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# CANADIAN MAGAZINE OF Science and the Industrial Arts. Patent Office Record.

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

*The Editor does not hold himself responsible for opinions expressed by his correspondents.*

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## *NEW BOOKS.*

*Fire Protection of Mills,* by C. J. H. Woodbury. (New York : John Wiley & Sons.)

This work is one of especial value to mill-owners and indeed to all who have to do with the management with mills. The annual fire tax in this country amounts to more than $125,000,000, and for the most part is paid for incompetency and defective construction. How to diminish this large sum is a matter of considerable importance, and, as competition has reduced the cost of insurance in respect to the actual risk involved, to a minimum, it only remains to take such precautionary measures as will lessen the risk. The question is carefully discussed by Mr. Woodbury, who divides the subject into two parts, in the first of which he deals with the most efficient methods of equipment and general management. He classifies arrangements for the defence of property from fire in four divisions, *viz :*

First. The anticipating of all preventable causes of fire.

Second. The preparation of methods of fighting fires, by fire organization of the men.

Third. The provision of a water-supply for fire purposes, and of the best apparatus for mill-protection.

Fourth. The most effective elements of construction.

The author discusses each of these divisions in detail. After giving an account of the various fire apparatus such as fire pails, different kinds of pumps, valves, hydrants, stand-pipes, etc., he goes on to consider the causes of mill fires, and enumerates 575 cases which occurred between the years 1851 and 1882, of which 114 were due to the spontaneous combustion of oils, dyed cloth or yarn, and bituminous coal, 27 to sparks and defective chimneys, 40 to matches, 138 to foreign substances in picker, 134 to friction, 36 to lighting apparatus and the remainder to fireworks, stoves, pipes, cigars, lightning, broken lanterns, etc. He describes the fireproof doors for use in picker buildings, and concludes this portion of the work by a statement of the advantages of electric lighting, of the precautions to be adopted in its use, and by a brief notice of other important points.

It must be remembered, however, as Mr. Woodbury remarks, that the value of the best apparatus is limited by the competency with which it is managed; and it is generally worthless, except when its use is directed by the wise, cool head of the leader.

In the second part, defective features of construction are pointed out, attention is drawn to principles of sound construction, and the author explains how iron columns should be protected and how the roofs should be covered. He carefully considers the strength, stiffness, and nature of the floors, and gives very valuable and original tables of tests of full size timber columns. Abstruse mathematical formulæ are avoided, and the subject is perfectly intelligible even to a man of the most ordinary mathematical attainments.

The book is interesting, well printed, and well illustrated.

*The Air we Breathe and Ventilation,* by H. A, Mott, Jr, Ph. D. and C. (New York : John Wiley & Sons.

The problem of providing proper ventilation for dwelling houses and public buildings is confessedly a most difficult one, and one which has not yet been well solved. Information respecting all undertakings of this kind is very important, whether it may serve as a guide for showing courses to be followed with advantage in the future or to indicate what should be avoided. In the little book before us, Mr. Mott first considers the composition of the atmosphere, and points out the various characteristics of its constituent elements (oxygen, ozone, nitrogen, ammonia, carbonic oxide, etc.,) and their relative influence. He then carefully discusses what is called the aspirating system of ventilation, being convinced that this system is founded on a correct principle. The impure air is drawn or aspirated out of a room, and its place is replaced by fresh air admitted through cracks and pores in the walls, doors, windows, etc. Instead, however, of relying on such modes of admission, it would be both advisable and preferable to provide suitable ducts, the openings of which could be regulated at will. The author describes the Cameron, Gouge and other systems, and refers at some length to the application of the former to railroad cars. The question of fans, air-meters, etc. is also dealt with, and the work is illustrated by several clear and carefully executed diagrams.

## ENGLISH AND AMERICAN FISHING VESSELS.

One of the most valuable features in the late Fisheries Exhibition was the opportunity it afforded to practical fishermen—a class unapt to acquire instruction from books—for comparing their own vessels, gear, and modes of fishing with those of other nations. The British seaman is proverbially self-satisfied, and the characteristic is certainly as well defined amongst the fishing classes as in any other branch of our maritime population. Nevertheless it must have been brought home very forcibly to all but the most case-hardened egotists that, at any rate, there are a few points of foreign fishing practice which we in England might study with advantage. The United States Court was, without doubt, the most complete and best organized amongst all the foreign displays, and it was to that one naturally looked for affording a comparison. With respect to fishing gear there was a vast deal that it would be desirable to see, at least tried, in British waters; amongst so many that are new to us, and so much that has proved entirely successful on the western side of the Atlantic, we could scarcely fail to find many appliances which would be valuable as an addition to our means of capturing fish. With regard to the fishing vessels of the two countries, no doubt there is less that is desirable for us to acquire. Taking only the larger craft engaged in ocean fishery, the North Sea trawler and the New England schooner may be considered as the most important vessels of each nation. Our own country had the advantage in the matter of representation, Messrs. Alward and Ekeritt's splendid model being without doubt the finest exhibit of the class in the whole Exhibition, and very rightly took the special prize. Although the Americans had no single model that for accurate representation of a typical vessel in shape, rig, and equipment equalled this English boat, yet their collective exhibit, illustrating nearly every type of fishing boats in use throughout the United States, stands, we should think, unrivalled as a comprehensive illustration of the fishing vessels of any nation. Of the New England schooner there were about half a dozen models, all giving faithful illustrations of the type of craft they represented in the manner of model and rig. We were not fortunate enough to get the lines from which any of these were taken, but on page 36 will be found those of a fishing schooner designed by Captain J. W. Collins, a member of the United States Fish Commission. Fig. 1 is a fore and aft section, showing the general arrangement. Fig. 2 shown construction and cabin plan. Figs. 3 and 5 are respectively half-breadth plan and body section. Fig. 4 is a section through the ice lockers and well. Fig. 6 is the sail plan. This vessel in general contour may be taken as a typical Yankee schooner, but the beam is 10 in. less and the depth 18 in. more than is usual with the New England craft. In order, therefore, to make a fair comparison the middle body should have a lower bilge, in fact the sections should be somewhat flattened the characteristic hollow floor being however, retained. The rig, too, differs in some respects. The well also is an unusual feature in craft of this description.* On page 36, Figs. 7, 8, and 9 we give the lines of a typical North Sea trawler, taken from drawings kindly furnished to us by Mr. W. E. Redway, late of Dartmouth, who has designed many successful trawlers now working in the North Sea. The vast difference between the English and American vessels will be seen at a glance, the broad characteristic of our home model being safety, whilst the New England lines are calculated to afford high speed.† The American fishing schooners carry an immense spread of canvas in terms of their displacement, and have great natural stability, which enables them almost to dispense with ballast; a mackerel schooner of from 70 tons to 80 tons, carrying about 10 tons of stone only. On the other hand, the round sections of the North Sea trawlers are not calculated to afford the stability requisite for sail-carrying power unless aided by ballast; a modern North Sea trawler having as much as 50 tons to 55 tons of iron stowed as ballast. The English form is, however, one of very great strength, and a good depth of the hull being under water, gives the vessel power and ability to live through heavy weather. It is of course impossible to say how far the two types of vessel fulfil the conditions they are especially designed to meet. The terrible losses incurred by the North Sea fleet during the gale of March 6th last place us at a special disadvantage when comparing our national type. On that occasion 47 vessels and 240 lives were lost, besides casualities of a less series nature.

During the gales of December, 1876, on the American side of the Atlantic, 12 schooners and 95 men were lost on the banks from the Gloucester (Massachusetts) fishing fleet alone. Of course these figures prove nothing. The gale of last March in the North Sea was entirely exceptional. It was not so much the strength of the wind that overwhelmed the fishing boats, as it was the vast tidal wave which arose and carried all before it.

The average annual loss of British fishing vessels for the last five years 1876-77 to 1880-81 was 34 2-5th, and during the year 1881-82, 40 British were lost or missing.

We have no particulars of the losses of fishing vessels throughout the United States, but those hailing from the port of Gloucester—by far the most important fishing station in America—are recorded in the Fisherman's Own Book, a publication to which we have on former occasions referred.

In 1876, 27 vessels and 212 men were lost. 1877 (a year of depression in the fishing trade), 7 vessels and 38 men. 1878, 11 vessels and 55 men. 1879, 29 vessels and 249 men. 1880, 4 vessels and 52 men.

In comparing the American schooner and English ketch-rigged trawler it will be of course remembered that the mode of fishing followed by each type of craft is essentially different. A vessels with quarters like the New England schooners could not be used for towing a large beam trawl during average winter weather in the North Sea. Still our cod smacks, which are used for much the same purpose as the American craft, are built nearly on the same line as the trawlers, and the two types of Yankee schooner and North Sea ketch may be taken as nationally characteristic, independently of the style of fishing pursued.

Since we gave some particulars in our number of October 5th last year of the mode of fishing pursued by the New England vessels by means of the small boats called dories we have had many inquiries for further particulars of these little vessels. On page 36, Figs 10 and 11, we give illustrations taken from a model shown in the Fisheries Exhibition. This a shore dory, and is fitted with a sail and centre board. There are also small pieces of decking, or water-ways, at the sides. The dories carries in nests on board the schooners have neither decking, centre board, or rudder, and thwarts are made to take out. We have already given particulars of these small but important craft, and of the dory winch used with them, which we also illustrate in Fig. 12.—*Engineering.*

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* There are, however, a few well vessels used in America. They are mostly sloop-rigged, and catch cod, halibut, blue fish, black bass, sheep's head, etc.

† In Mr. Dixon Kemp's "Yacht and Boat Sailing" comparison is made between the English and American types of schooner, to which those interested in the subject would do well to refer.

## STRUCTURAL STEEL.

BY E. B. DORSEY, M. AM. SOC. C.E.*

The paper gave the results of an examination by the writer into the subject during two recent trips to Europe. The steel used for structural purposes is called generally in England mild steel, and in Germany, homogeneous iron. Experts in Great Britain generally rely more upon physical tests and the reputation of the manufacturer than upon chemical composition. The physical requirements are stated, and the manufacturer uses his discretion as to the composition which will answer these requirements.

The rules for testing steel adopted by the British Admiralty, by Lloyd's Register, and by the British Board of Trade, were given. The tendency among English engineers is to use steel still softer than has heretofore been thought best. Some large builders use nothing in their boilers over 26 long tons tensile strength per square inch and 25 per cent elongation in 8 inches, Others advise the use of steel of from 23 to 25 long tons tensile strength with the same elongation.

American engineers require from 15 to 20 per cent higher tensile strength than the English. The Siemens-Martin, or open hearth steel is preferred by nearly all experts for structural purposes, the Bessemer steel being principally used for rails. Ship-builders are decided in their preference for the open hearth steel. A much larger number of plates would be condemned of the best wrought iron than of steel. Data were given as to loss of strength in steel plates by punching. Steel can be manufactured into much heavier, larger and wider pieces than wrought iron. Steel rivets are used on the Clyde exclusively in rivetting steel. The new Forth bridge is to be built of mild steel. The use of mild steel is extending very

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* A Paper read before the American Society of Civil Engineers.

rapidly in Europe, and has fast superseded iron for structural purposes.

The paper was discussed by members present. During the discussion Mr. Theodore Cooper referred to the conservative stand taken by him in a paper presented to the Society some four years since and expressed the opinion that at the present time he would feel still more conservative in regard to the use of iron instead of steel for structural purposes, particularly for bridges or other similar constructions.

For boilers for ships, etc., steel has answered very well, but for structures he would be inclined as yet to advise the use of wrought iron. In compression, in his opinion, steel has not been proved to be as strong as wrought iron, and the necessity for most careful inspection is greater for steel than for wrought iron.

Mr. M. N. Forney referred to the increasing use of steel for rails, for wheel tires, and for various parts of locomotive machinery. He referred to the record of accidents which showed that some 66 per cent of accidents in this country are due to derailment, and only 8 per cent due to the same cause in England. In this country the number of broken wheels is very great and the tendency towards the use of steel for tires is decided.

Vice-President Paine gave details of the methods of tests of steel in use during the construction of the Brooklyn Bridge, and expressed an opinion favorable to the use of steel.

The paper was also discussed by Messrs. Collingwood, Frith and North.

◆

## SOLID AND GASEOUS FUEL.

In view of the large amount of attention that is just now being directed to the comparative value of solid and gaseous fuel, the following, from *Le Gaz Belge*, will be read with interest :

When solid fuel is employed, it is not only necessary to provide the supply of oxygen required for combustion, but also to convey into the furnace sufficient air to drive off the products of that combustion, by ensuring the contact of the oxygen with the whole surface of the combustible material. In practice it is found that nearly twice the quantity of air theoretically required has to be provided, and this, of course, doubles the volume of the gases that have to be heated. It may thus be assumed that half of the air admitted into a furnace does not serve for combustion ; and this excess of air naturally carries off a considerable quantity of heat. The loss, however, is a necessity, for if less air were supplied there would be a possibility of combustion being incomplete, and the evil would become greater. In fact, the carbon passing into the condition of carbonic acid (the result of the most complete combustion) develops 7,200 heat units, while with a less perfect transformation it furnishes carbonic oxide, giving only 1,400 units. When gaseous combustibles are utilized, these losses may be prevented, since very nearly the determined quantity of oxygen may be supplied, and this be caused to mix more closely with the combustible elements, without necessitating the expenditure, on the part of the mixture, of an amount of energy comparable with that required by the solid combustibles.

The commercial value of the two kinds of combustibles may be approximately stated as follows : Coals have, according to their quantity, a standard of from 4,500 to 7,500—say an average of 6,000 heat units. From this number must be deducted 500 heat units lost in effecting combustion. There remain, therefore, 5,500 heat units. Now the absolute available heat of furnaces employed for industrial purposes does not exceed 40 per cent of their theoretic-heating capacity, and, therefore, effective caloric power is reduced to about 2,000 calories. The cost of furnace coal of average quality ranges from 6 to 8 francs per 1,000 kilos—say 0.8c per killogramme (2.2 pounds). The 2,000 calories heating power therefor cost 0.8c. If coal gas is taken as the element of comparison, its yield in heat being 12,000 units of the net cost of 7 cents, the ratio becomes 1.4 for coal gas respectively. This, however, is exclusive of the cost of labor, maintainance of appliances, transport of fuel, etc., all of which would double the net cost of the solid combustible material, so that the proportion really become 2 for coal and 1.4 for gas. But the solid combustible furnishes only 2,000 calories, while if it is transformed into lighting gas it would furnish 3,000 calories. The final ratio of the net cost, therefore, become 3 for coal against 1.4 for gas. In other words, the employment of illuminating gas as a combustible is attended with about twice the economy that results from the use of ordinary coal.

## TORPEDO BOATS.

In Figs. 10 to 17, on page 37, is illustrated a second-class torpedo boat built by Messrs. Yarrow and Co. for the English Government. The hull is of galvanized steel. The engines are of the usual compound condensing type. Separate engines are sometimes provided in these boats for working the air, circulating, and feed pumps. The advantages claimed for this arrangement are, that it allows a vacuum to be always maintained in the condenser, and the main engines are consequently more under control. It also enables the high-pressure steam to be blown into the condenser in the event of a sudden stoppage, so that the firing may be continued and a too sudden change of temperature in the firebox be avoided. In boats of this class it is undesirable to allow any escape of steam into the open air which might in action betray the presence of the boat to an enemy. In the case of the main engines racing in rough weather, there is less risk of a breakdown to the pumps if they are worked separately. In these boats the main engines are provided with piston valves, which, in Messrs. Yarrow and Co.'s opinion, are more suitable than the ordinary slide valves in engines running at as high a speed as 500 revolutions a minute.

The following are the principal dimensions of the boat and engines :

| | | ft. | in. |
|---|---|---|---|
| *Hull:* | | | |
| Length over all | | 63 | 0 |
| Breadth | | 7 | 9 |
| Draught of water amidships when loaded | | 2 | 3 |
| Displacement | | 12.5 tons. | |
| *Engines:* | | ft. | in. |
| Diameter of cylinders | H.P. | 0 | 8 |
| | L.P. | 0 | 13 |
| Stroke | | 0 | 10 |
| Cooling surfsce in condenser | | 230 sq, ft. | |
| | | ft. | in. |
| Diameter of cylinders of air-pump enfines | H.P. | 0 | 3¾ |
| | L.P. | 0 | 6¼ |
| Length of strokes of cylinders of air-pump engines | | 0 | 4¼ |
| Diameter of ram of feed pumps | | 0 | 2¼ |
| Length of stroke | | 0 | 2¼ |
| *Boiler:* | | | |
| Diameter of barrel | | 3 | 4 |
| Length over all | | 7 | 6 |
| Number of tubes | 135 | | |
| Diameter of tubes | | 0 | 1¼ |
| Total heating surface | | 225 sq. ft. | |

The condenser is of copper with brass tubes. A small engine 3½ in. in diameter by 3 in. stroke which runs at 1200 to 1500 revolutions a minute, is provided for working the fan, the diameter of the latter being 31 in. The speed of the boat when loaded in accordance with Admiralty requirements, is 17.27 knots on a two hours' run.

It will be seen from the illustrations that the torpedoes are placed in two troughs at the bow, these troughs being inclined downwards, the angle of inclination when the boat is at rest being 6 deg. The torpedoes are projected by means of steam impulse gear, and this system is now adopted in all second-class torpedo boats built for the English Government. The impulse cylinders have a diameter of 6 in. and a stroke of 7 ft. The steam presses against the pistons through 5½ ft. of the stroke, after which the pistons are cushioned by air, whilts at the same time a valve shuts up the steam and opens a connection to the condenser, by which means the pistons are drawn back into their original position, and are ready to eject another torpedo immediately it is lowered into its trough. This impulse gear is arranged so that it can be started by the officer in charge in the conning tower, who is able from thence to fire the torpedo, and also to steer the boat. In the former operation, only one valve has to be opened, and as it is of the equilibrium type very little power is required to work it.

This arrangement was introduced by Messrs. Yarrow and Co. and was tested by the Admiralty officials at Portsmouth in March last, giving very satisfactory results. The impulse cylinders, as will be seen by the illustrations, are completely covered by the deck of the boat, and, being to the boiler, they are kept warm, and thus always ready for use. Were the cylinders exposed it would be necessary to warm them before they could be put in action, and the delay caused by this process would render the system entirely impracticable.

The steam trials of the last boat Messrs. Yarrow built for the English Government took place on Thames on the 26th of February, 1883, when the following results were obtained :

| | |
|---|---|
| Pressure of steam | 116 lbs. |
| Vacuum | 24 in. |
| Revolutions per minute | 554 |
| Speed | 17.27 knots. |

We believe that this is the highest result that has hitherto been obtained by a boat of this size tested under the Admiralty conditions.—*Engineering*.

# ENGLISH AND AMERICAN FISHING VESSELS.

(*For Description, see Page* **34.**)

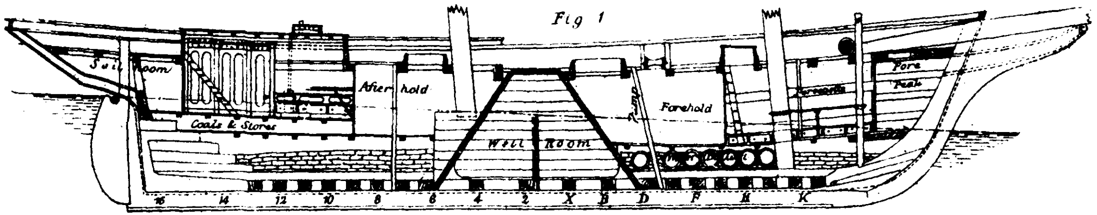
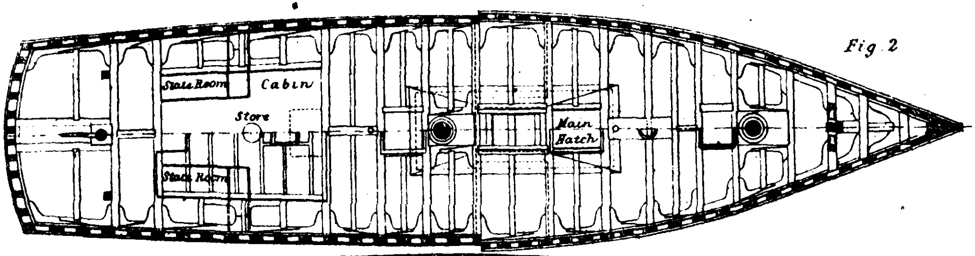


Fig 1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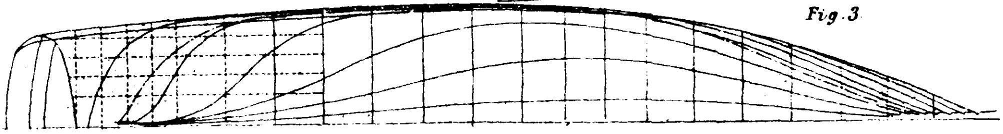
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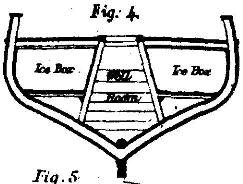


Fig: 4.

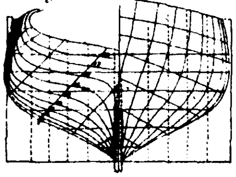


Fig. 5

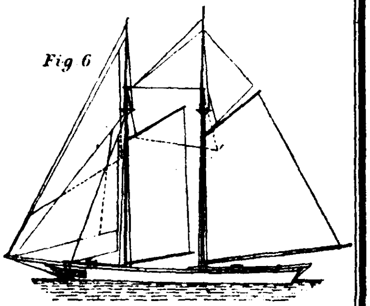


Fig 6

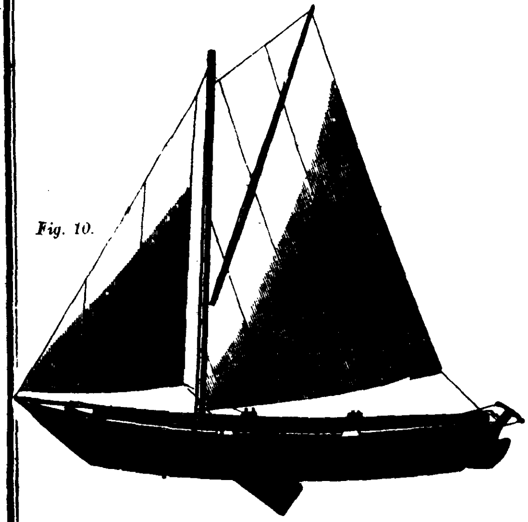


Fig. 10.

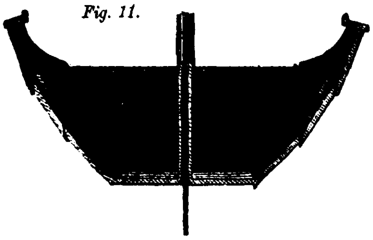


Fig. 11.

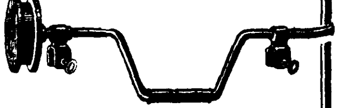


Fig. 12.

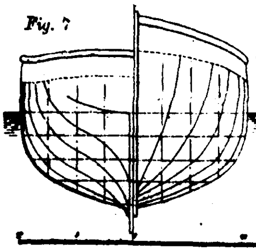


Fig. 7

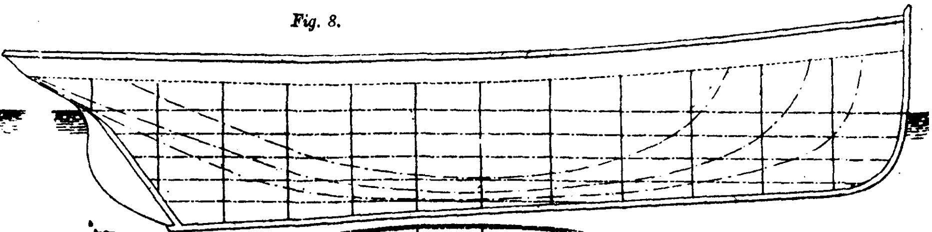


Fig. 8.

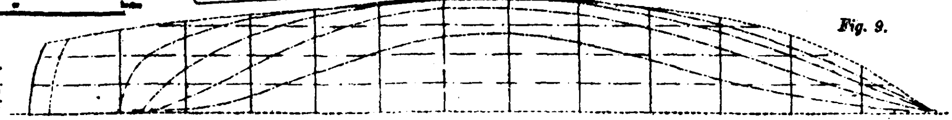


Fig. 9.

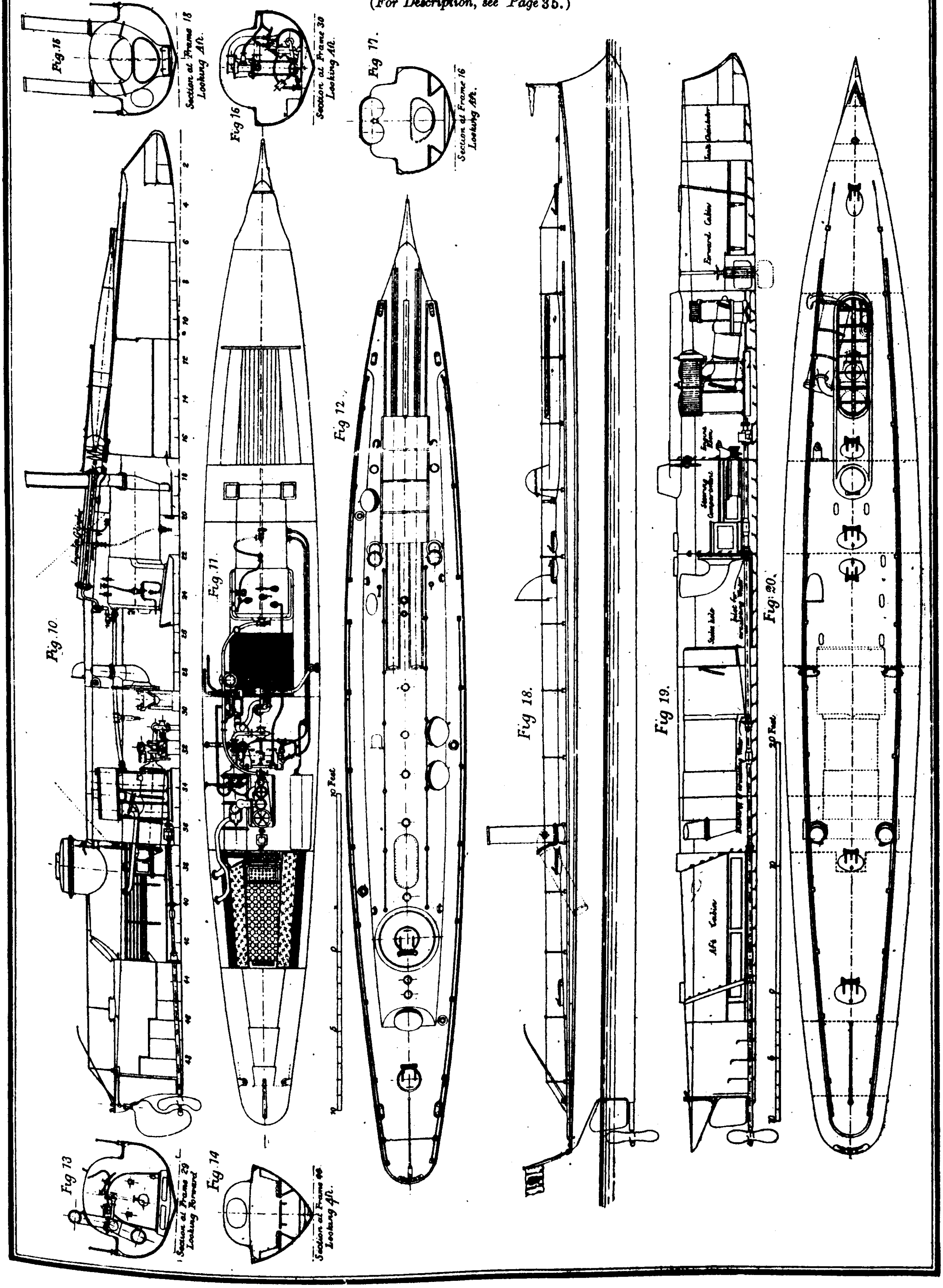
DIMENSIONS

| | | |
|---|---|---|
| Length (on L.W.L.) | 78' | 6" |
| Breadth | 20' | 0" |
| Draught (Mean) | 9' | 0" |

# TORPEDO BOATS.

CONSTRUCTED BY MESSRS. YARROW AND COMPANY, ENGINEERS, LONDON.

(*For Description, see Page* 35.)



## ARCHITECTURE AS A STUDY.*

*(Being a glance at the origin and development of some of the modern styles.)*

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

The origin and gradual development of anything affecting the happiness or comfort of mankind, is interesting and instructive. In all departments of research there is a reaching back to first causes and a tracing of developments.

To rightly understand the present conditions of architecture, we must go back to remoter times and we shall find a continuous chain running down the ages, in which there is no missing link and which forms an invaluable testimony to scientific and artistic knowledge and research, whether it be in the form of the Moabite stone, or cuniform inscriptions, in sculptured Assyrian pictorial tablets, in the celebrated Elgin marbles, or in some vast and mysterious pyramid or solemn and awe inspiring cathedral.

Architecture was born while the world was young. At first man was content with a covering from the rain, the sun, and the dews of night—a leafy bower made by some drooping tree,—a cave in the rock—failing these, two or three upright saplings placed against rising ground and covered with branches, or placed wigwam-fashion, or where rising ground was not available, uprights and cross-pieces laid on top and between, sufficed for his simple needs. In process of time these developed into larger and more permanent structures, but still bore evidence of the original types, the stately column being but a development of the rough upright post, the massive lintel of the cross-pieces, the metopes and other ornaments of Greek architecture, bearing unmistakeably their wooden origin.

The building races of mankind may be roughly divided into four divisions:—

1. The Turanians, represented in ancient times by the Egyptians, and in modern by the Chinese and Japanese.

The Turanians appear to have been the first to spread over the world beyond the original cradle of man. They were in the valley of the Euphrates before the Semitics or Arians. In Italy they appeared as the Pelasgi and Etruscans; in the north as the Finns and Lapps, and in India as the Tartars. .

They were great tomb builders as evidenced in the Pyramids of Egypt, the Mausoleum of Hyder Ali in India, and other well-known remains.

II. The Semitics—generally known as the Jews have had an influence on the world out of all proportion to their numbers. Keeping almost exclusively to themselves and favoured by Providence as the chosen nation to whom was entrusted a divine revelation, they have bulked large in the history of the world. They never achieved much success as builders; with the exception of Solomon's Temple, which was indebted for its magnificent appearance largely to the overlay of gold and silver, and on the erection of which they had to get Turanians to help them, we know of no buildings of much importance. It was not until they learnt from the Romans how to build the temple of Herod that they had any buildings worthy of note.

The early Assyrians were partly Semitic, but their buildings being chiefly of wood and baked clay, were soon buried under their own earthen roofs.

III. The Celtic.—Unlike the Semitics they mixed freely with the people they came in contact with, so that they soon largely lost distinctiveness. Coming originally from Asia, they displaced the Turanians who had settled in Europe and mixed with them. One branch went to Italy and penetrated as far south as Rome, but the main body settled in Gaul and Belgium, from whence they peopled Britain and Ireland. They are splendid builders. It may be said that architecture and art has flourished in the exact ratio in which Celtic blood is found in a people and has died out as Aryan influence prevailed.

IV. Aryan.—3000 years B.C. they crossed the Indus and settled themselves in India and gradually became absorbed by the Turanians.

Those who wandered westward uniting with the Pelasgi—a people originally of Turanian stock, produced the Greek nation. They next appeared in Rome mixing with the Turanians, Etruscans and Celts of Italy, and lastly in Northern Europe.

Passing from this brief outline of the primary origin of the broad and wide distinctions in style we come now to two of the principal factors in shaping a nation's architecture and building; *viz.*, the climatic necessities, and the possibilities in the way of obtaining building materials. In all genuine and natural styles which have developed and not simply been borrowed this is invariable, and in examining all styles worthy to be so called this should be borne in mind to arrive at a right understanding of them. Thus in warm and sunny climates the architecture is of a light and gay order—in a cold and severe climate of a stern and grave character. In regard to material:—In a stone country the architecture is heavy, massive and monumental, in a timber country lighter and less enduring, and when both stone and wood are scarce, we find the capabilities and uses of brick and terra cotta turned to account, resulting in a picturesque and more varied style with multitudinous parts.

All modern architecture is based upon modifications either of the Classic or of the Gothic, or upon combinations of both. In order to a right understanding therefore of these and to be in a position critically to examine modern styles with any degree of knowledge, it is necessary that we should know what is meant by the terms "Classic and Gothic," wherein they differ, and what forms their distinguishing features. To many of you such explanation may not be necessary, but for the sake of such as may not know I trust you will bear with with me while I endeavour to make these distinctions plain.

The march of architecture, like the march of progress and civilization, has ever been westward, and from the massive and symbolic architecture of Egypt which I do not dwell upon now, was distilled the refined and intellectual architecture of the Greeks. That wonderful nation which stands unique in the history of the world for the perfection to which it brought its literature, and its plastic arts, developed and beautified, shaped and moulded architectural forms until they culuminated in the Parthenon; than which it is almost impossible to conceive of anything nobler or better—judged from their standpoint and viewed in relation to their climatic requirements, their faith and morals.

As I have already said, all true national architecture must bear the impress of the people, must grow natur-

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* The first of three lectures delivered before the Faculty of Applied Science, McGill University.

ally out of their needs and necessities, and be subject to climatic requirements. Just as all true work of individuals must bear the stamp of their true selves upon it. Thus it was with the Greeks.

Paul found at Athens innumerable temples to gods whose names were legion, and he was forced to confess that he found them "very religious." These were like their worship—cultured, refined, placid, but cold. No yearning after the infinite is seen in those long horizontal lines of entablature and rows of columns. They are the very antithesis of the Gothic with its restless upheaving of stone-like dumb prayers appealing to heaven in pinnacle and spire and gable. They personify,the worship of humanity, or of gods like unto men and viewed from that standpoint, I do not know that the world will ever see edifices more beautiful.

It is customary to speak of early classic architecture under the title of the five orders, although more properly there are only three. These are—1st. The Doric. 2nd. The Ionic. 3rd. The Corinthian, and at the risk of being elementary I should like to point out to you the distinguishing features of each of these orders.

The Doric is massive and heavy. The Ionic is lighter and more graceful. The Corinthian is luxurious and rich. The Doric represents the young, vigorous, sturdy nation; the Ionic a greater degree of luxury; the Corinthian, a culuminating magnificence, on the borderland of a commencing decline, when prosperity and luxury were eating out the nobility of the nation.

Some writers have found a fanciful likeness to the female adornment of curls in the volutes of the capitals of the Ionic order, and have therefore spoken of it as the feminine order.

There is also a pretty legend about the origin of the Corinthian Capital.—A young Greek girl having died, her nurse placed a small basket on her grave filled with a few of her trinkets and laid a tile on the top. Callimachus, a well-known sculptor, happened to pass that way and noticed that the leaves of an acanthus plant, on the root of which the basket had been placed, had sprouted and grown up round the basket, and reaching the tile curled over towards the top. He was greatly struck with the beauty of the arrangement and adopted it, with the result which you see. When the Romans conquered the Grecks they immediately seized upon their architecture and transferred the forms and features to their own buildings, but as often happens in translations the spirit of the original was lost, and so we find in the Roman architecture, it gained in vigour but it lost in refinement and delicacy of detail. Those mighty conquerors and mighty builders wanted something more bold and striking and magnificent. So they made two additional so-called orders—namely, the Tuscan and the Composite; but as the Tuscan was but a clumsy adaptation of the Doric, and the Composite, as its name denotes, is but a combination of the Ionic and the Corinthian Capitals, these are hardly worthy of being called separate orders. Their ambition was not content with one-storied buildings like the Greeks, so to give height they piled one order on the top of the other,andnot having large stones for building purposes they could not continue to use flat lintels except for very small openings, and therefore they now adopted the arch from the ancient Etruscans this speedily revolutionized their architecture and made possible the obtaining of large unobstructed interiors and wide openings, and although for a time they used it timidly and always in combination with the Greek columns and other features, they soon modified these and developed the arch as a leading characteristic. The use of the arch once demonstrated was never again laid aside, but in some form or other, as we will afterwards see, has entered largely into the architecture of every country since.

I need hardly mention examples of Roman architecture as these must be familiar to you all. I will simply remind you of the Pantheon, the Colisseum, the basilica of Maxentius, the numerous baths, triumphal arches, etc., and, as magnificent engineering works, their bridges and specially their aqueducts, which, even in their ruins, fill the traveller with admiration, as they stretch away into distance on the level Campagnas around Rome. These aqueducts are full of interest as well as instruction to every student of engineering, and although almost always devoid of any ornamentation, are yet, by reason of their good proportions, sensible construction, and massiveness, entirely admirable. The Pont du Gard at Nîmes, in France, is also specially worthy of study.

The introduction of the Christian religion brought a change over the spirit of the age which affected architecture as well as the other arts. In the time of Constantine, when, for the first time almost, the church was allowed liberty, the basilicas were found to be the most convenient places for their assembling in. These basilicas were the halls in which business had been transacted in pagan times and sometimes formed part of the palaces of the nobles. They therefore continued for a long time to be the model on which all christian churches were designed. Gradually a marked change was taking place all over Italy, and what is commonly known as the Romanesque style developed itself, of which earlier examples are still existing in that most interesting old town of Ravenna, and there are numerous other examples of earlier and later work in Rome and elsewhere.

When Constantine established the seat of the Empire at Constantinople, the Greeks again showed their versatility and inventiveness in originating and developing what is known as the Byzantine style, a style very similar in character with the Romanesque, and often confounded with it, but possessing its own peculiar features.

St. Sophia, at Constantinople, is one of the most striking churches in this or any other style. The development of the dome was achieved by these Byzantine builders and showed great advance in constructive skill over that of the Pantheon or of any other attempted to be constructed by the Romans.

The famous church of St. Mark's, at Venice, is almost wholly Byzantine in feeling and detail, and with its mosaic Bible spread out on ceiling and walls and floor is a gem in its green-sea setting.

The invasion of Italy by the Goths and Huns, and the breaking up of the Roman Empire furnishes another link in the architectural chain, and as the tide of Northern invaders rolled back we will accompany them and glance now at the development of the Gothic in Northern Europe. There was a widespread belief that the year 1000 A.D. was to see the end of the world, but when that period had safely passed and the sun

INVENTIONS OF WATT.

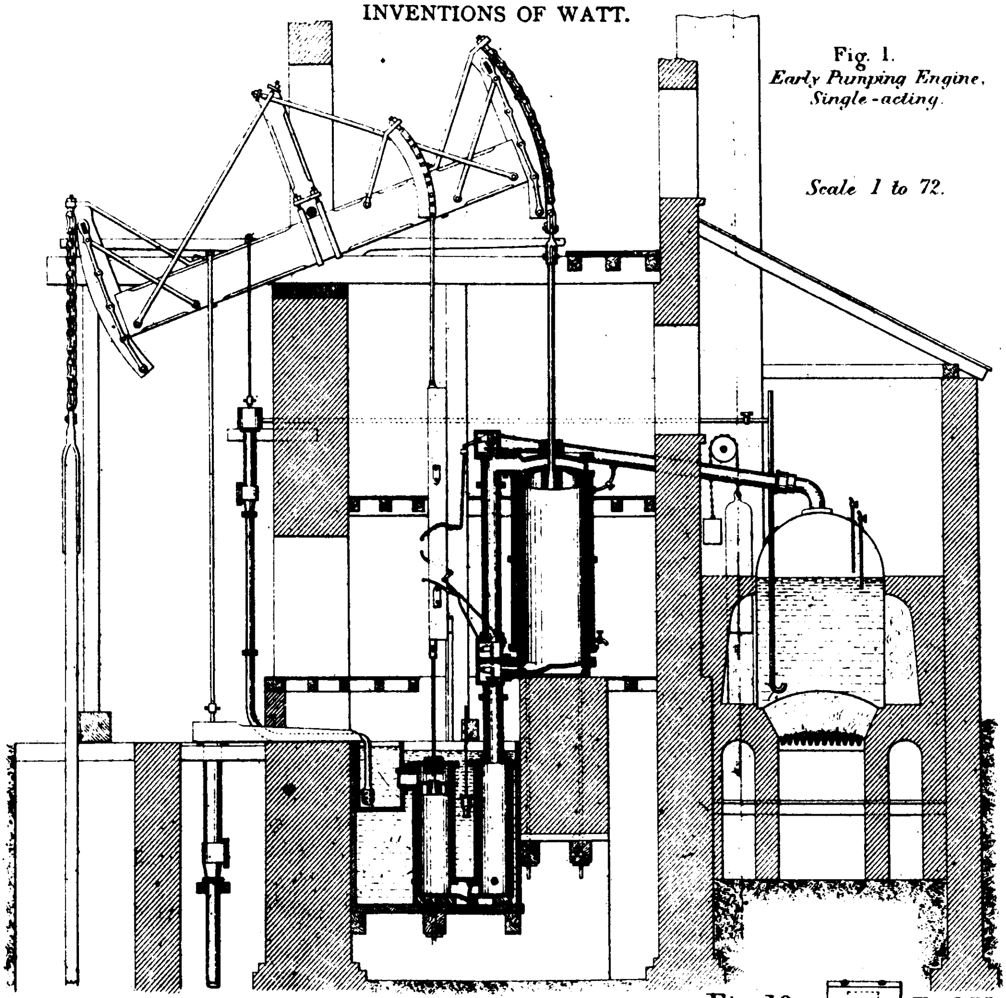


Fig. 1.
*Early Pumping Engine,*
*Single-acting.*

*Scale 1 to 72.*

*Sun and Planet Engine.*

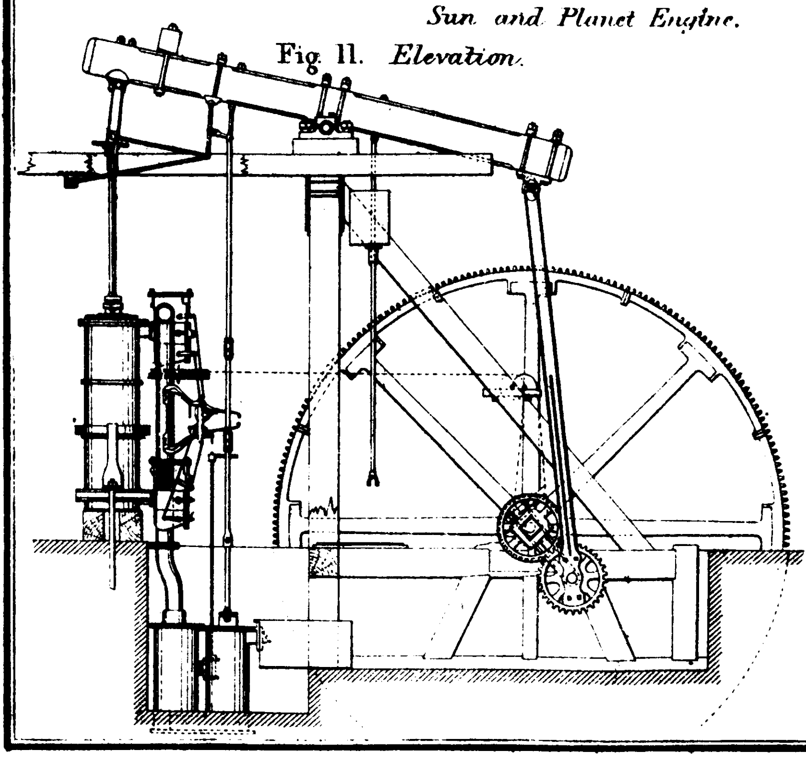


Fig. 11. *Elevation.*

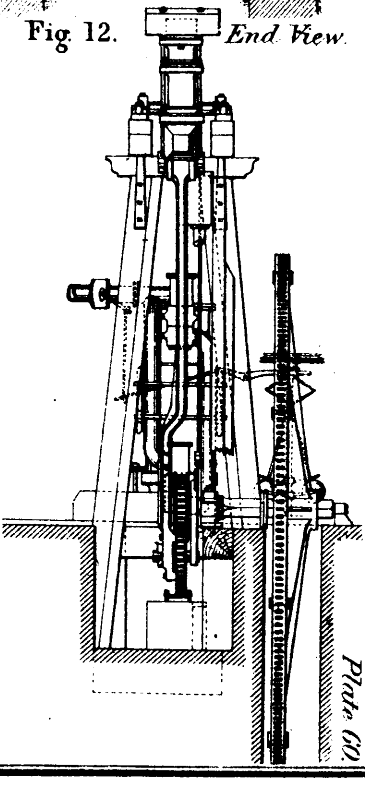


Fig. 12. *End View.*

*Plate 60.*

## INVENTIONS OF WATT.

Surface Condenser.

Fig. 3. Section.

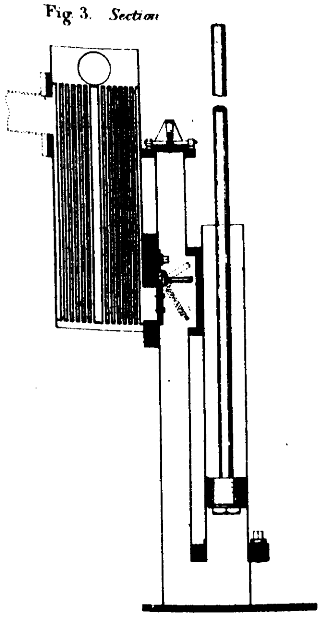
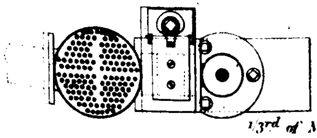


Fig. 4. Plan.



1/3rd of Model.

Rotatory Motions.

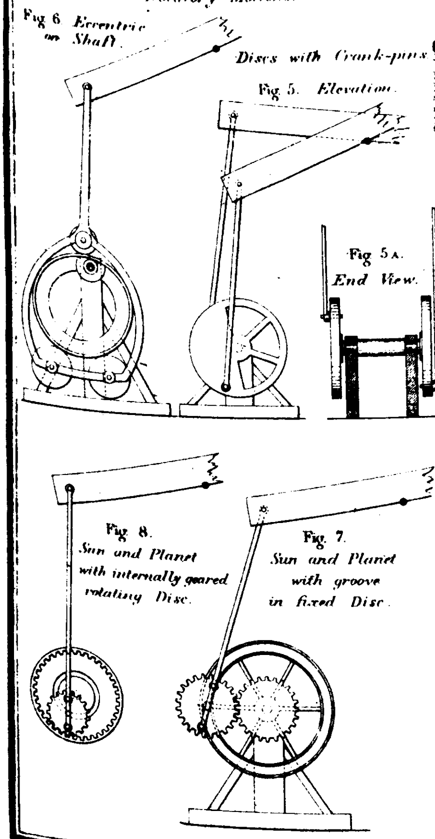


Fig. 6. Eccentric on Shaft.

Discs with Crank-pins.

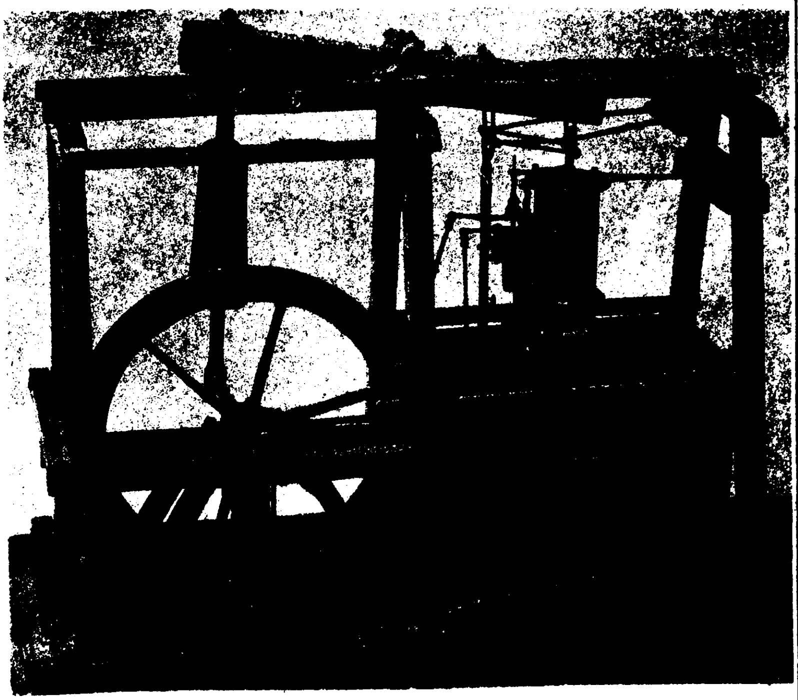
Fig. 5. Elevation.

Fig. 5A. End View.

Fig. 8. Sun and Planet with internally geared rotating Disc.

Fig. 7. Sun and Planet with groove in fixed Disc.

*Model of Single-acting Engine, with balance-weight.*



still rose and set, and seasons came and went and things went on as before, a new vitality sprang up. The rugged Normans were great builders, and soon there began to spring up all over Normandy, bold massive churches. We can easily trace in these Romanesque influence, but crude and rough, of course, as befitted the ruder life and manners and sterner climate. On the Norman Conquest of England in the middle and latter part of the 11th century, they introduced their architecture into England of which there are many notable examples still existing both in England and Scotland.*

The distinguishing features of the Norman are the round arch, cushion capital, zigzag, fillet and other ornaments, but these are better explained by the diagrams than by any description.

The style increased in richness as successive buildings were erected until the general use of the pointed arch inaugurated a new development to which has been given the name of the Early English or 13th Century Gothic. The later period of this style may be called the culminating point of Gothic architecture.

The period from 1190 to 1270 is usually assigned to the Early English Style. Most of the best work in our magnificent English Cathedrals was executed about this time—Lincoln, Salisbury, part of Canterbury, part of York, most of Westminster, the splendid west front of Wells, the Choir of Worcester, the Choir of Rochester, the Temple Church, and many other churches too numerous to mention.

Every one ought to have a general idea of the leading characteristics of the different periods of Gothic, as in these days of European travel I can imagine nothing more calculated to add to the interest of the traveller than to have an intelligent understanding of the architecture which forms such a large part of the interest of English places; to be able quietly to trace in the massive columns, the noble arches, the lofty roof, the delicately cut mouldings and exquisite carvings, the march of successive master minds stamping their genius on these aged stones, is an occupation manifestly at once profitable and pleasant and more likely to leave substantial results, than a hasty and superficial glance around, as has too often to suffice.

Who these men were we know not,
Ages since their race was run
They have heard, those faithful servants,
The Master's words, well done,
But the minister standeth ever,
Standeth ever old and gray,
Where many a weary soul hath learned
Of Him who is the way.

I have sometimes watched in some cathedral groups of visitors taken round by a verger who poured forth his well-worn tale in monotonous tones, and I have wondered how many were able to obtain an intelligent idea of what they were looking at, or whether they were satisfied at feeling they had "done" another cathedral.

(*To be continued.*)

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An important obstacle has been encountered in the construction of the Arlberg Tunnel, in France, being in the form of a bed of quicksand, which, despite all efforts thus far made, seems to effectually bar further progress. Shoring has been found useless, and as the sand is renewed as rapidly as it can be removed, the completion of the tunnel is in some quarters regarded as an impossibility.

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[*] The Saxon architecture which it supplanted was of the most primitive character and is not of sufficient importance to be dwelt upon to-night.

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## SPEED ON CANALS.*

BY MR. FRANCIS ROUBILIAC CONDER, M. INST., C.E.

The important question of the resistance to the movement of vessels due to the size and form of channel, or to the depth of open water, through which they passed, was one as yet but little studied. It was only about seven years since, that the researches of the late Mr. W. Froude threw an entirely new light on the relations existing between speed and the proportions of vessels. A similar study was desirable as to the relations between speed, and area and form of water-way. It was known that a great loss of speed occurred when a steam-vessel passed from open water into a more or less restricted channel. Instances of this had been given in the Proceedings of the Institution. It was also known that a sudden and remarkable increase of speed accompanied the passage of a boat over an increased depth of water, even if it were a mere ballast-hole in the bed of a river or canal. But neither the reason nor the mechanical cause of this phenomenon had been clearly ascertained by hydraulic writers. In the most important inland navigation of the day, that of the Suez Canal, the low speed attained in the transit was one of the causes of the dissatisfaction felt by the commercial world, and the very small capacity of the Canal for transport was painfully evident. The average speed at which vessels passed through the Suez Canal in 1882 was a little under 2 miles per hour; and if the speed were taken, not for the whole transit, but for the portion of time during which the vessels were actually in motion, it was only 5⅓ statute miles per hour, in the year 1882. The greatest speed recorded, as having been attained on the Canal by any vessel since the opening of the route, was 8·016 statute miles per hour in the year 1870.

The cross-section of the Suez Canal was about one-half the area on promise of which the concession of the enterprise was sanctioned by the Porte; being 72 feet wide at a depth of 26 feet, instead of 144 feet wide at that depth. The sides were constructed with flat shallow shoulders, the rush of water over which at once eroded the slopes, and dragged back the vessel under way. The sides were now being gradually protected by artificial stone. If a cross-section of a semi-elliptical form had been adopted, with adequate side walling, in the first instance, for an equal quantity of excavation below the water-line to that of the permanent canal the hydraulic radius would have been double what it now was; the resistance to propulsion would have been proportionately less; vessels of 4 feet greater draught of water could have passed, and traffic in both directions at the same time would have been uninterrupted. By giving a larger cross-section of the same scientific form, any conceivable amount of traffic could be carried on. The cost of the Canal, as constructed, was returned at £143,585 per mile for execution (to the end of 1882), and £56,496 per mile management, financing, and interest of money, making £200,081 per mile in all. The cost, at fair contractor's prices, of the walled semi-elliptical Canal, 163 feet wide at the top, and 30 feet deep, came to £80,682 per mile; and that for the large section, 240 feet wide and 30 feet deep, to £112,280 per mile. The area of the present cross-section of the Canal was only three times as large as the immersed cross-section of such a vessel as the "Warrior." It was impassable for modern vessels like the "City of Rome," or the "Alaska" (to say nothing of the "Great Eastern"), or for any vessel drawing more than 24 feet 9 inches of water. A mathematical calculation of the retardation caused by back-current in the Canal, showed that in the case of such a vessel as the "Warrior," the retardation from this cause, due to the small size of the Suez Canal, was such as to reduce a speed in the open sea of 14·356 knots, to one of 9·812 knots per hour in the Canal. This was independent of the further retardation due to the bad form of cross-section, and also of the direct retardation from shallowness and narrowness, which formed the subject of a separate mathematical investigation.

The various speeds attained on river and canal navigations in different parts of the world had been collected, and were shown in a tabular form. The sizes of locks; the time consumed in passing through locks, hydraulic lifts, and hydraulic inclined-planes; and the dates of the River-and Canal-Acts of Parliament authorizing improvements in the inland navigation of the United Kingdom, were also tabulated. The loss of time at present experienced was reduced to a function of the changes of level overcome by a canal. The heights to be surmounted

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[*] A paper read before the Inst. of Civil Engineers.

by different canal-routes in crossing England were indicated, and the conclusion was arrived at, that by a scientific construction of canals and the application of steam-power, a normal speed of 5 miles per hour, which was equal to the terminus speed of the mineral-trains on certain English railways, might be readily attained on the inland water-ways of the country. For the cost of constructing and of working canals, reference was made to the thirty-seven pages of the Report of the Select Committee on Canals in 1883, contributed by the Author of the Paper, and to his Reports on the Comparative Cost of Transport by Railway and by Canal, which were reprinted by that Committee. The cost, both of construction and of working, on the railways and canals of the Unitod Kingdom, France, Belgium, and the United States; on the railways of New South Wales, India, and Pennsylvania; on the canals and lakes of America by steam-colliers and by sea-going ships, was given in the Appendix to the Report of the Select Committee; and there was a statistical comparison between the capital cost and net earnings of the French and English railways; and of the mineral-carrying and non-mineral carrying trunk-lines among the latter. The cost of one-third of a penny per ton of cargo per mile was shown to pay working expenses, and 5 per cent. interest on capital for canal-transport, being about one-third of the cost of corresponding transport by railway. The actual limit of the work done on a double line of railway in various countries was shown in a table, and might be compared with the almost unlimited capacity for traffic of a first-class canal.

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## ELECTRICAL CONDUCTORS.

At the ordinary meeting of the Inst. Civil Engineers, (Eng.) on the 4th Dec., a Paper was read by Mr. W. H. Preece, F.R.S., M. Inst. E.E.

The Author stated that the first aerial conductors were made of copper, and the gutta-percha-covered wires were of iron; but the positions were soon changed, copper being universally used for insulated conductors, and iron, until lately, for overhead lines. Sir William Thomson detected great variations in the quality of copper, and Matthiessen detected great causes, and established a standard of purity. Such improvements had been made in the quality, that copper wire was now twice as good as it was in 1856. Increased speed of working, improved efficiency of apparatus, and reduced waste of energy had followed the great increase in the purity of the copper. Temperature was a disturbing agent in the conductivity of the wire. Resistance increased more than 20 per cent. between winter and summer temperatures. Copper had recently been much used for aerial lines, it was less attacked by acids, and had great durability. Hard-drawn wire was now produced which had a breaking strain of 28 tons on the square inch, iron wire giving only 22 tons on the same area. Age did not seem to affect its quality, nor did it appear to be influenced by the currents employed for electric lighting was not yet known. The size of conductors was controlled by commercial considerations. Sir William Thomson had laid down the law that should control the size of leads for electric light, while that for cables followed strictly theoretical conditions. The best copper for electrical purposes came from Japan, Chili, Australia, and from Lake Superior; but much pure copper was obtained by electro-deposition, either directly from a solution, or by using impure copper as the anode in a depositing bath. Electro-deposited copper had not the strength of ordinarily refined copper. The electrical resistance of commercial iron was from six to seven times that of copper, but its variation, due to the presence of impurities was even greater. The weight of a cylindrical wire 1 mile in length and giving one ohm resistance at 60° Fahr., was called an ohm-mile. While the first iron wire was specified to give an ohm-mile of 5,500 lbs., it was now obtained as low as 4,520 lbs., and the maximum resistance was specified at 4,800 lbs. The ordinary best puddled iron was at present used only for fencing purposes, but a mild English Bessemer steel was largely used for railway telegraphs and for stays; however, the resistance was very high, owing to the presence of maganese.

The wire used by the Post Office was made from Swedish charcoal-iron, with an ohm-mile resistance, of about 4,520 lbs. Swedish Bessemer, or a specially prepared low-carbon English Bessemer, was adopted by the Indian Government, with an ohm-mile resistance of about 5,000 lbs. Cast-steel wire, with a breaking weight of about 80 tons to the square inch, had been adopted on the Continent for telephone currents, with an ohm-mile resistance of 8,000 lbs., while in England, where speed of working was the prime consideration, and length of span was negligible, electricians were satisfied with a breaking-strain of 22 tons on the square inch; in the Colonies, where long spans were essential, and speed of working was not so important, the specification was 30 tons on the square inch.

The electrical conductivity of iron was increased with the percentage of pure iron, except where the percentage of maganese was high; an increase in the percentage of manganese augmented the electrical resistance considerably more than an increase in the percentage of sulphur or phosphorus. The durability of iron wire was maintained by galvanizing. When the galvanized wire was to be suspended in smoky districts it was additionally protected by a braided covering, well tarred. In some countries galvanizing was not resorted to but dependence was placed on simple oiling with boiled linseed oil. Such a wire was erected in 1856 between London and Crewe, but the result was very unsatisfactory. More recently (1881) the experiment had been repeated with a similar result. In this climate galvanization was imperative.

But it was not alone in smoky districts that iron wire decayed. It suffered much along the seashore. The salt spray decomposed the zinc oxide into soluble compounds, which were washed away and left the iron exposed, and this was speedily reduced to mere thin red line.

Where external decay was not evident, time, seemed to have no apparent effect on iron wire. Thirty-nine years of incessant service in conveying currents for telegraphy had not apparently altered the molecular structure of the iron wires in the open country on the London and South Western Railway.

Swedish charcoal-iron was imported either in bloom or in rods, principally in rods. Each rod was rolled down to about 0·26 inch in diameter, and weighed on the average about 1 cwt. Iron wire could be rolled and drawn into coils 0·171 inch in diameter, weighing 400 lbs. and measuring 1 mile; but 110 lbs. was about the best practical limit for transport and use. The Swedish iron owed its value, not only to its comparative purity, but to the fact that it was smelted and puddled entirely with charcoal. The best qualities were a mixture of various ores, and they were known by various brands, the conditions determining those brands being secrets.

The operation of testing was a most important one, and requisite not only for the user, but also for the manufacturer. Flaws, impurities, faults, notwithstanding the greatest care, would occur, and they would be detected only by the most rigid examination and tests. Tests were mechanical and electrical. The mechanical tests embraced one for breaking strain, another for elongation, and a third for resistance to torsion. For hard steel wire, in place of the torsion test it was usual to specify that the wire should bear wrapping round its own diameter and unwrapping again without breaking. The electrical test was simply that for resistance—1-30th of a mile of the wire to be examined was wound round a dry wooden drum, and its electrical resistance was taken in ohms by means of a Wheatstone's bridge. Galvanization was tested by dipping in sulphate of copper, and by bending or rolling round a bar of varying diameter, according to the size of the wire. Special machines were constructed for the mechanical tests, the condition to be fulfilled being that for the breaking-strain the increasing load or stress should be applied uniformly, without jerks or jumps, and the elongation machine should correctly register the actual stretch without the wire slipping. The resistance to torsion of the wire was determined by an ink mark which formed a spiral on the wire during torsion, the number of spires indicating the number of twists taken before breaking.

The perfection to which the manufacture of iron wire had been brought was very much due to the care bestowed upon the specifications by the authorities of the Post Office. The standard had been gradually raised, until it had attained a very high one.

Many administrations objected to the expense of thorough inspection, with the result that they were the recipients of the rejected material of those who did rigidly inspect. One break in the wire cost far more than the inspection, and one extra ohm per mile affected the earning capacity of the wire in inverse proportion. It was, however, necessary to remark that the mechanical quality of charcoal iron wire sometimes changed with time—its electrical quality remaining unaffected. Tests repeated at some subsequent period might therefore be deceptive unless allowance were made for the effect of time. Bessemer or homogeneous iron wire as a rule improved in its mechanical properties by being kept in stock.

The Post Office authorities had decided to abandon a guage

## INVENTIONS OF WATT.

FIG. 13.

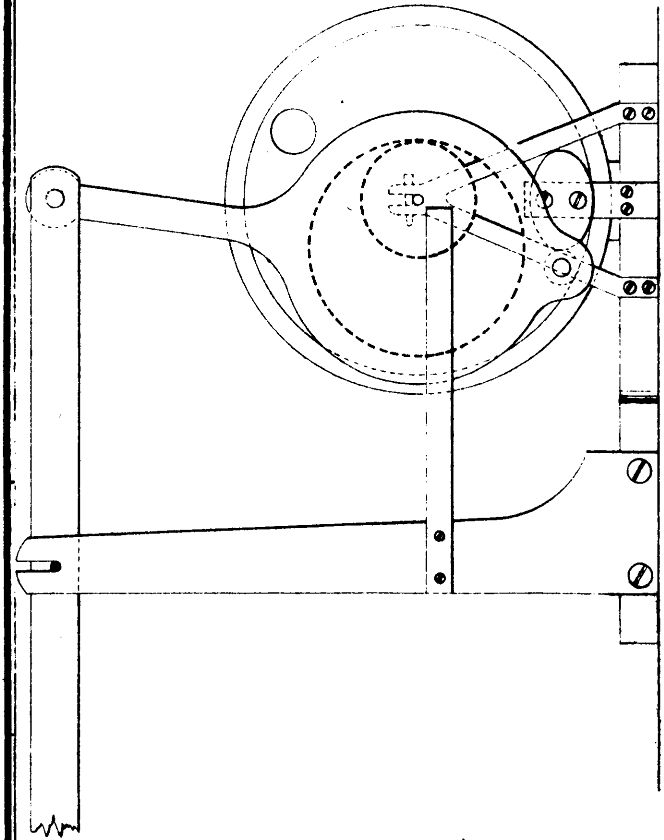
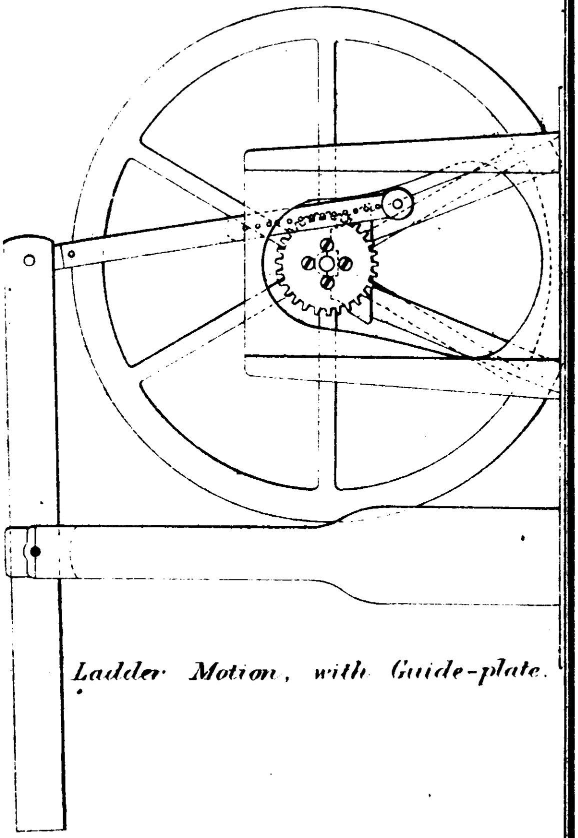


Fig. 14.



*Ladder Motion, with Guide-plate.*

*Winding Gear, with Crown Cam.*

Fig. 17. *Side Elevation.*

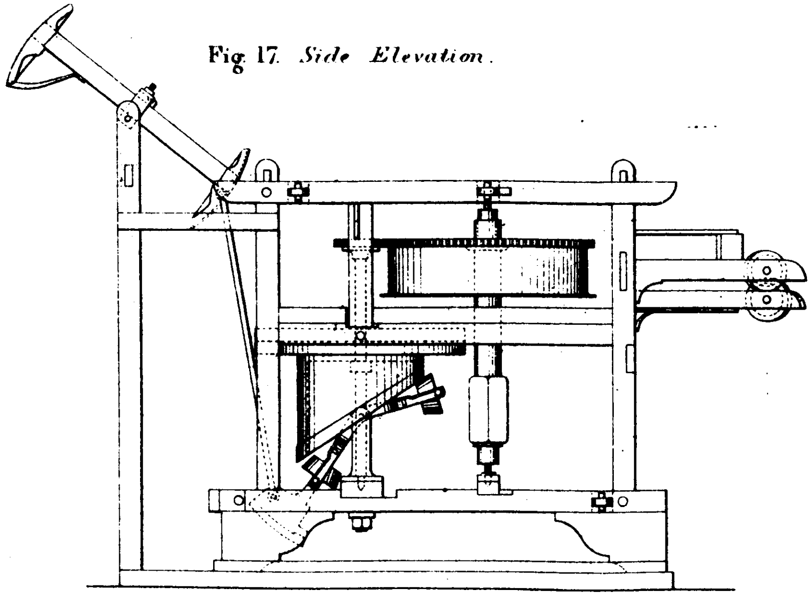
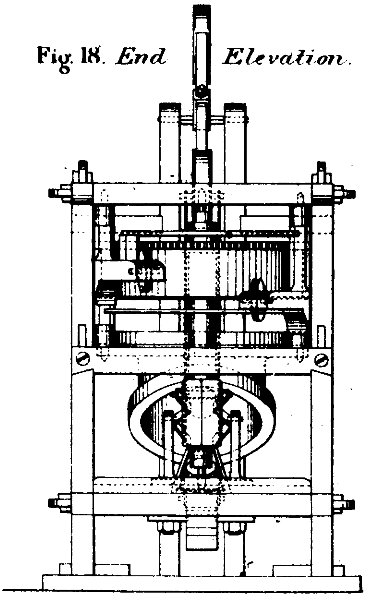


Fig. 18. *End Elevation.*



INVENTIONS OF WATT.

*Ladder Motion, with two Guide pins.*

Fig. 16.

*View showing Guides.*
*⅓rd of Model.*

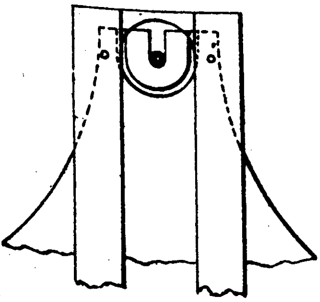
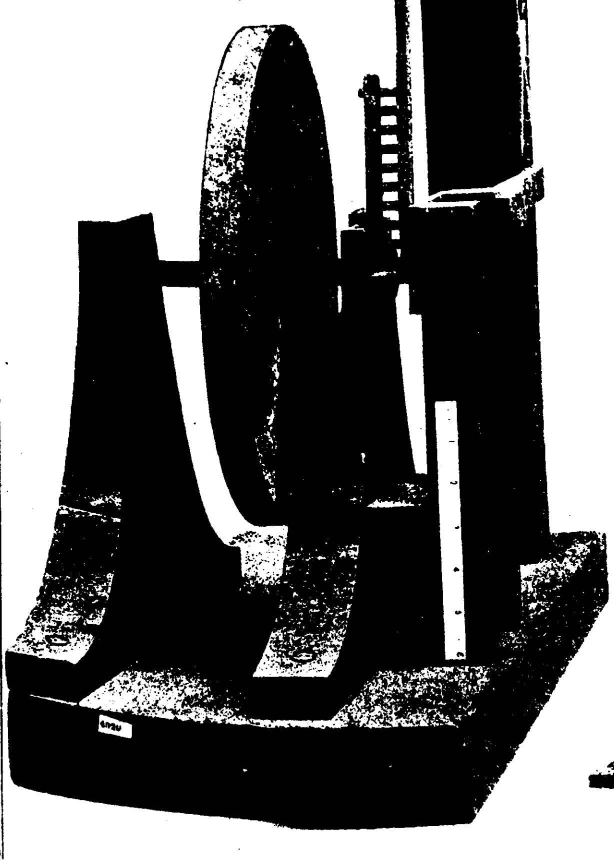
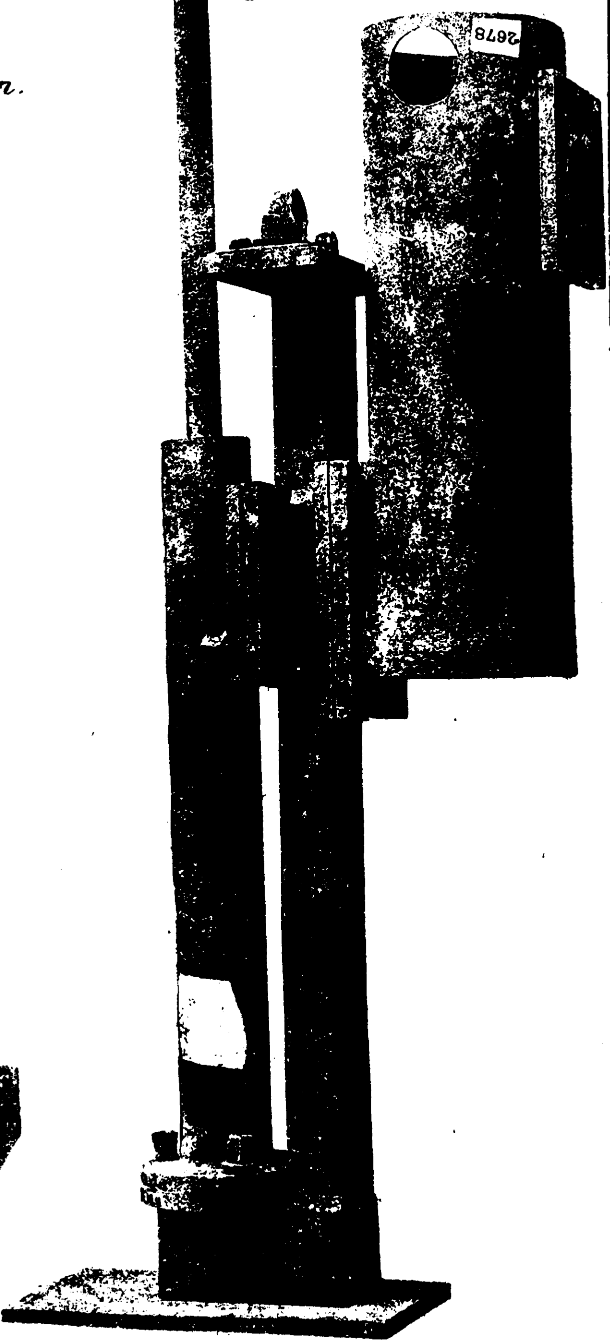


Fig. 15.
*Elevation.*



*Surface Condenser.*
Fig. 2. *Elevation.*
*Half size of Model*



altogether as applied to conductors, and to define size by diameter and weight. In future, all copper wires would be known by their diameters in "mils," or thousandths of an inch, and all iron wires by their weight in lbs. per mile.

Steel wire was used for long spans, or for places where great tensile strength was needed; but it was for the external strengthening of deep sea cables that steel wire was principally adopted. It was first employed in the Atlantic cable of 1865 for this purpose. It had since been generally used for deep-sea cables. The usual diameter was 0·099 m., and it was specified to bear a breaking-strain of 1,400 lbs., which was equivalent to 81 tons on the square inch. Steel wire had been produced giving a much higher tensile-strength. A compound wire of steel and copper was introduced in America about 1874, and it had been extensively tried in both hemispheres, but without success. Recently a compound wire had been erected between New York and Chicago, a distance of 1,000 miles. giving only 1·7 ohm resistance per mile. It had a steel core 0 125 inch in diameter, and was coated with copper electrolytically to a diameter of 0·25 inch. It weighed 700 lbs. per mile. Hard-drawn copper, or silicious-bronze of a much lighter character would be equally efficient.

Phosphor-bronze the hard mechanical qualities and great resisting powers of which were well-known, was introduced for telegraph wire about five years. Several lengths were erected by the Post Office. Two long spans crossed the channel that separated the Mumbles Lighthouse from the headland near Swansea. The object in view was to obtain great tensile-strength with a power to resist oxidation, especially active where the wire was exposed to sea spray. This was done in 1879, and in November, 1883, not the slightest change was noticeable in the wire. But phosphor-bronze, though extensively used, had high electrical resistance; its conductivity was only 20 per cent. that of copper. Moreover, the phosphor-bronze supplied was irregular in dimensions and brittle in character. It would not bear bends or kinks. A new alloy, silicious-bronze, had recently been introduced to remedy these disadvantages. Phosphor-bronze had disappeared for telegraph wire, and had been replaced by silicious-bronze. The electric resistance of silicious-bronze could be made nearly to that of copper, but its mechanical strength diminished as its conductivity increased. Wire, whose resistance equalled 90 per cent. of pure copper, gave a tensile strength of 28 tons on the square inch; but when its conductivity was 34 per cent. of pure copper, its strength was 50 tons on the square inch. Its lightness, combined with its mechanical strength, its high conductivity and indestructibility, rendered it eminently adapted for telegraphs. If overhead wires were erected of such a material, upon sightly supports, and with some method, there would be an end to the meaningless crusade now made in some quarters against aerial lines. These, if constructed judiciously, and under proper control, were far more efficient than underground lines. Corporations and local authorities should control the erection rather than force administrations to needless expense and to reduced efficiency by putting them underground. Not only did light wires hold less snow and less wind, but they produced less electrical disturbance, they could be rendered noiseless, and they allowed existing supports to carry a much greater number of wires.

German-silver was employed generally for rheostats, resistance-coils, and other parts of appaatus in which high resistance was required. It consisted of copper, 4 parts, nickel 2 parts, and zinc 1 part. It possessed great permanence, and the variation in its resistance due to changes of temperature was small. The effect of age on German-silver was to make it brittle. Mr. Willoughby-Smith had found a similar change with age even with wire drawn from an alloy of gold and silver.

The form and character of electrical conductors must vary with the purposes for which they ware intended. For submarine cables and for electric-light mains, where mechanical strength was not required, and where dimensions were of the utmost consequence, the conductors must be constructed of the purest copper producible, for copper was the best practical material at command. For aerial lines they must not only have great tensile-strength, but in these days of high-speed apparatus they must have high conductivity, low electrostatic capacity, expose lo wind and snow the least possible surface, and must be practically indestructible. Iron had hitherto occupied the field, but copper and alloys of copper seemed destined in many instances to supplant that metal, and to fulfill all the conditions required in a more efficient way, and at no greater cost per mile.

## BOILER EXPLOSIONS.

The English Board of Trade report states that their engineer-surveyors have investigated and reported on 45 explosions, whereby 35 persons were killed and 33 others injured. The report attributes the explosions to the following causes: 14 explosions, killing 9 persons, to deteriation, corrosion, &c.; 5, killing 4 persons, to weak or defective design; 4, killing 10 persons, to over-heating through shortness of water; 4, killing 1 person, to the safety valves being insufficient or defective; 3, killing three persons, to undue pressure; 3, killing 1 person, to ignorance or neglect of the attendant; and 12, killing 7 persons, to miscellaneous causes.

The Board of Trade draws the following conclusions on the year's worklng:

1. The terms "inevitable accident" and "accident" are entirely inapplicable to these explosions. The reports show that so far from the explosions being accidental, the only accidental thing about many of them is that the explosions should have been so long deferred.

2. As in three cases only can the explosion be attributed to neglect or ignorance of management on the part of the boiler attendants, there is no reason for yet assuming that any material diminution in the number of explosions may be expected to result from the systematic examination of and granting certificates to the men employed in working the boilers.

The prevailing cause of explosion is the unsafe condition of the boilers through age, corrosion, wasting, &c.; and a noticeable feature in many cases is the absence of any effort on the part of the steam user to ascertain the condition of the boiler, and consequently of any attempt on his part to repair, renew or replace defective plates or fittings.

3. That inspection by insurers of boilers does not insure safety, for we find that one-fifth of the explosions which happened during the year happened from boilers not only inspected by, but insured in boiler insurance companies.

Mr. Fletcher points out that the conclusion that explosions are seldom due to the neglect of the attendants, but in the main to the unsafe condition of the boilers through age, corrision, &c., shows that Mr. Broadhurst's Bill, forbidding any one to tend a boiler who does not hold a Board of Trade certificate, which would be extremely harassing to the steam user, is necessary, and further that it does not strike at the root of the evil. To this he adds, that there was nothing new in the facts brought out by the Board of Trade report. They had been repeated by the Manchester Steam Users' Association over and over again, but it was satisfactory to find so impartial a judge pronouncing a sentence so entirely in accord with the views advocated by the Association for years.

## WATER POWER WITH HIGH PRESSURES.

A paper on the above subject was read by Hamilton Smith, jr., before the American Society of Civil Engineers.

For the purpose of supplying water to the placer mine in California, numerous ditches were constructed on the western slope of the Sierra Nevadas, and in many cases the mines having been exhausted, or abandoned, the water is now used for power for various purposes, and it is probable that as manufacturing assumes larger proportions, much of the motive power required will be obtained from these ditches which in the aggregate would afford several hundred thousand horse power. The problem presented has been the utilization of a small quantity of water—few of the ditches carrying more than 70 or 80 cubic feet per second with high heads ranging from 280 to 600 feet. Turbines have not given satisfactory results, because the great speed due to the high head resulted in excessive wear and tear. Partial turbines or tangential wheels had better success. In some cases large overshot wheels were built, one having a diameter of 65 feet. A wheel of a very simple form called the "hurdy-gurdy" was introduced some twenty years ago, and has almost superseded all other hydraulic motors. It has been improved from time to time and now gives an astonishingly high per centage of useful effects. As at first used the "hurdy-gurdy" was a narrow wooden disk fastened to a cast iron spider frame; the faces of the large wheels being from 4 to 6 inches wide; ths buckets being iron castings, and such wheels were built as large as 21 feet in diameter. These wheels cost little, required but light foundation, and when large really acted as fly-wheels. There was also nearly entire immunity from accidents. With the flat bucket an efficiency of not more than 40 per cent. could be obtained. D'Aubuissou describes somewhat similar horizontal wheels used in the Alps, the water being led to them by steeply inclined troughs. Probably the use of a jet escaping from a pipe is a California invention. The first improvement on these wheels was made by putting flanges on the side of the rim with curved sheet iron buckets between. Useful effects of from 35 to 45 per cent. were obtained from these wheels; the best results being obtained with the use of comparatively large nozzles discharging the water. The next important improvement was what is known as the Knight wheel made of cast iron with curved buckets set close together, the nozzle being a narrow slip curved to fit the outer edge of the wheel in order that the jet might strike the buckets as close as possible. An efficiency of from 54 to 65 per cent. was obtained from these. The wheel known as Collins' wheel gave still more effective results, running up to an efficiency of 70 per cent. The latest so far used is known as the Pelton wheel which has a bucket constructed so as to split the jet as it strikes the wheel, the bucket consisting of two sections of circles intersecting at the centre of the wheel, and with convex surfaces presented to the jet.

Details of various experiments upon those wheels were given, showing an efficiency of from 82½ to 87 per cent., and the writer believes that with heads above 100 feet or even less, a larger amount of work can be gotten out of water by the "hurdy-gurdy" than by any other form of wheel. Possibly water pressure engines may give as good, or even better results, but their cost is very much greater. Where a wheel is so placed that it will at times be submerged the turbine is preferable—in other respects however, the "hurdy-gurdy" possesses the advantage. A description was then given of the method of using water power for drilling the North Bloomfield tunnel in California, which was accomplished by the use of the "hurdy-gurdy" wheel. The water was carried by a pipe main of single rivetted sheet iron, number 14 guage, in lengths of 20 feet, put together stove-pipe fashion with the joints made tight by tarred cloth strips and pine edges, the diameter of the pipe being 15 inches at the penstock, diminishing to 7 inches at the lower end. The aggregate length of the main and branches was about 10,000 feet. The pipe was laid on the surface of the ground, the range of temperature being from 10 degrees to 107° Fahrenheit in the shade. Both the pumping and the working of the diamond drills were done by the use of the "hurdy-gurdy" wheel. The head of water here averaged from 280 to 560 feet.

Descriptions were also given of the water power in use at the Idaho gold mines in California where the supply main is of wrought iron 22 inches in diameter, 8,700 feet long. The pipe is placed in a bath of boiling coal tar and asphalt before laying. This pipe is double rivetted and has rivetted joints, the head being about 525 feet. Seven "hurdy-gurdy" wheels are employed driving air compressors, pumps, hoists and stamp mills.

The power is transmitted by Manilla rope at high speed. The writer also referred to the wrought iron pipe used for the water supply of San Francisco, which had been laid for a number of years and seemed now to be in perfectly good order, and without tubercles.

The paper was discussed by members present.

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## ON THE INVENTIONS OF JAMES WATT, AND HIS MODELS PRESERVED AT HANDSWORTH AND SOUTH KENSINGTON.[*]

BY MR. EDWARD A. COWPER, M. INST. M. E., &C.

It is generally known that James Watt left a number of models of various kinds, some at his house, Heathfield Hall, Handsworth, near Birmingham, and some at his works, Soho, near Birmingham; but no general description has appeared of them, and as no explanation or description is appended to them, it is necessary to "*read*" their meaning after careful examination and comparison. This has been attempted by the author, who also suggested that, as many of the Watt models at South Kensington had got the dry rot, and were very badly worm-eaten, drawings and photographs should be taken of them by the Institution, so that a perfect record of them might be obtained before they were entirely destroyed.

The Department of Science and Art at South Kensington very kindly entertained the idea of photographing such models as it was useful to photograph, and have very liberally presented copies to our Institution.

Colonel Stuart Wortley (the Curator of the Patent Office Museum) also kindly allowed particulars to be taken of the parts of Watt's engine and other machines which are in that museum.

Mr. George Tangye, one of our members, has very kindly responded to the author's request to have photographs of the two important machines in the "Watt Room" in Heathfield Hall (now inhabited by Mr. Tangye); and he has had photographs taken of a number of other interesting articles and tools, including Watt's own lathe, work-bench, tools, and old apron, as selected by the author, who had the pleasure of spending parts of two days in inspecting everything in the room carefully, and of sleeping a night in the old house. Mr. Tangye has very liberally presented these photographs to the Institution; and our Council, in the interest of the members, has had drawings and diagrams made under the author's direction to illustrate the several models and inventions.

It has been found necessary to make a selection from the mass of information so obtained, and it is purposed to engrave and print the greater portion for the use of the members.

In some cases the models are simply duplicates of others, slightly varied in form, but drawings of the most important of them are included in the Figures shown, as per the following list:—

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At the risk of commencing a description of the inventions of James Watt with a thrice-told tale, the author feels bound to take into account, to some extent at all events, the sequence of the inventions of the great man whose works we are endeavouring to decipher. It is sometimes a matter of intense interest to any one who has attempted to improve a machine, to realize the process of thought, through which a successful man of science and practice has arrived at his conclusions, and his triumphs over the elements; as in this case, where literally earth (metals), air, fire, and water have been pressed into the service of man, as much as any "Jack Tar" was ever pressed into His Majesty's service to fulfil a given duty.

The author is obliged to refer to such history as is available, and finds that Watt's patents are probably the most reliable for the dates of his inventions. Many of the models agree with the patent drawings, but there are some models not shown in the patents, and some drawings of which there are no corresponding models.

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[*] A paper read before the Institution of Mechanical Engineers.

## INVENTIONS OF WATT.

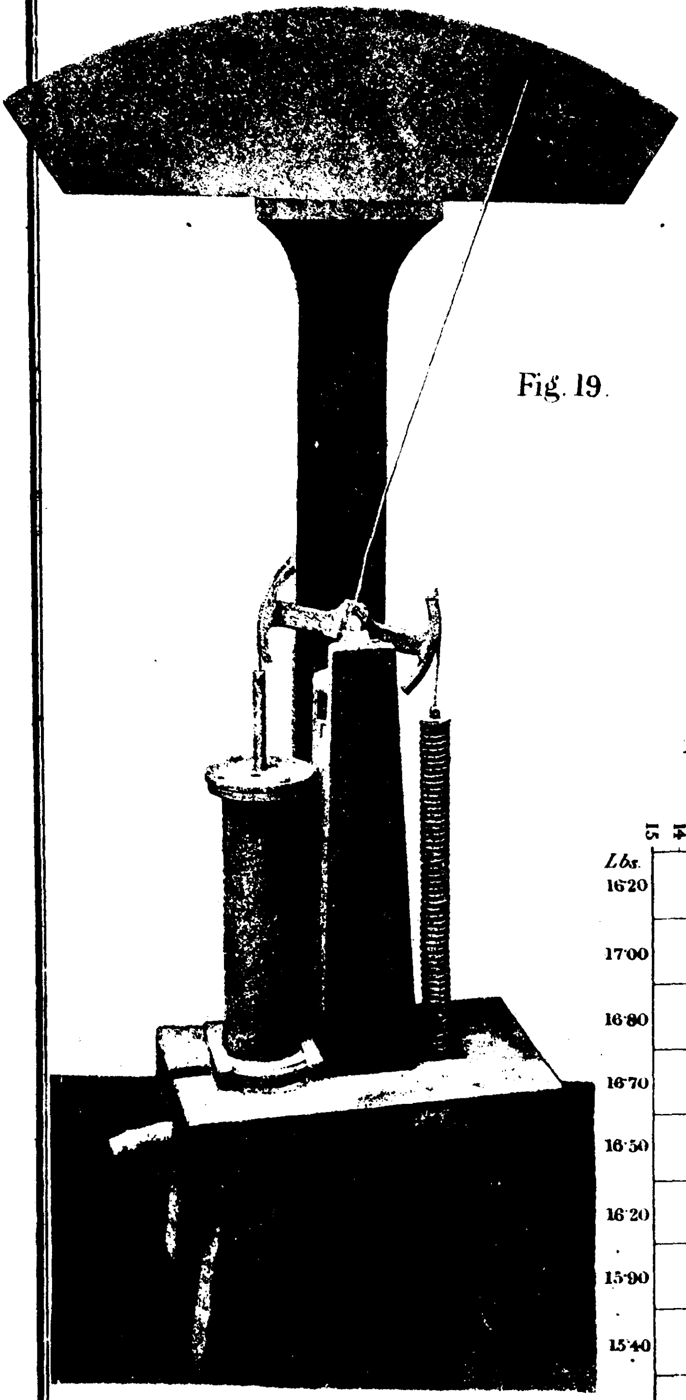
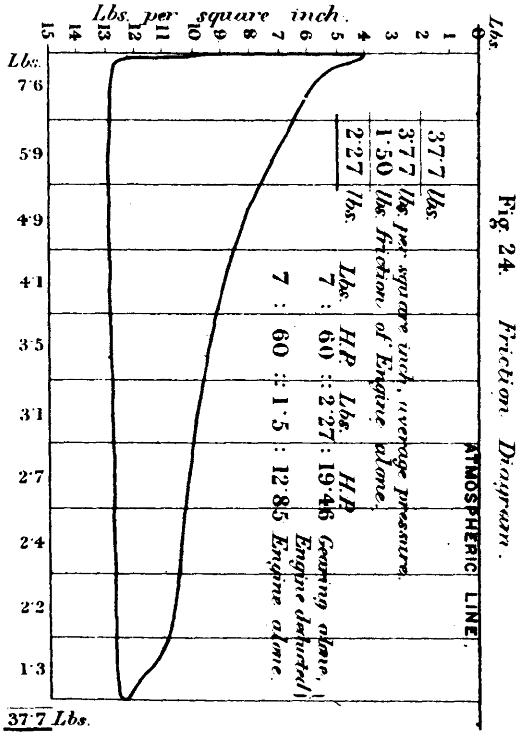
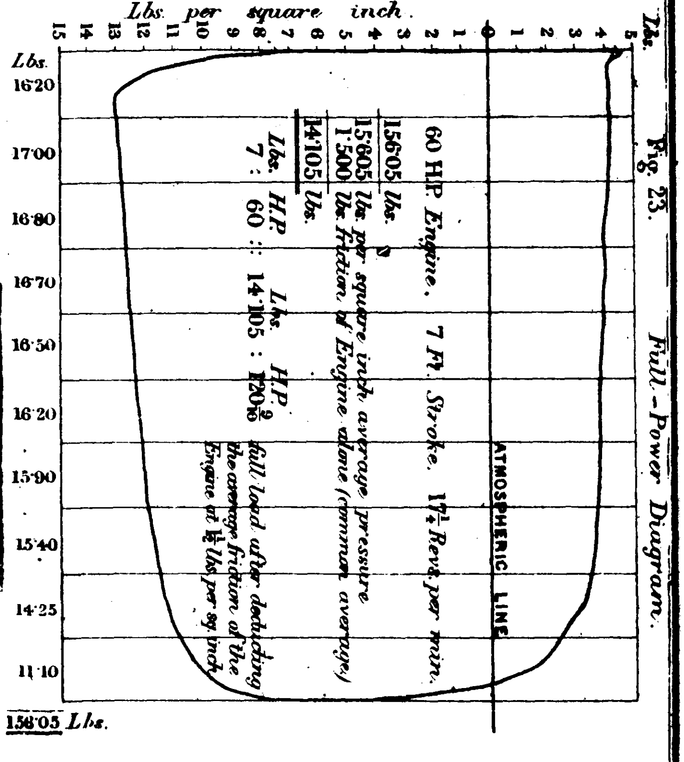


Fig. 19.



*Diagrams taken with Watt Indicator, by Edward Cowper, Esq. August, 1840.*



## INVENTIONS OF WATT.

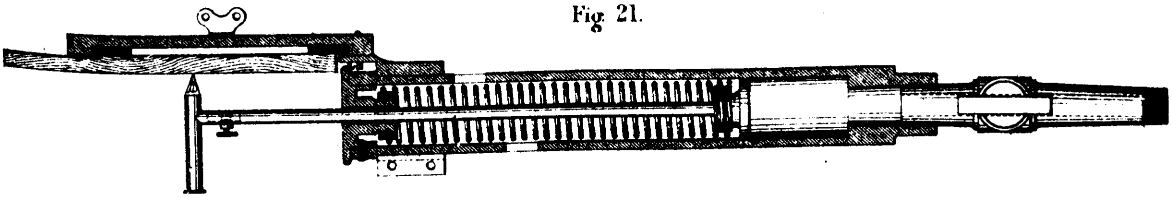


Fig. 21.

Section.

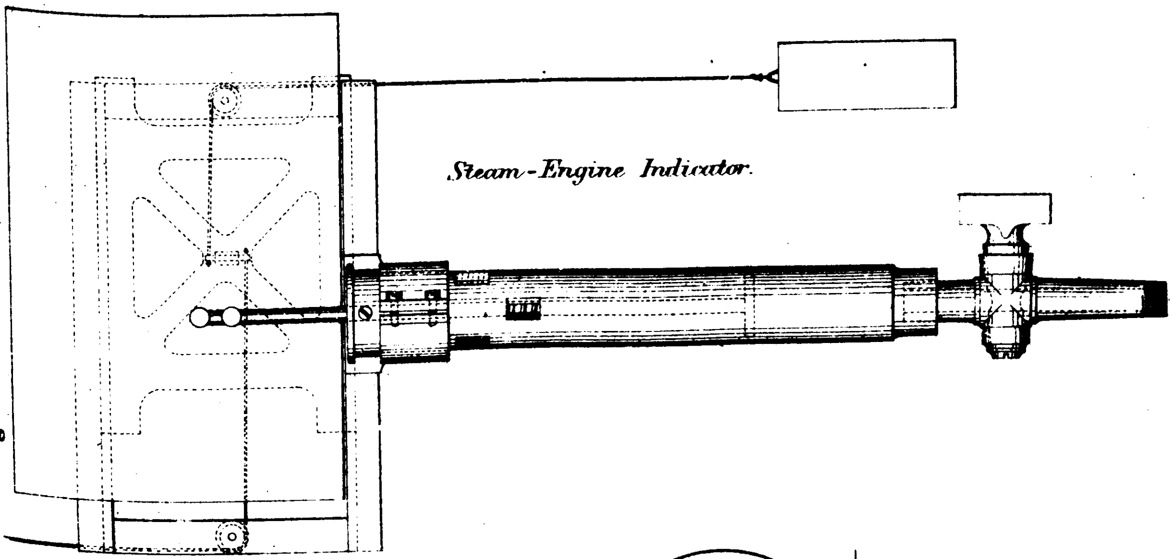


Fig. 20. Elevation.

Steam-Engine Indicator.

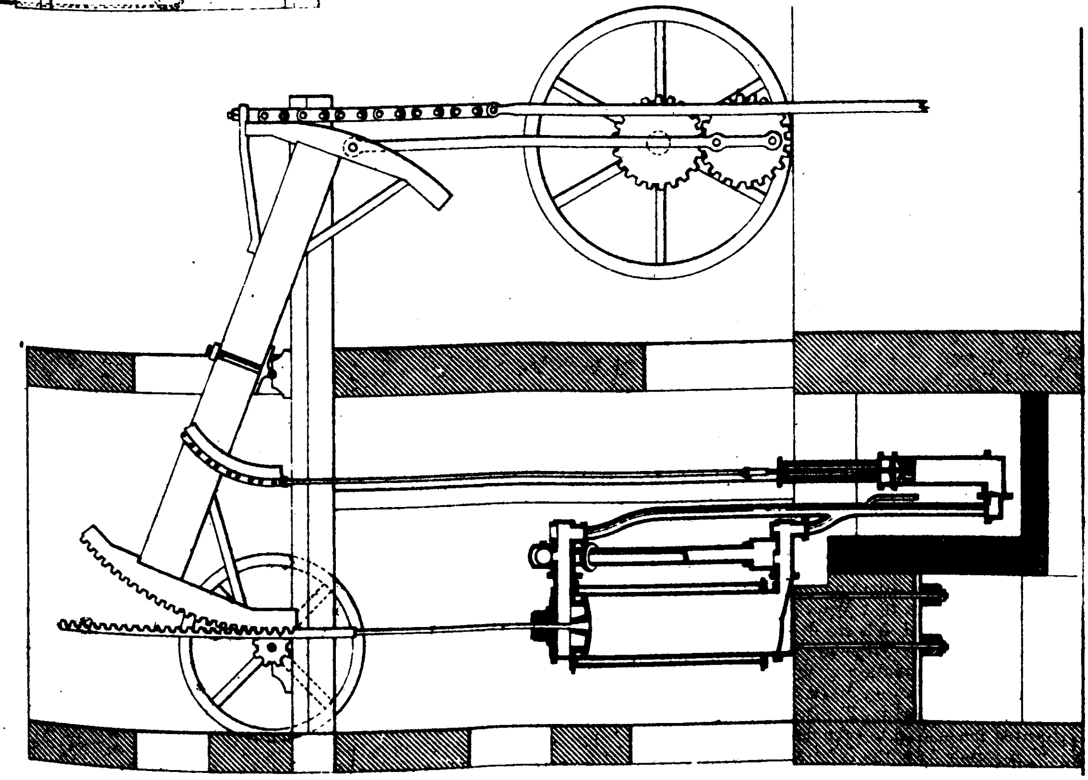


Fig. 22. Balance-wheel Rotative Engine.

Now, Watt's first patent of 1769 clearly lays it down (in his own words) that the working cylinder (or "vessel" as he chose to call it) was to "be kept as hot as the steam that enters it, first, by enclosing it in a case of wood or any other materials that transmit heat slowly; secondly, by surrounding it with steam or other heated bodies; and thirdly, by suffering neither water nor any other substance colder than the steam to enter or touch it during the time. The author may perhaps be pardoned for observing here, hat it is extraordinary that there should ever have been any doubt in the minds of engineers, since the time of Watt, as to the advantages of steam-jacketing any cylinder that would be otherwise exposed to cooling influences, foa the effect on the indicator figure obtained is very marked, as he has before had occasion to observe; indeed engines of the most economical construction cannot be made without steam-jackets. Watt's first patent has no drawings, but in his second patent the steam-jacket is distinctly shown.

Now we must just bear in mind that up to this time the pumping engines that were then at work were *Newcomen's*, and that the practice was to let the steam into the cylinder under the piston, to *allow* it to go up, by means of the weight of the pump-rod, &c., at the other of the beam, and then to *condense the steam in the cylinder*, by allowing *a jet of cold water to play into the cylinder*, thus in time forming a partial vacuum, and causing the piston to come down by the pressure of the atmosphere on the top of the piston; whilst great leakage of *air* past the piston was prevented by the fact that there were several inches of water on it. The cylinder of course was very considerably cooled by the operation. There was no air-pump to such engines, but when the piston had made its down stroke or "gone indoors," there was the condensing water and the condensing steam, with what air there might be in the cylinder; then, instead of all this being taken out by an air-pump, it was *expelled*, through a small valve called a "snifting valve" at the side of the cylinder, close to the bottom, by the fresh steam when it was admitted te the bottom of the cylinder, to let the piston go up again. Such ennines could of course only work very slowly, as the cylinder had to be heated up a good deal before the steam would fill it.

The author is orry to say that the old pumping engine first made by James Watt and used at Soho, for pumping water up into Soho pool, to be used on a water wheel there, has not been preserved; it was ruthlessly thrown away on the scrap heap when dismantled to make room for a larger engine, viz.: "Old Bess" as it was called, which the author well remembers seeing as a lad.

His late friend, Mr. Bennett Woodcroft, who had charge of the Patent Office Museum, did all he could to obtain some portion of the first engine, but failed. He was a man who would do much more for science, had he not been greatly hampered in his work; but it is to be hoped that the Patent Office Museum will in future be the receptacle of many good models of successful inventions, and be in fact a Museum of Reference.

But to return to she history of the inventions we are following. Watt says in a very few but distinct words, that the condenser "ought to be *kept cold*," "by application of water or other cold bodies." He does not say by injection of cold water, neither does he say in words by surface condensation; but it is clear that if the condenser is "*kept cold*' by the application of cold water outside of it, it is in fact a surface condenser, and some books state that he held on to the idea of surface condensation, and persevered in it to a considerable extent, until his condensers got rather unmanageable in size. It will presently be seen how he met this difficulty by an excellent surface condenser, but it is certain that he gradually used more and more injection, as a mattor of practice.

It is a curions fact that Watt's most important patent, viz: his first one of 1769, has no drawings at all attached to the specification, but his claims are very clearly stated.

With regard to maintaining a vacuum in the condenser, as every cubic foot of steam takes over a cubic inch or more of air, and as Watt had no "snifting valve" like Newcomen's, he rsquired iomething to take out such air as entered his condenser, together with the injection water, if any, and the condensed steam; and he says very shortly, "Thirdly, whatever "air or other elastic vapour is not condensed by the cold of "the condenser, and may impede the working ef the engine, "is to be drawn out of the steam vessels or condensers by "means of pumps wrought by the engines themselves or "otherwise." Thus we have the beautiful invention of the air-pump, to maintain the vacuum in an engine by removing the air.

Fig. 2, Page 43, is a drawing of perhaps one of the most interesting models of the whole collection, next to those showing the condensation of steam in a separate vessel or condenser, by means of an injection of cold water; as this model shows the condensation of steam in a separate vessel, or Surface Condenser, composed of a large number of small vertical tubes with the cold water in them, and the steam outside them, which is the best arrangement. It is provided with a an air-pump. A section and plan are shown in Figs. 3 and 4, Page 41.

There are 140 small vertical tubes, and if they are taken to represent tubes about three-quarters of an inch diameter, they would be about 5 feet long. They are, in the model, soldered into the tube plates at top and bottom.

One very remarkable thing about this model, which was suspected by the author before the model was taken to pieces, is that the vertical air-pump has a valve in it, and is worked very much in the same excellent manner that our best horizontal air-pumps in marine engines now work, viz: to move (or "see saw") *the water* from the inlet valve *up to the delivery valve*, thus ensuring the delivery first of all of the air on the top of the water, and then of the water that has to follow the air; so that *no air* may be left in the air-pump. It is to be wished that all modern air-pumps were made as perfect in their action as this one.

This is a remarkable case of a first inventor making an apparatus almost perfect at once, though Watt did not make many of these surface condensers, probably from the expense attending them.

Then follow, in the 1769 patent, clauses for a high pressure engine to work without a vacuum, when water is scare, the steam being discharged into the open air after it has done "its office."

It is certainly to be regretted that Watt never followed up the use of *high pressure steam*, as no doubt he would have accomplished much more, and have made more powerful engines, in smaller compass; but he left a great deal of this to Trevithick to accomplish, though he objected strongly to Trevithick, or Bull, using a *separate vessel* for condensation.

In this first patent Watt had other claims for a kind of rotary steam wheel; alfo for a caloric engine, and for using "oils, wax, resinous bodies, fat of animals, quicksilver, and "other metals, in their fluid state, to make pissons air and steam tight;" but we have no models of such schemes.

Many of his letters prove that he used oil on the piston and pumped it up to use over again, and then he complained that a quantity went awap with the condensed steam and was lost. Some piston packings were of pasteboard, soaked in oil and boked, and some of cork; but they did not follow the bad cylinders well, and it would seem to us *now* that it was a pity he did not insist upon having a good cylinder, truly bored out, much earlier.

It is worthy of note that in a letter to a friend he said that he thought he had got his cylinder bored so perfectly that you could not get half-a-crown between the piston and the cylinder anywhere.

Now we must not be altogether surprised at this remark, when we consider with what materials he was in the habit of making his models. He used tin cylinders and soldered joints in many cases, and in one letter he says the cylinder was not very true as it had not been bored, but hammered; and in another letter he says that he shall in future make his cylinders of copper, as though that was a great improvement upon the material he had been using.

He speaks of his "White-Iron-man," who was so useful, being dead, meaning his "Tin-man"; but it does seem sad that a block tin cylinder that he used, 18 in. diam. and ¼ inch thick, should be ⅜ in. out of truth, and he speaks of trying to improve it by hammerfng it with a mallet outside, on r piece of wood fitted to the inside. It is curious to think of an optician and mathematician spending time over such imperfect work. His partner Boulton one day writes to Watt, who was away, that he had put in hand a block or boring head, to bore a cast-iron cylinder then in hand, probably one 7½ in. diam.

However' it does not do always to think lightly of others' work, unless we are sure cf our ground ourselves. It is possible that there may be a few present, who are not aware that if an ordinary cast-iron cylinder of good size is bored horizontally, it is not fit to be used vertically, or *vice versa*; as it springs very perceptibly *out of round with its own weight*, independently of the strain due to any chains that may be used to fix it whilst boring. Thus a cylinder, 1⅛ in. thick, and 4 ft. in diam., will spring out of round with its own weight 1-32 in., as proved by repeated experiments. This was tried by the author in 1845, and again lately ; and it is evident that different parts will spring differently, according to their stiffness and size of flanges, &c.

Fig. 1, Page 40, taken from "Farey's Treatise on the Steam Engine," is in fact one of Watt's earliest pumping engines, single-acting, without a fly-wheel or any rotary motion, but with a steam-jacket to keep the cylinder warm, and a separate condenser to condense the steam without cooling the cylinder; with an injection pipe and an air-pump, but no parallel motion, there being segments on the ends of the beam, commonly called "Horse-heads" in those days.

Now, an open-topped cylinder is shown in his 1781 patent, and a stuffing box to the cylinder cover in his 1782 patent ; but it appears from Watt's notes to Robinson's articles on Steam and Steam engines, written for the Encyclopædia Britannica, that Watt, even by 1774, had closed the cylinder at top, and put a stuffing box for the piston-rod to pass through. The useful effect of so doing in a single-acting pumping engine is to exclude the atmospheric air from the cylinder, and let the *steam act* on the top of the piston when there is a vacuum below the piston, and it is making its stroke "in-doors ;" then, when the piston is about to rise or go "out-doors," the steam on the top of the piston is allowed to pass to the bottom through a valvo, called the "Equilibrium Valve," and, when the piston has risen, this steam is let out into the condenser, and fresh steam is allowed to flow on to the top of the piston. In this way the cylinder never has any air admitted inside it.

This was a grand improvement upon Newcomen's engine ; for less steam was required to do a given duty in pumping, and the engine could be worked much quicker, as no time was lost in heating up the cylinder and cooling it down again to obtain a vacuum.

The time required for a stroke was simply the time the steam took to flow through the passages, and the water to move through the pump.

A noticeable feature in most of the models is the absence of anything like a large condenser or separate "vessel" for condensation, as in most cases the injection pipe is shown throwing its water up the education pipe, so as to meet the steam coming from the cylinder to the air-pump, thus making the pipe itself into the condenser.

In Watt's patent of 1781, a number of very ingenious contrivances for converting the reciprocating motion of the piston into a continuous rotatory motion are shown and described, though it must be at once freely admitted that none of them are so good as a common crank.

It appears that a man of the name of J. Pickard in 1780 took out a patent simply for the one object of converting reciprocating to rotary motion in a steam engine by means of a crank, and it has been said (but the author cannot say with what truth), that he was a workman of Watt's, who learnt that Watt had invented such a mode, and then went himself and patented it ; it has further been said that Watt would not attempt to make any terms with the man, and would not run the risk of a lawsuit. However, in the speeification to the patent of 1781, Watt shows both a single crank, and two cranks at right angles, having connecting-rods to them, to enable the two engines to work on one crank-shaft. These cranks are pins in discs, and are not called cranks in the specification, but "*points of attachment of the connecting rods*" ; this would seem to be a distinction without a difference. See Figs. 5 and 5*a*, Page 41.

The model now exhibited is a model of an engine made according to Watt's patent of 1781 ; it is single-acting, and has an open-topped cylinder with air-pump, condenser, and heavy balance weight on the connecting rod, to give the impulse in one direction, while the piston at the other end of the beam gives the impulse in the other direction by means of the vacuum then produced in the cylinder ; thus obtaining rotative motion. This model has been kindly sent here by Mr. E. B. Martin for exhibition, and is shown in Figs. 9 and 10, Page 41.

The next best plan is the well known "Sun and Planet" motion, Fig. 7, Page 41, in which a spur wheel, *rigidly fixed* on the end of the connecting-rod, gears into a spur wheel of equal diameter on the engine shaft, and is kept in gear with it by a pin or roller behind the centre of the pinion, running in a circular chase or groove provided for it. Another plan of keeping the wheels in gear (Figs. 11 and 12, Page 40), which has been adopted, is that of a *link*, having one end turning freely on the engine-shaft, whilst the other end confines the centre pin of the spur wheel fixed on the connecting-rod. The author has had to make some alterations in one of these engines within a very few years ; it is only a "stand-by" engine, but is occasionally worked, and goes very well when the motice pinion has been recently re-geared. Of course the engine-shaft goes double the speed of an engine with a crank. Figs. 11 and 12 represent an actual engine of this type, now preserved at the Patent Office Museum.

Another form of "Sun and Planet" motion (Fig. 13, Page 44) is one in which the "Planet" sun-wheel is an internally-geared wheel, and is kept in gear by means of a roller at the lower end of the connecting-rod, running around an oval-shaped ram or guide-block.

Fig. 8, Page 41, shows a "Spur Planet" on the connecting-rod, and internal gear on the shaft.

Then there are two forms of eccentrics on shafts, one a solid one, with an eccentric-rod embracing it, but provided with rollers to bear against the eccentric to reduce friction (Fig. 6, Page 41), and the other a hollow eccentric, with the end of the eccentric-rod fitting inside it, but provided with a roller to reduce friction.

Another scheme in this specification for producing rotatory motion is a very peculiar one, and consists of a very large and heavy "Crown Cam" (Figs. 17 and 18, Page 44) on a vertical axis, and having two rollers on a rocking frame to act against its curved face ; this rocking frame being moved up and down by the beam of an engine.

Another model, of which Figs. 15 and 16, Page 45, are drawings, consists of a long rack on the end of the connecting-rod, as much like a ladder as possible, taking into the teeth of a spur-wheel on the engine shaft ; the rod being guided by two fixed pins or rollers, which keep it close in gear with the spur-wheal throughout the greater part of its stroke, up or down, and by two projecting pins on the rod to keep it in gear when turning the centres, one pin working in a semicircular guide when turning the top centre, and the other pin working in another semicircular guide when turning the bottom centre.

Fig. 14, Page 44, shows another arrangement of rack and pinion, or "Ladder Motion," as it may be called, in which the bottom end of the ladder carries a roller, and this roller works in a large opening of peculiar form in a guide-plate round the shaft and pinion which the "Ladder" drives, as it is moved up and down by the engine. The guide-plates thus keeps the "Ladder" always in gear with the pinion on the shaft.

One strong peculiarity throughout this 1781 specification is that all the engines are *single-acting*, so that in every case a *heavy-balance weight is required*, to make the piston of the engine make the "out-door" or up-stroke. The rotative engine thus arranged is twelve years after the pumping engine.

Referring now to the 1782 *patent* (thirteen years after the first patent), a further *great improvement* is found in an engine that Watt describes as "The new improved engine, the piston "of which is pressed forcibly *both upwards* and *downwards* by "the power of steam," that is to say, the engine is no longer single-acting but *double-acting*, as in Figs. 30 and 31, March Number. Here we find the chain, which hitherto commonly connected the piston-rod to the beam in a pumping engine, entirely put aside, and a *parallel motion* or other connection introduced to enable the piston to *push* as well as to *pull*, thus superseding the heavy balance-weight. The parallel motion, in several forms, including those now used, is distinctly the invention of James Watt.

It would appear from the specification of this 1782 patent that the closing of the top of the cylinder, and the addition of the stuffing-box, was new at this date ; but Watt's notes on Robinson's work, mentioned above, show that he was using it about 1774, and if so, some of the early single-acting, pumping engines, and the rotative engines with heavy balance-weights, probably had covers and stuffing-boxes.

The author well remembers several old rotative engines in the Black Country (one near West Bromwich, and one near Netherton), with a heavy weight in the form of a large slab of cast iron on the connecting-rod, and an open-topped cylinder, in which one could *see* the piston rising and falling ; such engines were worked with steam of several pounds pressure above the atmosphere.

*(To be continued.)*

## MOVEMENTS OF THE EARTH.—(*Nature*.)

(*Continued from page* 30.)

To turn now to the gyroscope. We shall expect, if we succeed in imparting to it a rotation which is independent of and unaffected by the earth's rotation, that the angular change shown by it will be the same as that indicated by the pendulum, or, in other words, that the number of degrees passed over will be the same in both cases.

In the gyroscope, that portion which corresponds to the swinging part of the pendulum is the heavy disk seen in Fig. 28, to which a very rapid rotation can be imparted. This disk is mounted upon the horizontal circle shown in the figure, which circle in its turn is mounted in a vertical one suspended by a bundle of raw silk fibres which depend from the little screw shown at the top, by means of which the whole system can be raised, so preventing the vertical circle from resting its whole weight upon the pivot below, the use of which is not so much to support the apparatus as to guide it in its movements.

Now in order that the rotation of the disk shall be uninfluenced by the motion of the earth a great number of precautions have to be taken. The first of these is to insure that the whole of the apparatus shall be perfectly free to rotate, and that, however much the silk fibres supporting the vertical circle may be screwed up in order that it may not rest its weight upon the pivot, its motion shall not be interfered with—that there shall be no twist in the thread. This is the first precaution; and, when this has been done, a condition of things is obtained in which the apparatus is perfectly free to move round a vertical axis represented by the silk fibres prolonged. Then, having fulfilled this condition, the next matter of importance is to see that the disk is perfectly free to move on the horizontal axis. For this purpose the wheel which holds the two extremities of the axis of the rotating disk is armed with counterpoise weights (see Fig. 28), two in a horizontal plane, A A, and two in a vertical plane, of which one is seen at B.

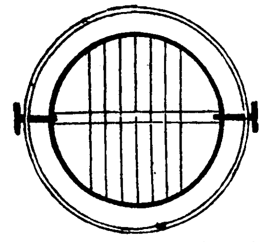


FIG. 31.—Wires in transit eyepiece.

Then the knife edges, C C, which are exactly in the plane of the centre of motion of the whole system, are made to rest on two steel plates mounted on a separate stand, in order to ascertain if the moving parts are perfectly balanced, the perfection of balance being determined by the slowness with which it oscillates up and down. But this is not all; it must not only be so adjusted by these weights, A A, that the ring shall remain horizontal, but it must be so perfectly balanced by the two weights, one of which is seen at B in Fig. 28, that if a considerable inclination be made from the horizontal it will be taken up equally on both sides. Finally, the instrument must be so adjusted that when the two delicate knife edges are placed on the two steel plates in the outer ring (see Fig. 28) the ring carrying the disk shall be perfectly free to move and have its centre of motion exactly identical with the centre of motion of the outer ring and of the disk itself. Then, when all these precautions have been taken, and the disk is set rotating with considerable velocity by means of a multiplying wheelwork train, we have, as far as the mechanics of the thing are concerned, an experiment just like the other, with this important difference, however, that, whereas the pendulum experiment always succeeds, much trouble is often experienced in experimenting with the gyroscope. But, when the multiplicity of the conditions necessary to the success of the experiment is considered, this is not surprising. If, however, all the conditions have been adhered to, the pointer with which the instrument is fitted (see Fig. 29) ought to move over the scale at exactly the same rate that the pendulum moves over the scale beneath it. But even supposing that the pointer of the gyroscope does move over the paper and in the right direction when the apparatus rotates one way, this is not enough. The demonstration of the validity of the result given by it is that an equivalent deviation is obtained when the apparatus is turned about in every possible direction. The first test of course is to rotate in the opposite way, then, if all the adjustments have been properly made, the deviation obtained will be the same in amount and direction as before, and it may be taken that the result obtained is then really due to the earth's rotation.

With this reference to the most important points connected with the gyroscope, we may bring our inquiries under this head to a close. So many men have worked with the instrument in so many lands, and under such rigid conditions, that there can be no doubt that the rotation of the earth is demonstrable by it, although certainly its verdict is not anything like so sharp, or so clear, or so easily obtained, as that given by the pendulum.

Our appeal to physics has at once put out of court the old view of the arrangement of the universe, which placed an immovable earth at its centre. How Copernicus was the first to point out that this old view was incorrect, and that it was the earth which moved, and how Galileo was persecuted because he, in times much less fortunate than our own, had the courage to say so,—these are familiar points in the history of the discovery of the earth's rotation.

Having then demonstrated the existence of this particular movement of the earth, we must now proceed to a consideration of the rate, direction, and results of the movement,—connect in fact the pendulum of Foucault with that of Huyghens, and regard the physical pendulum as giving an important use to the experiments of Galileo and of Huyghens in which they caused it to act as a controller of time.

Turn back to our two tables. They are not without interest at the present moment. In the first table, "Hourly Motion of Pendulum Plane," the observed motion of the pendulum plane per hour is connected with the latitude of the place at which it swings, varying as that varies; and therefore the observed motion in any latitude ought to give the same value for the earth's rotation, the closeness of which to the real value will at the same time be a measure of the accuracy of our pendulum observations.

Let us endeavour then to find out in what time the earth must go round in order that the pendulum plane may vary (say) $1\frac{8}{10}°$ per hour in Ceylon, $11\frac{8}{10}°$ in Dublin, and so forth.

Taking our clock as being divided into twelve hours, each hour into sixty minutes, and each of these again into sixty seconds, it is found (see Table 2) that the value for Ceylon is 23h. 14m. 20s., and for Dublin 24h. 14m. 7s., the mean value of the observations at the various places mentioned in the table being 23h. 53m., so that according to that table the earth rotates on its axis in a few minutes less than twenty four hours.

Now although such an approximation to the real value may suffice for the great mass of mankind, it is not an astronomical way of dealing with the question. We have seen the circumference of a circle divided first into degrees, then into $\frac{1}{3}$ degrees, next into seconds, and finally into tenths of seconds; by the application of electrical principles, time has been even more finely divided, and the question naturally arises, Are there any means of determining the exact period of the earth's rotation?

There are means of doing this. In the last lecture occasion was taken to point out that the stars are infinitely removed from the earth; the stars being so infinitely distant, a slight change in their position will not be perceptible to an observer on the earth, and the place of a star to-day and its place to-morrow are the same so far as relates to any parallactic change of position.

This being premised, it will be clear that, in order to get out the exact period of the earth's rotation, one only has to make an observation of any star on one particular day (such observation being of course made with a clock), and repeat the observation when the star is in the same position on the succeeding day. The time which elapses between the observations must be the time taken by the earth to make a complete rotation. But it will be asked, How are these observations made, and how is it known when the star *is* in the same position when the second observation is made?

For this purpose a transit instrument is used (see Fig. 30). This differs from an ordinary telescope, being so mounted as to move only up and down, and is armed not with simple cross wires, but with an odd number of parallel and equidistant vertical wires crossed by a single horizontal wire. It is also usually provided with a circle to give declination. If from any part of the earth an observation be made on any particular star on one day, and then another observation made on the same star when it is in the same position the next day, as has been said, the interval between the two observations must be the time taken by the earth to move round once.

By having such an arrangement as exists in the transit instrument, by which it can swing in the plane which coincides with the axis on which the earth turns, any star may be chosen for the observation. Suppose, for instance, the instrument be pointed to the north pole star, then, in consequence of the tremendous distance of the stars, the axis of the telescope is practically coincident with the axis of the earth. But suppose another star to be observed, it will be quite clear that we may make the observation on it, or any other star we choose. When the instrument is upright it points to the zenith. A star in the zenith may therefore be selected for the observation.

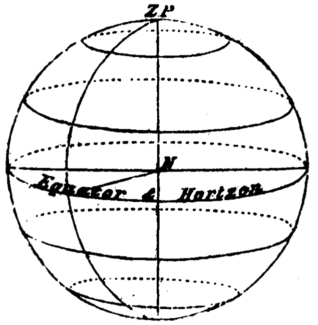


FIG. 32.—Showing that the true horizon of a pole is the equator.

It is observed when crossing the central wire of the instrument one day, and noted again when it crosses that wire on the succeeding day. But the observer does not limit his observation to the one central wire, in order to ascertain when the star is in the centre of the field. If he did so, he might miss his observation. That is why the simple cross wires have been replaced by a system of wires (see Fig. 31). As the star crosses the field of view, the observer, listening to the beats of the clock alongside, notes the time when it crosses each of the wires, and takes the mean of these observations, thus attaining to a much greater accuracy than if he had merely observed the transit over the central wire. With an ordinary clock it is found that a period, less by a few moments than twenty-four hours, elapses between two successive transits.

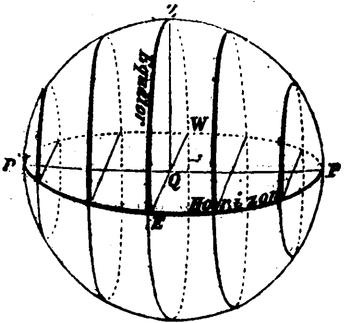


FIG. 33.—Showing that the poles lie in the horison at the equator.

In order to get an absolutely perfect measure of time, the clock may be so rated that it should not be any indeterminate number of hours, minutes, and seconds, but twenty-four hours exactly between the two transits of that star. With a clock thus arranged, the time at which a star crossed the central wire of the transit instrument would really give a most perfect method of determining that star's place in the heavens, because, if the earth's rotation is an equable one and takes place in a period which we choose to call twenty-four hours, then two stars 180° apart will be observed twelve hours after one another, four stars 90° apart will be observed six hours apart, and so on; and clocks like this, regulated to this star time, exist in our observatories, being called sidereal clocks, because the time they give, which is not quite familiar to everybody, is called sidereal time.

Now let us consider our position on the earth with regard to the stars. This is a very interesting part of our subject, not only in its scientific aspect, but from the point of view of its usefulness, whether we wish to study the stars or define places on the earth's surface, the latter matter, however, being so intimately connected with astronomy proper that it is impossible to talk about the one without talking about the other.

Since we divide all circles into 360°, the circumference of the earth may be so divided, and the method in use of defining positions on the earth is to say of a place that its latitude is so much and its longitude is so much. Latitude begins at the equator with 0°, and terminates at the poles with 90°, being north latitude in the one case, and south latitude in the other. In the case of longitude, there is no such simple starting point, for whilst latitude is counted from the equator by everybody all over the world, longitude may commence at any point. In England we count longitude from the meridian of Greenwich. When the transit instrument at Greenwich is swept from the north point through the zenith to the south point it describes a half circle, which is called the meridian of Greenwich.

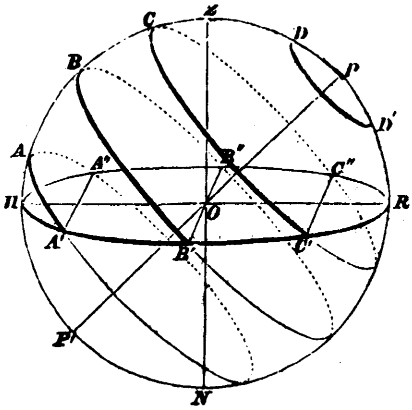


FIG. 34.—Horizon of a place in mid-latitude.

That is one point. Another point is this. Suppose the instrument to be set up not at Greenwich but at the north pole. Then the true horizon of the observer will be along the equator. Remove the instrument to the equator, and the true horizon will cut the poles. At a place in mid-latitude the true horizon would cut neither the pole nor the equator, but would be inclined to both (see Figs. 32, 33, and 34).

Then comes the important relationship between the latitude of the place and the altitude of the pole star above its horizon; that the number of degrees this star—be it north or south—is above the horizon of the observer will be the number of degrees of north or south latitude of the place where the observation is made. A place therefore in 10° N. lat. will (roughly) have the north pole star at a height of 10° above its horizon.

So much for this part of our subject. Let us now leave it, because, interesting as it is, it refers to a branch of astronomy with which at present we have less to do than with the more physical one; but it was well that we should pause for a few moments to note the tremendous importance to mankind of that particular movement of the earth which we have been considering.

J. NORMAN LOCKYER

(*To be continued.*)

## DYNAMO-ELECTRIC MACHINES FOR LABORATORY PURPOSES.[*]

(*For Illustrations see Page 64.*)

The dynamo machine described below is calculated, says Mr. W. E. Fein, of Stuttgart,[*] to fill up a void which has become more and more perceptible between my small dynamo machine, driven by hand, as formerly described, and the larger sorts driven by steam power. It is applicable for both purposes. For hand use it is connected with a fly-wheel, supported by a cast iron pillar, and capable of being set in motion by a handle· If requisite for more prolonged use, or for a more complete utilisation of the machine a second handle may be fixed to the handle of the fly-wheel, so that the machine may be driven by two men. These handles can be shifted so as to increase or diminish their radius according to the power described. The cast iron pillar and the dynamo machine are mounted upon one and the same foot of oak. The fly-wheel with its small driving drum are connected directly by a belt, so that the entire apparatus is conveniently arranged.

The machine is at all times ready for use, and offers a perfect substitute for galvanic elements which are troublesome to keep in order and circumstantial to manage. It is therefore an indispensable adjunct for the class-room and the laboratory, whilst its solid and strong construction admits also of continuous use for industrial purposes. A considerable number of these machines have been found to give satifaction in workshops for galvanic precipitation, and even for small lighting installations.

The construction of these machines is carried out on the principles of my patent, No. 13,159 (German, and they are prepared in three kinds. The machine for quantitative currents is made with a coil of correspondingly strong wire. The medium make has thinner wires, whilst the third make, for producing tension-current is provided with correspondingly fine coils.

By means of an accompanying rheostat, at the front of the upright column different resistances can be introduced by turning a small handle; these resistances correspond in the three classes of machines to the following values :—

| Machine. | | | | Rheostat. | | | |
|---|---|---|---|---|---|---|---|
| Thick coils .... | 0.1 | 0.3 | 0-5 | 0.75 | 1 | 1.5 | 3 ohms. |
| Medium " .... | 0.2 | 0.6 | 1 | 1.5 | 2 | 3.5 | 5 " |
| Fine " .... | 0.2 | 0.6 | 1 | 2 | 4 | 6 | 8 " |

Above the journals of the fly-wheel there is fixed, at a convenient height, a small table for experiments, upon which are three wire clamps, the two anterior ones of which (1 and 2 in the figure) are in direct connection with the poles of the machine.

If these are connected with each other, and if the apparatus to be introduced is brought in contact with the clamps, 2 and 3, by means of an accompanying brass rod, the rheostat abovementioned is brought into the lateral circuit, which is to be arranged when experimenting with apparatus possessing a great resistance (single vacuum lamps, &c.), or in which the current is often interruptued (spark inductors, &c.)

The electric dimensions of these machines are, on an average :—

| Machine. | Internal Resistance. | Strength of Current. | Tension. | Electre motive Power. | External Resistance. |
|---|---|---|---|---|---|
| | Ohms. | Ampères. | Volts. | Volts. | Ohms. |
| With thick coils | 0.5 | 13 | 13 | 19.5 | 1 |
| | o.5 | 18 | 9 | 18 | 0.5 |
| | 0.5 | 30 | 3 | 18 | 0.1 |
| With medium coils........ | 1.2 | 5.5 | 27.5 | 34.1 | 5 |
| | 1.2 | 15 | 15 | 33 | 2 |
| | 1.2 | 22 | 4.4 | 30.8 | 0.2 |
| With fine coils. | 4.5 | 5 | 40 | 62.5 | 8 |
| | 4.5 | 7 | 28 | 50.5 | 4 |
| | 4.5 | 10 | 10 | 55 | 1 |

The fly-wheel should have a speed of 60—80 revolutions per minute, which can be kept up by two men with the double handle for any required length of time. A greater speed can be attained by the use of steam, &c., power when the performance of the machine is proportionately greater. Experiments made with the machine, when driven by hand, give the following results :—

| | Thick Coils. | Medium. | Fine. |
|---|---|---|---|
| Length of millimetres of platinum wire kept in bright ignition.......... | 500 | 1,000 | 1,500 |
| Diameter of wire in millimetres.................. | 0.7 | 0.5 | 0.3 |
| Detonation gas evolved per minute, in cubic centimetres.................. | 300 | 300 | 150 |
| Copper precipitated per minute in milligrammes. | 567 | 472 | 283 |

The machine with thick coils is best adapted for ignitions, evolution of gas, galvanoplastics, &c. The medium form is best adapted for the purposes of demonstration and serves for illumination with a small arc lamp, with one or two contact glow lamps or four to six vacuum lamps at 25 volts; for experiments on ignition and fusion, the tranfer of power, charging accumulators, &c.

The machine with fine coils serves for the production of an intense arc light (250 volts), or to work three to four Swan lamps (40 volts), for which purposes, if driven by a small engine, it is quite sufficient to light up a small shop, &c.

With proper care accumulators can be easily charged with this machine.

It must not, however, be forgotten to cut off the connection between both apparatusus before the rotation of the machine is slackened or interrupted.

Another machine, Fig. 2, which we find illustrated in the New-York *Electrician*, is made by I. W. Colburn & Co., of Fitchburg, Mass. The object was to produce a machine capable of developing a current of sufficient quantity and intensity to meet the demands of any laboratory and one absolutely free from the defects common in other machines of this class.

They furnish a current of enough power to operate three incandescent lamps, or one small arc light, sufficiently strong for illustrative purposes. The machine requires about two man-power to operate it at its fullest capacity; but one man can develop sufficient electrical energy for general experimenting, the current developed being according to the power expended in operating the machine.

This apparatus, besides being very useful for general experimenting, is used to a considerable extent for practical purposes. A large number have been constructed for cautery use, and in every case are said to have given the greatest satisfaction.

With the use of this machine for cautery a great deal of annoyance is avoided by the surgeon having the operation in charge. It will heat, white hot, a long piece of No. 16 platinum wire.

The machine is made very rigid, and runs perfectly even and free from noise, the gears being cut.

As will be seen, the machine rests upon a heavy and strong iron base, with an upright column all cast in one piece. The weight of base and column is 375 lbs. There are bolt holes in base for securing the machine to the floor. The machine is so speeded that with a slight exertion on the part of the person operating the crank a very fast speed can be attained for the armature.

The machine can be run up to a speed of 1,800 revolutions per minute, and kept so without showing any heat in the armature or field-coils.

The frame of the machine is cast in one piece, which gives it absolute rigidity; besides, the pole pieces of the exciting field are all secured to a solid composition ring, one on each side of poles. The machine is thus enabled to run perfectly free from vibration.

The armature is of the improved Gramme type. The current passes from the armature-coil through the insulated wire in the centre of the shaft to the commutator, which is outside the bearings. This gives easy access to the brushes, and they can be readily adjusted.

Unlike other machines, the commutator brushes, instead of being horizontally parallel, are set at an angle of 90° from each other.

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[*] *Zeitschrift des Electrotech.* Vereins in Wein.

The machine, when constructed for experimental purposes, is wound with quite small wire, and furnishes a current of 60 volts and 3½ ampères; when constructed for cautery use it is wound with large wire, and then develops 4 volts and 50 ampères.

## CIRCULATION OF SAP IN PLANTS.

BY PROF. PENHALLOW.

In animals, the fluids which accomplish the distribution of food to various parts of the system and permit the nutrition of the various tissues, are observed to flow in the channels of a well defined circulatory system, being first distributed from a common centre to the most remote parts of the organism, thence returning by other channels to their first point of departure. If we seek to establish any comparison between this circulation in the animal and corresponding movements in the plant, we will be met with several difficulties at the outset. First of all we observe that we are unable to trace any definite system of channels through which the nutrient fluid of the plant flows and to which it is chiefly confined, though it is apparent from the changes peculiar to growth that there must be some sort of fluid movement or circulation constantly operating, otherwise it would be impossible for the various parts to receive their due proportion of nutrition.

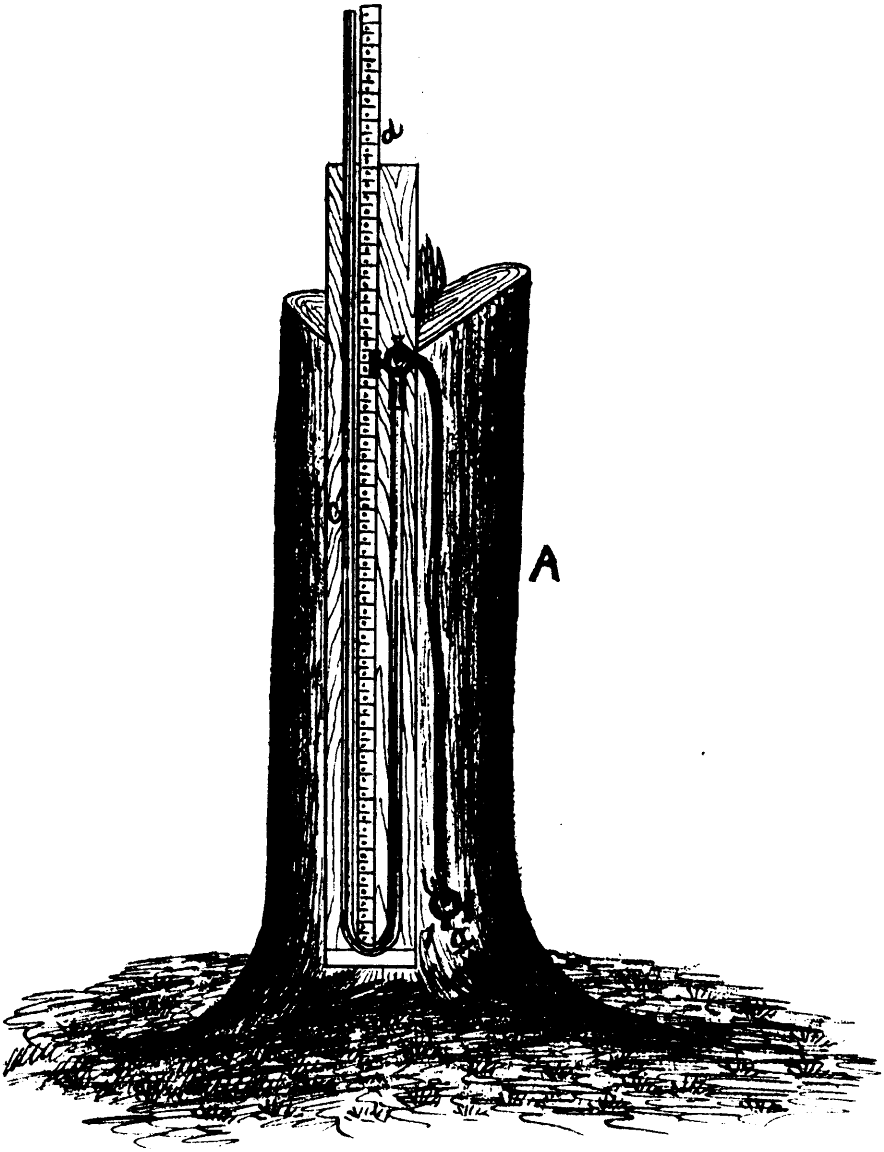
It will be found upon inspection of a plant that all its parts are filled with water, which not only occupies all available space in individual cells, but penetrates the substance of the cellular structure also. This hygrometric condition is most strongly defined in small, herbaceous plants where the tissues present the least difference of structure, but in larger vegetable structures such as are to be met with in trees, where the tissues are more highly modified and differentiated from one another, it will be possible to find that the contained water is somewhat variable. Thus, if pith be present, it will usually be found quite devoid of water, while the surrounding wood will be well saturated; or again, the heart wood may be comparatively dry while the surrounding sap wood will be quite moist.

Again we observe that seasons have their influence upon the contained water of certain vegetable organs at least, and in the case of herbaceous plants, of the whole structure. Upon general principles, the water will be found in greatest quantity during the period of maximum growth in spring and early summer, while it will diminish towards the period of full maturity,—this being especially conspicuous in seeds and leaves. In large trees, however, which are less sensitive to external conditions, it seems highly probable that the percentage of contained water is subject to but slight variations the year round. From these considerations, it will be evident that in the movement and distribution of fluid in the vegetable, we have to encounter rather more complex conditions than are met with in the circulatory system of the animal.

Both Grew and Malpighi, two of the earliest investigators who undertook to study the minute anatomy of plants, held the view that the woody cells were the special organs through which the sap circulated, a view which we now know to be in a measure true, though not in the full sense in which these authors held it. Malpighi also entertained the view that the spiral structures of certain vessels were mechanical contrivances directly connected with the elevation of sap in plants through the various cells and vessels. Other early observers within the present century, attributed to the medullary rays—those little shining plates which form the so-called silver grain of maple and other trees—an important function in the movement of sap, their belief being that these plates were capable of sudden and strong expansion and contraction under varying conditions of temperature; thus, alternately compressing the adjacent wood cells and vessels and then allowing them to expand, they developed a sort of pumping action by means of which the sap was forced up into the branches and leaves. However much we may admire the great ingenuity of this theory, in the light of more recent knowledge concerning both the anatomy of plants and their physiological processes, we are led to see that it rested upon a very insufficient basis of fact and is, indeed, not at all a tenable explanation of the process.

According to our present knowledge, we recognize that there are two well defined movements of water in the plant. The first is of a purely physical character, being entirely independent of vital processes, and is to be best observed in trees where the woody structure is highly developed. To understand this thoroughly, it will first be necessary to state what changes occur in a plant saturated with water when exposed to a freezing temperature. When a tree freezes, as in winter, the water contained in the substance of the cell walls separates out and then fills all the vessels and other unoccupied spaces of the plant structure. When again exposed to a gradually increasing and thawing temperature, the water is gradually reabsorbed into the substance of the cell walls, and all parts return to their normal condition. But let us suppose the transition from cold to heat occurs with considerable rapidity as is common in early spring, the sap is not allowed time to be reabsorbed into the cellulose substance and must perforce remain in the spaces of the tissues and in the cell cavities where it was frozen. If, while the plant is in this condition, we break a limb, sap is observed to flow, or the limb bleeds, often at a very rapid rate. If we bore a hole in the trunk, the tree also bleeds, and all for the reason that the sap, now in the tree as a free fluid, seeks an exit from the hole or end of the broken branch precisely as water would flow from an open stop-cock. Furthermore, external conditions greatly operate to promote or retard this movement. As the heat of the day increases, it warms up all parts of the tree and causes a general expansion, especially of the contained air, and this expansion reacts upon the liberated sap to force it through an outlet with greater energy. The best illustration of this form of movement in sap, is seen in the sugar maple, since success in the collection of sap here depends entirely upon the laws just stated. According to these laws also, it is easy to find an explanation of the well known facts that the best sugar weather is when the nights are cold and the days warm; that the sap flows most freely early in the day and decreases towards night, and that the flow is also greatest in the early part of the season, gradually diminishing towards the close as the weather gets warmer and there is greater equality of temperature between night and day.

The force exerted by sap when passing out of a tree under these circumstances is often very great and may be readily determined in the following way: Let A be a maple tree. At 1 insert a half-inch, three-way cock with an overflow *a;* to *b* secure a strong, half-inch lead pipe, to the other end of which is fastened another three-way cock, this in turn being securely attached to one arm of an U tube of thick glass, of which the arm *c* shall be the longer. Secure the tube to a board which carries a graduated scale *d.* Fill the tube with a convenient quantity of clean mercury and see that all the connections are perfectly tight. Open both stop-cocks, and into the upper one pour water until it issues from the lower one free from air; close the latter and then the former and the connections will now be completed. When this is done, if the sap is flowing well, it will be observed that the mercury at once begins to rise in the long tube of the manometer and perhaps with considerable rapidity. One may now observe all the varying effects which conditions of heat and cold produce upon the flow of sap, and measure the force exerted in pounds to the square inch by simply reducing the height of the mercurial column to pounds and carrying the process through to the desired result.



By means of such an instrument, it was observed only a few years since, that the elevation of the mercurial column was directly related to the heat of the day; that at night, when the air in the plant was condensed, the action was reversed and a section developed, thus showing the tendency of the tissues to reabsorb, and of the now vacant cavities to be refilled; and that the force exerted by the moving sap was sufficient to raise the column of mercury very nearly four feet, which, in round numbers, would be equivalent to a pressure of 2.6 atmosphere or 39 pounds to the squrre inch.

(*To be continued.*)

# THE EVOLUTION OF FLOWERS.

By Grant Allen.

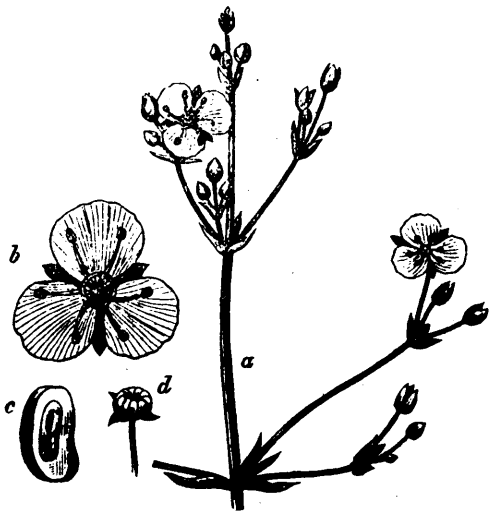
## I.—THE STARTING-POINT.

I PROPOSE in this set of papers that we should follow out together, so far as is possible, the various steps in the evolution of a single great group of plants, illustrated for the most part either by native English wild flowers, or by such common garden favourites as are within the easy reach and familiar knowledge of almost everybody. Starting from the simplest known form, which we may conceive to represent very nearly the peculiarities of the primitive ancestor, we must trace the gradual changes by which the various successively higher forms have been developed; and at each stage we must try to discover what was the advantage gained by the plant through the different new arrangements, and in consequence of what special agency these arrangements became finally stereotyped in the persons of its descendants. In this way, we shall obtain a more clear and connected view of the methods of evolution in the vegetable world than we could ever obtain by the study of mere casual isolated instances, and we shall be able more fully to understand the underlying meaning and reasons for the classifications long since half blindly (though very wisely) adopted by the earlier pre-Darwinian botanists. We shall see that the classes they mapped out are really genealogical divisions, and that all the members of each family or genus are really bound together by genuine ties of blood in their common descent from a single central and typical ancestor.

The great group of plants to which I propose to apply our present scrutiny is one that may be roughly described for unbotanical readers as that of the Lilies. Botanists will know more clearly what is meant if I say that our subject is to be the Monocotyledons, especially those with conspicuous petals or perianths, comprising the main central body of the class, from the Alismas up to the Orchids. This group may fairly enough be described throughout for popular purposes under the general name of Lilies, both because most of the flowers are moderately lily-like in form and texture, and because the true lilies occupy a central place in the class as a whole, presenting the peculiarities of the entire body in a comparatively simple and recognisable form.

What, then, is the simplest and most primitive existing type of lily, or, to speak more correctly, of Monocotyledon? I believe, if we take relative simplicity in the arrangement of parts as our guide, we shall come to the conclusion that no lily-like plant is more primitive or antiquated in type than our own common English water-plantains. Let us begin, therefore, by looking briefly at the nature and structure of this familiar and pretty little British pond-haunter; and then let us inquire what are the marks which it still bears on its very face of its own archaic and ancient characteristics.

Everybody must often have seen and noticed the water-plantain, with its tall sparse whitish flowers rising in large, loose masses high above the stagnant surface of still pools or flooded ditches. It is a pretty, glossy-leaved plant, with long-stalked bright green blades, and a spreading panicle of starry little blossoms, which look white in the mass as you see them growing, but turn out to be delicately pink or rose-colour when you gather them for close inspection. In fact, if ever you have seen a lush and succulent water-weed, with a perfect pyramid of straggling white bloom clustered in its centre, overtopping the calm levels of a shallow English pond, you may be pretty sure that that was a water-plantain. Its botanical name (which I shall always add here for the benefit of those readers who already take an interest in structural botany) is *Alisma plantago.*



Alisma plantago.

Now, what are the reasons which induce us to begin our review of the lily tribe with this little inconspicuous English wild-flower? Well, let us premise first of all that evolution runs habitually from the simpler to the more complex; from the like to the unlike; from the less consolidated to the more consolidated. Suppose we find two flowers, one of which has five distinct petals, all alike, and the other of which, resembling it in every other way, has two of those petals specially modified into a peculiar form, we rightly conclude that the former is the more primitive and original of the two. Not necessarily that the second is directly derived from the first; about that we can only judge by means of very minute and circumstantial evidence; but that, at least, the first stands nearer in type than the second to the common ancestor from which both are presumably descended. Again, if we find one flower with five separate petals, and another just like it, only with the five petals united into a single tubular corolla, we once more rightly conclude that the former is more primitive and original than the latter. Distinctness of parts is almost always a mark of the early unconsolidated stage; coalescence of parts is almost always a mark of the later consolidated stage. For example, most simpler crustaceans have the body divided into several nearly equal and similar joints or segments; but in the crabs and lobsters, the princes among crustaceans, seven such segments have become united together to form the large head-piece with its single solid shell or carapace. In such a case, everybody can see at once that the union of parts is an obvious sign of higher and more complete development.

If we look at the flower of the water-plantain, we shall similarly see that it presents many such symptoms of an early, uncompounded, simple type. In the technical language of botany, there is very little cohesion or adhesion among its parts: it shows us in the easiest and most separate form the ground-plan upon which all the lilies, high or low, are ultimately constructed. Only, while in the higher lilies we have to pick out the various component elements of the flower with some difficulty from their entangled and combined condition, in the water-plantain we get them all distinct and individualised, so that there need be no hesitation at all in recognising their nature and meaning.

This, in brief, is the original ground-plan of the blossom in the common ancestor from which the great lily group has ultimately descended. Its parts were all arranged in whorls of three members each. It must have had (as we know by comparison of all existing forms) first of all a protective calyx whorl of three outer green sepals, enclosing and shielding the unopened bud from all attacks of cold weather or greedy insects. Inside this must have come a second or corolla whorl of three brightly-coloured and delicate petals, intended for the attraction of its insect fertilizers. Within the petals, again, were the pollen-bearing stamens, arranged in alternate rows of three each; and of these rows there may have been one, two, three, or more; though the fact that most existing monocotyledons have six stamens apiece, or else exhibit traces of having originally had six, would seem to show that two rows were most probably the contingent possessed by the prime ancestor. Last of all, in the very centre, came the carpels or young seed-vessels, of which there were also three, six, nine, or more, according to circumstances.

To such a primitive ground-plan our existing English water-plantain very closely adheres. The little pale pink flowers that grow in loose flat bunches at the end of its branched stem are each divisible into very nearly the same divisions as the fancy flower we have here sketched out. Each of them has three small green calyx-pieces, quite separate from one another, and quite unlike the petals that adjoin them. Next it has three petals, larger and broader than the sepals, very delicate, and coloured white with a faintly roseate tinge. There are six stamens, arranged in two alternating rows of three outer and three inner, the former opposite the sepals, and the latter opposite the petals. Finally, in the centre there are a great many small, one-seeded, distinct carpels, from eighteen to thirty in number, arranged in a ring round a broad, flat receptacle, which forms the boss or axis of the whole flower.

It is to these carpels that we must most especially direct our attention at the outset, because they are, so to speak, the very patents of nobility of the Alisma family, the grand evidence that the water-plantain and its congeners do really form the most primitive existing members of the great lily group. In the first place, all the other lilies without exception (save only the Alisma family and a few closely related small orders) have the carpels more or less combined into a single compound ovary, the walls of the different carpels having coalesced, for a reason which we shall have hereafter to consider. In the second place, the number of carpels in the water-plantains is exceptionally large; and we know by the analogy of the buttercups, which are the simplest members of the other great group of flowering plants (the Dicotyledons), that primitive flowers always have a great many distinct carpels and that with the advance towards higher types, the carpels tend to become reduced in number as well as to cohere with one another. In the third place, the water-plantains have only one seed to each carpel; and we also know by analogies elsewhere that primitive flowers always have only one seed in each carpel, but that more advanced types, while lessening the number of carpels, increase the number of seeds in each.

I know this first exposition has necessarily been a little dull, because we have here to dwell chiefly on fundamental points of structure, which are always dry, and to say very little about points of function and the practical use of parts, which are always comparatively interesting; but that could hardly be helped in an introductory sketch, where it is needful, above all things, that we should have a clear conception of the raw form from which we take our first departure. In future papers. I trust we shall be able to make the final development of the various lily-like plants from this simple original a little more graphic and a little less dull. Meanwhile, I hope my readers will try to master the first principles laid down in this opening part; as a firm grasp of the architectural plan of the water-plantain will greatly assist in following out the subsequent course of evolution on which we are about to embark.

One word more, as the preachers say, and I have done. It is a very significant fact that the water-plantain and its congeners are all, without exception, aquatic plants of the marshes, ponds, and ditches. Now, it frequently happens that fresh-water animals and plants preserve for us very antique and otherwise extinct types—creatures of a sort which have become extinct in the fiercer competition of the great continents and the great oceans, but which have lingered on in the less-occupied reaches of inland, rivers, lakes or pools. It has been ingeniously noted that meres or ponds may be regarded in this respect as the aquatic analogues of oceanic islands, where so many very archaic forms have been preserved for us, far from the wild struggle for life which rages so incessantly in the wider stretches of land or water. Indeed, it may be said, roughly speaking, that almost all very early or primæval types of plants or animals yet existing belong to one or other of three peculiar habitats—islands, fresh-water lakes or streams, and caves. And the one point these three habitats have in common is just this—freedom from competition save by the members of a very small and local fauna or flora.

## ELECTRICITY AND MAGNETISM.

BY PROF. W. GARNETT.

The quadrant electrometer of Sir Wm. Thomson consists essentially of an aluminium "needle" of special form suspended by two silk fibres within a cylindrical box of brass. Above the "needle" and outside the box, is placed a small mirror, which turns with the needle, and records its deflections by means of a beam of light reflected from its silvered surface. From the lower side of the needle, and passing through a hole in the cylindrical box, there hangs a plantinum wire, which dips into sulphuric acid contained in a glass dish, the exterior of which is coated with tinfoil. This vessel with its sulphuric acid constitutes a Leyden jar, the interior of which is charged with positive electricity, and serves to keep the needle positively charged. The cylindrical box is divided into four quadrants, which are supported on insulating glass pillars, but the quadrants which are diagonally opposite to each other are connected by wires. The *electrodes* of the instrument are two brass rods, one of which is attached to each pair of quadrants. The "bifilar suspension" is adjusted so that when the needle is uncharged its axis is parallel to one of the division of the cylindrical box, so that equal portions of the needle are within each pair of quadrants. The quadrants are then adjusted symmetrically with respect to the needle, so that when the needle is charged, but all the quadrants connected together, the needle still retains its former position. If one pair of quadrants be now raised to a higher potential than the other the positively electrified neele will tend to pass from places where the potential is high to places where it is low, and will consequently turn so as to come within the pair of quadrants which have the lower potential. This motion will be resisted by the bifilar suspension, and the needle will come to rest after turning through an angle which will be proportional to the difference of potential between the quadrants if the deflection is not very great. In this way the quadrant electrometer serves to detect and *measure* differences of electric potential.

The best electrometers are furnished with a "replenisher," for keeping up the charge of the Leyden jar, and an "idiostotic gauge," to determine when the electrification of the needle has reached a standard amount. These instruments will be referred to later on.

DEF. The capacity of a conductor is the number of units of electricity required to raise it to unit potential.

When a conductor is *isolated*, that is, removed from the action of all other bodies, it will have a definite capacity depending only on its shape and size. If there be other insulated conductors in its neighbourhood its capacity will be increased. If these surrounding conductors be uninsulated, so that they are always maintained at zero potential, its capacity will be still further increased. The capacity of an isolated sphere is numerically equal to its radius, so that the unit of capacity is that of a sphere of one centimetre radius. The capacity of an insulated sphere which is surrounded by a concentric sphere in connection with the earth, the space between the two being occupied by air, is equal to the product of the radii of the sphere divided by the difference of th- two radii (or the distance between the spheres). Such an arrangement constitutes a *condenser* or electric accumulator. A Leyden jar usually consists of a glass bottle coated inside and outside with tinfoil to about two-thirds of its height. A brass rod terminating in a knob at its upper extremity passes through the cover of the jar, and by means of a chain or wire makes a connection with the inner coating or armature of the jar. The coated pane is a simple form of accumulator, consisting of a sheet of glass, the central portion of each side of which is covered with tinfoil. The air condenser consists of two equal plates of brass supported on insulating pillars, so arranged that the plates can be made to approach or recede from one another. As two parallel plates may be regarded as small portions of concentric spheres of very great radius it follows that when the distance between the plates is very small compared with the dimensions of the plates themselves the capacity of the condenser is inversely proportional to the distance between the plates, and directly proportional to the area of either. By changing the dtstance between the plates the capacity of the condenser can be altered at will. In charging rn accumulator one armature is generally connected with the earth and the other with the source of electricity.

Let the plates or armatures of the condenser be called A and B respectively, A denoting the receiving plate whose potential is to be raised and B the condensing plate, which is in connection with the earth. Suppose that a certain positive charge is given to A, sufficient to raise its potential to unity if no other electricity were near. Then the potential of A will be raised, and that of all bodies in the neighbonrhood will also be raised in virtue of the positive charge communicated to A. Therefore the potential of B will be raised to an amount depending upon its nearness to A. But B is in connection with the earth, and therefore its potential will no sooner be raised than positive electricity will flow from B to the earth, and B will become negatively charged. This negative charge upon B would, of itself, produce a negative potedtial everywhere in the neighbourhood, and therefore upon the conductor A. The potential of A is therefore that due to its own charge, together with that due to the negative electrification of B. If B be very near to A the potential at A due to the negative charge on B may be *nearly* (but never quite) equal to the potential due to the charge on A itself, though of opposite sign, and thus the resultant potential of A, instead of being unity, is very small indeed. To raise the potential of A to unity the charge must be correspondingly increased, the charge of B increasing in the same ratio, and hence the capacity of A is also increased in the same ratio.

If, as in the case of the concentric spheres, the conductor A is completely surrounded by B, then at all points outside B, the potential due to the charge on A is completely neutralized by the charge on B, and however strongly the conductor may be charged it produces no effect at any point outside it. A Leyden jar would nearly fulfil this condition if it had no projecting knob.

Faraday shewed that when a positively charged body is placed inside a hollow conductor which is closed, or closed, a quantity of negative electrification is induced on the inner surface of the conductor numerically equal to the charge on the body, while a positive charge equal to that on the body is repelled to the outside of the closed conductor. Faraday proved this by shewing that when the conductor was insulated, but connected with an electroscope, the divergence of the gold leaves remained precisely the same however a charged ball was moved about within the conductor, and even when it was allowed to touch the sides, and that after touching the sides the ball was found to be completely discharged. (Faraday employed an ice-pail for the hollow conducttor.) Hence it appears that when a Leyden jar is charged an equal and opposite charge will be induced on the inner surface of the outer coating.

The "ice-pail experiment" of Faraday indicates a method of comparing electric charges without allowing them to leave the bodies which possess them. A hollow conductor is insulated and connected with an electrometer. The charged body is then suspended within the hollow conductor. The indication of the electrometer will then be independent of the size or shape of the charged body or of its position within the conductor, provided it be not very near the opening, and will depend only on its total charge. In this way it can be shewn that when two bodies are rubbed together the amount of positive and negative electricification are equal. For example, let a piece of flannel be attached to an insulating handle. Rub it against a piece of ebonite. Introduce the ebonite into the hollow conductor, and the electro-meter indicates positive electrification. Introduce the flannel and ebonite simultaneously, and the electro-meter remains at zero. A holow conductor employed in this way is often called an *electric cage*.

If Q units of electricity are brought from the earth, and all raised to potential V, the potential remaining the same throughout the operation, the work done will be V Q units. This is analogous to carry a weight of W lb. to the top of a hill H feet high: when the work done is W H foot-pounds.

Suppose that a quantity of bricks weighing W lb. lying upon the ground are built into a tower of uniform section and H feet high. The work done in raising these bricks into their positions in the tower will be only $\frac{1}{2}$ W H foot-pounds, for it is only the last course of bricks that is raised to the top of the tower, and the *averag* height through which the bricks are raised is only $\frac{1}{2}$ H feet. Similarly, when a conductor originally at zero potential is charged to potential V it is only the last element of electricity that has to be raised to potential V to introduce it into the conductor, and the

**average difference of potential through which the charge has to be raised is only $\frac{1}{2}V$ units, so that the work done in charging the jar is $\frac{1}{2}QV$ ergs. This also represents, of course, the *energy* of the jar when charged, and the work it can do in discharging itself.**

**If C denote the capacity of the jar then C is the number of units of electricity required to charge it to unit potential, and therefore to charge it to potential V the charge Q must be equal to CV. Hence the energy may be represented by $\frac{1}{2}QV$ or $\frac{1}{2}CV^2$.**

(*To be continued.*)

## *THE ERUPTION OF KRAKATOA*[1]

"SIXTEEN volcanoes now working between the spot where Krakatoa was before and Sebesie." Such was one of the first reports which was sent by cable to Singapore, and which we heard at Pontianak. Never before had we been so longing for news from Java, for when H.M. ship *Hydrograaf* steamed into the Padang-Tikar River, we heard heavy detonations and explosions like far-off shots, so that we were alarmed about Java. As we expected, our ship was soon ordered to survey the Sunda Straits. This survey was finished at the end of October, and the reader will probably feel interested to know what really has happened there.

Krakatoa has not entirely disappeared, while, till now, no new volcanoes are visible in the neighbourhood. But the report that new islands were said to have arisen between Sebesie and Krakatoa is easily to be explained, for the new islands are like a mass of smoking and steaming rocks, and if seen from afar they may easily suggest the idea of a great number of working volcanoes. But, when looked at closely, it appeared that the masses of rock were composed of hot pumice-stone, mixed with eruptive masses. In them there were a great many cracks and splits, in which, by the heavy breakers, steam of water was continually generated.

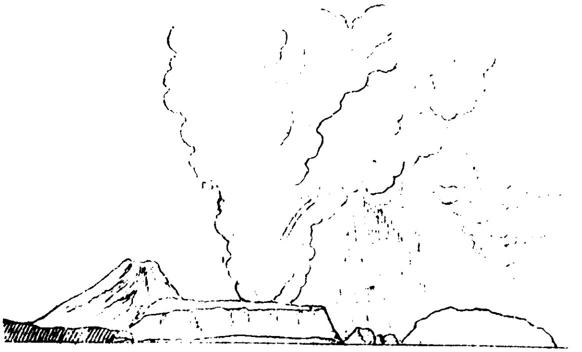


Fig. 1.—Krakatoa during the eruption of May, after a drawing of the Military Survey Bureau, Batavia.

The northern part of the island has entirely disappeared. At what is now the northern edge the peak rises nearly perpendicularly from the sea, and forms a crumbled and rugged wall, and shows a vertical cutting (which is more than 800 metres high) of Krakatoa.

Where was land before, there is now no bottom to be found; at least we could not fathom it with lines of 200 fathoms (360 metres) long. When we had quite calm weather, and steamed slowly and cautiously to and fro along the base of the peak, or had turned off steam and let the ship drift, and were busy in measuring the depth, we could distinctly see the different strata and rocks of the bare, opened mountain. Only here and there a slight trace of melted volcanic matter was to be seen, which, after half of the mountain had crumbled away, had flowed over the wall, which is still there. What remains of the slopes is covered with a grayish-yellow stuff (which, as plainly appears, had been in a melted or fluid state), full of cracks or splits from which steam is continually coming out.

In the same way steam is also coming forth from the deeper cracks of the steep wall, which is still remaining. Sometimes this is accompanied by slight explosions; at that time clouds of brown dust fly up from the cracks, and stones roll down which are often so big as to disturb the sea around the entire base of the mountain. Our entire survey of the north of Krakatoa suggested the idea that we were above a crater which had been filled with water and quenched by it, and this idea was still strengthened on observing that the decrease of depth, south of Sebesie, had principally been caused by matters which were cast out and flung away.

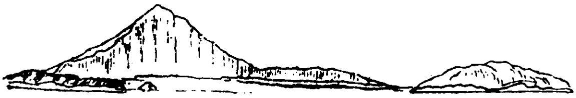


Fig. 2.—Krakatoa after the eruption in May, after a drawing of the Military Survey Bureau, Batavia.

Almost in every place here the lead came up from the bottom, filled with black sand or carbonised dust, sometimes mixed with pulverised pumice-stone and little black stones, which apparently had been in a red-hot or melted state. Moreover, the soundings were very different, and the new rocks resemble clods of substances which, when in a melted or very hot state, had contact with water. Probably such a whimsical shape of the rocks above the sea-level suggests the state of the bottom of the sea in the neighbourhood. The stones were still too hot to allow us to discover whether massive stones are under the pumice-stone also. It was not difficult, it is true, to knock off large pieces of these rocks by a hatchet or a chopper, but when a big block fell unexpectedly down, the sailors had often to flee on account of the gases which suddenly arose. The knocked off pieces which were brought on board were still warm after they had been in the boat for an hour.

Fig. 3.—Peak of Krakatoa after the eruption in August, by M. C. van Doorn.

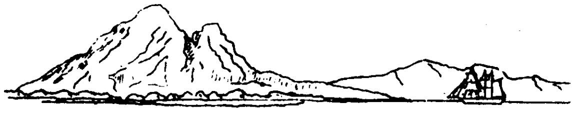


Fig. 4.—Peak of Sebesie and the volcanic rocks before it, by M. C. van Doorn.

As is to be seen from the map, a great part of the lost ground of Krakatoa is found again at the bottom of the sea, a few miles to the north at least, if we suppose that no undulations of the ground took place. After having passed the limits to which the matters were thrown out, one finds the same soundings as were found before, and the decrease of depth is so local that the idea of an upraised bottom is dissipated at once. If such an elevation had taken place, it certainly would be remarked over a far greater extent and be more regularly ascending and descending. The firmer and stronger part of the crater wall, the peak of Krakatoa, which is still there,

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[1] By M. C. van Doorn, officer in command of H.M. ship *Hydrograaf*. Translated (and partially abridged) by E. Metzger from *Eigen Haard*, 1883, No. 51.

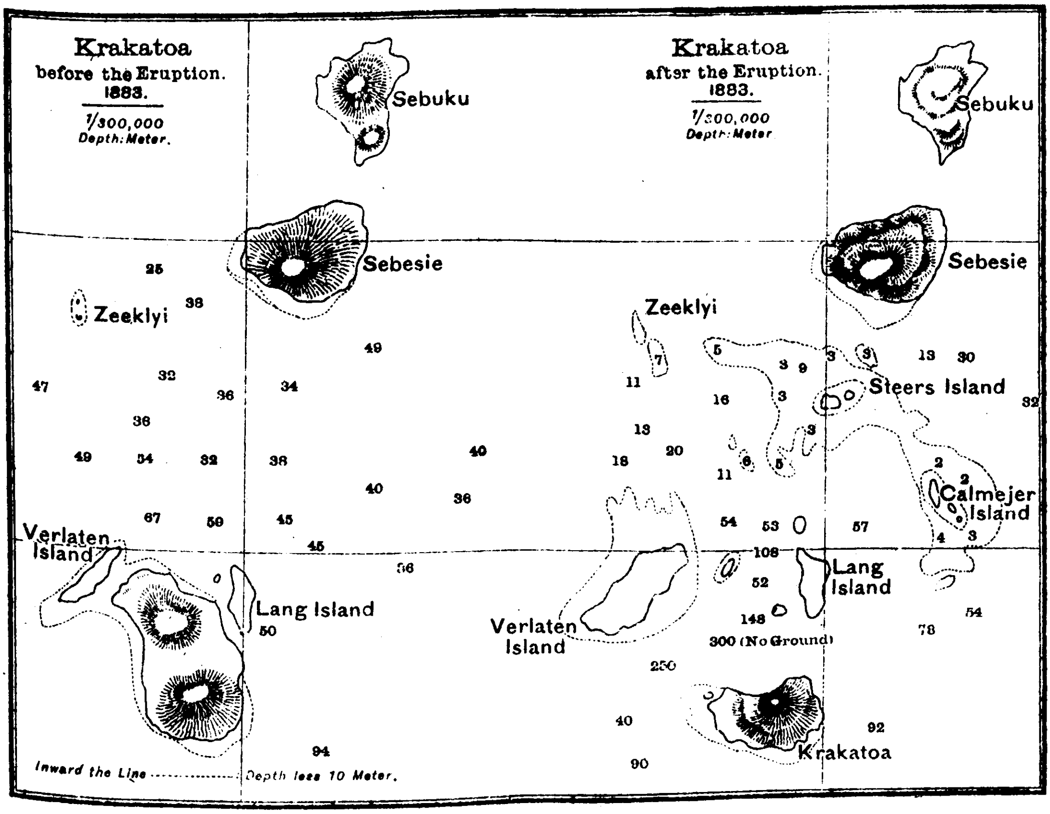
remained standing when the lower and feebler part dropped down, and the water found its way into the fearful boiling pool. We cannot wonder therefore that then a quantity of steam came forth (of which we are not able to form an idea), which caused a strong explosion. The movements of the sea which followed it caused tidal waves, the destroying force of which was experienced in such a fearful manner at the coast of Bantam and the Lampongs.

It is also worth mentioning that a change took place in the figure of Verlaten Island; the area is now triple what it was before, though it is plainly visible that large pieces of the beach were there knocked off a short time ago.

Lang Island, in size and formation, has remained almost unaltered. The sight of these islands, which were formerly covered by a luxurious vegetation, is now very melancholy. They are now buried under a mass of pumice-stone, and appear like shapeless clods of burst clay (*i.e.* covered with cracks). After a torrent of rain, the coming forth of steam is sometimes so dense that these islands, when seen from afar, appear like hilly ground covered here and there with snow. If looking at these spots with the telescopes, one can plainly see that these white specks are formed by a great number of clouds, which issued like steam from the fissures.

Sebesie is also covered with ashes up to the top—859 metres—which appear like a grayish-yellow cloth. But it seems that the cover is already less thick here, for here and there one sees the stumps of dead trees peeping out from the crust.

Sebuku shows a dreadful scene of devastation. Perhaps all that lived here is not so completely destroyed as was the case on the southern islands, but the sight of the bare fields of ashes, alternating with destroyed woods, the trees of which are all either dead or uprooted, gives one a still better idea of the destructive powers which were here at work. It is not until we come to the small islands northward of Sebuku that our eyes are gladdened by little specks of green.



Krakatoa and neighbouring islands before and after the eruption, from official surveys.

I do not try to describe the scene of destruction and misery which we saw at Anjer and the villages along the coast. The papers have already reported the full particulars, and therefore I do not care to repeat melancholy facts which are already known.

It was a dreadful narrative which was related to us by a native, a lighthouse-keeper of Fourth Point, one of the few men at the lighthouse, who by a wonder was saved. When the wave approached, all fled to the tower (the light was 46 metres above the sea), which, though shaking, resisted the violent waves for a long time. It was a terrible moment, when at last an enormous rock, which was swept away by the stream, crushed the base of the tower, which then fell down. The man who was saved saw his wife and his children drowned before his eyes. He related this fact in the very resigned way of a Javanese, and considered it the most natural thing in the world that he was now obliged to light the interim light, which was erected as soon as possible.

It has been almost a month that we have been in the Sunda Straits, and even in this short period we could observe that the coasts of Bantam commence to revive. From many places from the heavy rain the ashes are washed down, and a fresh green appears again. Even on the beach young cocoanut trees and banana trees are shooting out between the chaos of dead trees, blocks of rocks, &c.

Off Batavia, October 23, 1883

# Miscellaneous Notes.

THE STEAM-ENGINE.—The third of the six Lectures on "Heat in its Mechanical Applications," was delivered on Thursday evening, the 17th of January, by Mr. E. A. Cowper, M. Inst. C.E., the subject being "The Steam-Engine.

The Lecturer, in introducing his subject, dwelt shortly upon the power produced by the actual creation of Steam by the application of Heat, and the mode of utilizing that power when so produced. In passing shortly over the earlier attempts at forming the steam-engine,—such as Hero's, Leupold's, Savery's, Papin's and others,—he came to the construction of the first steam-engine, namely, that by Newcomen, in 1712, and noticed the successful working of many of these engines for fifty-seven years, up to the time of Watt, in 1769, when that great inventor introduced the beautiful idea of condensing the steam in a separate vessel from the cylinder; the separation of the boiler from the cylinder having been already effected by Newcomen. There was thus produced a practical engine, in which the steam might be applied to press on the piston, and such steam be condensed as quickly as might be necessary, thereby enabling a good working engine to be constructed. About eleven years after Watt introduced the mode of making rotative engines with double action, and other improvements tending to the more economical use of steam. Shortly afterwards, steam began to be applied for navigation—at first on the Dalwinston Lake, and afterwards on the Forth and Clyde Canal. Numerous inventors followed quickly after 1800, notably Hornblower, Cartwright, Woolf, and others. Some years subsequently, when steam began to be more generally applied for navigation, many inventors arose with different forms of engines more particularly applicable for driving paddle-wheels, and in recent times screw-propellers had been driven by engines especially adapted for the purpose. The pressure of steam had been constantly increased, and a more perfect mode of working it expansively introduced, resulting in very great economy. One of the special forms of engines now in favour was that of the compound engine, using the steam first expansively in a high-pressure cylinder, and then expansively in a low-pressure cylinder; many such engines had a steam jacketed reservoir between the two cylinders, whilst the cylinders themselves were thoroughly steam-jacketed. Some peculiar forms of engines were next noticed, such as the "Davey Compound Pumping Engine" with combined differential motion; the "Brotherhood" Engine, with very quick rotation; Messrs. Simpson and Co.'s highly economical engines, for pumping, and some of the larger forms of marine-engine up to 9,000 h.p., as made for the "*America*" by Messrs. J. & G. Thompson, of Glasgow. It was curious and interesting to observe the great contract between the model of the first steam-engine, and one of the most recent, namely, Messrs. Maudslay, Sons & Field's high-class marine-engine. Many comparisons of Indicator figures, some good, others exceedingly defective, were also made, and the true practical way of obtaining the greatest amount of power out of a given quantity of steam was sketched. Besides a model of the first Newcomen engine that of very early Watt beam-engine was shown, as well as of Trevithick's early locomotive. An instructive engraving of the first Newcomen engine (of which only two copies are extant) was also exhibited, and in the Library were placed a large number of models, drawings and working-diagrams of some modern examples of engines by the most distinguished marine engineers. One interesting engine noticed, was that by Mr. Webb, of Crewe, namely, his three-cylinder high-pressure expansive locomotive, fitted with Mr. David Joy's slide-valve motion, which was now being largely used both for marine and locomotive engine. Palmer's Shipbuilding Co., of Jarrow, also contributed some excellent models of engines, and Messrs. Rennie, of the engines of the "*Bacchante*" and "*Boadicea*."

TINNED FOODS.—According to the *Medical Times*, tinned meats, soups, vegetables, and more especially fruits, are all, without exception, contaminated by metals; such is the irresistible conclusion of recent scientific investigation. In 1878 Mr. Albert E. Menke communicated to the *Chemical News* results of analysis of a tin of lobster, one of apples, and another of pineapple. The latter contained tin dissolved in the juice equal to 1.3 grains per pound, the lobster and apples a much smaller quantity. Mr. Hehner in 1880 communicated to the *Analyst* the results of a long and thorough investigation of the subject. He found tin in tinned French asparagus, American asparagus, peas, tomatoes, peaches, pineapples, white cherries, red cherries, marmalades, corned beef (five different brands), ox-cheek (three kinds), collared head, tripe, oysters, sardines preserved in oil, salmon, lobster. shrimps, curried fowl (two kinds), boiled rabbit, boiled mutton, roast chicken, roast turkey, soup, and in three brands of condensed milk. The amount of tin found does not appear large—*e.g.*, in the milk one tenth of a grain per pound, in one of the soups half a grain per pound, and in a pound tin of preserved oysters seven-tenths of a grain per pound. On a later research Mr. Wynter-Blyth has found far larger quantities. In a recent report to the vestry of St. Marylebone, detailing the examination of twenty-three samples of tinned apricots, tomatoes, pineapples, and cranberries, the amounts found calculated as stannous hydrate range from 1.9 grains to 14.3 grains per pound, the mean amount being 5.2 grains. The juice and fruit in some instances had a metallic taste. Several of the tins showed signs of corrosion. The little that is known of the action of stannous hydrate may be summed up in a few lines. Doses of about .174 gramme per kilogramme of body weight cause in guinea-pigs death with signs of intestinal irritation; but with doses smaller than .17 to .2 gramme the effects are uncertain, and the animals generally recover. Hence, supposing man to be affected in the same proportion, he would have to take from three to four drachms, or consume at a meal 10 lb. of the most contaminated of Mr. Wynter-Blyth's tinned fruits. But it is not a question of immediate lethality; it is rather one for inquiry as to the action of small repeated doses continued for a long time.

COLORING SOFT SOLDER YELLOW.—When brass is soldered with soft solder, the difference in color is so marked as to direct attention to the spot mended. The following method of coloring soft solder is given by the *Metallarbeiter*: First, prepare a saturated solution of sulphate of copper (bluestone) in water, and apply some of this on the end of a stick to the solder. On touching it with a steel or iron wire it becomes coppered, and by repeating the experiment the deposit of copper may be made thicker and darker. To give the solders a yellower color, mix one part of a saturated solution of sulphate of zinc with two of sulphate of copper, apply this to the coppered spot and rub it with a zinc rod. The color can be still further improved by applying gilt powder and polishing. On gold jewelry or colored gold, the solder is first colored as above, then a thin coat of gum or isinglass solution is applied and bronze powder dusted over it, which can be polished after the gum is dry and made very smooth and brilliant; or the article may be electroplated with gold, and then it will have the same color. On silverware the coppered spots of solder are rubbed with silvering powder, or polished with the brush and then carefully scratched with the scratch brush, then finally polished.

AN ELECTRIC BRAKE.—The *Hamburger Nachrichten* gives a detailed notice of an appliance now being exhibited at Vienna by the French Chemin de fer du Nord. It is a metal electrical apparatus intended to be placed within the rails at a point near the entrance signal of a station. By a mechanical contrivance worked from the station itself this apparatus can be so fixed as to come into contact with an appliance fitted upon the locomotives, which opens the steam whistle and by automatic action brings into effect the tender-broke. By this means even a careless engine-driver could not proceed at full speed into a station thus protected. The matter has attracted interest on account of the late deplorable accident at Steglitz.

NEW ELECTRIC LAMP.—Mr. F. Varley has devised a new form of electric lamp. His carbons are made of twisted hemp fibres soaked in ozokerite and carbonised in a crucible filled with some hydro-carbon vapour. This carbonized hemp is flexible; it can be wound on a reel and moved out by clockwork. The arc between the poles is said to be so saturated with incandescent carbon that the resistance is much reduced and the light of greater area.

THE BANANA TREE AS A FOOD PRODUCER.—The Spaniards have a superstitious reverence for the banana, believing it to be the fruit of which Eve partook in Paradise. It is asserted that 44,000 pounds of bananas can be produced on the soil that would be required for 1,000 pounds of potatoes, and that the area that would be required to raise wheat enough for one man would produce bananas enough to feed 70 men.

**THE SEASONING OF WOODS.**—Wood requires time in which to season very much in proportion to the density of the fibre. But this rule is not without an exception, for pitch pine, which is not a densely fibred wood, require a long time in which to season, even when the process is conducted under favourable conditions. This occurs in consequence of the resinous character of pitch pine, the resin clogging the pores of the wood, and thus stopping the channels through which the moisture would otherwise exude. There are some woods—and mahogany, ebony and some other of the tropical woods are of the number—that even in their living state contain very little moisture. Plants that are of slow growth contain less moisture when in living state than do those whose growths are rapid. A mahogany tree requires 500 years in which to mature, and, as a consequence, its texture is exceedingly dense. Being dense in texture it requires a long time to properly season, and during that lengthened period it shrinks very little. Mahogany should not be kept longer than necessary in the log, because, inasmuch as the outside portion of a log contains the greatest amount of moisture, and it being the exposed part, it will, as the wood dries, shrink more than the inner wood, and so, to allow for the outside shrinking, outside shakes will and must occur. The remark applies with equal force to all log timber, but we name the circumstance in connection with mahogany particularly for the reason that it is a general practice with some to keep their mahogany logs for a long time in an unsawed state.—*Saw Mill Gazette.*

**INJURIOUS EFFECTS OF BAKING POWDERS.**—A writer in the *Journal of the American Medical Association* avers that there is no doubt that baking powders, even the best of them, are damaging to health. He says: To make the matter clear, it may be stated that the average baking powder is composed of bicarbonate of soda, cream tartar, and starch, with a possible admixture of other things. The continued use of even this purest baking powder will affect the system seriously, commencing with only a slight derangement of the digestive organs, which gradually becomes chronic, changing the secretions of the stomach necessary for digestion (muriatic acid); in fact, altering the whole chemistry of the human stomach. The continued use of alkalies in any form injures the health. Look at the alkali country west of us, where the alkali is found in the *drinking water*. The same dangers will arise from the persistent alkaline medication of our *daily bread*. The various forms of dyspepsia, bladder troubles, Bright's Disease, consumption—the newest researches speak about a wrong proportion of the alkalies in this disease—are only too often caused by this modern substitute of the old, time-honoured, common sense practice of using yeast.

**A NEW FORM OF STEEL.**—At a recent meeting of the Institution of Mechanical Engineers, London, the Hadfield Steel Foundry Company showed specimens of steel castings and pieces of steel wholly without magnetic capacity, including axes and other tools carrying a fine-cutting edge, which were the subjects of very great interest to those present, for these cast tool require no treatment of any kind when they come from the mould. They are very hard, but what is the more remarkable is that they are very tough at the same time. They require no hardening or tempering. The steel of these remarkable properties is made by thoroughly incorporating, under Mr. Robert Hadfield's patent, from 7 to 12 per cent. of rich ferro-manganese, containing about 80 per cent of manganese. The applications of this remarkable metal are, it need hardly be said, innumerable. Tools of almost every description can now go straight from foundry to grinding and finishing rooms, while for the numerous engineering purposes to which steel is applied, for strength, toughness, and hardness are now added.

**CARRINGTON'S PATENT WIRE ROPE TRANSPORT SYSTEM** is of great value for rugged and undeveloped countries. It consists of an endless wire rope, supported on a series of pulleys carried by substantial posts, ordinarily set about 150 feet apart, but sometimes as far as 600 feet. The rope passes at one end of the line round an arrangement of drums driven by a steam engine, or other available power, at a spead of three miles an hour. Boxes capable of carrying from 1 to 4 cwt. are hung on the rope at the loading end, the attachment consisting of a pendant of peculiar shape which maintains the load in perfect equilibrium and enables it to pass the supporting pulley with ease. The carrying capabilities of the system range from 10 tons to 500 tons per day. The system avoids expense of cuttings and embankments, requires no bridges over rivers or ravines, occupies scarcely any land, and is very portable.

## PROCEEDINGS OF SOCIETIES.

**AMERICAN SOCIETY OF CIVIL ENGINEERS, NOVEMBER 21ST, 1883.**—The Seciety met at 8 p.m. Director Geo. S. Greene, Jr., in the chair; John Bogart, Secretary.

A paper by E. H. Keating, M. Am. Soc. C. E., upon the Shubenacadie Canal, was read.

This canal is located between the city of Halifax, Nova Scotia, and the Basin of Mines, an arm of the Bay of Fundy. It was commenced in 1826, and the intention was to build it so as to accommodate vessels drawing 11 feet. It was to have 15 locks, 87 feet in length and 22½ feet in width, with a lockage ascending from Halifax of 95 feet 10 inches, and, descending to the Bay of Fundy, of 95 feet 4 inches. The total length is about 54 miles, the greator portion of which was to be in the Shubenacadic River, and in a chain of lakes existing along the line ef the canal.

Mr. Thomas Telford, the celebrated engineer, made a very favorable report upon the proposed canal and its prospects. Up to the close of 1831, £72,000 had been expended upon the work, which was, however, in an entirely incompleted state. Some of the locks near Halifax had not been commenced, and large and expensive work remained to be done upon the line of the canal. All the available capital being exhausted, the works were abandoned and fell into ruin, never having been completed on the original plan. In 1856 a report was made by Mr. W. H. Talcott, C. E., upon a scheme for completing the works upon a very much smaller soale than at first proposed, substituting for certain of the locks the inelined plane near Halifax, with a lift of 55 feet, and a similar plane with a lift of 33 feet at another point. The planes to be worked by hydraulic machinery. This report was adopted, and the work was completed in 1862, at a cost of $200,000. The diminished canal has, however, proved a failnre as a commercial enterprise, and since 1870 no trade of any account has been carried on through it.

There was also presented a description, by Charles C. Smith, M. Am. Soe. C. E., of a Hydraulic Canal built at Minneapolis, Minn., during the severely cold winter of 1881. This canal is under Main Street, Minneapolis, its entrance being at right angles to the street. It is covered with a semi-circular rubble stone arch of 17½ ft. span, and where the line turns the angle of 90° the abutments of the arch were built of curved lines of the radius of 31¼ and 48¾ feet. The arch was built of rubble masonry of stone, varying from 4 to 6 inches thick, and from 18 to 36 inches long; the joints at the soffit being slightly hammered off to approximately form beds eonforming to the radical lines of the arch. The mortar was made of one part Louisville cement to two parts of sand, and was mixed in hot water wiihout salt. During its construction the weather was extremely cold, the frost having penetrated the ground to the depth of six feet. An examination of this work having been made quite recently, it was found to be perfectly sound and free from any indication of settlement or rupture two years after its construction.

A discussion followed by the members present, more partioularly in reference to the best methods of laying masonry in very cold weather, the experience of a numbes of members being favorable to the use of a strong solution of salt in the water with which the mortar was made.

The recent adoption of a system of time standards by the railways was discussed, and Prof. Julius E. Hilgard, M. Am. Soc. C. E., gave a statement as to the measures which were in progress in reference to securing a standard prime meridian, together with other measures pertaining to the determination of standard time by the various nations of the world.

He also described the results of the recent meeting at Rome, Italy, of the Superintendents of the Geodetic Surveys of various nations.

A paper by Mr. L. J. LeConte, M. Am. Soc. C.E., describing the dredging operations at Oakland Harbor, Cal., was, in the absence of the writer, read by the Secretary. The work described was the excavation of a tidal basin, and the deposit of the excavated material on the adjoining salt marshes. The machine used was a pump dredge with a cutting apparatus consisting of a horizontal wheel with ordinary plows upon its lower face. The rotation of this wheel makes the excavation. Over this cutter, and partly surrounding it is a hood, which allows water to enter only from beneath. Over the top of this hood a 20-inch pipe leads up to the large centrifugal pump of six feet in diameter. From this a line of wrought iron pipe, supported partly on pontoons, and partly on the marsh, extends several hundred feet upon the tract to be reclaimed. The material, after leaving the cutter is taken up by the water, passes through the pump and through the pipe to its place of deposit, without at any time during the transportation coming to a state of rest. The engines are two 16 x 20 inch engines, and exclusively for driving the centrifugal pump, and two 12 x 12 inch engines for driving the cutting apparatus, swinging the gear, &c. The steam is supplied by two 100-horse power boilers, generally carrying 90 to 95 pounds of steam. The amount of material transported with the water, runs at times as high as 40 per cent. by volume, but experience has shown that in the material excavated at this point which is a blue clay mud, it is not advisable to carry more than 15 per cent., particularly in order to secure a uniform distribution at the place of deposit. The total quantity moved by one dredge in eight months was 250,000 cubic yards. The best work in one month was somewhat over 60,000 cubic yards in 230 engine hours; the average distance of transportation being 1,100 feet. The greatest distance transported was during October, when 45,000 yards were deposited in 190 engine hours, through 1,600 to 2,000 feet of 2 in. pipe. The average daily expense account was stated as approximately $102, but this did not include the cost of the 9 or 10 men on shore, employed to secure a proper disposition of the material, particularly as the fill approaches completion, nor did it include the cost of retaining embankments where required. The result of the work was stated to be, with this one pump dredge, an average of 30,000 cubic yards measured in the cut at a maximum cost of 10c. per cubic yard, and in one particular month of 23 days' work, 60,000 cubic yards were deposited on shore at a distance of 1,600 to 2,000 feet from the dredge at a cost of $5 per cubic yard. The complete distribution of the material at the place of deposit has been very satisfactory, the result being a cluster of cones whose slopes are very flat,—not more than 1½ per cent., and frequently so slight as to appear almost level.

## DYNAMO-ELECTRIC MACHINES.

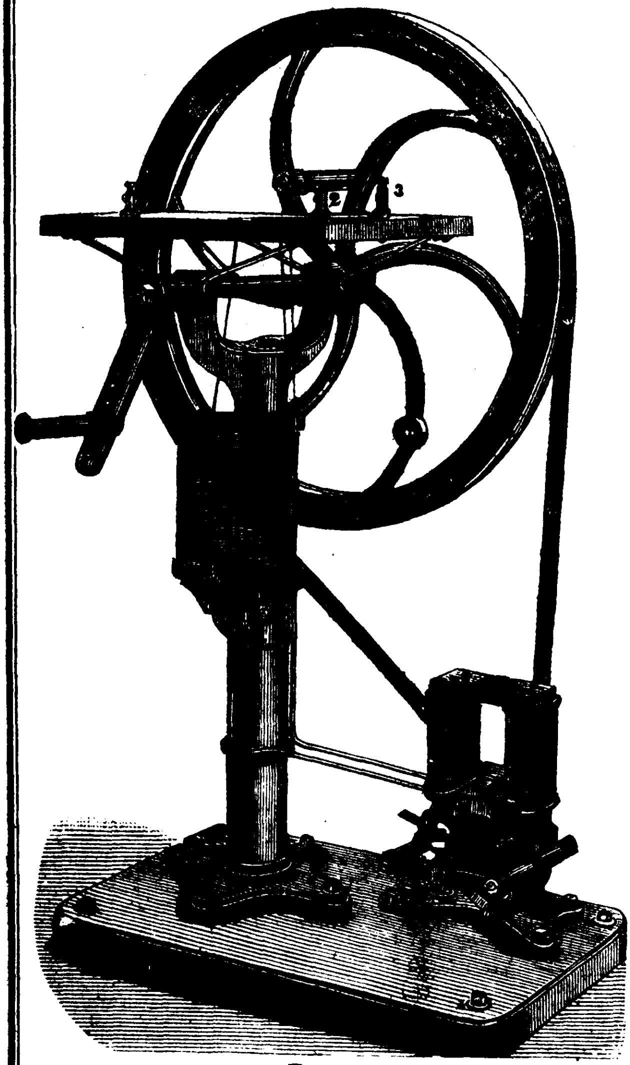


FIG. 1.

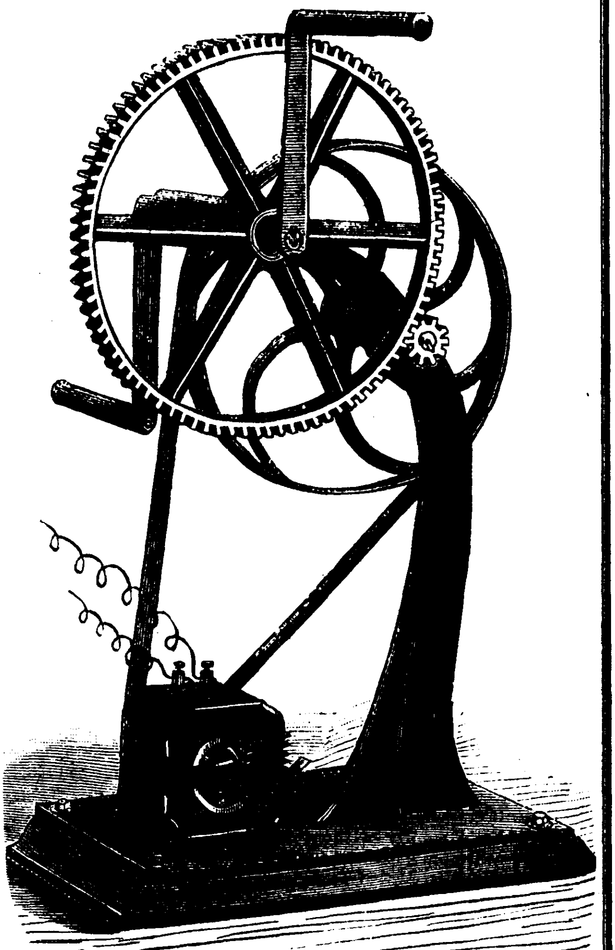


FIG. 2.

A paper by Mr. A. V. Abbott on "Some improvements in testing machines" was read by the author, and illustrated by a stereopticon. A 200,000 pound testing machine was first described, its general construction providing for weighing the forces applied by means of platforms and levers somewhat similar to those used in ordinary scale work with special arrangements to reduce friction. To secure the direction of the pressure upon the test pieces in the axis of the machine, both ends of the piece are connected with segments of spheres moving freely in spherical sockets which take the proper position upon the first application of the stress. Arrangements are also made by means of wedges, to grip and hold uniformly the ends of the test pieces. The machine is arranged to test in tension, compression, for transverse stress, for shearing, bulging and torsion. In the machine illustrated, the action of applying stress is automatic and at the same time the same power gives an autographic record of the stress applied, and of any variations which may occur during the continuance of the stress, and with an instantaneous autographic record of the result at the conclusion of the test. The stresses are applied by means of weights which slide upon two parallel lever beams, the one registering up to 10,000 pounds, and the other up to 200,000. By means of a remarkably ingenious electrical attachment, connected with clock work, the movement of these weights is continuous and automatic, and the registering apparatus is also controlled by the same electric current. It is impossible in this abstract, and without the aid of a diagram to fairly describe the details of these movements, but they seem to be very complete and accurate. Diagrams automatically made by the machine were exhibited and described.

A number of broken pieces of steel were exhibited, and also specimens of woods which had been tested in various ways. Machines of smaller power were also described, and a number of cements were broken upon a small automatic machine which was exhibited.

The discussion of the paper was postponed to a subsequent meeting.