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CANADIAN MAGAZINE OF Science and the Industrial Arts.

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

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NEW BOOKS.

The Strains in Framed Structures, with numerous practical applications for cranes, bridge, roof and suspension trusses, braced arches, pivot and draw spans, continuous girders, etc., also determination of dimensions and designing of details—specifications and contracts—complete designs and working drawings. By A. Jay DuBois, C.E., Ph. D., etc., etc. (New York, John Wiley & Sons), 1883.—Price $10.

The aim of this work is to treat the subject of "Strains in Framed Structures" in such a complete manner as to render its principles intelligible to any one acquainted with elementary mechanics and easy of application to questions of practical importance. The first part of the book is divided into two sections. Section I is subdivided into four chapters giving a full account of the *resolution of forces* and of the *method of moments* both from a graphical and analytical point of view.

Section II sets forth the practical application of the methods of the preceding section to various structures and is subdivided into nine chapters of which the first eight deal with *Roof and Bridges Trusses, Continuous girders, Swing Bridges,* and *Braced Arches,* which are well illustrated with examples but which do not present any striking novelty in the mode of treatment. In Chapter IX the subject of the *Suspension Bridges* is taken up and the greater part of the discussion seems, as is claimed by the author, to be entirely new. In the interests of simplicity, it might have been well to have inserted, in addition to the analytical proof, the geometrical proof of the fact "that the curve of a flexible string uniformly loaded is a parabola," which at once follows from the conditions of equilibrium."

As regards the theory of the *Stiffening truss,* the author repudiates the ordinarily accepted one since it is based on the untrue assumption that the effect of the stiffening truss is to distribute a partial load uniformly over the cables. Neglecting the slight increase of length in the suspenders so that the "deflections of truss and cable at any point are equal," he finds the differential equation of the new cable curve, which is also a curve of equilibrium. The moment of the entire distributed cable load at any point is then found, and hence the differential equation (of the 4th degree) of the elastic curve of the truss, which can be easily integrated in an exponential form.

The second part of the book deals with the "important topics of cross-sectioning and designing of details and connections," and although necessarily far from exhaustive in its treatment, it will be found of much value and interest to the engineer.

The book is excellently printed and illustrated, and is a valuable addition to engineering literature, but we would suggest that an edition of smaller size would better meet the needs of the ordinary student.

Explosive Compounds, Machine Rock Drills and Blasting,—BY HENRY S. DRINKER, E.M., (NEW YORK: John Wiley & Sons. 15 Astor place, 1883, MONTREAL: Dawson Bros.)

This work is an abstract from the Author's valuable treatise on Tunnelling of those portions relating to Explosive Compounds, Rock Drills, and Blasting. Beginning with an historical account of rock excavation, tunnelling, blasting, rock drilling, and explosive compounds, the Author in Chapter III. discusses the latter more in detail, and gives the chemical composition and method of manipulation of all the most important. Chapter IV. commences with a description of various fuses, tamping, drills, expanding borers, the hammer, and the advantages of electric firing; which on page 112 are summarized into:—

(*a*) Simultaneous firing of different charges.

(*b*) Premature escape of any of the gas developed absolutely avoided by close tamping.

(*c*) No smoke or gas from fuses.

(*d*) Greatest safety.

(*e*) Rapidity of work.

The remainder of the Chapter consists of a discussion as to the "Principles of Blasting," and the estimates of the volumes thrown out in blasting and of the cost of extraction. Chapter V. is subdivided into two parts, the first dealing with air compressors and machine rock drills, while the second gives the history and characteristics of the latter. Chapter VI. is subdivided into six parts, and illustrates the practical application of machine rock drills and high explosives with reference to the most important tunnels of modern times, etc ,- the Hoosac, Sutro, Mont Cinis, and St. Gothard tunnels.

"*Electricity and its Uses.*" By J. Munro, (London: the Religious Tract Society, 56 Paternoster Row.)

In this work Mr. Munro has endeavoured to give a popular account of electrical science in all its branches, and to render the subject intelligible to readers who have previously had no knowledge of electricity. That the author has to a large extent succeeded will be readily admitted. The matter is well chosen, the illustrations are numerous and on the whole accurate, and the book will prove a great help as a preliminary introduction to this important branch of science. It is to be regretted, however, that the work should be marred by many inaccuracies and misspellings, which might have been easily avoided with a little more care in the preparation and in the revision of the proof sheets.

BOOKS RECEIVED.

Weisbach's Mechanics of Engineering and Machinery.—REVISED AND ENLARGED BY G. HERMANN, (NEW YORK: John Wiley & Sons. MONTREAL: Dawson Bros, 1883.)

Kinematics or Mechanical Movements—BY C. W. MACCORD, (NEW YORK. John Wiley & Sons. MONTREAL. Dawson Bros, 1883.)

These works will be noticed in the November number of the Magazine.

Also received, the Philadelphia Medical Times, J. B. Lippincott & Co.; *the Mechanical Milling News*, the Beaver Co., Toronto; *The Treasury of Facts*, H. R Warner & Co., Rochester.

NOTES ON THE CONDITION AND DISTRIBUTION OF THE CANADIAN FORESTS.

BY ANDREW T. DRUMMOND.

The growing requirements of the world arising from increased population, a more progressive spirit, and greater wealth, have led us in this later age to see that there are great natural laws on which the prosperity of communities and even of nations largely depends. National prosperity arises from the aggregated enterprise and success of the individuals who go to make up the nation, and whilst this prosperity continues, individuals and nations are sometimes slow to foresee the ultimate results to which the stimulus of success may lead to in the breaking of these natural laws. The individual does not immediately recognize this, but in national aggregates it is clearly seen. This has been well exemplified in the timber trade of the United States and Canada.

From the earliest days of the settlement of these countries to the present time there has been a constant drain on the resources of their forests. At first, it was necessary to clear the forests in order to make room for agricultural operations. Farmers, however, as time went on, everywhere, became more wasteful and reckless of the future, and lumbermen even more so. With wood so plentiful, it did not appear necessary to consider the wants of another generation, and now, not only that other but still other generations have appeared, and what results do we find? The forests of the United States are so nearly depleted of their larger white pine timber that but a few years' further supply is left uncut, and there remains the prospect of having largely to fall back on Canada only to find that the Canadian supply is already on the wane. Similar results are elsewhere apparent. In fact, notwithstanding the increasing substitution of iron for timber, and the increasing use of coals and other fuels, the forests of the world are being rapidly diminished, much of this—especially in new countries, arising from simple wastefulness.

We are accustomed to esteem those states and provinces wealthy, which have underlying fields of coal, and yet those which have forests are in reality the richer; the forests can be renewed, and the supply by proper management made to keep pace with the demand through future centuries. This is a position which in the past we have been slow to realize. Individuals are selfish and are not inclined to undertake labour and expense, of which they themselves will not reap the advantage. Shall states and provinces view the question in the same selfish spirit? Or shall they not rather legislate for posterity when the future of the country depends on the advantages which that posterity will find ready at hand? In Canada, more perhaps than in the United States, do we realize the importance of immediate legislative interference, to prevent our lumber resources from being entirely cut off. At present the lumber dues and the proceeds of the sale of timber limits [chiefly pine] in Ontario Quebec and New Brunswick form an important item of annual revenue to the governments of these respective provinces. The loss of these sources of revenue would be severely felt, and yet their gradual diminution is in early prospect. Those who have made this subject a careful study cannot be blind to the fact that each year the lumbermen are extending their operations farther north and west, and although the area in which is to be found white pine of merchantable size and in fair abundance, may be extensive, yet, if the timber limits continue to be worked at the same rate as in the past, there must soon be a marked diminution in the exports of this class of timber. Already the size of the square timber exported from the city of Quebec is much less than it was years ago. It is not with timber as with other agricultural products. Reproduction cannot take place in a year or in a decade. Not until pine is from *seventy-five* to *one hundred* years old is it of sufficient size for the market, so that at least three-quarters of a century must elapse ere these timber limits can be re-stocked. Here, clearly, is a case in which the government should intervene if only in its own interests, but apart from this it seems we have yet to learn that so far from having a right to injure the inheritance which will in time pass to our children a positive duty is imposed on us of leaving it the better.

In the present paper it is proposed to indicate briefly, *first*, the forest areas of Canada, *second*, the ranges northward and westward, as we now know them, of a few of the leading economic trees in these areas, and *third* the extent to which these species individually occur. As there is no forest tree distinctively Canadian, the details which will be given have a further interest, in serving to show the range northward of some representative United States species.

Speaking generally, there are in Canada four great forest areas, or zones, which can be distinctly traced, besidea fifth zone in south western Ontario. These zones may be referred to as the zones of the [1] Douglas Fir, [2] Poplar, [3] White and Red Pine, and [4] Beech.

The zone of the Douglas Fir [*Abies Douglasii*] virtually includes the whole of the lower half of British Columbia, extending from the eastern slopes of the Rocky Mountains at the sources of the Saskatchewan, Bow and Belly Rivers, westward to Vancouver Island, and southwards to Oregon. In this area the timber trees are similar to those in Oregon. The peculiar physical features of the country, embracing successive ranges of high mountains which run the whole length of the Province, and combining in most sections all the characteristics of high peaks, deep valleys and level plateaus, would serve to distribute the flora somewhat generally over this zone, the more northern plants finding their way southward on the mountain sides, and the more southern forms ranging northward through the valleys. The larger proportion of rainfall along the coast and in certain parts of the country has, however, considerable influence in determining the range of many of the species.

The most noticeable feature of the timber region of British Columbia is the distinctive character of its trees as compared with those eastward of the Rocky Mountains. *Populus tremuloides, Michx,* the common aspen, is probably the only tree of eastern range found somewhat generally over the Province. *Abies alba Michx,* the White Spruce, and *Larix Americana, Michx,* the Tamarack, both common in Ontario and Quebec, are found within the north-eastern borders of British Columbia, but do not range much beyond.

The Douglas Fir—the characteristic tree of this zone—oftens exceeds 8 ft. in diameter and attains a height of 200 to 300 ft. It occurs most abundantly and in best growth near, but not on the coast, for it seems to avoid the exposure of the immediate coast line. At the heads of some of the deep inlets which penetrate the Cascade Mountains it forms extensive forests. The timber from this tree is very valuable and forms an important item of commerce. It is the only wood which as yet is exported from British Columbia on any considerable scale.

Among other important timber trees in British Columbia occuring within this zone, and which will prove of economic importance are, *Thuja gigantea, Nutt,* the western *arbor vitae,* or red cedar—a magnificent tree, often attaining 100 to 150 ft. in height and 10 ft. to 15 ft. in diameter. It is found in abundance near the whole of the coast line of British Columbia, and again inland on the Selkirk and Gold Ranges of mountains. The wood has not yet been largely used.

Abies mertensiana Lindl, the western hemlock, which on the coast sometimes attains a height of 200 feet. The wood of this tree, though seldom used, is said to be good.

Abies Engelmanni Parry, Engelmann's pine, a fine tall tree attaining 3 ft. in diameter. It resembles the black spruce, but curiously enough appears, in the Peace and Athabasca River districts, to run into the white spruce [*Abies alba*] until it is quite undistinguishable from the latter. On the eastern and nothern parts of the province the tree is very common.

Pinus ponderosa Douglas, the yellow or pitch pine—a smaller tree in British Columbia than further south where it attains a diameter of twelve feet or more. It occurs chiefly in the central valleys and plateaus between the Selkirk and Coast Ranges of mountains, and is commonly used for lumber purposes in these districts.

Chamaecyparis nutkaensis Lamb—Yellow Cypress—a large tree attaining as much as six feet in diameter, and occurring somewhat abundantly on Vancouver Island and throughout the vicinity of the whole coast on the mainland. This tree has as yet been but little utilized in commerce.

The zone of the *Poplars* may be said in general terms to have its southern limits along the rivers South Saskatchewan, Qu'Appelle and Assiniboine and thence inland eastward *viâ* the north end of Lake Nepigon to Anticosti, in the Gulf of St. Lawrence. The trees named are found south of these limits, but not in the abundance which makes them here characteristic species.] The southern limits include, in Manitoba and the North-West Territory, a very considerable tract of prairie country, but, even there, in the river valleys, and among the scattered timber bluffs, the poplar is almost the only tree. South of the Assiniboine and Qu' Appelle, cottonwood, oaks and other trees begin to appear.

This zone practically extends to the northernmost limit of the growth of trees, but includes very few species attaining a sufficient size to be of commercial value. Individually, however, these few species, with the poplar, constitute vast forests. We now know, from recent explorations, something of the northward range of these species in what has hitherto been a *terra incognita, viz.,* the country surrounding the west coasts of Hudson Bay. The proposed opening up of railway communication between Dakota, Minnesota and the Canadian northwest on the one hand, and Churchill Harbour in Hudson Bay on the other, thus affording a new and immensely shorter route to Europe for the products of these vast western territories, has awakened an interest in the resources of this part of the country. At the outlet of Lake Winnipeg into the Nelson River, the white spruce has still sometimes a diameter of three feet and even in the lower reaches of the Nelson River is large enough for building purposes; the balsam fir does not here extend northward much beyond Lake Winnipeg and Oxford House on the Hayes River. The white birch ranges as far as the country lying between the Hayes and Nelson Rivers. The tamarac, in company with the poplars, nearly reaches the entrance of the Churchill River, whilst the black spruce is found as far beyond this on Hudson Bay as the Seal River.

The Banksian pine is a familiar tree in this zone and in some places west of Lake Superior is said to be of good quatity and sufficiently large to be utilized by the lumbermen.

The white spruce, as found in Manitoba, is considered by builders in Winnipeg, to be fully equal in strength and durability to white pine. The poplar in Manitoba is pronounced by those who have had experience in both kinds, to be better adapted to the various purposes of farm buildings and fencing than the poplar of the eastern provinces. Such differences must be attributed to the climate and perhaps the soil, a result which might naturally be expected when we remember the decided superiority of Manitoba wheat—

CUTTING OF METALS.

Drills.

Fig. 24.

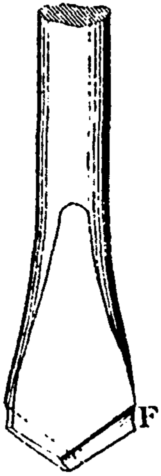


Fig. 25.

Fig. 26.

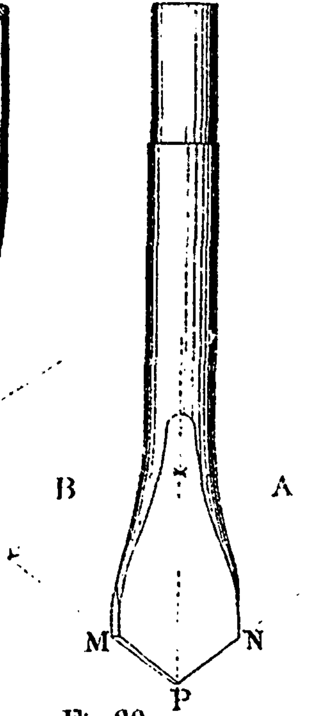


Fig. 27.

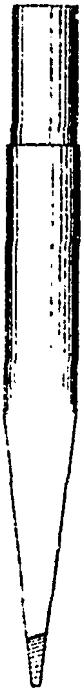
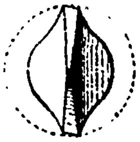


Fig. 27A.

Fig. 28A.



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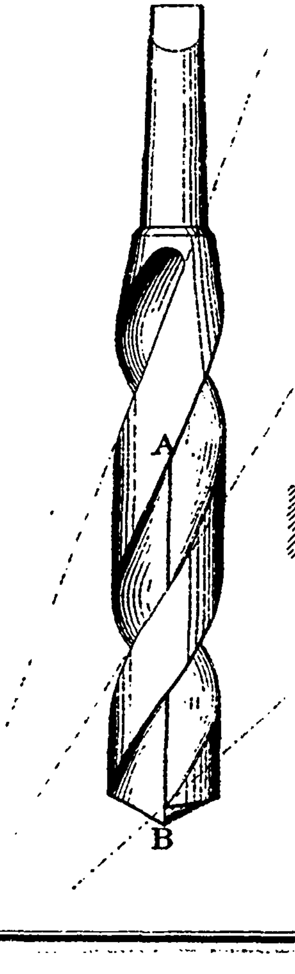

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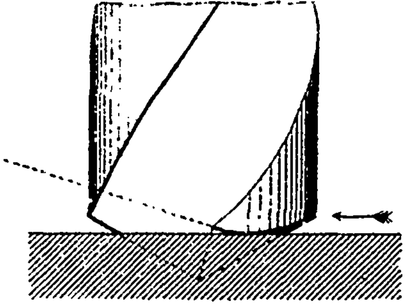
Fig. 30.



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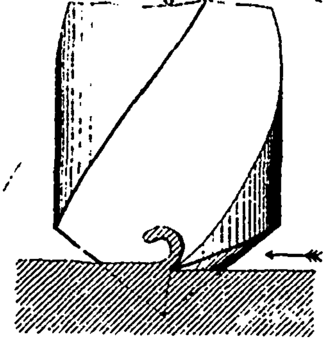

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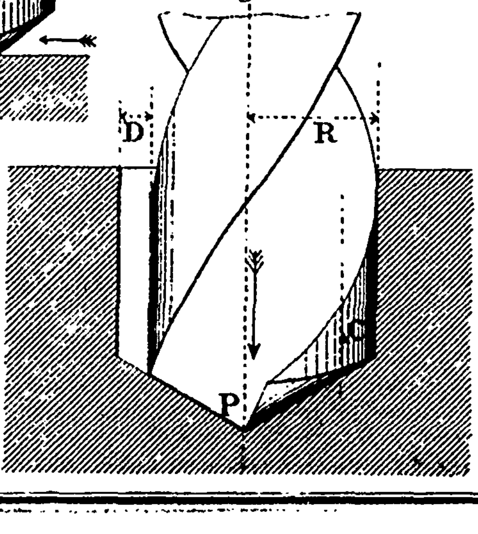
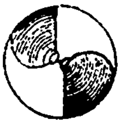


Fig. 29A.



CUTTING OF METALS.

Milling Cutters.

Fig. 33.

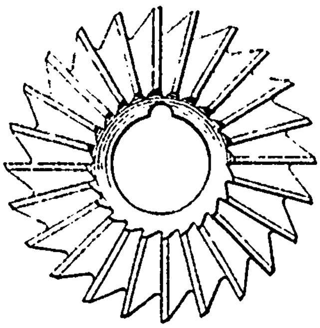
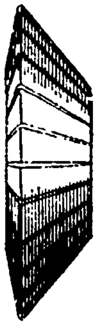


Fig. 34.



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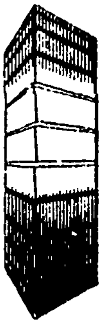
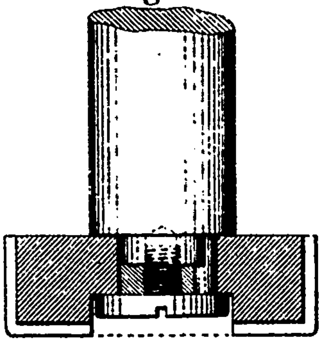


Fig. 36.

Fig. 38.

Fig. 40.



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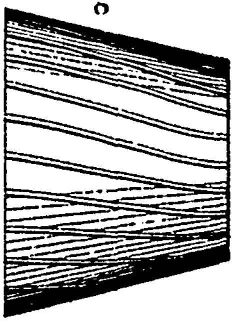


Fig. 39.

Method of Grinding Cutters.

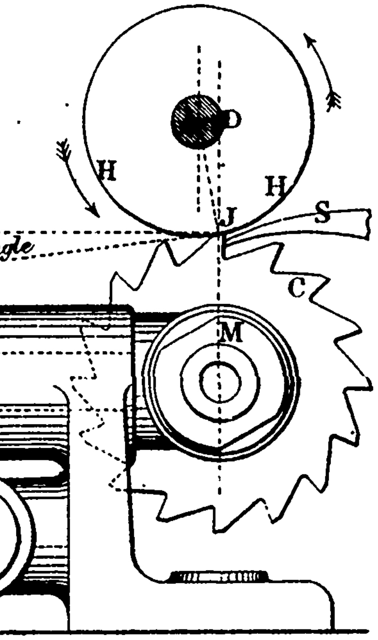


Fig. 41.

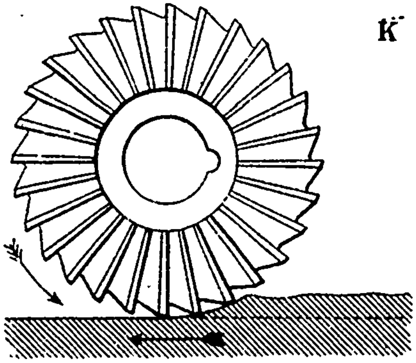


Fig. 42.

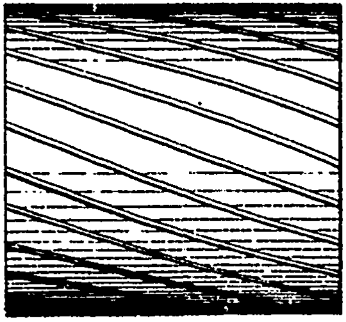


Fig. 43.

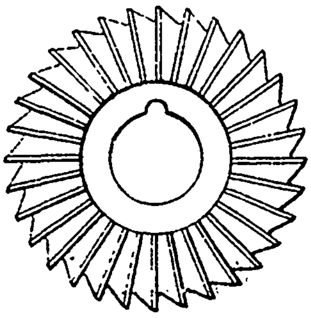


Fig. 44.

Fig. 45.

a superiority understood to be entirely due to the longer sunlight, the cooler nights and the rich black loam of the country.

The ranges of the *white pine* and the *red pine* in Canada are very similar and are now well defined. The extent of distribution is specially interesting at this time in view of the possible scarcity of pine timber in the United States in the near future. If an irregular line be drawn commencing on the north shore of the Gulf of St. Lawrence, opposite Anticosti, extending westward past Lake St. John and the headwaters of the Ottawa River, then following rather closely the height of land to Lake Nepigon and crossing to the River Winnipeg and Lake of the Woods, it will approximately indicate the easterly, northerly and westerly limits of both these trees. To the immediate south are found the northern limits of numerous trees, like the white elm, yellow birch, sugar maple, hemlock, basswood, white ash and red oak. The areas of the white and red pine in Canada, practically belong to the Government and are denominated Crown lands. Under the system for some years in vogue, timber limits are put up at auction at an upset price and sold to the highest bidder. By the subsequent payment of an annual fee, in addition to the dues on the timber or logs cut, the purchaser can retain the limit in Ontario so long as he complies with the regulations, and, in the Province of Quebec until 1889. In Ontario he can cut any size of tree, in Quebec he is limited to those over twelve inches in diameter, but the violation of this rule entails no penalty beyond the possible forfeiture of the license. The great objection to this system is that it subjects the public lands to unrestricted use for just such a length of time as the lumberman may find it profitable, without any reference to the future, and regardless of the fact that the early impoverishment of these lands can be the only result of such a course. The true remedy would seem to be that these lumber limits should be leased for shorter periods of time and in smaller areas than hitherto has been the case; that the cutting of trees under fifty inches in girth should be prohibited, that the strictest regulations should be enforced to prevent damage to the younger trees and that every timber limit, on reverting to the Government, should have a rest of twenty-five years to enable the younger trees to attain merchantable size.

There is, however, a greater and more serious drain on our pine timber. Forest fires have in the past destroyed immense areas and the ruin has been the more complete from the fact that large and small trees have been alike consumed. That these fires can be to a great extent prevented by more effective legislation is beyond question. They generally arise from wanton carelessness which should be made criminal. Last year it was estimated that in the Ottawa Valley alone over $5,000,000 worth of pine timber was ruined by forest fires. What then must be the annual loss for the whole Dominion!

The zone of the *beech* covers the whole area in Canada south of a line drawn from the outlet of Lake Superior to the City of Quebec and then eastward so as to include New Brunswick, Nova Scotia and Prince Edward Island. Within this area a large number of other trees have in Canada their northern limits of distribution, including the white oak, ironwood, blue beech, butternut, red cedar, and white ash; all of these occurring in fair abundance. The southwestern part of the Peninsula of Ontario has a very southerly latitude and here are to be found representatives of a more southern flora than is met with elsewhere in Canada—the trees including black walnut, the buttonwood, chestnut, tulip tree and sassafras. The number of these trees is, however, very limited, and in some cases, as in that of the black walnut which has been largely removed for lumber purposes, is rapidly diminishing.

ON SOME MODERN SYSTEMS OF METAL CUTTING.

BY W. FORD SMITH.

(*Concluded from Page* 270)

TWIST-DRILLS.

During the last thirty years many attempts have been made to introduce a better system of drilling and boring; and on this subject very much might be written if time permitted. Many engineers have used square bar-steel, which the blacksmith has twisted, and then flattened at one end to form a drill. The object of the twisted stem was to screw the cuttings out of the hole, and to some extent this succeeded, but not perfectly. The twisted square section revolving in the round hole had a tendency to crush or grind up the cuttings; and if they were once reduced to powder it was difficult (especially in drilling vertically) for the drill to lift the powdered metal out of the hole.

In most cases the lips of these drills were of such form that the cutting angle, or face of each lip, which ought to have been about 60°, Fig. 21, page 268 was 90°, or even still more obtuse; this being an angle which would scrape only, but could hardly be expected to cut sweetly or rapidly.

Again, there were attempts to make the cutting angles of the two lips of much the same number of degrees as that given by the twist itself in a good twist drill. This was done by forging or filing a semicircular or curved groove on the lower face F of each lip, Figs. 24 and 25, page 292 For a short time lips thus formed cut fairly well; but a very small amount of re-grinding soon put them out of shape, and made them of such obtuse cutting angles that good results could no longer be expected from them; and to be constantly sending such drills to the jobbing or tool smith, and then to the fitter to file into form again before they were re-hardened, was found to be too tedious and too expensive. Again, to arrive at the best results in drilling, each of the cuttting lips should make the same angle with a central line taken through the body of the drill; in other words, the angles A and B, Fig 26, page 292 should each have exactly the same number of degrees, say 60°. The clearance angles also should be identical, and the leading point P should form the exact centre point of the drill. From practice it is found that, if these proportions are not correct, the drill cannot pierce the metal at more than about half the proper speed, and the hole produced will also be larger than the drill itself. To give an idea of the excessive accuracy which must be imparted to a twist-drill, we must bear in mind that even a good feed is only one 100th in. to each revolution; and as two lips are employed to remove this thickness of metal, each lip has only half that quantity to cut, or one 200th in. This one 200th in. is as much as can be taken in practice by each lip in drills of ordinary sizes. It will therefore be readily understood that if one lip of a drill stands before the other to the extent of one 200th in. only, the prominent lip, or portion of a lip, will have to remove the whole thickness of the metal from the hole at each turn. The lip of a drill will not stand such treatment; and it is therefore obvious that if this were attempted the prominent lip would either break or become too rapidly blunted. To get over these difficulties, the driller would no doubt reduce his feed by one-half, or to one 200th in. per turn, which would mean about half the number of holes drilled in a given time.

This nice accuracy, although absolutely requisite, cannot be produced by hand-grinding; neither can a common drill, having a rough black stem more or less eccentric, be ground accurately, even by aid of a grinding machine with mechanism for holding it. To grind any drill accurately, it must be concentric and perfectly true throughout with the shank, as that part has to be held by the drill-grinding machine. If the drilling is to be done in the most rapid manner — in other words, at the smallest cost, — and if the best class of work is also desired, it seems certain that a twist-drill, with all the accuracy which can possibly be imparted to it in its manufacture, and with the greatest care employed in the re-sharpening, is the only instrument which can be employed.

About a quarter of a century ago both Sir Joseph Whitworth and the late Mr. Greenwood of Leeds made some twist-drills, but it is to be presumed that a large amount of success was not achieved with them. and for some reason the system was not persevered with. After that period the Manhattan Fire-arms Company in America produced some beautifully-finished twist-drills. Though the workmanship in these was of a superior description, the drills would not endure hardship. It was found that the two lips were too keen in their cutting angles, and that they were too apt to drag themselves into the metal they were cutting, and finally to dig in and jam fast, and twist themselves into fragments. Mr. Morse then took the matter up, and by diminishing by about 50 per cent. the keenness of the cutting lips of twist-drills made a great success of them. He used the grinding line, AB, Fig. 29, and an increasing twist. In such a drill, of the standard length, and before it is worn shorter by grinding, the twist is so rapid toward the lips that the angle they present, or what has been already referred to as the angle of the cutting surface, is very nearly the same as that which the writer had previously established for cutters cutting metals, as in Fig. 21.

If however the angle of twist is made to increase towards the lips, it will of course decrease towards the shank, as in Fig. 29, The shorter the drill is worn, the more obtuse the cutting angle becomes, and the less freedom will it cut with : supposing of course that, when the drill was new, the angle was the most efficient. Suppose this decrease of twist were carried still further by lengthening the drill, a cutting angle of 90° would eventually be arrived at. The old common style of drill usually has such a cutting edge which is so obtuse as not to cut the metal sweetly, but on the contrary to have more of a tearing action, and thus to put so much torsional strain on the drill that fracture is certain to take place, even if what the writer would now consider a moderate feed was put on by the drilling machine.

It is therefore obviously advantageous to adopt from the first the best cutting angle for all twist-drills. and to preserve this same angle through the whole length of the twisted part, so that, however short the drill may be worn, it always presents the same angle, and that the most efficient which can be obtained. This cutting angle is easy to fix, and becomes an unalterable standard which will give the best attainable results. This has been adopted at the Gresley Works Manchester, and of course applies to both lips.

A common drill may "run," as it is usually termed, and produce a hole which is anything but straight. This means that the point of the drill will run away from the denser parts of the metal it is cutting, and penetrate into the opposite side which is soft and spongy. This is specially the case in castings ; where, for instance, a boss may be quite sound on the one side, while the other side, being next to a heavy mass of metal, may be drawn away by the contraction of the mass in cooling, so as to be very soft and porous. In such cases it is perfectly impossible to prevent a common drill from running into the soft side. This sort of imperfect hole is most trying to the fitter or erector ; and if it has to be tapped, to receive a screwed bolt or stud, is most destructive to steel taps. The taps are very liable to be broken, and an immense loss of time may also take place in attempting to tap the hole square with the planed face. A twist drill, on the other hand, from its construction, is bound to penetrate truly, and to produce holes which are as perfect as it is possible to make them.

The next important step in twist-drills has been to fix a standard shape and angle of clearance for both lips, which should also give the best attainable result. This angle might be tampered with if the re grinding were done by hand, and too much or too little clearance might easily be imparted to the drill from want of sufficient knowledge on the part of the workman. If too little clearance, Fig. 30, or in some cases none at all, is given to the drill, the cutting lips then cannot reach the metal, consequently they cannot cut. The self-acting feed of the drilling machine keeps crowding on the feed until either the machine or the drill gives way. Usually it will be the latter.

Again if too much clearance is given, Fig. 31, the keen edges of the lips dig into the metal, and embed themselves there, and of course break off.

Fig. 32, is drawn exaggerated, in order to show the ill effect of grinding one lip of a drill longer than the other. It is found that the centre point P of the drill will be kept, by the pressure of the feed in the direction shown by the arrow, in the centre of the hole which is being drilled. Then there is a long lip and a short one sweeping round the hole drilled will therefore be in diameter twice the radius of the longer lip R, or larger by the distance D than the size of the drill itself. This is very undesirable. A much graver defect, arising from this incorrect grinding, is that the drill can only penetrate into the metal it is boring at about half the speed it ought to attain if it were accurately ground. For each lip can only take a certain thickness of shaving per revolution, and if this maximum thickness were taken by the two lips they would remain comparatively uninjured. But the portion C of the long lip would have a double cut upon it (the other lip not cutting at all at this outer portion of the conical hole): hence it would not stand such usage, and would either rapidly blunt itself or would break.

The grinding line A B, Fig. 29, was introduced in the United States, to assist the operator in keeping both lips of the drill identically the same. To arrive at this however is more than can be accomplished by hand-grinding, as not less than three points have to be carefully watched, namely :—

1st. That both lips are exactly the same length ;

2nd. That both have the same clearance angles ;

3rd. That both make the same angle with the centre line on the body of the drill.

If these are not attended to, the drill lips may for instance be both ground so as to converge exactly to the grinding line at the point or centre of the drill, and may still be of such different lengths and angles as to produce very bad results in drilling.

Much ingenuity has been expended on machines for the grinding of the two lips with mechanical accuracy. The one which has been the most successful in the United States has three motions, ingeniously combined with each other. So many motions however entail complication, and this, added to a system of holding the drill which was not sufficiently reliable, failed to produce the extreme accuracy it is requisite to impart to the two angles.

The grinding line too is found to be more or less a source of weakness. It is therefore advisable to dispense with it if possible ; and where a good twist-drill grinding machine is used, the grinding line is seldom or never looked at, and in that case is useless. If it is still desirable to have grinding lines (as in some cases where the hand grinding has to be relied upon), they should be made as faint as possible, and not cut deeply into the thin central part of the drill, so as to weaken it.

A simple and efficient twist-drill grinding machine was so much needed that within the last three years the writer, aided by his firm, has designed one. The twist-drill in this machine has only one motion imparted to it, to produce the two lips of each drill as perfect facsimiles of each other and with the desired amount of clearance. Many of these machines are now at work. That the drills ground by them are accurate is proved by the holes drilled being so nearly the size of the twist-drill itself that in many cases the drill will not afterwards drop vertically through the drilled hole by its own gravity ; in other words, the hole is no larger than the drill which has drilled it. It is not generally known that this is the most severe test which can be made of the accuracy of re-grinding, and of the uniformity of all parts of the twist drill.

One of the smallest-sized machines is exhibited. The largest machine grinds drills of 3 in. diam. ; and there are intermediate sizes.

The whole of the drilling in many establishments is now done entirely by twist-drills. Since their introduction it is found that the self-acting feed can be increased about 90 per cent. ; and in some engineering works the feeds in some machines have been increased by fully 200 per cent., and consequently three holes are now being drilled in the same time that one was originally drilled with the old style of drill and with old machines.

It may be interesting to give a few results out of numerous tests and experiments made with twist-drills.

Many thousands of holes ½ in. diam. and 2¾ in. deep have been drilled, by Smith and Coventry's ½-in. twist-drills, at so high a rate of feed that the spindle of the drilling machine could be seen visibly descending and driving the drill before it. The time occupied from the starting of each hole, in a hammered scrap-iron bar, till the drill pierced through it,

CUTTING OF METALS.

Fig. 47. *French Milling Cutter. Scale 1 to 2.*

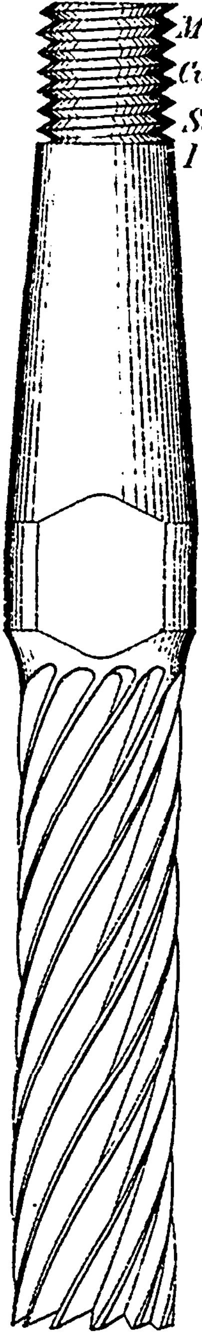
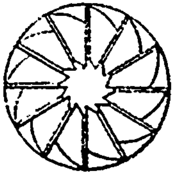


Fig. 48.



Tool-holders with slight overhang.

Fig. 50. *Elevation.*

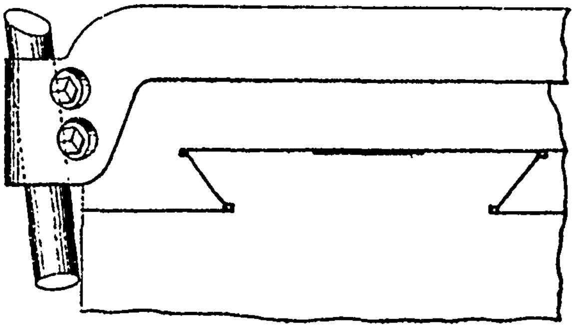


Fig. 51. *Plan.*

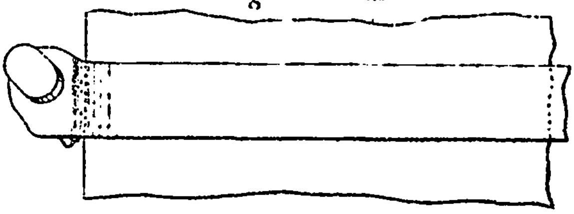


Fig. 52. *Plan.*

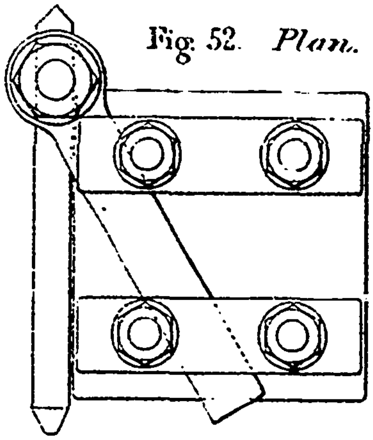


Fig. 49.

Section of Flute, French Cutter. Full size.

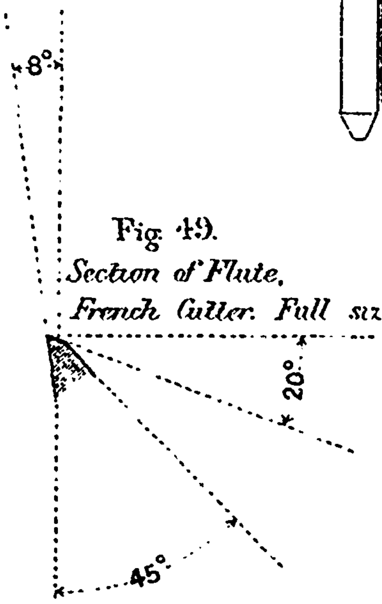
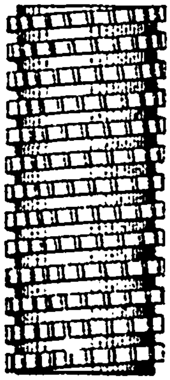


Fig. 46. *Grooved Milling Cutter.*



varied from 1 minute 20 seconds to 1½ minutes. The holes drilled were perfectly straight. The speed at which the drill was cutting was nearly 20 ft. per min. in its periphery, and the feed was 100 revolutions per inch of depth drilled.

The drill was lubricated with soap and water, and went clean through the 2¾ in. without being withdrawn; and after it had drilled each hole it felt quite cool to the hand; its temperature being about 75°. It is found that 120 to 130 such holes can be drilled before it is advisable to re-sharpen the twist-drill. This ought to be done immediately the drill exhibits the slightest sign of distress. If carefully examined, after this number of holes has been drilled, the prominent cutting parts of the lips, which have removed the metal, will be found very slightly blunted or rounded, to the extent of about one 100th inch; and on this length being carefully ground by the machine off the end of the twist-drill, the lips are brought up to perfectly sharp cutting edges again.

The same sized holes, ½ in. diam. and 2¾ in. deep, have been drilled through the same hammered scrap iron at the extraordinary speed of 2¾ in. deep in one minute and five seconds, the number of revolutions per inch being 75. An average number of 70 holes can be drilled in this case before the drill requires re-sharpening. The writer considers this test to be rather too severe, and prefers the slower speed.

The drills in both cases were driven by a drilling machine in a true-running spindle, having a round taper hole, which also was perfectly true; the taper shank, and the body or twisted part of the drills, also ran perfectly concentric when placed in the spindle, or in a reducer or socket, having a taper end to fit the spindle. When the drills run without any eccentricity, there is no pressure, and next to no friction, on the sides of the flutes; the whole of the pressure and work being taken on the ends of the drills. Consequently they are not found to wear smaller in diameter at the lip end, and with careful usage they retain their sizes in a wonderful manner. The drills used were carefully sharpened in one of the twist-drill grinders mentioned above.

In London upwards of 3000 holes were drilled ⅝ in. diam. and ⅜ in. deep, through steel bars, by one drill without regrinding it. The cutting speed was in this instance too great for cutting steel, being from 18 to 20 ft. per minute; and the result is extraordinary.

Many thousands of holes were drilled ⅜ in. diameter, through cast iron 7-16th in. deep, with straight-shank twist-drills gripped by an eccentric chuck in the end of the spindle of a quick-speed drilling machine. The time occupied for each hole was from nine to ten seconds only. Again, ¼ in. holes have been drilled through wrought copper, 1⅜ in. thick, at the speed of one hole in ten seconds.

With special twist-drills, made for piercing hard Bessemer steel, rail holes, 13-16th in. deep and 29-32th in. diameter, have been drilled at the rate of one hole in one minute and twenty seconds, in an ordinary drilling machine. Had the machine been stiffer and more powerful, better results could have been obtained. A similar twist-drill, 29-32th in. diameter, drilled a hard steel rail 13-16th in. deep in one minute, and another in one minute and ten seconds. Another drill, ⅝ in. diameter, drilled ¾ in. deep in thirty-eight seconds, the circumferential cutting speed being 22 ft. per minute. This speed of cutting rather distressed the drill; a speed of 16 ft. per minute would have been better. The steel rail was specially selected as being one of the hardest of the lot.

Milling.

The writer considers milling the most important system used in the cutting of metals, and would willingly dwell more upon it if time would permit. He will confine himself however to giving a few particulars as to the time occupied and the finish produced by milling machines, in comparison with the planing machine, the shaping machine, and the slotting machine. It is found practicable, and in most cases it is exceedingly advantageous, to finish (or as it is usually termed to "machine") almost every class of work, such as is now usually finished by planing, shaping, or slotting machines, in one or other of the numerous kinds of milling machines already in use.

It may not be generally known that in this class of machine milling cutters are being used of diameters ranging from 12 ft., used for heavy engine-work, down to ¾ in. or ½ in., used principally for the intricate work required in sewing machines, small-arms, etc. By the former, the work done is what is known as face-milling: the mill itself is somewhat similar to a large lathe face-plate, and the several cutting portions are steel tools inserted into it and firmly secured by a series of set-screws or keys. On the other hand, the milling cutters of the small sizes, from ½ in. up to about 8 in. diameter, are made from solid blocks of cast steel, or blanks, as shown in Figs. 33 to 38.

The term "milling" is more generally understood in the United States than in this country. It means the cuttings of metals by aid of serrated revolving cutters, each having a number of cutting teeth. Milling cutters have been used in this country for many years, but until recently with only a limited amount of success, owing to the expense and difficulty of producing their cutting edges and keeping them in order. This was next to impossible before the introduction of a machine, with a small emery-wheel and compound slides, etc., for carrying the milling cutter while being re-sharpened. Hence in the old system of milling, which did not permit of the re-sharpening of the hard teeth, the results were, that after much expense and time had been bestowed on a cutter (including a quantity of hand-labour spent upon it while in its unhardened state), the whole was as it were upset by the process of tempering; the accuracy which had previously been imparted to it being usually quite destroyed by the action of the fire and sudden cooling. In some cases the cutter would be found slightly warped or twisted; in others it would be oval or eccentric; and most frequently, when set to work on a truly-running mandril in the milling machine, not more than one-third of the number of its teeth were found to be cutting at all, the others not coming in contact with the work. This really meant that not more than one-third of the proper feed per revolution could be applied, and not more than one-third of the proper work produced. Nor was this the only drawback: the quality of the workmanship produced by such a milling cutter was not of the best, and deteriorated hourly from blunting and wear. Such a cutter would probably not work for more than two whole days before it would require to be again softened by being heated red-hot and allowed to cool gradually. The expensive and unreliable process of re-sharpening by hand-filing had to be gone through once more; then the re-tempering, which caused the cutter again to become warped, swelled, or eccentric; and each time it was subjected to the heat of the fire, it ran the risk of being destroyed by cracking when plunged into the cold bath.

It is necessary now to describe the modern system of making and maintaining the improved milling cutters. A cast-steel forging, or blank as it is usually styled, is bored, and then turned to its proper shape in a lathe. The teeth are then machined out of the solid to their required forms, in a universal milling or other machine. This work is so accurately produced, direct from the machine, that no costly hard-labour need be expended upon the milled cutter, which is taken direct from the milling machine to the hardening furnace, and tempered. The hole in the centre of the cutter is then carefully ground out to standard size, so that it may fit accurately and without shake on the mandrils both of the grinding machine and of its own milling machine.

The cutter or mill C, Fig. 39, is now placed on the mandril M of the small cutter-grinding machine; the mandril itself is adjusted vertically and horizontally by ordinary slides, and by means of a worm W and worm-wheel B, to its required angular position; and each tooth is ground or re-sharpened by passing it once rapidly forward and backward under the small revolving emery-wheel H. The mandril fits easily into the cutter which is being ground, so that the latter may be readily turned round by the thumb and finger of the operator.

The exact mode of setting such cutters is as follows:— The clearance angle L J K on each tooth is obtained and maintained by the emery wheel H, of which a specimen is exhibited. The clearance is obtained by adjusting the centre I of the emery-wheel H a short distance horizontally behind the vertical line D M through the centre of the milling cutter. The shorter this distance D I, the less the amount of the clearance imparted to each tooth of the milling cutter C. The upper dotted line J L is a tangent to the circumference of the milling cutter, drawn from the point of contact J; and the lower dotted line J K is a tangent to the emery wheel from the same point. The angle formed by these two lines is the angle of clearance.

Each tooth is held in its correct position by means of a stop S, while the milling cutter is rapidly traversed once forward and backward under the emery wheel. As will be seen by the arrows, the tendency of the emery wheel is to keep the cutting edge which is being ground close up against the stop S. There is no more difficulty in grinding spiral cutting edges than straight ones; and face and conical cutters can also be ground correctly, and *with the same amount of ease.*

Milling cutters are made of the required forms to suit the various shapes they are intended to produce; and all the ordinary forms can be used in any milling machine either of the horizontal or vertical class.

The face milling cutters, Figs. 40 and 41, are of disc form, and are among the most useful. They are constructed to cut on one face and on the periphery; and they produce very perfect finish, especially on cast iron. This form is also very useful for stepped work, which, even when not of the simplest form, can be readily and reliably finished to standard breadths and depths: so that the pieces may be interchangeable, and fit together without the slightest shake or play, just as they leave the machine, and without any hand labour bestowed on them.

Another ordinary and very useful form is the cylindrical cutter, Fig. 42, with teeth cut spirally over its circumference. *This is largely employed for cutting flat, vertical, or horizontal surfaces,* for finishing concave and convex curves, and for complicated forms made up of straight lines and curves. With this spiral arrangement of the teeth, and with reliable means of re-grinding or re-sharpening them, very high class machine work can be produced. *Some experiments* have been made by cutting a spiral groove or thread into the outer surface of one of this class of mills, and thus reducing the aggregate length of its cutting surface. The results appear to be practically as follows: — If half the length of cutting edges are dispensed with, only about half the maximum feed per revolution of the cutter can be applied by the machine, if three quarters of the length of the cutting lips are left intact, three quarters only of the aggregate feed can be used; and so on in the same proportion.

Other mills again are made in the form of small circular saws, varying from ¼ in. to 1½ in. or more in thickness. The teeth in some of these are simply cut around the circumference; others have these teeth extending some distance down each side, their edges radiating from the centre of the mill, as in Figs. 43 to 45. Towards the centre they are reduced in thickness so as to clear themselves. These cutters are useful for a very great variety of work, for instance the cutting of key ways, parting off or cutting through pieces of metal, and making parallel slots of various widths, for the broader of which two or more cutters may be used side by side.

Conical and angular milling cutters, Figs. 33 to 38, are much employed for a great variety of work, such as the cutting of rymers, the making of milling cutters themselves, bevelling, cutting the serrated part of hand and thumb screws, nuts, etc. Figs. 34 to 37 are edge views of four of these cutters; Fig. 33 is a face view, and Fig. 38 a section of one of them.

Any complex forms, such as the spaces between the teeth of spur, mitre, and other wheels, can be machined by using what are known as the patent cutters, which can be re-sharpened as often as required by simply grinding the face of each tooth They are so constructed that, however often they are re-ground, they never lose their original curved forms, and always produce the same depths of cut. One of these cutters, for instance, will cut the same standard shapes of teeth in a spur wheel, after it has been used for years, as it did the first day it was started.

There is a risk of fracture in making large milling cutters out of one solid cast steel blank, the principal difficulty being in the tempering. In practice it is found that if they are required of larger diameter than about 8 ins. they are better made of wrought iron or mild steel discs, with hardened cast steel teeth so securely fitted into them that they do not require to be removed. The cutting edges can then be re-sharpened in their own places, as in the case of the ordinary milling cutters: thus ensuring that each shall have the same angle of cutting and clearance, run perfectly concentric, and therefore do a maximum amount of cutting in a given time. It must however be borne in mind that the smaller the diameter of the milling cutter, the better finish it will produce; and cutters of large diameters should only be used to reach into depths where one of smaller diameter could *not, or to do the heavier classes* of work. Again, the smaller the cutter, the less does it cost to make and maintain.

The writer has not had an opportunity of actually testing the relative amounts of engine power required for driving milling machines; but, as far as he can judge from ordinary practice in doing ordinary work, he has not perceived that any more power is required to remove a given weight of shavings than that required for a lathe, planing machine, or shaping *machine, with efficient cutting tools in each case.*

The cutting speed which can be employed in milling is much greater than that which can be used in any of the ordinary operations of turning in the lathe, or of planing, shaping, or slotting. A milling cutter, with a plentiful supply of oil, or soap and water, can be run at from 80 to 100 ft. per minute when cutting wrought iron. The same metal can only be turned in a lathe, with a tool holder having a good cutter, at the rate of 30 ft. per minute, or at about one third the speed of milling. Again, a milling cutter will cut cast steel at the rate of 25 to 30 ft. per minute.

The increased cutting speed is due to the fact that a milling cutter, having some thirty cutting points, has rarely more than three of these cutting at the same time. Each cutting point therefore is only in contact with the metal during one tenth of each revolution. Thus, if we suppose it is cutting for one second, it is out of contact, and therefore cooling, for *the succeeding nine seconds, before it has made* a complete revolution and commences to cut again. On the other hand, a turning tool while cutting is constantly in contact with the metal; and there is no time for it to cool down and lose the heat imparted to it by the cutting. Hence, if the cutting speed exceeds 30 ft. per minute, so much heat will be produced that the temper will be drawn from the tool. The same difficulty to a great extent applies to the cutting tools in planing, shaping, and slotting machines. The speed of cutting is governed also by the thickness of the shaving, and by the hardness and tenacity of the metal which is being cut: for instance, in *cutting* mild *steel, with a traverse of ⅜ in. per revolution* or stroke, and with a shaving about ⅜ in. thick, the speed of cutting must be reduced to about 8 ft. per minute. A good average cutting speed for wrought or cast iron is 20 ft. per minute, whether for the lathe, planing, shaping, or slotting machine.

EXPERIMENTS ON THE STRENGTH OF WROUGHT IRON STRUTS.*

A paper by Mr. James Christie, M. Am. Soc. C. E., on "Experiments on the Strength of Wrought Iron Struts," was then read by the Secretary, in the absence of the author. These experiments were made at the Pencoyd Iron Works for the purpose of determining the comparative resistances to compression of long and short struts of rolled angles, tees, beams and channel sections. The specimens were tested by four different methods, viz., with flat ends between parallel plates to which the specimen was in no way connected; *with fixed ends* or ends rigidly clamped to parallel plates, the plates substantially forming flanges to the specimen; with hinged ends, or both ends fitted to hemispherical balls and sockets or cylindrical pins; with round ends or both ends fitted to balls resting on flat plates. The specimens varied in length from six inches up to 16 feet and were selected to obtain a uniform character of material. The paper give tabulated results of 299 experiments, and these results are illustrated by a number of diagrams. There were also results given of a number of tests of welded tubes. The general conclusions drawn from these experiments were as follows. (*$\frac{l}{r}$ being length divided by least* radius of gyration.)

When struts are short, say l/r below 20, there will be no practical difference in the strength of the four classes, so long as reasonable care is taken to keep the centre of pressure in the centre of the strut. Hinged ended struts vary all the way from round ended up to flat ended in strength. If the hinges are pins of substantial diameter, well fitted, and exactly coincident with the axis of greatest resistance of the strut, the strength of the strut will be fully equal to that of a flat ended, but considering the impracticability of maintaining this rigid accuracy, *the average hinged struts as compared with flat* ended will fall in strength as the length is increased until l/r is about 250, when they will average one-third less resistance than flat ended. From this point they will gain comparatively until $\frac{l}{r}$ become about 500 when both classes will be practically equal. *Fixed ended struts gain in comparative resistance,* from the shortest lengths upwards until $\frac{l}{r}$ becomes about 500 when they are twice as strong as either the flat or hinged ended.

Round ended struts continually lose in comparative resistance as *the length is increased. When $\frac{l}{r}$ is about 340, they*

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* A paper read before the Am. Soc. of Civil Engineers.

will be half as strong as hinged ended, and when $\frac{l}{r}$ is about 160, they will have only half the strength of flat ended.

The iron from which the tests were made exhibited the following resistances to direct compression, being the general results of several tests of small section, fifteen inches long, and secured in such a manner as to prevent lateral flexure.

With 30,000 lbs. pressure per sq. in. incipient, permanent reduction of length was observed.

With 35,000 lbs. pressure per sq. in., failure of elasticity occurred, and marked permanent reduction of length.

With 50,000 lbs. per sq. in., a permanent reduction of length of three per cent occurred.

With 75,000 lbs., a permanent reduction of ten per cent and with 100,000 lbs. pressure per sq. in., a permanent reduction of twenty-eight (28) per cent of the length.

The paper was discussed by Messrs. Theodore Cooper and Charles S. Emery, who both expressed the opinion that these experiments were of very great value, being made with material of uniform character, and in such a way that comparisons could be made directly between the different methods adapted in testing.

THE REFORESTING OF MOUNTAINS.

BY P. DEMONTZEY

(*La Nature*, *3rd and 7th Feb., and 3rd and 24th March*, 1883, *pp.* 151, 182, 215, *and* 260, 6 *pl.*)

The state of sterility of the mountain slopes of the Alps, the Pyrenees, and the Cevennes, is traced to the removal of the forests which used to cover these mountains. The unrestrained torrents have gradually stripped the soil from the slopes, which, in the absence of trees, is deprived of its source of renewal, so that each year the area of vegetation becomes more restricted, and the rapid descent of the floods spreads devastation in the fertile valleys below. The first tentative measures for remedying this disastrous condition were undertaken in 1860, by encouraging the growth of forests in various mountain districts in the south of France, and the experiments have resulted in converting desolate regions into tracts covered with young forests, and in changing formidable torrents into harmless streams. In order to promote the growth of trees, it is necessary both to cover the denuded rocky slopes with a covering of softer ground, into which the roots can penetrate, and also to protect the young vegetation from being washed away by the torrent.

These objects are accomplished by erecting numerous dams at suitable spots across the bed of the torrent, some constructed of masonry, designed to be permanent, and others merely temporary constructions formed with hurdles and fascines, and by protecting and regulating the sides and bed of the torrent by lines of hurdles and brushwood. The dams and cross lines of hurdles reduce the slope and increase the width of the bed of the torrent, and consequently diminish the velocity of flow, and cause an accumulation of detritus; whilst the hurdles along the banks protect the side slopes from scour, and the accretions diminish their declivity. The growth of forests is thereby rendered feasible, which in their turn protect the slopes from denudation, check the descent of the small streams into the torrent, and, by the fall of their leaves furnish a supply of soil for promoting vegetation. The kind of trees that should be planted depends upon the site, the exposure, and the altitude; but whereas, under the recent unfavoured conditions, the limit of altitude of the growth of forest was placed at about 6,500 feet, pine firs and larches, of from ten to fifteen years' growth, may now be seen covering large tracts of ground at an altitude of about 9,000 feet, where the old forests do not extend beyond the original limit assigned of 6,500 feet. The result of the above kind of work, carried out in the valley of St. Bernard, near Barcelonette, has been to retain all the detritus in the valley so that nothing but pure water passes away. The slopes are, in consequence, becoming flatter, and it only remains to facilitate the growth of trees higher up the banks by promoting the extension of the covering of soil, which is rapidly effected by layers of willows along the banks, and even occasionally across the bed of the stream, producing a network of roots and layers, increasing with the growth of the plants. In the case of some strata traversed by numerous ravines, the accumulation of detritus would be too slow to yield satisfactory results, and it becomes necessary, after constructing a dam at the base of the ravine, to remove all the projecting portions of the slopes, and throw them into the bed of the stream, so as to raise the bed at least 3 to 6 feet. A series of lines of fascines are then placed across the new bed to maintain it, and the upper layer of rocky débris is converted, by exposure to the atmosphere, into soil suitable for some kinds of vegetation. A law was passed in France, in 1882, for replanting forests and preserving them on the mountains, and the State has undertaken the execution of the work in the most important districts. It is anticipated that the results of these works will be, security of the population and land from inundation, by the regulation of the torrents; prevention of detritus from filling up the beds of the rivers below; extension of land suitable for cultivation; increase in the discharge of rivers, and consequent possibility of extending irrigation; and a large development in the supply of wood.—*Tr. Ins. C. E.*

ON CEMENT CONCRETE.

BY — SCHUMANN.

(*Wochenschrift des Vereines deutscher Ingenieure*, 1883, *p.* 138)

The Author refers at some length to Dyckerhoff's experiments with cement concrete containing a certain proportion of lime. According to these, concrete is stronger if made by adding cement mortar to gravel, instead of mixing cement and gravel direct. The strength of concrete was found to be much greater when mixed in the air and afterwards immersed, than when it was moulded under water. The porosity of the samples of concrete was tested by subjecting slabs $\frac{3}{4}$ thick to a pressure of 16 feet of water, after they had been allowed to harden for seven days in a damp atmosphere. The finer the sand used, the less porous was the mortar, and it was found that the porosity was diminished by prolonged immersion in water. A mortar composed of equal parts of cement and sand remained porous for seven days. When lime was added to the mortar the porosity was greatly diminished—a mixture of one part of cement, six of sand, and two of slaked lime in the form of a paste, allowed no water to pass after hardening for seven days.

The cracks which are usually found in concrete work are attributed to the contraction of the cement. Prisms seven inches long, made of neat cement, were observed during a period of one year; after the lapse of this time it was found that a prism kept in a room had shrunk 0·162 per cent., and one exposed to the atmosphere 0·113 per cent.

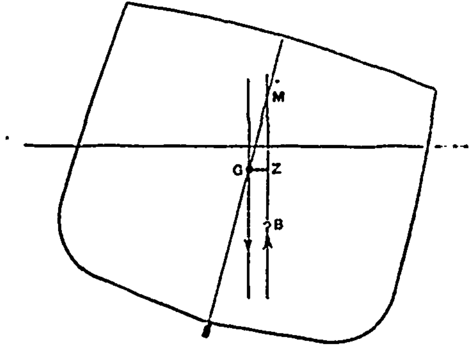
In the discussion upon this Paper, it was remarked that cement concrete, when used for the foundations of machinery, is liable to disintegration by the lubricating oil.—*Tr. Ins. C. E.*

THE STABILITY OF MERCHANT STEAMSHIPS.

I propose to state, and in part to restate, the more important scientific considerations concerning the stability of merchant steamships which the investigation of the *Daphne* disaster has brought to light, following the main lines of the second part of my Report, which has been published *in extenso* in several newspapers. In this case, as in all cases touching the complicated question of ship stability, it is very necessary to be careful not to draw hasty inferences or any inferences at all which are not strictly deducible from the facts or principles established.

It is desirable to guard the reader in the first place against considering the cases of the ships *Daphne* and *Hammonia*—which I have had occasion to associate somewhat closely in my Report—as identical in more than a certain number of features, there being other features in respect of which there is little or no resemblance. I will presently point out both the resemblances and the differences, but first let me remind the reader unfamiliar with naval science what is meant by a curve of stability, quoting the Report as far as may be necessary for the purpose. Fig. 1, page 300, may be taken as the transverse section of a vessel inclined at an angle of 15 degrees to the upright. The total weight or gravity of the vessel will act downwards through the centre of gravity G, and the total buoyancy will act upwards through the centre of buoyancy B, as the arrows indicate. It will be obvious that the vessel cannot rest in the inclined position with these forces and no other operating upon her; she must revolve until gravity and buoyancy act in the same vertical line, but in opposite directions. The further she is inclined the more will the ship be immersed on one side and emersed on the other, and therefore the further out will the centre of buoyancy move. Now as neither the gravity nor the buoyancy need be altered in amount by mere inclination, and as they are equal and opposite in direction, it follows that, whatever the inclination, the force acting will always be the same, but the leverage, marked GZ, will vary as the centre of buoyancy moves. At 30 degrees inclination, for example, GZ is much greater than it is in Fig. 1 at 15 degrees. In Fig. 2 these lengths are set up as ordinates of a curve, and similar lengths for inclinations of 45 and of 60 degrees are similarly set up; the curve drawn through their upper extremities is this vessel's "curve of stability," observing that the base line is divided into equal lengths for equal angle intervals on any convenient scale.

FIG. 1.



As regards the "metacentre," I must explain here, as I did in my Report, that in former times, when "initial stability" alone was calculated, the word "metacentre" had a much more limited meaning than it possesses now. It formerly had relation to the upright position of the vessel, in which case the buoyancy acts upwards through the centre line of the ship's section—along G M, for example, in Fig. 1. After receiving a slight inclination, the vessel has, as we have said, a new centre of buoyancy, and the buoyancy itself will act upwards along a fresh line slightly inclined to what was previously the upright line, and will intersect it at some point, M. This point was called the "metacentre," and if we suppose the angle in Fig 1 to be very small (very much less than 15 degrees), then the M shown there approximately marks the "metacentre." When a ship is much more inclined, the point at which two consecutive lines of the buoyancy's upward action will intersect may not be, and often will not be, in the middle line of the ship at all, but this point is nevertheless called the "metacentre," and the use of the word in this extended sense has recently become general. In Fig. 3 is shown a floating body of square section, inclined in the water at an angle of about 30 degrees. W.L. is the water line or line of flotation; B is its centre of buoyancy. By giving it a "slight" inclination from the position, it will of course have a new centre of buoyancy given to it. If we incline it one way *b* will show this, if we incline it the other way *b'* will show it, and for each of these positions there will be a new line of action or buoyancy. But these lines of action, together with that through B, will all meet or intersect in one point, and this point (M) will be the metacentre at 30 degrees of inclination. In Fig. 4 I have shown curves of stability for a prismatic body, with the centre of gravity in the centre of form, and also with that centre in some cases raised and in others placed below the centre of form. In this figure the draught of water is taken at 3/25ths of the total depth of the prism. In Fig. 5 I have given curves of stability for the prismatic body with the centre of gravity and the centre of form taken as coincident, but with different draughts of water. In Fig. 6 I have given the curve of stability of a similar prismatic body, immersed 2/5ths of its depth, and having its centre of gravity situated 6 inches below its metacentre. These figures serve to illustrate very clearly the error involved in the assumption that with stability at the upright position and stability at 90 degrees—or but little instability at the latter, which is what some authors have instructed the profession to be content with—there need be no apprehension of any deficiency of stability at intermediate angles of inclination. They show that with square sections and prismatic forms there may be various dispositions of centre of gravity and draughts of water, with which stability in the upright position and again at 90 degrees are not proofs of safety, but indications of the gravest danger.

FIG. 2.

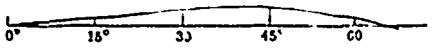
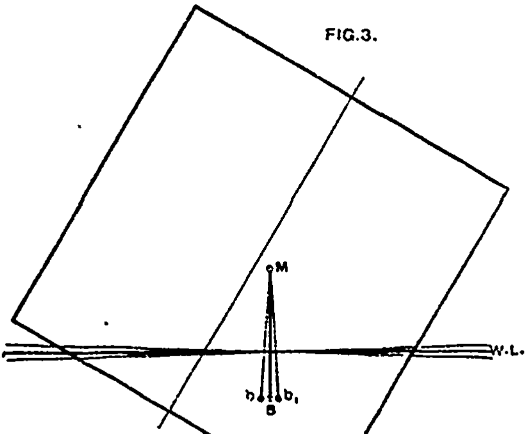


FIG. 3.



With these figures before us, we now have both the *Hammonia* case and the *Daphne* case amply illustrated, and can carefully distinguish between the two. The *Hammonia* case—as put forward by Mr. Biles, who conducted her calculations—is that of a high-sided vessel with her stability reaching a maximum soon after she had inclined 30 degrees; and she therefore finds her analogy in one or other of the cases shown in Fig. 5. In the latter figure it will be seen that with the centre of gravity in the centre of form all positive stability vanishes at an inclination of 45 degrees in the two cases A and B; but the *growth and decline* of the stability are very different indeed at the different immersions. When the immersion is smallest the stability rises in a steep curve (A), attaining a comparatively large maximum something under 20 degrees, and then declines, more gradually than it rose, as the inclination goes on. By increasing the immersion from 3/25ths to 5/25ths the curve B is produced, and here we see a vast change of stability, the curve, which rises very slowly from the base line, never reaching one-fourth the maximum ordinate of curve A; only attaining its maximum beyond 30 degrees of inclination, and then declining less slowly than it rose, until it vanishes. Immerse the body to double the last immersion, and we find in curve C that now, instead of vanishing at 45 degrees, the stability only there begins, rising to a small maximum a little beyond 60 degrees and vanishing at 90 degrees. It is in curve B that we find a state of things very closely analogous to that disclosed by the *Hammonia* curve, which I now give in Fig. 7. In both cases the stability increases but slowly; in both it reaches early a maximum; and in both it disappears altogether before the vessel is more, or much more, than inclined through half a right angle. The case of the *Daphne* resembles this in the slowness with which the stability increases as the vessel is inclined, this slowness being due to the same causes in both cases doubtless, but an examination of the triple-branched curve of her stability given in Fig. 8 shows that the analogy between the two cases ends at quite a moderate angle of inclination, say 30 to 31 degrees. In this figure (8) the curve A is constructed on the assumption that the ship was free to take water on board as the main deck became immersed; the branch B presumes the poop to have been watertight, and the branch C is calculated to show how the stability curve would have increased until the bulwarks came under water, provided these bulwarks had been watertight. It will at once be seen that the *Daphne* cannot be regarded as analogous to the *Hammonia* or to the curve B in Fig. 5, in so far as the stability at very large angles is concerned. On the contrary she would have more resembled the case of Fig. 6, provided her sides had gone as high as her topsides and been there decked over. The *Daphne's* curve A ceases to rise soon after the main deck becomes immersed, and then falls rapidly away in the same manner and for the same reason as all ships lose stability when, or soon after, the freeboard has become exhausted. It must therefore be clearly understood that it is in the early stages of the two curves that the cases which I have had to make public find their resemblance, at the later stages the *Daphne* illustrates the consequences of the immersion of the deck, while the *Hammonia*, by losing all stability before the deck became immersed, opened up a state of things which startled her builders, surprised the profession, and confounded the text-books, and

FIG. 4.

CURVES of STABILITY of PRISMATIC BODY of SQUARE SECTION

DRAUGHT of WATER 3/25ths of DEPTH.

A WITH CENTRE OF GRAVITY AT CENTRE OF FORM.
B .. .. .. 1 FOOT ABOVE .. ..
C .. .. .. 2 FEET .. .. ..
B .. .. .. 1 FOOT BELOW .. ..
C .. .. .. 2 FEET .. .. ..

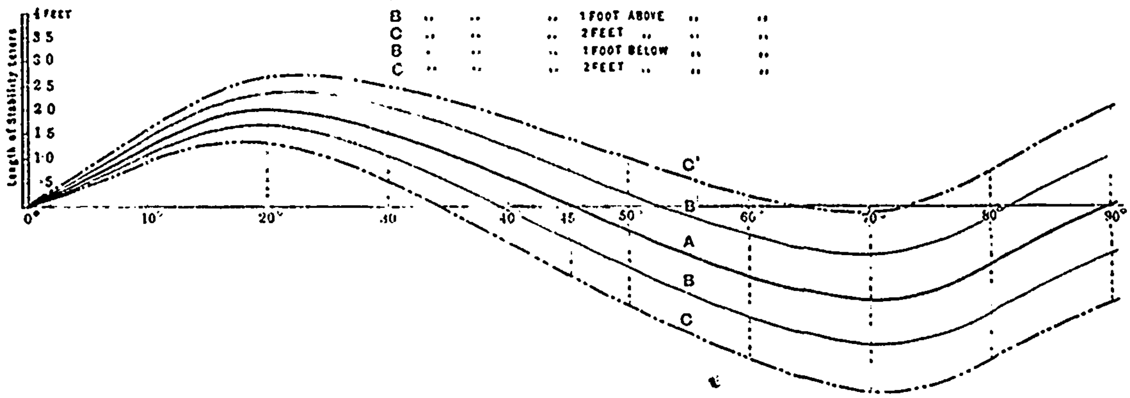


FIG. 5.

CURVES of STABILITY of PRISMATIC BODY of SQUARE SECTION

WITH CENTRE OF GRAVITY AT CENTRE OF FORM.

A. WITH DRAUGHT OF WATER 3/5ths OF DEPTH.
B. .. .. .. 1/2 th ..
C. .. .. .. 2/5 ths ..

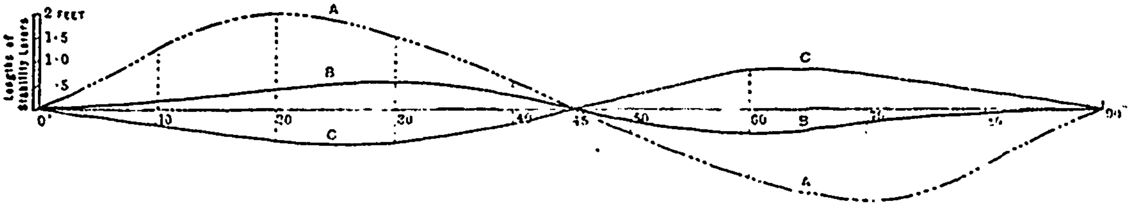
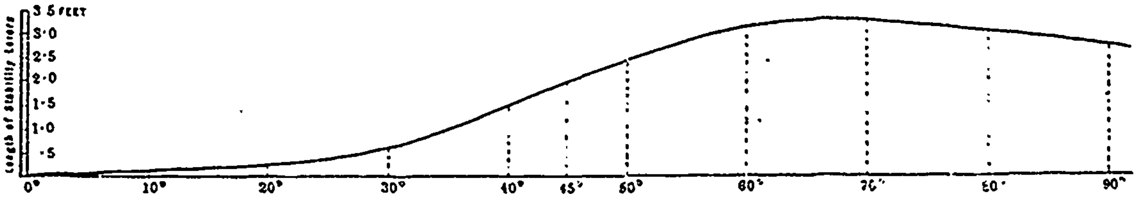


FIG. 6.

CURVE of STABILITY of PRISMATIC BODY of SQUARE SECTION

DRAUGHT of WATER 2/5ths of DEPTH.

WITH CENTRE OF GRAVITY 6 INS. BELOW THE METACENTRE.



must force extended calculations upon all those who hereafter undertake to launch ships upon the stability of which any doubt can by possibility exist.

It is pretty widely regarded as a remarkable fact that there should have been any deficiency in the knowledge of shipbuilders concerning the conditions or possible conditions of the stability of ships at their launching draughts. But to me this deficiency seems the most natural thing possible. It needs no explanation to those who remember what immense transformations and extensions have come upon the shipbuilding trade during even my own professional experience. I well remember looking with wondering interest in Sheerness dockyard at the first iron ship ever seen there, and yet the construction of iron ships had become so universal fifteen years ago that I wrote my work on "Shipbuilding in Iron and Steel" to meet a widespread necessity, the idea of writing descriptions of wood ships having already passed away. I equally well remember the building at Sheerness of the first screw steamship ever constructed there, but where now are any but screw steamships built for ordinary ocean work? Some sailing ships and some paddle steamers doubtless are built even now, but the screw steamer has almost undisputed possession of the world's ocean trade. With these changes have come in wholly new developments of shipbuilding science, and the present is not by any means the first instance in which it has fallen to my lot to point out errors of doctrine—false deductions from former practice—which were misleading the shipbuilder. In the case of the strains to which ships are subjected, the deductions made by the most eminent men who discussed the subject scientifically at the end of the last and the beginning of the present century seemed to me to be irreconcilable with the conditions of modern ships, and after lengthened investigations I found that they were not only wrong, but in some cases the reverse of the truth, and I contributed to the Royal Society a paper on the subject which has brought modern theory and modern practice into better relationship. In the matter of stability it was most natural that as we abandoned the employment of wind as our propelling power—which of course imposed upon ships the necessity for large stability to withstand the wind-pressure—shipbuilders were able to resort to greater proportionate length and to enlarged proportionate area of midship section; and thus to bring about conditions in *which large initial or early stability, so to speak, fell out of* demand. Nor is it easy to say when deficient stability would have come under close investigation, had it not been for the accident of certain ships of very *low freeboard* coming under consideration at the Admiralty, as explained in my Report. These led to the calculation of stability at successive angles of inclination, and to the method of recording the results in the form of the "curve of stability" previously described. But besides the *change* of the seagoing ship, there has been the enormous extension of its employment, our carrying trade on the sea having increased by leaps and bounds. Every one knows that when the demands of commerce are very urgent, science and scientific research are apt to be neglected. The *necessity for great carrying power and speed at sea has been* attended by an equal necessity for quickening the loading and discharging of ships in port, and consequently steam windlasses and cranes, and many other modern appliances involving upper weight have come into vogue, and their effect upon stability has not been always considered. From these and other causes there has been brought about that somewhat extensive employment of ships of small stability, or of no stability at all in themselves, to which it lately became my duty to direct attention. It is no doubt the general belief that a high sided ship having some initial stability, will, as she inclines, gather large additional stability, and will retain some even at very large angles, that, as my Report states, has greatly encouraged people to be satisfied with very small initial stability, in some cases with none at all, and even less than none. Many steamships of large tonnage have been built of late years for influential steam companies and other owners, which ships are totally incapable of floating upright without the aid of ballast or of cargo, and which cannot be unloaded in dock without being held upright with hawsers attached to the shore. Such ships, even when capable of floating unballasted without capsizing, can only do so by lolling over at large angles of inclination, and there finding a position of stable equilibrium When carefully watched over and stowed with suitable cargoes, these ships can usually be made safe at sea, and sometimes even safer than ships with larger initial stability but less range—a circumstances to which undue prominence has perhaps been given, and which has diverted many from the grave elements of danger which more often are associated with small initial stability. "There is not the least doubt, however, that a very small initial stability given to many modern mercantile steamships —given in the belief that much more is sure to be gained as the ship inclines (within large limits)—has resulted in the capsizing of many ships at sea, and to grave danger to many that are still afloat, not in the same manner, because not in the same condition as to lightness as the *Hammonia* and *Daphne*, but from other not less real deficiencies." Sad and serious as this statement is, I repeat it here with perfect confidence in its accuracy.

Sometimes such vessels are brought into a condition of apparent safety by the stowage of their own coal, but as the coal is consumed their stability diminishes, they capsize, disappear, and the word "missing" is recorded against them in an official return. No means exists, notwithstanding all our shipping legislation, for insuring that the facts will be brought to light —indeed, at the official inquiry which follows under the present conditions, the question of stability may not even be mentioned. As the stability of a ship is often an intricate matter which can be effectually controlled only by close and careful calculation, and as no Government department is at present charged with the duties even of collecting, recording, and making known those dimensions and particulars of ships which determine their stability, the matter must be left to right itself. Maritime ships of small stability incur dangers from, and are doubtless lost by, the operation of causes which are but very imperfectly appreciated.

It is under the urgent pressure of a very rapidly growing mercantile steam marine that the shipbuilding trade has somewhat, I fear much, outrun the companionship and regulation of science. It is only quite recently that the necessity for developing their scientific staff and appliances has been borne in upon the minds of shipbuilders. There never, even yet, has been so much as a training school or college established by them for the education of young naval architects and draughtsmen throughout the country. But the Admiralty have had their dockyard schools at work for nearly forty years; school after school of Government naval architecture has been established; the Institution of Naval Architects has been formed and done invaluable work, for more than twenty years; and some private shipbuilders have at length entered with spirit *and enterprise upon the labour of developing the practice of* scientific naval architecture. No part of my duty in connection with the *Daphne* inquiry has been so agreeable to me as that of bearing witness to the admirable efforts of several Clyde firms in this respect; and there is no result than can follow from the inquiry which I should esteem so highly as the emulation of their efforts throughout our shipbuilding establishments generally—unless, indeed, it were that of a general awakening of *shipowners* to their great and enduring responsibilities in this matter. EDWARD J. REED.

THE USE OF CAST IRON FOR HOUSE DRAINS.*

By W. D. SCOTT-MONCRIEFF, C. E.

The materials used for the construction of house drains are practically limited to bricks, earthenware, and cast iron. The advantages of cast iron are (1) its superior strength and capacity to resist fracture, (2) the greater lengths in which it can be manufactured, and the corresponding reduction in the number of joints, (3) the greater facilities for making the joints secure by means of lead, sulphur oxidired iron filings, &c. The points to be considered in adopting cast iron are (*a*) the available means for preserving it, (*b*) the determination of the capacity and weight of the pipes, (*c*) the character of the connections best suited to the material, (*d*) the nature of the joints, (*e*) the comparative cost. The experience of gas and water companies ought to be a guide as to the life of the cast iron drainpipe in regard to corrosion from the outside inwards. When there is no oxide of iron in the soil through which it is laid, the destruction of the pipe from exterior rusting is so slow as to justify its use without any special means of protection. In the case of drainpipes there is no reason to exclude a good protecting medium because it is poisonous—an objection which, of course, holds good in the case of pipes used for the distribution of drinking water. In addition to the ordinary kinds of paint made from preparations of lead, &c., there are two methods of preserving pipes from oxidation which

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* National Health Lecture read at the Society's Exhibition, Knightsbridge, Eng.

deserve more than a passing notice. One of these consists in coating with a preparation of tar, known as Dr. Angus Smith's composition, and the other I refer to is known as the Bower-Barff process, in which the surfaces are covered with magnetic oxide, produced at a high temperature in a furnace built for the purpose In a letter with which Dr. Angus Smith favoured me a few days ago, he mentioned a temperature of 400° F. as the most suitable for the application of his preparation. A certain amount of practice is required in dealing with it, in order to insure the proper consistency of the material when cooled. If it has been subjected for some time to the necessary temperature, evaporation makes the residual mixture hard and brittle after cooling. To avoid this, a barrel of oil must be kept at hand to mix with the composition, so as to keep it in its original proportions. If too much oil is added, the coating will not be hard enough. I have arranged an apparatus consisting of a trough heated by means of gas jets for applying the mixture, but it is better, I believe, to have the pipes dipped vertically. The use of steam in a double lined chamber would be an advantageous method of working it, if the temperature of 300° F. recommended is sufficient. In that case, a steam boiler would need to be provided capable of standing a working pressure of 75lbs. on the square inch. If 400° F. is necessary, the boiler would require to be able to stand a working pressure of 250lbs. There are several specimens of the composition shown by the North British Plumbing Company in the present exhibition. Before coating cast iron, care should be taken that the surfaces are thoroughly free from sand and other foreign substances. A steel wire brush, circular, and provided with a long handle, is useful for scouring out the interior of pipes, and they may afterwards be wiped out with an oily cloth. I have here two specimens of Dr. Angus Smith's composition, kindly lent me by Mr. Rawlinson. One of them has lain in the ground for 28 years, and though the composition does not seem to have been very well applied to begin with, you see that the iron is still in an excellent state of preservation. The other specimen shows the application of the protecting medium in the greatest perfection, and the test of its condition as regards consistency and temperature is to be found in the high glazing or varnish which is given to the surface of the iron when it is properly applied. The Bower-Barff process has recently been brought prominently into public notice. It consists in coating the surfaces of the iron to be preserved with magnetic oxide. In this exhibiton are shown some specimens of pipes treated in this way They were coated at St. Neot's, Huntingdonshire, under the direction of Mr. Bower, to whom my thanks are due for having done so for the purpose of this exhibition. I have no doubt of the efficacy of this plan when the surfaces of the iron to be dealt with are so exposed as to be capable of thorough cleansing The interior of cast-iron pipes requires special care in this respect. The "cores," from which they are made being of "green sand," leave rough particles behind them, which, at high temperature required for the production of the magnetic oxide, must be apt, I think, to form a vitreous glazing, unless the pipes are very carefully cleansed beforehand. To return to the pipes themselves, the diameter I have adopted for ordinary house drains is 5in. This is the same as has been recently recommended by the engineers of the London Sanitary Protection Association. In cases of considerable fall, more especially when the drain is flushed by means of a flushing tank, a velocity of flow is obtained which would be apt to tell severely upon the points of earthenware pipes lain in cement and considering the first sanitary importance of the rapid movement, this is a point in favour of cast iron. In Lord Ducie's house in Portman-square, the sanitary arrangements of which have recently been altered, there is a direct line of cast iron drainpipe 5in. diam. and 99ft. in length, with a fall of 1 in 33. The end nearest the street sewer is provided with a Kenyon air-chamber floor and manhole. At the other extremity of the length of 99ft. there is a similar provision for inspection, but upon a smaller scale. Beyond this point, a further stretch of 5in. cast-iron drainpipe, about 70ft. in length, passes on to the back of the premises, and is provided with an 80-gallon flush tank. It is found that the velocity of flow between the two disconnecting chambers along the length of 99ft., first spoken of, is at the rate of 5ft. per second. As the drainpipe is running nearly full bore, this condition of things renders it impossible that any obstruction in the shape of sewage matter can remain behind. The elements essential to the creation of sewer gas being wanting, its absence from the drain is practically guaranteed. The after part of the flush, in this case, always runs clear. The formulas which are commonly used for calculating the velocity of water in pipes running full must be considerably modified for the flow of house drainage in 5in. pipes. I do not think much is to be gained by making the pipes less than 5in diameter, and, on the other hand, a greater capacity is certainly not required for the purposes of an ordinary household. I therefore look upon it as a useful dimension for ordinary cases. As there is an absence of hydraulic pressure in cast-iron pipes used for the conveyance of ordinary housedrainage, no extrathickness of metal is required on that account, and they may, therefore, be made thinner than ordinary street mains. The following is a table of the thickness and weight of pipes of different diameter suitable for the purpose.

Bore	Thickness of Metal.			
inches.	$\frac{3}{8}$	$\frac{1}{2}$	$\frac{5}{8}$	
4	16 1	22 1	28 3	lb. per foot
5	19 8	26 9	32.4	" "
6	23 4	31 9	40 6	" "

In practice, I believe pipes five-sixteenths of an inch in thickness are sufficient for drainage purposes and this would give about 100lb. as the weight of a 6ft. length of pipe 5in. diameter. Among the various kinds of joints, that known as the "socket joint" appears to me to be the best suited for iron house drains, and although the pipes themselves may be made lighter than main pipes, the socket should not be reduced in weight or strength, because they are subjected to the same strain from the staving of the lead. Great care should be used in this respect, the more so as workmen may be employed who are not so experienced as those in the service of water companies. A joint has been brought under my notice, which has been patented by Mr. Eaton, C.E. It is intended for the use of Spence's metal or sulphur, and consists of an excentric ring with a pouring hole on its top side. This overlaps the joint on both sides, and would be useful, I think, where it was required to insert a length of pipe between two already in position, as this could be done without the necessity of lifting more than the piece which was to be removed. With regard to the connections and appliances suitable for attachment to cast-iron pipes, you will see exhibited a cast iron air-chamber floor, which is an effort to simplify the arrangement now so frequently adopted with advantage, of having a manhole, with a floor composed of half pipes as a channel for the passage of the sewage, and a trap beyond it to cut off the drain from the main sewer. In the cast-iron substitute for this appliance, the mouth of the trap is practically extended so as to form a floor for the manhole in itself, and this extension has the advantage of affording a provision for side inlets for the passage of surface water and for other purposes. At the further or house end of the drain, instead of building a shallow manhole, a cast-iron terminal is provided which is easily accessible, and which is made secure by means of a brass plug fixed in a ground seating of the same metal. In making a connection between a lead soilpipe and an iron socket, it is well to have a strong copper piece, with brazed lap-seam, slipped over the lead and soldered. This allows for an oakum and red-lead joint to be made with sufficient substance to admit of caulking. As regards the comparative cost of iron and earthenware for house drains, it must be borne in mind that a great proportion of the total expense of lifting an old drain and laying a new one is common to both systems. For instance, the cost of excavating, filling in, and making good is practically identical. The time occupied in making good the joints of an earthenware drain is as six to one as compared to an iron drain, the number of joints being as three to one in the case of 2ft. lengths of stoneware, and 6ft. lengths of iron, and I estimate the time occupied upon each as two to one in favour of the metal. This, I estimate, balances the extra cost of the material. The connections, including the air-chamber floor, are more costly than earthenware; but this, in the case of an ordinary London house drain, should not amount to more than £5 in all. I think that the greater security to be obtained from the use of cast iron quite justifies the expenditure of this additional sum. These remarks hold good so long as cast iron is to be obtained at its present price. Other kinds of materials are used for house drains, although bricks are now obsolete. The practical objections to the use of earthenware pipes are 1st. Their liability to twist in fixing. Mr. Ernest Turner, speaks of having rejected as much as 60 per cent. of pipes sup-

THE STABILITY OF MERCHANT STEAMSHIPS.—For Description see Page 299.

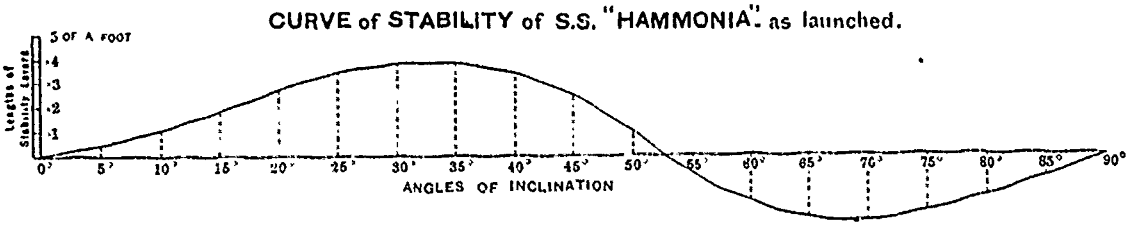
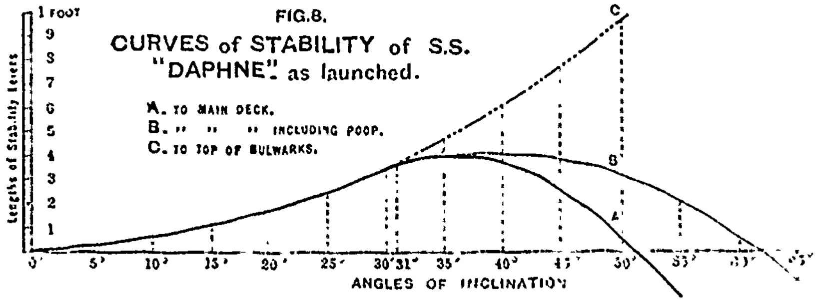


FIG. 8.



plied by "well-known manufacturers." 2nd. Their liability to fracture. Concussion without fracture of the surface is often sufficient to detach a branch piece from a pipe in which the material seems to be continuous, although the connection is often secured by little or nothing but the glazing. As such a contingency may delay a squad of workmen for several hours, until another pipe and branch has been obtained, there is a temptation to make use of defective pipes. Experience shows that workmen are not above yielding to the temptation of concealment. Broken bends and bad connections are frequently found in places which are most available for the passage of sewer gas into a dwelling. 3rd. The short lengths in which earthenware pipes are made necessitate an excessive number of joints, in order to make up the length of an ordinary house drain. The joints, when made with clay are inefficient; and when made with cement, are subject to many drawbacks which nothing but great and uncommon pains on the part of the workmen can overcome. The projection of cement to the interior of the joint is a necessary condition, and this must be removed. In doing so, the pipe is liable to movement during the critical period when the cement is setting. The position of a pipe at the bottom of a deep cutting renders it difficult to pack the joint from the bottom. Only a small proportion of earthenware house-drains are found to be tight when tested with a pressure of even a few inches head of water. These are among the considerations which have led me to adopt iron in preference to other materials, and I shall be glad if this paper has the effect of calling further attention to the subject.

* * *

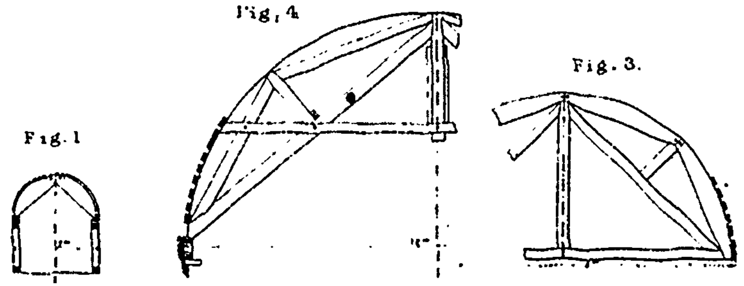
DOMESTIC CHIMNEYS.

The construction of the domestic fireplace and chimney no doubt is one of the most important items to any householder, and yet it is strange to note the small amount of attention that is paid to their efficient construction, and the carelessness frequently shown by builders in the way in which they are built and finished.

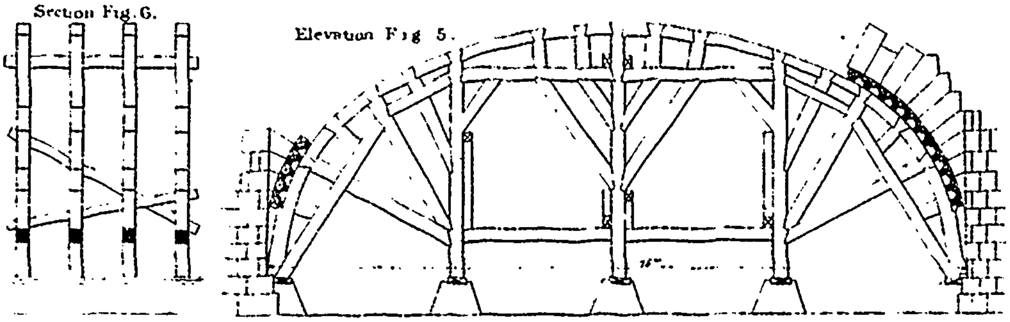
In the first place the matter of efficient draught is an item of extreme importance to the comfort of the occupants of the room. There should be three points in the construction of the fireplace and chimney to which attention should be directed for the formatian of an efficient up-draught. The first is proper proportion in the dimensions of the flue itself; second, the height and formation of the chimney stack; and thirdly, the provision of a suitable supply of cold air to produce an up-draught. Taking these points in succession we may remark that many builders nowadays adhere without reason, or without thought, to the old internal dimensions of flues, 14 in. by 9 in., which were necessitated as a minimum when climbing boys were used, to provide a free passage for them up and down the flue. The area so provided is undoubtedly very much greater than is necessitated by the volume of hot air generated in the ordinary domestic hearth.

We had better first define the scientific conditions under which the heated column of air develops an up-draught. The draught, in other words, merely represents the velocity with which the air is travelling through the shaft of the chimney, and all arrangements should be thus made with a view to develop the formation of that upward velocity. In the column of hot air the velocity of up-draught is generated simply by the difference of specific gravity of the hot air in the chimney, as compared with an equal column of cold air in the external atmosphere. The cold column of heavier weight, by the well-known law of gaseous and fluid pressure displaces the hot column from the inequality of pressure at the base of the chimney, endeavouring to reproduce equilibrium. As however, every succeeding supply of cold air becomes heated in its turn as it passes through or over the fire the constant circulation is maintained, and the result is a draught. The intensity or velocity of this draught is determined by the rise in temperature of the ascending column of air and by the smallness of the passage or shaft through which the air is travelling, so long as the passage is not too small to choke the draught. In an excessively wide shaft then, the temperature to which the large volume of air passing through it can be raised, is very much lower than would have been caused had the shaft been more restricted in area. This will serve to explain why we object, technically, to the construction of chimney shafts of anything like the area of 14 in. by 9 in.; even the more reduced dimensions of 9 in. by 9 in. are considerably greater than what is necessary, since the efficiency of the flue as a draught producer is limited by the final area of the inside of the chimney pot. This we know is usually limited to some 6 in. in diameter, more or less, and it is therefore the height of absurdity and very injurious to the effective draught to have an area at any part of the shaft of greater dimensions than that of the chimney pot. By neglecting this consideration in the design of the flues builders seem to go out of their way to develope a smoky chimney. To produce the easiest and best draught through a flue the area should be greatest at the exit or chimney pot and reduced towards the fire.

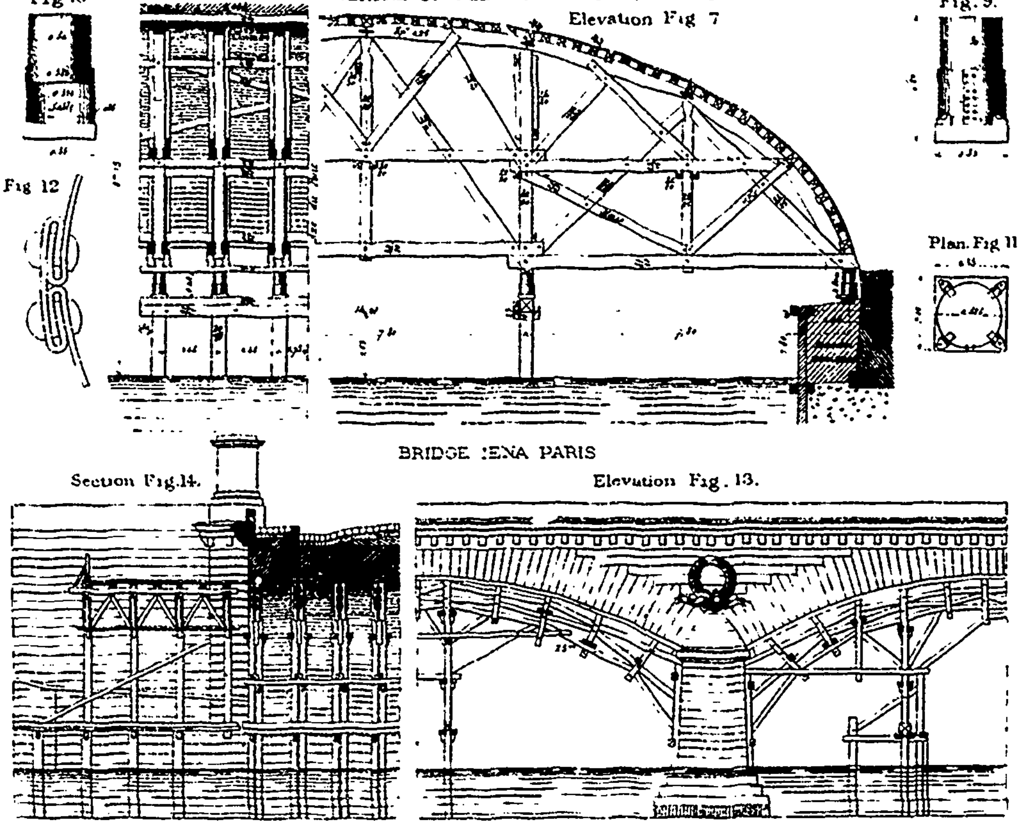
We have only to look at the immense number of cowls and zinc chimney pots that disfigure so large a number of roofs, to see that if the builder desired to maintain the architectural effect of the roof line of his building, the usual chimney shaft supplied is far shorter than requisite to maintain the proper draught. This, no doubt, is frequently caused by the interposition of high gables, or the height of buildings in their immediate vicinity, but we think that it behoves architects and builders to construct their chimney shafts so as to provide for



CENTRE OF MOULINS BRIDGE



CENTRE OF PLESSIS-LES-TOURS BRIDGE



BRIDGE IENA PARIS

EXAMPLES OF BRIDGE-CENTRES.

the proper draught without the necessary addition of six or eight feet to the height of the shaft in the shape of a zinc chimney top. That this can be done is proved by the three hundred Board Schools in London—not one of which, we believe, has any addition to the original chimneys as provided by the architect.

Having so fully dealt with the construction of the flue to determine a rapid up-draught, we have still to provide a ready access for the column of cold air which is really the effective motive power to the hot column of air in the chimney shaft. If the rooms to which the chimneys and hearths are fitted are themselves supplied with a suitable system of ventilation, such as Tobin's, by which the cold air obtains steady ingress to the room, no doubt a sufficient colum of cold air will be supplied by these means. There are, however, many rooms in an ordinary domestic household which are in themselves small and stuffy, and to which no proper appliances are used for the introduction of a steady current of cold air, and it will be found frequently that it is exactly these small and stuffy rooms which are most subjected to downdraughts in the chimney. These we consider to be caused almost entirely by the absence of a sufficiently regular supply of cold air to cause a driving medium to eject the hot air from the chimney. We would suggest that if ventilation into the room is apt to produce draughts sensible to those occupying it, that a smoky chimney may be often cured by the direct admission of cold air from the external wall to the hearth underneath the grate. We should in that way have direct communication between the external column of air and the hot ascending column of air in the chimney, and would undoubtedly have a rapid and effectual circulation or draught of air created up the chimney. This would by no means destroy ventilation from the body of air in the room, as such an ascending draught has a strong inductive effect.

We see also that too frequently the builders are careless with regard to the thickness of the walls forming the lining or side of the flue. It is not an unusual case to find that thickness to consist of only half a brick. This produces two very bad effects: First, it leads to a very considerable chilling or cooling of the ascending column of air, and therefore a partial destruction of the rapidity of the draught; secondly, it is a source of danger to the house itself, as very often the mortar in which the bricks are set is imperfect, and the pargeting is omitted in the interior of the flue, thus causing a very great radiation of heat from the surface of the chimney. If wood fittings, wooden beams, or the ends of joists are fitted into, or in close contact with the chimney breasts, which is too often the case, a great danger is run of accidental ignition, and many houses that are built in an old fashioned style for picturesque effects are sacrificed to that danger.

We have noticed several suggestions, amongst our contemporaties that it would be of great importance in the construction of chimneys for them to be lined with circular fireclay pipes. We do not see why the ordinary clay drain pipes would not answer amply well for the purpose, and consider the suggestion a very valuable one as offering the greatest protection against the radiation of heat, the proper and limited area for efficiency of draught, and at the same time the smooth glaze of the entire surface would prevent the deposition of soot, and greatly facilitate the cleaning operations of the sweep.—*The (London) Building and Engineering Times.*

A NEW WAY OF REMOVING A BLUFF.

The hydraulic machinery which has been brought to this city to be used in washing away the threatening bluffs which hang over the track of the Milwaukee road two miles west, was hut to a test yesterday. The best possible arrangements for undertaking the difficult work have been made. From the Worthington pump, which is considered the more powerful of the two on the boat, an 8-in. pipe extends up the bank to a height of about 60 feet, where it reaches the road-bed of the track. It then runs under the track nearly to the base of the bluff and terminates in a movable iron nozzle, with a 2-in. end. From the point where the nozzle is directed toward the bluff begins a sluiceway constructed of boards and about two feet deep. The sluiceway leads under the track, downward in a diagonal course to the river. The pipe through which the water rushes to the nozzle is well secured. The sluiceway is constructed on timber and is strongly braced. As the nozzle points toward the bluff, without the water rushing from its mouth and when the sluiceway is dry, there is nothing particularly curious or interesting in the machinery's appearance; but when the big boiler at the water below begins to puff, the powerful pump commences action, and the glittering stream shoots from the mouth of the nozzle with lightning speed, and, hardly spraying, strikes the bluff with terrific force, boring deep into earth and causing the dust to rise in clouds, some appreciation of the force of the water can be gained, Then, too, the practical result of the aqueous battering-ram's power is seen in the mass of mud which rushes through the sluice. Hundreds of tons of earth, made soluble melt away in an hour and are swiftly carried off through the apparently small board runway to the river below. When the pumps started yesterday afternoon it was just 2.30 o'clock. General Superintendent Clark, General Master Mechanic Lowrey, Assistant Master Mechanic Campbell and Division Superintendent Jackson were present, directing the movements of about thirty men who assisted the machinery in its workr. As spectators, fully fifty gentlemen from this city were also on hand, watching with great interest the action of the water on the bluff. Some way below J. M. Finch. of Milwaukee, who superintended the putting together of the hydraulic machinery, and Engineer Joseph Powell, of Yankton, waited for the signal to "set her going." Thr boiler showed 120 pounds of steam—a full head. The sluiceway was inspected and strengthened. S. Coleman, of this city, stood at the nozzle, clad in a rubber suit, while four assistants were near the nozzle, similarly protected from the water and ready with shovels and hoes to clear the sluice at its mouth from obstructing masses of turf or [illegible]. When all was ready the signal was given and the water began to rush through the pipe and pound away at the bank. In five minutes immense quantities of the dirt were melting and rushing through the sluice. The cutting was done in a scientific manner. First, the water was sent against the bluff sixty feet up, and holes bored to weaken its dry solidity. Then the boring began underneath, and the foundation of a mass of earth sixty feet high and ten feet thick by about fifty feet in width was dug away. All at once the big chunk gave way and with vast clouds of dust and much noise fell downward and toward the track. The plucky pipe-man and his assistants were the least disturbed by the slide and advance of the earth, but they had cause for alarm, as for an instant it looked as if a large part of the bluff would be affected by the movement of that detached and would break loose to sweep everything before it to the river. During the hour, while the crowd of visitors remained, a much larger quantity of earth was washed away than was expected when the work commenced, and the officials generally seemed to be satisfied that at last an effective way of conquering the dangerous bluff had been found. It being understood that General Superintendent J. T. Clark was the proposer of the hydraulic method of cutting away the bluff, and that principally through his efforts it has been brought to a practical test, he was briefly interviewed. He expressed himself much pleased with the result of the experiment as far as it had gone. He added that it was only an experiment, but that it looked to him as being much more effective than blasting and shoveling, while the ultimate expense would not be half so great. Just at that moment, as if to furnish him an example to illustrate by, a blast of giant powder was fired about 300 ft. down the track by two men who had been working two hours to put it in and get it ready to fiss. The quantity of dirt which came down was inconsiderable, and it did not need explanation to show that the blast only displaced the dirt, but did not move it. The advantage of the hydraulic over every other system is that the dirt is carried away as fast as washed down. The only difficulty in the way of carrying the work to a successful conclusion all along the line of the bluffs may be found in the places where the bluffs are very near the track and precipitous. The obstacle in that event is to carry away the earth as fast as it caves down. Some means of overcoming this may be found. At any rate, for the point of attack chosen at present, the hydraulic engine and the shooting stream of water seem to be about what is needed.—*The Sioux City Journal.*

THE OVERFLOW ON THE MISSISSIPPI RIVER.

This great river drains a watershed of 1,147,000 square miles, and has an annual downfall of eighty trillions (80,000,000,000,000) of cubic feet of water, and a drainage of twenty trillions cubic feet, which is a ratio of 25 per cent. of the downfall per annum.

New problems and new conditions present themselves to a large extent in this river on account of the immense area of land brought under cultivation, and of forest cut down, also from the gradual straightening of the river, which during the last hundred and sixty years has shortened its course 240 miles between Cairo and Orleans.

The annual rainfall on the watershed of the Mississippi and its tributaries would take the bed of the river, at the present rate of the current, three years to carry to the Gulf; or taking the ratio of 25 per cent. which is universally admitted, had it an average daily drainage, it takes nine months of the year at its maximum to carry off the immense volume of water. But when it is considered that the overflowed reservoirs on either side of the river, once filled, represent a volume of water nearly 50 miles in width and 12 feet deep from Cairo to New Orleans, or about twelve billions of cubic feet of water, which would take the maximum capacity of the Mississippi eighty-four days to carry away, even though it had no reinforcement constantly forced upon it above, it is conclusive that no system of levees below Red River, thus far constructed or proposed, can take away this yearly inland sea, having but 322 feet of fall from Cairo to the mouth of the Mississippi, and whose current is increased from ½ mile an hour at mediumstages to 3 miles per hour at flood stages.

Some other means must therefore be provided for the overflow above the maximum capacity of the river; and the Author asserts that the overflow has never been carried off by the Mississippi, and that its maximum capacity in time of floods never can be the medium or channel of the overflow at the flood-stage, without many years of labour and great expense in deepening the river-channel, and that the old natural channel or cut off *via* the Atchafalaya River should be the main channel of relief aided by the Placquemine Bayou to the Atchafalaya, and the Bonnet Carré to Lake Pontchartrain.

Over $100,000,000 (£20,833,333) has been expended in the construction of the Mississippi levees already; and during the last fifteen years over 100 miles of these have caved in, and been lost to owners and the country.—*Abst. from Trans. Am. Soc. C. E.*

Scientific.

THE VENTILATION OF THE ST. GOTHARD TUNNEL.

Epitome of a Report by Dr. STAPFF, Geologist of the Company.

In the number of the "Giornale del Genio Civile" for January 1880 appeared a paper upon Dr. Stapff's report upon the temperature of the rock in the St. Gothard tunnel. The present paper is an abstract of his report for 1881, which appeared in the last quarterly report of the Swiss Federal Council, and which deals with the temperature, humidity and ventilation, after the completion of the heading, and during the works for widening and lining the tunnel, and also with the rules which (founded upon the numerous observations taken during that time) show what currents of air may be anticipated in the working.

Temperature.—The currents of air at the entrances lower the temperature only through a portion of each half of the tunnel, while towards the central portion they have the effect of raising it. The southern end is generally warmer than the northern, owing to the external air being warmer at the south. The following figures show the gradual and absolute cooling throughout the tunnel. During the driving of the heading the mean temperature of the rock was 24°.43 Centigrade; on February 29th, 1880, after the heading was complete, the temperature of the air was 21°.69 Centigrade; on Febuary 11, 1881, it was 19°.30 Centigrade; and on Febuary 24th, 1882, it was 14°·15 Centigrade.

Humidity of the Air.—This, which has such an injurious effect on the workmen, is gradually diminishing, but is still considerable, particularly at the southern end.

Ventilation.—The natural ventilation depends upon the difference of the atmospheric pressure at the two ends, the temperature and the moisture. The current comes from the end at which the pressure is the greater, and its velocity increases with the square root of the difference of the pressures. The difference in level between the two ends (118 feet) increases or diminishes the velocity of the currant according as the internal air is lighter or heavier than the external, and as the current comes from the north or from the south, or *vice versâ*. The augmentation of volume of the air which enters the tunnel and becomes warmer interferes with the circulation, as also does friction.

If v represents the velocity of the air in metres per second; d' and d'' the weights of a cubic foot of air at the northern and southern ends; u a coefficient depending upon the resistance due to friction;

$$v = u\ 281.8 \sqrt{d - d'' + 0{\cdot}00032} \text{ for currents from the north;}$$

$$v = u\ 281.8 \sqrt{d' - d' - 0\ 00032} \text{ for those from the south.}$$

The figure 0 00032 is due to the difference in density of the air at the centre of the tunnel and that outside at the two ends. It is the mean of ten observations, and diminishes with the gradual cooling of the tunnel. The density of the air is calculated by the formula $d = \dfrac{0{\cdot}00171 \times b}{1 \times 0{\cdot}00367\ t}$ where t is the temperature and b the height of the barometer at the centre of the entrance. The value of u has been ascertained to be 0.0796 by means of a series of experiments, during which it was found that the passage of trains seriously affected it.

The Author then proceeds to show that very slight atmospheric differences at the two ends suffice to alter the direction of the currents through the tunnel, and he gives tables showing from observation and calculation what would have been the direction and velocity of the current at different times throughout the year 1881 had the tunnel been complete, and from these tables he concludes that in that case the maximum velocities would have been from 10.88 feet to 14.27 per second, or a mean of 12.30. and the minimum velocities (after deducting the changes in direction) from 0.00 to 4 feet, or a mean of 2 feet per second.

If the question of ventilation could be decided by averages it would be seen that even in the worst case there would be a current of 4 feet per second, which would clear the tunnel of smoke (if no trains were running) in three and a quarter hours, so that, to ensure complete ventilation, it would only be necessary so to time the trains that there would be once in every twenty-four hours an interval of three and a quarter hours between them.

Unfortunately, however, at each change in the direction of the current there is a period when the air is at rest, and though generally these changes in the direction occur only at intervals of several days, and do not seriously interfere with the ventilation, there are times when they occur at such frequent intervals, that it may be anticipated that the current may be arrested for four days at a time; and here the question of the necessity of artificial venstlation arises. The Author gives the number of trains passing through daily, the amount of coal and of oxygen consumed, and of carbonic acid and carbonic oxide produced, the cubic capacity of the tunnel, and the percentage of noxious gases which would be contained in the air after four days' working with no natural current, and he concludes that the air would by that time be insupportable. He thinks, however, that such a state of things could not occur more than once a year, and might be avoided altogether by stopping some of the luggage trains at such times. He considers that it would be foolish to provide a costly method of artificial ventilation, which would be absolutely useless except upon these rare occasions. He is, however, of opinion that compressed air should always be available for the benefit of the workmen by means of cocks placed at intervals upon pipes running through the tunnel, and that a supply of drinking water should also be provided. The editor adds in a note that steps have been taken to provide air and water for the workmen.

EDISON ELECTRIC LIGHT FITTINGS.

The Edison generators are shunt wound, that is, the coils of the field magnets are excited from a derived circuit branching from the poles of the armature, and hence they are to a certain extent self regulating. But the regulation is far from perfect, and when any considerable proportion of the lamps are turned out, say 20 per cent, there is a marked increase in the brilliancy of the remainder, and the current passing through them attains an intensity, which if allowed to continue would shorten the life of the filament. To prevent this a regulator is supplied with each installation, and this requires to be adjusted rfom time to time when the variations of a pilot light or the deflections of a galvanometer indicate that the difference of potential between the poles differs from the normal. This regulator (see p. 308, Fig. 1) consists of a box

EDISON ELECTRIC LIGHT FITTINGS.

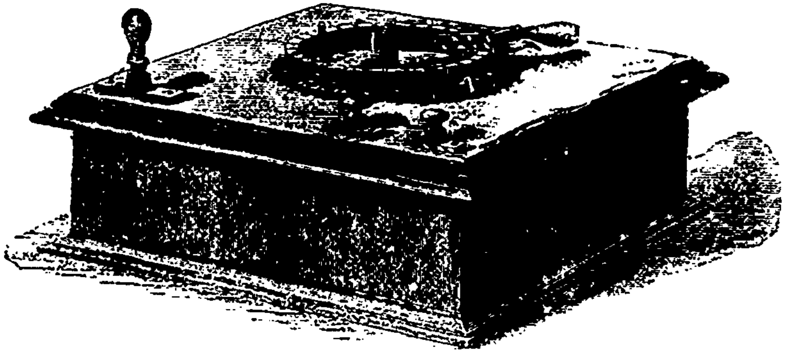


Fig. 1. Resistance box.

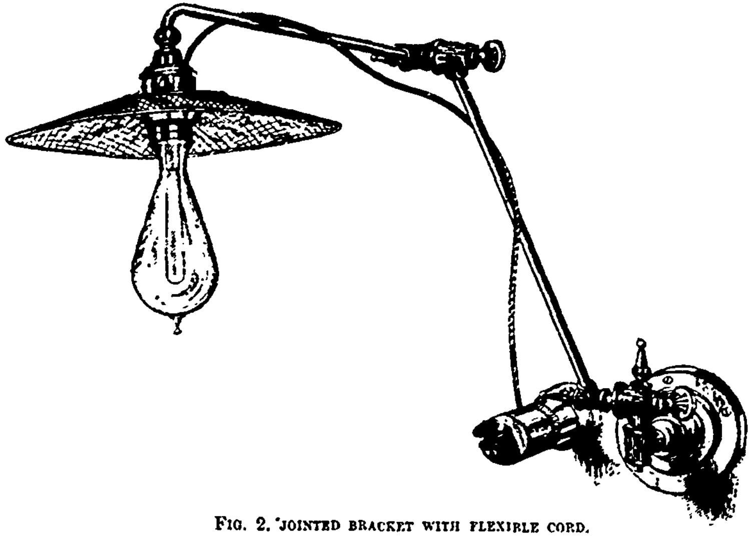


Fig. 2. Jointed bracket with flexible cord.

Fig. 3. Epergne with four lamps.

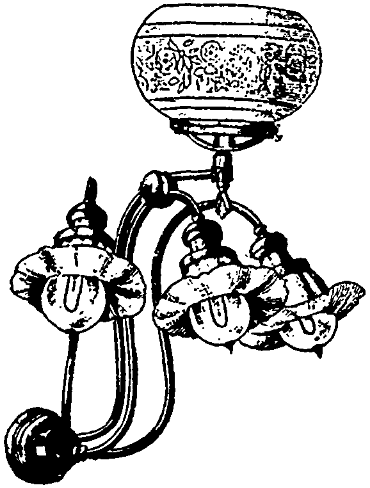


Fig. 4. Combined electric and gas bracket.

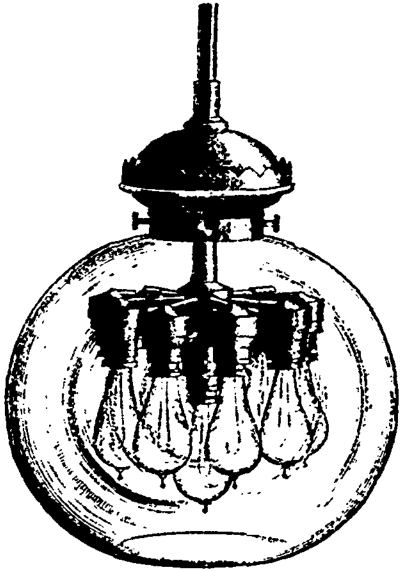


Fig. 5. Group of ten lamps.

of resistance coils joined up in series, and so arranged that by the movement of the handle any number of them can be included in the field magnet circuit, and so add to its electrical resistance, causing a corresponding decrease in the current flowing through it, and consequently reducing the intensity of the magnetic field. From the junction between each adjacent pair of coils a conductor is led to a contact piece on the top of the box, just as in a Gramme ring a wire connects the coupling piece of each pair of bobbins to the commutator. The commencement of the first coil is connected to the first contact piece, and the end of the last coil to the last contact piece. The positive conductor from the pole of the armature is coupled also to the first contact piece, and the conductor leading to the coils is joined to the spindle upon which the handle turns. Thus when the handle is at zero the current passes through it from the first contact piece without traversing any of the resistance coils; when it is (say) 90 deg. one-fourth of the coils are included in the circuit and the current must circulate through them before it can reach the handle and proceed to the magnets.

In this country the use of self-regulating generators is gradually displacing devices of this kind, but in theatres and places of amusement where many graduations of illumination are required, they will probably always be used. Fig. 4 illustrates a combined electric and gas bracket as erected in the Bijou Theatre, Boston, U.S.A., by the Edison Company for Isolated Lighting. The state of nervous apprehension which has been developed in large audiences by the fearful disasters which have occurred in theatres during the last few years, has rendered them peculiarly liable to panic, and there are but few cases where electric light installations are so organized that total extension is an impossibility. Therefore, as managers naturally decline to place entire dependence upon electricity, the Edison Company has boldly faced the situation and has brought out a fitting which admits of the use of both illuminants, either of which can be turned up or down with equal facility.

Figs. 2, 3, and 5, page 309, are illustrations of three other varieties of electric light fittings used by the Edison Company for Isolated Lighting. Fig. 2 shows an inexpensive form of jointed bracket with shade. The joints are mechanical not electrical, the current being carried by a flexible cord, and they are provided with thumb-screws by which they can be set in any position, a very convenient provision, as it allows of the use of long branches. In designing such fittings there is much greater scope than in gas brackets, for, although it is both unhealthy and dangerous to bring a gas flame down to a level of the table, an incandescent lamp may be placed in the most convenient position which can be found, provided the direct rays are screened from the eye. Fig. 2 shows an epergne with four lamps, the design representing four luminous flowers, set in a bouquet of metal work. Fig. 5 is a bell fitting of 10 lamps, the whole enclosed in large globe to protect them from dust and injury.

EVOLUTION OF THE STETHOSCOPE.

By Samuel Wilks, M.D., F.R.S.,

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Instead of placing on the table every imaginary form of stethoscope manufactured out of every possible material gathered from the shops of the instrument-makers, I will carry you back to the origin of the stethoscope, and you will see how, on the principle of selection and the survival of the fittest, the primitive instruments have departed from the scene and are now only to be found among the fossilized curiosities, the relics of former ages, on the antiquated shelves of some very old medical practitioner. The stethoscope, as you know, was invented by Laennec. He relates how in the year 1816 he happened to recollect the well-known fact in acoustics of solid bodies conveying sound, and he goes on to say: "Immediately on this suggestion I rolled a quire of paper into a kind of cylinder and applied one end of it to the region of the heart and the other to my ear, and was not a little surprised and pleased to find that I could thereby perceive the action of the heart in a manner much more clear than by the application of the ear... The first instrument which I used was a cylinder of paper formed of three quires completely rolled together and kept in shape by paste." Laennec then goes on to describe how he copied this roll of paper in wood, metals, glass and other substances, and finally he says: "In consequence of these various experiments I now employ a cylinder of wood an inch and a half in diameter and a foot long, perforated longitudinally by a bore three lines wide and hollowed out into a funnel-shape to the depth of an inch and a half at one of the extremities. It is divided into two portions, partly for the convenience of carriage and partly to permit its being used of half the usual length. The instrument in this form—that is, with the funnel-shaped extremity—is used in exploring the respiration and rattle; when applied to the exploration of the heart and the voice, it is converted into a simple tube with thick sides, by inserting into its excavated extremity a stopper or plug traversed by a small aperture and accurately adjusted to the excavation. The instrument I have denominated the *stethoscope*."

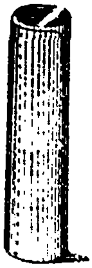


Fig. 1.

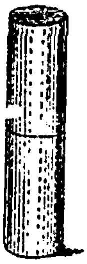


Fig. 2.


Fig. 3.

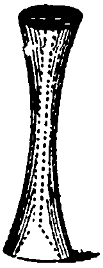


Fig. 4.

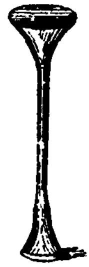


Fig. 5.


Fig. 6.

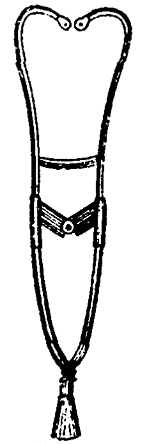


Fig. 7.

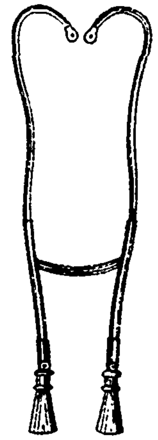


Fig. 8.

Fig. 1, page 309, represent Laennec's roll of paper, and Figs. 2 and 3 the copy of this in wood as he describes. The latter figure is drawn from an instrument kindly given me by Dr. Galton, of Norwood, being the stethoscope long used by his father. It does not separate into two pieces, but contains the plug which can be removed so as to leave the end hollow. Fig. 4 is the same instrument with the sides cut out to make it lighter and more elegant, the ear-piece being the same as before, and the mouth also hollowed out. This was *the stethoscope* used and recommended by the late Dr. Hughes. By making the instrument still more elegant and slender we have the modern stethoscope in endless variety; as in Fig. 5. It is thus very evident how the modern instrument has been framed out of the original block of wood which was made the counterpart of Laennec's roll of paper.

I know not who invented the instruments with flexible tubes, but I have no doubt that a search into medical history could tell us. I remember, however, that the first flexible stethoscope which I ever saw was the one depicted in Fig. 6, and used by Dr. Golding Bird when he saw out-patients in the year 1843. *Being much crippled with rheumatism, and therefore not wishing to rise from his chair, he found this instru-*

ment very convenient, he also was enabled to pass the ear-piece to gentlemen standing near him, while he held the cup on the part to be examined. I always thought it was his own invention. But, whether so or not, I do not think any great effort of genius was required to frame a flexible instrument, and then adapt it for the use of one or two ears. This being done, the next step would be to make two mouth-pieces to apply to the chest at different spots. Various modifications of these instruments have been made of late years, but the first notice of them I have any knowledge of in my reading is to be found in a letter to the "Lancet" of August 29, 1829, by Mr. Comins, of Edinburgh, headed "A Flexible Stethoscope." This was only twelve years after Laennec's invention. It is difficult from his description to picture the instrument, but it seems to have been composed of jointed tubes, and made for two ears as well as one. Mr. Comins expresses his surprise that the discoverer of mediate auscultation did not suggest a flexible instrument, as he says "it can be used in the highest ranks of society without offending fastidious delicacy."

A very interesting fact was first pointed out to me by Dr. Andrew Clark, with respect to a peculiarity of the binaural in the objective appreciation of sounds; that if each ear-piece be separately used, and any sound be made near the mouth-piece, it is heard in the ear itself, but, if the two pieces are employed together, the sound is heard at the spot where it is produced. The fact is very interesting in a physiological point of view, and further corroborates the theory as to the value of a double set of senses, or, in a word, of the body being made up of two halves, for just as the two hands feeling different parts of an object gain an idea of extension, and the two eyes by obtaining different views of any substance get a knowledge of its solidity, so in the same way the two ears listening to the same sound more thoroughly appreciate its objectivity.

If you look at this series of drawings you may perceive but little resemblance between the first figure and the last, but take them one by one and you will see that the figures are really progressive. My story of development is not imaginary, but historical.—*Lancet.*

Notes of a Course of Lectures on Electricity and Magnetism.

By Prof. W. Garnett.

INTRODUCTORY.

N. B.—These lectures were delivered in connection with the Cambridge University extension system of higher education.

It was noticed at a very early date that amber when rubbed had the power of attracting light bodies. Thales, of Miletus, mentioned this property about B.C. 600, and it is also referred to by Theophrastus and Pliny. The shocks of the Torpedo were mentioned by Pliny (A.D. 70) and by Aristotle.

Dr. Gilbert, of Colchester, Physician to Queen Elizabeth, may be regarded as the founder of the science of Electricity. He found that a very large number of bodies could be excited by friction so as to attract other bodies; but that a second very large class, including the metals, could not be excited. He divided all bodies into the two classes of *electrics*, or bodies which could be excited by friction, and *non-electrics*, or bodies which could not be so excited.

Robert Boyle found that some bodies retained their electrification for a long time after the friction which excited it had ceased. He added several other bodies to Gilbert's list of *electrics*.

Otto von Guericke, about the middle of the seventeenth century, constructed the first electric machine by mounting a ball of sulphur on an axis, and causing it to rotate against the friction exerted by the hand. He noticed the light which accompanied the electric discharge, and also observed that when a light body was attracted by an electrified body, and came in contact with it, it was afterwards repelled. He also discovered electric *induction*, by observing that certain bodies placed near to strongly electrified bodies acquired the same powers of attraction as the electrified bodies themselves.

Sir Isaac Newton was the first to employ a glass globe in place of the sulphur globe of Von Guericke. A machine similar to that of Newton was afterwards employed by Hawksbee.

Stephen Gray, in 1729, discovered that some bodies had the power of conducting electrification through their substance, while others did not allow of its transmission. He succeeded in conducting electricity to a distance of 886 feet by means of pack-thread supported by silk loops.

Desaguliers shewed that Gilbert's *electrics* were those bodies which had not the power of conducting electricity, while all conductors were *non-electrics.* About the same time Dufay found that all bodies could be electrified by friction if supported on insulating stands. This established the true distinction between the so-called electrics and non-electrics. *Conductors* cannot be electrified by friction unless supported on insulating stands, because the electrification escapes to the earth as soon as generated. *Non-conductors*, or *insulators*, on the other hand, retain the electrification which has been imparted to them. The division of bodies into *electrics* and *non-electrics* consequently gave place to the division into *conductors* and *non conductors.*

Dufay also observed the dual character of electrification, and called that kind of electrification which is generally excited upon glass *vitreous*, while that which is excited upon resin, amber, sealing-wax, etc., he called *resinous*. Gray, Hawksbee, and Dr. Wall, all noticed a similarity between the electric discharge and thunder and lightning.

In the early part of the eighteenth century, Boze, of Wittenberg, added the prime conductor to the electric machine; Winkler, of Leipsic, employed a cushion instead of the hand for the excitation of the glass; and Gordon, of Erfurt, a Scotch Benedictine Monk, replaced Newton's globe by a glass cylinder.

The Leyden Jar, which serves for the accumulation of large charges of electricity, appears to have been accidentally discovered by Cuneus, a pupil of Muschenbroeck, of Leyden, about 1745. Cuneus was attempting to electrify water which was contained in a phial held in his hand, the connection between the electric machine and the water being made by a nail which passed through the cork. On touching the nail with the other hand after charging the water, he experienced a severe shock. The present form of the Leyden Jar is due to Sir William Watson, who enunciated the germ of the one fluid theory of electricity as now held.

In June, 1752, Franklin succeeded in collecting electricity from thunder clouds by means of his kite. In August, 1753, Professor Richman, of St. Petersburg, was killed by discharge from an iron rod which he had erected to collect electricity from the clouds.

Canton, in 1753, found that *ground* glass received resinous electricity when rubbed with flannel, and that generally the character of the electrification depends on the nature of the rubber as well as of the body rubbed.

Symmer enunciated the two-fluid theory of electricity, maintaining that there are two electric fluids, which when present in equal quantities neutralise one another, and that a body positively electrified has an excess of positive or vitreous electricity, while a body is negatively electrified because it has an excess of negative or resinous electricity.

Cavendish and Œpinus independently completed the one-fluid theory of Franklin, and Cavendish shewed that electricity behaves in many respects like a perfectly incompressible fluid. He compared the resistance offered by different conductors to the flow of electricity, and obtained results which were astonishingly accurate, considering the apparatus he employed. He measured resistance by comparing the shocks which he experienced on discharging a Leyden jar through his own body. Cavendish also established the law that the attraction or repulsion exerted between two charges of electricity varies inversely as the square of the distance between them, by the most conclusive experiment with which we are acquainted.

In 1790 Galvani discovered the muscular contractions produced in a frog's legs when dissimilar metals are put in contact with the sciatic nerve and gastrocnemius muscle and then made to touch one another. Volta in 1800 constructed the Voltaic pile, and in 1807 Davy obtained the metals of the alkalies by electrolysis.

In 1820 Oersted discovered the effects of an electric current on a magnet, and thus invented the galvanometer . and immediately afterwards Ampère developed the laws of electro-magnetic action by a simple but complete set of experiments which have not since been improved upon. In the same year in which Oersted made his discovery Arago and Davy independently discovered the power of an electric current to magnetise iron, and thus provided us with the electro-magnet.

To avoid the loss of power due to *polarization* which was experienced in the older batteries, Daniell in 1836 invented the *constant* battery known by his name, and this battery continues the most constant of any which have found their way into general use. Grove's battery was invented at the same time, and is used where very great currents are required. In 1840 Smee adopted the artifice of coating silver plates with platinum deposited upon them so as to form a rough surface. This diminishes the accumulation of hydrogen, but does not *prevent* polarisation.

In 1833 Faraday announced the law of electro chemical equivalents as applied to electrolysis, and thus provided a method of measuring the total amount of electricity conveyed by a current in any time. This method has recently been applied to the measurement of quantities of electricity employed in electric lighting.

In 1822 Seebeck discovered that when two different metals are joined in a closed circuit and the junctions unequally heated, there is generally a current set up in the circuit. In 1834 Peltier showed that when a current passes from one metal to another the junction is generally heated when the current passes in one direction, and cooled when it passes in the opposite direction. Sir Wm. Thomson in 1856 shewed that when a current passes along a metal bar, the temperature of which changes continuously from end to end, there is in some cases a heating and in others a cooling effect produced, which is independent of the resistance of the bar.

In 1827 G. S. Ohm enunciated the law of electrical resistance which is known by his name, and which states that the current produced in any conductor is always proportional to the electro-motive force urging it.

Joule, in 1841, published the result of his investigations on the heat generated in conductors by the passage of an electric current, and showed that the heat generated was equivalent to the work done by the battery or other source of the current, thus supplying another example of the principle of the conservation of energy.

In 1824 Arago performed his celebrated experiment, in which he showed that a magnet suspended freely over a rotating copper disc tended to follow the disc in its rotation. This was the first experiment on the induction of currents, but its explanation remained a mystery until Faraday discovered the induction of currents in 1831.

Faraday (1831 and 1832) found that whenever the number of magnetic lines of force passing through a conducting circuit is changed, there is an electric current induced in the circuit. This is the principle of all the so-called dynamo or dynamo-magneto-electric machines now employed in electric lighting and the transmission of power.

Lenz, in 1833, enunciated the law known by his name, which enables us to deduce the direction of the current induced by any motion of conductors in a magnetic field, from the laws of Ampère respecting the mechanical force exerted upon a conductor conveying a current.

In 1861-2, Maxwell published his electro-magnetic theory of light, according to which the same medium serves for the transmission of light, and of all electric, magnetic, and electro-magnetic actions.

RÉSUMÉ OF MECHANICAL PRINCIPLES.

At the threshold of physical science we find ourselves face to face with at least three primary conceptions, or quantities which cannot be defined in terms of anything simpler than themselves. They are time, length, and mass.

Each of these quantities, like all others, must be measured by comparison with a unit of its own kind. The unit of time invariably adopted for scientific purposes is the *second of the mean solar time.*

The British unit of length is the imperial standard yard. One third of this length, or the foot, is the unit generally employed by engineers. The metric unit of length is the metre, which is subdivided into 10 decimetres, 100 centimetres, and 1,000 millimetres. The centimetre is the unit of length generally adopted by electricians. The metre is equal to 39·370432 English inches, and the centimetre is therefore equal to ·39370432 inch, or nearly ·03281 of a foot. A centimetre may be roughly regarded as about two-fifths of an inch, and the millimetre is about 1/25th of an inch.

The British unit of mass is the imperial standard pound avoirdupoids. The standard itself is a mass of platinum, and is defined by the Act which gave it authority as the only standard of *weight.* It is clear, however, that the object of authorizing a standard for commercial purposes is to provide a unit in terms of which quantities of material may be measured, and it is an accident that weight is generally taken advantage of for making the comparison. The pound ought, therefore, to be regarded as the unit of mass, not of weight. This is further indicated by the fact that the weight of a pound is different in different latitudes and at different altitudes, while its mass remains invariable, so that if a material standard were adopted as a unit of *weight*, that is, of *force*, it would have to be varied whenever it is moved from place to place, and would only remain the standard so long as it is kept in the same place.

The metric unit of mass is the kilogramme, but the gramme, which is one thousandth of the kilogramme, is the unit generally adopted for scientific purposes. The gramme is approximately equal to the mass of a cubic centimetre of distilled water at the temperature corresponding to its maximum density. It is equal to about 15·43234874 grains, or ·0022046212 lb. avoirdupois.

Every person is supposed to be provided with the requisite means for measuring time, length, and mass, and when the measurement of any other physical quantity can be reduced to the determination of these three fundamental quantities, it may be regarded as completed, at least theoretically. When any quantity is measured in terms of the fundamental units of time, length, and mass only, it is said to be expressed in *absolute* measure. It will be one of our objects in these lectures to show that all electrical quantities may be expressed in terms of the second, the centimetre, and the gramme, or in terms of any other set of fundamental units. The system, which is based on the centimetre, gramme, and second, is called the C.G.S. system of units.

Geometry is the science which deals with pure space. If we consider space and time together we enter on the subject of kinematics. When we introduce the notion of mass as well as space and time we have dynamics. Thus dynamics must be regarded as the basis of all physical science.

Except when otherwise stated, we shall confine ourselves to the units of the C.G.S. system and the practical units derived from them.

DEF. Velocity is the degree of quickness with which anything is moving. The unit of velocity is the velocity of a point which traverses the unit of length in the unit of time. Hence our unit of velocity will be a centimetre per second. The measure of the velocity of any point moving uniformly will then be equal to the number of centimetres passed over by it in the course of a second.

DEF. Acceleration is the rate of increase of velocity. The unit of acceleration is that of a point whose velocity is increased by unity in the unit of time, or by one centimetre per second in each second, so that the measure of a uniform acceleration is equal to the number of units of velocity added in the unit of time.

DEF. The momentum of a body is the product of its mass and its velocity. The C.G.S. unit of momentum is that of a gramme moving at the rate of a centimetre per second.

When we pass from the consideration of pure kinematics to that of the motion of material bodies, we must have recourse to observation and experiment. Newton summed up the results of such observations and experiments in three brief statements, called the *Laws of Motion*. These, like other physical laws, must be regarded simply as concise statements of the results of experience.

LAW I. *A body under the action of no external force will remain at rest or continue to move uniformly in a straight line.*

Hence we deduce the definition of force, viz. :—

Force is that which changes or tends to change a body's state of rest or motion.

The first law of motion thus furnishes a *qualitative* definition of force. The second law gives its *quantitave* measure.

LAW II. *Rate of change of momentum is proportional to the impressed force, and takes place in the direction in which that force acts.*

A force is, therefore, proportional to the change of momentum it produces in the unit of time. If we take as unit force that force which produces the unit of momentum in the unit of time, the measure of any force will be equal to the number of units of momentum which it generates in the unit of time. The C.G.S. unit of force is that force which acting on a gramme for a second produces in it a velocity of a centimetre per second, and is called a *dyne*.

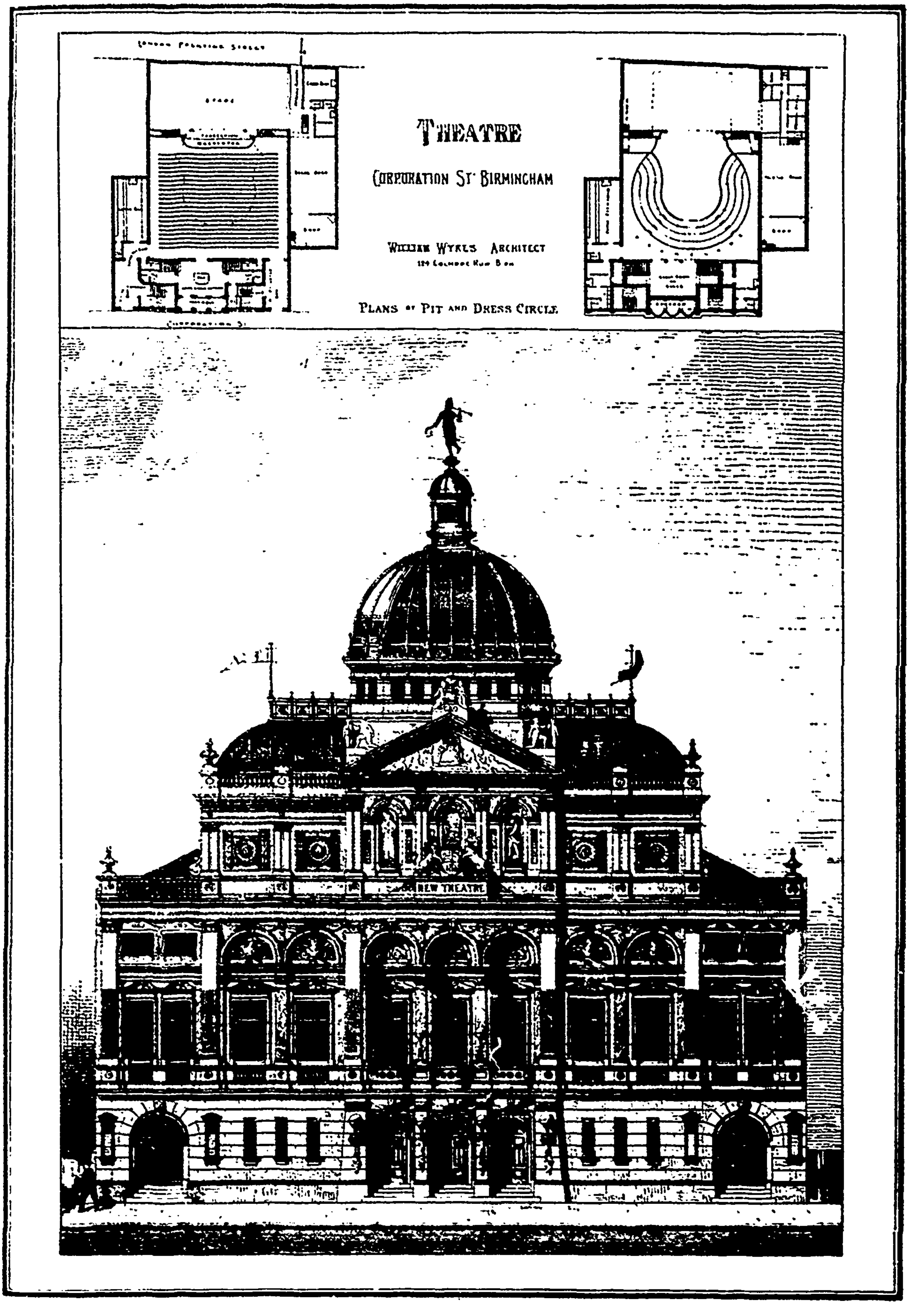
DEF. A force is said to do work when it moves its point of application in its own direction, or an agent is said to do work when it overcomes resistance.

The work done is proportional to the product of the force and the distance through which its moves its point of application in its own direction, or proportional to the product of the resistance overcome and the distance through which it is overcome. If the force act vertically, and the body be moved along an incline, in estimating the work done we must measure only the vertical height through which the body is raised or falls, and generally, in whatever direction the force acts, the displacement must be measured in that direction. If the body moves in the *sense* in which the force acts, work is done *by the force*, but if it be made to move in the opposite *sense*, work is done *against the force*. The unit of work is the work done by the unit of force in moving its point of application over the unit of length. The C.G.S. unit of work is the work done by a dyne in moving its point of application over a centimetre, and is called an *erg*.

The weight of some particular body, such as the unit of mass, is sometimes taken as the unit of force, and is called a *gravitation* unit. The objection to such a unit is that it varies in different localities, being about one-half per cent. less near the equator than near the poles. If the weight of a pound be taken as the unit of force, the unit of work will be the work done in lifting a pound one foot high against gravity, and this is called a foot-pound. It is equal to about 13,560,000 ergs.

DEF. The power of an agent is the rate at which it can work. The unit of power is that of an agent which can do the unit of work in the unit of time. The C.G.S. unit of power is that of an agent which can do one erg in one second, and one erg per second is the C.G.S. unit rate of doing work.

DEF. An agent which can perform 33,000 foot-pounds of work in one minute, or 550 foot-pounds in one second, is said to be of *one horse-power*. The horse-power is equal to about 7,458,000,000 C.G.S.


THEATRE
Corporation St Birmingham
William Wykes Architect
124 Colmore Row B'ham
Plans of Pit and Dress Circle
Stage
Corporation St
NEW THEATRE

units of power. Thus, an agent of one horse power can do 7,458,000,000 ergs per second, and we can always determine the H.-P. at which any agent is working by dividing the number of ergs done in a second by 7,458,000,000, or, with sufficient accuracy for most purposes, by dividing by 7,460,000,000. The rate of doing work equivalent to 10,000,000 ergs per second is called a *watt*.

(*To be Continued.*)

THE ADMIXTURE OF LESS VALUABLE INGREDIENTS WITH PORTLAND CEMENT.

(*Transaction of the German Association of Cement makers, March*, 1883.

It had been already laid down as a proposition, at a previous meeting of the Association, that the sale of cement containing an admixture of foreign ingredients, added after the burning, was a fraud on the consumer, leaving out of the question how far the quality of the cement was impaired by such additions. A large number of makers had agreed to this decision (though others, secretly or openly, resisted it), and steps were taken to enfore its general acceptance throughout the trade. Apart from the moral considerations of fair dealing, the authorities of the Association felt bound to investigate whether or not the addition of silicates, ground slag, and other materials, had an injurious effect on Portland cement, and they therefore caused enquiry to be made as follows:—(*a*) Concerning the influence on the quality of the cement of such additions being made during or after the burning; and (*b*) The discovery of some simple tests to indicate with certainty the existence of impurities in the cement. Various members of the Association conducted experiments bearing upon these points, and some of the results laid before the meeting were of much importance. Mr. Dyckerhoff undertook the following tests to prove the influence of various mixtures upon the quality of such cement:—(*a*) An examination of the strength of pure cement, and of cement mixed with powdered slag, limestone, lime and fine sand. (*b*) Of mixtures of slacked lime and sand, to which powdered slag, trass, and ultramarine were added. (*c*) Of mixtures of cement with trass and ultramarine. (*d*) Of cement lime-mortar, where the cement is pure or mixed with powdered slag. Tables are given of the breaking weights of test briquettes of samples of these different mixtures in various proportions; the tests were mainly made after twenty-eight days, but some samples were kept for half a year before being broken. The general results proved that, with the sole exception of ultramarine, all such addition to Portland cement impaired its strength.

Other investigations of a similar nature were undertaken by Drs. Herzog and Delbrueck, and Messrs. Bernoully and Heyn, Dr. Herzog made three series of experiments; the first intended to demonstrate the effect of various proportions of powdered slag, the second the influence of plaster of Paris upon mixtures of cement and ground slag, and the third the special relations which exist between the ground slag and the plaster. From the first series of experiments he arrived at similar conclusions to those of Dyckerhoff, namely, that all additions of ground slag are injurious to the strength of the cement, and that the reduction in strength is directly proportionate to the amount of slag employed. The result of the second series of tests proved that the addition of plaster of Paris improved the quality of cement mixed with slag, but that the amount which could be so used with safety varied with each particular mixture, and that a maximum limit was soon reached. The third set of experiments indicated that in order to obtain the best results, the amount of plaster used must be proportionately increased in accordance with the quantity of ground slag employed.

The experiments undertaken by Dr. Delbrueck proved that the results of the admixture of foreign ingredients depended mainly on the fineness with which the cement was ground, or the extent to which the added material lent itself to improve the mere physical qualities of the mixture, in point of adhesion and cohesion. If to a cement, which is a mixture, in certain proportions, of fine and coarse particles, a foreign material in a very fine state of subdivision is added, the result may be, owing to the more complete filling up of the interstices between the cement particles, that a denser, and therefore a stronger, mortar is formed. This points to the fact that normal sand, or one from which all the finer grains have been removed, is likely to give unreliable results when employed with adulterated cements. From a second set of tests Dr. Delbrueck proved that a mixture of finely-powdered slag had a corresponding effect on the cement mortar to that which would result from the addition to the mortar of an increased amount of sand; and the same held good with other materials used for degrading the cement. Mr. Bournoully arrived at identical conclusions from a set of independent tests, and he found also that plaster of Paris had a beneficial effect. He noticed that the cement to which ground slag had been added required more than the standard volume of 10 per cent. of water on making from it the normal test-briquettes. Mr. Heyn's experiments were partly favourable, partly adverse to the addition of slag; they tended to prove that particular qualities of ground slag had, in some cases, a beneficial effect on certain kinds of cement. Mr. Blankenstein pointed out that mixtures of cement and powdered slag gave bad results when used for stucco. In addition to the facts adverse to adulteration, the instances in favor of this precedure are noticed. One firm have, they state, for years blended their cement with certain quantities of selected silicate of lime and other minerals, with the effect of considerably improving its strength.

With respect to the investigation of methods for detecting the use of adulterating materials, Dr. Schumann states that the specific gravity of genuine, pure Portland cement never sinks below 3·11 whereas, out of seventeen adulterated cements examined by him, not one attained to this amount. Many plans were presented to the authorities for ascertaining the presence of ground slag, both quantitatively and qualitatively, but they deemed it expedient to withhold their publication, as if simple means were pointed for indicating the existence of this class of adulterants, fraudulent manufacturers would merely be induced to seek for other materials for sophistication. It came to the knowledge of the meeting that adulteration was not only undertaken by the manufacturers, but that the middlemen and dealers were also answerable for this practice, and that in some cases samples of cement had been met with which contained, no less than 50 per cent. of foreign ingredients. As the result of the debate, the following six articles were adopted by the meeting:—

1. Portland cement is a material resulting from an intimate admixture of lime and clay, as its essential components, calcined to incipient vitrification and reduced to a fine powder.

2. Every product formed in a different way, or to which foreign ingredients are added during or after the calcination, is not to be considered as Portland cement. This is not, however to exclude the addition of not more than 2 per cent., of plaster of Paris.

3. The sale of cements, containing no admixture of foreign foreign materials, under the designation of Portland cement is therefore to be considered as a fraud on the consumer.

4. Good Portland cement is not improved by the admixture of foreign ingredients; as, for instance, silicates of lime (powdered blast furnace slag, &c.), trass, ground clay-shales, limestones, &c.

But even if, in certain cases, it were possible to adduce results showing that an improvement could be effected by such mixtures, the manufacturer is not to be allowed to adopt them, because the consumer has no means of so far checking the amount and the quality of such additions as to be able to protect himself against abuses.

5. Every addition to the cement is to be regarded as the commencement of its employment for mortar, and can therefore never be considered to be the business of the manufacturer, but must be undertaken by the consumer.

6. As the normal test, at the period when it was adopted, was introduced for the testing of Portland cement, unmixed with foreign ingredients, and, as the specific character of Portland cement is changed by such mixtures, the normal tests cannot be employed for the comparison of adulterated with unmixed or pure cements.—*Tr. Ins. C. E.*

G. R. R.

THE COLOURED CURTAIN IN THE EYE.

BY WILLIAM ACKROYD.

This ring like curtain in the eye, of grey, green, bluish-green, brown, and other colours, is one among the very many remarkable contrivances of the organic world. The eye cannot bear too much light entering into it, and the coloured curtain so regulates its own movements that too much light cannot enter the eye. The dark circular aperture in the centre, known as the pupil, is consequently for ever altering its size; on a bright sunshiny day, out in the open, it may be only the size of a pin's head, but at night, when there is no light stronger than starlight, it is even bigger than a pea.

This coloured ring curtain is fixed at its outer edge, and its inner edge expands or contracts so readily and, apparently, so easily, preserving its circular outline all the while, that it is quite provoking to the inventor, who has been trying to invent movable "stops" or "diaphragms" for years, and after all his labour cannot even approach it in perfection, and his despair is complete when he learns that the movements of this eye-curtain are automatic and quite independent of the will.

It is unlike the ordinary window-blind, which is generally of a rectangular shape, and is drawn up or let down according to the amount of light entering the room. The eye-curtain or iris is of ring-shape, and possesses a wonderful power of expanding itself so as to diminish the area of the pupil, and of shrinking in, so as to enlarge the area of the pupil. Its movements may be watched in a variety of ways, some of which we shall describe.

The common way of watching the movements of the iris is to regard it closely in a looking-glass while the amount of light entering the eye is varied. Place yourself before a looking-glass and with your face to the window. Probaby the iris will *be expanded, and there will only be a very small opening or* pupil in the centre. Now shut one eye suddenly, while narrowly watching the other in the glass all the time. At the moment the light is cut off from one eye, the iris of the other contracts or is drawn up so as to enlarge the pupil. This shows that there is a remarkable independence between the curtain of the two eyes, as well as that they are affected by variations in the quantity of light falling on them.

Perhaps one of the most interesting ways of watching the movements of these sympathetic eye-curtains is one which may be followed while you are out walking on the streets these dark winter nights. A gas lamp seen at a distance is comparatively speaking, a point of light, with bars of light emanating from it in many directions. These bars, which give the peculiar spoked appearance to a star, are probably formed by optical defects of the lens within the eye, or by the tear-fluid on the exterior surface of the eye, or by a combination of all these causes. Be that as it may, the length of the spokes of light are limited by the inner margin of the eye curtain; if the curtain be drawn up, then the spokes are long; if the curtain be let down, or, in other words, if the pupil be very small and contracted, then one cannot see any spokes at all. Hence, as I look at a distant gas-light, with its radiating golden spokes, I am looking at something which will give me a sure indication of any movements of the eye-curtains. I strike a match, and allow its light to fall into the eyes; the spokes of the distant gas-lamp have retreated into the point of flame as if by magic; as I take the burning away from before my eyes, the spokes of the gas-lamp venture forth again. The experiment may be utilized to see how much light is required to move the window-curtains of the eyes. Suppose you are walking towards a couple of gas-lamps, A and B; B about fifty yards behind A. Then, if you steadfastly look at B and at the golden spokes apparently issuing from it, you may make these spokes a test of how soon the light of A will move your ires. As you gradually approach A you come at last to a position where its light is strong enough to make the spokes of B begin to shorten; a little nearer still and they vanish altogether. I have found that about a third of the light which is competent to contract the pupil very markedly will serve to commence its movement.—*Knowledge.*

Inventions and Miscellaneous Notes.

A New Photometer.—Sir John Conroy has devised an improvement in Ritchie's photometer. The whitened screens are no longer placed so as to meet in a line and form a closed angle. One projects beyond the other, and the eye sees the inside of the projecting part, and the outside of the part of the other screen which is inclined to it. The light of two sources placed on either side of the screens illuminates both surfaces to an equal degree, which is told by the eye. A blackened box *encloses both screens. The results would seem to show that* this way of arranging the screens is preferable to the old plan.

FACULTY OF APPLIED SCIENCE, McGILL UNIVERSITY.

SESSION 1883-84.

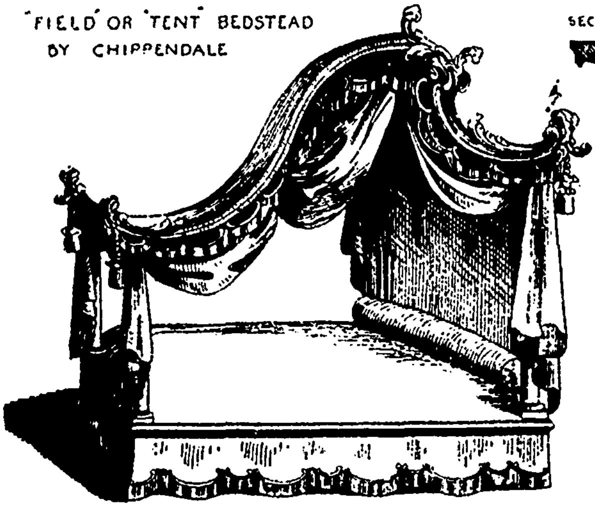
The Matriculation examinations in Applied Science have resulted in the admission of an unusually large number of students in Engineering and Practical Chemistry. Of the 63 students now in the Faculty, a considerable proportion are from various parts of Ontario and the Maritime Provinces, a gratifying proof that this Faculty is in no danger of losing its reputation as the leading Engineering School of Canada.

The $50 Exhibition for Applied Mechanics was awarded to C. B. Smith, fourth year. The mathematical prizes for students of the second, third, and fourth years were awarded respectively to J. G. G. Kerry, H. V. Thompson, and C. B. Smith. In the examinations for second and fourth year prizes A. W. Strong and David Ogilvy deserve particular mention as having obtained marks which were but little below those of the winners of the prizes. The competition for the Scott Exhibition of $66 also very close and the decision of the examiners will be made known in a few days. The Jeffrey Burland Exhibiton will also be awarded shortly.

To Determine the Heating Power of Coal.—In determining the heating power of coal and other combustibles, an apparatus is now employed, consisting of a cylindrical vessel of copper, punctured below with numerous small holes and to the top of which is attached a hollow tube of the same material, closed with a stop cock; a small vessel of the same form to contain the materials, and a basal piece in which to fit it. In practice a weighed portion of the finely powdered combustible, is intimately mixed in the mortar with a certain quantity of nitrate and chlorate of potassa, and this mixture is next placed in the small copper cylinder, and ignited with a fuse of known dimensions. Before the combustion place, the outer cylinder is slid down over it, being held there by springs attached to the basal piece, the whole contrivance being then plunged into a vessel containing a quantity of water of known temperature. The combustion soon sets in, continuing with vigor until the material has burned completely out. The instant the combustion has ceased, the stop cock in the tube is turned, and the water allowed to enter the air chamber, to cool down the heated interior; the temperature of the water is now observed. From these data it is easy to calculate the results, making allowance for the slight loss occa*sioned by the impossibility of bringing the apparatus back to* its first temperature—owing to the increased temperature of the water—and the very small losses by radiation and conduction.

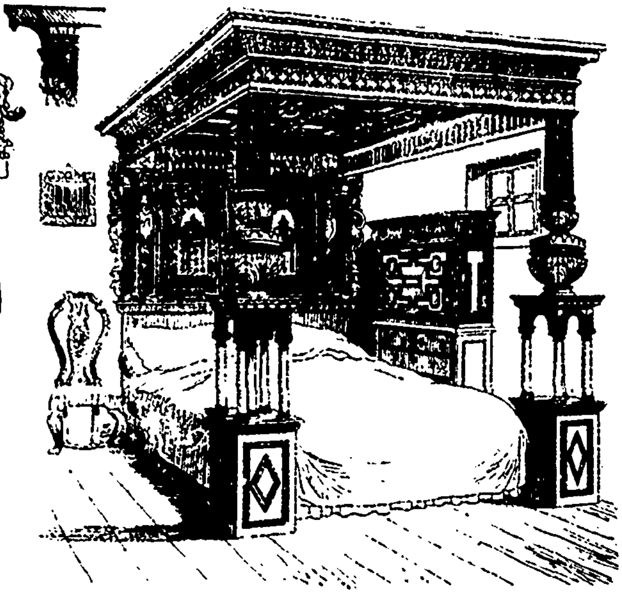
How to Recognize Good Wood.—Rankine says that there are certain appearances characteristic of good wood, to what class soever it belongs. In the same species of wood that specimen will in general be the strongest and most durable which has grown the slowest, as shown by the narrowness of the annular rings. The cellular tissue, as seen in the medullary rays (when visible), should be hard and compact. The vascular or fibrous tissue should adhere firmly together, and should show no wooliness at a freshly cut surface; nor should it clog the teeth of the saw with loose fibers. If the wood is colored, darkness of color is in general a sign of strength and durability. The freshly cut surface of the wood should be firm and shining, and should have somewhat of a translucent appearance. In wood of a given species the heavy specimens are in general the stronger and the more lasting. Among the resinous woods, those having the least resin in their pores, and among non-resinous woods those which have least sap or gum in them, are in general the strongest and most lasting. Timber should be free from such blemishes as "clefts," or cracks radiating from the center; "cup shakes," or cracks which partially separate one layer from another; "upsets," where the fibers have been crippled by compression; "wind galls," or wounds in a layer of wood, which have been covered and concealed by the growth of subsequent layers over them; *and hollow or spongy places in the centre or elsewhere,* indicating the commencement of decay.

"FIELD" OR "TENT" BEDSTEAD
BY CHIPPENDALE



SECTION OF CORNICE

REIGN OF QUEEN ELIZABETH

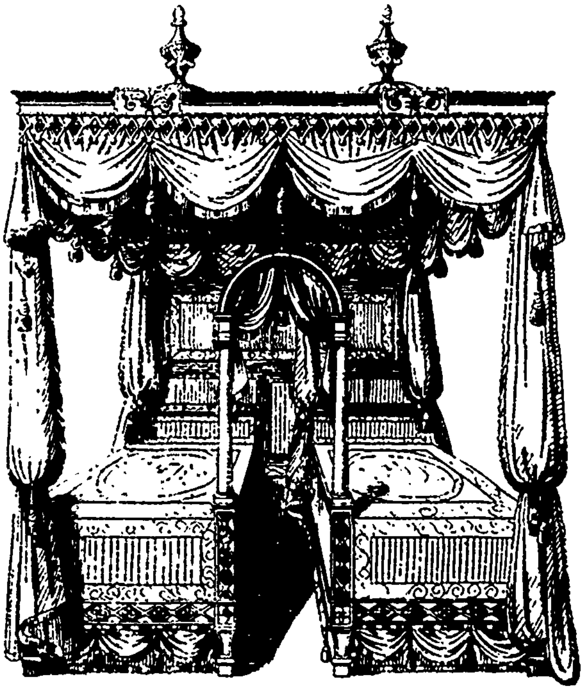


THE GREAT BED FROM WARE

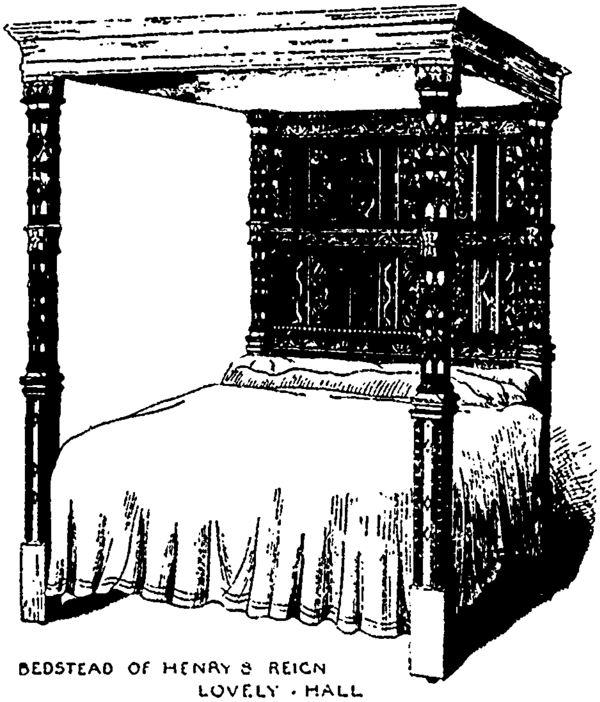
KING SOLOMONS BED
·12TH CENTURY M S
STRASBOURG

RESTORED BED
FROM 10TH CENT
M S BIBLE, BY
VIOLLET·LE·DUC.

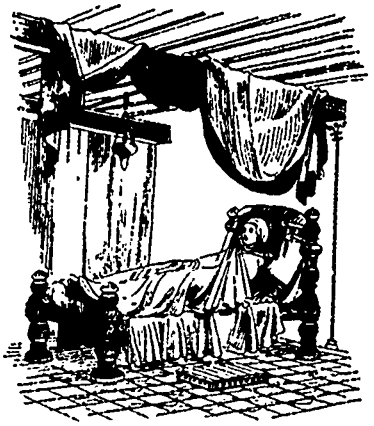
XIV CENT M·S VIGNETTE
"MIRACLES DE NOTRE DAME" SOISSONS



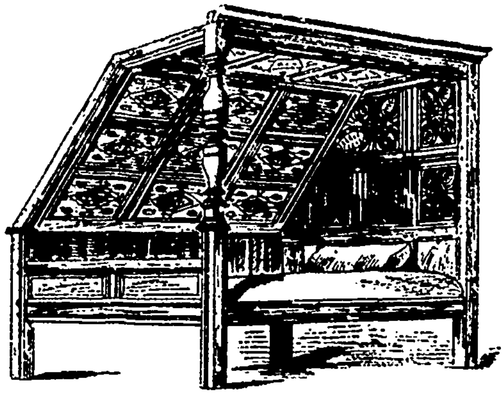
A SUMMER BED IN TWO COMPARTMENTS.
BY SHERATON 1792



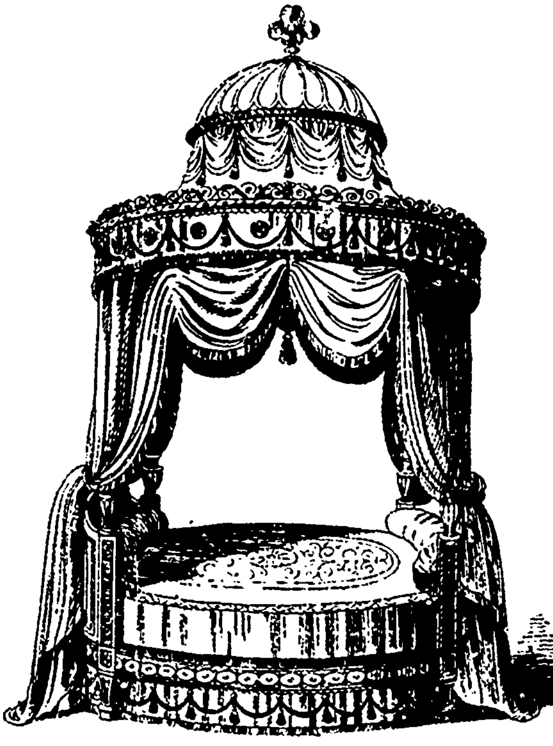
BEDSTEAD OF HENRY 8 REIGN
LOVELY · HALL
MAURICE B ADAMS DEL
BLACKBURN



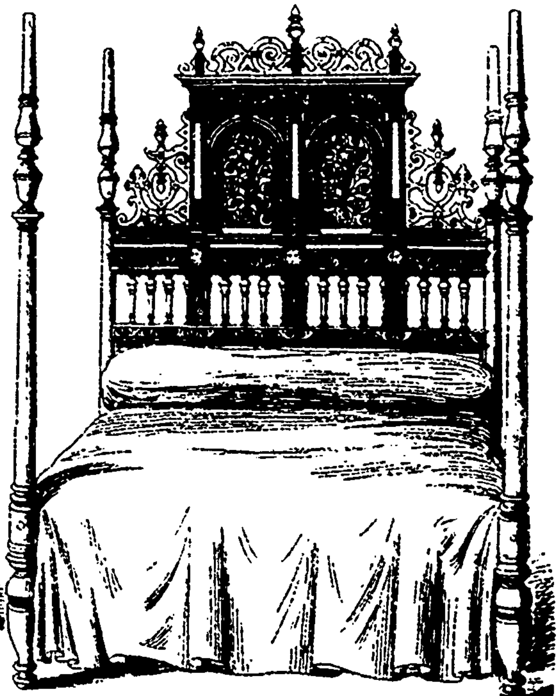
12TH CENTURY BEDSTEAD FROM
MS MONT-SAINT-MICHEL



CANTED ROOF BED STEAD
AT TABLEY OLD HALL CHESHIRE



AN ELIPTIC BED FOR A SINGLE LADY
BY SHERATON 1793



BEDSTEAD TIME OF JAMES I FROM
GOODRICH COURT HEREFORD

A SCALE FOR HARDNESS FOR METALS.

The Author describes a scale of hardness in use in the laboratory of the Technical High School at Prague, composed of the following eighteen metallic substances, arranged in ascending order from the softest to the hardest.

1. Pure soft lead.
2. Pure tin.
3. Pure hard lead.
4. Pure annealed copper.
5. Cast fine copper.
6. Soft bearing metal (copper, 85 ; tin, 10 ; zinc, 5).
7. Cast iron (annealed).
8. Fibrous wrought iron.
9. Fine-grained light grey cast iron.
10. Strengthened cast iron (melted with 10 per cent. of wrought turnings).
11. Soft ingot iron, with 0·15 per cent. carbon (will not harden).
12. Steel, with 0·45 per cent. carbon (not hardened).
13. Steel, with 0·96 per cent. carbon (not hardened).
14. Crucible cast steel, hardened and tempered, blue.
15. Crucible steel hardened and tempered, violet to orange yellow.
16. Crucible steel, hardened and tempered, straw yellow.
17. Hard bearing-metal, copper, 83 ; zinc, 17.)
18. Crubible steel, glass hard.

The test is made by drawing a cylindrical piece with a conical point along a polished surface of the metal to be tested. In the case described, that of a bronze used for the cross-head guide of a locomotive, the point, when loaded with five kilograms, was drawn six times through a distance of 3 centimetres. Under these conditions the points of the number below 5 in the scale were blunted without marking the surface ; with Nos. 5 and 5 neither point nor surface was abraded ; but No. 7 while being slightly worn on the point, began to scratch the surface. The hardness was therefore that of pure copper or soft bronze. The absolute tensile resistance was found to be 2051·7 kilograms per square centimetre, while that of copper is 1920 kilograms per square centimetre and that of the bronze, No. 6, is 2300 per square centimetre, thus showing an intimate relation between the strength and hardness of similar metallic compounds.

◆

THE VALUE OF METALS.—Following are the names of those metals valued at over $1,000 an avoirdupois pound, the figures given representing the value per pound :

Vanadium—A white metal discovered in 1830, $10,000.

Rubidium—An alkaline metal, so-called from exhibiting dark red lines in the spectrum analysis, $9,070.

Zirconium—A metal obtained from the minerals zircon and hyacinth, in the form of a black powder, $7,200.

Lithium—An alkanine metal, the lightest metal known, $7,000.

Glucinum—A metal in the form of a grayish black powder, $5,400.

Calcium—The metallic base of lime, $4,500.

Strontium—A malleable metal of a yellowish color, $4,200.

Terbium—Obtained from the mineral gadolinite, found in Sweden, $4,080.

Yttrium—Discovered in 1828, is of a grayish black color, and its lustre perfectly metallic, $4,080.

Erbium—A metal found associated with yttrium, $3,400.

Cerium—A metal of high specific gravity, a grayish white color, and a lamellar texture, $3,400.

Didymium.—A metal found associated with cericum, $3,200.

Ruthenium—Of a gray color, very hard and brittle ; extracted from the ores of platinum, $2,400.

Rhodium—Of a white color and metallic lustre, and extremely hard and brittle. It requires the strongest heat that can be produced by a wind furnace for its fusion, $2,300.

Niobium—Previously named columbium, first discovered in an ore found at New London, Conn., $2,300.

Barium—The metallic base of baryta, $1,800.

Palladium—A metal discovered in 1803, and found in very small grains, of a steel gray color and fibrous structure, $1,400.

Osmium—A brittle, gray-colored metal, found with platinum, $1,300.

Iridium—Found native as an alloy with osmium in lead gray scales, and is the heaviest of known substances, $1,090. —*American Inventor.*

HOW CELLULOID BILLIARD BALLS ARE MANUFACTURED.—The manufacture of billiard balls from celluloid and bonsilate is a peculiar industry, and is, according to an American contemporary, confined to the city of Albany, N. Y. A large proportion of the balls now made are of celluloid, but only for the reason that the machinery is not as well adapted to the manufacture of bonsilate balls. The time will come, however, when all balls will be made of the latter material. The celluloid, which is received in large, white sheets, is first cut into small square pieces about five-eighths of an in inch in size. These are placed in moulds, previously heated by steam to the proper temperature. They are then placed in the hydraulic presses, and with a pressure of from 1,500 lb. to 2,000 lb. to the square inch, are roughly moulded, heat being applied at the same time. The various positions of the blocks in the mould give the ball the peculiar mottled appearance when finished. Experiments have been made by grinding the celluloid to a powder, and using it in that form, but nothing has succeeded so well as the present method. After being taken from the moulds, the balls are turned absolutely spherical by an ingenious device. The processes in the manufacture of bonsilate balls are quite different in many respects. The material is placed in the moulds in powder, and the balls, after being roughly pressed up, considerably larger than the required size, are covered with rubber and tinfoil, to prevent the material from being injured by water, and are then placed under water pressure. By means of this, the balls are placed under a pressure of from 3,000 lb. to 4,000 lb. to the square inch. The water touching the ball at every point, and the pressure being equally transmitted, the result is a perfectly pressed sphere, of just the same specific gravity in one spot as in another. Without this apparatus the successful manufacture of billiards balls from bonsilate would have been impossible. A simple but ingenious contrivance is also employed to ascertain when the balls are perfectly poised or balanced. They are first weighed, and are then placed in a flat dish of mercury. This subtle fluid detects the slightest shade of inaccuracy, and the balls are put in the lathe and corrected until they are absolutely true. Not only billiard, put pool and bagatelle balls are also thus made.

FELT HOUSES.—An officer in the German cavalry has invented a form of transportable dwelling, which he considers will do much to obviate the inconveniences of bivouacs and the dangers to health often resulting from them. These houses are made of felt, impregnated with substances which render them impervious to water. The idea is intended to apply specially to hospital tents and the larger kinds of such dwellings. In addition to being watertight, these tents are cool in hot weather, and, to some extent, are able to moderate a severely cold temperature. They can be packed into a few comparatively small boxes, and ventilation is duly provided for. They resist hurricanes better than linen tents. Their erection and removal is very simple, and their cost is said to be small in comparison with that of linen tents. They have been permanently introduced into the Danish army. The *Vossische Zeitung* says that leading medical authorities have approved of them.

THE CHANNEL TUNNEL. — *Le Moniteur Industriel* advises the protection of the Channel Tunnel by means of water, as a precaution to be adopted at the French end, equally with the English, and which ought to secure both nations from any fear of invasion. The system proposed is :—A small intermediary basin, somewhat inland, with communication which can be opened and closed between the sea on the one hand and the tunnel on the other ; a steam engine, rotary pump, pulsometer, etc., for pumping the water in and out. The admission of 176,000 gallons of water would render the tunnel impassable, without destroying the apparatus for illumination, telegraphy, etc., which it would contain, and could be extracted when the danger was over, without excessive expenditure of time and money.

SILVERING GLASS.—Professor Palmieri has devised a process for silvering glass by means of the reducing action on the salts of silver, which is said to have the advantage of producing a very brilliant metallic deposit. When into a ammoniacal solution of nitrate of silver is poured, first a little caustic potash, and then a few drops of glycerine, the reduction begins at once ; and this action is accelerated if ether or alcohol be added to the mixture. A moderate heat and darkness are said to increase the brilliancy of the precipitate, and darkness also favours the adhesion to the mirror of the deposits.

AN ELECTRIC THERMOMETER.

M. Becquerel has been engaged during the winter in experiments, the object of which was to ascertain whether snow had the effect of protecting the ground from frost. In carrying out these experiments, he pressed electricity into his service in a most ingenious manner. Before describing his apparatus, we may, however, state that the result of his experiments were as follows: That a covering of snow does not protect the soil and seed from freezing, but only hinders to a certain degree the too extensive radiation of heat from the soil, and is converted into water at thirty-two degrees, which sinks into the earth and somewhat raises its temperature. Also, that a heavy sod does more to protect the soil and raise its temperature than ever so thick a layer of snow. The experiments were carried out in the Jardin des Plantes, Paris, and in the following manner. Two covered wires of unlike metals—copper and iron—were soldered together at both ends, which were left uncovered for this purpose; otherwise they were covered their whole lengh, for the purpose of insulation, with gutta percha and silk. On the soldered ends of these double wires being exposed to different temperatures, a current is generated in them, and the greater the difference in temperatures, the stronger the current; but the current ceases when both are exposed to the same temperature. This electric current was caused to act on a magnetic needle suspended so as to move freely over a graduated circle. The copper wire formed a vertical frame around the needle parallel to its normal direction. As long as both ends of the double wire are at the same temperature, the needle continues to point to the north, being subject only to the earth's magnetism; but as soon as there is any variation in temperature, the needle is sure to move instantly and take another position which it will keep until some other change of temperature takes place; The application of this apparatus to the measurement of soil temperatures was made as follows: One of the soldered joints was buried in the earth to a depth at which it was desired to take the temperature, and the other end was put in a water bath at any desired distance from the first. The temperature of the latter could be increased or diminished at pleasure, and was measured by a very sensitive thermometer. To ascertain the temperature in the soil where the other end was buried, it was only necessary to raise or lower the temperature of the water bath until the magnetic needle stood at zero, and then read the thermometer.—

NOTES ON THE CRIMINAL STATISTICS FOR THE YEAR 1880-1.

The accompanying table of criminal statistics is reprinted from the blue-book recently issued by the Department of Agriculture for the Dominion of Canada, and seems of sufficient importance to deserve notice in our columns, especially as there are one or two points of interest that its results suggest. The sum total of convictions for offences, *viz.*, 29,225, is further subdivided into offences falling into the following classes:

1. Offences against the person, such as murder, assault, stabbing, etc.,	4,353.
2. Offences against property with violence,	144
3. do. without violence,	2,094.
4. Malicious offences against property,	499.
5. Forgery and offences against the currency,	35.
6. Other offences not included,	22,100.

In class six, by far the largest count in the indictment, the headings are as follows:—

Breaches of liquor laws,	1,747.
Vagrancy,	2,082.
Drunkenness,	9,575.
Breaches of Municipal Acts and By-laws,	2,563.
Riot and breaches of the Peace,	2,820.

It would be an interesting point to discover to what extent the immoderate use of liquor is chargeable with the offences registered, but upon this point the figures given are unhappily all but useless. It would have been a valuable addition to the table if the number of crimes committed under the *temporary* influence of

	Ontario.	Quebec.	Nova Scotia.	New Brunswick.	Prince Edward Island.	British Columbia.	Manitoba.	N. W. Territories.	TOTAL OF CANADA.
TOTAL CONVICTIONS......	17,110	6,430	1,590	1,859	527	451	1,054	204	29,225
RESIDENCE.—Cities and Towns........	8,572	5,115	1,374	1,487	354	316	757	3	17,978
Rural Districts..........	1.781	624	130	228	107	42	263	200	3,375
OCCUPATIONS.—Agricultural..........	663	163	37	96	63	7	79	3	1,111
Commercial..........	1,091	1,821	307	341	73	101	102	12	3,848
Domestic............	1,167	372	110	96	28	21	82	6	1,882
Industrial...........	2,432	1,133	305	350	77	50	101	12	4,460
Professional..........	142	74	49	19	5	3	24	14	320
Labourers...........	4,124	1,619	397	684	189	199	370	128	7,700
CONJUGAL STATE.—Married..........	4,694	2,518	461	493	146	53	337	28	8,710
Widowed.........	579	411	42	72	11	9	8	....	1,132
Single...........	5,442	3,349	1,000	1,202	297	370	671	161	12,492
EDUCATIONAL STATUS.—Illiterate......	1,558	1,944	415	310	154	215	255	11	4,862
Elementary....	8,463	3,919	1,078	1,455	297	198	650	168	16,228
Superior......	144	91	12	11	3	3	16	8	288
USE OF LIQUORS.—Moderate..........	3,838	2,305	1,054	339	105	124	283	131	8,179
Immoderate........	6,879	2,905	451	1,433	345	302	709	49	13,073
PLACE OF BIRTH. British Isles. England and Wales	1,370	345	110	65	12	71	56	2	2,031
Ireland..........	2,432	828	133	251	16	65	135	10	3,870
Scotland..........	603	163	76	23	3	11	61	....	940
Canada............	5,477	4,486	1,063	1,328	418	197	577	139	13,685
United States.......	754	157	42	51	6	33	137	15	1,195
Foreign............	169	193	33	44	1	44	55	12	551
Other Brit. Possessions	16	29	44	11	2	7	....	....	109
RELIGIONS.—Baptists..............	251	7	91	182	14	2	16	5	568
R. Catholics............	4,140	5,335	764	990	272	135	443	80	12,159
Church of England......	1,586	226	205	218	43	79	261	11	2,629
Methodists...........	1,137	34	50	127	36	26	67	8	1,485
Presbyterians..........	1,268	72	106	129	79	19	118	33	1,824

liquor had been included. Upon this point, however, it is silent.

It has often been attempted to prove by statistics the influence of education upon crime, but here again any conclusion must be misleading. Those possessed of merely elementary education—a very vague term—would naturally be the greater proportion of the population, and we have no statistics with which to compare the present figures under this head. But besides this, it is a notorious fact that a preponderating share of the offences committed by persons of comparatively high educational status, such as embezzlement, breach of trust, etc., never find a place among the total of convictions, as they are compromised by lawyers, or trial is evaded by flight. It is more instructive to compare the present statistics with the figures given by the late census (1880-81). By comparing these together we arrive at the following results:

1. The proportion of criminal offences to population, expressed in percentages:

Ontario	.89
Quebec	.47
Nova Scotia	.36
New Brunswick . . .	.58
Prince Edward Island .	.49
British Columbia	.91
Manitoba	1.51
Territories	.36
Dom. of Canada . . .	.67

We, in Quebec, should feel stronger grounds for congratulating ourselves on the comparatively low percentage of crime shown (.47) by these results, if we could be sure that the numbers given in the census of population represented the actual number of residents in our province, and were not swelled by absentees in the States and other provinces.

2. The proportion of criminal offences to the Religions, expressed in percentages:

Baptists . . .	0.19
Roman Catholics . .	0.67
Church of England .	0.48
Methodists . .	0.20
Presbyterians . .	0.21

3. The number of criminal offences as compared with the statistics given as to place of birth, expressed in percentages:

PLACES OF BIRTH.

England . .	1.19
Ireland . .	2.08
Scotland . .	.81
Canada . . .	.36
United States . .	1.53

The total of convictions throughout the Dominion for 1880-81 *viz.*, 29,225 is about one thousand greater than the total for the preceding year, *viz.*, 28,209.

R. W. B.

PROCEEDINGS OF SOCIETIES.

American Society of Civil Engineers, Sept. 5th, 1883.—The Society met at 8 p.m., Vice-President Wm. H. Paine in the Chair, John Bogart, Secretary.

The death of the following named members was announced, Col. F. U. Farquhar, Corps of Engineers U. S. A. who died July 3rd, 1883; and Mr. R. J. Brough, of Toronto, Canada, who died July 21st, 1883.

The following elections were announced.

As Fellows: John Lawler, Prairie du Chien, Wis.; Albert Conro, Milwaukee, Wis.; Alexander Mitchell, Milwaukee, Wis.; D. L. Wells, Milwaukee, Wis.; Chas. L. Colby, Milwaukee, Wis.; E. P. Allis, Milwaukee, Wis.; F. de. Garay, Mexico.

As Members: Andrew Bell, Carillon, Canada; Henry I. Bliss, La Crosse, Wis.; Wm. W. Card, Pittsburgh, Pa.; Frank C. Doran, Richmond, Ind.; George Downe, Ranwick, Sydney, New South Wales, Australia; Christopher L. Gates, Milwaukee, Wis.; Wm. H. Jennings, Columbus, Ohio; Albon P. Man, jr., St Louis, Mo.; Daniel McCool, Marquette, Mich.; Wallace McGrath, Parkersburg, W., Va.; John L. P. O'Hanly, Ottawa, Canada; Geo. W. Polk, San Antonio, Tex.; Watson W. Rich, St Paul, Minn.; Leonard W. Rundlett, St. Paul, Minn.; Edward H. Williams, Philadelphia, Pa.

As Associates: Joseph P. Card, St. Louis, Mo.; Geo. F. Swain, Boston, Mass.

As Juniors: George B. Francis, Portland, Oregon; Alfred W. Trotter, New York City; Fred. N. Willson, Princeton, N. J.; Herbert M. Wilson, New York City.

A paper by James L. Randolph, member of the Society, and Ch. Eng. Balt and Ohio R. R. upon "Vibration, or the Effect of Passing Trains on Iron Bridges, Masonry and other Structures" was then read. Mr. Randolph refers to the fact that double-track bridges are moved in the direction of passing trains, and are consequently twisted, and strains are produced not provided for. Also that cattle stops and open culverts where built of rubble work have the walls shaken to pieces by vibration.

The remedy he has supplied for these culverts and stops has been to build them of large stone as nearly the same size as possible. The tall, thin bridge piers and abutments on which iron bridges rest have their stone so much disarranged by vibration as to make it necessary to secure them with timber and iron straps. Iron bridges resting on stone pedestals vibrate in this manner, and receive a return blow from the vibration of the pedestal, particularly if the pedestal is a light structure, but as the iron and the stone do not vibrate in the same period, there must be times when the result is a movement in the direction of the force. The effect of this vibration has been particularly noticeable at the Harper's Ferry bridge where there was a movement of four inches in four years. After the insertion of planks between the stone and iron, this movement ceased. Where the masonry of piers has a platform of timber between its foundation and solid rock, no displacement of stone has been noticed. Mr. Randolph contends that a monolith would be the best support for structures subject to vibration caused by strains, but that a monolith of the specific gravity of granite would give a damaging return blow. Timber would answer the purpose, but is perishable. The material which in his opinion is most serviceable is an artificial stone which is about ¾ the weight of granite, is compact, durable, and with very little elasticity.

The paper was discussed by Messrs. Theodore Cooper, Chas. E. Emery, H. D. Blunden, and Wm. H. Paine.

Sept. 19th, 1883.—The Society met at 8 p.m. Vice-President Wm. A. Paine in the Chair, John Bogart, Secretary.

A discussion by Mr. Charles Douglas Fox, of London, Corresponding Member of the Society "On the Increased Efficiency of Railways" was read by the Secretary.

Mr. Fox referred to the fact that English railway managers and engineers, have long realized the importance and economy of a thoroughly substantial road bed. The formation widths of their chief railways are now made 30 feet both in cuttings and embankments for the double lines, and very great care is taken to thoroughly drain this formation in cuttings by deep ditches on each side, with earthenware drain pipes in them, and fill in with broken stone or other dry material. The ballast, consisting of broken stone, clean gravel, coarse sand, burnt clay or ashes, is not allowed to be less than one foot in thickness below the bottom of the tie. For lines of constant and heavy traffic, the bull-head grade, double-headed rail, having a large top member for wear, and a very small bottom member is found to be the best section for steel rails. The weight of these rails is 84 pounds per yard. The chairs are from 40 to 46 pounds each and the rails are secured in them by keys of compressed oak. The tendency of the English companies is to expedite traffic both passenger and goods not by higher rates of speed, but by reducing the number of stoppages. The traffic lines are gradually quadruplicating their track, in some cases throughout, in others by sidings several miles in length. There is a very general feeling in England in favour of identifying the driver with his engine, and holding him responsible for its working. On some lines the name of the driver is conspicuously attached to the engine. Mr. Fox forwarded also the railway regulation of the English Board of Trade, which give very minute directions in reference to the construction and running of railways.

A paper by Mr. Wm. Howard White, M. Am. Soc. C.E. was also read upon the subject of "Railroad Bridge Floors." Mr. White advocates inside guard rails for the purpose of preventing, as far as possible, serious results from the derailment of wheels.

His reasons for advocating the inside guard rail are that he considers them more efficient for the same height above the tie than the outside guard; that they can be placed so as to hold the wheel nearer the rail, particularly, when the use of the snow plough is considered; that they can be more strongly secured at the ends for the purpose of drawing derailed wheels towards the rail, or to secure the ditching of a car which has gone too far to be safely drawn back; that they are more economical. He considers that the ties should have five inches of clear distance between them.

The papers were discussed by Messrs. Wm. H. Paine, Cooper, Blunden and Bogart.

October 3rd, 1883. The Society met at 8 p.m. Director Geo. S. Greene, jr., in the chair, John Bogart, Secretary.

The following candidates were elected members: — Charles E. H. Campbell, Council Bluffs, Ia.; George A. Marr, St. Paul, Minn.; Charles J. A. Morris, St. Paul, Minn.; Andrew Rosewater, Omaha, Neb.: Frank S. Stevens, Albany, N.Y.; Henry R. Towne, Stamford, Conn.; Frederick W. Watkins, New York City.

The death on Sept. 22nd, 1883, was announced of Mr. Geo. D. Ansley, Member of the Society, City Surveyor, Montreal, Canada.

The death of Mr. S. S. Montague, Chief Engineer Central Pacific of California was also announced, and remarks were made by Mr. R. L. Harris in reference to the engineering career of Mr. Montague.