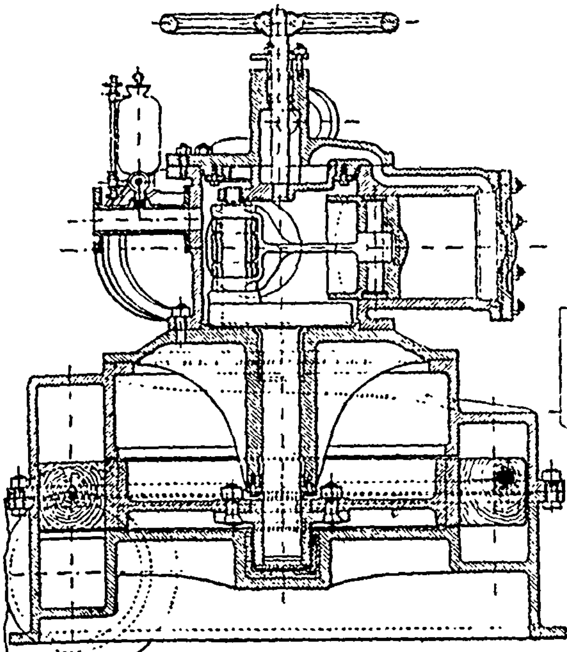


Fig. 2.

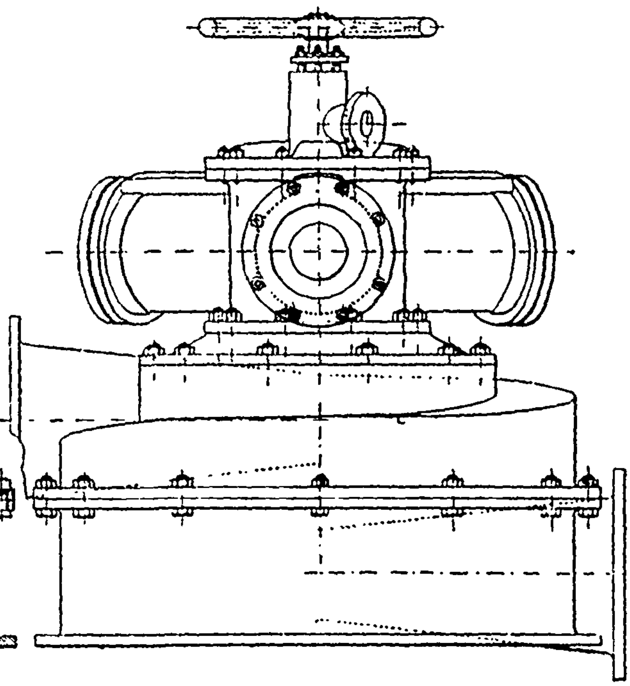
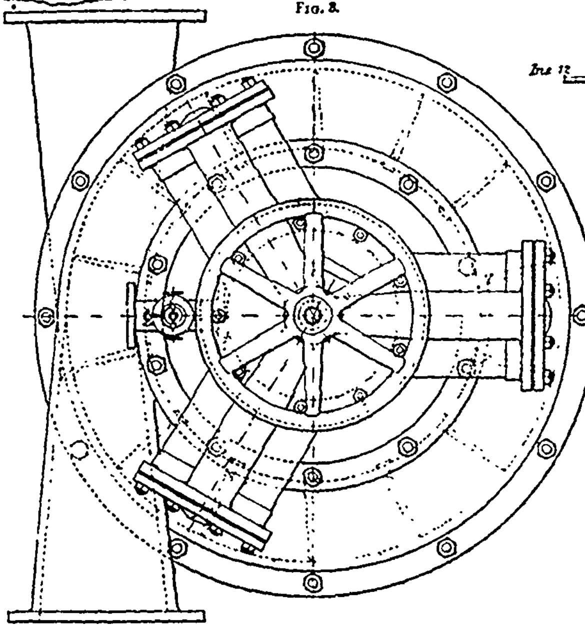


Fig. 3.



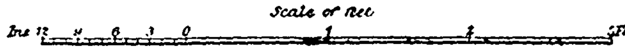
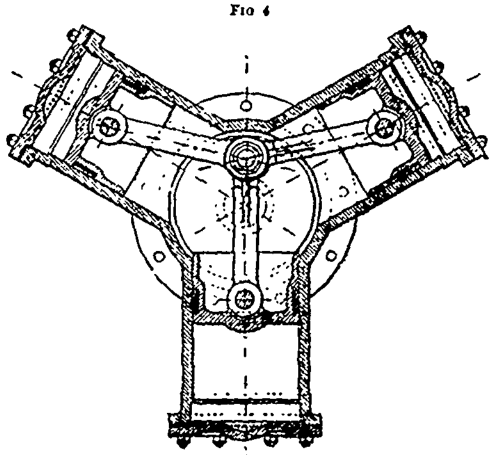


Fig 4



THREE-CYLINDER ENGINE AND HELICAL PUMP, AT THE VIENNA EXHIBITION.

Each cylinder has its own piston and connecting rod, the three rods taking on to one common crank. The crank pin, after passing through the connecting-rod eyes, is prolonged, and fits into a hole in a rotary slide valve, which it thus actuates. The valve has a steam and an exhaust port, which are alternately placed in communication with the passage belonging to each cylinder. In working this engine steam is admitted to the central chamber, and exerts an equal pressure on the inner sides of the three pistons. Thus far the machine would be *in equilibrio*. But steam now passes through the slide valve to the outer side of one piston, thus throwing that piston into equilibrium, but the three pistons collectively out of equilibrium. In other words, it renders the pressure on the inner sides of the other two pistons effective. A rotary motion of the crank and slide valve ensues, and the other pistons are alternately operated upon in a similar manner, the constant effective area for pressure being that of a piston and a half. If steam be not admitted during the whole of the inward stroke of a piston, it follows that the piston is not entirely thrown into equilibrium, and the crank has to assist it in the return stroke. The effect is of course equivalent to working steam expansively in an ordinary engine.

It will now be seen, and this is the most important feature of the engine, that a piston, when moving in one direction, pulls the crank, and when moving in the other, is pulled by the crank. Hence, the strain on the connecting rod is always a tensile one. No knock can therefore take place in the connecting-rod eyes on the alteration in the direction of the piston's movement; so the fit may everywhere be quite loose, and instead of constantly adjusting brasses it is only necessary to renew a few bushes when excessive wear has taken place. Similarly, the slide valve is free to slide on the crank pin, and adjust itself to its face as wear takes place, and the back of the crank disc always maintains a steam-tight joint in the same manner. The lubrication at first proved a source of difficulty, but it is now amply secured by the simple addition of an impermeator to the steam pipe, the oil being carried by the steam as a medium to all the working parts.

In the course of a series of experiments undertaken with the view of determining the point, it was found that few metals would stand heavy work in high-pressure steam under such conditions. Ultimately, hard phosphor-bronze bushes for the connecting-rod eyes working on a hardened steel crank-pin, were adopted, and these are found to last a long time without any oil whatever, the steam affording of itself sufficient lubrication for these two metals. The whole machine being so well balanced, and there being, as already pointed out, no possibility of a knock taking place in any of the working parts, very high speeds are permissible for the engine, such for instance, as two thousand revolutions per minute. An average speed, however, of about 300 ft. per minute for the pistons gives a very high indicated horse power in proportion to the size and cost, besides which, there are the advantages due to the absence of dead-centre, and consequent avoidance of fly-wheel, involving a considerable amount of saving in weight. It will be seen that great protection is afforded to the moving parts, and that cleanliness of working is insured. The economy arising from the friction being so much reduced is very considerable, whilst the ready applicability of the engine to a great variety of uses is one of its chief merits.

LIGHTNING AND LIGHTNING-RODS.

By John M. Mott.

Read before the Meteorological Section of the Franklin Institute.

Summary.

1st Lightning-rods, as usually erected, do not afford much protection.

2nd. Insulators, glasses, at the points of support, are of no use in any case, they destroy the most valuable influence of the rod, and may, under certain circumstances, be the cause of most terrific and destructive return strokes.

3rd. The conducting power of lightning-rods is proportional to their solid contents or sectional area, with similar metals of equal lengths, and not to their surfaces.

4th A lightning-rod should have the conducting power of a copper rod one-half inch square, and perfect metallic union of all its parts. A rod made exclusively from copper wires, if of sufficient size, constitutes one which is perfect in theory.

5th. Sharp points for the upper termination of rods are necessary. Rods are of but little value without them. Points should be plated, to prevent oxidation. They are also of value when used at the lower terminus of the rod.

6th. It is necessary to place a point at each gable, chimney, and ventilator, to connect all together, to connect the rod with metallic roofs, gutters, valleys, steam-pipes, gas-pipes, water pipes, speaking tubes, and other permanent metallic bodies about buildings, and the more numerous the connections with the earth the better.

7th. The rod must be attached directly to the building, the closer the better. It must not be insulated by being passed through or over rings of glass, horn, or other non-conducting substances, nor be placed at a distance from the object to be protected.

8th. Ground rods must have two or more branches penetrating the earth to permanent moisture; must extend below the foundation walls or the bottom of the cellar. In some instances, where it is difficult to reach moist earth, they must be imbedded in charcoal.

9th. Lightning-rods, constructed and erected in accordance with the foregoing principles, will afford full protection in the hour of danger, and their use is strongly urged as a necessary means of safety.

QUANTITATIVE SPECTRUM ANALYSIS.

The subject of spectrum analysis has of late been so frequently and prominently brought before the public that it is only necessary briefly to recapitulate what has been done in order to understand the most recent tendency of investigation with this wonderful instrument, to which science already owes so much.

We must remember then, to begin with, that chemical substances, when volatilized in a flame, make known their composition by causing certain light lines to appear in the spectrum produced by making the light from the flame pass through a prism Every chemical element has lines peculiar to itself, and their relative position in the spectrum is so constant that their appearance enables the observer at once to recognize the presence of substances. We can tell whether a light to be examined is due to a glowing gas, or proceeds from a liquid or solid body. A gas will produce bright colored bands separated by dark spaces, while a liquid or solid will give rise to a spectrum containing every shade of color without gaps Thus the nature of the light coming from heavenly bodies is revealed to us, and it has been found, for example, that about one third of the nebulæ are composed of incandescent gas. A glowing vapour will absorb the same kind of light as that which it emits, if therefore a brilliant source of light is surrounded by a glowing vapour, that vapour will not permit certain portions of the light behind it to pass through, and the absorption will be indicated by dark lines in the spectrum These dark lines will be in the same places where the glowing vapour alone would produce bright ones. Hence it is that the spectrum of the sun, which is surrounded by an envelope of glowing gas, contains a great number of dark lines whose position reveals to us the substances present in the incandescent envelope. The same is true of the fixed stars, whose spectra are also characterized by dark lines.

When a luminous body is approaching us with great velocity, the waves of light crowd upon each other, become more rapid and shorter, and hence more refrangible, than if the body were stationary. Any given line in the spectrum of such a body will therefore be found nearer the more refrangible or violet portion of the spectrum than its normal position. If the luminous body is receding, the line will move towards the less refrangible or red end of the spectrum. The displacement of the line being accurately measured, we can calculate, from its known wave length and the velocity of light, the rate at which a fixed star is approaching, or receding from, the earth.

Terrific hydrogen storms are constantly taking place on the surface of the sun. On account of the glare of the light, these could only be seen formerly around the edge of the moon's disk during a total eclipse Now they can be observed at any time by means of a spectroscope of high dispersive power, which extinguishes the blaze of the sun sufficiently to allow them to be seen. The enormous velocity of the currents of glowing hydrogen projected upwards from the sun's surface can be measured on the same principle as that of a star approaching the earth.

If the light passing through coloured solutions is examined by the spectroscope, certain portions of it will be found to be absorbed, and their spectra will be characterized by dark bands, whose position and arrangement varies with the nature of the solution. It is thus that we can distinguish between different dyes, detect artificial colouring of wines (as, for example, by means of logwood), and decide upon the important question, likely to arise in criminal cases, whether a substance to be examined is human blood or not.

The fluorescent light produced, in a large class of substances, when illuminated by blue and violet light affords, on examination by the spectroscope, a ready and most delicate means of determining their composition and even their state of hydration. Fluorescing substances, moreover, by rendering visible the actinic rays, increased the effective length of the spectrum and hence the delicacy of analysis.

Among many practical applications of spectrum analysis, one of the most important is in the manufacture of steel by the Bessemer process. A blast of air is forced through the melted iron to deprive it of a certain proportion of carbon. If this blast is continued a few minutes too long or stopped a few minutes too soon, the whole operation is vitiated. By examining the flame of the converter with the spectroscope, the proper time to stop the blast is clearly indicated by the disappearance of the carbon lines and the change to a continuous spectrum.

But the uses of the spectroscope do not stop here. Scientific men have of late been turning their attention in a new direction, that of quantitative analysis by means of the spectrum. Not content with discovering what substances are contained in a given compound, they are devising means to determine the quantity of these substances.

In a session of the French Academy of Science held November 7, 1870, Janssen stated that he believed he would soon be able to determine sodium quantitatively by means of the spectroscope. In his analyses, he was much annoyed by the constant presence of the sodium line, caused by the sea salt in the air; so he directed the slit of the spectroscope upon the most brilliant portion of the flame of an ordinary gas burner instead of a Bunsen burner, in order to get a continuous spectrum in which the D line did not appear sensibly, because of the abundance of the neighbouring lines Sometimes he had to interpose several flames between the testing flame and the spectroscope. This led him to conceive the possibility of estimating the quantity of the sodium by the number of flames necessary. He also stated that the length of time it takes the sodium to volatilize might serve as a criterion of its quantity

These crude ideas form the basis of a series of experiments undertaken quite recently by MM Champion, Bellet and Grenier. After substituting coloured glasses and coloured solutions for Janssen's flames, and making a great many experiments, they constructed the "spectronatrometer," an instrument of considerable delicacy, but rather complicated in its arrangement. We will therefore confine ourselves to a description of its principles.

The soda in the substance to be analyzed is converted into the sulphate, the volatility of which is found to be intermediate between that of the chloride and the phosphate. Into the solution obtained a wire, of platinum-iridium ·04 of an inch thick, is dipped and dried. It is then carried into a flat Bunsen flame with a perfectly regular motion by means of clockwork; and the intensity of the sodium line, produced in the spectroscope directed upon the flame, is compared with that of a line produced from a solution containing a known quantity of sodium or from the volatilizing of solid pure sulphate of soda. The comparison is effected by causing the rays of the substance to be examined to pass through a glass prism containing a coloured solution. This prism being wedge-shaped, permits the experimenter to make the light pass through different thicknesses of the absorbing liquid (that is, from 04 to 60 inch) until he gets a sodium line equal in intensity to that of the standard of comparison. The inventors have made a large number of observations on solutions of known strength, and constructed a curve, whose abscissas represent the thickness of the layer of the solution in the prism through which the light has to pass, and whose ordinates correspond to the quality of sodium present.

Dr. K. Vierordt, of Tübingen, the inventor of a delicate method of photometry by means of the spectroscope, solves the problem of quantitative analysis of bodies giving an absorption spectrum in the following way: The slit of the spectroscope, adjusted to a certain width, is divided into two parts Opposite one half is placed a solution of the body to be determined, and opposite the other a solution of the same body whose strength is known. The first slit is then narrowed or widened until the absorption is the same in both halves of the spectrum, when the width is read off By using a series of solutions varying decimally in strength, from the weakest to the strongest through which light will pass, curves may be constructed, in which solutions of unknown strength can be interpolated and their value ascertained When a certain point is reached, further concentration of a solution will not affect its absorbing power regularly, and it is therefore necessary to dilute liquids which are very concentrated. Tables to facilitate calculation have been computed by Dr. Vierordt.

The most recent and perhaps the most important method yet discovered is due to Lockyer of England. It is based upon the following principles: When an alloy is introduced into the electric arch, the most volatile metal will be carried across to the other pole first and its vapour will form so good a conductor that but little of the less volatile metal will get into the arch. To make the principle perfectly plain, we will quote an explanation given by Tyndall. When showing his audience the characteristic lines of silver and thallium, he found that the latter were far brighter, and that the former were diminished, when a bit of thallium was put in with the silver in the electric arch "It is the resistance," he went on to say, "offered to the passage of the electric current from carbon that calls forth the power of the current to produce heat. If the resistance were materially lessened, the heat would be materially lessened: and if all resistance were abolished, there would be no heat at all. Now thallium is a much more fusible and vaporizable metal than silver, and its vapour facilitates the passage of the current to such a degree as to render it almost incompetent to vaporize silver" The more, therefore, of the more volatile metal is present in an alloy, the less of the other can be vaporized by the arch.

Now on examining the arch by means of the spectroscope, Lockyer found lines extending across the whole width of the spectrum and shorter ones reaching only part of the way. The former corresponded to the more volatile, and the latter increases with the quantity of the metal present, it is evident that by measuring them we can ascertain that quantity. In these determinations, the electric current is obtained either from a powerful battery, a Ruhmkorff coil or a magneto-electric machine; and the heat of the spark is intensified and at the same time rendered constant by means of Leyden jars of constant surface. Instead of placing the alloy to be tested in one of the carbon electrodes, we might have the electrodes themselves composed of the metals Suppose we make one of pure gold and the other of some alloy whose percentage of gold we wish to ascertain. Then by separating the electrodes sufficiently, we finally arrive at a point where the gold lines from the alloy no longer meet the lines from the pure gold, but will extend only part of the way, leaving a gap on their half of the spectrum. If we now keep the same distance between the electrodes, and experiment on alloys containing different percentages of gold, the length of their gold lines will be found to vary with that percentage. The length of the lines can easily be measured by causing the reflection of a graduated scale to fall upon the spectrum. In assaying, where we frequently have to do with samples of gold whose fineness differs but little, a series of electrodes of known composition may be prepared; and by comparing them with alloys of unknown fineness, it is easy to tell, by simple inspection of the spectrum, which is the finer. The lines of the one containing less gold will not extend all the way across.

The attention of the United States Mint has been called to this discovery of Mr. Lockyer's; and while this article was in course of preparation, an officer from the Philadelphia branch was experimenting in the Stevens Institute of Technology with a view of testing its practical utility.—*American Artisan*

THE SOUDAN RAILWAY EXPEDITION.

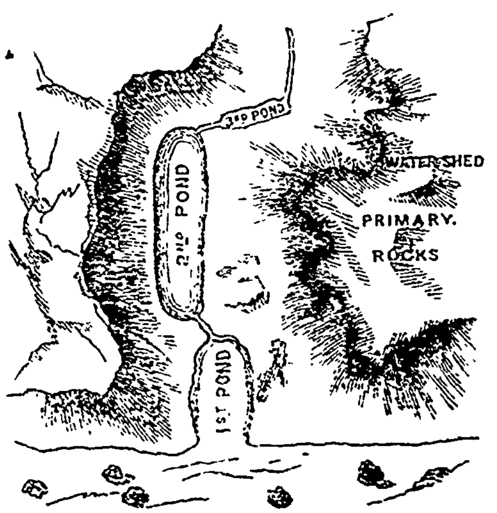
(*Continued from page* 167.)

In the Bahiuda desert the rainfall takes place between May and August, but the quantity is very variable, and it sometimes happens, indeed, that two consecutive seasons are entirely rainless. The total absence of all regular observations leaves the question of this rainfall very uncertain.

A few remarks upon the drainage lines in this district will find a suitable place here The desert plains, which are practically level, receive, of course, a considerable amount of moisture during the rainy seasons, but this is soon evaporated by the heat of the sun. At Abou Halfa a river bed, and remains of trees washed up on its southern bank, show the line of drainage taken by the water from the neighbouring hills. The hills near Gakdoul also pour down a considerable quantity of water, which falls away towards the north, and culverts would have to be provided on the line of railway to carry off this water. The district here is, however, largely cultivated, and, as the soil is deep, and absorbs the moisture rapidly, the greater part of the rainfall would disappear before reaching the culverts, and a maximum allowance of 4 ft. depth of water in times of highest flood would be ample.

The next important point along the line of railway in this district, where floods must be provided against, is at Abou Deleah, where the southern side of a range of sandstone and porphyry hills drains into a Wady, and thence to the wells of Abou Deleah. At this place a maximum depth of 4 ft would also be provided for, but such an accumulation

THE WELLS OF GAKDOUL.



PLAN OF WELLS OF GAKDOUL.

has occurred only once in twenty-four years, and it then lasted but a very short time.

On the plains a low bank from the side cuttings will always keep the rails above flood level, and side ditches would be made where drainage has to be provided for, thus reducing the number of culverts, and consequently the skilled labour required, to a minimum.

We pass next to the consideration of the water supply along this section of the railway. At the commencement of the fourth division the wells of Abou Halfa, situated in the bed of the river, are the first requiring notice. They are formed like those of Abou Deleah and El Fouragh, and are used in the same manner; although these wells are not lined they stand well, but in the wet seasons they become partially filled with sand and other deposit.

Certainly the most remarkable wells in the desert are those of Gakdoul. They consist of three large water-worn cavities, each at a different level, and shut in by precipitous cliffs. The lowest of these pools forms an irregular oval in plan, about 120 ft. long, by 60 ft. broad, and for three-fourths of its length it is enclosed between perpendicular rocks. Whether any labour has been expended in making these excavations it is impossible to say, but it is evident that the cavities have been mainly produced by the torrents rushing through a small passage about 8 ft. above the highest water level, and thus wearing away the softer portions of the rock to a considerable depth below the ground level. These reservoirs contain always sufficient water for two years' supply of the existing demand, and are never dry. The lowest well is daily visited by large numbers of animals, and the water is consequently unfit for any other use. The second pool, about 10 ft. above the first one, lies in the bottom of an almost inaccessible channel, the sides of the gorge rising in some places nearly perpendicular, and to a height of about 80 ft. from the water. The approximate length of this pool is 200 ft., and its width is 40 ft. The quality of the water is excellent, and from this, and the upper pool, the skins or Girbas, used to carry the drinking water, are filled, a cord and bucket being employed to raise the water from the wells. The third pool is about 5 ft. higher than the second, and lies in a direction nearly at right angles to the latter. Its size is about 80 ft. by 15 ft.

A very tortuous and contracted channel, about 20 ft. long, and 3 ft. wide at the bottom, forms the connexion between the second and the lowest pool, and above this the gorge widens out, and by the construction of a dam, a fine reservoir and ample water supply would be obtained.

The wells of El Faar, situated about 8 or 9 miles east of the line at Gakdoul, consist of a number of holes 3 or 4 ft. in diameter, and a few feet in depth, which are formed in the usual manner, and they are sunk in the channel of a large river bed. The wells are rudely excavated, and are unlined; their falling in is therefore a matter of frequent occurrence, and these accidents are repaired by the excavation of new holes.

The water is drawn from these wells by skins formed roughly into buckets, by being tied at the four corners, and lowered with a line. A basin with puddled sides is formed on the surface, for the use of animals. During the rainy season the holes are rapidly filled with deposit, and they have then to be remade; on the other hand, in the dry season, the wells are gradually deepened, and the water level falls through use, absorption, and evaporation. Cattle, sheep, and goats are driven here in large numbers, and it is the custom during the hot season to water the sheep and goats once every four days, and the cattle every other day. In the winter season they are driven to the wells every sixth and fourth day respectively. The water at these wells is good, and the supply generally plentiful; only once, indeed, during the past thirty years have they dried up, after a continued drought of two years.

The river bed of El Fourâgh, at the site of the wells, is about 150 yards in width, but the scour on each bank, extending for a distance of half a mile, points to the fact that a large quantity of water passes down this watercourse during a rainy season. A few miles south of the wells, the river bed is from 12 to 15 ft. deep, and the width about 300 yards. Many small tributaries cross the camel route between Gakdoul and the wells of El Fourâgh, which carry off the drainage from the range of hills running in a north-easterly direction from Gakdoul towards El Fouràgh.

Following the river bed from its wells, it is seen to take a bend to the west, while on the east it receives the drainage from the hill range just mentioned. The principal drainage, however, runs towards that bend of the river which turns westward, near the hills. Following the base of a range of a sandstone hills for nearly half a mile, it suddenly sweeps round in a northerly direction, and passing through a gorge, enters a plain where vegetation is as abundant as at Gakdoul. The hills of sandstone and porphyry which surround this plain, provide an immense watershed, which pours from seven or eight mountain torrents into basins, and thence into the river bed of El Fouràgh, where it is gradually absorbed into the desert sand further south, or evaporated by the heat.

The wells of Abou Deleah lie close to the line of the proposed railway. They are sunk in the same manner as those just described, but as the soil does not stand so well, they are constantly falling in, and have, therefore, very frequently to be reconstructed. The water at this spot is excellent for drinking, and the supply is good, having failed like that of El Fouràgh only once during the last thirty years. Being on the camel route to El Metemmeh, the wells are constantly visited by caravans. They also form a favourite watering-place for the herds and flocks of the Arabs.

The well of El Shabocat is about 7 miles from El Metemmeh, and is also upon the camel route.

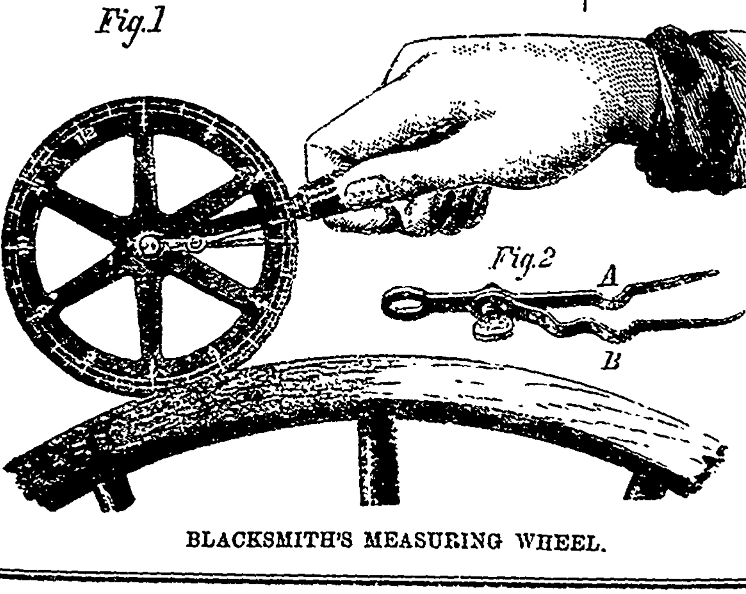
BLACKSMITH'S MEASURING WHEEL.

Mr. Thomas B. Way, of Springfield, Ohio, is the inventor of the device herewith illustrated, for measuring the circumference of wheels and the length of the iron from which tyres therefore are to be made. The peculiarity of the apparatus consists in an extra pointer pivoted to the hand which indicates the wheel measure, for the purpose of deducting from the latter the amount to be allowed for expansion of the metal.

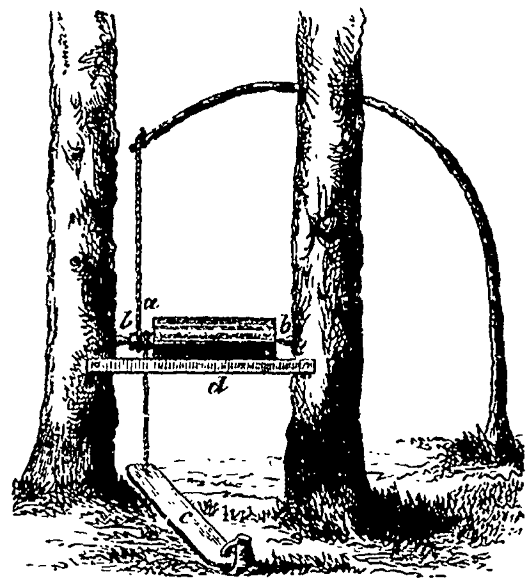
The wheel shown revolves freely on its axle, to which, however, the hand A, is rigidly affixed. The pointer B, is secured to the hand A, by a screw, as shown in Fig. 2, so that its end may be set at any desired distance from that of its support. The device is applied and carried around the wheel to be measured, as represented in Fig. 1, where the hand A, indicates the length of circumference passed over. The pointer B, is then fastened with its end at a distance to one side of the hand equal to the amount of expansion of the iron. The apparatus is afterward carried over the tyre, which is cut at the point indicated by B.

The invention may also be employed by coopers for measuring hoops, in which case the extra pointer may be used to indicate the allowance for lap.

Fig.1



BLACKSMITH'S MEASURING WHEEL.



AN ANCIENT LATHE.

A correspondent writes to *Engineering* as follows concerning the above exhibit at Vienna by the Austrian Ministry of Commerce and Agriculture:

"Besides many interesting objects, we there find turned objects of wood, such as wooden glasses, bottles, basins &c., manufactured by the Huculen, the remnants of an old Asiatic nation which had settled at the time of the general migration of nations in the remotest part of Galicia in the dense forests of the Carpathians. These people manufacture the articles named above, and the instrument they are using for turning them is worth noticing, seeing that it has been employed unaltered since times immemorial. If a Hucule wants to manufacture a turned basin, bottle, &c., he arms himself with a a hatchet, a chisel and a rope, and enters the dense forest which surrounds all human habitations in his part of the country. After having cut the tree out of which he wants to manufacture the desired articles, he looks round for two trees of about 1 ft. or 2 ft. diameter, and sufficiently close together for his purpose. But it is an essential point in selecting these tree that a young maple or beech should also grow near at hand. Having found this necessary combination for the work to be done, the Hucule makes two holes at a proper height in the two trees, and inserts in these opposite holes maple cones, serving as dead centres. One of these cones is fixed, and the other removable. In the annexed sketch of this arrangement these cones are marked *b b*. The wood-blank to be turned is then prepared with the hatchet, so as to be fixed between the centres, and is fitted at one end with a small cylindrical part, *a*, to take up the rope for giving a rotary movement to the piece of work.

The rope is then taken two or three times round the small cylindrical part, *a*, and is attached to the top of the young maple, as shown in the sketch. The lower end of the rope is fastened to a piece of wood *c*, which, at its other end, is attached to one of the roots of the trees, and thus serves as a foot-board. After this the man fastens a cross-bar, *d*, to the trees, and begins to turn with his chisel whatever he wants to produce.

It is clear that this lathe has a reciprocating motion, but nevertheless the objects manufactured with this primitive machine are nicely turned, and do not lead to the supposition of so rough a tool.

THE MONUMENT OF VICTORY AT BERLIN.

Every newspaper reader knows that the Monument of Victory at Berlin was unveiled by the Emperor of Germany with considerable military display on September 2, and as sketches of the event have appeared in the illustrated papers some notion of the column may be formed, but hitherto no technical description of the structure has been published. The monument, as is well known, is intended to commemorate the three distinct Prussian triumphs, first over Denmark, then over Austria, and, lastly, over France; and although the last of these was still in the womb of time when the first stone was laid in 1869, the original design had to be but slightly altered when its object became the witness to future generations, not of two, but of three successive triumphs.

The monument consists, in the first place, of a square pedestal of dark red Swedish granite, 93 feet by 93 feet and 23 feet high, having cornice die and base, with flat piers at the angles. Upon the die, between the piers, are affixed four bronze reliefs illustrating various scenes of the drama which the edifice commemorates. Upon the east side, a work by Calandrelli depicts the preparation and departure of troops, as also the storming of Düppel; upon the north Moritz Schultz has reproduced the Battle of Koniggratz, choosing the moment when the king, accompanied by Moltke and Bismarck, meets the Crown Prince The western relief, the work of Karl Keil, shows the capitulation of Sedan, the delivery of the Emperor's letter to the king by General Reille, and the entry into Paris. The last, on the south side, is by Albert Wolff, and represents the re-entry of troops into Berlin at the close of the campaign on June 16, 1871. It was the architect's intention to gild these bronze reliefs, but he was (fortunately) overruled by his sculptor colleagues, and the castings retain their original hue.

Upon the square pedestal rises a circular sort of temple, consisting of sixteen Doric columns about 20 feet high, standing upon a circular flight of four steps, the diameter of the top step being about 51 feet. The columns have architrave, frieze and cornice, the cyma recta of the latter being ornamented with lions' heads. The columns and cornice are of red polished granite, and the inner paneled ceiling is of green marble resting on ornamental bronze girders. From the centre of this circular space rises a column of grey sandstone, 24 feet 6 inches in diameter at the base, and, passing through the low-pitched stone roof, reaches a height of 115 feet, measured from the platform of which it stands; a bold attic base rests upon the circular roof, and above this the shaft is divided horizontally into three tiers of flutings, the lower portions of each tier being filled with Danish, Austrian, and French cannon connected by wreaths of laurel festooned from one cannon to another. All the metal work is strongly gilded, and is said to produce a very brilliant effect The cap of the column is 9 feet in height, ornamented with Prussian eagles and wreaths of laurel, above which the abacus is octogonal, with a diameter of 15 feet This forms a platform, which is reached by a circular stair passing up the centre of the column, and is protected for that purpose by a strong iron railing of rich design. Springing from this platform is the pedestal of the colossal figure which crowns the whole. The latter is draped in flowing skirts and tunic; the lifted wings measure 26 feet from tip to tip; in her right uplifted hand she holds a victor's laurel crown, whilst in her left is grasped a furled standard surmounted by the "iron cross;" and on her head is perched the Prussian eagle, apparently ready to soar off once more at any moment.

The entire structure, from the ground to the top of the standard, is 199 feet in height. The cost of the whole is stated to be 90,000*l*, and the architect from whose designs and under whose immediate superintendence the monument was erected was Herr Strack, whose official title, by the way, is an appallingly long one, to wit, Mr. Secret-Chief-Court-Councillor-of-Buildings. With him were associated the architects Hollin Luthmer, Jacobstal, Haberlin, and Hosfeld, in minor capacities, the contractor having been M. Rasche, of Berlin. With regard to that portion of the great column which stands within the circular hall above described, it should be mentioned that a periphery of 74 feet by a height of 12 feet (888 square feet) affords a good opportunity for pictorial decoration. This is being prepared at the Salviati Mosaic Works at Venice, from designs by A. von Werners, the subjects chosen being—the French declaring war, the banding together of all Germans in the face of a common danger, and the proclamation at Versailles of the Prussian King as German Emperor.—*The Architect.*

BEES AS ARCHITECTS.

Now we exercise a patient observation on Nature, analyzing, investigating, calculating and combining our facts, and say coolly with Professor Haughton, "Bees construct the largest amount of cells with the smallest amount of material;" or with Quatrefages, "their instinct is certainly the most developed of all living creatures with the exception of ants." "The hexagons and rhomboids of bee architecture show the proper proportions, between the length and breadth of the cell, which will save most wax, as is found by the closest mathematical investigation," says another great authority. Man is obliged to use all sorts of engines for measurement—angles, rules, plumb lines—to produce his buildings, and guide his hand; the bee executes her work immediately from her mind without instruments or tools of any kind. "She has successfully solved a problem in higher mathematics, which the discovery of the differential calculus, a century and a half ago, alone enables us to solve at all without the greatest difficulty." "The inclination of the planes of the cell is always just, so that, if the surfaces on which she works are unequal, still the axis running through its inequalities is in the true direction, and the junction of the two axes forms the angle 60° as accurately as if there were none." The manner in which she adapts her work to the requirements of the moment and the place is marvelous. A center comb burdened with honey was seen by Huber and others to have broken away from its place, and to be leaning against the next so as to prevent the passage of the bees. As it was October, and the bees could get no fresh material, they immediately gnawed away wax from the older structure, with which they made two horizontal bridges to keep the comb in its place, and then fastened it above and at the sides, with all sorts of irregular pillars, joists, and buttresses; after which they removed so much of the lower cells and honey, which blocked the way, as to leave the necessary thoroughfares to different parts of the hive, showing design, sagacity, and resource. Huber mentions how they will find out a mistake in their work, and remedy it. Certain pieces of wood had been fastened by him inside a glass hive, to receive the foundation of combs. These had been placed too close to allow of the customary passages. The bees at first built on, not perceiving the defect, but soon changed their lines so as to give the proper distance, though they were obliged to curve the combs out of all usual form. Huber then tried the experiment another way. He glazed the floor as well as the roof of the hive. The bees cannot make their work adhere to glass, and they began to build horizontally from side to side; he interposed other plates of glass in different directions, and they curved their combs into the strangest shapes, in order to make them reach the wooden supports. He says that this proceeding denoted more than instinct, as glass was not a substance against which bees could be warned by Nature, and that they changed the direction of the work before reaching the glass, at the distance precisely suitable for making the necessary turns—enlarging the cells on the outer side greatly, and on the inner side diminishing them proportionately. As different insects were working on the different sides, there must have been some means of communicating the proportion to be observed; while the bottom being common to both sets of cells, the difficulty of thus regularly varying their dimensions must have been great indeed. The diameter of the cells also varies according to the grubs to be bred in them. Those for males have the same six sides, with three lozenges at bottom, as those for workers, and the angles are the same; but the diameter of the first is $3\frac{1}{2}$ lines—that for the workers only two-fifths. When changing from one size to another, they will make several rows of cells intermediate in size, gradually increasing or diminishing, as required. When there is a great abundance of honey, they will increase both the diameter and the depth of their cells, which are found sometimes as much as an inch and a half in depth.—*Good Words.*

An exchange says: "The Niagara Suspension Bridge, which connects the New York Central and Great Western railways over Niagara river, has been for months past undergoing improvement It has been thoroughly inspected, with a purpose to discover the condition of its anchorage and concealed parts. Everything was found to be as perfect as when laid twenty years ago. The entire wood work has been replaced with new, and there is nothing about the bridge which is not just as perfect as on the day it was first completed. A strong new cord has been put under the carriage way of the bridge and the one above has been rebuilt. Engineers declare that the bridge could not fall if the cables were wholly removed The popular idea has been that the whole weight of the structure depended on the cables. Those cables that have so long supported a bridge full of loaded cars without flinching will no doubt long continue to do all that is required of them.

Education and the Brain.—M le Dr. Broca, in a long dissertation published in the *Revue Scientifique*, takes the ground that education is reflected in brain development. He concludes as follows: "It is this influence of education upon the brain which I have sought to determine, and I think I have demonstrated that cultivation of the mind and the exercise of intellectual labour augment the volume of the brain, and that the increase is principally upon the frontal lobes, which are the seat of the most elevated faculties of the intelligence. Education not only makes man himself better; it not only gives him that superiority, relatively to what he would be without it, which enables him to use all the intelligence with which nature has endowed him; it even transforms him, and renders him, as it were, superior to himself, by increasing the volume and perfecting the forms of the brain Those who call for universal instruction justify their demand upon grounds both social and national. We may now invoke an interest, perhaps, still higher—that of the *race* To diffuse instruction is to improve the race. Society can do it, and it is the highest duty."

FUSION OF PLATINUM.

The following arrangement of a furnace enables us to effect this fusion easily, and to produce a temperature which may be useful both in research and in practice. In a saltpetre refinery at Lille there is a large chimney, 30 metres high and one-fifth metre in diameter. It serves for a vent to eight large steam-boiler furnaces, fed with coal, and which maintain a constant and energetic draught. A small door, opening into the base of the chimney, and generally closed by a small brick wall, communicates with the interior. Before this door, at the foot of the chimney, a small wind-furnace is constructed, of which the outside bulk does not exceed a cubic metre The grate, of movable iron bars, is a square of 0 30 metre. The capacity of fire-box is 45 litres, and the flue communicating with the interior of the chimney is one-fifth of a metre in width. The first experiments were made with coke as fuel Parisian and Hessian crucibles were tried, as well as those of black-lead and lime, and in each were placed, to try the heat, about 50 grammes of iron nails. The operation lasted scarcely an hour; the combustion was very active, the draught roared loudly, and the light of the fire was dazzling. In every case, crucible and metal were fused together, leaving on the bars a vitreous slag. Coke was replaced with gas-coke, in the hope of obtaining a more moderate action. The phenomena were the same, but even more intense. The best result was obtained by cutting a piece of gas-coke into the shape of a crucible, and placing it within a Hessian crucible. In this 50 grammes of platinum were placed, partly in the spongy state and partly in clippings. After the fire had been maintained for an hour, a button of platinum was obtained, perfectly fused, and weighing 50 grammes.

The experiment of Ebelmen was repeated, who obtained crystalline alumina, by heating in a porcelain furnace a mixture of alumina and borax After the borax was volatilised the interior of the crucible was covered with a layer of small hard crystals of alumina, translucid and very brilliant.

PROPOSED CENTENNIAL EXPOSITION BUILDING, PHILADELPHIA.

To obtain the best building, or set of buildings, for the Exposition proposed to be held in Philadelphia in 1876, a competition was invited, and forty-three designs were sent in. From these ten were selected, the designers of each being permitted to revise and alter the details, and having for this purpose access to all the others. There was then a second competition of the revised designs, from which the successful plan was chosen. This design is by our countrymen, Mr. Calvert Vaux, and Mr. G. K Radford, somewhat modified, we believe, by details taken from a design furnished by Messrs. Sims & Brother, of Philadelphia.

We have engraved a view of the interior of the building and the plan, as originally sent, and which it will be seen is novel in construction. We will let the designers speak for themselves.

Although several large structures are to be erected in connexion with the proposed scheme for the International Exhibition in 1876, it was evident that the problem to be first solved was the plan for the main temporary building, and to that they mainly confined themselves.

The schedule of instructions clearly recognised the advantages to be gained by providing for the various groups of exhibits in concentric zones, as in the last Paris building.

The present study in its floor plan is based on a zone arrangement, with square instead of rounded ends, it being contended that this corresponds with the facts better than the circular plan, as the angles give to the nations that require it a greater proportional increase of exhibition space in the departments, illustrating the results of high civilisation. It has, on the other hand, the main element of the Vienna plan in its twelve interior open courts, which have been designed with the idea of making them as small as practicable, but are 60 ft. in diameter; and essential features in reference to the light and air of the building, and the discharge of water from its roof.

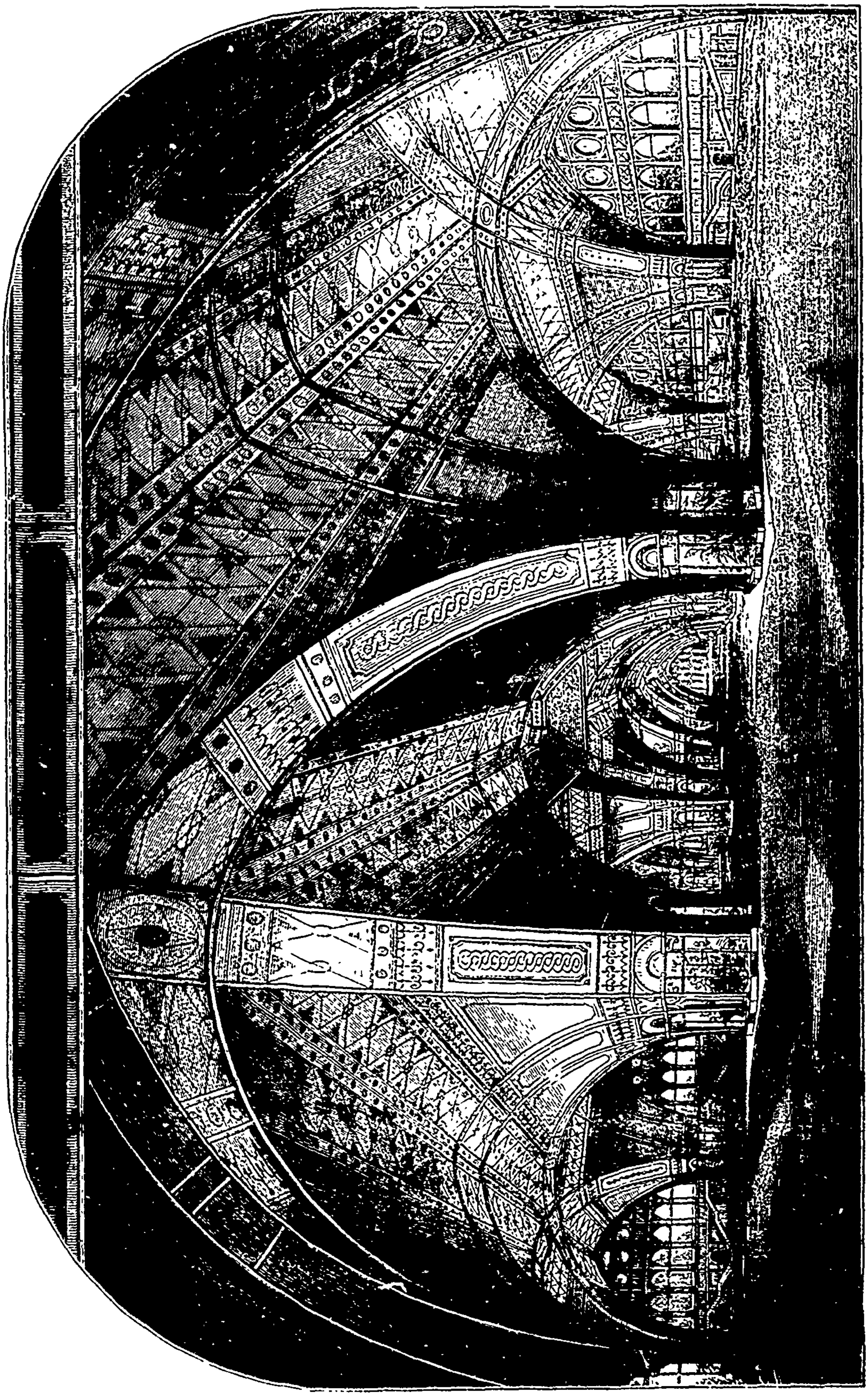
The delivery and distribution of goods was difficult and tedious in the Paris building, as its mode of construction did not allow of access by railroad cars to all parts of the interior. This is proposed to be remedied in the present instance,—direct communications being provided for throughout the building, on three lines of double-track railroad.

In the Paris building no general interior effect was attempted, and no special emphasis was possible anywhere, so that the impressions of the visitor in regard to position were easily confused, and the interminable circular line prevented vista effects of any greater length than about one-third of the short diameter.

In the Vienna building the nave and transept arrangement, which includes all the proposed exhibition-room, was not depended on to produce any sufficiently satisfactory general effect, and a central dome, 333 ft. in diameter, was erected of permanent materials, to give an adequately grand impression In the present study the aim has been to make the temporary building itself furnish the elements of a spacious and impressive design, that shall be equal in desirability for exhibition purposes in every part.

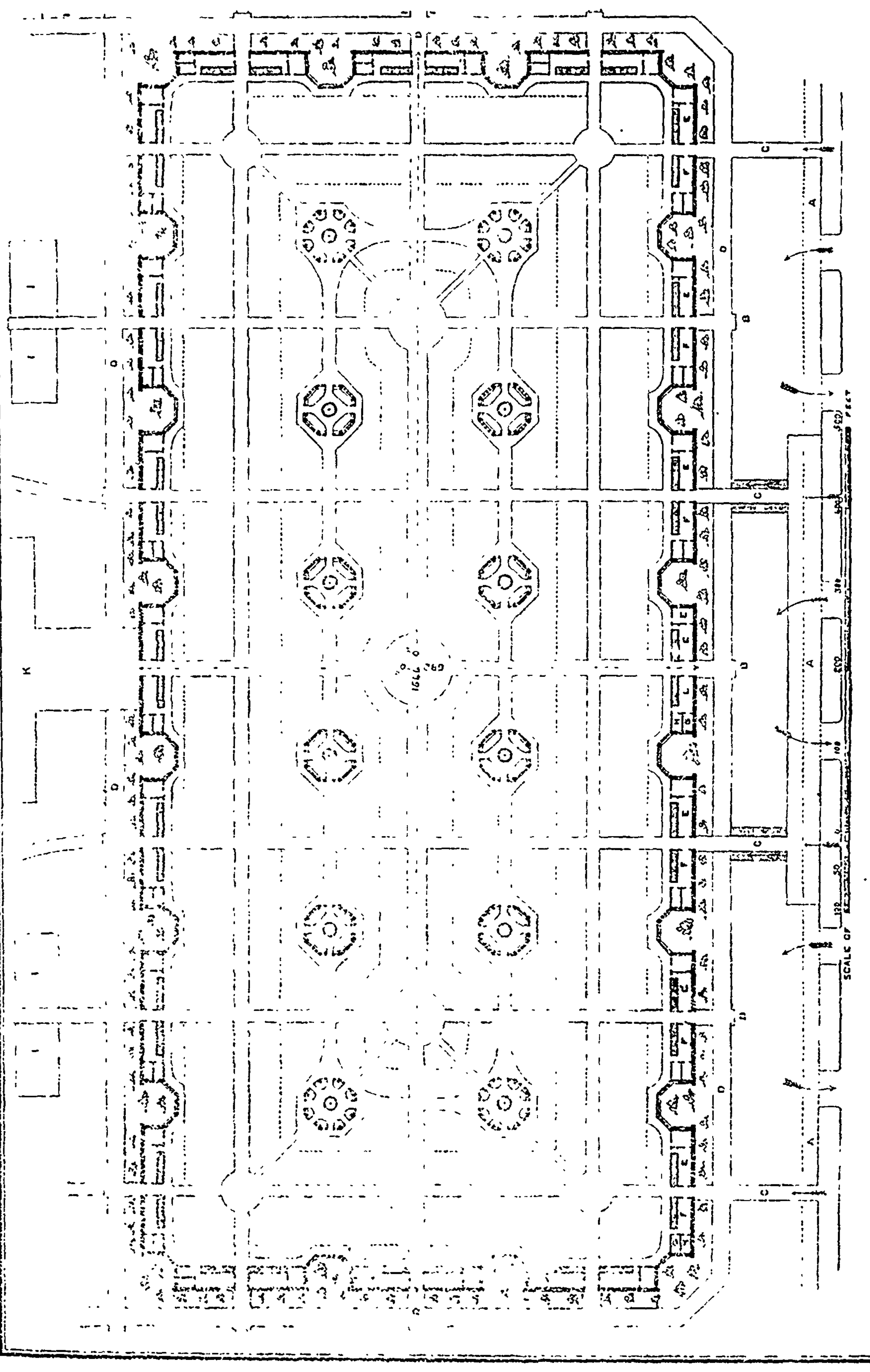
Instead of one detached dome with a span of 333 ft, the present design is made up of twenty-one domed or vaulted pavilions, each 240 ft. in diameter, clustered together, and connected by arches of 150 ft. opening, and fountain-courts 60 ft in diameter. The various parts of the building are thus included in one grand whole, and the result becomes a spacious hall, adequate to the emergencies of the occasion. with long vistas, central and intermediate points of emphasis, direct lines of transit throughout its length and breadth, diagonal lines of communication where really needed, and an entire relief from any appearance of contraction anywhere, for the visitor is always in an apartment over 200 ft. wide, that opens without any intermediate corridor into other apartments, also over 200 ft. wide. This result is obtained by employing semi-circular roof-trusses, springing from the ground-level.

The difficulty ordinarily experienced in this method of construction, is that a long stretch of roof is liable to be blown over while in progress of erection, even where moderate spans are used, because the design does not include provision for lateral support or stay. In the present plan this difficulty is avoided; for the principal trusses used in the construction of



CENTENNIAL ANNIVERSARY BUILDING, PHILADELPHIA, U.S.: SELECTED DESIGN.

MR. CALVERT VAUX, ARCHITECT; MR. G. K. RADFORD, ENGINEER.



BUILDING FOR THE CENTENNIAL EXPOSITION, PHILADELPHIA : 1876.

A. High-level Passenger Railway
B. Carriage-porch.
C. Foot entrance.
D. Covered Promenade.
E. Office.
F. Buffet.
G. Ladies.
H. Gentlemen.
I. Site for Restaurant.
K. Site suggested for permanent Art Building.
L. Waiting-room.

each pavilion are so arranged that each pair intersects another pair at right angles, the two groups being put in place at the same time, from the same centre frame or scaffold, so that when the centre frame, after serving its immediate purpose, is moved on to the site of the next pavilion, the structure from which it is removed is left standing squarely on four broad feet, and is entirely secure from any incidental disaster arising from a sudden wind-storm

The trusses and framing of the roof and flooring are to be of timber, with iron shoes and connexions as required, the roof-covering to be shingles, and the gables and skylight to be glazed with rough or fluted glass, and the interior to be lined with painted canvas or other suitable material. The work would probably be started with a centre frame at the end of each main longitudinal passage-way, the building advancing by three pavilions at a time, from one end to the other.

The circular of instructions issued by the Commissioners calls for a floor-space of 25 acres, of which not more than five acres are to be included in a permanent memorial building.

In the design illustrated the main temporary building provides twenty-two acres of floor-space, exclusive of galleries.

The principle of classification that has been adopted by the Commissioners requires that five departments and a portion of the sixth should unquestionably be exhibited in the main building. The motive machinery and fine arts are intended by the scheme to be provided for in separate buildings, and it is suggested that other departments may with propriety also be accommodated in a separate structure, containing about 3 acres, and which may be located in a part of the park, which will be more suitable for the permanent art building than any portion of the site to be occupied by the temporary building.

Offices for the various exhibiting nations, buffets, retiring-rooms for ladies and gentlemen, and other necessary conveniences, are provided in the gables, as shown on plan, and sites for exterior restaurants are indicated. Galleries are formed over the offices in which light refreshments may be served, and visitors enabled to rest and quietly survey the scene below.

A covered piazza surrounds the building, giving access to and communicating with all the entrances and restaurants The question of approaches to the building is a matter of detail requiring close examination and full discussion hereafter.

In the design as submitted it was proposed that a branch from the existing rail road, arranged for passenger traffic, should pass at a level of about 20 ft. above the side-walk, inside the boundary-line of the Exhibition-ground, and parallel to Elm-avenue, with high and low level entrances to the building. This would bring all visitors who may arrive by railroad, to the main entrance, without interfering with pedestrians or those who come in carriages or street-cars.

The cost of the designe, as modified and much enlarged, has been stated at about $4,000,000. The committee of the Exhibition have now recommended the erection of the following buildings, viz.: — 1. The art gallery, covering one acre and a half. 2 The grand pavilion, or main industrial hall, covering thirty-six acres. 3. The machinery hall, covering ten acres. 4. The agricultural hall, covering five acres 5 The conservatory. 6. Also, from time to time, smaller buildings for specific purposes, as annexes to the above.

For the art gallery, to remain as a permanent Memorial Hall, the design of Messrs. Collins & Autenreith, architects, of Philadelphia, has, we believe, been selected.—*The Builder.*

THE St Catharines' *News* is informed by a gentleman from the line of the new Welland Canal, that the work on the enlargement is making extraordinary progress. The weather is unusually favourable, and labour is very abundant and cheap. The estimates were based upon $1 25 per day for labour but all the men that can be handled, it is stated, are working for 75 cents and $1 a day There is a sanguine belief that the enlargement will be completed at an earlier day than has been fixed by former regulations

DOMINION.

THE Sandwichites want a railway to run from a point in the township of Mersea to intersect the Canada Southern on the Detroit River.

A MANGANESE mine has been discovered on the Six Mile Road near Wallace, Nova Scotia. In digging a ditch large quantities of this mineral were discovered, and samples were sent to Halifax and pronounced pure and valuable.

THE St. Catharines *Times* understands that a large number of contracts for new buildings, to be commenced as early as possible in spring, have been already let to our local builders, and that the coming season promises to be even better than the last.

IT is expected that the Government Railway workshops at Halifax will undergo important enlargement and extension early next spring, as they are now smaller than they should be to meet the requirements of the railways. So says the Acadian *Recorder*.

THE list of new vessels reported at Halifax in 1873 reaches the splendid total of 47, of 17,971 tons. The vessels transferred and registered anew were 34, with a tonnage of 4,072 tons. Of the new vessels, there were two ships and seventeen barques. St. John, N. B., exhibits a progress in ship building and ship-owning equally gratifying.

THE Buffalo *Commercial* says:—The work at the Sault canal is progressing finely. A gang of 400 men are constantly employed The weather has been favourable. From a letter from Sault Ste. Marie, dated Dec. 17, 1873, we learn that the coffer-dam was built this year in three days in consequence of the work having been commenced before the heavy frost set in; while heretofore, when the work commenced late in the season, it took from three to four weeks to do the same work and make it water-tight. The contractors have taken out about 10,000 yards of gravel and 4,000 yards of rock up to date. From present prospects the work will be completed before the opening of navigation, unless that event occurs earlier than usual.

SUBAQUEOUS TUNNELLING.

A French engineer, M. Durand, has devised a method of constructing tunnels under water which, whatever may be its practical value, has at least the merit of novelty. By it the old-fashioned ways are superseded, there are no coffer-dams needed, nor the costly process of exhausting the air.

It must be confessed that the new plan, when reduced to its simplest expression, sounds very oddly. It is nothing more than forming the tunnel within a strong waterproof bag attached to a shield which is drawn gradually across the river. The perfection to which the manufacture of waterproof fabrics is brought, says the inventor, is now so great that there would be no difficulty in making such a fabric as would bear the pressure of a hundred mètres of superincumbent water.

The shield is formed of cast and wrought iron, and of such weight as to maintain itself at the bottom of the water in spite of the volume of air within, and a circular chamber is former around it in which the required length of waterproof tubing is packed away. The shield is crossed in its central portion by iron girders, to which the necessary weights are suspended, to give stability to the whole apparatus, which is to be drawn forward across the channel or river as the works proceeds, paying out the waterproof sack as it advances. From the fore end of the shield rises a vertical pipe for ventilation, maintained in position at the surface of the water by buoys.

The proposed method of operation is as follows:—The bed of the channel is dredged across to such a depth that the top of the tunnel shall be level with the bed, the ends of the trench thus formed rising by gentle gradients to the shores. The shield is then placed in front of the dry cutting on one side of the river, and the end of the waterproof tube is there made secure, an operation which would certainly present some difficulty in deep water. The shield and tube being once in position, the masonry of the tunnel is commenced, the bottom being first constructed, then the sides, and lastly the roof, the new masonry being always within the strong iron sides of the shield. When the other side of the channel is reached the operation is finished, in the same manner as it was commenced, in the dry cutting. At the conclusion of the operation the waterproof tube lies beneath the floor of the tunnel, and all around it, protecting the cement until it is thoroughly set.

THE SAND BLAST.

On Tilghman's Patent Sand Blast for Cutting, Grinding, Engraving, and Ornamenting Glass, Stone, Wood, Iron, and other Hard Substances.

Paper read before the British Association at Bradford. We may mention here, also, that at the very successful *soirée*, held by the British Association at Bradford, a sand blast apparatus of Mr Tilghman's was shown in action, the necessary blast being furnished by a small Root's blower, provided by Messrs. Thwaites & Carbutt, of Bradford. These well-known blowers seem excellently adapted for supplying blast to the sand-engraving apparatus, and we understand that they are now being regularly adopted for that purpose.

The cutting, grinding, engraving and ornamenting of glass, stone, wood, iron, and other hard substances are operations requiring a considerable expenditure of time and labour, and some of them a vast amount of skill.

The object of Mr. Tilghman's invention is to economise time, and reduce the amount of skilled labour required to produce ornamental patterns and architectural devices in stone and other hard substances. The invention is based upon the idea that if grain or sharp sand are driven with a certain velocity against a hard surface, such as glass, stone, wood, or iron, such surface will be gradually cut away. The action of the sand on the hard surface of the glass or stone is very rapid; and if a sheet of plain polished glass be subjected to the sand blast it will be quickly depolished or ground; but if a portion of its surface be protected by covering it with some suitable material (cut to any particular pattern or device) all those parts so covered will remain intact, while the exposed surfaces will be ground or cut away by the impact of the sand.

The sand is fed into a jet or current of steam at from 60 lb. to 120 lb. pressure, or a blast of air may be used. The blast of steam or air carrying with it the sand is directed upon the surface of the stone, glass, wood, or metal, which it rapidly grinds or wears away.

The machine employed resembles a Giffard's injector. The central tube is supplied with a jet of steam or a stream of air under considerable pressure, and sand is used instead of water the grains of sand being projected forward with a velocity proportioned to the pressure of the steam or air, or carried along by the steam.

In the stone-cutting machine the sand is introduced by a central iron tube, such as that shown at Fig. 1, page 226. This tube is about $\frac{1}{8}$ in. bore, and the steam issues through an annular passage ($\frac{7}{16}$ in. external, and $\frac{5}{16}$ in. internal diameter) surrounding the sand tube. A tube of chilled cast iron is fixed as a prolongation of the steam passage, and serves as the gun or tube in which the steam mixes with the sand, and imparts velocity to the latter. The central sand tube is connected by a flexible tube and funnel, with a box containing dry sand, and the outer annular tube is connected by another flexible tube with a steam boiler. The apparatus is thus entirely movable, and can be held or moved in any direction either by hand or by machinery, and can be made to cut upwards or downwards, or at any angle of inclination.

Fig. 1, on page 226, is, as has been stated, a sectional view of the simple steam jet for acting on or incising stone, slate, granite, or wood. The operation of this machine is as follows · Steam of about 60 lb. pressure per square inch is turned on, and rushes with great velocity through the steam tube into the annular tube of the injector; this causes a suction of air through the central tube.

A stream of sand of about a pint per minute is let fall into the funnel, and is carried along by the current of air or steam, and is drawn into the annular jet of steam, and driven by it at a high velocity, and strikes upon the stone

To cut an ornament or inscription in relief upon a flat surface of stone, a pattern of iron is fastened to the stone. The movable jet pipe is made to traverse to and fro over the surface of the stone, which is placed at a distance of 8 in. The stone is mounted on a carriage which has a slow motion in a direction at right angles to that of the jet pipe, so that every part of the surface is thus exposed to the action of the sand. A cast-iron pattern about three-sixteenths of an inch thick may be used 100 times to produce the same pattern. If made of malleable iron it will last about four times as long. A pattern made of caoutchouc, if held 24 in. to 30 in. distant, will last a long time, but if placed only 8 in. or 10 in. from the jet-pipe, it will be cut through in a few minutes.

To cut a flat or curved surface of a block of rough stone, a narrow groove or channel is first cut by holding the jet-pipe about 1 in. from the side of the stone, and making it move steadily along the desired line, which may be either straight or curved. When the groove has been cut about an inch deep the overhanging lip or edge of stone is to be broken off by the hammer. The jet-pipe is then advanced an inch, a new groove is cut, and the overhanging part is broken off, and so on. Balusters have been thus roughed out of a block of granite by a single series of cuts.

To cut a long deep channel vertically or horizontally in a bed of rock, as in quarrying, two jet-pipes are used, making two parallel grooves about 3 in apart, leaving a projecting pin or lip of the stone between them, which is broken off by a wedge-shaped tool. The jet-pipes are then advanced and new grooves cut. The sand employed is of the ordinary quality used for sawing stone, the harder and sharper the better. In cutting hard rock about one-tenth of the sand is reduced to powder, but the rest can be again used.

Small shot or grains of cast iron, of about one-twenty-fifth of an inch diameter, and in place of the sand, have been found to cut granite more rapidly, probably because they are not broken by the shock, and the whole force of the blow is thus expended in disintegrating the stone, instead of being partly wasted in crushing the grains of sand.

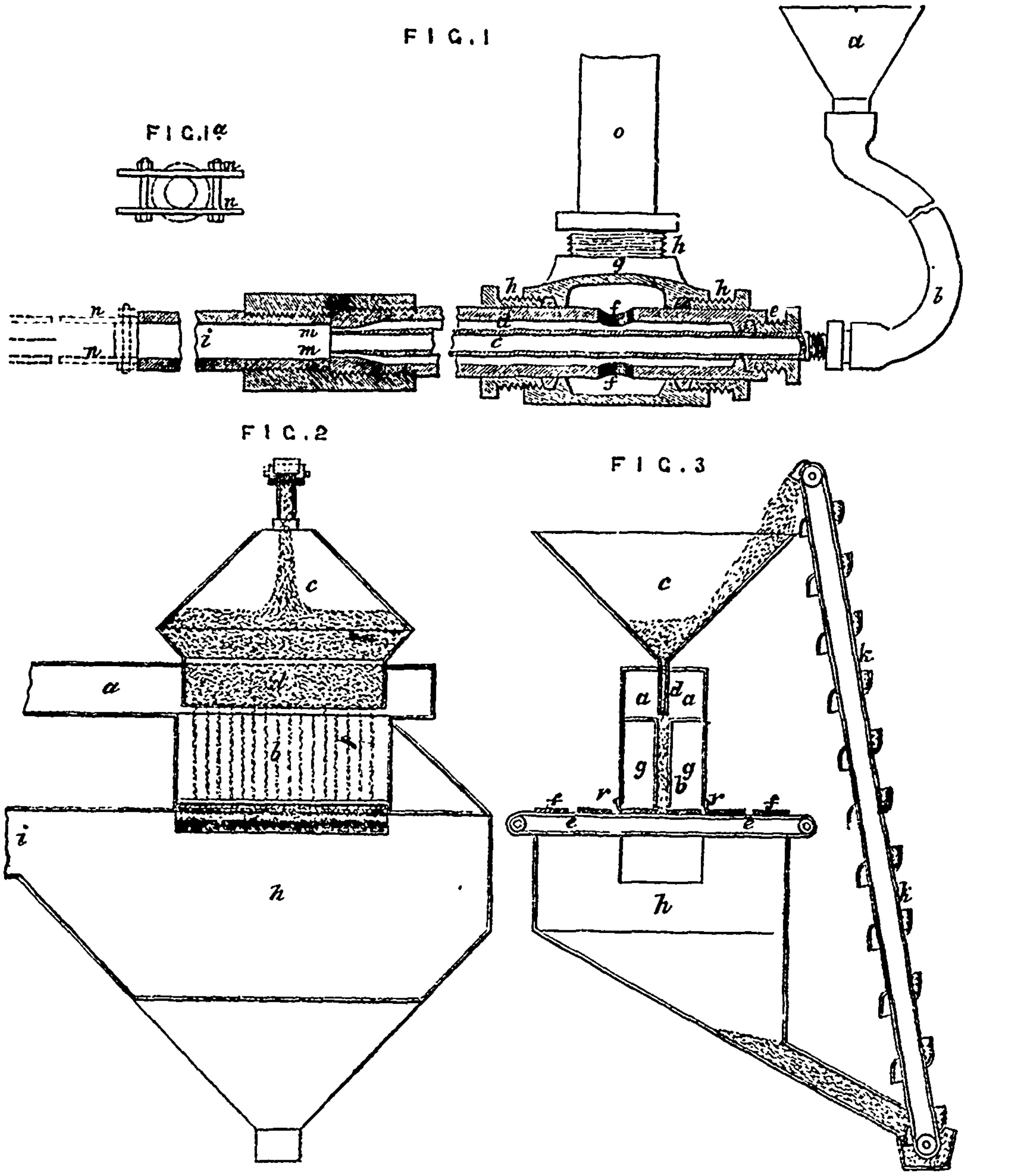
When the object is to cut or engrave in fine lines, or to grind away only small quantities of the material the blast of air from an ordinary rotary blower or fan is used as the propelling medium, and the machine shown at Figs. 2 and 3, page 226, is employed, and driven by an air blast of the pressure of 4 in. of water, will completely grind or depolish the surface of glass in ten seconds.

If the glass be covered by a stencil of paper or lace, or by a design drawn on any tough elastic substance, a picture will be engraved on the surface of the glass, the sand cutting on the bare parts, but being rebounded from the elastic lace or paint without touching the surface beneath. Photographic copies by chromated gelatine from delicate line engravings, have been thus faithfully reproduced on glass.

In the machine for grinding and engraving glass, shown at Figures 2 and 3, a rotary fan drives a current of air downward through a vertical jet-pipe 15 in. deep, and 36 in. long by $\frac{1}{2}$ in. wide, at a pressure of about four-tenths of a pound per square inch. Into the top of this jet-pipe a thin regular stream of sand is made to fall, which being caught by the rush of air, is driven down with it through the pipe, or long narrow channel, and shoots out against any substance placed beneath.

A set of caoutchouc tapes moving horizontally at a speed of 8 in. per minute, and about 4 in. below the jet-pipe, will carry forward sheets of glass 3 ft. wide beneath the sand blast. This glass will come out on the other side perfectly ground or depolished, although each spot of their surface has been exposed to the action of the sand during less than four seconds. The sand after striking the glass flies off at an angle, and is picked up by an elevator, and returned to the sand-box on the top of the machine ready to be again used.

If we apply the sand blast to a cake of resin on which a picture has been produced by photography in gelatine, or drawn by hand in oil or gum, the bare parts of the surface will be cut away to any desired depth. The lines left in relief will be well supported, their base being broader than their top. An electrotype from this matrix can be printed from an ordinary press. The sand blast has been applied to



TILGHMAN'S SAND BLAST APPARATUS.

(FOR DESCRIPTION SEE PAGE 225.)

cutting ornaments in wood, also for cleaning metals from sand and scale, graining, or frosting metals, and for a variety of other purposes.

The sand blast may be used for cleaning the fronts of buildings by removing the soot, dust, and other substances therefrom. The impact of the sand on the surface removes the soot or dust from all the crevices and indentations without perceptibly interfering with the sharpness of the architectural ornamentation.

With the exception of the motive power and blower, or other device for giving motion to the air or steam, all the essential parts of the apparatus are shown at Fig. 1. It will be seen, therefore, that the apparatus is of the simplest and most inexpensive character.

To Clean Looking-Glasses.—Take a newspaper, or part of one, according to the size of the glass. Fold it small, and dip it into a basin of clean, cold water; when thoroughly wet, squeeze it out in your hand, as you would a sponge, and then rub it hard all over the face of the glass, taking care that it is not so wet as to run down in streams. In fact, the paper must only be completely moistened, or damped all through. After the glass has been well rubbed with wet paper, let it rest a few minutes, and then go over it with a fresh, dry newspaper (folded small in your hand), till it looks clear and bright—which it will almost immediately, and with no further trouble. This method, simple as it is, is the best and most expeditious for cleaning mirrors, and it will be found so on trial—giving a clearness and polish that can be produced by no other process. It is equally convenient, speedy and effective. The inside of window frames may be cleaned in this manner to look beautifully clear; the windows being first washed from the outside; also the glasses of spectacles, &c. The glass globe of an astral lamp may be cleaned with a newspaper in the above manner.