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NEW BOOKS.

The Materials of Engineering in Three Parts. Part III. By Robert H. Thurston, A.M. C.E. (New York: John Wiley & Sons. Montreal: Dawson Bro's.

Parts I and II. of this valuable and important work have already been noticed in the pages of this magazine, and Part III. the volume now before us, does not fall below the high standard of merit attained by the first two parts. It deals with non-ferrous metals and alloys such as copper, tin, zinc, brass, bronze, &c., opening with the history and characteristics of the metals and their alloys, which is more or less a repetition of the introduction to Part II.

Chap. II. deals in detail with the history, distribution, qualities, uses and manufacture of copper, zinc, lead, bismuth, nickel, and their respective ores, of aluminum, mercury, platinum, magnesium, arsenic, iridium, manganese, and the rarer metals. It concludes with an article on the market prices of the various metals referred to. In Chapter III. the author discusses the properties of the alloys, and, begins by giving the following resume of the results of his investigations as to their characteristics :—

"Alloys, being composed of metallic bodies, possess all the physical and chemical characteristics of metals; they have the metallic lustre, are more or less ductile, malleable, elastic and sonorous, and conduct heat and electricity with remarkable facility. In retaining these properties, however, the compound is so modified in some of its qualities, that it often does not resemble either of its constituents, and might consequently be regarded as a new metal having characteristics peculiar to itself, This is especially the case with those which are used in the arts. It would almost seem there is no department of the arts requiring the use of metals for which an alloy may not be prepared possessing all the requisite qualities, when these are not found in the original metals. The physical properties of an alloy are often quite different from those of its constituent metals. Thus copper and tin mixed in certain proportions, form a sonorous bell-metal, possessing properties in which both metals are deficient; in another proportion, they form speculum metal, which is as brittle as glass, while both of the constituent metals are ductile. It is impossible to predict from the character of lead metals what will be the character of an alloy formed from given proportions of each. In most cases, however, it will be found that the hardness, tenacity and fusibility will be greater than the mean of the same proportion as the constituents, and sometimes greater than in either, while the ductilty is usually less, and the specific gravity is sometimes greater and sometimes less. Thi colour is not always dependent upon the colours of the constituent metals, as is shown by the brilliant white of speculum metal which contain 67 % of copper. Chapter IV. treats of the bronzes, chapter VI. of the kalchoids and miscellaneous alloys, and Chapter VII. of the manufacture and working of the alloys. In Chapters VIII. to XIV. the author gives an instructive discussion of the strength and elasticity of the non-ferrous metals and the alloys, as well as of the conditions affecting the strength and concludes a clear and well-written work with a chapter on the *mechanical* treatment of metals and alloys.

The Meteorological System of the Great Pyramid. By F. A. P. Barnard, L.L.D., S.T.D. (New York: John Wiley & Sons. Montreal: Dawson Bro.)

This work, will be noticed in the next number of Magazine.

We have also received from the Yale and Town Manufacturing Co.; a pamphlet entitled "a new system of weighing Machinery," in which is elaborately described the justly celebrated Emery Scales and Testing Machines.

THERE is being built at the Delamater Iron Works, an iron steamboat designed to run under water. It is 30 feet long, 7½ ft. broad and 6 ft. deep. Water ballast under control of the crew will enable them to sink or float her, and by the device of two rudders whose planes are at right angles to each other, she can be pointed in any direction. The usual outfit of electric engines, compressed air and diving suits, with which readers of Jules Verne are familiar, is included in the design. In war times she may also be used as a torpedo boat.

THE POETRY OF ARCHITECTURE,

OR

Architecture in its relation to the other Fine Arts.

BY ANDREW T. TAYLOR, M.R.J.B.A.

(*Continued from page* 163.)

If we turn to Gothic sculpture and carving we find a complete change. It is not so much man as the soul of man that the Gothic carvers tried to represent. It is entirely dominated by a religious or at least an ecclesiastical tone. The figures are now closely draped, and are modelled from the Franciscan monk or the Capuchin friar. The carver was often a shrewd witty fellow and instead of sending his jokes to a "Punch" or a "Grip" he carved them in stone. Did he want a saint? his boon companion in the next cell served for a model. Had the prior or abbot offended him? he immediately gibbetted him high up in some corner as a spouting gargoyle, or put him in the act of being carried off by some imp of Satan. Just as the story goes that Michael Angelo, while painting his great picture of the "Last Judgment," in the Sistine Chapel at Rome, nettled by the impertinence of some empty headed courtier of the pope, who had come to see how he was progressing, copied his features for one of the figures in hell. Very indignant the courtier complained to the pope. He asked where the painter had put him, and on replying that he had put him in the lowest hell, the pope said, "had he put you in Purgatory I might have got you out, but down there I am afraid I can do nothing for you."

The Gothic carvers laid all nature under contribution and lovingly studied the loveliest plants and flowers, that they might bloom perennially twined round some massive pillar, or clasping delicately some panelled surface, or proudly crowning some gable top. The animal world was also not overlooked, and bird, and beast and fish, now in grave posture and now in grotesque shape and feature took their place in the mighty fabric. Angels were even brought down to earth, bearing messages of peace for mankind, and petrified into abiding permanence.

Their sculpture was at first very rude but gradually improved, until for versatility, for conception, for marvellous delicacy of execution it would be difficult to match those later Gothic carvers of our Cathedrals. They cut and hewed and carved their thoughts into the stone many centuries ago,—sometimes in idle jest, at other times in deepest earnestness, perchance like Fra Angelico they may have worked on their knees, and we come in lightest mood and lo! there is a lesson in the stone for us instinct with life. Perhaps you will permit me to read a few verses with reference to this, which I came across lately and which I think are very beautiful and have much of truth in them.

> "Trust me, no mere skill of subtle tracery,
> No mere practice of a dexterous hand,
> Will suffice, without a hidden spirit,
> That we may, or may not understand.
>
> "All those quaint old fragments that are left us,
> Have their power in this;—the carver brought,
> Earnest care, and reverent patience, only
> Worthily to clothe some noble thought.
>
> "Shut, then, in the petals of the flowers,
> Round the stems of all the lilies twine,
> Hide beneath each bird's or angel's pinion,
> Some wise meaning, or some thought divine.
>
> "Place in stony hands that play for ever,
> Tender words of peace, and strive to wind
> Round the graceful scrolls and corbelled niches,
> Some true loving message to your kind.
>
> "Some will praise, some blame and soon forgetting,
> Come and go, nor even pause to gaze;
> Only now and then a passing stranger
> Just may loiter with a word of praise.
>
> "Yet, I think, when years have floated onward
> And the stone is grey, and dim, and old,
> And the hand's forgotten that has carved it.
> And the heart that dreamt it, still and cold,
>
> "There may come some weary soul o'erladen
> With perplexed struggle in his brain,
> Or, it may be, fretted with life's turmoil,
> Or made sore with some perpetual pain,
>
> "Then, I think, those stony hands will open,
> And the gentle lilies overflow
> With the blessing and the loving token,
> That you hid there many years ago.
>
> "And the tendrils will enroll and teach him
> How to solve the problem of his pain,
> And the birds' and angels' wings shake downward
> On his heart a sweet and tender rain.
>
> "While he marvels at his fancy,
> Reading meaning in each quaint and ancient scroll,
> Little guessing that the loving carver,
> Left a message for his weary soul."

Before the art of printing when books were few, and those who could read them fewer, it was a wise thought which prompted the carving of Bible scenes and subjects round the cathedral portals. Thus the unlearned peasant could spell out and teach his children the story of Adam and Eve, the fall, the flood, the wanderings of the Israelites, the history of David, and all down the ages to the life of our Lord and on to the history of the early church. Thus we have a compendium of Scripture story on the magnificent western portals of the Cathedral, which Mr. Ruskin has been recently describing under the title of the "Bible of Amiens." The front of Milan Cathedral, the portals of Orvietto, St. Antonio, Verona, the Gates of Ghiberti at Florence, and a long list which time would fail me to mention.

It is a curious fact that the Jews, although by no means averse to carving on their buildings, do not permit to be carved any representation of the "likeness of anything which is in heaven above or that is in the earth beneath," translating literally the Second Commandment, and remembering as one must do, the terrible results of idolatry to them as a nation one hardly wonders at it, more especially as we know that not not the Jews alone, but Christians also worshipped images. The introduction of printing and books, and the era of the Reformation with its laudable zeal for for purity of their worship, did much to bring sculpture into disuse for a time; but it is again asserting its lawful place, not as a thing to be worshipped either for itself or what it represented, but for the thought, the life aud the additional beauty it gave to the building it adorned.

Much however of the modern carving and sculpture is not worthy of the name, and would be better away. All carving should have some distinct motive, and have a story or a thought to express. It should not be distributed all over the building, but should be gathered up into bouquets, as flowers are gathered, or as ornaments are worn, to emphasize the design of the building—here adding strength, there giving delicacy, here producing piquancy, there sinking into rest.

I have a few examples here both of ancient and modern carving, and I think you will agree with me that much of the modern work is excellent, notably that designed by the late lamented and very gifted French artist, Viollet le Duc. Sculpture in relation to architecture is an extremely interesting subject, but I must not linger longer upon it but pass on now to architecture in its relation to painting.

As we found that sculpture began in the most primitive manner, so painting had a humble origin also. Just as a child will scrawl on a slate, rude forms intended to be imitative, or traced with a charred stick on a wall something which may bear a distance resemblance to a cow or a horse, so the child of the ages essays in pictorial art decoration were of the rudest. Soon however rapid progress was made, not only as a style of decoration, but also as a medium for the expression of his thoughts and wishes, and much of Egyptian decoration is but his language in symbol.

The Assyrians also wrote their history on their walls not only by sculpture but by painting, and we have examples of this in which the colours are fresh to this day, affording in common with their sculpture valuable assistance to historical research.

In the buried cities of Herculanean and Pompei have been found many evidences of internal pictorial decorations not always of an exalted or an ennobling order, but throwing much light on the manners and customs, the thought, the morals,.and the culture of the inhabitants.

But it is in their architecture that we find painting laid most under contribution to heighten archite tural effects, and these are of surpassing interest. Some of the earliest examples we have are in the catacombs, very rude but pathetic in the story they tell of heroic faith kept alive under most bitter and unrelenting persecution in those underground cells and passages.

But when Christianity was not only tolerated but patronized by the civil powers, as they grew in power and wealth, their pictorial art expanded into more ambitious channels and more enduring mediums. Working on the Roman method of mosaic work, they adopted glass mosaic largely, and in this material they portrayed often in ludicrous, but always in original and vigorous form, the incidents and virtues of the Christian faith, and with these they lined the walls of their churches, so that they were ever surrounded with Scripture story.

The old town of Ravenna, in Italy, contains more of these than almost any other town, and in the Bapistry especially, the dome of which is completely lined with Scripture subjects relating to Baptism, in mosaic, the custom was not only useful but the result was also very beautiful.

In the Baptistry at Florence we have also similarly beautiful work; and in the famous and well-known church of St. Marks in Venice, we have mosaics outside and in,—covering walls, roof, dome and floor mellowed down to a beautiful tone by time and the incense of ages, and giving a soft harmonious result that needs to be seen to be understood.

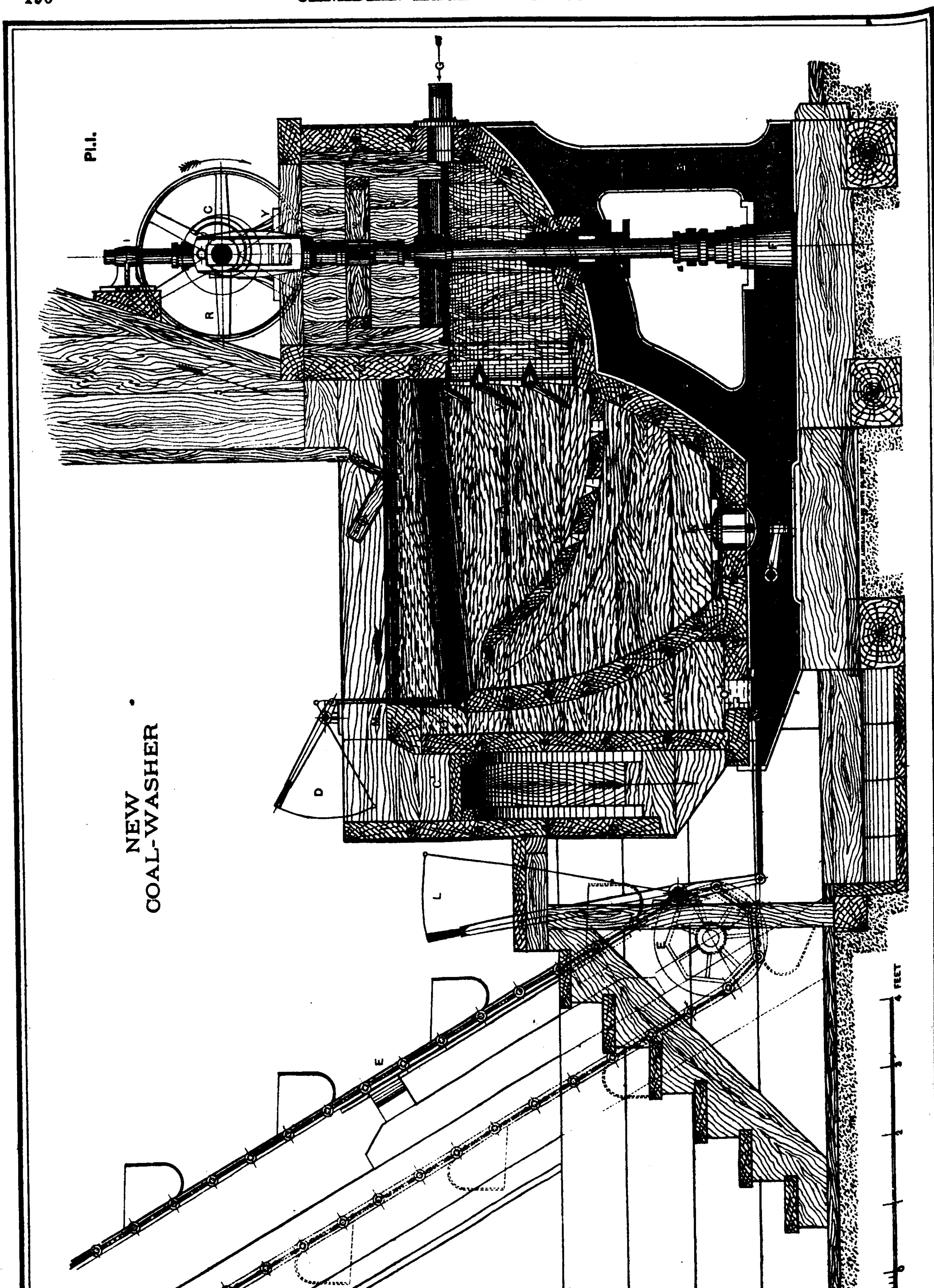
But there was a shepherd boy tending sheep on an Italian slope, who, to wile away the time, took to sketching his sheep on a smooth slaty stone. Cimabue at that time a well known painter, happening to pass that way noticed the boy and seeing him busy at his drawing detected the genius in embryo, which was later on to make him famous, took him from the sheep folds and trained him in his own studio. As has happened often since, the pupil eclipsed his master and Giotto introduced a new era in painting. His masterpieces are not found in any picture galleries, but are frescoed on the walls of the Arena Chapel at Padua, in Santa Maria Novello at Florence, and elsewhere. There in their magnificent framework, they add charm to the building, and derive beauty from it. These pictures are a series depicting the lives of some of the saints and are most exquisite in their thoughtfulness, their delicacy and yet firmness of touch and their beauty and harmony of color. Then oil painting was unknown, and these are done as fresco work in distemper, and are much more suited to the decoration of a building with their quiet flat tone than oil painting with its glossy, shining surface distorting and reflecting the light.

Others followed in his footsteps and we soon find in quiet chapels and cool cloisters and shady corners, sweet faces and lovely forms looking down on us from these frescoed walls, all over Italy. But I must not forget to mention the saintly Fra Angelico—the angelical painter, who was so devout that it was reported he painted on his knees. He has left behind him in the Convent of San Marco at Florence, so identified with the great lion-hearted Reformer Savonarola,—memorials of his piety, his devotion, and of his genius such as any one might envy. On the end wall of the Chapter House, a crucifixion, so tender yet so true, transforms the place into a Holy of Holies, and in the brother's cells—generally with characteristic humility in some obscure dark corner,—he has painted various scenes from the life of our Lord, or other Scripture subjects which change the cold, bare, narrow cells into lovely shrines.

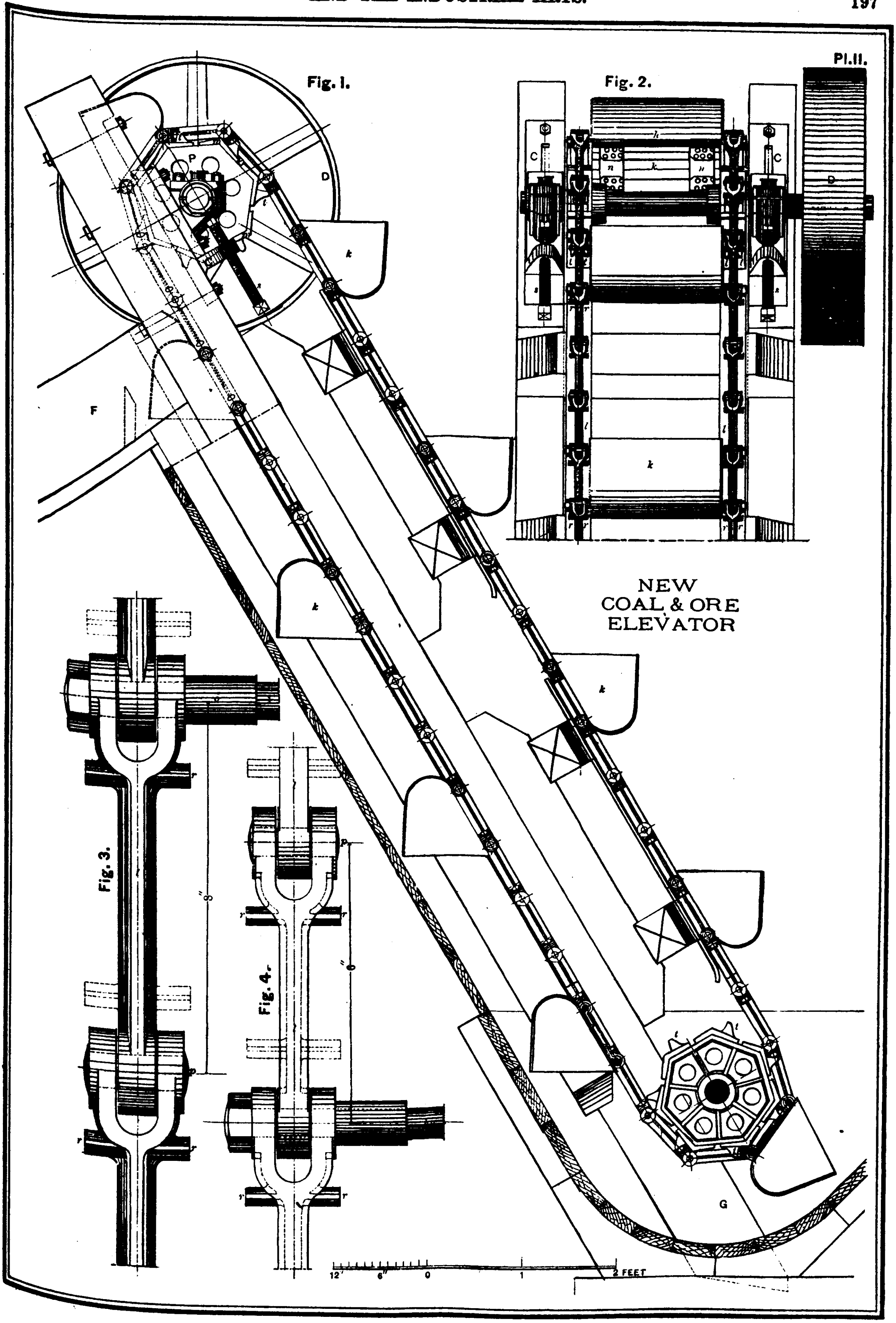
A great many of those celebrated pictures which are now in the European picture galleries, were originally painted for altar pieces, or for special decoration panels in the churches and other buildings but have been transferred sometimes on the destruction of the church or on the dissolution of the monastery or convent, or oftentimes appropriated from existing churches by conquerors and others, and therefore are not seen by us at a disadvantage.

ENGINEERING.

Defective Castings.—It is stated in the English papers that an examination of the broken girders of the fallen railway bridge at Denmark Hill showed that one of them was "honeycombed with air bubbles;" and it is assumed that, as this girder gave way, the extra weight thus thrown upon the others caused the accident. It is almost unnecessary to say, according to a correspondent in *Iron* that the so-called "air bubbles" are really hydrogen cells, and that the only explanation that has been (and probably ever will be) afforded of the source of this hydrogen is that, if not exclusively, it is mainly derived from the moisture of the atmospheric blast, which becomes decomposed on coming in contact with molten iron or steel, its hydrogen being thereupon absorbed by the metal. This occurs not only in the steel converter, but also in the blast furnace and in the remelting cupola. As a consequence, both steel and iron castings are unreliable, and a constant source of danger wherever their soundness is essential to safety; and they are accordingly unfitted for a number of important purposes for which forged metal, at a far higher cost, is considered necessary. I do not propose, adds Mr. Fryer, to refer to any of the various methods and expedients which have been devised, and which are sometimes employed to cure the evil. It will, however, seem remarkable that no attempt has yet been made to get rid of the defect itself by eliminating the moisture from the blast, and thus removing the cause. One practical trial in that direction would go further to solve the whole question than all the theories that have been advanced, and all the laboratory experiments that have been tried since Dr. Muller's famous discovery of the real nature of the so-called "air bubbles" or "blow-holes."


Pl.I.
NEW
COAL-WASHER
4 FEET

Pl. II.



IMPROVEMENTS IN COAL-WASHING, ELEVATING AND CONVEYING MACHINERY.

BY S. STUTZ, M.E., PITTSBURGH, PA.

Three years ago, at the Philadelphia meeting, in February, 1881, the author had the pleasure of presenting to the Institute a paper on coal-washing machinery. Since that time many new machines, with important improvements and labor-saving apparatus, have been introduced, the construction and description of which may be of interest to some of the members of the Institute. By referring to the above mentioned paper, and especially to Page IV., representing a vertical section of a coal-washer, it will be noticed that the bottom of the plunger-box *B* is made level or horizontal, and supports a spring-buffer *F* for the purpose of limiting the down-stroke of the plunger *P* and receiving the impacts of the latter. Although the construction of the box, in view of these impacts, received from the start the proper attention (the bottom of the chamber *B* being made of three thicknesses of 3-inch planks, resting on 6-inch square columns), yet, through careless working of the machinery, without the necessary water in the box, it proved in several instances not strong enough, and had to be changed. To prevent such interruptions in future, it became necessary to devise some means for relieving the machine from the impacts of the plunger altogether. This has been accomplished by the arrangement shown upon Page 196. of this paper, representing a new washer; and not only has the difficulty been overcome, but also other advantages have been obtained, as will be seen further on.

The compartments A, A' of the separator-box have been set upon heavy cast-iron brackets *B*, leaving sufficient space below the bottom for the buffer *F* and the sediment-valve *K*. By means of the plunger-rod *b* passing through the stuffing-box *s* to the outside, and provided at its lower end with a shoe *a*, the impacts of the plunger are now transmitted from the buffer *F* directly to the foundation. At the same time a better guide for the plunger *P* in its up and down movement has been obtained. The plunger of the former machine had only the guide *I* and the yoke *Y*, whereas the new machine has an additional guide in the stuffing-box *s*, thus preventing wear and friction of the plunger against the lining of the box. Furthermore, the mechanism for regulating the stroke of the plunger has been simplified in dispensing with the hand-wheel. The screw-nut *e*, swiveled to the yoke *Y*, is provided with a long thread to receive the upper end of the plunger-rod *b*, and is made of steel, sufficiently strong for all purposes. It is provided with four notches *n*, into which a piece of iron can be engaged; and, by turning to the right or left, the yoke *Y* is raised or lowered as may be required. Thus it is very easy to get the proper stroke for any kind of material, or to set the machine out of operation altogether, if necessary. With the exception of the gate *O* for the outlet of the impurities, the other parts of the machine are left the same as before. The bottom of the plunger-box being now inclined towards the sieve-chamber, less power or less weight of the plunger is required to produce the same action of the water as was obtained in the former machine. The operation of the present machine is the same as previously described. Fresh water is taken in through *G*, and the slack-coal, brought upon the sieve *S* by means of the chute *J*, is separated into coal and impurities, while passing from the rear to the front of the machine. The clean coal, delivered over the bridge *M* into the channel C', goes to the elevator *E*, which brings it into storage-bins, while the impurities pass through the gate opening *O* into the chamber *W*, and thence through the opening *O'* to the trough *T*, where they are carried away by the action of the waste water. A number of the new machines have been erected during the last two years, and give full satisfaction in every respect. They are considered the best in the market, and offer the following important advantages:

1. The use of a differential cam for the working of the plunger allows to the material, after each stroke, the necessary time to deposit according to gravity. An eccentric or a crank cannot produce such a movement.

2. The use of valves between the plunger-chamber and sieve-chamber prevents the filtration and back suction of the water during the upward stroke of the plunger, and thus saves the very small coal, which otherwise will pass through the meshes of the sieve and go to waste.

3. There is a saving of motive power in the working of the washer. The body of the water in the box *A* being divided by the partition *N*, the inertia of the small part above the latter has only to be overcome.

4. The current of the water produced by the plunger *P* not only lifts up the material upon the sieve *S* to effect the separation, but also moves the separated parts, coal and impurities, towards the delivery-bridge *M* and gate *O* respectively. This is especially valuable, since the continuous and regular separation of material containing heavy impurities, such as iron pyrites, fire-clay, etc., is assured.

5. There is great economy of water. In the older machines the separated coal is floated out of the apparatus at the expense of an enormous volume of water; yet the impurities have to be removed from the sieve by the shovel, thus interrupting the working of the machine and making it intermittent and wasteful.

6. The forming of a special receptacle below the partition *N* allows the fine particles of pyrites, slate, etc., falling through the meshes of the sieve, to settle. Thus the clean water is not mixed with the slimy sediments, and the latter are not forced back again into the material.

7. This machine has greater capacity per square foot of sieve-surface, with less water, than any other in use. An apparatus of, say, two sieves, 3 feet by 4 feet 9 inches, or 28½ square feet surface, can wash properly 200 to 250 tons of coal per day of ten hours with from 300 to 500 gallons of water per ton of coal, according to percentage of impurities, or about 7 to 9 tons per square foot of sieve-surface. The cost of washing will be from 2 to 5 cents per ton, according to locality and arrangements.

Elevators.—The hoisting or elevating apparatus is, especially as a labor-saving device, an important part of the washing machinery, and requires close attention. Its object is first to bring the material to be separated to the machinery, and afterwards to deliver the different parts to storage-bins or cars. For handling minerals or heavy substances, the elevators are usually composed of endless chains and buckets, caused to move around polygonal pulleys or sheaves. A steady movement without jerking or slipping of the chains is very desirable. Chains formed of common flat iron links, render such a movement difficult and often impossible, no means being provided to prevent slipping. The apparatus shown on Pages 197 and 200 gives great satisfaction, and insures a steady and continuous working. The chains are composed of malleable iron or steel links specially designed for the purpose, and connected by means of rivets or bolts and nuts. Each link is provided with lateral projections, *r*, which regularly, at the proper time, are taken up by corresponding teeth, *t*, of the polygonal sprocket-wheels, *P*, as shown by Figures 1 and 2 of Page 197. Thus the chain is carried around with the wheels, perfectly secured and maintained, no stopping or jerking being possible, till it arrives at the rear, where it is developed again and set free. Rods, *h*, reaching across from one chain to the other, support the bucket *k*. They are kept in place by screw nuts and pieces of gas-pipe *o* inserted between the links and the buckets. According to the dimensions of the latter, links are made of different sizes and length. Figures 3 and 4 represent 8-inch and 6-inch links, with either two or four lateral projections *r*. They are always well-proportioned, and have large wearing-surfaces at their connecting-points. The sprocket-wheels *P* have independent angle-pieces *m*, with their teeth, *t*, which are riveted or bolted to the sides. The teeth may also be cast with the wheel in a single piece, as shown by Page 200. The upper pillow-blocks, supporting the sprocket-wheels and the chains, are fixed movably upon guide-plates, *C*, and can be lowered and raised by means of the set-screws *s*. Elevators may receive an inclined or vertical position, or a combination of both together. The inclination of the apparatus on Page 197 is 60 degrees, with half-bushel buckets attached to 8-inch links. It receives movement by the pulley *D*, and takes the material from the bin *G* to the delivery-chute *F*. The ordinary speed is about 15 revolutions per minute, and the capacity, with seven-sided sprocket-wheels,

$$\frac{7 \times 15}{4} = 26\tfrac{1}{4} \text{ buckets} = 13 \text{ bushels, or about 300 tons per day}$$

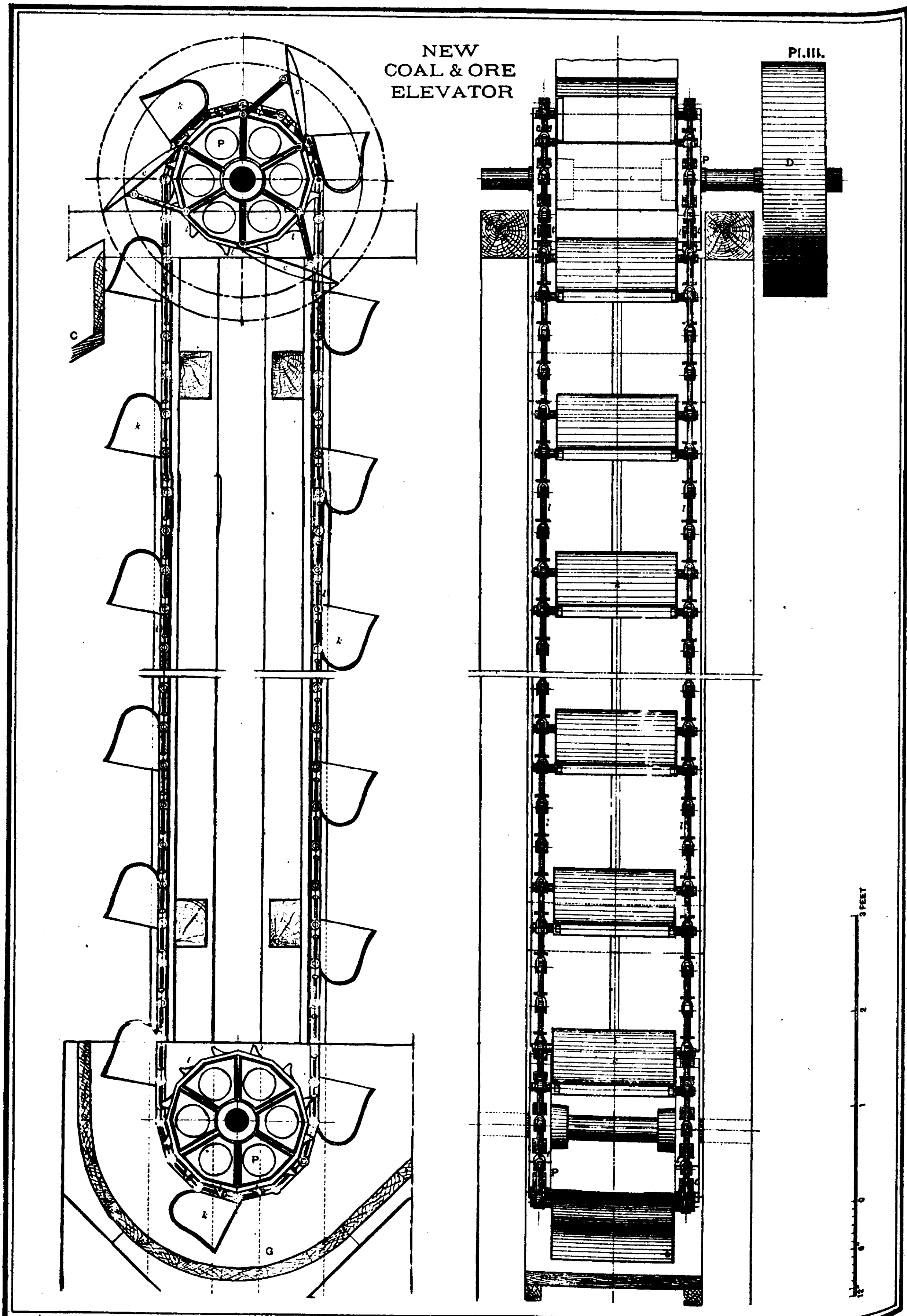
of ten hours. With a speed of 20 revolutions per minute such an apparatus can hoist and deliver 400 tons of material per day of ten hours. An elevator raising its load vertically is illustrated upon Page 200. It has quarter-bushel buckets, attached to 5-inch links, and is caused to move around twelve-sided sprocket-wheels *P*. The links and buckets are connected in the same way as previously described, and their form and dimensions only are different. But a special mechanism for delivering the material has been added to the wheels. As the receiving-trough or chute *C* has to be set outside the return passage of the buckets *k*, the material emptied out of the latter would not be delivered, but would fall on the back of the preceding bucket. and down again to the bin *G*, but for the additional mechanism. For this purpose, the inclined planes *c* are fixed between the sprocket-wheels *P* in such a manner, that turning around with the latter, between the chains, they invariably mesh in in front of each ascending bucket, and precede the latter to the delivery side, where they first receive the material, to let it slide afterwards into the receptacle *C*, as may be seen from the drawing. Their object, therefore, is to bridge over the space between the receptacle and the buckets. This method is far preferable to the one frequently used, consisting in the run of the elevator at high speed, whereby the contents of the buckets are drawn over into the receiving chute. Of all the systems employed, that certainly is the worst, since it renders necessary the frequent renewing of the chains.

A mixed system of elevators, which is working very satisfactorily, is shown upon Page 204. It is vertical in its lower part and inclined at 60 degrees on top for the convenient delivery of the material. Instead of running both chains inclined, the return-chains only are often bent below the top wheels to bring the receptacle near enough, but this requires larger wheels and increases friction. Most of the power necessary to drive elevators is consumed in overcoming friction. It is advisable to make the links forming the chains as long as is reasonably practicable, consistently with the buckets or pans of the apparatus. For supporting and guiding the upper or ascending chains between the wheels, short pieces of angle-iron and stationary friction-rollers are preferable to loose and movable rollers. The latter are expensive to keep up, and make the chain too complicated.

Conveyers.—Another great labor-saving apparatus for handling or carrying minerals and other heavy substances from one place to another, is the conveyer, represented upon Page 201. It consists, similarly to the elevators, of endless chains, formed of pivotally-connected links, pans or plates, secured to and carried by the links, sprocket-wheels for driving the chains, and rollers for supporting and guiding the table between the wheels. *A* represents a framework of timber on which are mounted the shafts a a_1 journaled in pillow-blocks a_{11}. Each shaft has two sprocket-wheels *E* supporting the endless chains C C_1. The pillow-blocks of one of the shafts a a_1, or of both if desired, are set upon guide-plates g g_1, and made adjustable by set-screws *s* in order to tighten or loosen the chains. Projecting lugs or sprockets *e* are cast on the periphery-sides of the wheels, by preference one after the other side. These lugs are designed to engage the links of the chains and prevent the latter, by means of corresponding projections, *r*, Fig. 3. from slipping, in whichever direction the table may be caused to move. The links are of the same kind as previously described and used for the elevators, with an eye at one end and a socket at the opposite end adapted to receive the adjacent link, and a pair of projections *r* near each connecting end. At or near the centre of each link, a flattened base or attachment *p* is formed to receive the sheet-metal pans or plates *m* of the conveying-table. The width of the plates is about equal to the length of the links. They are secured either by means of bolts and nuts or rivets. As is shown by the drawing, Fig. 1, the forward or leading edge of each plate overlaps the rear or following edge of the preceding pan. This is necessary and of great importance to form and maintain a close and tight joint between successive plates while turning around the angles of the wheels. Waste of small coal or mineral, etc., is thus entirely avoided. As a means for guiding and supporting the table between the driving-wheels, friction rollers *n* reaching across the table are employed for the upper part and its load, while for the return or lower part, small malleable iron rolles, *n'*, Fig. 4, in any desired number, suitably mounted on metal frames, are fastened by rivets or otherwise to the upper or carrying face of the plates *m*. These rollers, in the under or lower passage of the conveyer, from wheel to wheel, travel or ride upon suitable stringers or beams A_2 secured to the framework *A*. It is preferable to fasten them immediately over the carrying chains, in connection with the attachments of the links. Large tables designed to carry heavy minerals, etc., require three or more chains to prevent bending or sagging of the pans in the centre. In order to hold the mineral or earth to be conveyed upon the plates of the table, side-boards *R* supported by brackets *d* are employed, as shown in Figures 1 and 2. The brackets are fixed to the timber of the frame *A*. Sufficient clearance must be provided between the lower edge of the sides and the upper surface of the conveyer-pans to prevent friction. If desired, however, the ends of the conveyer-plates may be bent upwards at an angle and serve the same purpose as the sides *R* in preventing the falling over of the mineral, etc., or in many cases guards may be omitted entirely. It is however, preferable, when any provision of this kind is needed, to use the fixed side-boards *R*, because the pans are not loaded thereby, and they are also free from the liability to become choked or bent, so as to interfere with the proper working of the table. Provision for charging the minerals, etc., upon the table, may be made by means of hoppers, or otherwise, as will be shown here-after.

Arrangement and Disposition of Elevators and Conveyers.—This part of the paper is intended to illustrate some of the many cases to which this kind of machinery may be profitably applied. Page 204 is a part of the coking-plant at the Long Run mine, New Bethlehem, Pa., and shows the arrangement of two vertical elevators *E E'* in combination with the conveyer *C* to bring the slack coal to the washing machinery. On the left hand side is the washer-building with the separator *A* at the ground floor and a 4-roll crusher *R* above it. Two railroad-tracks are in front of the building, one for lump coal or the run of the mine, or the other for nut coal and unwashed slack. The coal intended to be washed, is collected in the hopper *H* to be fed into the crusher-rolls, by means of the conveyer *C*. The different apparatus have been designed in view of handling 200 to 250 tons of slack coal per day. During the regular or normal run of the works all the slack may be easily taken away by the conveyer, but it often happens that railroad cars have to be loaded in a very short time, and owing to the small capacity of the hopper *H*, it became necessary to provide for some additional storage-room. This has been accomplished by means of an auxiliary bin *B* between the tracks and the building, holding about 150 tons. Dumping and loading may thus be done at almost any rate of speed, the surplus slack being let into the bin. and does not interfere with the regular working of the machinery. The object of the two short elevators *E E'* is to hoist this coal up again, when needed, without any extra labor or additional expense. As long as the conveyer is supplied with coal from the hopper *H* the elevators are at rest. They receive motion from the shaft *a* by means of a counter-shaft *b* and cog-wheels *e e'*. Both are provided with friction-clutches *f f'*, operated by levers *l l'*, and may be run independently one from the other. Usually only one of them is at work at the time. The buckets *k* deliver the coal upon the inclined chute *c c'*, by which it goes to the conveyer, and thence to the separating machinery. The length of the table is 17 feet 6 inches between the centres of shafts, by 36 inches width. Its speed is only about 40 feet per minute. No side-boards or guards are used here. Two men attend to all the machinery, the machinist and his assistant.

Page 205 represents a different arrangement from the former, which, however, has the same object in view, namely, the handling of the surplus slack, produced at certain hours of the day, without additional expense of labor. It is a part of the coking-plant at the Rochester mines, Dubois, Pa., with the coal tipples in the centre, a large auxiliary slack-bin *B* to the right, and a part of the coal-washer building to the left-hand side. *E E'* are two inclined elevators to delivery the slack from below the screens. Their capacity is about 250 tons each per day of ten hours. While dumping coal into railroad cars at the normal speed, the elevator *E* leading to the washing-machinery is quite sufficient to handle all the slack produced, but the time allowed for unloading pit cars is very irregular. In the morning between the hours of 7 and 10 o'clock, relatively few cars are taken out of the mine, because this time is required for the miners to loosen the coal and get ready for the day's work. Most of the coal is loaded between the hours of 10 and 3 P.M., and dumping is usually very lively about noon. A greater amount of slack is then produced than the elevator *E* can take away. Before the erection of the second elevator *E'*, and the auxiliary storage-bin *B*, the surplus has been very troublesome, interfering with the regular working of the washer. Two boys and two mules were kept busy to haul a part of the slack to the dump and bring it back again afterwards. That such a system of working could not pay, is easily to be seen. After this had been carried on for some time, the writer was consulted, and proposed the arrangement shown by the drawing, viz., an additional elevator *E'*, taking the surplus slack into the storage-bin *B*, and a conveyer *C* to bring the same back again when needed, the mechanism to be arranged in such


NEW
COAL & ORE
ELEVATOR
Pl.III.
3 FEET
2
1
0

a manner, that either part may be worked independently, or both apparatus set out of motion. This has been carried out and gives full satisfaction. The elevator is of the kind shown upon Page 197, with half-bushel buckets, and about 56 feet long between the shaft-centres. Provision is made for about 300 tons of slack. At the bottom of the bin *B* are three gate-openings *i* to let the slack out again upon the table of the conveyer *C*. The latter is located on the side of the elevator, and passes through the middle of the storage-room about 2 feet below its bottom. It is 54 feet 9 inches long, from centre to centre of shafts, by 24 inches width of table, and the same in construction as shown upon Page 201. The necessary power to drive the elevator and the conveyer is obtained from the main shaft *a* of the washing-machinery, and, by means of the pulleys *p p'* and a wire rope, is transmitted to the counter-shaft *b*. The latter, by means of two sets of bevel wheels *w w'*, and an inclined shaft, running outside and along the elevator-post, transmits motion to the upper chain-wheel of the elevator *E*. A second counter-shaft *b'*, also receiving motion from the shaft *b* through the spur-wheels *e e'*, gives motion to the conveyer. This is done by the pulleys *g g'* and a rubber belt. The pinions *e* and *w* are connected with the female parts of the friction-clutches *f f'* respectively, and receive only when the clutches are set in. As soon as the slack commences to accumulate before the buckets of the elevator *E*, the second elevator *E'* is started by setting the clutch *f'* tight. The surplus is then taken taken to the bin *B* until its volume has diminished to that required by the washer. The clutch *f* is now drawn out again, or the elevator allowed to run empty. To start the conveyer *C* the clutch *f* is pushed in, and, as the male parts of both clutchers are connected together, this will set the elevator E' out of motion. One of more gates *i* below the bottom of the bin are then slightly opened, fo let the slack upon the table and back again to the foot of the elevator *E*. No extra labor is needed; the work is performed by the engine which runs the washing-machinery. (*A paper read before the Am. Inst. of Mining Engineers.*)

Pl. IV.

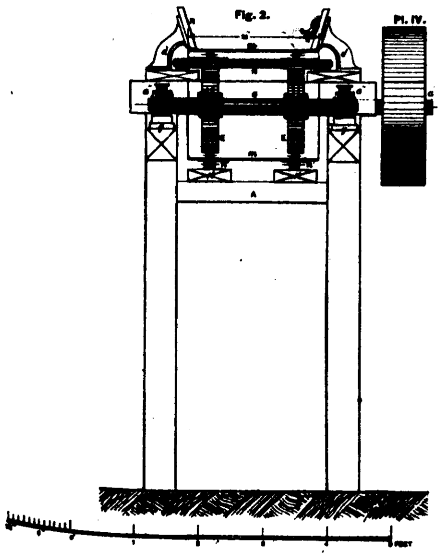
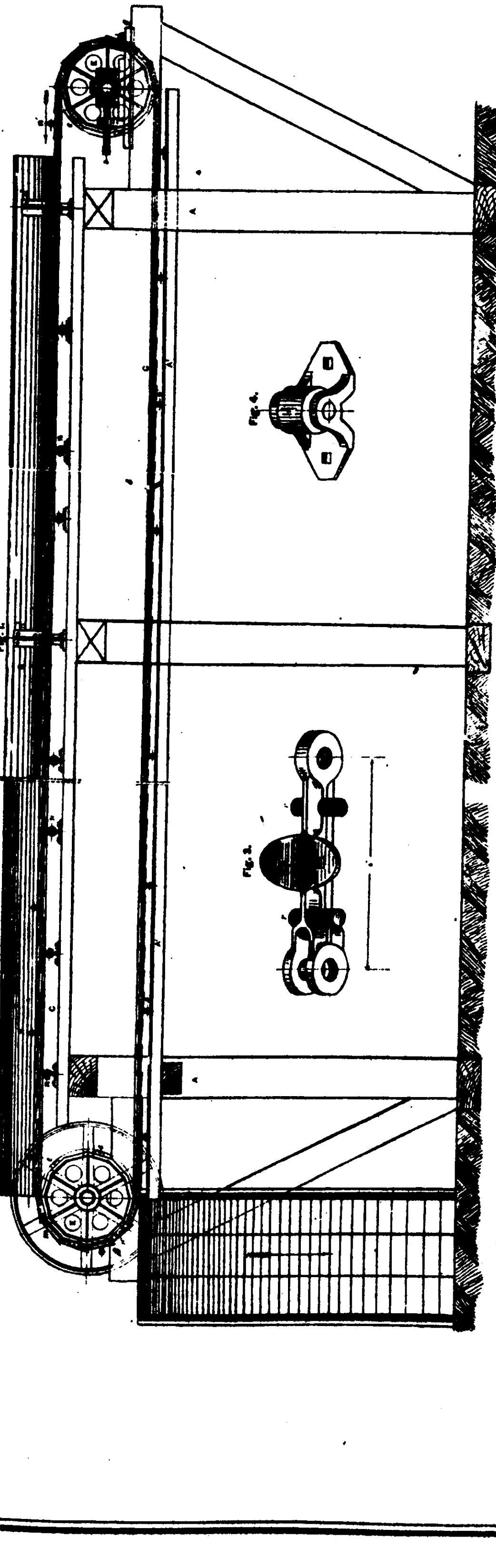


TABLE-CONVEYER FOR COAL, ORE, ETC.



"WOOD PAVEMENT IN THE METROPOLIS," BY GEORGE H. STAYTON, ASSOC. M. INST. C.E.

A PAPER ROAD BEFORE THE INSTITUTION OF CIVIL ENGINEERS.

The Author directed attention to the nature and extent of the various Wood Pavements in the Metropolis, and to a comparison of the results obtained. The aggregate length of the streets of London was 1,966 miles, of which, excluding 248 miles in course of formation. 1,718 miles were thus maintained by various authorities, namely :—

Macadam	573 miles
Granite	280 "
Wood	53 "
Asphalt	13¼ "
Flints or Gravel	798½ "

The existing area of Wood Pavement was 980,533 square yards, and its estimated cost £600,000. Not more than 4.38 per cent, was east of the City or south of the Thames. The method of construction adopted by the author was described and illustrated. His practice was set out the levels of the channels so as to allow a rise to the crown of the road equivalent to 1 in 36 above the mean channel-level. The inclinations of the channels should not exceed 1 in 150, and numerous street gulleys should be provided. An extra cost of 4 per cent, for gulleys was money well spent. The foundation of the Chelsea pavements consisted of a bed of concrete 6 inches deep, composed of 5¼ parts of Thames ballast to 1 part of Portland cement; the entire cost for materials and labour when completed was 2s. 3½d. per square yard. The use of old broken granite as a substitute for Thames ballast, although cheaper, was not recommended. Concrete made from that material was less homogeneous than pure ballast concrete.

The greater part of the Wood Pavement in London was composed of rectangular blocks of yellow deal. Before adopting Wood Pavements the Author inspected the various kinds of pavement then laid, and came to the conclusion that a plain but substantial system was the best. The blocks were 3 inches by 9 inches by 6 inches, and were specified to be cut from close and evenly-grained, well-seasonsed, and thoroughly bright and sound Swedish yellow deals (Gothenburg Thirds). The Author knew of no more suitable wood in the market, which so satisfactorily stood the wear of traffic and atmospheric changes. Of hard woods, pitch pine took a high place in point of wear, the ascertained annual vertical wear of the section in King's Road during four and a half years being 0,055 inch only. Neither elm nor oak blocks would withstand the atmospheric changes to which street surfaces were exposed; larch would probably take a high position, but the available supply was limited. In many pavements the blocks had been dipped in a cresote mixture; in a few instances they had been creosoted or mineralired, but at least one-third had been laid in their natural condition. The ordinary dipping process was of little value as a preservative, but might be utilized as an external discoloration for infeeior blocks. The Author had tried creosoted blocks, but experience had convinced him that they were nct more durable than plain, that their surface was less clean, that the system was 20 per cent, more costly, and that it tended to produced premature internal decay. The Wood Pavement in Chelsa required forty and one-half blocks per square yard; they were laid upon the concrete in their natural state, with the fibres vertical, and with intervening spaces ⅜ inches wide. The joints were filled with cement grout composed of 3 parts of Thames sand, to 1 part of Portland cement; they were kept parallel by means of three cast-iron studs fixed in each block, which rendered the pavement firm and steady until the grout was thoroughly set. A top-dressing of fine gritty material compl ted the work. If practicable, traffic should be excluded from a newly laid pavement for at least one week after completion. The result of five years' wear convinced the Author that the plain system comprised all the essentials of a sound pavement; that it provided a quiet and smooth surface for vehicles, and safe foothold for horses; that the cement joint adhered to the wood, effectually resisted wet, did not unduly wear below the wood surface and thereby allow dirt to accumulate in the joints, neither did it displace the blocks. The net cost was 10s. 6d. per square yard, and but comparatively slight repairs had been found necessary. The blocks were originally 5·87 inches deep, but their present average depth was 5·22 inches in King's Road, and 5·60 inches in Sloane Street, their probable life being seven and eight years respectively.

Peculiars of Wood Pavements in various parts of London were given at considerable length; and in those instances where the approximate weight of the traffic per yard width was known, the details of cost, maintenance, durability, ascertained vertical wear of wood, &c. were described. The experience of the Improved Wood Pavement Company was probably greater than any other, that system having been laid in King William Street, Leadenhall Street, Bishopsgate Street, Aldersgate Street, Ludgate Hill, Queen Victoria Street, Northumberland Avenue, Parliament Street, Whitehall, Piccadilly, Knightsbridge, Bond Street, Park Lane, Old Brompton Road, and in other places. Henson's system had been tried in Leadenhall Street, Fleet Street, the western part of Oxford Street, Brompton Road, Euston Road, and Uxbridge Road. The Asphaltic system had been laid in Fleet Street, the Strand, Oxford Street, High Holborn, Regent Street, and Brampton Road. Lloyd's "keyed" pavement in Pall Mall had proved a failure, owing to careless work, and to the mode of jointing and blocking. The same pavement in the upper part of Regent Street also showed considerable wear. Carey's pavement had been laid in Cannon Street for over nine years, but the Author did not class it among successful pavements. The Ligno-Mineral pavement was laid throughout Coleman Street in June, 1875, but in April, 1882, asphalt was substituted. Messrs. Mowlem and Co's., pavement had been laid in the City, St. Gile'ss St. Marylebone, St. Pancras and Kensington. In Princess Street, Cavendish Square, blocks which had been put down in September, 1874, were still in existence. A large area upon the plain system had been paved by Messrs. Nowell and Robson, in Kensington Road, Fulham Road, Uxbridge Road, and High Street, Notting Hill. In order Metropolitan districts besides Chelsea, the Vestries had laid a plain system by means of their own staff. The Vestry of St. Marylebone paved the eastern portion of Oxford Street in October, 1878. The blocks now averaged 3·30 inches deep, but in certain parts the depth was 1⅝ inch only. The Paddington Vestry had laid 125,000 square yards in various streets, with satisfactory results.

The essentials of good management consisted in the prompt removal of defective blocks, the constant use of hand-scrapers and brooms in removing horse-droppings and mud, and the judicious application of water and sand. The cost of this service was 4½d. per square yard per annum, as against 11d. per square yard for macadam previous to the substitution of wood. The Author considered it undesirable to lay blocks of a greater depth than would provide for a life of seven years as very few pavements retained a good surface after about six years' wear. Experience suggested that 5-inch blocks were preferable. Taking the life of the blocks in King's Road at seven years, the first cost, repairs, renewals, and cleansing, spread over twenty years, amounted to 1s. 9d. per square yard per annum, and over fifteen years to 2s. 1¾d. The repairs of Sloane Street and King's Road, when macadamised, amounted to 2s. 10d. per square yard, excluding first cost, but including 11d. for cleansing. In Westminster the annual cost of macadam repairs alone was :—

	s.	d.
In Parliament Street	2	10
" Whitehall	2	10½
" Victoria Street	2	0

The annual cost of wood relatively to the traffic-weight per yard width was classified in the table on the opposite page :—

It was strongly urged that local authorities should adopt measures for ascertaining the weight of traffic before laying down wood, that greater discretion was necessary in accepting tenders for construction and maintenance, and that no reasonable expense should be spared in supervision. On the whole, the Author submitted that Wood Pavement was economical and convenient, that notwithstanding many failures the modern system had achieved a fair amount of success, and that there was no apparent reason why its use should not be extended.

The Paper included tables and statistics showing the first-cost and annual cost of various Wood Pavements, the comparative vertical wear of wood in various streets as reduced to a traffic standard, together with the ascertained and estimated life of the blocks.

System.	Daily Traffic weight per yard width of Pavement.				
	400 Tons.	500 Tons.	750 Tons.	1,000 Ton.	1,250 Tons.
	s. d.	s. d.	s. d.	s. d.	s. d.
Plain Yellow Deal ...	1 4	...	1 9	...	1 10¼
Plain Pitch Pine ...	...	1 6	...	...	..
Creosoted Yellow Deal ...	1 6½	1 10¾	...	...	...
Henson's ...	...	...	1 9½	1 9½	2 0
Improved ...	...	...	...	1 11	2 1½
Asphaltic ...	...	...	2 0	...	2 0¼
Lloyd's ...	...	...	2 2	...	...

JOURNAL FRICTION.

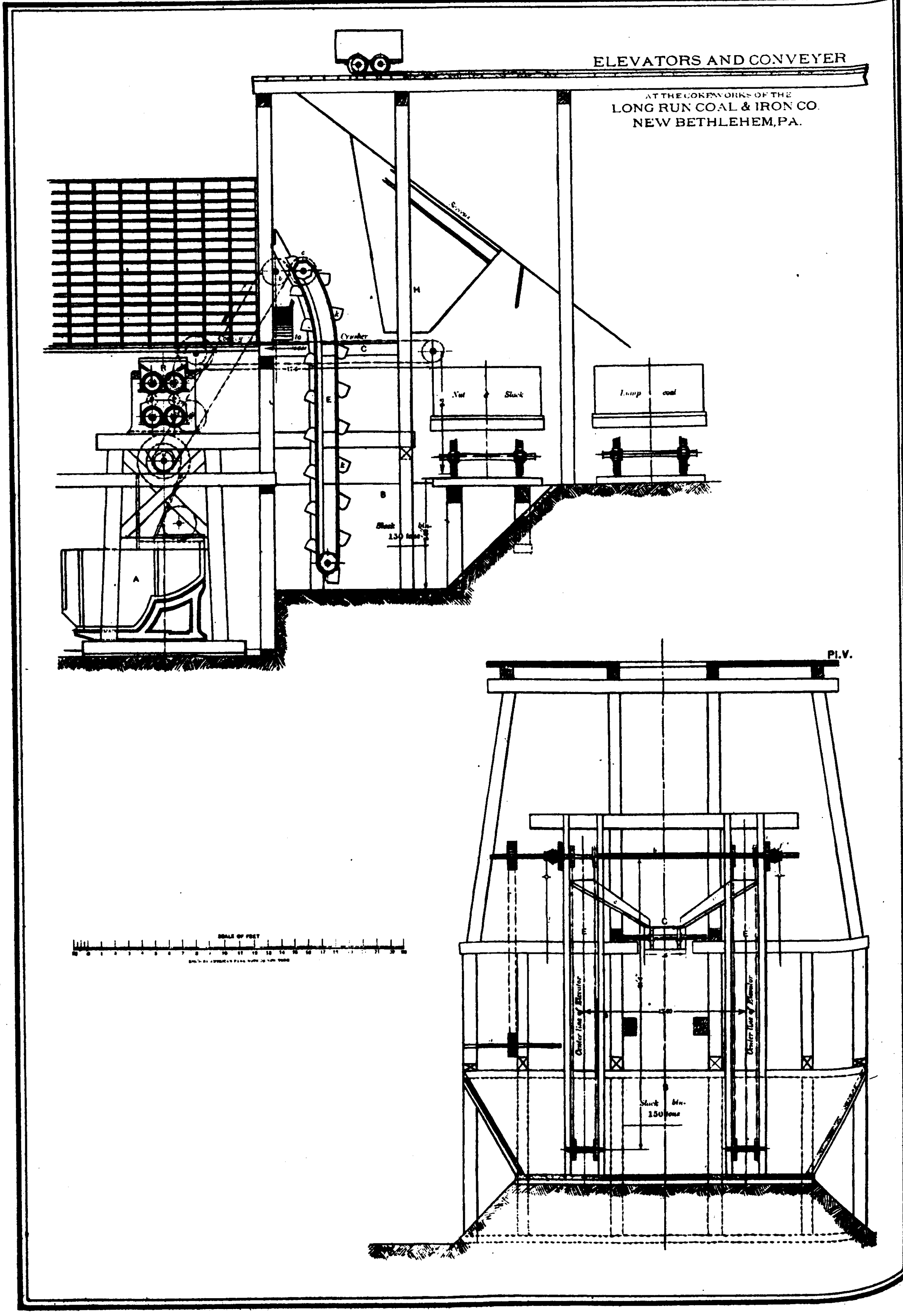
A paper was read before the Am. Soc. of C. E., by Mr. A. M. Wellington, giving the details and results of experiments with a new apparatus upon the friction of car journals at low velocities. These experiments were undertaken to test the correctness of a series of tests described in a previous paper, which were made by starting cars from a state of rest down a known grade and deducing the resistances from the velocity acquired. The present experiments were made by an apparatus in which the axle to be tested is placed in an ordinary lathe having a great variety of speeds, the resistance of the axle being measured by the levers connected with a yoke encircling the axle and transmitting the pressures to a suitable weighing apparatus. It was found important that this weighing apparatus should be direct, as, for instance, a platform scale rather than a spring scale. The results of these experiments as to initial friction were that friction at very low journal speed is abnormally great and more nearly constant than any other element of friction. This abnormal increase of friction is due solely to the velocity of revolution. At velocities slightly greater, but still very low, the friction is still large, the co-efficient failing very slowly and regularly as velocity is increased, but being constantly more and more effected by differences of lubrication, load and temperature. A very slight excess of initial friction would generally be observed. There is no such thing in journal friction as a friction of rest in distinction from a friction of motion. The fact that friction of rest appears to exist is due solely to the fact that no journal or other solid body can be instantly set into rapid motion by any force however great. At ordinary operating velocities the character and eompleteness of lubrication seems to be much more important than the kind of oil used, or even the pressure or temperature.

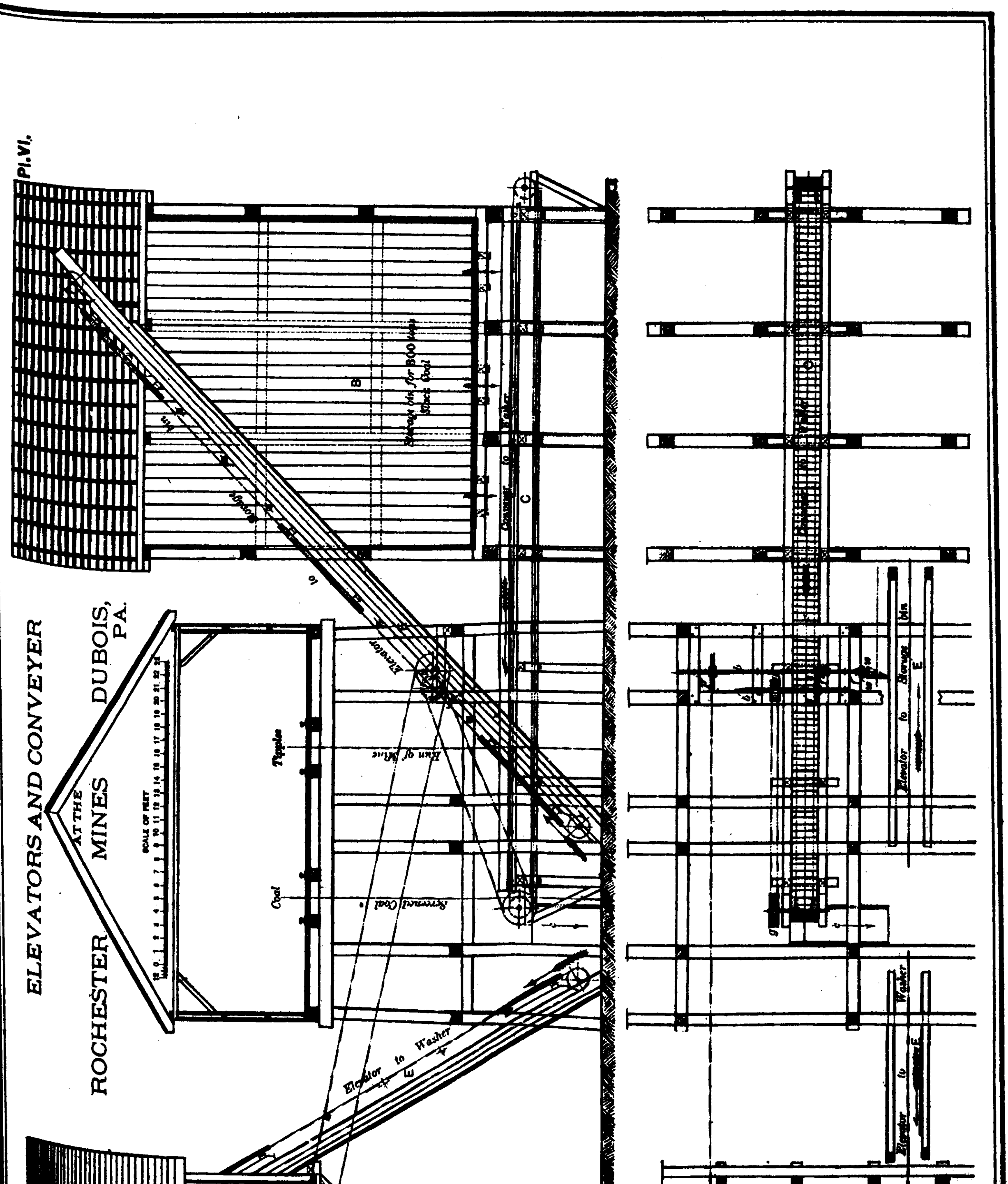
Comparisons were made of experiments by Prof. Thurston and by Mr. Power and the experiments of the author. The rolling friction proper in railroad service seems to be very small indeed, not exceeding one pound per ton. As to the resistance of freight trains in starting, it is believed that the resistance at the beginning of motion in each journal is about 20 pounds per ton. A velocity of from one-half to three miles an hour must be obtained before the journal friction falls to ten pounds per ton. At six miles per hour the journal friction is at least one pound per ton higher than at usual working speeds. Temperature exerts a very marked adverse influence upon friction at low velocities. The velocity of lowest journal friction is 10 to fifteen miles per hour. With bath or other very perfect lubrication there is a very slight increase of journal friction accompanying velocities up to 55 miles per hour. With less perfect lubrication, as with pad or syphon, greater velocity is as apt to decrease as to increase the co-efficient. The latter being more like the ordinary lubrication in railroad service, we may say without sensible error that the co-efficient of journal friction is approximately constant for velocities of 15 to 50 miles per hour.

Ship-Repairing Slip on Loch Tay.—Loch Tay, a splendid sheet of fresh water, some fifteen miles in length, in the very heart of the Perthshire Highlands, has, through the enterprise of the Earl of Breadalbane. been provided with four steamers within the past three years, to accommodate tourists and the residents on the sides of the loch. A large slip on which these steamers can be taken for repairs has just been erected from designs by, and under the superintendence of Mr. Thomas Pitcairn, inspector to Mr. Strain, C. E., Glasgow, on the Loch Tay Works and the Killin Railway. The slip is 450 ft. in length, and is supported on piles. On each side of the ways, which are 17 ft. in width, there is a pier 350 ft. long from which vessels can be steadied while being taken out of the water. Mr. Pitcairn began the sinking of the piles from the shore, and put up the two stages, on which he subsequently placed the machinery for driving the piles by which the deep end of the ways is supported. There are three lines of rails in the ways, the one in tbe centre being toothed as a ratchet to prevent the carriage or cradle on which the steamers are placed for slipping into the loch. The ways are bolted to three rows of piles, of which there are as many as 400 in the structure. When all the supports were in position, Mr. Pitcairn constructed 250 ft. of the ways on shore, fitted on the mountings, and then floated the structure into the place where it was to be sunk, after which all that the diver had to do was to bolt down the ways and saw off the projecting pieces of the timber. The remainder of the work was of a comparatively easy character, and was accomplished from the shore. At the summer level of the loch, the slip, which has an incline of 1 in 20, will have ten ft. of water above the lower end, and in time of flood the depth will, of course, be much greater. The material used in the construction of the repairing slip, as also in the construction of seven steamboat pierse along the shores of the loch, was larchwood, which grows to great perfection on the Breadalbane estates. Already the slip has been found most admirably to serve the purpose for which it was erected. A few weeks ago the Lady of the Lake was placed upon it in order to have a couple of damaged plates removed and to be fitted with a new propeller of greater power than the original one; and the slip then worked so well that although the vessel is of 100 tons burthen, she was easily taken from the water by means of a hand winch. (*Engineering.*)

The "Delta" Steam Launch.—A steam launch constructed of "delta metal" is being exhibited at the Crystal Palace in the joint names of Mr. Alexander Dick, the manufacturer of the new alloy, and Messrs. Yarrow and Co., the builders of the launch. As it has been proved by repeated experiments that delta metal is equal in strength, ductility, and toughness to mild steel, the plates and angle pieces of this launch were made of the same thickness as if they had been of steel, namely $\frac{3}{32}$ in. The length of the boat over all, is 36 ft., the breadth of beam 5 ft. 6 in., and the depth from gunwale to keel 3 ft., the capacity being sufficient to provide sitting accommodation for twenty-five persons. The stern, keel, and stern-post are of forged delta metal, and are scarfed together in the usual way. The angle frames are made of the same material and are placed longitudinally instead of transvrsely, to give greater longitudinal strength. The propeller, cast in delta metal, is four-bladed, 2 ft. 4 in. in diameter, and 3 ft. pitch. The engine is of the usual direct-acting type, and of sufficient power to propel the boat at a speed of eight to nine knots per hour. The advantage of delta metal over steel and iron for shipbuilding, is that it does not rust. It is well known that a thin steel vessel, unless continually painted, will rust through very rapidly. This difficulty has been found to exist to a remarkable extent in the rivers of Central Africa; in these the waters, from some unexplained cause, possesses an extraordinary power of corroding and eating through steel plates. This fact is of special interest at the present moment when the rapid development of the African continent may be looked for. An important advantage possessed by delta metal for the construction of large boats, where its weight must be reckoned by tons, is that it is offered at a moderate price, and consequently the undoubted advantages of non-corrodibility are not eclipsed by a prohibitive cost.

Polishing Wood in the Lathe.—After sand papering a very little preparation is required. Fill up the grain with oil and plaster of Paris, wipe off clean, polish with French polish, and finish off with alcohol.


ELEVATORS AND CONVEYER
AT THE COKEWORKS OF THE
LONG RUN COAL & IRON CO.
NEW BETHLEHEM, PA.
Crusher
Nut
Slack
Lump
coal
Slack bin
150 tons
A
B
C
E
H
R
Center line of Elevator
Pl. V.


Pl. VI.
ELEVATORS AND CONVEYER
AT THE
ROCHESTER MINES
DUBOIS, PA.
SCALE OF FEET
B
C
Conveyer to Washer
Elevator
Run of Mine
Tipple
Coal
Screened Coal
Elevator to Washer
Elevator to Storage bin
E

SCREW PILES.

(*For illustrations see page 208.*)

THE APPLICATION OF SCREW PILES TO FOUNDATIONS.

Screw piles are applicable to every description of ground except rock, provided the diameters of the pile shaft and screw are proportioned to the nature of the soil. Driving or sinking piles not fitted with the screw is an operation of extreme difficulty in sand, and it is sometimes impracticable to force them down. Notwithstanding that many ingenious contrivances have been more or less successfully applied, there is no certainty that a row or group of piles can be sunk (fixed) to an equal depth to bear their load in the same strata. With Screw Piles the groups can be brought to a true level in any strata. (Fig. 1.) Screw Piles have been screwed to a depth of 40 feet through pure compact sea sand with comparative ease, and with the application of manual power only. (Fig. 2.) The screws enter a clay strata more easily than almost any other, and they have been inserted in sand and clay, in many instances, from 20 to 39 feet. The principle of the Screw Pile introduced by Alexander Mitchell about 50 years ago, and the advantages derivable from its use, have enabled engineers to execute works under circumstances of no ordinary difficulty, especially in instances where the soil is unstable and incapable of supporting structures of the ordinary type.

In the execution of work in treacherous localities where the structures are subject to the influence of floods in rivers, or wide estuaries, and all the contingencies arising from shifting sand channels, and strong tide currents and scour, none of the several inventions that have been brought forward to overcome these known difficulties have been so effectual as the Screw Pile. An immense advantage pertaining to the Screw Pile is that, in cases where it is most wanted, *i.e.*, on a shifting or loose sand, it is easily applied. They have been used in the erection of lighthouses (Fig. 3), beacons, breakwaters, piers, jetties, wharves, in-bridge foundations, bridge structures, viaducts, aqueducts, etc. It is scarcely possible to enumerate the many instances of their application. In fact, without them many of the difficulties connected with some of our most important public works would have been almost insurmountable.

THE APPLICATION OF THE GROUND SCREW TO MOORINGS.

The screw mooring can be employed in every description of ground, hard rock alone excepted. The proper area of the screw should in every case be determined by the nature of the ground in which it is to be placed, which should be ascertained by boring. The depth to which these moorings are required to be screwed varies with the character of the ground. Every description of earth is more or less adhesive, and the greater its tenacity the larger must be the portion disturbed before the mooring can be displaced by any direct force. Their holding power is indeed so great that, in several instances, chains made of iron 3¼ inches diameter have been broken, without bringing up the screw.

Besides their security, the advantages of screw moorings, in other respects over those formerly in use, are very considerable. In most cases all ground chain is dispensed with, the buoy chain going down direct to the screw. This not only saves a very heavy expense, but does away with the inconvenience always arising in narrow harbours, from anchors getting foul of these chains.

Wherever ground chains are used in connection with screws, they are stretched up and down the stream. The advantages of this system are its simplicity and cheapness of construction, with the powerful resistance, even to a vertical strain, which generally proves fatal to sinker, mushroom, or anchor moorings, depending (as they do) chiefly on their specific gravity. In confined situations the screw moorings are particularly valuable, from the small scope which may be given to the buoy chain on account of the great holding power of the screw. This is often a matter of very great importance.

The usual form of mooring screw is given in the wood cut (Fig. 4). The dimensions as to the diameter of the screw blades, spindle, shackles, etc., are determined by the nature of the ground into which the mooring screw has to be sunk, and the strain to be borne by it.

Besides their ordinary use in mooring vessels, either singly or in tiers, a smaller class of screw is extensively employed for warping and marking buoys, and for guys and temporary purposes. Modified forms have also been usefully employed in many ways on shore. and it will be perceived how easily the principle can be adapted to such purposes as holding down chains for suspension bridges. (Fig. 5.) The guys of standpipes or signal-posts—as a perfectly safe mode of securing light buildings in countries subject to hurricanes (Fig. 6), as a substitute for tent pegs, or as a convenient fastening for rack clothes, etc., etc.

METROPOLETAN SEWAGE DISCHARGE.*

BY MR. R. W. PEREGRINE BIRCH, M. INST. C.E.

In this paper a description was given of a method laid before the "Royal Commission on Metropolitan Sewage Discharge" by the author, to ascertain the rate of progress out to sea of the sewage discharged at Crossness and at Barking. It was now known that this problem could not be dealt with satisfactorily by means of float-experiments; and the author submitted that its only true solution lay in the accurate measurement and localization of the sea-water and fresh-water contained in the river, considered together with the records of the upland-flow contributing to the latter. If it were not for the incoming of sea-water, the time occupied by the sewage-polluted Thames water at Barking in travelling to any lower point, say Gravesend, would be exactly the same as the time required by the Thames, with its tributaries and sewage, to fill the channel between Barking and that point. But the salt-water occupied part of the channel, and by diminishing the space available for the fresh-water reduced the time required for the fresh-water to fill that space and pass through it. The author showed that by a complete set of salt-tests made at regular distances apart in the length of the river, and at fixed tidal periods, it could be ascertained with great nicety to what extent any section of the river was occupied by sea-water, and consequently what space was left for sewage-polluted river-water. The time occupied by the journey of the upland-water would be the time required to fill the latter space. It was shown that in dry weather such as prevailed in September, 1882, the sewage discharged at Barking would reach southward in thirty-two or thirty-three days, and in a time of heavy flood, as in November, 1882, in twelve days. The general effect of the calculations was to indicate that, owing to the greater specific gravity of sea-water and its tendency to diffusion, the exchange of river-water and sea-water took place very quickly—much more so than was commonly supposed—so that the uplahd-water passed even more rapidly through the estuary at Southend than at Barking, where the cross-sectional area was not one-twelfth the size.

Engineering Notes.

TORPEDO EXPERIMENTS.—Some recent experiments of Admiral Jaurés of the French navy with torpedoes have resulted very satisfactorily to those who claim a high degree of efficiency for this class of naval engines.

When starting on a voyage from Toulon to Lisbon with a small fleet, the admiral took with him two torpedo, boats, Nos. 63 and 64. The plan of the test was simple, the torpedo boats were to do their best to reach the ships, the ships were to avoid and thwart them if possible. Everything favored the latter, the night was calm, the moon full, the ships provided with powerful electric lights, and their officers and lookouts informed of the hour of attack. In spite of all this, torpedo boat No. 64 which appoached the squadron in front, was not discovered until within 1,000 yards of the vessels, and moving at a speed which would cover that space in a little over one minute. When it is remembered that these boats discharge their torpedoes with absolute certainty at 300 yards, and with fair chances of success at 400, it will be seen that pretty quick work would be required of the crew of an iron-clad, even under the favorable conditions of the experiment, to destroy the torpedo boat before having their own vessel sunk under them. In rough weather or on a dark night, three or four boats of this description would keep a hostile cruiser well occupied in defending hereself.

THE new dynamite gun, so called, is really an air gun. The dynamite is in the bomb discharged. The experimental gun was of 4 in. bore and 40 ft. in length. An air pressure of 500 lbs. was used, which threw a shell containing 16 lbs. of dynamite a distance of a mile and a quarter.

* A paper read before the Institution of Civil Engineers.

Automatic Lighting of Beacons.—In America a system of automatic beacon lights has been adopted. Each beacon is furnished with a reservoir of sheet iron, containing gas under a pressure of fifteen atmospheres. The quantity is sufficient to light the beacon for three months; and fresh supplies are periodically delivered by a vessel which conveys the gas from the factory. A clock-work installed in the beacon, turns on, and lights the gas at the hour fixed for this purpose. The experience of several months has served to test this plan and it has proved so far successful. Attendants live on the shore near the beacon, and see if they are working properly.

The Floods of the Ohio.—An interesting note on this subject has been communicated to the French Academy of Sciences by MM. Lemoine and Mahan. The Ohio floods, as is well known, produce great havoc at Pittsburg, Cincinnati, and other cities, on the banks of the river. The river rises to a great height, and floods the houses and manufactories on its banks. In February last, more than 1200 buildings were flooded at Pittsburg, and at Cincinnati (275,000 inhabitants) the damage was estimated at the about 200,000*l*. The basin of the Ohio has an area little less than the whole of France; and a great many affluents join the main stream. Although a few flood observations have been made on the river itself, the tributaries have been neglected in this respect. MM. Lemoine and Mahan propose to organise a methodical system to observations on the river system of the Ohio valley, such as Bellegrand introduced in the basin of the Seine. The important stations will be in communication with the engineer of navigation at Cincinnati, who will forward warnings to all places threatened with a flood. Certain stations will send daily reports by letter, others by telegraph; and the data thus collected will, when sifted out, lead to the prediction of floods at different parts of the basin.

Lartigue's Electric Railway.—M. Lartigue, the well-known French engineer, has applied electricity to the traction of the panniers or cars of his single-rail tramway. This tramway is, as we stated some time since, employed in Algeria for transporting esparto grass from the interior by the traction of camels. It was an easy step from animal to electric traction, and M. Lartigue has successfully taken it. At the recent Agricultural Exhibition in the Palais de l'Industrie, of Paris, an experimental line was shown on which five iron panniers, or double cars in the form of seats, were drawn by a dynamo-electric locomotive at the rate of seven miles an hour. The total weight of the five cars and the electric locomotive was about a ton, and the maximum power required was three horsepower. The dynamo of the locomotive was a Siemens D^6, and the generator, which stood about 100 yards from the line, was a Siemens D^2 dynamo capable of developing from 5 to 6 electric horse-power. It was driven by a Herman-Lachapelle steam engine. The total length of the line was 123 metres. It was built of forty-one rails, each 3 metres long, and comprised curves of 7½ metres radius. The locomotive dynamo was carried by a platform car or pannier, and geared with a grooved driving wheel 30 centimetres in diameter, which ran upon the rail. A rheostat to graduate the speed, switches to stop, start, and reverse the motor, and a seat for the conductor, were also carried by the locomotive car. The train was properly coupled to the locomotive, and ran on small grooved wheels. The current was brought to the dynamo by two insulated conductors, one connected to the rail, the other to the dynamo through small contact rollers in connexion with the commutator. One switch was employed to start or stop the train by making or breaking the circuit; the other to reverse its motion by reversing the current. The rheostat, by interpolating resistance into the circuit, allows the strength of the current to be varied and the speed of the train to be increased or diminished as the case may be. The work was carried out by Messrs. Siemens, and under the direction of M. G. Boistel. The economy of the working is of course largely dependent on local circumstances.

Glass Bridges.—It is said that glass is gradually beginning to take the place of wood and iron in the construction of bridges in England. The inventor makes blocks of glass which he hardens by a special process. In solidity it is said to leave nothing to be desired. The experiments already made have given surprising results, and the cost is below that of bridges of wood or iron. Moreover the glass cannot be injured by insects like wood, nor rusted like iron.

Lincoln and Brigg Tramway.—An effort is about to be made to carry out a tramway from Lincoln to Brigg, for which a Board of Trade order was obtain some time since. It is intended to lay the line (which will be twenty-sven miles in length, including sidings and passing places, the gauge being 3 ft. 6 in.), along the waste land at the sides of the fine old Roman road, known as Ermine-street, so as not to interfere with carriage traffic. The Great Northern Railway Company has agreed to afford the freest access to their goods yard at Lincoln, with permission to put in sidings and banks to facilitate the exchange of traffic from and to their ordinary railway wagons; and the Manchester, Sheffield, and Lincolnshire Railway Company has agreed to afford similar facilities in their goods yard at Brigg.

Improved Boiler Tubes.—In order to obtain the greatest possible efficiency in the steam-heating surface of boilers, a new kind of vertical steam boiler has recently been invented by a Mr. Armer. To obtain this efficiency, the boiler tubes have a helical twist given them, which does not interfere with the ease with which they may be cleansed, but which causes greater impingement of the gases against the tube walls, and gives more freedom for expansion than straight tubes.

The Fuel Cost of High Speed.—Some experiments have recently been made upon the Pennsylvania road, near Philadelphia, to ascertain the difference in the consumption of coal between running a train very rapidly and at a very low speed. The same conditions, same number of cars and similar engines were employed. The trains in each case run the same distance —119 miles out and back. Some stops were made. The fast train ran on schedule express time. The slow train ran at the funeral pace of twelve miles an hour. The fast train consumed 6,725 lbs. of coal. The slow train consumed 4,420—saving effected, 2,305 lbs.

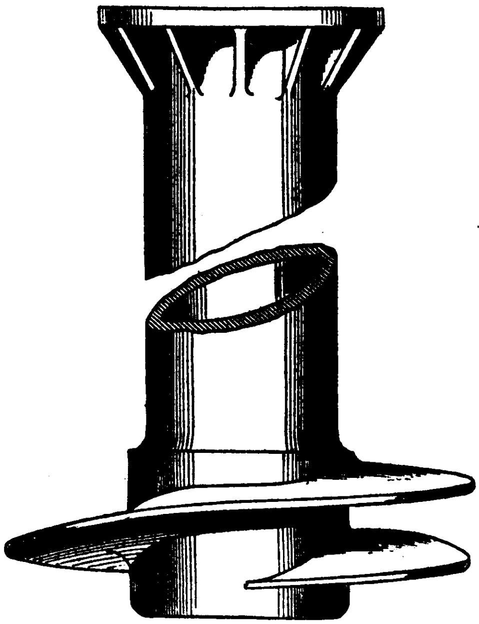
Glass Bearings.—To what purpose may not glass be put? Bearings made of glass are now being experimented with in the rolling stock of railroads in regard to their frictionless qualities. This material is a hard, clear substance, and must wear down smooth and give a fine bearing surface for an axle to rest upon. It is a non-conductor of electricity, if not of heat, and the fine particles have as good a chance to work down the bearings of the axle to a running fit as in the grinding in of a valve seat for a brass valve, and much power is expected to be saved by converting the wearing of a journal into some other agency, than by converting it into heat.

Fresh Paint.—The current belief among house-holders, the smell of fresh lead paint is noxious, is founded on pretty general experience but is supposed by the opinion eqnally current among chemists, that lead compounds are not volatile. A fact recently brought to the notice of our excellent contemporary, the *Lancet*, supports the domestic theory. The basis of the useful and popular luminous paint is known to be sulphide of calcium. Now, this compound, when unprotected by varnish, glass, or some other impervious substance, is slowly acted on by the acids of the air, and sulphureted hydrogen is evolved, which blackens lead paint. This is well known, and can easily be avoided by proper protection of the paint. But the curious thing is that unprotected luminous paint is found to be perceptibly blackened by the fumes from fresh lead paint. There seems to be only one possible explanation of this: namely, that a surface freshly covered with lead paint does actually emit some volatile compound of lead. We believe that many physicians could confirm this view from their own observations in regard to newly painted houses.

Curiosities of Magnetism.—If an iron wire be twisted during or soon after the passage of a voltaic current through it, the wire becomes magnetic. When the wire is twisted in the manner of a right head screw, the point at which the current enters, becomes a south pole in the opposite case it becomes a north pole. If during the passage of the current, the wire be twisted in different directions, the polarity changes with the direction of the twist.

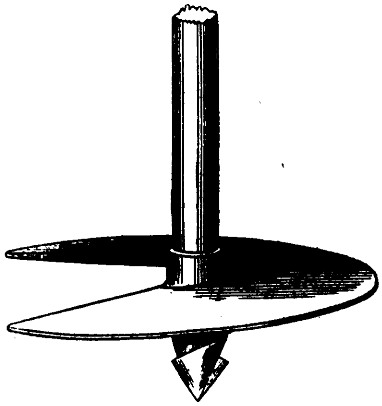
It is proposed to have a universal exhibition of railroad material at St. Etienne, in France, next year. St. Etienne is a city of nearly 100,000 inhabitants in Southeastern France, some thirty miles southweast of Lyons. It is proposed to have tracks in the form of an immense figure 8, in which different systems of iron substructure, joints, chairs, rails switches, signals. etc., shall be employed and tested.

Fig. 1.



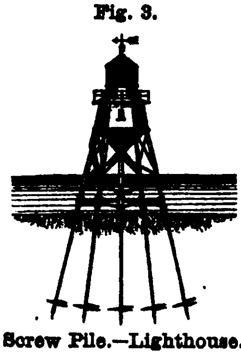
Screw with Hollow Cast-iron Piles.

Fig. 2.



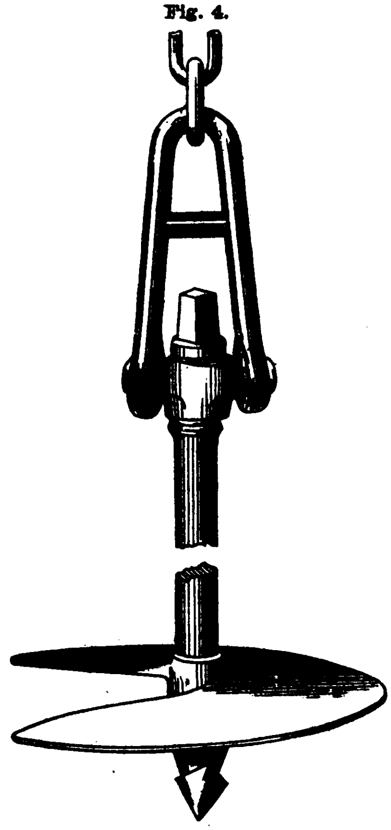
Screw with Solid Wrought-iron Pile, for Piers, Bridges, Lighthouses etc.

Fig. 3.



Screw Pile.—Lighthouse.

Fig. 4.

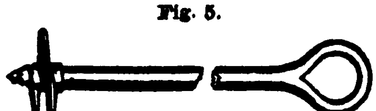


Mooring Screw.

Fig. 6.

Holding-down Screw for Tents, Rickcloths, etc.

Fig. 5.



Mooring for Marking Buoys, Guys, Landties, and for Temporary purposes.

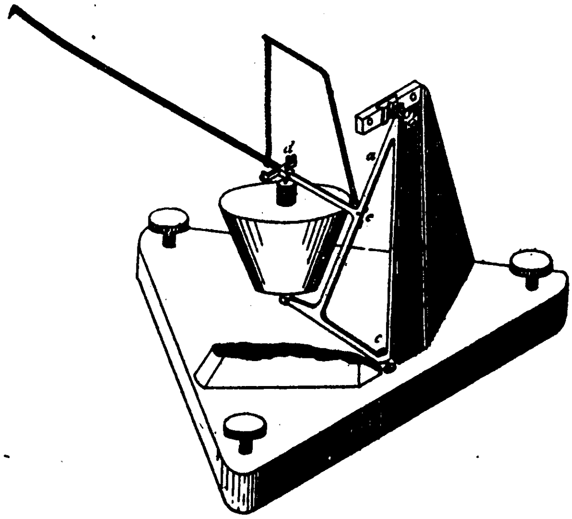


Fig. 1

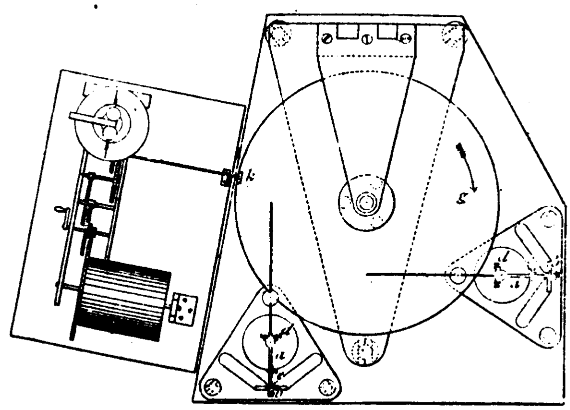


Fig. 2

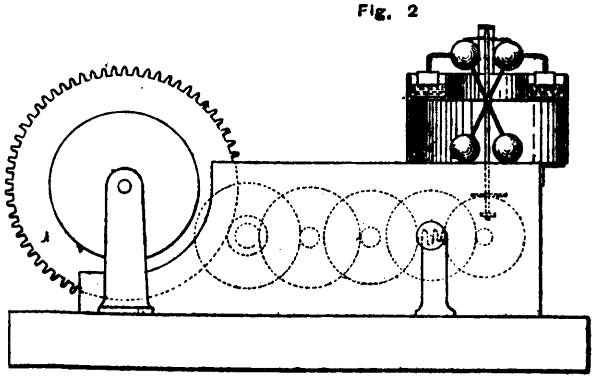


Fig. 3

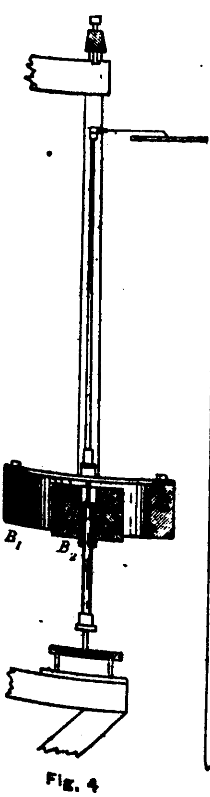


Fig. 4

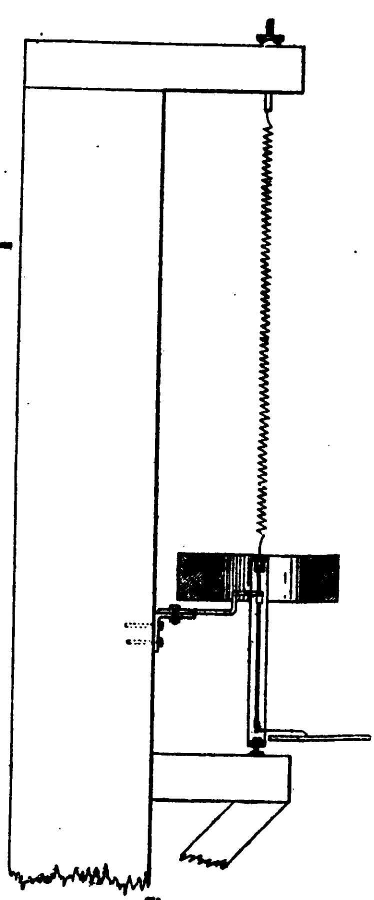


Fig. 5

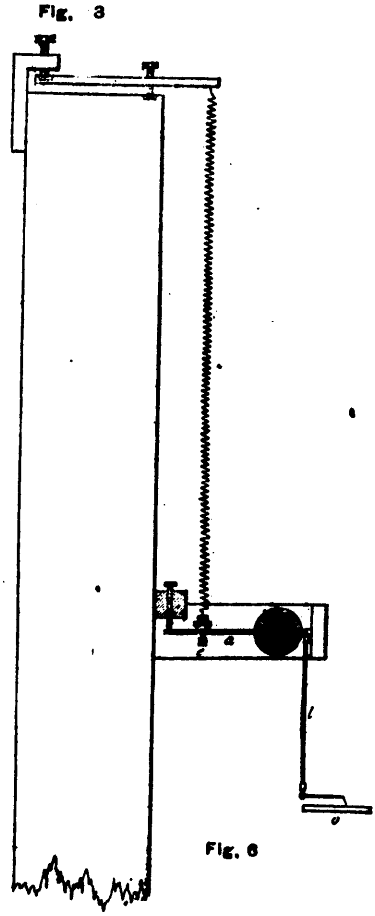


Fig. 6

MEASURING EARTHQUAKES. (*Nature.*)

(*For Illustrations see pages 209, 212, 213, 216.*)

I.—Methods.

It is difficult to define the word earthquake in terms which will not cover cases to which the name is inappropriate. To say that an earthquake is a local disturbance of the earth's crust, propagated by the elasticity of the crust to neighbouring portions, is true, but the definition does not exclude, on the one hand, such tremors of the soil as are set up by the rumbling of a carriage, by the tread of a foot, or even by the chirp of a grasshopper, nor, on the other, those slow elastic yieldings which result from changes of atmospheric pressure, from the rise and fall of the tides, and perhaps from many other causes. One writer, in his definition of the word, limits the name earthquake to disturbances whose causes are unknown—a course open to the obvious objection that if the study of earthquakes ever advanced so far as to make the causes perfectly intelligible we should, by definition, be left with no earthquakes to study. It must be admitted, however, that in the present state of seismology this objection has no force, for in assigning an origin to any disturbance likely to be called an earthquake, we have, so far, been able to do little more than guess at possibilities. The more practicable task of determining what, at any one point within the disturbed area, the motions of the ground during an earthquake exactly are has lately received much attention, and in this department of seismology distinct progress has been made.

Apart from its scientific interest, this absolute measurement of earthquake motion is not without its practical use. Through the recent shape earthquake in the Eastern Counties has reminded us that no part of the earth's surface can be pronounced free from liability to occasional shocks, these occur so rarely in this country that English builders are little likely to let the risk of an earthquake affect their practice. If Glasgow or Manchester had been shaken instead of Colchester, the chimneys of the mills would, we suppose, have risen again in a few weeks no less tall than before. The case is different in an "earthquake country," such, for example, as some parts of Japan, where the present writer had the good fortune to experience, during five years, some three hundred earthquakes. Where the chances are that a structure will have to stand a shock, not once in a few centuries, but half-a-dozen times a month, the value of data which will enable an architect or engineer to calculate the frequency and amplitude of the vibrations, and the greatest probable rate of acceleration of the earth's surface, does not need to be pointed out.

To know how the earth's surface moves during the passage of a disturbance we must obtain, as a standard of reference, a "steady-point," or point which will remain (at least approximately) at rest. This is a matter of no small difficulty, for (as will be shown in a second paper) the motions during any single earthquake are not only very numerous but remarkably various in direction and extent. Most early seismometers were based on the idea that an earthquake consists mainly of a single great impulse, easily distinguishable from any minor vibrations which may precede or follow it. The writer's observations of Japanese earthquakes do not bear this out. They show, on the contrary, during the passage of almost every earthquake, scores of successive movements, of which no single one is very prominently greater than the rest. Moreover, the direction in which a particle vibrates is so far from constant that it is usually impossible to specify even roughly any particular direction as that of principal movement. For these reasons attempts are futile to obtain knowledge of earthquake motions from instruments intended to show only the greatest displacement or "the direction of the shock." The indications of such instruments are, in fact, unintelligible, and it is safe to say that no seismometer is of value which does not exhibit continuously the displacement of a point from its original position during the whole course of the disturbance. The value of the observation is enormously increased if, in addition to the amount and direction of the successive displacements being shown, these are recorded in their relation to the time. We can then, besides seeing the frequency of the vibrations, calculate the greatest velocity of the motion of the surface, and also its greatest rate of acceleration—an element of chief importance in determining an earthquake's capacity for mischief, since in a right and rigidly founded structure the shearing force through the base is equal to the product of the acceleration into the mass, and the moment tending to cause overthrow is that product into the height of the centre o gravity.1

Seismographs used during the last three or four years by the writer and others in Japan give a record of the earth's motion during disturbance by dividing that into three components, along the vertical and two horizontal lines. In the writer's apparatus these three are independently recorded on a revolving sheet of smoked glass, which is either maintained in uniform rotation ready for an earthquake to begin at any moment, or is started into rotation (by help of an electromagnetic arrangement) by the earliest tremors of the earthquake itself. The relative position of the marks on the glass serves to connect the three components with each other, and a knowledge of its speed of rotation connects them with the time. It is sufficient that the "steady-point" for each of the three components should be steady with respect to motion in one direction only. It may move with the earth in either or both of the other two directions, and in fact it is generally most convenient to provide three distinct steady-points, each with no more than one degree of freedom.

In that case each steady-point is obtained by pivoting a piece about an axis fixed to the earth, and in nearly neutral equilibrium with respect to displacements about the axis of support. When the earth's surface shakes in the direction in which the piece is free to move, the support, which is rigid, moves with it, but the centre of percussion of the pivoted piece remains approximately at rest, and so affords a point of reference with respect to which the earth's movements may be recorded. If we could get rid of friction, and if it were practicable to have the equilibrium of the pivoted piece absolutely neutral, the centre of percussion would remain (for small motions) rigorously at rest even during a prolonged disturbances. But there must be some friction at the axis of support and also at the tracer which records the relative position of a point moving with the earth and the steady-point of the seismograph. And the pivoted mass must have some small stability, to prevent a tendency to creep away from its normal position during a long continued shaking, or in consequence of changes of the vertical. If, however, the mass be so nearly astatic that its free period of oscillation is much longer than the longest period of the earthquake waves, and if great care be taken to avoid friction, the centre of percussion behaves almost exactly as a true steady-point with respect to all the most important motion of even a very insignificant earthquake. The effective inertia of the system may be further increased by pivoting a second mass on an axis passing through the centre of percussion of the first piece and parallel to the axis of support. An instrument designed on these lines in which the pivoted pieces in neutral equilibrium were two light frames, supported as horizontal pendulums at right angles to each other, and with a massive bob pivoted at the centre of percussion of each, gave (in 1880) the earliest complete records of the horizontal movement of the ground during an earthquake. A description of it has been given in the *Proceedings of the Royal Society*, No. 210.

Figs. 1 and 2 show this seismograph, improved in many of its details. The frame shown is one which has done excellent service in a seismological observatory which the writer was enabled to establish in the University of Tokio, through the interest of the Japanese directors. A similar instrument has also been supplied to the Government of Manila. Fig. 1 shows one of the two horizontal pendulums with a portion of one of its upright supports removed. The axis of support (which slopes very slightly forward to give a small degree of stability) is formed by two steel points, *b* and *c*, working in an agate V-groove and a conical hole. The frame of the pendulum is a light steel triangle, *a*, the effective inertia being given almost wholly by a second mass pivoted at *d* on a vertical axis which passes through the centre of percussion of the frame. The tracer, which serves to magnify as well as to record the motion, is a straw, tipped with steel, and attached to the pendulum by a horizontal joint at *d*, which allows it to accommodate itself to any inequalities in the height of the glass plate on which its distant end rests. A portion of its weight is borne by a spring, adjustable by a clamp at *e*, by which the pressure of the tracer on the glass plate may be reduced to an amount just sufficient to scratch off a thin coating of lamp-black with which the glass is covered. In Fig. 2 the two pendulums are

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1. The case is different and much less simple where he structure is so flexible as to have a period of free vibration comparallel with the periods of the earthquake vibrations.

seen in plan, with their tracing pointers touching the glass plate, g, at different distances from its centre. The plate and pendulums are mounted on a single base, which is very rigidly secured to the top of a broad post, struck firmly in the earth and projecting only a few inches above the surface. Continuous rotation is communicated to the plate by a friction roller, k, held in a slot guide and connected by a universal joint to one of the arbors of a clock, which is wound up once a day. Government by an escapement being out of the question, the clock is controlled by a fluid-friction governor connected to the wheel train, also by friction gear, as shown in Fig. 3. The balls are four in number to prevent disturbance of them by an earthquake. The vanes dip into oil, and are drawn back by two springs which tie them to the spindle.

When the earth shakes the axis, d, of each bob remains sensibly at rest as regards components of motion perpendicular to the corresponding pendulum, and the tracing point is this case is four times the motion of the earth. So long as no earthquake occurs each pointer traces over and over again a single circle on the plate. The circle frequently tends to widen inconveniently, especially if the pendulum is very nearly astatic. This is in part at least due to such changes of the vertical as have been observed by d'Abbadie, Plantamour, G. H. Darwin, and others. The plate consequently requires frequent attention, and where that cannot be given, an electric starting arrangement is to be preferred. When an earthquake has occurred, the plate is removed, varnished, and photographed by using it as a "negative."

The bob of each pendulum may of course be rigidly attached to instead of pivoted on the pendulum frame. In that case the center of percussion of the frame and bob together (which will then be a little farther from the support than the center of the bob) will be the steady-point. The writer, however, prefers the arrangement described above, which gives great compactness and a maximum of effective inertia, and which has the advantage of making the position of the steady point at once determinate.

It would take too much space to describe or even to enumerate the many other devices which have been suggested to secure a steady-point by various methods of astatic support,[1] leaving one, or in some cases two, degrees of freedom to move horizontally. The horizontal pendulum has been modified by substituting a flexible wire and spring for its rigid pivots thereby avoiding all but molecular friction at the axis of support. Spheres and cylinders, free to roll on plane or curved surfaces with or without a slab above them, have been tried, but their friction is excessive. The approximate straight-line motions of Watt and of Tchebicheff have been pressed into the service as means of suspending a mass with freedom to move in a horizontal path. The commod or vertical pendulum, an old favourite with seismologists, has suffered many transformations in the efforts to reduce its stability, which is perposterously great unless we make the pendulum very long. A 20 foot pendulum consisting of a cast-iron ring weighing half a hundred-weight hung by three wires from a rigid tower, has done good work in the writer's observatory, but such an instrument has obvious drawbacks. Fig 4. shows an arrangement, also used by the writer, and called a "duplex pendulum." A common pendulum with a ring bob, B^I, is connected to an inverted pendulum, B_2, by a ball-and-tube joint, which compels the bobs to move horizontally together. The combination can be made as nearly astatic as may be desired by proportioning the masses of the bobs to the lengths of the suspension-rods. The inverted pendulum stands on a joint which gives two freedoms to rotate but prevents twisting about a vertical axis; an extension of its rod upwards forms the multiplying arm, and carries a tracing pointer.

Another plan is shown in Fig. 5, which may be described as a duplex dendulum with a single bob, whose weight is borne partly by a socket blow and partly by a spring from a support above. Any one of these instruments affords a single steady-point with respect to all motions in azimuth. Their principal use is to give "static" records of the horizontal motion, that is, records traced on *fixed* plates, which show at a glance the changes in direction of displacement during the occurrence of an earthquake.

In attempting to register the vertical component of earthquake motions, we meet with the difficulty that the weight of the mass whose inertia is to furnish a steady point acts in the direction in which freedom of motion is to be retained. A weight hung by a spiral spring from a support above it is too stable to act as a seismometer, unless the spring be impracticably long. A horizontal bar fixed to a wall by a flexible joint and loaded at its end—an old device used by the British Association Committee at Comrie in 1845—is open to the same objection. If the loaded bar is rigid, but pivoted about a fixed horizontal axis, and held up by a spiral spring near the axis of support, we obtain a much slower period of free oscillation than if the spring were directly loaded with a weight which would stretch it to the same extent. Mr. Gray has rendered this device as nearly astatic as may be desired by adding a small tube containing mercury, whose effect is to increase the load when the bar goes down and to decrease it when the bar goes up. Another and simpler way of attaining the same result is shown in Fig. 6, which represents the vertical seismograph used in Japan by the present writer. There a is a horizontal axis on two points at c, with a heavy bob b, whose weight is borne by a pair of springs, d. But the upward pull of the springs, instead of being applied to the bar in the line joining the axis c with the centre of gravity, is applied *below* that line by means of the stirrup e. Consequently, if the bar goes down, the pull of the springs, although increased above its normal value, is applied nearer to the axis, and (by properly adjusting the depth of e below the bar) the moment of the pull of the springs may thus be kept as nearly equal to the moment of the weight as may be desired—a condition which of course secures astaticism. The centre of percussion of the loaded bar is the steady point, with respect to which the vertical motions of the ground are recorded by the multiplying lever l on the rim of a revolving glass' plate, o, which may be the same plate as that which receives the record of the two horizontal components.

The instruments which have been briefly described succeed in registering very completely all the movements of the ground at an observing station during the occurrence of an ordinary earthquake, and some of the could be adapted with little difficulty to the registration of violent convulsions. It would be outside the scope of this paper to deal with the appliances by which Rossi and others have investigated those minute and almost incessant tremors of the soil whose very existence no observations less fine and careful would serve to detect.

[1] See papers by Gray, Milne, the writer in the *Transactions of the Seismological Society of Japan*, vols. i. to vi; or a memoir on "Earthquake Measurement," published a year ago by the University of Tokio.

ANTIQUITY OF LIGHTNING RODS.

Attention has recently been called to the use of iron as a metal for lightning rods. In this country, where the subject has been left in the hands of the manufacturers, lightning rods are made of pure copper, and consequently are far too expensive for general use. In France, America and other countries iron rods are in vogue, and found to answer the purpose very well, besides being inexpensive. In Canada a church was recently protected by a round iron rod three-quarters of an inch in diameter, and welded at each joint. The upper end of the rod was drawn to a point, and a damp ground connection provided for the lower end. The rod was secured to the church by galvanized iron staples. The total cost was under £3. While upon this subject we may mention that Franklin was probably anticipated in his discovery of lightning conduction. According to M. de Rochas, the ancient Etruscans understood the art of guiding the lightning. Tervius, relates that in ancient times the priests ignited their sacrifices by lightning, and on one occasion Tullus Hostillus was struck dead because he neglected the precautions laid down by Numa.

FREDERICK HERMANN PŒTSCH, the inventor of the freezing method for sinking shafts and foundations in water-bearing strata, was born in Anhalt, about 1842. He graduated at Freiburg, as a Mining Engineer, and for the first ten years of his active life was engaged as Mining and Smelting Engineer for Anhalt; after that he went into the prussian State Service as Government Mining Surveyor and Superintendent. He was mainly employed in Saxony, at Ashersleben, and the frequent trouble from quick sand in shaft-sinking in that section early attracted his attention. It was only in February, 1883, however that the method, patented in October, 1883, suggested itself, and it was at once put in practice in the Archibald Mine. Mr. Pœtsch is a patient, persevering and hard working engineer, an for some years past has been devoting himself to the solution of this quick sand problem.

MEASURING EARTHQUAKES[1]

II.—RESULTS.

IN this paper a short account will be given of the chief results of two and a half years' observations in the Seismological Observatory of the University of Tokio. The first instruments to be successfully used were the horizontal pendulum, or rather a pair of horizontal pendulums writing a multiplied record of two rectangular horizontal components of the earth's motion on a revolving plate of smoked glass, and also a very long common pendulum. The duplex pendulum, an astatic vertical-motion seismograph, and other instruments which have been mentioned in the former article, were added later.[1]

The earliest records were those of five small earthquakes in November 1880.[2] In the first of these the vibration of the ground lasted continuously for 1⅓ minutes, and no fewer than 150 complete oscillations could be counted in the record. The shaking began feebly, speedily rose to a maximum, fluctuated irregularly, and died out very gradually. The greatest movement from side to side was less than one-third of a millimetre. Both

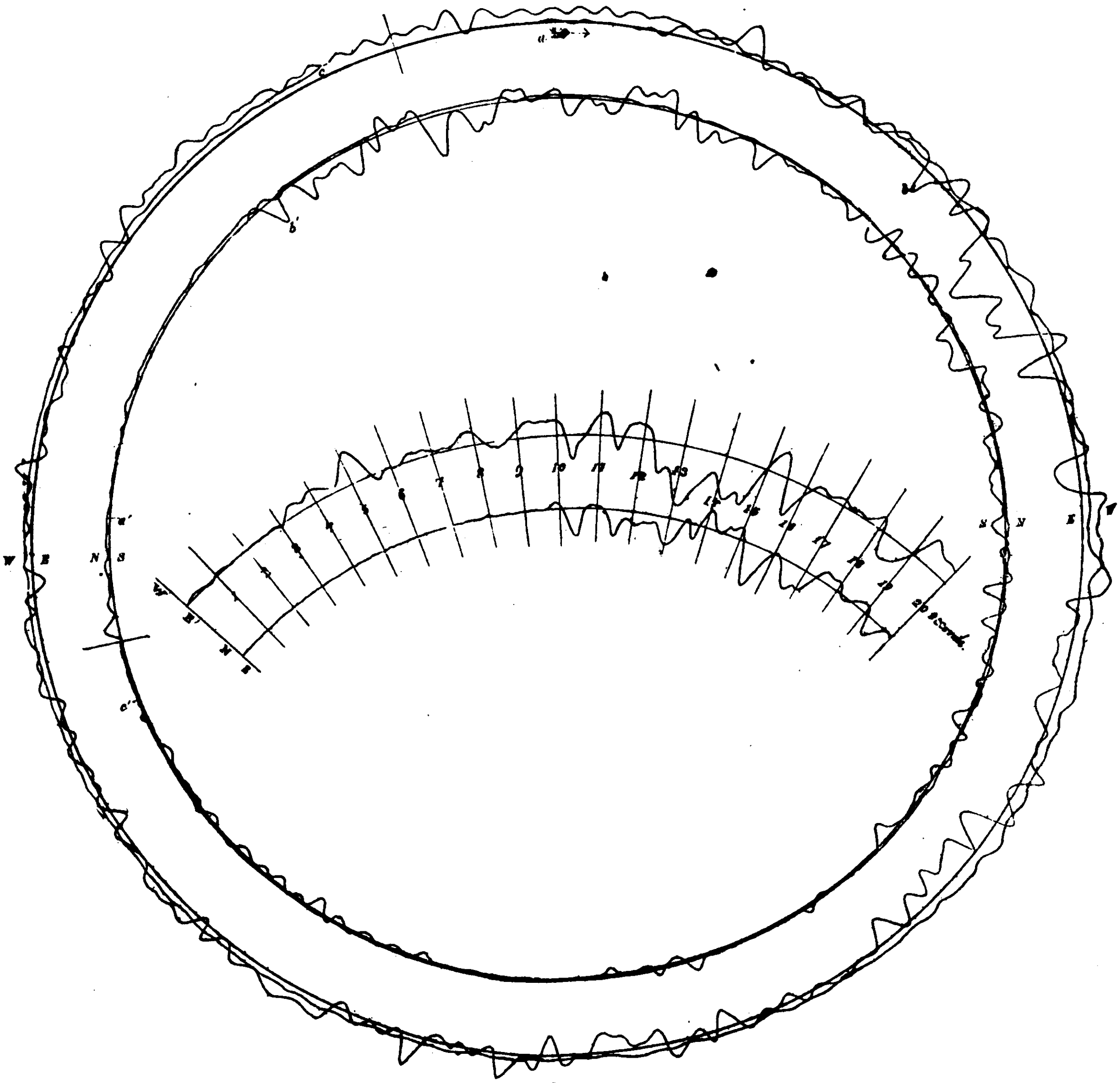

FIG. 7.

in amplitude and in period the successive waves were far from equal. A rough idea of the greatest velocity and greatest acceleration was, however, obtained by treating the greatest movement as a simple harmonic vibration, with a period of three-fifths of a second. This gave 1·6 mm. per second for the greatest velocity, and 16·4 mm. per second per second for the greatest acceleration, showing that bodies attached rigidly to the earth's surface must have experienced a horizontal force equal to about one-six hundredth of their own weight. In three of the five earthquakes recorded in the same month the greatest range of motion was less than one-fifth of a millimetre. In all of them there were many and unequal vibrations, but in none was there any single impulse prominently greater than the other movements.

Later observations showed that these were fairly representative of a very large proportion of the earthquakes which occur so frequently in the Plain of Yedo. Earthquakes of this class do no damage to buildings, but they are strong enough to make their presence felt by the shaking and creaking of houses, and even, in the night, to startle residents out of sleep. Lamps and other pendulous bodies are frequently set into considerable oscillation through the long continuance of the disturbance, the period of some consecutive vibrations of the ground being nearly uniform and equal to the free period of the lamp. The shaking lasts rarely less than one and sometimes as much as ten minutes.

In some cases, however, the amplitude of the earth's motion is considerably greater; occasionally it rises to 5 and even 7 mm. With such an amplitude as this, and with the ordinary frequency which the earthquake waves have, the shock is more or less destructive—walls are cracked and chimneys are overthrown. The writer's observations do not include any earthquake of first-rate violence, but they show by several examples that in the alluvial soil of Tokio a sufficiently alarming and even damaging earthquake may occur, in which the range of horizontal motion is less than a single centimetre.

In the Yedo earthquakes the vertical motion is generally much less than the horizontal, and, as a rule, forms an unimportant part of the disturbance.

Fig. 7 is a copy, reduced to about half size, of the record of one of these more considerable earthquakes (on March 8, 1881), traced by a pair of horizontal pendulums on a revolving plate. The inner circle shows the N.S. component, and the outer circle the E.W. component of the displacement. The records begin simultaneously at the points marked *a'* and *a* respectively, and extend in the direction of the arrow over nearly two complete revolutions of the plate. At the point marked *c* in the outer circle, when the earthquake oscillations were slowly dying away, the writer (who happened to be present) withdrew the plate, to prevent the later portions of the record from confusing the earlier portions. By this time the earthquake had lasted for two minutes and a half, and some 200 vibrations had been registered. The motion, as recorded, was exaggerated in the ratio of 6 to 1; hence in the diagram as it appears here the displacements are nearly three times the natural size.

For the sake of exhibiting some interesting features of this earthquake more clearly, the records of the two components during the first twenty seconds of visible motion have been reproduced in the centre space of the diagram in such a manner that simultaneous parts of both are on the same radius. The short radial lines mark seconds of time. It will be seen that for three seconds the motions were very minute; then the E.W. seismograph became pretty sharply disturbed, but the other component was scarcely visible until the tenth second from the beginning. During the tenth and eleventh seconds the phases of the two components agree in the main, but they soon diverge; and in the fifteenth second, when the motion is greater than at any other part of the whole disturbance, they differ by about a quarter of a period. Hence at that time points on the earth's surface were vibrating not in a rectilineal path but in *loops*. This is strikingly shown by Fig. 8, which shows the path (exaggerated in the ratio of 6 to 1) of a point on the earth's surface, during three seconds at this epoch in the disturbance. Starting from *p* at 13·7 seconds from the beginning of the earthquake, a surface particle described the tortuous path shown in the figure, and reached *q* three seconds later. Similar rapid changes of phase-relation occur throughout the rest of the disturbance, and in the slowly dying oscillations with which the earthquake drew to a close the writer noticed one of the pointers moving vigorously when the other was nearly at rest, and *vice versâ*.

The evidence, first clearly given in this earthquake, of the non-rectilineal character of the ground's motion, was confirmed by very many later observations. In fact in every case where the records were sufficiently large and well-defined to admit of a satisfactory comparison of the phases of the two components, the same thing was exhibited. And not only in those cases, but even in very minute earthquakes, instruments having two degrees of horizontal freedom, such as the duplex pendulum, showed in the most direct manner that the earth's movements consisted of a multitude of twists and wriggles of the most fantastic character.

An excellent example of a still sharper earthquake is given in Fig. 9—a record (reduced to half size) given by two horizontal pendulums with a multiplying ratio of four to one on a plate which was turning once in fifty-four seconds. The beginning of motion can be detected on the outer circle at *a*. At *b* and the corresponding point *b'* it increases somewhat suddenly, and during the next few seconds we have the principal motions, followed during many minutes by a long trail of lesser irregular oscillations, in which a marked lengthening of period may be detected towards the close. To allow the phase-relation during the principal part of the shock to be examined, lines (numbered 1 to 16) have been drawn by the aid of templates through corresponding points in the two records. An examination will show that the phase-relation changes: in fact when the two components are combined the movements are found to be loops, agreeing very closely with the larger loops of Fig. 10, which is a "static" record of the same earthquake given by the duplex pendulum. In a

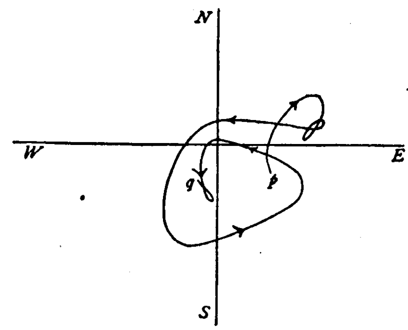

FIG. 8.

part of Fig. 10 the motions are so numerous and so much distributed over all azimuths, that the film of lamp-black has been completely rubbed away from a portion of the plate which received this record.

It frequently happens in the record of an earthquake that the motions which are first recorded are rapid vibrations, of short period and small amplitude, which are immediately followed by larger and less frequent movements. Sometimes, indeed, the former appear as a ripple of small waves superposed on larger ones. But in all cases where the short-period waves can be detected they die out early, and the later part of the earthquake consists of relatively long-period waves alone. Records of this class are exceedingly suggestive of the arrival of first a series of normal waves (that is, waves of compression and extension), constituting the rapid tremor, and then a series of transverse waves (that is, waves of distortion), forming the principal motions of the earthquake.

In fact it is difficult to explain the rapid changes of phase in the two components, or, in other words, the curved character of the horizontal movement, which most if not all the recorded earthquakes exhibit, otherwise than by supposing that the principal movements are transverse waves occurring in a plane not very much inclined to the horizon, and this conclusion is supported by the smallness of the vertical component.

It is true that the appearances presented by the diagrams could be accounted for by assuming the presence, together or normal and transverse waves, with a nearly horizontal direction of propagation ; but in that case we should expect to find normal waves occurring alone at the beginning of the earthquake with much greater amplitude than they actually have. Other still less probable solutions might be referred to ; but it is safe to say that the evidence furnished by these observations goes far to prove that the earthquakes of the Plain of Yedo consist chiefly of distortions, not compressions, of the ground, and emerge at Tokio in a direction not very far from vertical.

In the older seismology it was generally assumed not only that an earthquake consists mainly of one impulse, but that the motion of the ground has a definite direction, and that that is the same as the direction of propagation of the wave. All three assumptions were false. An old piece of seismic apparatus, based on these ideas, was a group of columns of various heights standing on a plane horizontal base. These were intended to show the direction and "intensity of the shock" by falling over. It is clear enough, however, that no appliance of this kind can give intelligible results from earthquakef of suck complexity as those described above. The very word "shock," accurately as it describes the feeling produced by an earthquake, is a singularly inappropriate name for what an apathetic seismograph records.

As evidence of the accuracy of the apparatus by which the foregoing results were obtained, it should be mentioned that the records given at the same place by different instruments during the same earthquake were found to agree remarkably well. Further, the instruments were tested experimentally by placing them on a shaky table, and obtaining, side by side, two records of table-quakes, one from the so-called "steady-point" of the instrument, and the other from a point in a fixed bracket projecting from a neighbouring wall, and known to be truly steady. When the table was shaken in such a way as to give records resembling those of actual earthquakes, the agreement of the two showed conclusively that the steady-point of the instrument did remain very nearly undisturbed, and that the records were in all important particulars substantially correct.

We have then the means of accurately observing the nature of the surface motion at an earthquake observatory. But this of itself tells us nothing of the speed and direction of transit of the disturbance, particulars which are only to be learnt by connected observations made at several stations. Any one earthquake, as a whole, lasts far too long and begins too gradually to admit of the measurement of time-intervals between its arrival at different points, but if we can identify any single vibration in the records given at several stations—spread over a moderate area, and connected telegraphically with each other —the problem admits of a fairly easy solution. A recording seismograph at each station will give a complete record of the earthquake as it appears there, and if, during its progress, time signals be sent from one station and marked on all the revolving plates, it will be possible to determine the differences in time of arrival of *the same phase of the same wave* at the successive stations in the group. From this, if the stations be sufficiently numerous, the speed and direction of transit, and even the origin of the disturbanee, may be found with more or less precision. But all this depends on our being able to recognize at the various stations some one wave out of the complex records deposited at each, and, especially in view of the curvilinear nature of the motion, it would be hazardous to say without trial whether this can be done. To ascertain whether it can be done. and if so to organize groups of connected stations to carry out the scheme roughly sketched above, should be the next step in observational seismology.

J. A. Ewing.

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PETROLEUM AS FUEL IN ROLLING MILLS.

Among the many ways in which efforts are being made to economically employ petroleum as a fuel, one lately tried at the Union Rolling Mill at Cleveland, Ohio, is said to have been a pronounced success. The apparatus is described in an American paper as quite simple, and easily attached to an ordinary puddling furnace. What may be styled shallow pans, or receivers, are set upon the floor of the furnace, and in these pans are heavy, closely-fitting perforated cast iron plates, lying upon shelves but half an inch raised from the bottom ; leading to the centres of these receivers, from beneath, are oil pipes connecting without with a tank or barrel sufficiently elevated to give the oil a good head ; intercepting the oil pipes near the furnace is a small cylinder in which is an automatic valve, which can be set at any position to automatically regulate the flow of oil. Auxiliary, are pipes for carrying exhaust steam for blast, a bridge wall back of the receivers to detain the flame, and a waterlined arch to protect the burners.

In operation, the automatic valve being set, the oil is allowed to flow into the receivers ; a handful of cotton waste, ignited starts the fire ; the plates become heated, and the oil, forcing its way up under the plates, is instantly automized, and rushes up through all the perforations—gases hydrocarbons, and all—into a brilliant flame, leaving no residuum whatever beneath. The first fire was lighted about 9.30 a.m., but the full heat was not let on until about 11. At 12.10 p.m., the furnace was charged, and at 1.22 p.m.—exactly one hour and 12 minutes—the first heat was concluded. The pig iron melted rapidly, the balling was performed without difficulty, and the ball went through the squeezer in excellent shape. Necessarily there were some drawbacks. The steam used for blast was scarcely dry enough, the pressure being only 70 lb. at most ; there was a slight escape of smoke from the rear of the furnace when the draught was open, and a high wind at the time did not conduce to the most favorable test ; nevertheless the results made a favorable impression on practical men who witnessed this trial.

This mode of burning petroleum is the plan of a Cleveland lady, and seems not unlike, in principle, the proposed way of burning petroleum in locomotives contemplated under the Holland patents.—Mechanical World. (*Chicago Journal of Commerce.*

Miscellaneous Notes.

Asbestos is becoming a valuable and much used mineral. It has been lately discovered, in its purest form, in lower Canada, and the quantity is said to be practically without limit. The fibres are long, pure white, and as fine as silk, and the district covered comprises two counties near Quebec, to which city the product is brought to be crushed and cleaned, and from which point large shipments are now being made to England and the United-States. The possibilities of this mineral range over a field that is simply marvellous. Fireproof paper, rope, and ink that resists the action of fire, as well as the weaving of textile fabrics, such as table cloths, abestos cloth gloves, etc., while in the range of building materials, fire-proof paint, packing for sases, floor deadening, roof protection, covering for steam pipes, etc., are among its more common uses. Its cheapness is its chief recommendation to many, but its thoroughly incombustible nature is of special value because, in spite of the so-called protection received from an insurance company's guarantee against fire, there are many combustible things that could not be replaced, which can be made of abestos and made secure from this destructive element.

Sanitation in New York.—An interesting experiment is just now being made in New York with a view to the utilization of the street sweepings and house refuse of that city. A large machine has been erected by a Stock company at the East River Wharf of the street cleaning department, which sifts and reduces to its elements all refuse of whatever description, which is brought to it. The average amount of stuff which is brought to this wharf is estimated at 40 loads per diem, but it is claimed that the machine could deal with more than three times that amount in a working day of 10 hours. By an ingenious arrangement all scraps of paper, rag, coal, cinder, glass, iron, &c., become separated, these are afterwards sold, with the exception of coal and cinder, which are used for firing the engine. The projectors estimate that every load of 1,800 pounds of refuse contains about 400 pounds of coal and cinder which is more than sufficient for their own purposes. The residuum refuse is cremated and the ashes are discharged into the sea. So far, it is said, the experiment has proved an entire success, and the promoters announce their intention of having machines at every city wharf to utilize all the refuse of the street cleaning department with profit to themselves and the city. Should these anticipations prove well founded a solution will be offered of a problem which has long perplexed New York. The system of the disposal of refuse which now prevails is most unsatisfactory, the whole of it being carried some little way out to sea in scows and then discharged. Year after year the pilots raise warning cries respecting the enormous injury which is being done to the harbour's mouth by the accumulation of ashe and street dirt there, and a radical change of method has long been sought.

THE PRESENT LIMIT OF MICROSCOPIC VISIBILITY.—Although there is perhaps much to be desired in the improvement of microscopic objectives, we may still consider our present state quite an advanced one. Although the present theoretical limit of visibility is fixed at 146,523 lines to the inch, we need not be deterred from attempting to pass this point. The limit which was accepted some years ago as the true one, although considerably lower, was quietly ignored as the angular aperture in objectives increased.' It is only a few years ago that the majority of microscopists refused to believe that *A. pellucida*, which has about 100,000 lines to the inch, could be resolved, and now it is the work of beginners to do so. But supposing 146,528 lines to be the limit, it is evident that a one-eighth or one-tenth objective with a one-half inch eyepiece is of amply sufficient magnifying power to make the lines visible to the eye, and there is therefore no need of using more. It is a good rule to follow, under all circumstances, not to use a greater power than is necessary to comfortably do the required work.

—A model of a novel canal boat has been placed on exhibition by a Cleveland inventor. The boat is to be propelled by a screw, so geared that it can be made to turn by horses or mules traveling in a circle in their stables in the boat. The inventor claims that abundant power can be had in this manner, and that a large saving can be effected, particularly in river towing bills, and by the reduction of help; that it would be cheaper than the present method of towing, even though no better time were made; but he is confident that four or five miles an hour can be accomplished.

PALPITATION OF THE HEART.—A French physician says that distressing or excessive palpitation of the heart can always be arrested by bending the body double, the head down and the arms hanging, so as to produce a temporary congestion of the upper portion of the body. In nearly every instance of nervous palpitation the heart resumes its natural function. If the movements of respirations are arrestedduring this action, the effect is stillmore sure and rapid..

DR. GUTHRIE'S EXPERIMENTS.—For several months past Guthri e has been making numerous experiments in the field which he has been working so long and so successfully, namely, the behaviour of solutions of salts, and a mixtures of salts when cooled down. One of his results is that as mixture in solution cools the salt which is present in richest quantity crystalises out until a certain critical point is reached. In his recent experiments Dr. Guthrie has shown that certain alloys of metal, such as the more fusible or, "entectic" alloys which melt at low temperatures, behave in the same way as mixtures of salts. Moreover, there seems to be no definite molecular proportion obtaining in these alloys. A mixture of 47.38 parts of bismuth, 19.97 of tin, 19,36 of lead, and 13.29 of cadmium fuses at 71 deg. Cent., or in boiling alcohol. This is a still lower temperature than the fusing of Rose's fusible metal. Dr. Guthrie has also shown that definite mixtures of water and tri-ethylamine become turbid at or between certain temperatures, and on this basis he has constructed a set of temperature tubes containing the mixtures in question. When placed under the tongue of a patient the temperature of the body at that point can be ascertained by their means. Dr. Tilden, of Edgbaston, has also shown that mixtures of water and butylic or amylic alcohols become turbid when between 20 deg. and 30 deg. Cent. and clear again between 60 deg and 70 deg. Cent.

HOUSE SANITATION.—One of the most common, andyet one of the most frequently neglected causes of trouble with all every forms of plumbing is the imperfect grading of pipes of description. Drain, water and air pipes are equally affected thereby, and their usefulness is thus measurably impaired. In a drain pipe an insufficient fall or a misplaced elbow will prevent its perfect flushing with water and tend to permit the accumulation of organic matter in portions of its extent. The efficiency of a ventilating pipe is also entirely dependent upon its mechanical disposition as related to the drain through which it is to induce a constant current of air to pass. Similar defects of arrangement in a house water-system are revealed only by the severe frosts of winter. If the pipes are not so graded as to secure their complete clearance of all residual water by means of a drainage faucet, whenever the house-supply is cut off, the freezing of the water in, and the probable bursting of unprotected or exposed pipes in a cold season will speedily discover he fact. A large proportion of such casualties are brought about solely by this means, at a great cost of money and inconvenience to the owners or employers to these defective systems.

The timely exercise of a little forethought and mechanical ingenuity in the disposition of pipes when they are first laid would wholly obviate these difficulties and secure more perfect drainage and an unembarrassed water service.

COPPER FOR ROOFING.—It is thought that the decline in the price of copper makes it probable that it will be used as roofing, among other new purposes. It does not require to be painted, like the tin roof, every two or three years, and it is not subject to rust. Even at present prices, though a copper roof might cost two or three times as much as a tin roof, in the end it would be much less expensive.

BURNING OF THE DEAD.—The body burns, whether placed in the earth or fire; in one case it takes 10 to 20 years, and in the other so many minutes. Cremation is the proper and scientific way to dispose of dead organic matter. When the body is cremated, there is no further fear from disease germs in the body. The only plausible objection which has been offered against cremation is that in case of homicide through the administration of deadly poisons valuable evidence might be destroyed; but this is not a serious objection in the face of the many advantages gained. All innovations in sanitary science have had to fight their way inch by inch. Vaccination had a hard struggle, but came out triumphant, and so we predict for cremation a glorious victory, a triumph of good sense and science.

PIPES MADE OF STEEL PLATES.—Pipes made of steel plates are coming into use in England for the conveyance of water under high pressure. The plates are coated with lead on both sides by immersion or otherwise, then rolled to form, rivetted, soldered the whole length, and covered with pitch. Of this method the first cost, it is said, is not much greater that of iron, and the steel pipes possess considerable advantages over those of iron.

A NEW TEXTILE PLANT, which received the name "kappe," is attracting considerable attention in Europe. It was first publicly exhibited last year at the Amsterdam Exhibition; It is indigenous to Java; and, when its fibres are carefully prepared, they resemble wool, and, when curled, at a moderate cost they can be used for stuffing mattresses. It can also be spun and dyed, but the fibrous appearance it retains shows that a radical improvement in the method of treating it has still to be discovered. All who examined the fibre at Amsterdam were satisfied of its contingent improvement as a textile material.

A VARNISH FOR PATTERNS.—A varnish has been invented in Germany for patterns and machinery. It dries, leaving a smooth surface almost as soon as it is applied. It is thus prepared: Thirty pounds of shellac, ten pounds of Manila copal, and ten pounds of Zanzibar copal are placed in a vessel, which is heated externally by steam, and stirred during from four to six hours, after which 150 parts of the finest potato spirit are added, and the whole heated for four hours to 67 degrees. This liquid is dyed by the addition of orange color, and can then be applied as a paint on wood. When used for painting and glazing machinery it consists of 35 pounds of shellac, five pounds of Manila copal and 150 pounds of spirit.

A FLOWER has been discovered in South America which is only visible when the wind is blowing. The shrub belongs to the cactus family, and is about three feethigh, with a crook at the top, giving it the appearance of a black hickory cane. When the wind blows a number of beautiful flowers protrude from little lumps on the stalk.

DR. STEVENSON has found that, contrary to a general belief, considerable quantities of zinc may be dissolved by water kept long in contact with it.

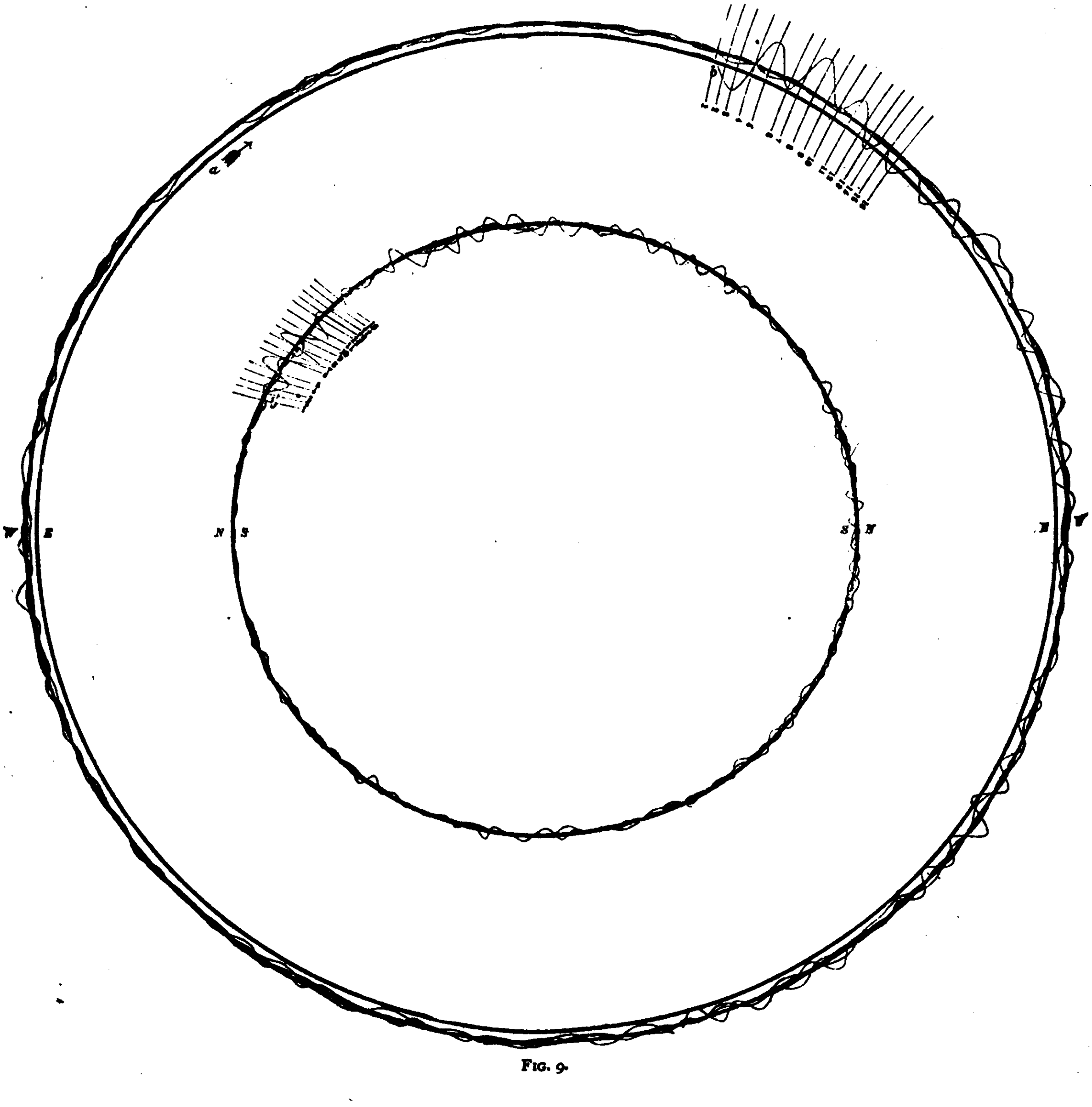

Fig. 9.

THE EVOLUTION OF FLOWERS.

By Grant Allen.

LILIES AND RUSHES.

On the dry, sunny hillsides behind Mentone, there grows in early spring a pretty little blue lily, erect and usually solitary on the end of a long, stiff stem, and singularly rush-like in its mode of growth and general appearance. It rejoices in the scientific name of *Aphyllanthes Montpeliensis*. As a rule, I don't care to go outside our own wild British flora, or the common cultivated flowers of our gardens, for my main examples, because it is best as far as possible to deal with well-known cases, where the reader's personal interest and memory count for something; and small as our native collection of plants really is, it generally affords quite as good illustrative examples of the various levels of evolution as could be got by ransacking the hothouses at Kew for the rarest and most unfamiliar exotic palms or orchids. This little blue lily of the Riviera, however, with a few of its congeners in Australia or the Malay Archipelago, forms such a beautiful specimen of a bridge or connecting-link between two somewhat distinct families that I am tempted to step aside from my usual practice for once, and interpolate a foreign plant among our illustrations of the evolution of flowers.

Aphyllanthes, as its Greek name imports, has no true leaves; its foliage has all been transmuted into short dry sheathing scales, which clasp and protect the base of each flowering stem. The work usually performed by the leaves—that of taking carbonic acid from the air to be built up into the living material of the plant as starch or cell-wall—is undertaken in this curious lily by the tall, green, rush-like flower-stalks alone. At the top of each such stalk, a few dry, brownish bracts form an involucre or protective covering for the unopened buds; and within this involucre, in due time, a single sky-blue flower (more rarely accompanied by one or two more) opens its bright blossom to the Italian sun. As in the true lilies, there are three sepals and three petals, all alike beautifully coloured; but one of the bracts (or very reduced leaves) here serves the place of a calyx, as the true calyx has been perverted from its original function to share in that of the corolla. There are six stamens, as usual, in two whorls—the three outer somewhat shorter than the three inner; and the pistil consists of three cells, welded firmly together into a single ovary. In short, so far as technical characters are concerned, the Aphyllanthes is a true lily. A botanist who went strictly by the artificial marks set down in the text-books would have no difficulty at all in deciding that it belonged to the true lilies, and not to the rushes. For the distinguishing mark of a rush, in formal botany, consists in the fact that its perianth is "dry and scarious, not petaloid;" and as the perianth of Aphyllanthes is bright and juicy, of course it is a lily by definition. But if you look at the accompanying figure of our common English rush, you will see that it differs essentially from Aphyllanthes in hardly anything except the comparative size and colour of the perianth. To be sure, the flowers on each stem are much more numerous in the rush; but that, as we know, is a very small matter; in all other respects the resemblance between the two is extremely noticeable. To put it briefly, Aphyllanthes is a lily far gone on the road toward the rushes—an arrested stage, no doubt, in the development of the family; while the rushes are lilies like Aphyllanthes which have given up producing brightly-coloured perianths, and taken to small, dry, brown, inconspicuous little blossoms instead.

Why is this? Well, the rushes afford us an excellent example of flowers in a retrogressive condition, though in their case the degeneration has not gone far, and has produced no evil effects upon the habits of the species. All the plants that we have yet considered have been fertilised by insects; the rushes have gone back to the possibly older, but somewhat wasteful, habit of being fertilised by the wind. The pollen is shaken out from their little, loose,

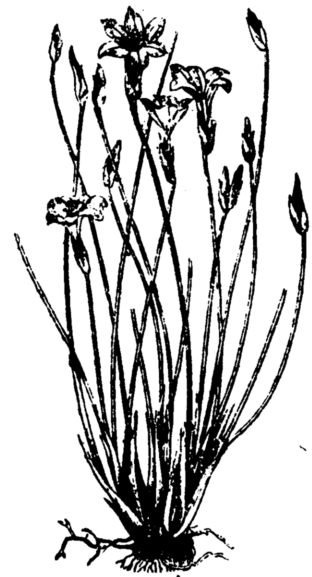

Fig. 1.—Aphyllanthes Montpeliensis.

Fig. 2.—Juncus communis.

hanging stamens by every puff of the summer breezes, and then floats away till it is caught by the three long, feathery stigmas of some other flower. These two conditions of the stamens and stigmas are very characteristic of all wind fertilised blossoms: the pollen-sacs always hang out in a very mobile fashion, shivering and quivering before the faintest breath, while the stigmas protrude boldly from the centre, and are minutely divided into tiny plume-like points, which catch and retain every grain of the fertilising dust wafted to them by the unconscious breeze.

But how do the rush flowers, then, escape the chance of self-fertilisation with its attendant evils? By a very simple but effectual contrivance. The stamens and stigmas of each blossom do not come to maturity together. The pistil is the first to ripen, and it protrudes its three tiny plume-like stigmas through the bud, before the six dry perianth-pieces begin to unfold; thus, it is pretty sure to catch a grain or two of pollen, carried towards it from some neighbouring head. Meanwhile, the stamens of its own flower are safely huddled up within the tightly-closed perianth. But, by-and-bye, the perianth in turn opens, the stamens unfold themselves upon their long thin footstalks, and the pollen-sacks split down their sides, and shed the pollen lightly to the breeze for the benefit of other surrounding flowers. This is a common device with many wind-fertilised blossoms.

Thus we see that the slight differences between the rushes and Aphyllanthes are solely caused by a single fact in their respective economies; the one is impregnated by the wind, and the other by insects. If the rushes were to take to the habit of insect fertilisation they would doubtless soon acquire brightly-coloured petals like those of the lilies; if Aphyllanthes were to take to the habit of wind-fertilisation it would doubtless soon lose its bright petals, because it would have no further need for them. Nay, they would even become a positive disadvantage to it, inasmuch as they would induce insects (for whose utilisation as carriers it was no longer adapted) to come and plunder it undeterred of its precious pollen. Observe however, that the rush has not entirely lost its petals, now that they are no longer of use to it as coloured advertisements; it has merely found a new mode of employment for them. By making them hard and dry it has turned them into a protective covering for the stamens before they mature, and as they are persistent (that is to say, do not drop off after flowering) they serve once more as a similar covering for the seeds and capsules during the ripening process. Such economy of existing structures meets us everywhere in Nature as an ordinary accompaniment of evolution.

The flower of the rush is still, however, essentially a lily, with three sepals, three petals, three outer stamens, three inner stamens, and a three-celled ovary, bearing a united style with three separate stigmas. In the common rushes, the seeds are also numerous in each cell, as in the simpler lilies; though in Aphyllanthes and the wood-rushes, they are reduced to one each, for a reason to which I must recur hereafter.

I have left myself hardly any room to notice the most conscipuous external peculiarity of the rushes with which we are usually most familiar. I mean the cylindrical, almost hollow, pithy leaves. But it is easy enough to see the use of these stout, strong, and often prickly-tipped organs; they are, of course, admirably adapted for the places in which rushes commonly grow, in wet, marshy spots, and they serve to protect them against being either trodden down or eaten by cattle. The cylindrical form, however, though frequent among the rushes, is by no means universal: and we can trace every intermediate stage, from the quite flat, grass-like or lily-like foliage of the two flowered rush (*Juncus biglumis*), through channelled leaves with a fine cylindrical tip like the chestnut rush (*J. castaneus*), to these in which the whole leaf has become cylindrical throughout, like the sharp rush (*J. acutus*) whose very stiff, prickly points are nasty things to pierce one's hand with on the coast in Devonshire.

ARTIST'S CANVAS.—The raw canvas must be stretched on a frame, wetted, and restretched if loosened by wetting, and coated with a mixture of equal parts of dry whiting and white lead, ground up with raw and boiled linseed oil, and laid on with a trowel like a plasterer's trowel, but longer and tinner in the blade. If the canvas shows through the first coat, a second and a third may be applied, the under coats being rubbed down with pumice stone. A little raw umber may be added if a stone-coloured surface is preferred. The use of the trowel, of course, requires the dexterity acquired by long practice.

NOTES ON ELECTRICITY AND MAGNETISM.

BY PROF. W. GARNETT.

(*Continued from page* 191.)

In 1844 Prince Louis Napoleon, than a prisoner, writing to Arago, described two forms of battery in which only one metal was employed, so that there was nowhere a contact of disiimilar metals. The first consisted of a copper plate immersed in dilute nitric acid, (which acts strongly on the copper), contained in a porous cell. The porous cell was placed in a jar containing dilute sulphuric acid in which was immersed a second copper plate. On connecting the plate with a galvanometer, a current flowed through the galvanometer from the plate immersed in the sulphuric acid to that immersed in the nitric acid. With a battery consisting of two of these cells he decomposed potassic iodide and cupric sulphate. The second battery consisted of two zinc plates, one immersed in dilute sulphuric acid contained in a porous pot, and the other in a vessel surrounding the porous pot. This battery produced effects similar to that just described.

Napoleon then attempted to reverse "the usual order of the metals." He placed a copper plate in dilute nitric acid contained in a porous jar, while a plate of zinc was placed in pure (?) water surrounding the porous jar. On connecting the metals a current flowed from the zinc to the copper through the wire. These experiments alone seem sufficient to condemn the contact theory, as held by those who maintain that the E. M. F. of the battery is due simply to the contact of dissimilar metals. More recently several other forms of battery have been devised, in which there is no contact of dissimilar metals. Napoleon complained that he was unable to measure the E, M. F. of his batteries, as the iron bars of his prison iterfered with his galvanometers.

It was supposed that when zinc and sulphuric acid are in contact and in equilibrium the potential of the acid is very much greater than that of the zinc, and similarly in the case of copper and sulphuric acid, the potential of the acid is much greater than that of the copper, but the difference in the case of the copper is less than in the case of the zinc, while we further suppose, as vindicated by the Peltier effect, that there is no sensible difference of potential between copper and zinc when in contact, we can explain the action of the Voltaic cell.

Suppose a plate of copper and a plate of zinc to be immersed is sulphuric acid, but no contact to be made between the plates. Then the acid must be at the same potential throughout, or it could not be in electrical equilibruim. Hence, since the difference of the potential between the acid and the zinc is greater than that between the acid and the copper, the potential of the zinc plate will be lower than that of the copper and a quadrant electrometer would be capable of measuring this difference of potential which will be the electro-motive force of the cell. If the copper and zinc are connected by a wire a current will flow from the copper to the zinc along the wire, lowering the potential of the copper and raising that of the zinc, so that the equilubrium between the metals end the acid becomes disturbed, electricity flows from the zinc to the acid and from the acid to the copper, so that the potential of the acid near the zinc is raised above that of the acid near the copper, and a current therefore flows through the acid from the zinc to the copper thus completing the circuit.

If a plate of copper and a plate of zinc be connected together, and the free end of the copper plate dipped into one vessel of dilute sulphuric acid and the free end of the zinc plate into another vessel of the same liquid, the acid into which the zinc is dipped will be at a higher potential than that into which the copper is dipped. If now a connection is made between the two vessels of acid by inverting a syphon filled with acid so that one leg is in one vessel and the other in the other, electricity must flow from the acid in the vessel in which the zinc dips to that in the other vessel, the equilibruim will be disturbed and a continuous current will flow through the circuit as before.

In the frictional electric machines, in the Voss and Holtz machines, in the replenisher and electrophorus the electrical energy developed is derived from the work done by the agent in overcoming the electrical energy developed is derived from the work done by agent tn overcoming the electrical attractions and keeping the machine in motion, or, in the case of the electrophorus, in raising the carrier plate in opposition to the attraction of the electrified ebonite. In the case of a thermo-electric couple the energy of the current is derived from the heat absorbed at the hot junction on account of the Peltier effect, or absorbed as the current flows from hot to cold or cold to hot along the metals on account of the Thomson effect. In the Voltaic circuit the energy of the current is derived from the chemical action which takes place between the metals, or one of the metals, and the acid (or electrolyte.) That the energy of the current in ordinary batteries is due to the aolution of the zinc in the acid was shewn by Dr. Jonle, who determined the amount of heat developed by a pound of zinc in sulphuric acid. He then immersed a battery in a colorimeter, and determined the whole amount of heat developed for each pound of zinc dissolved when the wire through which the current flowed was wholly contained within the calorimeter. The amount of heat so obtained was the same as when the zinc was dissolved in the acid without the production of any current. On causing the current from the battery to pass out of the calorimeter and to flow through a wire immersed in a second calorimetet, the heat developed in the battery for each pound of zinc dissolved was less than before, but the defiency was exactly compensated by the heat developed by the current in the external wire, and communicated to the water of the second calorimeter. From these experiments it appears that when a battery is employed in sending a current the heat corresponding to the chemical action toking place in the battery is not wholly developed within the battery, but a portion of it is employed in making the current flow through the circuit, and is reconverted into heat wherever the current does work against resistance.

Faraday seems to have seen the necessity for the energy of the electric current being derived from the chemical action going in the cell, and he consequently regarded this chemical action as the primary source of the electro-motive force, as it certainly is of the energy of the current. Faraday supposed the chemical attraction to throw the electrolyte (acid) into a state of electric "polarization," which state he supposed to be relieved by electric discharge (current) when chemical action actually takes place.

The supporters of the Voltaic or contact theory have spent much time in endeavouring to determine at which of the three places of contact in the Voltaic cell the chief difference of potential occurs, and many experimentalists have maintained that the electro-motive force is due principally or entirely to a difference of potential at the contact of the *dissimilar metals*, and have supposed that the differences of potential at the contacts of the metals and electrolyte are either zero or comparatively small. Several experiments have been cited in support of this view. One of the most recent is due to Sir William Thomson, who shewed that when two equal semicircles, one of copper and the other of zinc, are placed with their diameters in contact and a positively electrified "needle" suspended above them, so that before the plates are made to touch the needle points in the direction of the common diameter, on making contact between the copper and the zinc the needle turns towards the copper. If a quadrant electrometer be constructed with two quadrants of zinc and the other two (alternate quadrants) of copper, the needle if positively electrified will turn so as to enter the copper quadrants, the difference of potential indicated being nearly equal to the electro-motive force of a cell consisting of copper and zinc immersed in dilute sulphuric acid. It was at first supposed that these experiments proved a difference of potential to exist between the copper and the zinc sufficient to account for the electro-motive force of the Voltaic cell. It will be seen however that the electrified needle does not move *within the substance* of the copper and zinc, but in the air around the metals, and the experiment therefore only serves to determine the difference of potential of the air near the copper plate, and of that near the zinc plate.

In 1878 Mr. John Brown, of Belfast, experimenting with copper and iron, shewed that while the positively electrified needle turned towards the copper quadrants in an atmosphere of air the action was reversed in an atmosphere of sulphuretted hydrogen, the needle turning towards the iron, thus indicating that the gas in the neighbourhood of the iron had a lower oettipnal that that in the neighbourhood of the copper. Hence the motion of the needle is not due to a difference of potential between the metals themselves caused by their contact.

The only reliable method at our command for determining the difference of potential between two metals in contact is based upon the Peltier effect. When electricity flows from a metal at a high potential to one at a lower potential work is done by the electric forces, and as there is no other source of energy (in a thermo-electric circuit) this work must be derived from heat absorbed at the junction, the absorption constituting the Peltier effect. Thus, if Q units of electricity pass from one metal to another the difference of potentiel being E, a quantity of heat mechanically equivalent to QE ergs must be absorbed. By measuring the heat absorbed and the quantity of electricity that passes, we can determine E the difference of potential between the two metals.—(*To be continued.*)

THE first shipload of railway plant for Suakim left Woolwich Arsenal recently.

THE MOVEMENTS OF THE EARTH[1]

The Earth's Revolution

IT will be clear from what has gone before that the daily movement of the stars is an apparent one due to the real movement of the earth in an exactly opposite direction, and that the stars in the heavens appear to rise in the east and set in the west, because the earth rotates from west to east. And now comes this question: The period of twenty-four hours which is so familiar, and which is divided roughly into day and night, has apparently two perfectly different sides to it; for a certain period the stars are not seen at all in consequence of a body, which we call the sun, flooding the earth's atmosphere with its own tremendous light. Why should this be? In giving an answer to this question it is enough to say that the sun is a star so close to us, and so entirely outshining the other and more distant stars which are seen in the skies, that they seem to be things of a different order altogether. But they are not things of a different order, they are very much like our sun, and the different appearance is simply the result of the fact that the one is a star very near to us, whilst the others are suns inconceivably remote. In considering this apparent daily movement of the stars, and taking the sun into consideration, the fact is soon arrived at that the stars have another apparent movement differing somewhat from that one with which up to the present time we have alone been engaged. It has been said, and it is so obvious that it might almost have been left unsaid, that as a rule the stars are not seen when the sun is visible, so that the question whether the sun moves or appears to move among the stars must be attacked in a rather indirect manner. An observer on that part of the earth's surface directly under the sun sees it as at midday. Under these conditions the stars are of course not seen by him, but if he waited twelve sidereal hours, until that portion of the earth which he inhabited was opposite the sun's place, the stars would then be visible, and by noticing whether those seen by him each night were the same, he would be able to determine whether or not the sun moved or appeared to move among them. In one position of the sun it occupies that constellation of stars known as the Bull. These stars cannot then be seen, because the intense brilliancy of the sun puts them out, but with the sun in this position the group of stars known as the Scorpion is seen opposite at midnight. Then at a later period the sun gets into the constellation called the Crab, and we see at midnight no longer the Scorpion group but the group which is called the Goat. In this way it can be determined that the sun has an apparent movement among the stars, which is completed in a period which we call a year, at the end of which time the sun occupies the same position that it did a year previously, and the same group of stars is seen again in the south at midnight.

Not only, then, do the stars appear to make a complete revolution once a day, in consequence, as we have seen, of the earth's rotation, but once a year they also gradually change their apparent places, so that at the same hour each night different stars appear due south, thus indicating a movement of the sun among them.

The same difficulty that was met with before is again encountered here; is this movement of the sun among the stars a real or an apparent one? It is a question, however, which has been long since answered; and it can be very definitely stated, not only that the earth rotates on its axis in a period of twenty-four sidereal hours, but that it moves or revolves round the sun in a period which we call a year, and that it is this real movement which causes the apparent one of the sun among the stars. Let the reader take a top and spin it. Perhaps the top has a movement of progression as well as a movement of rotation, and it is in that way quite easy to see that the earth may rotate on its axis and revolve about the sun at one and the same time. And with a top of special construction its axis of rotation might be inclined so that its plane of rotation ceased to coincide with the plane of its motion of progression; still the two movements would go on, and in whatever position the top might be placed, its axis might be made to remain practically parallel to itself during its movements.

We may now, then, make the following statements:—*The earth revolves round the sun, and throughout the revolution the axis of rotation remains practically parallel to itself.* With regard to the latter part of this statement it may be added that if this were not so—if the axis of the earth were subject to perpetual change of direction—the declinations of the stars would also be subject to constant change.

The demonstration of this movement of the earth round the sun depends upon physical considerations in exactly the same way as does the demonstration of the earth's movement of rotation, and to these considerations attention must now be turned. It will be found that we have now to do with an entirely different branch of physics to that which we drew upon when seeking for a proof of the rotation. The utilisation of its principles for the purposes of astronomy is due to Dr. Bradley, a former Astronomer-Royal. In the year 1729 he made a series of observations of stars, expecting certain results to flow from them. Instead, however, of getting the results for which he had looked, his observations gave him some which differed entirely from his predicted ones, and which he failed to understand. For such a thing as this to happen is a piece of good fortune for the scientific investigator; it sets him thinking and working, and frequently leads him to the discovery of some hitherto unknown physical law. It set Dr. Bradley thinking and working. Curious as it may seem, the observation which led him to a complete understanding of this subject was what he observed one day when a boat at anchor near the shore at Greenwich began to get under weigh in a stiffish breeze. The little boat had one of those short pennants on its mast, and Dr. Bradley noticed that, as soon as the boat began to move, the direction of the wind, as indicated by the movements of this pennant, changed. Before proceeding to consider the bearing which this fact, seemingly remote from astronomy, has upon star work, it may be advisable

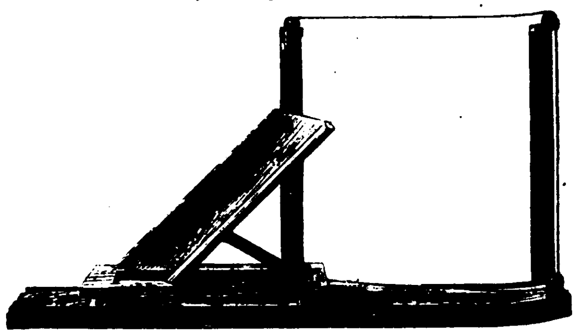

FIG. 35.—Model to illustrate the aberration of light. A square tube, with glass front and a slit along the centre of its upper side to allow the passage of a thread, is inclined at 45° and caused to run along a level track, while a weight suspended from a thread passing round three pulleys and attached at the other end to the front of the carriage is allowed to descend. In this figure the weight is at the commencement of its fall.

to take one or two simple illustrations which will show what must have passed through Bradley's mind as the explanation of the strange unexpected movements of the stars was slowly growing within it. The first illustration is one due to Sir George Airy. Suppose that a vessel is passing a fort, and that a shot is fired from the fort at the moving vessel. The shot will travel in a straight line; but it is evident that since the ship is moving, if that shot really pierces both sides of the vessel, then a line joining the spot where the ball pierced the one side to the spot where it pierced the other side will not be square to the direction of the ship's motion. During the short time taken by the shot to pass from one side of the ship to the other, the vessel has moved through a certain small distance, and if the line joining the two shot-holes were alone considered, it might be inferred that the shot had come from a direction in advance of the true one. That is one illustration, the point of it being that the motion of the vessel seems to have given a new direction to the shot. Take another illustration, more familiar, and perhaps almost as clear. In this country frequent opportunities offer themselves of travelling in cabs or railway trains, with the rain falling on their closed windows. Every one must have noticed that at such times there is always a very curious slant in the apparent direction of the drops whilst the train or the cab is in motion; the rain seems to come from a point in front of us; we always seem to meet the rain. The fact is that a body in motion, and especially a body with the velocity of an express train, does not receive the rain under the same conditions as when it is at rest. The question of its velocity has to be taken into consideration. An experiment will show better what is meant.

Imagine a weight supported by a piece of thread; the moment that thread is cut the weight falls in a straight line to the ground. If it be desired, therefore, to receive the falling weight in a tube at rest under the weight, and to so receive it that it shall not touch the sides of the tube as it passes through, the tube must be held in an upright position. Take another step, and suppose now that it is a question of causing the weight to fall through the tube whilst the tube itself is travelling at a certain rate, say at

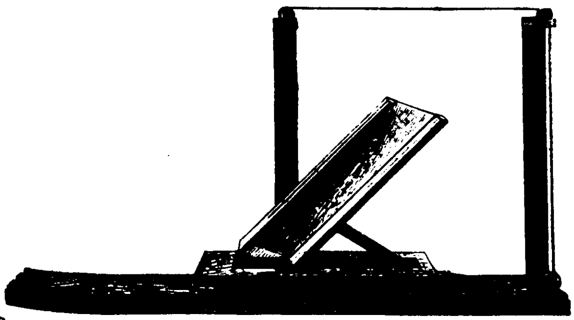

Fig. 36.—Same apparatus as preceding, but with the weight near the end of its fall.

the velocity of the falling weight. It is perfectly obvious that this cannot be done by holding the tube in a perpendicular position, the tube must be inclined, and the angle of its inclination will vary with the varying relative velocities of tube and weight. The more quickly the weight falls the less inclined must the tube be to receive it. This not only supplies the explanation of the slant of the rain on the windows of the railway carriage, but it explains what is very much more important from an astronomical point of view. Consider Fig. 37 for a moment. Here AB represents the path of anything falling, and a CB the angle of the tube destined to receive it. It may be called the angle of slant, but the point is not that we give it any particular name, but that its relation to the velocity of fall is a very fixed and definite one. Accept it as such, and then connect it,

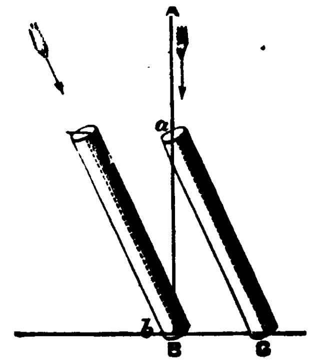

Fig. 37.

not with the falling weight or with the slant of the rain, but with the velocity of the light coming to the earth from any star in the heavens, and the velocity of the earth in its orbit round the sun.

It may be said that two assumptions are here made, first that light has a velocity, and secondly that the earth does move round the sun. Consider, then, the first of these, the question of the velocity of light. In our day, with all the experimental methods

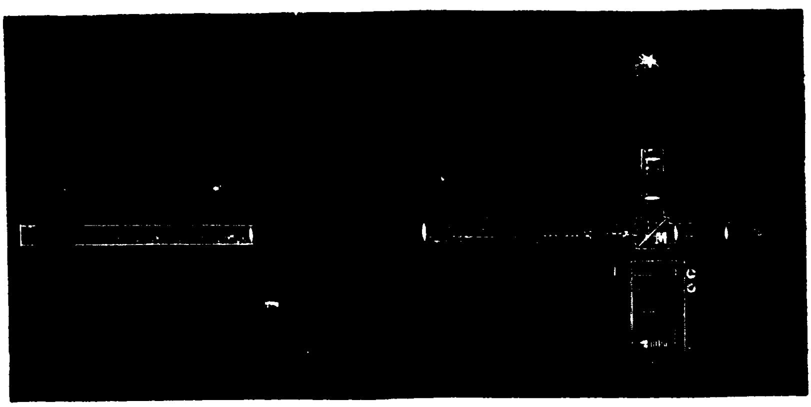

Fig. 38.—Fizeau's mode of determining the velocity of light.

niceties which the labours of those who have gone before have placed at our disposal, this question of the velocity of light can be answered by what may be called a laboratory experiment. The first real attempt to answer the question was made some years ago by a Frenchman, M. Fizeau. His method of observation was a beautifully simple one, and has turned out to be highly satisfactory in its results. All the essential parts of his apparatus are shown in Fig. 38. Light from a lamp was made to pass through a system of lenses and was brought to a focus after reflection from the front surface of a piece of plain glass. The light was then grasped by an object-glass and sent out in a parallel beam to a station distant about five miles. There it fell on another object-glass, which again brought it to a focus on a mirror at the end of this second telescope. Then having got the light to the second mirror, it was reflected on its path back again. When the reflected light returned, part of it was allowed to go through the plain glass mirror to the eyepiece seen at the end of the telescope in Fig. 38. At the point where the rays crossed in the first telescope there was interposed the edge of a cogged wheel, to which a great velocity of rotation could be imparted by clockwork, and through the intervals between the teeth of which the light had to pass. Suppose first that the wheel is at rest. The lamp is lighted, and looking through the cogs of the wheel the observer sees the image of the lamp reflected back to him as a star of light from that distant

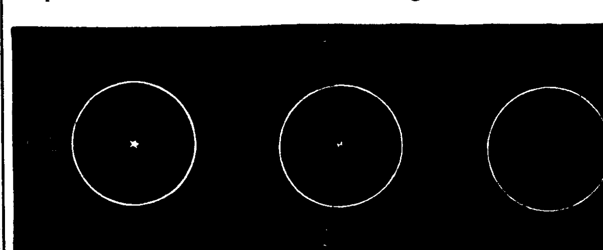

Fig. 39.—Fizeau's velocity of light apparatus. Appearance when the toothed wheel is at rest, when it is in slow motion, and when its rotation is so rapid as to cause complete extinction of the light.

mirror by means of the arrangement to which reference has been made.

Assume now that light occupies no time in travelling from the lamp to the first mirror, through the first telescope, across the space between the two telescopes, and back again after its reflection by the second mirror. Assume, in fact, that the velocity of light is infinite, then it is perfectly clear that an observer would keep on seeing that star of light whether the wheel remained at rest or were put in motion. But now assume that light does take a certain very small time to make the journey spoken of, and that the wheel can be turned with just such a velocity that when the light reaches it on its return it will meet, not an opening, but one of the cogs. Then the light would not be visible : it would find itself a cog behind, so that, if light travels very fast indeed and the wheel is made to travel with a great and known velocity and the relation existing between the velocities be known, the velocity of light can be measured in this way. That is the way in which Fizeau measured it, and he gave the velocity as being 190,000 miles per second.

It may be thought perhaps that this being the first attempt in a matter of this kind it was not very worthy of credit ; but the similarity of the results which have been obtained in all such experiments proves that they are all very worthy of credit, and that this velocity must be accepted as established within narrow limits.

We come now to Foucault, the man to whose genius science owes the experimental proof of the earth's rotation, to which reference has already been made. He also attacked this question of the velocity of light. Going to work in quite a different way from Fizeau, he succeeded in enriching science with a method quite as reliable in its operation and as accurate in its results.

A pencil of light coming from a slit at (see Fig. 40, Page 224) impinges upon the plane mirror R, which is capable of turning round a vertical axis. This mirror reflects the light falling on its surface, and the action of the lens, l, causes an image to be formed on the surface of the concave mirror, M, the centre of which coincides with the axis at R. This concave mirror reflects the image backwards on its path to the slit. Foucault's arrangement, as has been said, was to have the mirror, R, made to rotate. If. therefore, R be turned about its axis while the light from the slit, S, is falling upon its surface, for so long as the light falls on the lens so long will the image of the slit be formed on the surface of the distant mirror. Similarly for so long as the reflected image falls upon the lens, so long will the image be reflected back to the slit. Now if the mirror were made to rotate rapidly, and light were infinite in its velocity, then once during each revolution of the mirror at once particular angle the light would be reflected back to the slit ; but assume that light takes some very small fraction of time to travel over the space between the mirrors, it will be observed that the image will not be reflected back to the slit but will suffer a deflection in one direction or the other according as the mirror turns from left to right or from right to left, and, the velocity of the rotating mirror being known, the amount of this displacement will enable the velocity of light to be determined.

With two such different methods it might be supposed that the results obtained were very different. Not so, however ; the velocity obtained by Fizeau was, as I have said, 190,000 miles per second, that by Foucault 185,000 per second.

It so happens that both these methods have been gone over quite recently, Fizeau's method by another Frenchman, M. Cornu, and Foucault's by Mr. Michelson, an officer in the American navy.

Mr. Michelson modified Foucault's method somewhat, the fault in which was that the displacement obtained was so extremely small, being but the fraction of a milimetre ; and when it is remembered that the image is always more or less indistinct on account of atmospheric conditions and imperfection in the lenses and mirrors employed, it will be seen that it was difficult for Foucault to attain to any very great accuracy. Mr. Michelson therefore used an apparatus which would give him a greater deflection than that obtained by Foucault. As before, S (Fig. 41) was the slit, R the rotating mirror in the principal focus of the lens, but the distant mirror, instead of being concave, was a plane one, and the lens one of great focal length, for a reason that will appear immediately. This lens, in consequence of the smallness of its diameter in comparison with its great focal length, was not entirely convenient. In order that the displacement should be great, it is necessary that the distance between R and M, the distance from the revolving mirror to the slit, and the speed of rotation should be the greatest possible.

Unfortunately, the second condition clashes with the first, 1 for the distance from the revolving mirror to the slit, or the "radius" is the difference between the distance of principal and conjugate focus for the distant mirror, M, and the greater the distance the smaller the radius. Two methods were employed by Mr. Michelson in overcoming this difficulty : first, he had his lens of great focal length, 150 feet, and he placed the revolving mirror, not at the principal focus, but fifteen feet within it. He thus managed to get a distance between the mirrors of 2000 feet with a radius of thirty feet, and his mirror made 256 revolutions per second. He then obtained a deflection of 133 milimetres, that being about 200 times greater than the deflection obtained by Foucault. This deflection he measured to within three or four hundredths of a milimetre in each observation.

Mr. Michelson's experiments were made along an almost level stretch of sea wall at the Naval Academy.

We are therefore justified in saying, as the results of these experiments of Fizeau and Cornu, Foucault and Michelson, that light has a velocity of some 186,000 miles per secand.

If that be so, then, if the statement that the earth revolves about the sun be true, this must follow. In Fig. 42 *a b c d* represent the earth in different parts of its orbit around the sun ; the contention is that if there be this revolution of the earth round the sun, and if light really travels with anything short of an infinite velocity, then the position of a star must change, for the reason that the telescope of the astronomer must always be pointed in advance of the star to catch its light in the same way that to catch the falling weight we had to incline the tube in the direction of its motion.

When any observation is made on any star in the heavens, the telescope of the astronomer must therefore be pointed in advance of the star to catch its light, and taking, as in the diagram, four different points in the earth's orbit, it is obvious that the telescope at these four different points must be pointed in four different directions with regard to the star. For instance, if we take a point at *c*, where the earth is travelling in the direction of the arrow, and the point at which the star would be seen if the earth were at rest, or the velocity of light were infinite, be indicated by the star in the figure *c* is the direction in which the star would be seen, and in which the astronomer's telescope must be pointed to catch its light. Similarly with the earth at *d* the telescope must be pointed to *d'*, and so with the earth at *a* we must have it pointing towards *a'*. It was this strange anomaly which puzzled Dr. Bradley in the year 1729. He noticed that the stars moved in ellipses every year round a mean point. This fact of aberration, then, is a real thing. It has been said that the angle at which the tube had to be inclined to receive the weight pepended upon their respective velocities, that the faster the tube travelled, the greater must be its inclination, and therefore the greater the angle the greater the earth's velocity with reference to the velocity of light. In the case of the majority of the stars what we get is an ellipse, an in an ellipse we have certain differences which have to be taken inio account, the last difference of all being that an infinitely elongated ellipse is a straight line, and it is found that from one particular point of the heavens where, in consequence of this aberrational motion, the orbits of the stars round their mean places are almost circular, we at last get to a point where the motion is simply an oscillation of the star backwards and forwards to and from its mean place ; we are dealing, in fact, with that form of the ellipse when it is in the form of a straight line. When we deal with an ellipse we no longer talk of the radius, but of the semi-axis major, which is half the greatest length. The angle of aberration of which I have spoken only amounts to 20"· 4451, but though small, it is quite enough to prove that the earth does revolve, and that consequently the sun is the centre of the system to which the earth belongs. Now in order to show the importance of physical inquiry in this matter, there is another statement which must be made. If we consider this aberration question fully, we find in it what is perhaps the most perfect way of determining the distance of the sun from the earth, and it will be seen that it is perfectly simple, so simple in fact, that the wonder is that more attention has not been given to it in our tex-books. We have first the fact that the inclination of the tube depends upon the relative velocities of the tube and falling body; in the case of light it will of course depend upon the relative velocities of the earth in its orbit and light radiating from a star. Knowing this latter to be somewhere about 186,000 miles per second and the aberration angle to be 20' and something, we can get the relation of the earth's motion to the velocity of light, and it comes out to be about 1 to 10,089.

Now we know that the earth completes a revolution round the sun in 365¼ days. If it travelled with the velocity of light it would complete a revolution in 52m. 8·5s.

Again, we may say, and this is only a rough statement, that the radius of a circle is ⅙ of its circumference, so that if it took the earth fifty-two minutes to go round its circumference, or, as we call it, it orbit, it would take ⅙ of that time to go along the radius if it travelled with the velocity of light; it would therefore take 8m. 18s. But this radius is the distance of the earth from the sun, and having this time 8m. 18s., we have only to multiply the velocity of light 1 per second, by that, and we get 92,628,000 miles as the distance of the earth from the sun.

J. Norman Lockyer.

(*To be continued.*)

A New Standard of Illumination.—Some time ago Mr. W. H. Preece proposed a new standard of illumination for photometric purposes, based on the illumination of a surface, not the intensity of a standard light, such as the sperm candle or *bec carcel*. This standard is the illumination of space lighted by one British standard candle at 2.7 in. distance, or what is the same thing, by a French standard "bec" at one metre distance. The plan in vogue of comparing two lights by their effects at different distances on two surfaces, is open to the objection that the absorbent state of the air is not taken into account, although the distances are different, and that the diverse colours of the lights are ignored. Rumford's shadow photometer and Bouguer's (Ritchie's and Bunsen's) method of comparing equally illuminated surfaces have hitherto been found the most practical. But for these plans a uniform standard of light is essential, and none such exists. Various couutries have their own so-called standard, the French have the *carcel*, the Germans a standard candle, and so on, but these differ from each other and vary in themselves, and the new standard agreed on by the Electrical Congress is not yet in use. Mr. Preece employs a small Swan incandescence lamp, giving 2½ candle power with a current having an electromotive force of 5 volts. To illuminate the standard space he uses a contrivance consisting of a box in which the lamp is fixed. The box is blackened inside, and over the back part is stretched a diaphragm of drawing paper with a round grease spot in the centre, the size of a shilling, as in Bunsen's photometer. About 12 in. beyond the open end of the box, and behind the paper diaphragm, is another sheet or screen of drawing paper. No light falls on the diaphragm from without, except what comes from the screen which is illuminated by the light to be measured. This may be either directly received from a Lamp or the diffused daylight of a room. The current in the incandescence lamp is then varied until its light, shining on the grease spot within the box, is equal to that reflected from the screen from without. In this case the two lights are equal when the spot seems to disappear according to the well-known principle of Bunsen's photometer. The current is supplied by a secondary battery and modified by a resistance rheostat in circuit. Experiments made by Mr. Preece showed that the illuminating power increases in the ratio of the sixth power of the current. The apparatus worked well, but Mr. Preece confesses that it depends on the constancy of the lamp employed; the glass becomes smoky by use, the fibre deteriorates, and the vacuum sometimes fails. These results are, however, slow, he states, and it is sufficient to compare either the light given by unit current with that of a standard candle or Harcourt flame. He believes that the light given by this source is more uniform and easily reproduced than any other.—(*Ex.*)

Human skin and that young rabbits have been successfully applied in small pieces to large healing surfaces in wounds. Dr. Wilson, however, in the Medical News, claims to have obtained very much better results from the use of the internal membrane of hen's eggs. The egg should be fresh and warm.

THE ENTOMOLOGY OF A POND.—(*Knowledge.*)

BY E. A. BUTLER.

(*Continued from page 189.*)

II.—*The Middle Depths.*

Leaving now the surface and descending to the depths, we encounter a fauna wholly new, though still belonging principally to the same two orders, Coleoptera and Hemiptera, accompanied, however, by reinforcements from a third, the Diptera, but, so far as species are concerned, the beetles vastly preponderate. Commencing with the Hemiptera, the first insect that claims our attention is the well-known "Water-boatman," *Notonecta glauca*. Boatman though he is, his boat is almost always submerged; he often spends a good deal of his time just beneath the surface, where, resting on his oars, with the stern of his boat peeping just above the water, and its prow pointing dowuwards, he forms one of the most conospicuous and familiar objects in a pond. A rapid swimmer and a bloodthirsty and rapacious monster, he is a terror to the more easy-going inhabitants of the pond, whom he seizes with his forelegs and holds in a fatal hug, while he eagerly sucks out their juices. Let us take a glance at the form and general appearance of the insect. Flattened beneath, and strongly convex and slightly keeled above, we see at once some resemblance to an inverted boat. The creature, however, has the remarkable habit of always swimming on its back; in fact, in the water, it would hardly know itself right side up. This, of course, brings the "boat" into the proper position. The yellowish head carries two great masses of highly-polished eyes, and has an extremely bold appearance. After the thorax follow the various parts distinctive of bugs, as described in a former paper on "Neglected Insects." There is the large triangular shield-shaped piece, or seutellum, conspicuously placed in the centre, and the composite wings sloping down from its sides, yellowish, but more or less variegated with black. Opening the upper pair we find the others folded up, exquisitely thin and transparent, and with the principal nervures forming a nd of X-mark. The two front pairs of legs are slightly curved, and form efficient organs for the seizure and retention of struggling prey; and any poor creature that once falls into those clutches may think itself fortunate if it can manage to get free before the terrible beak is buried in its tissues, for this once effected there is no hope for the poor victim, which feels itself getting weaker and weaker as it is gradually being drained dry, 'till the last drop of its life-blood has been drawn out, when its insatiable captor, rejecting the now useless carcase, sets off again in quest of further adventures. The hind legs are very long, and form excellent rowing organs; when the insect is resting at the surface these are spread out at right angles to its sides, and there you have your boat and oars. The terminal joints of these limbs are furnished with long fringes of hair, which greatly increase their efficiency as a rowing apparatus. The larvæ are similar in shape to the adults, but have the body proportionately shorter; when out of the water they look most unfinished creatures, being pale in colour and having a sort of parboiled aspect. They have, of course, no wings, and must therefore spend their time wholly in the water.

Swimming with a similar jerky moeement, but not nearly so rapidly, and right side up instead of on their backs, is a whole family of bugs called the *Corixidæ*; they are yellowish, barred and variegated with black and not keeled, but flattened on the back; they are often extremely plentiful, going in large troops together, but as they keep well towards the bottom and do not often come near the surface, they easily escape notice. When one first takes to pond entomology, little more than a few hauls ith the net are needed to create a feeling of astonishment that there can be so much life so near at hand and apparently so easily within view, and yet so entirely unnoticed by the casual observer; it seems almost as if the very passage of the net through the water had been the means of calling into exi tence the multitudinous creatures that sprawl about on its dripping sides. So scarcely anyone ever notices the Corixidæ without dragging the water, but *then* so numerous do they show themselves to be that the wonder is they could possibly have escaped observation. The genus *Corixa* is a very extensive one, though it has figured in books as larger than Nature ever intended, because the species, while possessing a strong family likeness and general similarity, are extremely variable in the details of their markings, so as to make it difficult to fix on constant characters for their discrimination, and thus many mere varieties have been erroneously constituted species; at present, however, English entomologists reckon twenty-eight species as representing our British contribution towards the genus. Some of these are found only in Scotland, often high up amongst the mountains, and some occur even in brackish water. The genus forms a series gradually diminishing in size from ½ to 1-16 in., and the uninitiated would, no doubt, wish to consider the smaller species as young examples of the larger ones; but it must be remembered that insects do not grow when once they have assumed the adult form; their period of growth consists exclusively of their earlier stages, larvahood and puphood. Having once donned their wings, they have no further anxiety as to the fit of their chitinous clothing. Their dimensions are finally established. The limit of variability as to size are usually not very wide in any given species, the greatest divergence being found in subh insects as are dependent in their earlier stages upon food that is intermittent or precarious in supply. The Corixidæ possess fully-formed wings, and the hinder pairs are exquisitely delicate, and show rainbow tints. They readily take to flight, and at night are sometimes attracted to a light, so that if a window be left open on summer evenings near a pond they may be expected to be amongst the visitors that make headlong for the lamp. Dr. Puton, the French Hemipterist, says that in Mexico Corixæ are so abundant that a kind of bread is made of their eggs, and he further makes the astounding statement that on one occasion about a twelvemonth ago thousands fell from the air during a storm in Turkestan, coming down like rain in such enormous numbers as actually to extinguish a fire at a traveller's bivouac.

Fig. 1.—Naucoris cimicoides.

Our last representative of the Hemipter of this part of the pond is called *Naucoris cimicoides* (Fig. 1), it is a flattened creature of oval outline, with a *very* sharp beak which it is not at all slow to use, making its unwary captor drop it in most startled fashion under the impression that a severe wound has been inflicted. However, the pain is only temporary, the weapon being merely a piercer and not really a sting.

In all these insects, it appears at first sight as though the antennæ are wanting; this is not, however, really the case, The organs in question are very short, and concealed in depressions behind the eyes; hence the name Cryptocerata, hidden-horns, by which this particular section of the water-bugs is distinguished.

(*To be Continued.*)

MOVEMENTS OF THE EARTH.

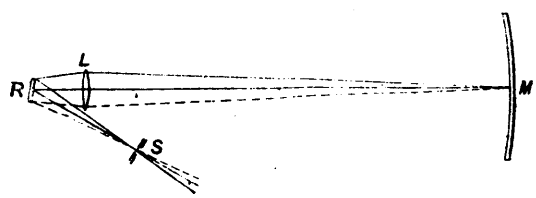

FIG. 40.—Foucault's arrangement for determining the velocity of light.

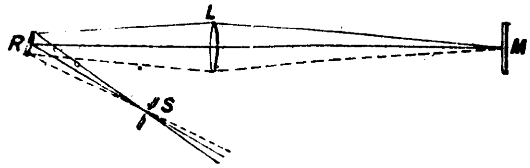

FIG. 41.—Michelson's variation of Foucault's experiment.

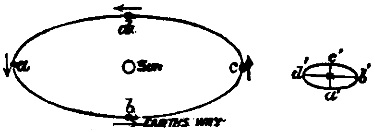

FIG. 42.—Annual change of a star's position, due to aberration: *a b c d*, the earth, in different parts of its orbit: *a' b' c' d'*, the corresponding aberration places of the star, varying from the true place in the direction of the earth's motion at the time.