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CANADIAN MAGAZINE OF Science and the Industrial Arts.

Patent Office Record.

Vol. 13. NOVEMBER, 1885. No. 11.

Communications relating to the Editorial Department should be addressed to the Managing Editor, P. O. Box 128, Montreal.

Business communications and subscriptions to be sent to the Burland Lithographic Co., Montreal.

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

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LONDON COLONIAL EXHIBITION.

The exhibition from the English colonies and India, which takes place in London next year, is intended to be a fair representation of the progress and condition of each dependency in the arts and manufactures. This will be specially interesting to the British people, but can serve no very useful purpose to the separate exhibitors as an advertisement or otherwise. But the good it will do each colony cannot be overestimated as a telling advertisement, while at the same time it will break down much of the ignorance, prejudice and superstition which prevails in the average English mind as to the capabilities of the colonies.

Under these circumstances it is only just that the governments of each country should liberally assist individual exhibitors, otherwise the result will be a failure, but we are glad to know that all the expense of transportation to and fro will be met by the respective governments, and, besides, every assistance will be extended to satisfactorily place and manage the exhibits during the exhibition term.

Canada, perhaps more than any other colony, should be able to make a most satisfactory showing, first, because she is nearer to London, and, second, because the condition of many of her industries are nearly on a par with England and the United States. But it is very doubtful if Canada will respond to the invitation as thoroughly and promptly as the promoters of the scheme intended, not only because of the reasons advanced above, but because Canada's great commercial interests are, as far as manufacturing goes, linked with her own internal trade, and in great measure identical with her American neighbours in the States.

We regret that Canada is not likely to give an exhibit equal to the occasion of satisfying John Bull of her independent capabilities; those that require this awakening can just spare the time to cross the pond and convince themselves that Canada is not an uncivilized portion of the North American Continent, and like the old Scotch lady who was asked what were her impressions of Canada, said, "Na they are more civileesed here than I expected to find them," they will doubtless be surprised to see us making our own cotton and woollen goods, building our own steamboats, locomotives, railway cars, bridges, etc., etc., also steam engines, boilers and machinery of every description.

No doubt Canada might easier convince and educate the average English mind in London than any where else, provided a direct advantage was to be derived, but this view of self-interest unfortunately is the all p evailing one with manufacturers, and unless Canada can be convinced of some special advantage in exhibiting she is not likely to take to the scheme very enthusiastically.

Sir Charles Tupper, who deserves well of his countrymen, is doing his best to induce parties to send over their exhibits, and it is to be hoped that notwithstanding the objections which are urged by individual exhibitors, that many from patriotic motives will yet be found doing their share to uphold the honour and reputation of the Dominion.

It is a question of national importance and national gain that Canada should either undertake the work thoroughly or not attempt it at all, and as such an opportunity in the life time of a nation seldom occurs, it is only proper, now that space has been allotted and large expectations expected, that Canadians will sink minor objections and send exhibits to London that will create a lasting and favourable impression on the English mind, and to this end we counsel all true Canadians to lend a willing and helping hand.

IMPERIAL AND COLONIAL FEDERATION.

The subject of Imperial Federation does not seem to be making much practical headway and the prospect for some practical solution of the problem is as far off as ever. The theory of uniting under one government all the English dependencies is certainly a grand theory, but until it proves itself likely to suit the aims and aspirations of all parties concerned it will remain a dead letter.

Both political parties in the old Country recognise the difficulties in the way and merely express themselves as favorable to the subject, but surely this is better to those who are agitating the question than no reference at all. Several leaders of thought and public opinion have openly declared that the idea can never be practically carried out, owing to the diversity of conditions and circumstances existing in the different colonies. While these facts offer great objection to the scheme of Federation this is certainly no reason to conclude that human ingenuity with liberal fair play cannot surmount the difficulties, when it is remembered at the outset that a very large share of local home government must be conceded to all the competent parts of the proposed Federal Empire.

While taking a rather gloomy view of the prospects of Federation we certainly differ from those who believe the realization quite impossible, and think that if all parties concerned were as anxious for a successful issue as they are indifferent, and in some cases, opposed to it, the matter might be solved as some equitable basis at no very distant date. Canada, more than any other English colony will be the most difficult convert, because her interests would be the most largely involved, and her prospects as she remains are with some few exceptions thoroughly satisfactory.

England, on the other hand, has far-reaching interests involved, and the question beset on every hand with supreme difficulty must be considered from every point of view in a very slow and deliberate manner.

TORONTO'S PROGRESS.

The Toronto city assessment returns lately made show the city of Toronto to be about 112,000 souls, this is about 30 per cent. in five years, or at the rate of 60 per cent. in ten years ; the Government census in 1881 gave the population as 86,415 an increase of 54 per cent. over 1871. This rate of increase which will doubtless hold in Toronto may bring it up to about 20,000 in 1900, while granting Montreal her rate of increase this figure may also be reached, then we will have in Canada two great cities each of a quarter million people, with other cities following in the rear and probably a total population for the whole Dominion in 1900, or fifteen years hence of about 6 million people. Toronto has unlimited scope to build upon and in this respect she is most highly favored,—situated in the gentle slope of a small portion of Lake Ontario's north western bank—her streets are wide and street-car service excellent, her railway facilities good although Montreal in many respect can claim to be superior as a railway centre and terminus in summer. Still Toronto is fast minimising this disadvantage.

Toronto is fast becoming a manufacturing centre. She is in the midst of a rich Province and surrounded with prosperous country towns and villages, whose industries are represented by office and branch establishments in the city.

The sewage of the city of Toronto at present runs into the bay, but a superior system will soon have to be adopted whereby the bay will be kept pure by diverting all the sewage far past the city and empty into the lake proper.

The water supply of Toronto is obtained by pumping direct from the lake by means of a suction pipe running across the bay and island into the deep and pure cold water of lake Ontario.

The pumping station is situated at the water level and water is forced into supply and distributing mains against a pressure of from 70 to 100 lbs., the surplus finding its way to a storage reservoir about 210 feet above the lake level. A very small reservoir suffices with this arrangement, and when pumping machinery is ample in power and capacity and thoroughly reliable and durable no fears need be entertained even in any emergency because the lake is a never-failing reservoir situated at a low level.

The management of Toronto's pumping station has been singularly defective and unnecessary fears and adverse criticism have been indulged in, no doubt for the city's good, but the appointment of a water-works manager who will attend specially to the important and growing events of the department will, no doubt soon yield a satisfactory result.

We cannot just give at present the number of square miles or acres embraced in the city limits of Toronto, nor can we say how many persons per square acre there are, but some of the figures connected with the Government's last census may not be uninteresting.

Toronto in 1881 had 9·31 square miles or 5,958 acres. Montreal had 5.15 square miles or 3,29 acres. Toronto had in 1881 14·5 persons per square acre and Montreal 42·6 per acre, nearly three times more closely populated.

Montreal is by far the most closely populated city in the Dominion ; next to it comes St. John, N.B with. 32·2 persons per acre. Toronto ranking about seventh ; but these facts are subject of course in some few special cases to qualification, because if we take the abnormal conditions of acreage in Quebec, for example we find it 7,386 with a population of about 60,000 people, bringing the persons per acre to only 8·4, which of course does not give the correct estimate of density of population in the city proper, but the figures of Toronto and Montreal give a fair idea of how densely each city is covered with people.

INCREASED RAILWAY LOADS.

Ten years ago a standard car lead on all first-class railroads was 20,000 pounds, the weight of the car being 20,500 pounds. In 1881 the load on most roads had increased to 40,000 pounds. but the weight of the car had increased to only 22,000 pounds The master car builders of the Pennsylvania road have now adapted cars to carry 60,000 pounds, while the weight of the cars will be very little increased. Instead of hauling more than one pound of car to one pound of freight, nearly three pounds of freight can now be hauled for one pound of car. The substitution of steel for iron rails has made the change possible. This condition of affairs makes it possible for the railroads to carry freights at the low rates they receive and yet make a small profit.—*Sc. Am.*

Mme. Boucicaut, proprietor of the famous Bon Marché, Paris, recently announced to her 2,690 employés that from her private fortun ehe had appropriated $200,000 to the foundation of a pension fund for aged and infirm employés. A similar fund of $180,000 already exists, given by the former proprietor in 1876.

—A dispatch from San Francisco says J. D. Spreckels has received a dispatch stating that Mr. Pearce a member of the Glasgow firm which owns the steamers Sealandia and Australia, now plying between here, Australia, and Zealand under a charter to the Pacific Mail Company, has accepted a contract to carry the New Zealand mails from here for £30,000 per year.

TELEGRAPHING BY CIPHERS.

Last Tuesday the countenance of the operator in charge of a branch office of the Western Union Telegraph Company, located on Broadway, above Canal street, indicated amazement tinctured with disgust as he surveyed a message held at arm's length. The message was written on one of the company's ordinary blanks and read:

To John Chalfant, Tufft's Elephant Corral, Salt Lake City, Utah :

Xabggortza, lzqboptxag, cxmrtzulyo, grmltpaait, lopxxyzabx, racgkpmolb, oozkmrabty, cqmtgdbalm, hiayrtolbc, golzqbagg.

In the corner was written, "Paid $1." That was its unfortunate feature, for it was not the alphabetic jumble of the message that excited the operator's disgust, but a note from the main office pinned to the disguised despatch. The note stated that the operator had been charged $7.30 for the message, and warned him to be careful in future about accepting cipher despatches at a lower rate than that of a full word for each letter.

"I thought ten letters constituted a word, no matter how they were placed; but I'll know better hereafter," sorrowfully remarked the operator, and then added: "The next man that comes in here with a lot of sausage-meat English will hear from me."

The rate to Salt Lake City is $1 for the first ten words, and seven cents per word in excess of that number.

"No, we do not accept ten letters for a word, no matter how they are placed," said an official at the company's main office. We have had to stop that and charge for the letters in cipher despatches at word rates. This cipher business is troublesome to the operator and makes slow work. Besides that, mistakes are possible. We take cipher messages now at rates as stated, but we do not hold ourselves responsible for their correct transmission."

"How about 'code' words?"

"Any word to be found in Webster's goes at regular rates, whether in a message that reads so that it is understood or otherwise. We only discriminate against the cipher."

"Is much telegraphing done by secret methods?"

"Lots of it. Merchants do it to reduce expenses, and others, from school girls up to the big market manipulators, do a great amount of secret telegraphing."

The use of code systems is greatly on the increase. Some make up their own, but the majority of business men have systems specially printed for them, or make them up out of the cipher books, which are to be had of all commercial stationers.

Mr E. Parke Coby, the adjutant of the Veteran Corps of the Forty-seventh Regiment, when asked about cipher systems took the questioner to the fourth story of a printing establishment, where a thin, dark little man, with intensely black eyes, was found cutting three dictionaries to pieces with a huge pair of shears. The dictionaries were in English, Spanish, and German, and the little man cut long strip of words from them, which he pasted on paper, and then drew lead pencil lines from the words to written sentences.

"He is connected with a South American steamship company, and is preparing copy for a cipher system for his line," explained the printer. "We will not print more than half a dozen of the books, but the cost will be over $200. After we strike off the required number of copies we destroy the forms, and do not even keep a sample for ourselves. You see the companies guard their secret ciphers as a man guards the apple of his eye. It would never to do let rivals or interested speculators get hold of their codes, or the company would often be forestalled in the market. We do considerable cipher work for exporters and importers, and men in the iron and foreign trade, as well as for steamship companies, but, we never allow the work, when off the press, to be seen by any one except its owners. Cipher systems are coming greatly into vogue with the business men of New York. There is a great saving of expense in the use of the wires and less chance written despatches. Some customers are very secretive about their systems, and others do not appear to care anything for concealment. We get up a cipher system on an interchangeable plan by which not even the printer of the book can know the meaning of the code words."

"What is the expense?"

"Cipher systems, or codes, as they are called, when they are made to order, cost from $50 up. Some run as high as $400, and even more when very extensive. We make a novelty in book form consisting of a system which becomes secretive by the selection of a number. Such are sold at stores, and can be used by anybody."

At the office of Hatch & Foote, the bankers, a small cipher book was exhibited to the reporter. It contained names of stocks, with orders to buy or sell, quantities, advice, etc., all to be represented by a word or two.

"There is nothing secretive about it," said Mr. Emmerson. "We give the books to our customers. It is a saving of money in telegraphing, and an easier and more certain way of communication. We have no need of a secretive system in our general business, though the large operators use private codes."

This was on inquiry found to be the case; but any attempt to get a view of the private codes was regarded as the trick of a stock sharp.

Cashier Quinlan, of the Chemical bank, pointed to a pile of books on his desk, and remarked that they were the cipher systems of various corresponding banks, and that much of the business communication between banks is being done by cipher. Banks generally get up a separate system for each bank with which they deal extensively. The cipher books are carefully guarded in the bank's vault, and even then code orders are verified back and forth by other code words, systematized for the purpose, before a transaction involving much money is consummated.

Some houses having foreign connections and the steamship companies use very elaborate and extensive cipher systems. In such systems, over a cipher word column, it may read: "Can you secure——bundles of hides and find room for the same on the next steamer? If so, telegraph us rates and particulars." At one side of the column of cipher words will be found a column of figures running from one up into the thousands. The figures indicate the number of bundles or quantity, and the entire expression quoted above, together with the number of bundles referred to, may read simply "Bones." If the message "Bones" is sent from New York city to Melbourne, Australia, by the way of the eastern route, it will cost $3, 40 cents being charged per word by the Atlantic cables, and $2,60 per word by the eastern or India lines. Written out in full the original twenty-four words would cost $72.

The atlanctic cables are more liberal in their treatment of ciphers than the land companies. The cables confine a word to ten letters generally, but accept of three cipher letters, whether they make sense or otherwise, for a word. Three figures also count as a word; but when figures and letters are mixed, as, for instance, 6 qk or g 5 m, each letter, and figure is charged for a distinct word. This is done to prevent too great a liberty being taken with cable despatches. Nearly all civilized nations including China and Japan and the nations of South America, permit messages to be sent and received in cipher. Russia and her dependencies are the exceptions. Telegrams to and from Russia, Bosnia, Bulgaria, Servia, Roumania, Montenegro, Herzegovina, and Siberian points must be in open language, that the censors of the wires may read and investigate them at their leisure.

The most expensive all-wire message sent from New York city is one to some of the interior South American towns. They cost by direct cable and by the way of the Eastern $8.20 per word. To go by the coast lines and cables saves considerable on this rate, but when these lines are out of order the message has to take a transatlantic trip. But a message can be sent to distant Bosnia or Servia for only 52 cents per word, 40 cents of which is claimed by the cable companies. To reach Japan costs about $2.70 per word, and China the same amount. Khartoum can be reached at 95 cents, Turkey at $1 via Malta, or 54 cents via France. Messages to the various South American countries run from $1.40 to $3. Siam can be reached for $2.30 per word, and St. Petersburg for 58 cents.

In view of the figures given it will be easily understood why the commercial world takes kindly to cipher systems.—N. Y. *Sun*, Sept. 20.

A NATURAL bow that is on exhibition at the Brownsville (Oregon) post office is described by the San Francisco *Examiner*. It is a maple about eight feet in length, has the curves of an ordinary Indian bow, and, strange to say, is already strung with a slender limb that grows out of one end into the other so perfectly that at first sight it would be quite difficult for one to detect at which end the limb began. The bow is about three inches thick, and the string part is about one-fifth of that thickness, and is strong enough to shoot an arrow 200 yards.

THE GREAT CLOCK AT LUCKNOW.

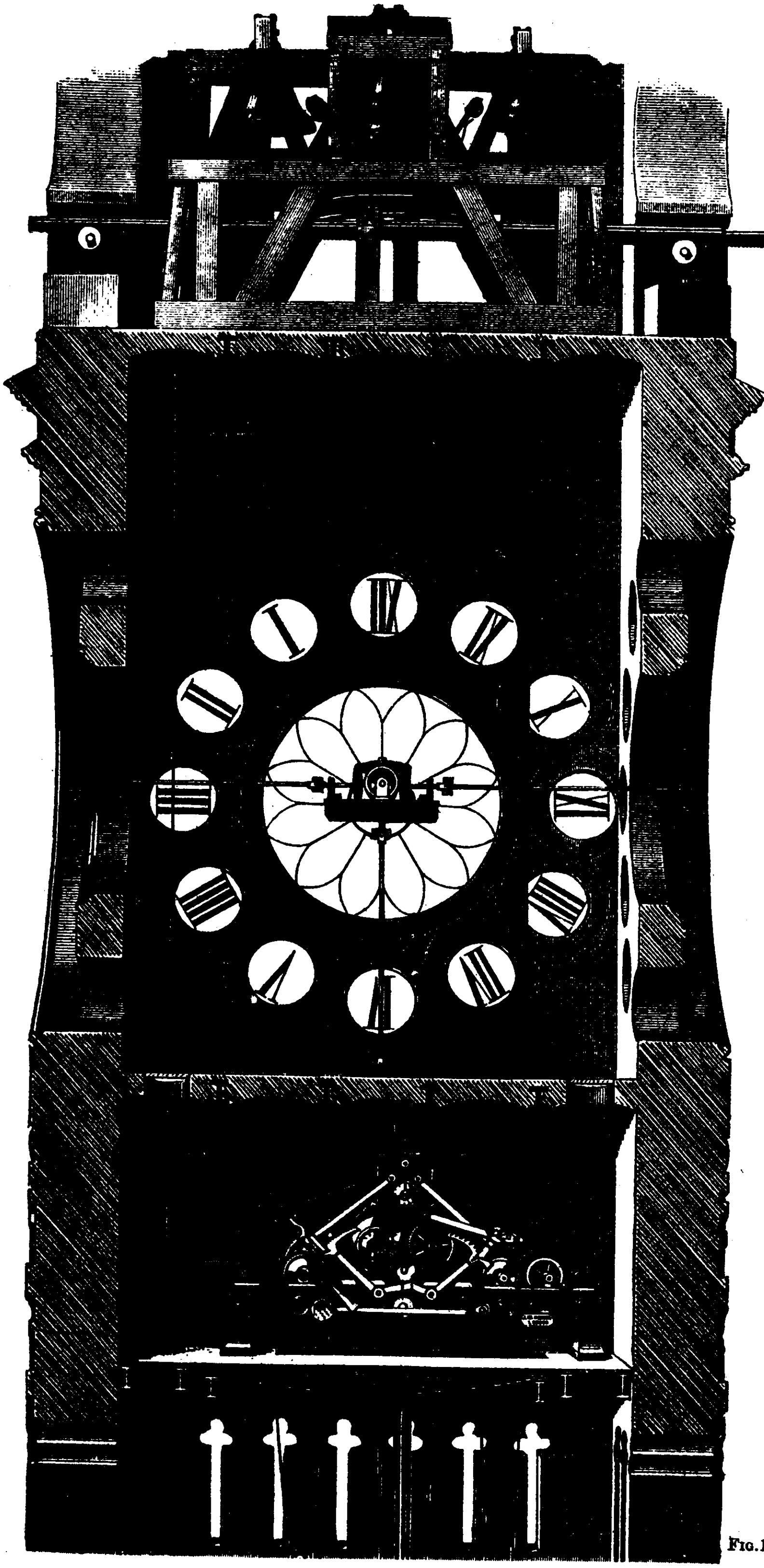


FIG. 1.

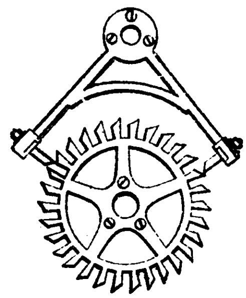


FIG. 3.

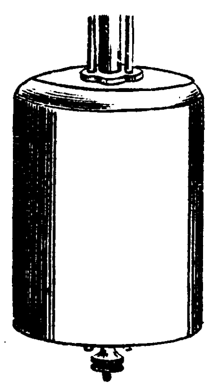


FIG. 4.

THE GREAT CLOCK AT LUCKNOW.

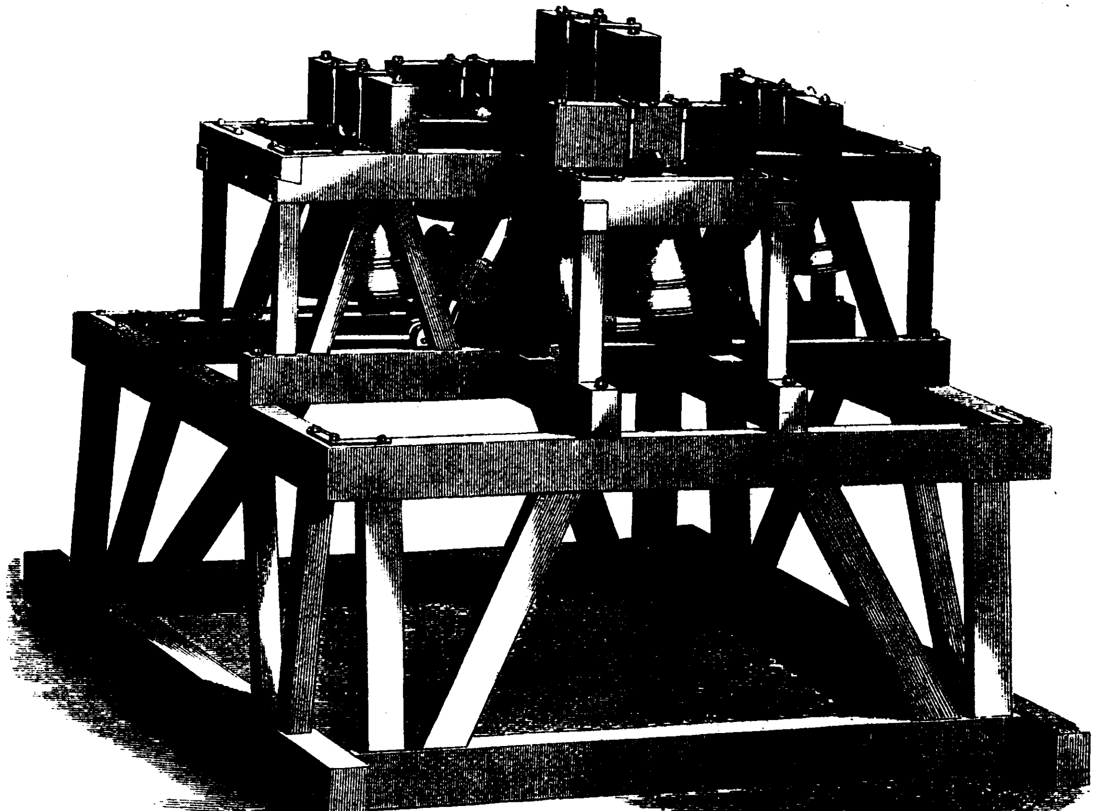


FIG. 5.

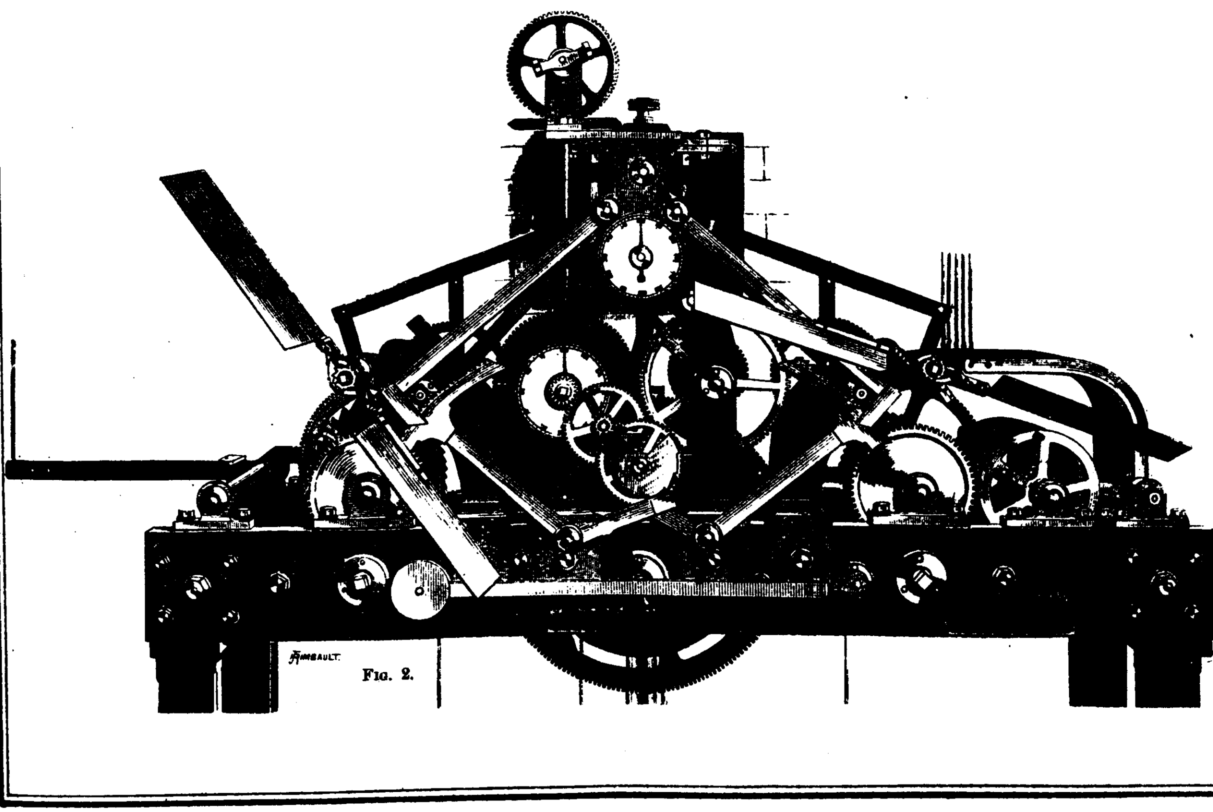


FIG. 2.

THE GREAT CLOCK AT LUCKNOW.

Lucknow, usually associated with the dark days of the Indian Mutiny, and the famous siege so gallantly sustained by our countrymen, will shortly have one of the largest and most perfect clocks in the world.

At the suggestion, and through the influence of Lieut-Colonel Norman T. Horsford, Bengal Staff Corps, the trustees of the Hoseinabad Endowment, who administer the fortune of 36 lacs of rupees (360,000l,) bequeathed by Mohammed Ali Shah, the late King of Oude, have erected a stately tower, 221 ft. high and 20 ft., square, from the designs of Mr. R. R. Bayne, of Calcutta for the reception of a clock of great size and power, made by Mr. J. W. Benson, Ludgate-hill, London, and of which we publish a two-page illustration this week.

Fig. 1 is a section of part of the tower, showing the clock movements, the dial rods, the nest of bevelled wheels for turning four pairs of hands, the dials, the bells and striking hammers. Also the lighting apparatus for illuminating the dials by night.

Fig. 2 shows the clock movement of which the following is a brief description. The bed or frame is horizontal, which allows any part to be removed for cleaning or repair without disturbing the rest, whereas in the upright frame, to gain access to a particular part, the whole machine has to be more or less taken to pieces. It consists of two wrought-iron sides having a massive pillar of the same material bolted between them at each end. The length is 6 ft. and the width 3 ft. All the train wheels are of gun-metal well hammered, the teeth being divided, cut, and polished by power, thereby insuring an accuracy impossible in hand-made work. The main wheel (projecting beneath the frame in centre of Fig. 2) is 24 in. in diameter and 1½ in. thick, and the other wheels are of proportionate size. In one of the designs for the great clock at Westminster, the main wheel was 18 in. in diameter, which although considered too small, will show by comparison the size of the present clock. The pinions are of hardened steel, cut from the solid, made and finished in the same manner as the wheels.

There are three trains of wheels, one in the centre to record the time on the dials, called "the going part," to the right of which is the quarter chiming train, and to the left the hour striking train. The barrels work in plummer-blocks, and the uprights which carry the trains are bolted on in such a manner as to be easily removable. All the bearings, which are of the best gun-metal, are screwed instead of being rivetted into their respective places as is usually done. The barrels for carrying the weights, and the spindles on which they are mounted, are of wrought iron, the drums being 12 in. in diameter, fitted between caps and ratchets by means of which the weights are wound without interrupting the motion of the great wheel. The weights are suspended by steel cords, which being much less bulky than rope, permit the barrels and frame to be greatly reduced in size and render the general arrangement more compact.

During the act of winding, which takes the motive power off the great wheel, it is obvious that the clock would stop unless some means were provided to continue the action.

This substitute, technically known as "the maintaining power," has been specially designed by the firm, and its working is as follows: To gain access to the winding square, the attendant must first raise a lever (see centre part of Fig. 2), one end of which gears into the teeth of the great wheel and the other being weighted, supplies the motion. The winding completed, the lever gradually drops with the revolution of the wheel into its old position. The escapement, see Fig. 3, is Graham's dead-beat, the advantages of which are that, being so simple and made on such true principles, it is not easily deranged, and in the unlikely event of its becoming so a man of ordinary capacity can rectify it, which is not the case with complicated gravity escapements. This is an important consideration for clocks in remote places, especially in the present instance, Lucknow being 781 miles "up country."

The pendulum is 14 ft. long, and has a bob of 3 cwt. It is compensated (see Fig. 4) with zinc and iron tubes to counteract the variations of temperature.

The rate of the new clock, which has been thoroughly tested in the factory, is reported to be a losing one of two seconds per week, so that it will give the standard time for the city and district.

Time is shown on four dials (see Fig. 1) each 13 ft. in diameter at an elevation of 120 ft. Each dial consists of twelve openings in the brickwork 2 ft. in diameter, glazed with white opal glass on which the numerals are marked in black enamel. The centre circle is also of the same material, and measures 5 ft 9 in. in diameter. The hands are of copper, and counterpoised on inside of tower. The minute hand is 6 ft., and the hour hand 4 ft. 6 in. long.

As it is impossible, owing to the large surface of brickwork which divides the circles, to illuminate the dials from behind, a special method has been devised for the purpose. On the bell chamber-floor above the clock room (see Fig 1) are eight copper lanterns, two for each dial, having plate-glass fronts and silver-plated holophotal reflectors. From these reflectors a powerfull stream of light is thrown upon an exterior reflector placed at such an angle as will project the light on the centre of the dial. The outside reflectors are movable, all four being extended or withdrawn at the same time, by an arrangement of wheels and cogs worked by the attendant.

This system of lighting, which has been thoroughly tested before adoption, is the best under the somewhat difficult conditions in which the clock has to be illuminated, and its advantages are that the lanterns being within the building, they can be of larger size than if suspended on the outside, whilst the light being better protected from wind and rain, will be steadier and more effective.

The striking part is made with all recent improvements, the hammer tail being raised by the great wheel, by which means a heavier blow and more sound are obtained than from the corresponding mechanism of the construction. The system used is the rack repeating work, which is the easiest in its action, safest in its lockings, and the most modern; whereas the old style of locking plate, or countwheel, was unreliable being apt to run past its lockings and stike the wrong hours. The clock will chime the Cambridge quarter the beauty of which is universally acknowledged being attributed to no less a musician than Handel.

Immediately above the dials is the bell-chamber, where upon a teak frame (see Fig. 5) the bells are so mounted as to produce the greatest volume of sound. These five bells have been specially cast for this clock, are of the finest gun-metal, and their tones are extremely clear and musical. The hammers are mounted in frames and fitted with steel counter-springs to prevent "chattering."

The following are the weights and notes of the bells:

	Weight. cwt.	qr.	lb.	Note.
Hour bell	20	2	0	$E_{\flat}$
Fourth quarter	8	3	11	$B\flat$
Third "	8	0	12	$E^{\flat}$
Second "	6	0	12	F
First "	5	3	0	G

The clock is now in course of being shipped for Calcutta, and when fixed will be by far the largest clock in India.—*Eng.*

THE SAINTIGNON PYROMETER.

In the pyrometer invented by M. de Saintignon, high temperatures are measured by inserting in the furnace a tube through which a current of water is passing at a uniform rate. The temperature of the water is measured by a mercurial thermometer as it enters the tube, and again as it leaves, and from the difference of the two readings, the intensity to which it has been exposed is deduced. The instrument is made in two forms. In the first it is applicable to heated spaces with thin walls, such as smokeboxes; and in the second, to furnaces inclosed with masonry. It is the latter form of which we annex an illustration. It comprises two thermometers, T1, T2, graduated with long scales, and connected by elastic tubes to the pipe E, which is passed through the wall into the furnace, the temperature of which it is desired to measure. A uniform current of water flows from a reservoir situated at a height of about 10 ft. above the pyrometer, passes through a filter, and descends into a vessel encircling the bulb of the thermometer T1. This thermometer indicates the initial temperature of the water. From it the water flows by the elastic tube E1 into the copper tube E, which is situated within the furnace, and is exposed to its heat at the particular point where it is stationed for the time being. The water becomes heated in its passage, and returns to the second thermometer E2, where its temperature is again measured. The speed of the current, and the length of the tube exposed to the action of the fire, are so adjusted that the water is raised 1 deg. for each 25 deg. of the furnace. A plate P, furnished with a handle *p*, carries a scale advancing 25 deg. for each degree of the thermometer scale ; its zero point is placed opposite the head of the column of mercury in the thermometer T1, and the temperature is read opposite the top of the mercury in T2. After leaving the second thermometer the water enters the pressure gauge M, which consists of a tube open at its upper extremity, and carrying at its lower end a cock R by which the water escapes. By adjusting the cock S, the flow is regulated until the water rises to the mark B in the tube ; and so long as it does not vary from this point, it is known that the calculated discharge is taking place through the cock R.

It is necessary, for correct determinations, that the water should not gather heat until it actually enters the furnace, and to this end the tube E is covered with a refrigerating envelope F, which encloses and protects all of it, except the part in the furnace. This envelope consists of a double copper pipe, to the centre of which there pass two small pipes E1, E2. A current of water, quite independent of that which flows in the pyrometer enters the envolope by the pipe N, passes along its entire length, and escapes by the tube O. The two tubes carrying the water used in the pyrometer are surrounded by a non-conducting covering ; and in order that the refrigerating envelope may not have any influence on the pyrometer tubes, it is arranged that the water leaving it shall be at a mean temperature between the initial and terminal temperatures of the water in the tube E. The pyrometer has been applied with much success to blast furnaces, glass works, porcelain and earthenware kilns, and gas works, bakehouses, and to many other apparatus requiring high temperatures. It is shown at the Inventions Exhibition in Group II. at the stand of M. Brin, who exhibits a method of making oxygen, in the North Court of the South Gallary.—*Eng.*

UMPHERSTON'S RAG ENGINE.

In Umpherston's rag engine the whole of the pulp is subjected to a uniform treatment, no part getting more beating than the remainder. This is effected by the adoption of a new method of circulation. Ordinarily the pulp, after it has passed the roll, turns away to the side and pursues an elliptical path, in order to again enter between the roll and the knives. That portion of it which travels along the outer side of the ellipse must go at a greater speed than the part which follows a shorter course ; and unless this is attained—and frequently it is not—part of the pulp gets more beating than the remainder, with the result that its quality is damaged. But in the machine we are describing, and which is illustrated on the opposite page, every particle has to travel the same distance, in passing from the delivery of the roll to the place where it again enters between the knives. This is attained by the use of a horizontal partition in the tank, in place of a vertical one so that the path of each particle of pulp, as seen in plan, is a straight line. After it has passed the knives it is driven over a breast, and emerges into the quiet space at the end of the machine. Here it sinks and moves backwards under the breast and the knives to the opposite end of the machine, ready for the next beating. In other respects this rag engine is very similar to the usual design, but as it relates to a process the knowledge of which is confined to a few, we will briefly describe its general features. The roll is a cylinder running at a high speed. Upon this cylinder there are cast lugs or joggles and between each pair of lugs there are fitted three knives or scrapers, running the whole width of the cylinder, and held in place by wooden distance-pieces and wedges. Below the roll are a number of fixed knives, set slightly at an angle to the knives on the roll. They slope each way from the side to the centre, so as not to divert the pulp to either side of the machine. Both sets of knives have square edges, and they exercise a tearing or grinding, rather than a cutting, action on the rags. The axis of the roll is carried in open topped bearings, which can be lowered by the handwheel shown in the figure, as the reduction of the material gradually proceeds, until a part or the whole of the weight is taken off the bearings, and the two sets of knives run in actual contact. When the water becomes dirty it is gradually removed by the cylinder shown at the right of the figure. This is lowered by the handwheel and the chain pulleys on the top shaft, until the spurwheel at the end comes into gear with the pinion to be seen at the back of the pulley. The cylinder is thus put into rotation, and lifts out the water, separating it from the pulp. For this purpose it has a grated surface covered with fine wire gauze, and within is provided with scoops communicating with a central pipe, which discharges through the bearing at the opposite end to that shown in the figure.

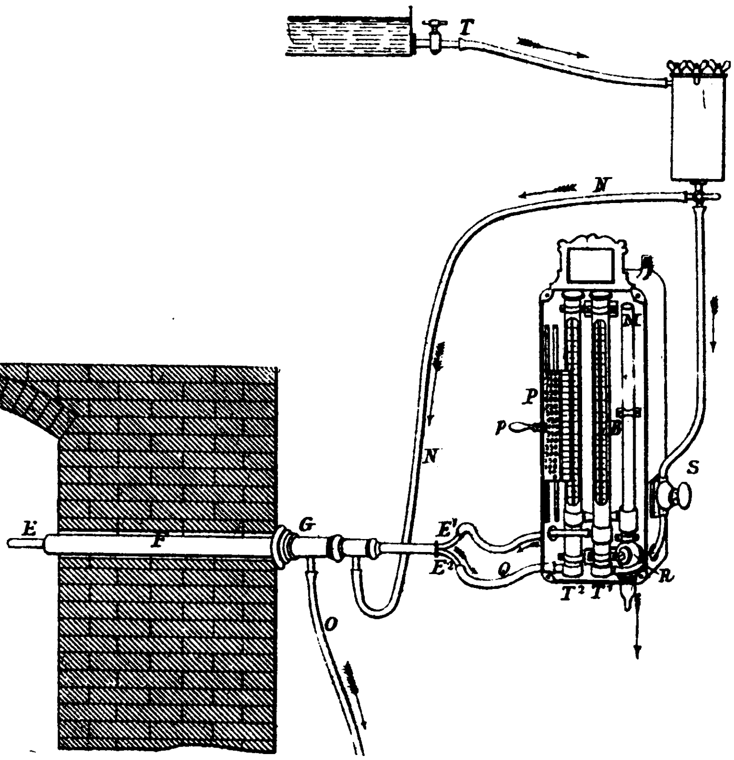
It is claimed for this machine (1) that the pulp circulates freely, although furnished thicker than can be done in engines of the ordinary kind, and (2) that it occupies only half the floor space required for an engine of the ordinary kind of equal capacity. The engines are made of various sizes from 60 to 300 cubic feet capacity, and upwards of 100 of them have been sold in the last three years by Messrs. Umpherston & Co., Limited. of Leith, and by Messrs. Bryan Donkin Co., of Bermondsey. London.—*Eng.*

NOTES ON SHIPBUILDING.

[A paper read at the Meeting of the Iron and Steel Institute, at Glasgow, Scotland, by Mr. J. H. Biles, Clydebank, Glasgow.]

When the Secretary of this Institution asked me, "as one who is in the thick of the work," to contribute a paper on steel shipbuilding, I could not but feel honored. The year that this Institution holds its meeting in the home of steel shipbuilding is not one when no contribution should be made to the literature of this subject unless there is absolutely nothing new to talk about, and I therefore, though reluctantly, have prepared a paper which, I hope, will serve to elicit a valuable discussion, if it does not by itself impart any information. There are two questions to be considered in undertaking to build any ship ; the first is the constructive possibility, the second is the commercial desirability. The first has become a certainty, as is evidenced by the increasing percentage of the total ships built which are steel, and by the confidence that is now felt by the great majority who have had the necessary enterprise to build in steel. The second has been several times demonstrated. First, by Mr. Parker, in 1878, who showed that a better profit could be made in a steel than in an iron ship ; secondly, by Mr. William Denny, in 1881, before this Institution, who showed the price per ton of steel in relation to iron which must rule in order that, per ton of dead-weight carried, a steel ship was as cheap as an iron one. Mr. William John, before this Institution, last year, pointed out that the relation between steel and iron necessary to make a steel ship as cheap in first cost per ton of dead-weight carried had been reached. This was a great point for steel to reach, because it made a comparison of profits independent of the freights, which was not the case in Mr. Martell's comparison. I shall endeavor to show later on that we have reached on the Clyde a relative price of steel to iron, where for the same size of ship the cost is practically equal, and therefore the ship-owner is in a position to have a considerable increase to his weight-carrying for the mere deciding whether his vessel shall be built of steel or iron. Why another iron cargo-carrying ship should be built upon the Clyde it is difficult to see ; and I shall endeavor to show later on that, even in ships where dead-weight carrying is not the desideratum, but capacity, by properly modifying the dimensions the full advantage gained by the dead-weight carrier can also be obtained by the measurement goods carrier. With the change from iron to steel as a common material of ship construction, there must necessarily follow some changes, great or small, in the construction of the ship, and in the general design in so far as the weight and strength of the structure-forming material affects the question of weight-carrying, stability, and principal dimensions. The experience of the last ten years in the manufacture of steel, and its application, among many other purposes, to ship construction, had enabled its users to say with certainty that a steel ship can be constructed with at least as much certainty of success in all respects as an iron one, provided that the dimensions are chosen, the structure is designed, and the work of building is carried out with a full appreciation of the fact that the ship is to be a steel one and not an iron one. With the adoption of the 20 per cent. reduction allowed by Lloyd's, and as carried out in their latest volume of rules by the substitution of the same number, twentieths of an inch in thickness in a steel ship for the corresponding number of sixteenths in an iron ship, the reduction in the weight of material, after allowance has been made for the different specific gravities of the two metals, must be about 17 per cent. But there are certain restrictions in this matter of reduction, such as thickness and arrangement of butt-straps, which prevent the full 17 per cent. from being realized. From approximate esti-

THE SAINTIGNON PYROMETER.

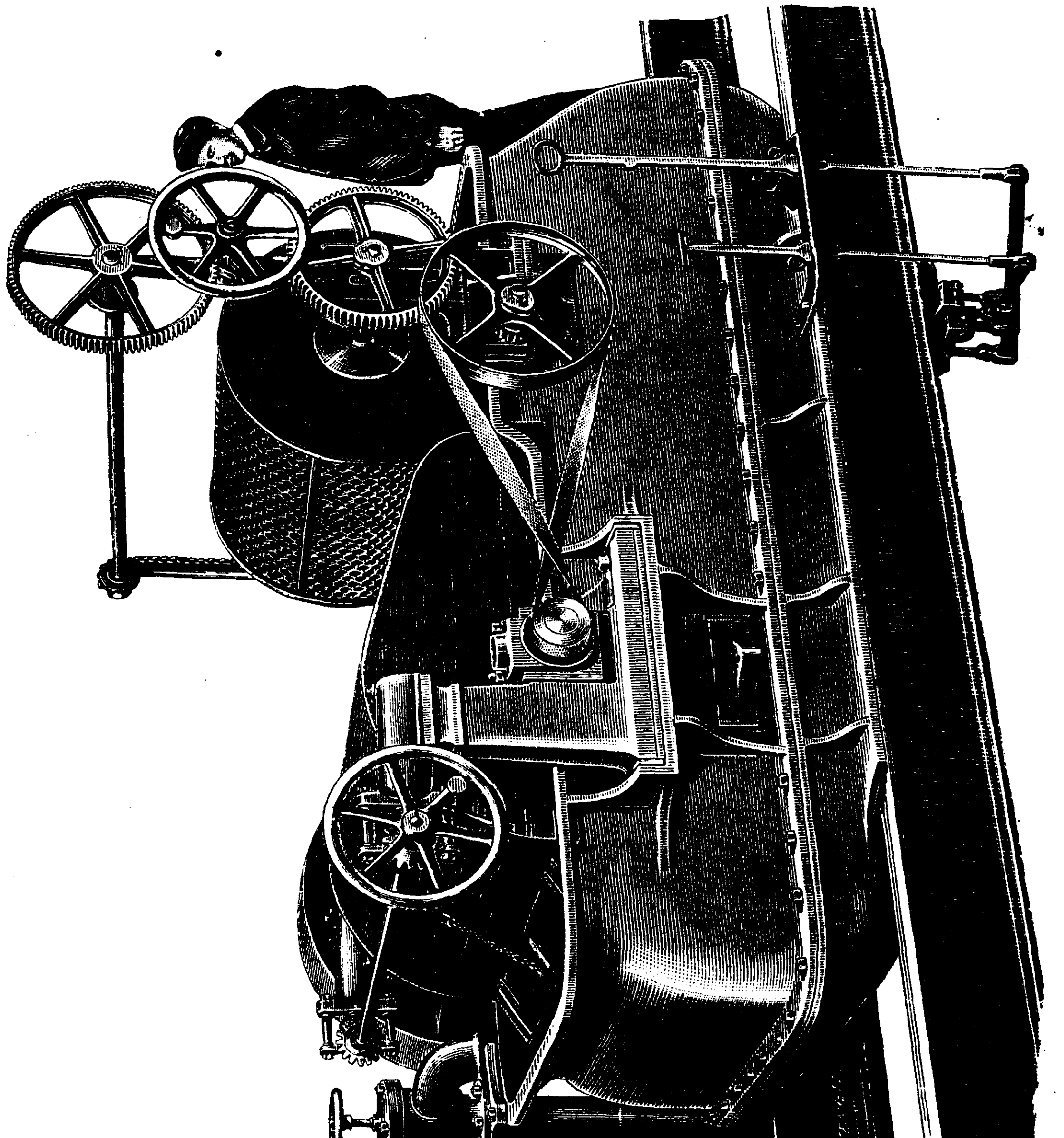


IRON.

Mineral.	Plate Thick.	Strap Thick.	Riveting.	Per cent. weight.
Below 8,000.	$\frac{7}{16}$	$\frac{8}{16}$	Straps of sheer stringer and one bilge strake $\frac{1}{16}$ thicker, and double rivet for ½ 1.	6.6
24 to 28,000.	.7 $\frac{11}{16}$ to $\frac{12}{16}$	.75 $\frac{12}{16}$ to $\frac{13}{16}$	Straps of sheer stringer and all outside strakes $\frac{1}{16}$ thicker, and treble rivet for ½ 1.	10.9
33,000 and above.	$\frac{12}{16}$	.875$\frac{14}{16}$	All straps of plating and U. & N. double stringers $\frac{2}{16}$ thicker, and treble rivet for ⅜ 1.	11.6
—	—	—	Length of plates, 14 feet.	—

STEEL.

Mineral.	Plate Thick.	Strap Thick.	Riveting.	Per cent. weight.
8,000	$\frac{7}{20}$	$\frac{8}{20}$	Straps of sheer stringer and one bilge strake $\frac{1}{20}$ thicker. Breadth of double-rivet straps, 9¾ in.	6.6
24 to 28,000	.55 $\frac{11}{20}$ to $\frac{12}{20}$	.75 $\frac{15}{20}$ to $\frac{16}{20}$	Allbutt strap, treble rivet back row complete for ¾ 1. Butt straps $\frac{4}{20}$ thicker for ½ 1. Remainder, $2\frac{2}{20}$.	13.6
			Straps—double, 11¼ in.; treble, 16¾ in.	
33.000	$\frac{12}{20}$	$8\frac{16}{20}$	Whole of butts fore and aft, treble rivet back row complete and straps, $\frac{4}{20}$ thicker.	13.8
			Straps—double, 11¼ in.; treble, 16¾ in.	
—	—	—	Length of plates, 14 feet.	—



UMPHERSTON'S RAG ENGINE.

mates made it appears that in the different classes of ships the amount of material saved per cent. is about as follows :

1,500 tons	13.9 per cent
2,500 "	13.7 "
3,500 "	13.5 "
4,500 "	13.3 "

These figures are based upon actual ships, which are principally cargo-carriers, but have a small amount of accommodation for passengers. It may be interesting to see why it is that though the scantlings or thicknesses are reduced by 17 per cent., the nett gain in weight of structure is only about 14 per cent. of the changed material. It is necessary here to state that, after allowing the 20 per cent. reduction in thickness generully, Lloyd's ask for an increase in the thickness of certain butt-straps in the outer bottom-plating and in the stringers, and also for an increase in the number of the rivets in the butts. To those two modifications are due the fact that the full 17 per cent. reduction cannot be gained. The following table shows for different sizes of ships the actual thickness and proportions of butt-straps to plates in iron and steel ships respectively :

(*See page* 328.)

From this it will be seen that there is in steel ships, with a number above 2,000 more butt straps required to the extent of from 2.7 to 1.7 per cent. of the weight of the plate than in iron. In the larger ships the butt-straps are actually as thick in the steel as in the iron ships. This is rather unfavourable to the steel ship, for the extra thickness cannot be required for tensile strength any more in the steel than in the iron ship, and if it is necessary to support the butt to resist compression, it may as well be iron as steel. If thes straps be iron instead of steel in a steel ship, a saving of about £100 in a 4,000-ton ship would be made. The following table has been prepared to show in some detail the changes which take place in every 100 tons of an iron ship, when it is modified to a steel ship of same dimensions, classing at Lloyd's in the 100 A1 class.

	1,500-ton Sailing-ship.			5,500-ton Steamer.		
	Iron plates assumed 14′ × 44″	Steel plates assumed 14′ × 44″	Steel plates a 16′ × 60″	Iron plates assumed 14′ × 44″	Steel plates assumed 14′ × 44″	Steel plates assumed 16′ × 60″
Outer bottom plating and stringers	31.2	25.9	25.9	22.8	18.9	18.8
Butt straps to ditto	2.23	2.22	1.95	2.13	2.37	2.04
Rivets to ditto	.68	.78	.68	.68	1.00	.88
Laps to outer bottom plating, etc	3.4	2.14	2.01	3.3	2.74	2.01
Rivets in ditto	2.23	2.16	1.57	2.23	2.16	1.57
Other iron which can be changed to steel	47.0	39.6	30.0	44.9	36.7	37.3
Rivets to ditto	2.9	2.9	2.7	2.7	2.7	2.5
Other iron which is not changed to steel	9.76	9.76	9.76	20.10	20.1	20.1
Rivets to ditto	.6	.60	.6	1.36	1.26	1.26
Totals	100.00	83.66	84.17	100.00	87.93	86.56

The results are given for two ships very widely different, a 1,500-ton sailing ship, and a 5,500-ton cargo passenger steamer. On the total weight of iron plates, angles, and rivets, there is a saving of 13⅓ per cent. in the sailing-ship and 12.07 per cent. in the steamer, on the assumption that the limits of length and breadth of the plates are the same. But it is at this point that steel has a great advantage over iron, and one which in the construction of ships will materially help it to completely displace iron as the staple structural metal. The effect of the advantage of using larger plates is that less weight for a given thickness is used in laps and butt-straps ; less riveting is required, less scrap is produced, less time is required in construction, and less cost for labor is involved. In the two third columns of the above table are given the percentages of the different items, on the assumption that the limits of length and breadth are 16 feet by 5 feet. The increased reduction due to this course is 2.5 per cent. in the sailing-ship, and 1.37 in the steamer, making the total reductions from iron 15.83 per cent. and 13.44 per cent. respectively. This is a point of the greatest importance in the future of ship construction ; and it is to be noted that the objections pointed out by Mr. Parker, in his paper read at the meetings of the Institute of Naval Architects in April last, to the use of large heavy plates in boilers do not hold to the bulk of ship-plates, as they are not subjected to furnace work. From the foregoing table it may be easily deduced that if iron plates and angles cost £5 per ton overhead, and rivets £8 10s., that the material for a steel ship can be bought for the same money as an iron ship, if steel is £6 per ton, if the limits of size are the same as iron, and £6 3s. 6d. if they are as indicated in the third columns, *i. e.*, with the increased size of plates. But this calculation takes no account of any of the other advantages due to the use of large plates. If we allow for one only—the reduced number of rivets—the overhead price of steel per ton, which must be quoted in order that the steel ship shall be built at least as cheaply as an iron one, is £6. 10s. Of the prices quoted to Messrs. Thomson during this year for steel and iron the mean ovorhead rates are—for steel, £6 9s. ; and for iron, £4 19s. 3d. Without dealing further with the question of difference in cost of labour, which is decidedly in favor of the steel ship, one is in a position to say that, on the Clyde, a ship built to class at Lloyd's according to their published tables, can be built at least as cheaply in steel as in iron. This being so the advantage to the steel ship is obvious, if weight-carrying power is of any commercial value to her. As a steel ship can be built as cheaply as an iron one of the same dimensions, it follows that, per ton of dead-weight carried, a steel ship must be cheaper. The 1,500 ton sailing vessel referred to will, if built of iron, carry about 2,260 tons, and if built af steel 2,400 tons, or 6¼ per cent. more cargo. In the 5,500-ton steamer the gain is 10 per cent. if the vessel be assumed to have a 12-knot sea speed, and to carry coals to take her from Liverpool to New York. If the voyage be longer the gain in cargo-carrying weight will be increased. As these gains in cargo-carrying can be obtained without any extra first cost, and with a very small increase of working expenses (dock, dues, coals, crew's wages and provisions, insurance, etc., all remaining unaltered), it is difficult to see why any iron sailing or steam ship should be built upon the Clyde or any other river where steel works are as close at hand as iron works. Experience has shown the reduced risk of total loss due to stranding in a steel ship, and now that Lloyd's have to a certain extent re-issued their "Rules for Steel Ships," it is fair to infer that they have no doubt that the 20 per cent. of reduction of scantlings makes a steel ship at least as strong as an iron ship. Two objections have usually been urged against steel ships. The first is that, as steel is so ductile, ships built of it are much less rigid than iron ones, and will soon begin to work. At Clydebank we have built, or are building, twenty-eight steel ships, representing over 50,000 tons, and in no single instance that has come to our knowledge has any defect in the structure been due to material. As these twenty-eight vessels include such great varieties as Transatlantic liners like the "Servia" and "America" sailing-ships, ordinary cargo steamers, and river steamers such as the "Columbia" and "Grenadier," the experience embraces all kinds of vessels, and it shows that ships can be constructed in steel, with a 20 per cent. reduction, that shall be as strong as iron ships. This experience is not uncommon with all ship-builders who have built largely in steel. The second objection is that steel more rapidly corrodes than iron. It is certain that if an iron ship be not watched and carefully coated, so as to prevent corrosion, she will very soon receive considerable injury. It is also certain that, if properly coated and watched, an iron ship is practically indestructible. It seems, therefore, to be much more a question of relative care necessary to protect the material, than the relative amount of corrosion which will go on if no care is taken ; and if a little extra care is required it cannot be anything like a set-off against all the other advantages. The Admiralty, however, having disoovered that most of the corrosion which has come under their notice is due to the galvanic action which takes place between the black oxide or scale and the metal itself, they treat all their outer bottom plating floors and lower plates of bulk-heads in a dilute acid bath to remove the scale. Messrs. Thomson, in carrying out this operation for the *Scout* class, which they are at present building for the British Admiralty, have devised a fast-running wire-brushing machine, which, after the plate has been dipped in the acid bath, burnishes the surface of the plate, leaving it almost like silver. This operation does not cost more than 1s. per ton extra over the whole of the ship, and it might be advisable for steel manufacturers to do this at their own works from the underwater portion of the outer bottom plating. The plant necessary is comparatively inexpensive. Another method of meeting this objection to steel is to galvanize those plates which are most liable to corrosion. The torpedo boats built by Messrs. Yarrow and Messrs. Thorneycroft, which have outer bottom plating varying from 1-16th inch to 3-16th inch, have a great portion of their structure galvanized. The floors and lower plates of bulk-heads of *Scout* are galvanized. Messrs. Denny have galvanized the plates of some of the light-draught vessels for the Irawaddy Company, and also have galvanized the tank-tops of some of their ships in the way of the boilers. It may be desirable to galvanize all the outer bottom plating of ordinary ships, and it has been pointed out by Mr. Denny that, unless something of this kind is done, it will not be possible to take full advantage of steel having higher tensile strength than that at present in use. This question of corrosion has a similar bearing in ships to that which it has in boilers, for it is certain that if the liability to corrosion is the same in both thick and thin plates, there must be a thickness beyond which it would not be advisable to reduce, however high a tensile strength the material may have. If galvanizing can be successfully and generally applied, this minimum will be much reduced, and the increase in tensile strength can be much further extended. At present the extra cost is its chief drawback ; but if higher tension steel be adopted, some of the saving in cost must go to pay for galvanizing. I think it may now be fairly claimed for a steel ship built to Lloyd's scantlings, as compared with an iron one of the same dimensions, that its first cost is not greater ; its strength is greater, liability to loss from collision or stranding is less, its liability to damage by corrosion need not be greater, and its dead-weight carrying capability (which is the *raison d'etre* of nine ships out of ten) is much greater. But a ship-owner in a measurement goods trade may say, " I do not want a stronger, a safer, or a greater weight-carrying ship, even for the same money, because, if I do not have the weight in the structure, I must put in ballast." This kind of objection may be applied to vessels like those of the Union and Donald Currie lines, which carry out general cargo to Cape Town and return with wool or nothing. To these shipowners it is necessary to point out that an increase in depth, accompanied by an increase in breadth, to preserve the stability, will add to the capacity, and, therefore, to the weight to be carried ; and if the operation be carried far enough, there will in most trades come a point where, even with a measurement cargo, it will be possible to overload a ship and lead the ship-owner to say, "I wish this ship's hull were not so heavy." In other words, by properly choosing the principal dimensions of a ship, it is possible to reduce all trades to dead-weight trades. I am quite aware that there are some considerations which come in to modify this statement, but they need not be further discussed here than to say that they may slightly reduce, but they cannot take away the force of the above proposition. To trades which are neither dead-weight nor capacity, such as high-speed passenger steamers, there is almost always a limitation of draught. The dead-weight carried by these vessels is almost wholly their machinery and coals, and consequently anything which tends to increase their weight-carrying may be made available for an increase of speed. Hence we are not likely to see high-speed passenger vessels built of iron again. There does not, therefore, appear to me to be any reason, with prices as they are at present, why another iron ship should be built upon the Clyde or any other river where steel can be produced relatively as cheap as it is here. The question of the reduced size of steel ships to carry the same dead weight, and the consequent reduced first cost, I have not dealt with, as Mr. William Denny so ably handled that subject in 1881. But if in the 1,500-ton sailing ship and in the 5,500-ton steamer there is a gain of 6½ per cent. and 10 per cent. respectively as before stated, it is obvious that there must be practically 6½ per cent. reduction of first cost in the sailing ship and 10 per cent. in the hull of the steamer. From the latter stands to be deducted from the first cost the saving in the cost of the engines of the smaller ship, and also as a recurring reduction the decreased dock dues and coal consumption. There is one point which I would respectfully suggest to Lloyd's that they should do in order to be quite equal in their treatment of iron and steel. It is that, as they insist on a breaking strain 26 to 32 per square inch on a reduction of 20 per cent. in the thickness in passing from iron to steel, they should insist on iron passing exactly similar tests, but with the limits of strength reduced in exactly the same proportion as the thickness of steel has been reduced. For instance, if an iron ship has plating 12-16 inch thick, and a corresponding steel one has plating 12-20 inch thick, the 12-20 plating per inch of breadth is expected to stand between 12-20 of 28 and 12-20 of 32 tons, or between 16 4-5 and 19 1-5 tons per inch of breadth ? It has to do the same work. If this were insisted on, the iron would have to possess a tensile strength of between $\frac{16\frac{4}{5}}{\frac{12}{16}}$ and $\frac{19\frac{1}{5}}{\frac{12}{16}}$ or 22 2-5 and 25 3-5 tons per square inch of sectional area. Some minor improvements in ship-building which are due to the use of steel may be briefly noticed. In a paddle-boat building by Messrs. Thomson there are no reverse bars on the floors, but the floor plates are flanged. This saves one leaf of an angle, and all the rivets which connect the reverse bar to the floors. This flanging is extensively adopted at Clydebank for all bracket work and intercostal work, instead of plates and angles, for bulkhead plates where the flanging of the plates takes the place of an angle, stiffening and various other purposes. For thin plates the flanging is done cold, but for plates above ⅜ inch it is done hot. Z frames have been extensively used in the framing of the *Scout*. We have found that for almost all the frames of a ship these Z's, when of the same depth and thickness as the frame, are cheaper than the ordinary method of frame and reverse. It was my intention to have noticed some modifications in the system of construction which appear to me to be desirable in a ship when built of steel, but time has not permitted it. One point may be worth noticing. In the National steamship " America," all the steel contributing to longitude strength above the lower deck, which is practically at the neutral axis, was made of a tensile strength of from 32 to 36 tons. All below was from 27 to 31 tons. I must apologize for the disjointed nature of this paper, but time did not permit of my giving more than a succession of notes on steel ship-building. I venture to hope that some of the points noted may be of sufficient interest to lead some of the members to speak upon them.

STEAM YACHT.

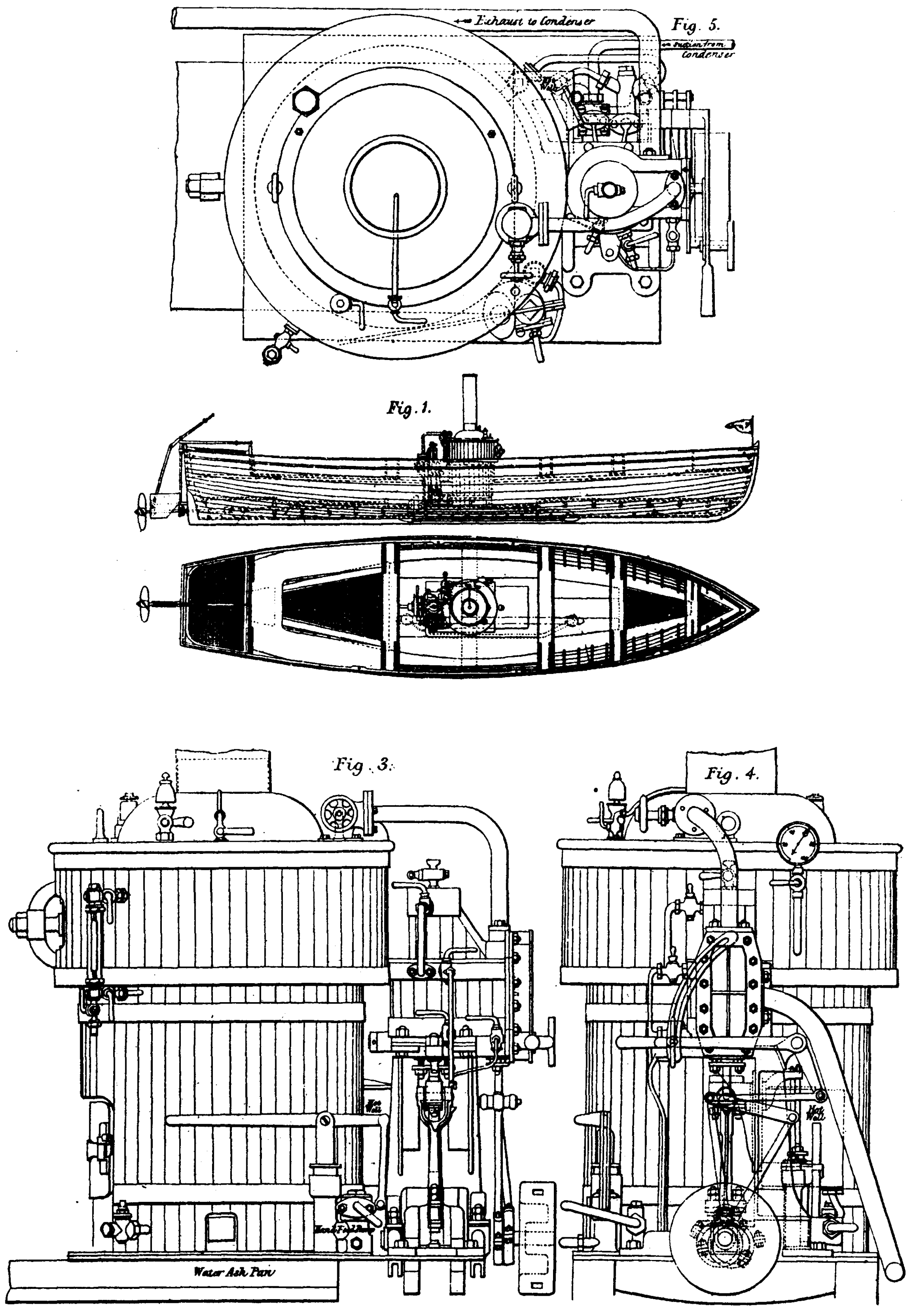
We give in Figs. 1 and 2 two views of the boat shown at the Exhibition, and in Figs 3, 4, and 5 on the same page three views of the engine. The boat itself is clinker-built of mahogany. She is open throughout and fitted with thwarts like an ordinary yatch's gig. The engines and boiler are, as may be seen by the illustrations, self-contained and are mounted on one bedplate, so that they may be lifted out bodily when the boat is to be hoisted to davits. The boiler is vertical and has a large firegrate so as to burn the required amount of coal with natural draught ; a somewhat difficult operation in small boats where the funnel must necessarily be low. The engine is arranged tandemwise, the high-pressure cylinder being 2 in., and the low-pressure cylinder 5 in. in diameter, the stroke being 3½ in.

There is, as our readers will remember, but one slide valve, and this work is a valve-chest, which is common to both cylinders. The exhaust steam from the high pressure cylinder is carried to a low-pressure cylinder through a port in the back of the slide valve, and it is claimed that the temperature of this steam is maintained during its passage by the live steam in the valve-chest. This is no doubt true, but we have always thought that it was bad policy to rob the steam from the boiler of any of its heat before it entered the high-pressure cylinder.

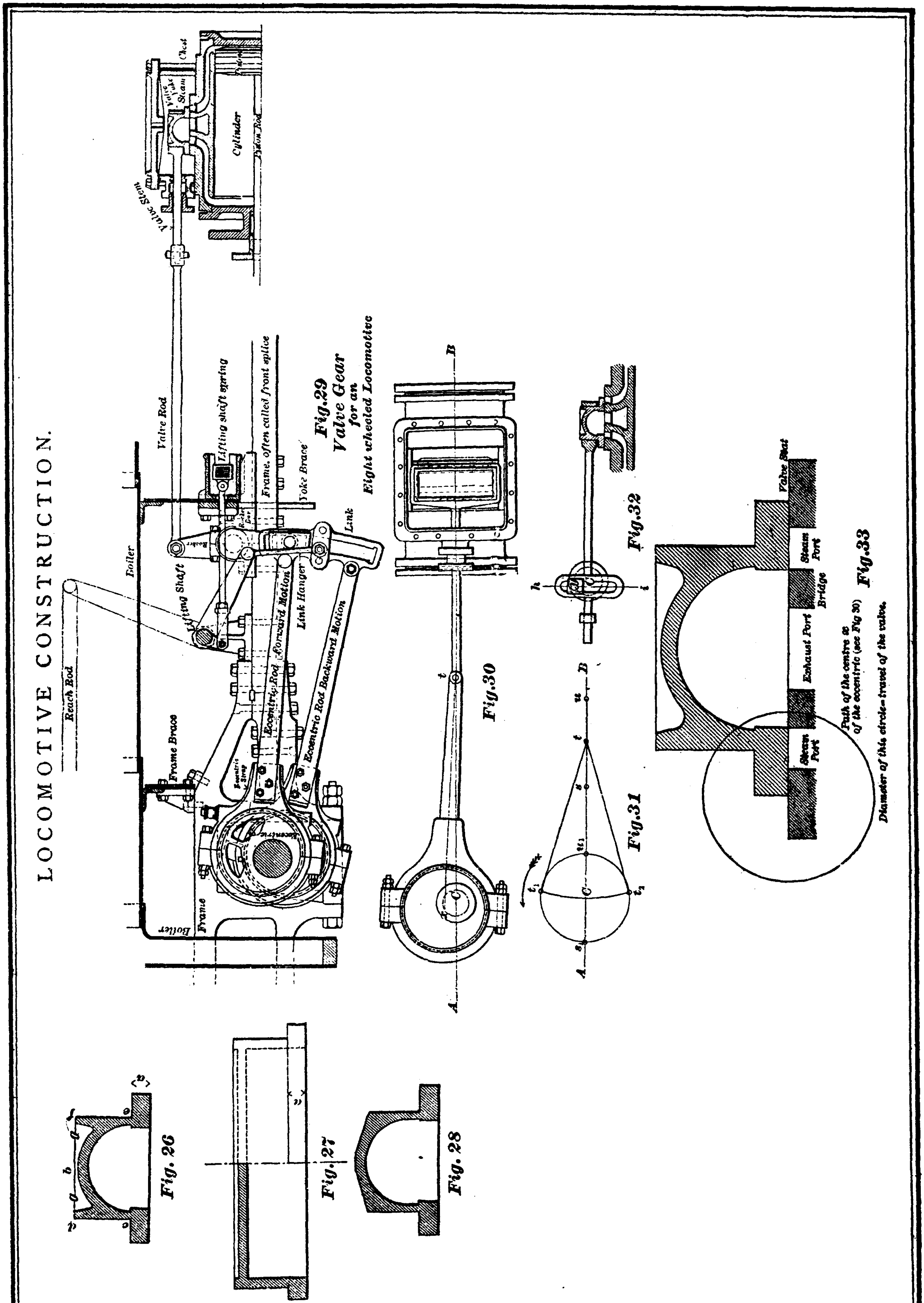
The feed and air pumps used by Messrs. Simpson and Denison are of a special type which was fully described in our former notice. Messrs. Simpson and Denison have adopted the outside pipe condenser, with which we are aware they have got very successful results. Probably this is mainly due to the excellent design of pumps already referred to, and we think it possible that with ordinary pumping gear this type of condenser might not prove so successful. The pumps made by this firm appear to be unfailing in their action, and those who have run small surface-condensing machinery where any cylinder lubrication is used will recognise how very far this goes to constitute succcess in boat machinery of this type.

Steam is carried in both the cylinders of Kingdon's engines for nine-tenths of the stroke, the expansion being obtained by the difference in the size of the two cylinders. In this way a more effort on the crankpin is got, a point of considerable advantage when there is only one crank. At the same time it is perhaps hardly correct to describe this engine as a compound

STEAM YACHT.



Exhaust to Condenser
Fig. 5.
Suction from Condenser
Fig. 1.
Fig. 3.
Fig. 4.
Water Ash Pan


LOCOMOTIVE CONSTRUCTION.
Fig.29
Valve Gear
for an
Eight wheeled Locomotive
Valve Stem
Valve Rod
Cylinder
Piston Rod
Steam Chest
Boiler
Reach Rod
Lifting shaft spring
Frame, often called front splice
Yoke Brace
Link
Rocker
Lifting Shaft
Frame Brace
Eccentric Rod Forward Motion
Link Hanger
Eccentric Rod Backward Motion
Eccentric Strap
Eccentric
Frame
Fig.30
Fig.31
Fig.32
Fig.33
Valve Seat
Steam Port
Bridge
Exhaust Port
Path of the centre x of the eccentric (see Fig 30)
Diameter of this circle=travel of the valve.
Fig. 26
Fig. 27
Fig. 28

engine; at any rate there is not present the great advantage of the compound system, which is the reduction of the range of temperature of steam acting in any one cylinder.

There is one special point about the gig in the Exhibition to which we have not made reference. The propeller, it will be seen, is carried abaft the rudder, and just outside the stern tube there is a universal joint in the shafting. The after end of the short length of propeller shafting is carried in a bearing which is at the end of the connecting-rod shown, the latter in turn being attached to a lever, the fulcrum of which is on the rudder head. The rudder itself is made of two sheets of metal spaced an inch or so apart, and by pressing down on the lever the propeller shaft will rise in the divisions between the two plates. In this way the propeller can be lifted when the boat gets into shallow places, but at the same time a good immersion is got for the screw when there is plenty of water. The movement of the rudder also moves the propeller in a horizontal direction, so that additional steering power is obtained, on the principle of the Kunstadter rudder, in which, it will be remembered, a small auxillary screw was placed abaft the rudder in a somewhat similar manner. Messrs. Simpson and Denison have provided what has long been wanted for yaching work, viz., a practicable surface-condensing engine for small vessels, and they quite deserve the very substantial success they have achieved.

MODERN LOCOMOTIVE CONSTRUCTION.

By J. G. A. Meyer.

TENTH PAPER.

SLIDE-VALVES, AND MOVEMENT OF SLIDE-VALVES.

Slide-valves are sometimes made of brass, but generally of cast-iron. Cast-iron slide-valves are more durable than brass valves, but the latter do not wear the valve's seat as quickly as the cast-iron valves.

The ordinary form of slide-valve, such as is generally used in locomotives, is shown in Figs. 26 and 27. Fig. 26 represents a cross-section of the valve; one-half of Fig. 27 shows a section lengthwise of the valve, and the other half an outside view of the same. The thickness of metal at *a* is generally made 1 in., and at *b* about ½ in. The sides *c*, *d*, *e*, *f* are extended upward until they become flush with the top *b* of the valve; in some cases these sides are extended a little beyond the top of the valve. This has been done for the following practical reasons: In the first place, a large surface is produced against which the valve yoke is to bear. Secondly, this form of valve can be laid on its back, and thus speedily and conveniently secured to the planer, when the valve face is to be planed; this is a matter of no small importance in a large locomotive establishment where a number of valves have to be planed daily. The recesses *g g* shown in Fig. 26 are simply for the purpose of making the valve as light as possible. Some master mechanics object to these recesses, because they believe that they will hold the oil (which is usually admitted through the top of the steam-chest), and prevent the oil from falling upon the valve-seat, and thus not find its way into the cylinder. For this reason a valve has been adopted having a form as shown in Fig. 28. This form of valve, although used on some roads, has not been favorably received on other roads, because it takes up too much room in height, and besides it is an inconvenient casting to fasten to the planer when the face is to be planed or replaned. The writer would recommend the adoption of a valve having a form as shown in Fig. 26, and believes that the fear of the recesses *g g* preventing the oil from flowing into the cylinder is groundless, and that the constant flow of steam into the chest will not allow the oil to lay still on any part of the valve.

The duty of the slide-valve is to control the flow of steam into and out of the cylinder, that is, the valve (as its name implies) slides backward and forward on the valve-seat, thus opening and closing the steam ports at proper times. Whether it will perform this duty or not, depends upon form and motion of the valve.

Fig. 29 shows a complete locomotive valve gear; the names of the different pieces of the mechanism are plainly marked on the drawing, so that here any further definitions of these pieces will be unnecessary.

To construct a slide-valve and assign to it the proper motion, such as shown in Fig. 29, may seem to be a difficult subject for solution; and so it would be, if, right in the beginning we do not—wheresoever we can—throw out of consideration all such pieces of mechanism as have a complicating influence upon the motion of the valve. Hence it is of the utmost importance first to reduce this subject to its simplest form. It will be noticed that the operation of the valve is controlled by two eccentrics: one eccentric is used for the forward motion and the other for the backward motion of the engine. Here we may simplify our subject by leaving out of consideration the backward eccentric, because when the valve is made to accomplish the desired results with one eccentric its form will not have to be changed when the other eccentric is added. But leaving the backward eccentric out of the question, we may also leave the link out of consideration, because the link only serves to connect the two eccentric-rods so as to enable the engineer to put wholly or partly into gear one or the other eccentric. The lifting-shaft is simply used for moving the link up or down as the case may be; and since the link has been thrown out of consideration we may treat the lifting shaft likewise. The rocker is simply used for the purpose of connecting the eccentric-rod to the valve-rod, and although it affects the position of the eccentrics, and in some cases the travel of the slide-valve, it will not affect the laws relating to the construction of the valve, and therefore we also throw this out of consideration.

Reducing our subject as described, and connecting the eccentric-rod directly to valve stem, we obtain a simple arrangement, Fig. 30, such as is often used in stationary engines; of course, in this arrangement we must assume that the driving axle of the locomotive is represented by the crank-shaft *C*, and the eccentric placed on the end of the shaft as shown. In this arrangement, simple as it is, a feature exists which has a somewhat complicating influence upon the motion of the valve, and therefore will interfere with the simplicity of our study of the laws relating to the form of the valve. The feature alluded to is the angle that the eccentric-rod makes with the center line, *A B*. This angle varies during the travel of the valve, and consequently the motion of the valve will be slower during one half of the travel than during the other half. Thus, for instance: Let the line *A B*, in Fig. 31, represent the line *A B* shown in Fig. 30. The circle s_1 t_1 u_1, Fig. 31, will represent, in an exaggerated manner, the path of the center *x* of the eccentric shown in Fig. 30, and, lastly, the distance from the centre *x* to the center *t* of the eccentric rod pin in Fig. 30, is represented by the line t_1 *t*, in Fig. 31. Now, referring only to Fig. 31, when the valve stands in an extreme position of its travel, the center of the eccentric-rod pin will be at *u*, the center of the eccentric will be at *u*, and the center line of the eccentric-rod will lie in the line *A B*. Again, when the valve stands in the other extreme position of its travel, the center of the eccentric rod pin will be at *s*, the center of the eccentric will be at s_1, and the center line of the eccentric rod will lie in the line *A B*. When the slide-valve stands central, that is midway between the extreme ends of its travel, the center of the eccentric rod pin will be at *t*, exactly midway between the points *s* and *u*.

From the point *t* as a center, and with a radius equal to the distance *Ct*, describe an arc; this arc will intersect the circumference s_1 t_1 u_1 in the points t_1 and t_2. Join the points *t* and t_1 by a straight line, also draw a straight line from the point *t* to the point t_2; then the straight line *t* t_1, and *t* t^2 will represent the center of the eccentric-rod when the valve stands in a midway position of its travel, the point *t* will be the center of the eccentric rod pin, and the point t_1, or the point t_2 will be the center of the eccentric. Assume that the shaft is turning in the direction indicated by the arrow. When the eccentric-rod pin has travelled from *u* to *t*, equal to half the travel, the slide-valve has also completed one-half of its travel, and the center of the eccentric has travelled through the arc u_1 t_1, Again, during the time that the eccentric-rod pin travels from *t* to *s*, equal to half the travel, the centre of the eccentric will travel through the arc t_1 s_1. But now notice the difference of length of the two arcs t_1 s_1 and t_1 u_1; this plainly shows that the eccentric-rod pin will travel slower from *u* to *t* than from *t* to *s*, and consequently the travel of the valve will be affected likewise. Or, we may say, that the angle formed by the lines *t* t_1, and *A B* destroys the symmetry of the valve motion. Now, in the study of the laws relating to the motion of the valve and the duties it has to perform, such a motion will complicate matters, and will prevent us from tracing the action of the valve so readily as when both valves of the travel are described in equal times, and therefore the reader will perceive the necessity of changing the valve gear to one which will give the valve a perfectly symmetrical motion.

In the first place, it will be easily seen that the longer we make the eccentric-rod—leaving the travel of the valve the same—the smaller will be the angle between the line *t t* (which represents the center of eccentric-rod) and the line *A B*, and consequently the times in which the halves of the travel of the valve are described will be nearer equal, and when we assume the eccentric-rod to be of an infinite length the angle will vanish and each half of the travel of the valve will be described in equal times, and the motion will be symmetrical; in fact, the valve will have precisely the same motion as that obtained with a valve gear, as shown in Fig. 32, to which we shall now call attention.

In this figure, in place of using an eccentric-rod, the valve-stem is lengthened, and to its end a slotted crosshead is forged. The eccentric has also been dispensed with, and in its place a pin *y* fastened into the end of the crank-shaft has been adopted. The distance between the center *C* of the crank-shaft and the center of the pin *y* must always be equal to the distance between the center *C* and the center *x* of the eccentric shown in Fig. 30. This distance from *C* to *x* is called the eccentricity of the eccentric, and is equal to one-half of the throw, or in other words, the throw of an eccentric is equal to twice its eccentricity. In this particular case, as shown in Fig. 30, the throw is equal to the travel of the valve; by the travel of the valve is meant the distance between the extreme points of its motion. In locomotives, the travel of the valve is not always equal to the throw of the eccentric, the difference being due to the influence of the link, and often to the unequal lengths of the rocker-arms.

Now, turning our attention to Fig. 32 we notice that by substituting for the eccentric a pin *y* in the end of the crank-shaft, we really adopt a crank, and this we can do without affecting the correctness of the reasoning relating to the movement of the valve, because the action of the eccentric is precisely the same as that of a crank whose length is equal to half the throw; the only reason why eccentrics are adopted, is that they are more convenient to use, in fact, cranks in some cases cannot be used, the peculiar construction of the machine preventing; in no case is an eccentric adopted because a different motion to that due to a crank is desired.

We have drawn particular attention to this fact, because some mechanics (a good many of them) have a misty notion of the action of an eccentric.

As the shaft revolves (see Fig. 32) the pin in the end of the shaft will move in the slot of valve-stem's crosshead, and thus, always allowing the center line of the valve-stem to coincide with the line *A B*. It must also be plain that as the shaft revolves the center of the pin will describe a circle, and it is the circumference of this circle that will enter into the solutions of the following problems. Once more, the reader will easily perceive that the length of the valve-stem will in no wise affect the motion of the valve, hence we may leave this also out of consideration, and place the circumference of the circle which represents the path of the pin *y*, on the end of the slide-valve, as shown in Fig. 33. Here then we notice that our original subject, that of finding the proper motion and form of a valve, a subject in which all the different pieces of mechanism, as shown in Fig. 29, had entered, has been reduced and simplified to that having only the pieces of mechanism as shown in Fig. 33.—*Am. Mach.*

BOILER EXPLOSIONS.

A great many engineers persist in clinging to the belief that a good boiler can not be exploded except through shortness of water. They also remain under the impression that, should the sheets of a boiler get hot, and the feed water afterward be turned on, an explosion is almost inevitable. There is diversity of opinion among the so-called "experts" who hold these views, as to the origin of the force which will cause an explosion under these conditions. Some believe that a mysterious gas is liberated, which tears the sheets asunder with irresistible force; others say that the imminent danger arises from the sudden generation of steam from the hot sheet. Those who have studied physical science, and understand the low capacity of iron for heat, readily perceive that the iron of a boiler could not retain enough heat to generate such steam; but the men who figure as experts at many boiler explosion investigations have not troubled themselves with exact data respecting natural laws. Much useful information might be obtained respecting boilers by reading the accounts of experiments made at various times in this country to ascertain the cause of boiler explosions.

Experiments were made with boilers at the Harrison Boiler Works, Philadelphia, many years ago, under the direction of the Franklin Institute. They were anxious to see how a boiler would act were it made red-hot, then had water pumped in, and arrangements were made to do this. Steam of 150 pounds pressure was raised on a boiler, then the water was run off. The boiler was permitted to get almost red-hot, then water was pumped into it; but, instead of making more steam suddenly and causing an explosion, the water merely cooled down the plate. This was repeated several times, always with the same result. The Pennsylvania Railroad Company made experiments with boilers about fifteen years ago to ascertain the cause of explosions. A locomotive, which was condemned, was run out on a side track away up in the woods. They fired up and fastened down the safety-valve. In the first test the safety-valve was not weighted heavy enough to cause an explosion, but a second trial permitted the steam to run up to about 200 pounds, when the boiler exploded with terrific violence. The boiler was full of water and had every condition that would ensure safety, except that the steam pressure was excessive. They then took a second engine and treated it in the same manner, but the boiler proved capable of sustaining a pressure of 200 pounds, so there was no explosion. They afterward took this engine and ran the water off till the crown sheet was exposed and got red-hot. In this condition water was pumped into the boiler, but no explosion took place. The sheets cooled down and leaked badly, but that was all.

In 1871 the united railway companies of New Jersey subscribed $10,000 to enable Mr. F. B. Stevens to enter upon series of experiments in testing steam-boilers to destruction. To further aid the investigations, the companies gave to Mr. Stevens several old boilers that had been removed from their steamers. A number of the leading engineering experts of that day volunteered their services to assist in the experiments. The old boilers were subjected to hydrostatic pressure until rupture occurred, then were repaired and ruptured again to indicate where the weakest spots were, which in turn, were strengthened. When the boilers had finally been put in good order, after going through a severe testing ordeal, they were removed to the War Department's reservation at Sandy Hook for the purpose of undergoing steam tests.

The first tests were made on a return-flue cylindrical boiler, 78 inches diameter, 20 feet 4 inches long, made of ½-inch iron. During the first of the preliminary hydrostatic tests made with this boiler, it gave out at 66 pounds per square inch, by the stay-bolts pulling through. After being repaired and taken to Sandy Hook, it was subjected to a hydrostatic pressure of 82 pounds without showing signs of distress. Under steam this boiler stood a pressure of 93 pounds, when a rent occurred, and other leaks prevented the increase of tension.

The calamitous explosion of the Westfield's boilers was still fresh in the public mind, and the second experiment was made with a small boiler which had been constructed to determine the probable strength of the stayed surface of the Westfield's boiler. It had the form of a square box, 6 feet long, 4 feet high and 4 inches thick, the two sides being held by screw stay-bolts, with their ends slightly riveted over. This boiler was tested to 138 pounds pressure by water, which it stood without any signs of weakness. Under steam this boiler exploded with terrific violence at about 167 pounds pressure. When the fragments were examined, it was found that the sides had stretched considerably, assuming a dished form 8 inches deep. All the stay-bolts drew out of the sheets without fracture, and without even stripping the thread of either the external or internal screw.

The third experiment was made with a return-tubular boiler that had been at work twenty-five years. This boiler had gone through several hydrostatic tests, and was strengthened at the points found weak. After it had been repeatedly repaired, the boiler was tested at Sandy Hook to 59 pounds cold pressure, and afterward a steam tension of 45 pounds all of which it stood without apparent injury. It was then filled with water 15 inches above the tubes, and a heavy fire of wood started in the furnace. When a pressure of 50 pounds to the square inch was reached, the gentlemen making the experiments heard a loud report, caused probably by the breaking of braces. When 53½ pounds was recorded on the gauge, the boiler exploded with a noise resembling the discharge of a heavy cannon. The boiler was found torn to fragments. The explosion happened with a pressure of steam

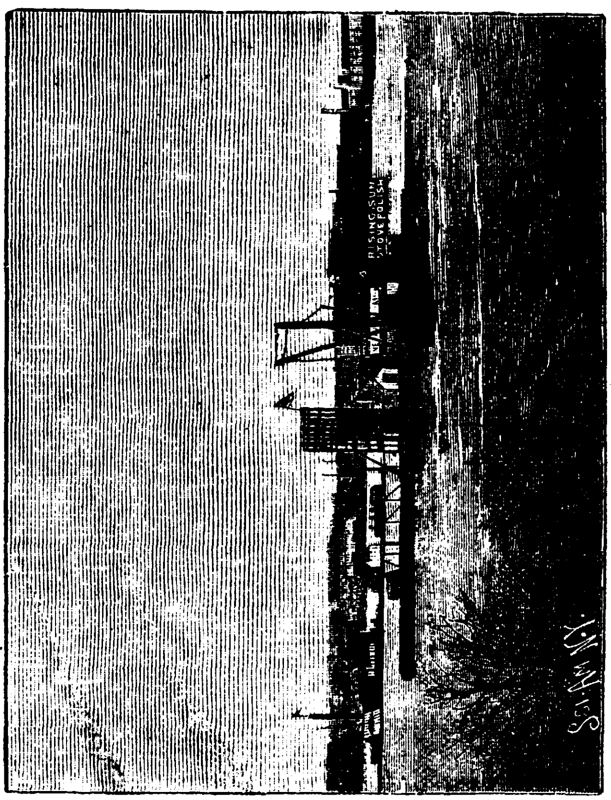


Fig. 1.—JUST BEFORE THE EXPLOSION.

Fig. 2.—JUST AFTER THE EXPLOSION.

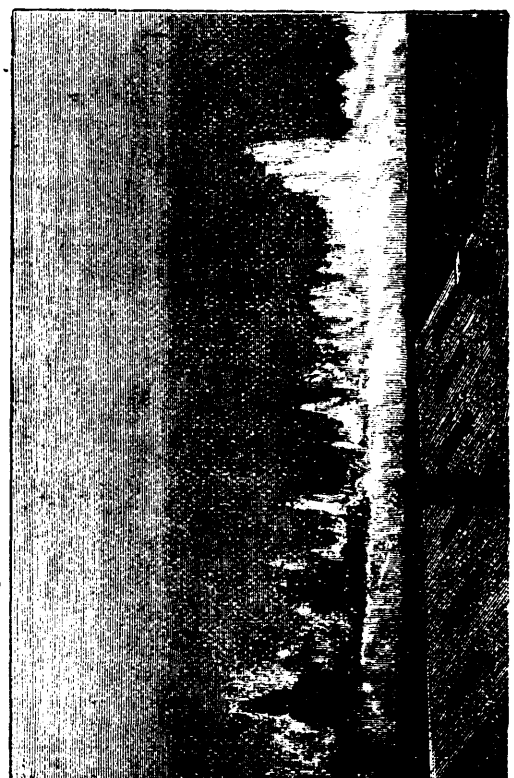


Fig. 3.—THE WATER RISING.

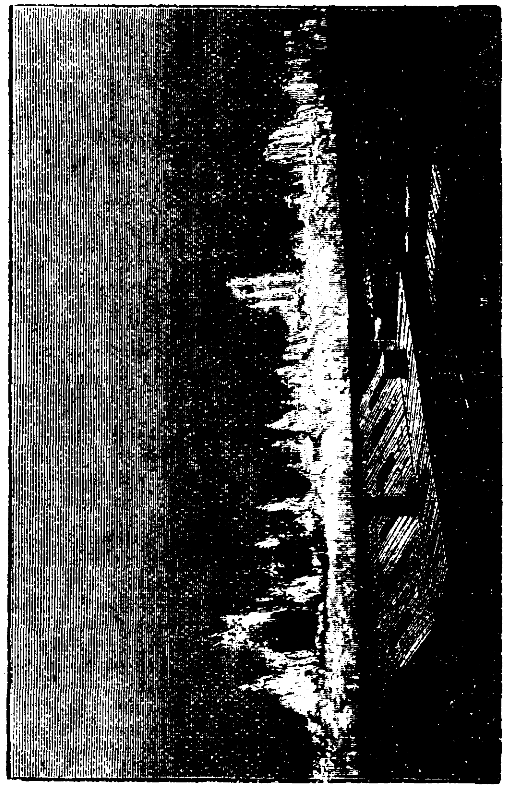


Fig. 4.—THE WATER NEARLY AT ITS HEIGHT.

Fig. 5.—FLOOD ROCK EXPLOSION—THE WATER AT ITS HEIGHT.

5½ pounds less than it had stood safely with water. In this case it was also observed that the stay-bolts pulled out of the the shell without injuring the threads of the screws.

Some months ago our attention was called to the case of a locomotive whose fire-box crown sheet came down when the engine was at work. The crown had been secured by radial stay-bolts, and on examination it was found that the stay-bolts had been drawn out of the sheet without injury to the threads. From this circumstance, it was concluded that the stay-bolts had been loosely put in, and that the accident resulted from inferior work. The experiments related indicate that pulling out of stay-bolts without injury to the thread is no indication of inferior work. The intense pressure appears to stretch open the sheet and fold it away from the thread. The same thing has been seen in many other exploded boilers.—*American Machinist.*

DIAMONDS IN SOUTH AFRICA.

Among the "curiosities of commerce," none perhaps is more curious than that the major portion of the produce exported from South Africa is simply used for the adornment of ladies. Out of a total value exported of $36,000,000, ostrich feathers and diamonds account for $25,000,000. Twenty years ago all known diamonds had come to Europe or the United States from immemorial Eastern stocks, or from the scanty produce of mines in Brazil and elsewhere, which were calculated to yield not more than $250,000 worth in the year. To-day, situated in the midst of a wide-stretching plain, affording at all points a sea-line horizon of flat "veldt," we find the town of Kimberly with a large European population of wealthy and well-to-do people, and a large native population earning every year more than $5,000,000 in wages. And from this mining oasis in the agricultural desert has been sent out in the last fifteen years something like $200,000,000 worth of diamonds in the rough, which, with the cost of cutting, setting and selling, must have taken from the pockets of the consumers something approaching $500,000,000.

As all the world knows, the South African diamond mines have their own story of unexpected discovery at the least as startling as that of any gold field or any other rich mineral deposit in the world. In 1867 the first diamond was found, the favorite toy of a little Boer girl, which she had picked out from among the roots of an old tree, Its genuineness was not long in doubt, and in a few months the bed of the Vaal river was known as a profitable diamond region. Prospecting became the rage, and here and there on the open, flat, grassy veldt diamonds were found in spots with common peculiarities of soil, and so forth. In three years' time the secret of the diamond deposits have been so far fathomed as to prove that they were strange circular deposits or patches of peculiar earth, isolated from one another and few in number. These were at once "rushed," and a regulation digging community took possession of the new district. Private individuals, previous proprietors, and governments fought for the claim to these new mineral riches ; but despite these squabbles the practical work was carried on of marking out these circular patches in diggers' claims over the flat surface. At first the rule was each digger for himself, and with pick and shovel diamonds were brought to grass in such profusion that the whole mining world was startled by a discovery exceeding in magnitude, real and prospective, any previous find. But as men dug deeper in their claims, so they found it necessary to arrange and amalgamate with their neighbors ; moreover, the deeper they went the more necessity for machinery to hoist the soil to the surface. And then, as they passed on through the top "yellow," they came upon a "blue" soil which was yet more rich in diamonds.

Suffice it to say, that in ten years' time each one of these greater circular areas had been so far emptied of soil as to represent great quarries 100 to 200 yards across and 300 or 400 feet deep. Early in the digging the geologist stepped in to point out that these circular basins were evidently a species of volcanic crater, hollowed out in the surface rock by subterranean action and filled up to the surface with a blue diamondferous mud. The walls of these basins are locally known as "the reefs," and in their greed to secure all they could the old miners cut out all the "blue" right up to the reef. When, however, the cuttings got down deep the walls, or reefs, began to fall in, owing to the disintegrating action of broiling sun and heavy rain, covering up in their fall large areas of valuable blue. At first the digging was simple and cheap—the mere turning up and searching of loose soil ; a second stage was reached when the soil had to be cut and hauled up to the surface with the aid of machinery ; a third stage brought the miners to a stiffened blue, which had not only to be brought to the surface, but then spread about and broken up by hand labor and exposed to the weather, and at the present moment all around the mines are to be seen literally miles of the "blue" laid out in shallow layers over the open veldt. With these more extended operations came elaborate machinery for hoisting, for spreading on the "floors," and for sorting. Now, around each great basin or quarry is a circle of steam engines working wire-rope lifts up and down to the bottom of the quarry, and around the brink run locomotives and trains of trucks whisking the "blue" so brought up away to be spread out like so much manure over the veldt, and to be taken thence, when duly disintegrated by the weather, broken up by hand and harrowed and rolled, to the washing places, where it is all sent by hydraulic action through a series of rotary sieves and pulsators, on the principle of, in successive mechanical operations, washing away all dirt that is lighter than diamonds.

The washers are so arranged that the outfall of each portion is graduated in size, and falls on a series of sorting tables. At these stand five or six of the principal men—owners and directors of companies among them—spreading out the clean washed stuff, graduated from the size of pebbles to that of sand ; and the visitor may stand by in wonder to see the searcher at the one end pick out his eight or ten "big" stones per hour, or assist the searcher at the other, busily sorting out of the sand innumerable white specks of diamonds. The day's work, tumbled into small snuff boxes, will frequently reach a local value of $5.000. None can fail to be struck, on looking into one of these great mines or quarries, that the whole of that great mass of earth and rock has been dug out, pulverized and searched for the diamonds it contains. One can look into a quarry of slate or stone and see the rocks themselves cut down and carted away for use ; but in these quarries the soil and the rock are cut out and dug out, and what for ? Simply that out of every 100 tons raised out of the quarry an ounce weight of diamonds may be secured. It is a startling and impressive thought, in gazing into these great quarries, that all that soil should have been dug out at a cost for labor alone of something like $75,000,000, and with the aid of invested capital of $5,000,000 in machinery, in order to distribute so many hundred weight of precious stones to decorate the ladies of civilized centers.

And now a fourth stage has been arrived at. As has been stated, these diggings have reached a depth of 300 or 400 feet, and the sides of the quarries are falling in. The new problem is how to continue to dig out the "blue" which now lies practically beneath the reef. The consequence is that around these quarries regular mining shafts are being sunk, and the "blue" is to be attacked by underground work. Good mining judges maintain that this is the wrong system, and that it would be better to terrace the reef sides and always work them as open mines or quarries. Thus, as years go by the cost of getting out these diamonds increases steadily, but it also happens that the price of diamonds has steadily and greatly fallen. The all round price per carat has fallen from $14 to $3.75 per carat. At this one can not be surprised. The fall in price has, however, already checked the output, as several of the smaller mining bodies, and also those working the less profitable mine, have ceased work. It seems probable, also, that even the larger mines will reduce operations in the face of low prices, and then as the supply falls off so may prices again be expected to rise.

But this fall in price is not only due to overproduction. It is estimated that 10 to 15 per cent. of the fall is due to the sale of stolen diamonds. These, of course, can be, and are, sold at a very low price, as their cost of production usually means some trifling sum paid to a native laborer for what he can secrete on his person or otherwise smuggle out of the mine. In the early days, when each man worked for himself, there was no diamond stealing ; but as it grew to be necessary to work on a larger scale, and by the aid of hired labor, and at the same time the process of operating afforded new opportunities for stealing, this crime grew to be one of the great curses of the industry. At present, at every stage of the process laborers or employés come across diamonds. The men down in the mine, blasting and picking out the "blue," frequently come upon the valued stones ; and as the "stuff" is handled at every stage diamonds show themselves. The natives posted to empty the buckets coming up from the mine watch keenly for what may gleam in the process, and so does the engine driver or mule man who runs the laden trucks out to the floors. And on these floors the regular gangs who unload and break it up find many and large "stones"; and so, right through the process, there is ample opportunity at every turn to pick up a stone which is sure to be worth many dollars, and may be worth thousands of dollars.

How to prevent, or even to check, this thieving has taxed the best energies of proprietors and police for many years past. Success has not yet appeared, for with every new appliance some new form of theft seems to come into being. There are endless means actually adopted. Swallowing the stones is quite common, and at one time the thief threw them, wrapped in dough, to dogs, which were killed and cut open by his confederates outside. Hiding them about the dress, and pitching them away to be picked up at night, are among the other means. From the commencement the method of collecting the stones has been "rough and ready" rather than careful and complete, and to the stranger there appears to be not only every chance, but every temptation, for employés to steal perpetually. The evils of this diamond stealing are far-reaching. Foremost among them stands an unnatural lowering of prices. The possessor of the stolen stone has paid but little for it, and although he will naturally endeavor to realize as high a price as he can, he nevertheless greatly undersells the possessors of stones that have honestly paid all the expenses of production. It is estimated that every year from one-fifth to one-sixth of the stones exported are stolen, or, in other words, something like £500,000 worth of stolen diamonds leaves the colony annually. At the digging at first there was a not unnatural laxity in dealing with this new and prolific wealth, and the social soil was at least congenial to the development of this laxity into customs little less than criminal. Nowadays there is danger that this stealing, with its necessary complement the "illicit diamond buying," or "I. D. B. trade," as it is euphemistically known, may sap the morality of the community; and against this vigorous protest is now being made. The mine owners are willing to pay large sums to stop this illicit trade. One mine calculates its losses each year at present £100,000 in unnecessarily depreciated price, and £100,000 in value of diamonds stolen, or a loss of £200,000 in an output of £1,000,000; but there seems ground for hope that this great evil may be succssfully put an end to.—*The Manufacturer and Builders.*

THE UTILIZATION OF SOLAR HEAT FOR THE ELEVATION OF WATER.

This article will treat of the combined application of two natural forces to the elevation of water. These forces are: first, the heat of the atmosphere; and second, the comparatively low temperature of the water to be raised.

The accompanying drawing shows the general arrangement of an apparatus worked on this principle. This apparatus has been built at Auteuil, where it operates very well, although our climate is not favorable to the operation of such a device.

F is a small building covered by a roof, E, which is exposed to the south, and this roof is formed of ten metallic plates, which are numbered 1, 2, 3, 4, 5, 6, 7, 8, 9, 10. Each of these plates consists of two sheets of iron riveted together on all their edges, and separated slightly by filling pieces. Each plate thus constitutes a water-tight receptacle, in which a volatile liquid can be held. Various liquids can be used, but I prefer a solution of ammonia. Under the influence of atmospheric heat, the solution emits vapors, and said vapors or gases escape through tubes, one of which is provided for each plate and are conducted to the receptacle N. Any liquid which may have been carried along by the gas is taken back to the plates by a tube. By another tube the gas escapes from the vessel N. This gas has a pressure of 1, 2, or 3 atmospheres, according to the work which is to be done. It is conducted through a tube to a hollow sphere, which is placed in the well or tank from which the water is to be elevated. This sphere contains a rubber diaphragm, which can attach itself to either half of the sphere.

Let us suppose, for instance, that the sphere is full of water; the rubber diaphragm, consequently, will rest against the upper half or hemisphere. If, now, the pressure of the ammonia gas is brought to bear on the diaphragm, it will be forced to rest on the lower hemisphere; but in order to do this, the diaphragm must eject the water whichfills the sphere. This causes the formation of a jet of water, as shown above the tank R, near the letter G. But the gas must be driven from the sphere after it has been emptied of water, so that the operation may be renewed.

This is accomplished in the following manner: In the centre of the diaphragm a float is inserted, which carries a rod by which a slide is actuated. One of the apertures in this slide coincides with the gas inlet and the other with the outlet. When the diaphragm rests on the upper hemisphere the inlet is opened, and the water escapes; when it moves toward the lower hemisphere the inlet is closed, the outlet is opened, the sphere is filled with water again, and so on.

This would complete the operation if the ammonia gas did not cost anything, but as it is expensive it must be used over and over indefinitely. Here we are aided by the low temperature of the water, which is made to pass through a serpentine pipe contained in a water-tight vessel containing part of the ammonia solution used. The solution is cooled by the water in the pipe, and is ready to absorb ammonia. Then, as soon as the outlet is opened, the ammonia gas conducted into it is absorbed, the pressure which was exerted in the sphere is removed, and water can again enter the sphere.

A final precaution is taken, which is to attach a little pump to the float, by means of which the ammonia solution can be pumped back into the roof E.

The apparatus at Auteuil raises over 300 gallons of water per hour. In warm countries the same apparatus would raise 792 gallons a distance of 65 feet. The calculation of the results to be obtained by this apparatus is based on the following considerations:

A sheet of metal one yard square absorbs 11 calories for a difference of one degree. Each plate which has a surface of 4 square yards absorbs 44 calories per hour. If there is a difference of 6 degrees, 264 calories will be taken from the atmosphere every hour; and by combining this quantity of heat with the cooling action of the water, it is easy, by the difference of tension produced, to obtain an inexpensive force for raising water.

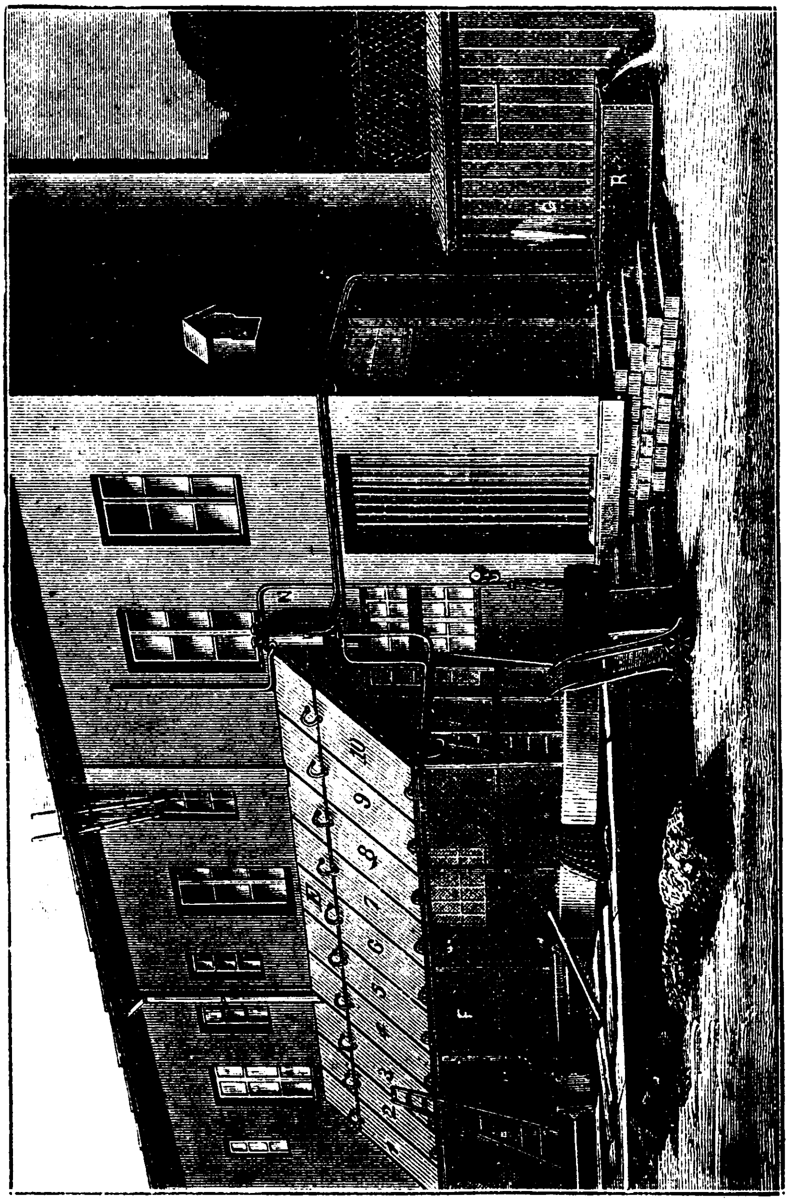
This apparatus differs from the numerous devices by which attempts have been made to utilize solar heat by means of the Archimedean mirror, by which only secondary heat is obtained. It is not necessary to concentrate the heat by metallic or other mirrors; the atmospheric heat is the basis of the operation, and all roofs exposed to the sun can be used for this purpose. In this manner a valuable motive power can be obtained in warm countries without loss of room. Generating plates, such as we have described, can be applied to any roof, and if we consider, that with only ten such plates 792 gallons can be raised 65 feet per hour, we can easily understand that a great elevating power can be obtained by increasing the number of plates.—*La Nature.*

FIFTEEN TON STEAM FORGE CRANES.

These cranes have been specially designed by Messrs. Abbot & Co., of Cannon Street, London, and Gateshead-on-Tyne, for the new forge of the Northeastern Marine Engineering Company at Wallsend. Two cranes are used to supply each hammer, one on either side, and work with two furnaces, so as to keep the hammer in constant work. The *Engineer* says the cylinders are 6 inches diameter, 10 inches stroke, ratio of gearing 20 to 1 and blocks 4 to 1. The extreme raike is 18 feet, and minimumraike, 12 feet. The turning is done by means of bevel wheels, and reversing clutches fixed on the second motion shaft, and the racking by means of large wrought-iron hand wheel at the side.

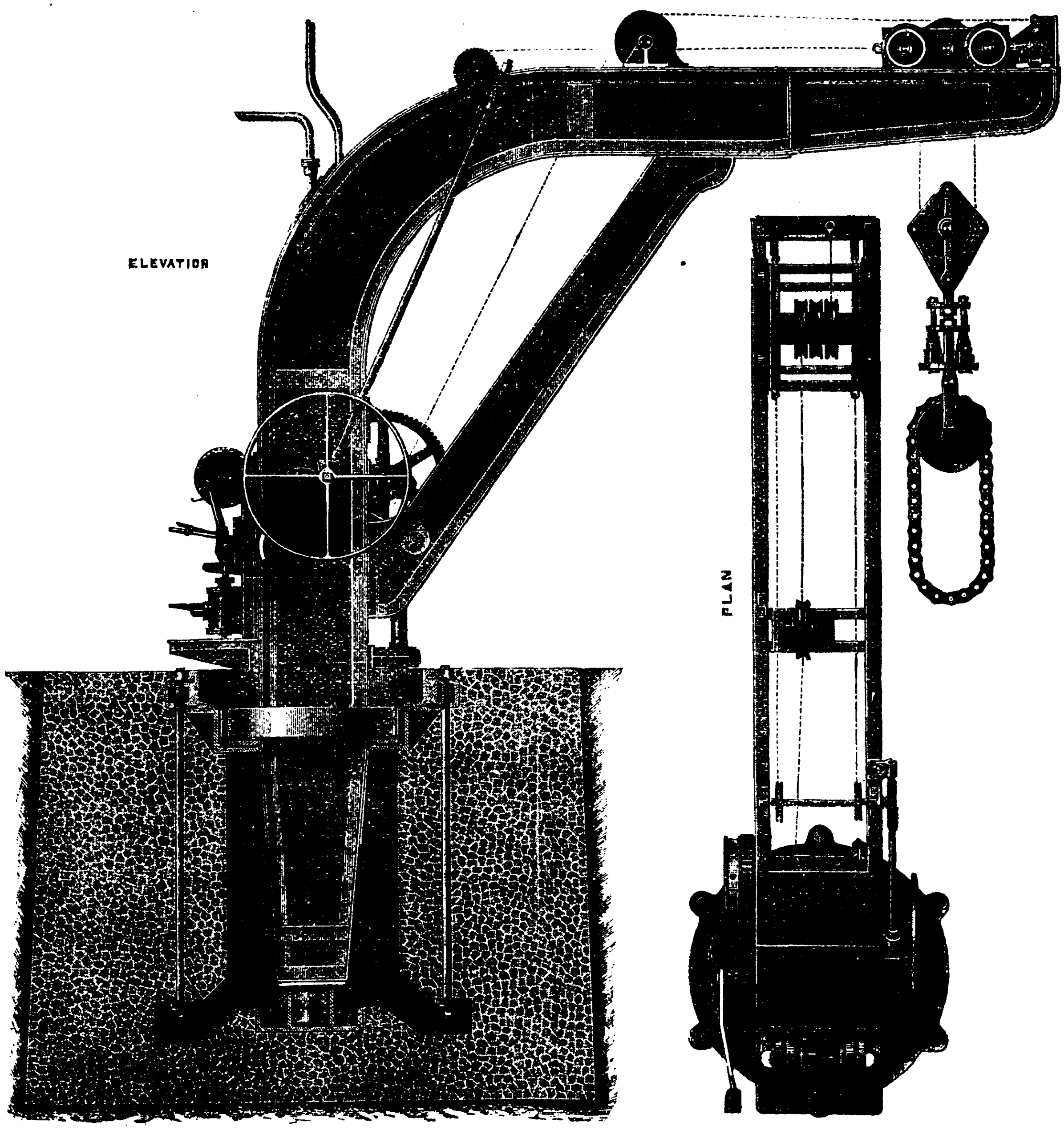
The special features about the cranes are the swan-neck jib, by means of which the top bearing, so common in forge cranes, is dispensed with, and all risk of damage to the building by the vibration from this bearing done away with; steel live rollers to reduce the friction of the center bearing, and the steel volute springs in the blocks to reduce shock of the blow. The bottom gudgeon is lined with gun metal, and has a hard gun metal disk, and the whole of the shafts have gun metal bearings.

The foundations are arranged with a subway, so as to allow a man to go down to examine and oil the bottom bearing, and the holding-down bolts have cotters, so that one could easily be replaced in case of breakage. Two 12 ton steam cranes were also supplied with the above of similar design, and also 4ton hand-power cranes.—*Sc. Am.*



THE UTILIZATION OF SOLAR HEAT FOR THE ELEVATION OF WATER.

FIFTEEN TON STEAM FORGE CRANE



A NEW FORM OF CUPOLA FURNACE.

[A paper read at the Autumn meeting of the Iron and Steel Institute, at Glasgow, Scotland, by MR. JAMES RILEY.]

The cupola furnace which I have to submit to the members of the Institute is the outcome of an earnest desire to shorten duration of the operations necessary in making open-hearth steel. These operations may be divided as follows, taking for illustration a charge for soft steel of 12 tons (say, 9 tons pig iron with 3 tons steel scraps, and working with ore): Charging, one hour; melting, three to four hours; boiling and finishing, six hours; repairing furnace, about half an hour. Looking at these operations with a view to reduction of cost, one naturally asks, can you not shorten the time occupied in charging, and reduce its cost in labor, by substituting machinery for manual labor? I know that others besides myself have given a good deal of thought to this matter, but probably with the same result— that no contrivance yet hit upon for charging solid materials is cheaper than manual labor. But, if our considerations turn in the direction of charging fluid metal, it will be at once apparent that this can be done in a very small fraction of the time now taken up, and with the very important advantage that we avoid the cooling down of the furnace due to the long operation and to the furnace doors being open the while. By these means we would have a gain of nearly 10 per cent. of time—equal to one charge more per week—as well as a considerable saving in fuel and repairs. Arrived at this point, it seems natural that we should look for an additional and a much greater saving than that just mentioned; for, surely, by charging fluid metal we must save the three or four hours usually occupied in melting. Under this conviction, or with a view of determining whether this assumption were correct, Mr. Hackney many years ago tried at Landore the experiment of pre-melting the pig iron in a cupola, whence the fluid charge was readily and quickly transferred to the melting furnaces. He has somewhere published the result, which was an almost inappreciable reduction of the time usually taken up in working the solid charge. At the instance, and to satisfy the directors, of the Steel Company of Scotland, immediately after I came to Glasgow I had two melting furnaces worked for a week with fluid charges obtained by pre-melting the pig-iron in the foundry cupola. In estimating the result we concluded that there was a doubtful gain of a quarter of an hour per charge, obtained at the expense of the coke and labor expended at the cupola. The explanation of the discrepancy between the expected and the actual result is known to many, but may nevertheless, be briefly stated. During the melting of a charge in an open-hearth furnace a large proportion of the silicon and carbon are removed, leaving little more than half the carbon to eliminate in the subsequent operations. Now, in the case of the fluid charge, which has been pre-melted with coke in the cupola, these changes have not taken place, and the time required to remove the impurities from the fluid metal, after being charged in the open-hearth furnace, is almost as long as that required to melt and purify the solid charge. Long ago it occurred to me that, if I could substitute gaseous for solid fuel in melting in the cupola, I might be able to alter the conditions and accomplish the much desired end. About eighteen months ago I determined to try if this could not be done, and accordingly got out designs for a cupola, which, however, seemed unsatisfactory in one or two parts. Some time later I discussed the matter with my friend Mr. Crossley, with the result that we modified the designs to pretty much what I now submit to you. The diagrams before you show two types of the cupola furnace, similar in principle, although differing in form. In both cases the gas generator has a closed grate, and is dependent upon forced blast—obtained from an ordinary blower—for supporting combustion in the production of gas from the coal, which is charged in at the top in the customary manner. In like manner the air for supporting combustion in the body of the furnace is obtained from the blower, and in the case of No. 1 is passed through the pipes or nozzles placed transversely across the body of the furnace, almost directly over the bridge which divides the generator and furnace. These pipes are inclined so as to direct the flame down upon the bath of metal held in thehearth of the furnace. In this design the air for combustion is heated in the passages in the back wall of the generator through which it is sent to the nozzles above referred to. In No. 2 the air for combustion passes twice round the hearth of the generator in the pipes shown in the figure, thence to the crown of the furnace body, whence, being thoroughly heated, it emerges by the air port directly over the gas port leading into the furnace and to the cupola; and, in addition, we can, if desired, turn this heated blast through the nozzles inserted in the sides of the furnace-hearth, as shown. The cupola is of ordinary foundry type, of nearly equal dimensions from the bottom to the charging hole, which is at about the usual height from the hearth. It is in two parts, the lower being removable and the upper supported on pillars. The hearth has a slight downward inclination to allow of the molten metal flowing readily into the furnace body. The hearth of the cupola is arranged so that it can be easily removed for repair, and another substituted when necessary. This hearth piece and the furnace body may be lined with either basic or acid material, as may be most suitable to the pig iron, etc., being melted and treated; for, besides melting, we are of opinion that with a basic lining and necessary mixtures and arrangements we shall be able to remove the phosphorus in the hearth of the furnace. If we can accomplish this; then we shall be able to melt common iron in the basic-lined cupola, remove the phosphorus, and afterwards finish the charge in the acid-lined open-hearth furnaces. With the permission of my directors, Mr. Dick, manager of the Blochairn Works, made a tentative experiment with a kind of improvised furnace and gas generator conjoined to a small foundry cupola. The furnace having been heated, pig iron was charged into the cupola through the ordinary charging hole—about 12 feet above the hearth—tumbling it in upon the hearth, and filling up to near the charging level. The blast was then turned on from the Root's blower, ordinarily used for blowing the cupola, and after about two hours' blowing we had the satisfaction of seeing the metal begin to melt and run down into the hearth, whence it was shortly afterwards tapped into the ordinary foundry ladle and run into castings. The experiment was continued long enough to indicate a few weak points in our apparatus, and also to remove some lingering doubts of the possibility of success. One or two more short trials having been made, I was anxious to make a more lengthened one—long enough, in fact, to furnish reliable data for action upon a large scale. Accordingly we heated up the furnace on Monday, put on blast on Tuesday morning, and worked almost without intermission night and day until the following Saturday. After some days' work in melting pig iron, finding that everything was satisfactory, and that we had a very high temperature in the furnace, I determined to try to melt the steel scrap which would ordinarily be charged into the steel furnace. Commencing with the addition of 10 per cent. of scrap, the proportions of pig and scrap were very gradually changed, until at the termination of our experiment we were melting charges in which the proportions were six of steel scrap to one of pig iron. Our operations were stopped by the failure of the furnace lining, which, being only ordinarily good firebrick, could not successfully resist the high temperature to which it was exposed. At the earlier stages of the experiment, when melting pig iron alone, as much as possible was made into castings, which were very satisfactory, being tough and clean. Analysis showed that we had removed 1 per cent. of the silicon and ½ per cent. of the carbon. Subsequently, by admitting more air into the furnace, and when melting steel scrap, the silicon was reduced to 0.396, and the carbon to under 1.0 per cent.; so that we may conclude that, when the fluid metal can be charged into the open-hearth furnace, the time required for its conversion into mild steel will be very greatly shortened. As these trials were made at a considerable distance from the steel-melting furnaces, and we were unable to transfer the metal from the cupola to the latter, I am not in a position to support this opinion by facts, but we are so satisfied on the point that we are now erecting a large cupola furnace near to the steel-melting furnaces, and I hope very shortly to have it in full operation. In the small experimental trials we melted at the rate of close on 2 tons per hour; in the large one we expect to put through double this quantity, or sufficient to supply four 12 ton melting furnaces as at present charged; but, as we expect to save about half the time of the operations in the latter, and that two furnaces will thus require the same weight of charge as is now taken by four, our cupola is placed midway between two of them, and at such an elevation that when it is tapped the metal shall flow directly into either of the melting. The pig and scrap will be placed direct from the waggons on to the charging carriage at the foot of the incline, up which it will be raised and tipped into the charging hole. The charging apparatus is one which was designed by Westray & Copeland of Barrow, and has been in use at their works for several years. We are erecting a gas-generator in connection with the cupola for two reasons—first, because we have no surplus supply of gas available at the works; and next, because I am not sure that we should obtain as satisfactory results when using cold gas from our mains as when it is passed hot from the generator direct into the furnace. On the important point of consumption of fuel in melting we were abundantly satisfied, for the coal charged into the generator during the about nine shifts' work only averaged 1.44 cwt. to the ton of metal charged into the cupola, thus surpassing the most economical cupola working which has come under our notice. On the results we obtained we think we are justified in believing that, besides its adaptability to the end I had in view in commencing these trials, this furnace is also extremely well fitted for extensive iron foundry practice, where continuous melting is required, and also, and more especially, to Bessemer steel works, where fluid metal is not available; and in this connection I may state that, as the flame can be made to a large extent oxidizing or reducing at will, the composition of the metal need not be changed during melting, the silicon, etc., necessary in the Bessemer operation remaining, therefore, untouched.

AN IMPROVED GRAIN DRIER.

The illustration herewith shows a new form of grain drier, said to be capable of thoroughly kiln-drying from two to three thousand bushels of corn in twenty-four hours, and to be equally well adapted to drying other grain, so as to offer great advantages to maltsters and others at present using kilns. The machine consists of a series of inclined hollow shelves, supported by columns of channel iron, which form the frame o the machine, the shelves being ribbed on their surfaces and connected together at alternate ends by return bends, by which the steam introduced at the upper shelves will circulate through them consecutively until it reaches the lowest one and passes out to the steam trap. The ends of the shelves are covered by semicircular hoods, thus forming a channel, down which the grain passes, being turned over in its descent by each shelf. At the back of the shelves, also, are steam pipes to heat the air which is drawn through by a suction fan connected to the discharge chamber on the opposite side, thus carrying off the moisture taken from the drying grain. The temperature is under complete control, and can easily be regulated by changing the quantities of steam and air allowed to pass through, so that the grain may, if desired, be discharged at a normal temperature. Adjustable oscillating valves at the bottom, operated by a crank and rocker arm, regulate the discharge, the only moving parts of the machine being this discharge mechanism and the exhaust fan. This drier is said, from tests which have been made in mills at Philadelphia and Wilmington, to be much more effective and economical than the kilns in ordinary use, its work, with an ordinarily good boiler, being equal to the drying a bushel of corn for each pound of coal used.—*Sc. American.*

DAVEY'S DIFFERENTIAL GEAR.

Realising the importance of considerable degrees of expansion, Mr. Davey has devised a means by which a Cornish or other direct-acting engine may be worked with the differential gear, so as to secure the very earliest cut-off. This improvement has been embodied in a gear lately applied to a 90 in. Cornish engine at the East London Water Works. The diagram on the next page (Fig. 1) shows what an early cut-off has been effected. Fig. 2 illustrates the mode of working the steam valve by which this early cut-off has been secured.

Referring to the illustration, *b* is the rocking shaft, which gives motion to all the valves. On it is keyed the lever *c*, at the extreme end of which is pivotted the lever *d*. The outer end of the lever *d* carries a pin moving in a loop on the end of the steam valve rod. The opposite or inner end of the lever *d* is curved to a radius struck to the centre of the rocking shaft. This curved end bears against a roller carried on the lever *c*, keyed on the rocking shaft *f*. The shaft *f* is so attached to the engine as to receive the motion of the piston on a reduced scale. At the commencement of the opening of the steam valve, the rocking shaft *f* and the roller *e* are stationary, but the rocking shaft *b* is at the same time receiving motion from the differential gear, causing the steam valve to be opened. Immediately the engine commences its stroke, it begins to close the steam valve, and closes it rapidly by the combined actions of the motions of the two rocking shafts *b* and *f*, causing them to move in the direction indicated by the arrows. It will be readily seen that those two actions combine to close the steam valve very rapidly. The point in the stroke at which the valve closes is determined by means of a link giving motion to the rocking shaft *f*.

In addition to the improvement above described, another important improvement has been made, which we illustrate in Fig. 3. This illustration represents a gear which Messrs. Hathorn, Davey, & Co., are making for the Wolverhampton Corporation Water Works. When the gear is applied to working engines non-expansively, the simple differential motion produced by combining the cataract with the engine motion, is all that is necessary for perfectly governing the engine under all conditions of load; but in working very expansively the conditions are altered, and something further is required, viz., a governing principle which can be brought into action after the steam is cut off. That is effected in the gear which we are about to describe by means of an appliance termed a "trip," by means of which the engine is stopped immediately it loses its load, or exceeds the speed of working to which it has been adjusted.

Referring to our illustration, *a* is the differential lever, which gives motion to all the engine valves by means of the rocking shaft *b*. The end *d* of the lever *a* receives a constant motion regulated by the cataract to which it is attached. The opposite end *e* receives the motion of the engine on a reduced scale. The connection between the engine and the point *e* is made so that it may be instantly broken by the release of a catch. That catch is held in position by means of a spring, and has a lever giving motion to the piston of a cataract. As long as the resistance of the cataract is not sufficient to overcome the resistance of the spring the catch secures the connection, but immediately the accelerated motion of the engine arising from loss of load or other cause, increases the resistance of the cataract, the catch is instantly withdrawn, and all the valves, being thereby liberated, fall to their seats and stop the engine.

From the description which we have just given it will be evident that great study and care has been taken to produce a gear more perfect, and at the same time more simple than the old Cornish gear.

It will be seen from our illustration that the gear is self-contained on a small bedplate made to stand in front of the engine, and in applying it to existing engines, it is only necessary to make the three valve rod connections, and to connect the outer end of the differential lever to a conveniently situated moving part of the engine.

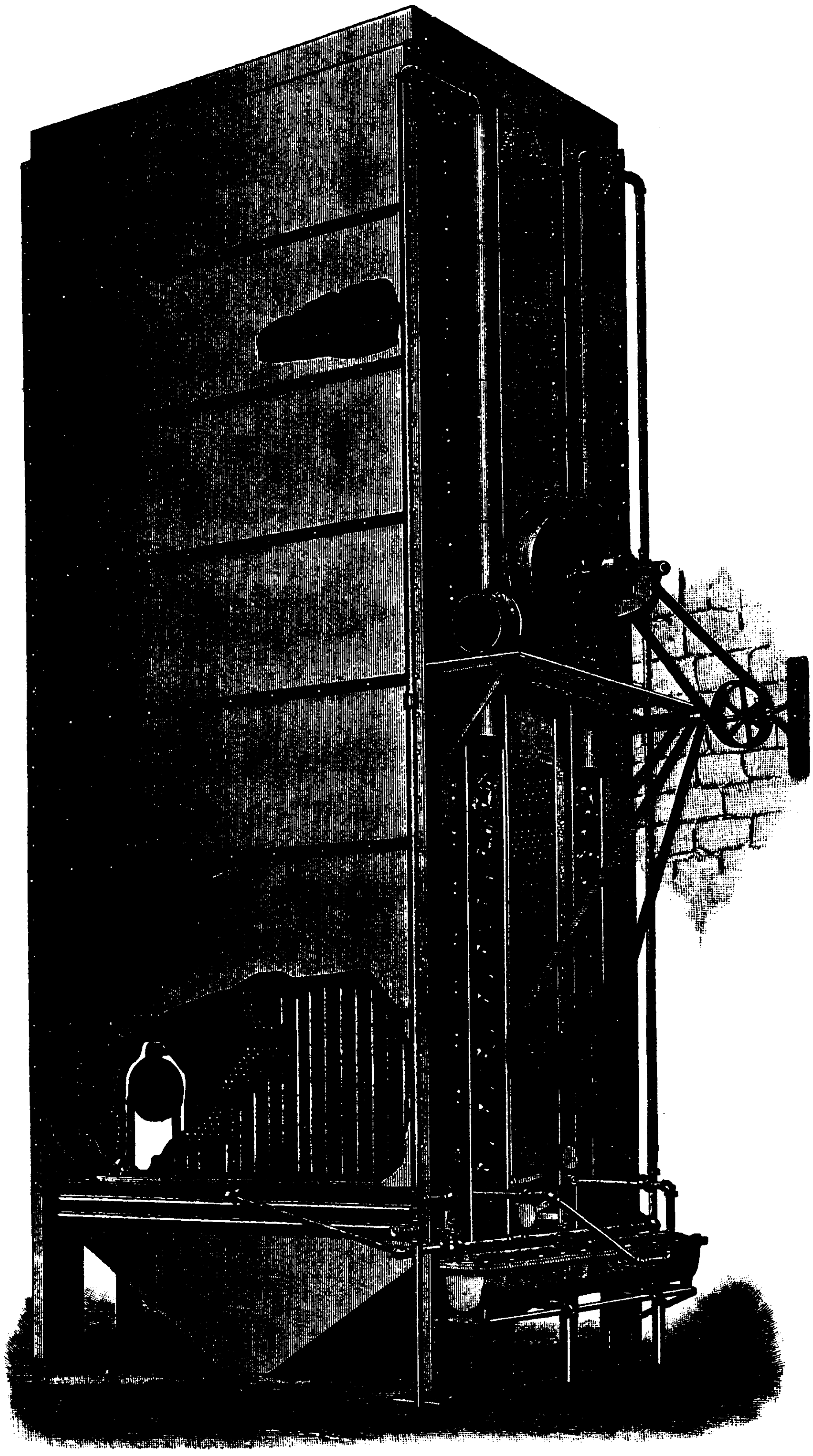
In this new gear there are three small handwheels; the first *f* for regulating the speed of the stroke, the second *g* for regulating the frame between the strokes, and the third *h* for adjusting the trip gear.

Comparing it with the Cornish gear, there is just one rocking shaft instead of three, and all the handles, quadrants and tappets are done away with. The paraphernalia of cataracts, levers, and weighted pedals connected with the Cornish gear, and usually placed in a cockpit under the engine, are also rendered unnecessary.—*Eng.*

THE NEW TORPEDO BOATS.

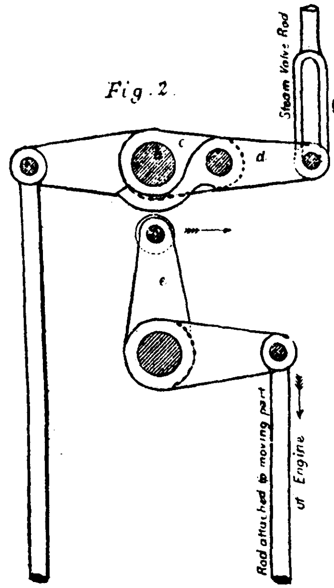
A large sea-going torpedo boat, the first of the series of forty which the country owes to the recent popular agitation on "The State of the Navy," was tried last week in the Thames. The vessel has been built by Messrs. Yarrow & Co., of Poplar, being one of twenty that the Government has ordered of that firm. The trial was, according to present regulations, for two hours' continuous steaming at full speed, and during that time, and as nearly as possible in the middle of the two hours, six runs were made on the measured mile. A mean speed of 19¼ knots was realised, 19 knots being the guaranteed speed, with an air pressure in the stoke-hold of only 3½ in. as shown by the air gauge. The boat is 125 ft. wide, and 8 ft. deep. She has naturally far more accommodation than the first-class torpedo boats hitherto constructed, being able to berth well a crew of twelve or thirteen men forward, whilst there is comfortable room for the officers aft. Special care has been taken to provide efficient ventilation in the new boats, and it is hoped that the great discomfort hitherto found when at sea for any lengthened period will be materially reduced. There is one tube forward for ejecting torpedoes right ahead, and arrangements are made for firing four torpedoes from either side, or two from one side and two from the other at the option of the officer in charge. The number of torpedoes carried will be five,

THE PHILADELPHIA GRAIN DRIER.



DAVEY'S DIFFERENTIAL GEAR.

Fig. 2



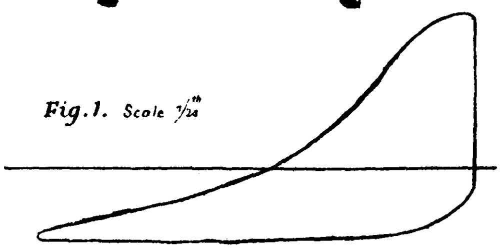
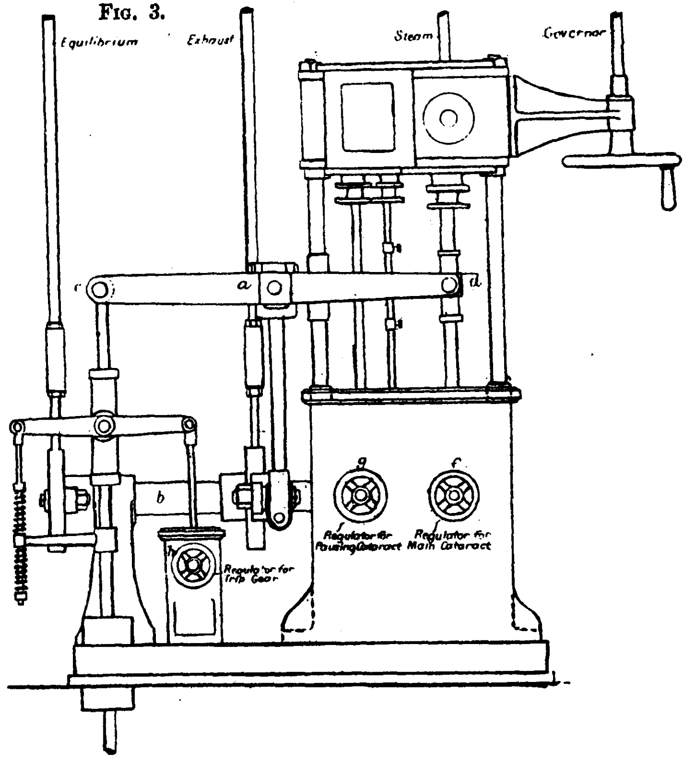


Fig. 1. Scale 1/24th

FIG. 3.



one in the bow gun and four in four guns for side firing. It will thus be seen that there are five torpedoes all ready to be discharged at a moment's notice. This is considered a far better arrangement than hampering the boat with a number of spare torpedoes, of which none will be carried. There will also be two machine guns, one being placed on the top of each conning tower. There are two conning towers, one forward and the other aft. Provision is made for steering the vessel from either of these towers, so that should one get damaged in action the other will be available. The four side-firing torpedo guns are fixed two to each conning tower in such a manner that they can be made to revolve so as to secure any angle of fire, which plan was originated by the authorities of the Vernon. The impulse by compressed air is to be superseded by the simpler and equally efficient system of ejecting by gunpowder. The engines are of the usual type fitted by Messrs. Yarrow in vessels of this class, the cylinders being 14½ in. in diameter by 16 in. stroke. The boiler is of the locomotive type, and contains the usual special features introduced by Messrs. Yarrow & Co., for torpedo boat work. The total heating surface is 1200 square feet and the grate surface 30 square feet. The indicated horse power on trial was not accurately obtained, but is estimated at 700, the steam pressure being 123 lb. and the engines running at 376 revolutions a minute. It was noticeable that throughout the two hours' trial the speed of the engines only varied within the small limits of 1½ per cent. more or less than 376. It is estimated that sufficient coal can be carried for a continuous run of 2000 knots at a speed of ten knots an hour, the bunkers holding about twenty-three tons. This most recent addition to our torpedo fleet would undoubtedly prove a very formidable antagonist at sea, being sufficiently powerful to operate in any reasonable weather. She is the result of the accumulated experience of several years, and the country is to be congratulated in having got her and her sister vessels well to the fore before they are actually wanted.—*Eng.*

THE VITAL MECHANISM.

The recent death of Sir Moses Montefiore, the eminent philanthropist, in the 101st year of his age, has drawn attention to the subject of longivity, and the possibility of so preserving and protecting the complex human machinery as to grew old without parting with all that makes life desirable. One thing appears to be well established, that the way to attain a healthy and vigorous old age is not to live an idle life. There is more danger, it appears from many examples, of rusting out than of wearing out, always provided that the activity of mind and body is not carried to excess. That intellectual labor, within reasonable bounds, does not shorten life, is evident from the fact that public men are proverbially long lived. A London journal says: "When Lord St. Leonard's, at 90, was the oldest of Her Majesty's Privy Councillors, the Duke of Leinster, at 80, was our oldest duke; the Marquis of Tweeddale, at 84, the oldest marquis; the Earl of Leven and Melville, at 85, the oldest earl; Viscount Molesworth the oldest viscount at 85; the oldest M. P. was then 87; the oldest judge 75; the oldest prelate, the Bishop of St. David's, 74; the oldest baronet 92; the oldest knight 89; the oldest recorder in England 84."

Mr. Gladstone is now in his 76th year, and is supposed to be still capable of guiding the destinies of the British Empire, should occasion and the popular vote in the coming election call on him to do so. Lord Beaconsfield was still in power at 74 years of age. Lord Palmerston died aged 81. Lord John Russell at 86; nearly all the British prime ministers have been octogenarians. The most illustrious of modern French authors, Victor Hugo, passed away a few weeks since in his 83d years. But the list might be indefinitely extended, so numerous are the examples which European history affords of great talents preserved and actively employed beyond the limit of three-score and ten.

In our own country there seems to be a more rapid consumption of the tissues. Very few of our leading statesmen of the period including and following the civil war attained the age of 70 years, the fierce excitement of the time seeming to have broken them down while yet in what should have been the height of their vigor and capabality. This has not always been true of American statesmen. Daniel Webster died at 70; Henry Clay at 75; Thomas H. Benton at 76, and these are but selections at random from a great number of instances of long life among the leaders in the political conflicts of the first half of this century. Josiah Quincy, of Boston, when upwards of 90 years old, wrote the life of John Quincy Adams; William C. Bryant was still an editor at 80, and began his translation of Homer at 71. Commodore Vanderbilt at 81 was the active manager of four of the largest railroads in America.

Most of our presidents have lived to an advanced age. John Adams died in his 91st. year, Madison at 86, Jefferson at 83, John Quincy Adams at 81 and Martin Van Buren at 80. The ages of the others at their decease, omitting those who died by violence were: Jackson 78, Buchanan 77, Fillmore 74, Monroe 73, Tyler 72, Harrison 68, Washington 67, Johnson 67 Taylor 66, Pierce 66, Grant 63, Polk 54. On the whole, it is clearly apparent that the men who take the most active part in affairs, who bear the heaviest responsibilities and endure the greatest strain upon their faculties, are in ordinary times the men who live longest.

Women are subject to peculiar cares and dangers, yet they are said to be longer lived than men. The remarkable statement is made that there were at one time 885 widows of revolutionary soldiers drawing pensions in the United States while only one revolutionary soldier remained on the roll. Here, again, to find the most illustrious examples of long survival, we must revert to the annals of the Old World, wherein it is abundantly shown that no woman need be old at 30, nor even at 50. Not only is actual long life an especial privilege of the sex, but their charms are susceptible of preservation far beyond the limit ordinarily assigned.—*St. Louis Miller.*

THE MANUFACTURE OF CHEAP ARTIFICIAL TEETH.

There are four, if not more, factories for the manufacture of false teeth for dentists' use in the city of Philadelphia and one in Camden. The materials used are feldspar, silex and German clay, all finely ground, and mixed in different proportions, and kneaded with water to the consistency of moist putty. Another preparation is necessary for the production of the pink portion of the tooth, which forms the imitation of the gum. The tooth and the gum are made in one piece, and the pink tinge of the gum is given by the use of the oxide of gold in the enamel, of which platinum and titanium are the principal ingredients. The tinted enamel having also been prepared, the materials are ready for the moulders. Each mould is for a full set of sixteen teeth. It is flat, not of the shape of the jaw, for the set is broken up into twos and threes to meet the necessities of manipulation by the dentist in fitting different mouths. Where the root of each tooth (were they natural) would fit in the mould are two tiny holes, in which a workman inserts the ends of two small platinum pins, with heads at each end. These heads are to prevent the pins from slipping out of the tooth at one end and at the other end out of the mouth plate, to which they are expected to hold the teeth.

The insertion of the pins completed, the mould is passed to a fellow workman, who coats the indentations which receive the "putty" with the enamel. The mould again passses into another workman's hands, who gently presses into that part of the mould corresponding to the tinted gum the preparation of the oxide of gold. By still another workman the feldspar, silex and clay mixture is pressed to complete the tooth. The mould is then closed, placed under enormous pressure, the excess of clay squeezed out, a clamp put on, and mould and clamp placed in the drying oven. After remaining in this oven until all the moisture is removed, the moulds are opened, and the teeth, with gum attached, allowed to drop out. They show no distinguishing characteristic, separate from that of the dirty chalk appearance of the single ingredient of the clay. The tooth and the gum appear to be homogeneous. They then pass into the hands of the finishers, generally women, who with fine saws and files cut away the rough edges and make more distinct the separation of the teeth. When these skilled fingers are through with them, eighteen sets of sixteen teeth are arranged upon a slide of fire clay, re-enforced with coarsely gound silex, which will not melt in the intense heat of the oven when uncombined with other substances. From this work-room the slides are passed to the baking ovens, which have been raised to a white heat. In these ovens one slide is baked at a time, the time of remaining therein varying from fifteen to twenty-five minutes, dependent upon the temperature of the oven. When the slides are removed from the oven, they are placed in other firebrick unheated ovens, where they are allowed to cool gradually. On cooling, the brilliancy of the white enamel and the delicate pink to which the heat has changed the oxide of gold gladden the baker's heart. The cooling process complete, the slides and the teeth are handled once more before the latter are shipped away. Thin pasteboard boxes, six inches square, and narrow strips of wax are provided. The teeth are pressed on the wax, projecting the heads of the pins holding them in place. The strips are arranged in the boxes, the lids fastened on, and the teeth are ready for the market.—*Philadelphia News.*

FREE TRADE ILLUSTRATED.

An Englishman, speaking in the Kensington Amateur Parliment recently, illustrated the results of free trade in the following simple but graphic style. The pungency of his argument is only equaled by the humorous vein which illuminates the amusing account of a day's experience with foreign commodities. The Kensington gentleman said: "Yesterday morning I rose early. My hot water was brought in a Belgian zinc jug, and, as is my wont, I worked half an hour in my garden with a Belgian fork and an American hoe. I then took off my French boots, put on a pair of Algerian slippers, and went in to breakfast, which consisted of bread made from Odessa wheat, Normandy butter, Russian Chicken (grilled), American bacon, Frencd eggs (poached), Mocha coffee and Swiss milk. Comparing my Geneva watch with the American clock, I found it was time to set forth; so I put some American tobacco into a French pipe, and, having lighted it with a Swedish match, I went to the railway station, with its Belgian iron frame-work, from which a German engine drew me to the city over rails made in Belgium. Here I worked for four hours with an American stylographic pen, and then went to luncheon—American wheat bread, Canadian butter, Australion mutton, Swiss cheese, Vienna beer; the knives were American, and the waiter was a Swiss. I consoled myself with a Havana cigar, and continued my toil. In the meantime, I dispatched a box to a friend, closing it down with French nails, and further securing the same with Russian cordage. My friend was advised on Belgian paper. Through stopping I found that I had lost a button, which was promptly replaced by a Dutch one. At seven I prepared for dinner by drinking half a glass of Spanish sherry with Dutch bitters. My dinner was made up by Portugal oysters and Chablis, consomme soup, which came in a powder from France, tinned entrees from the same country, Norwegian hare, Sweedish blackcock, American beef and Belgian potatoes, Italian cheese and French wine; a trifle of Chartreuse and a manilla cheroot followed, and a cup of East Indian coffee brightened me for my journey home. Arrived there, I entered by opening an American lock, which was on a Swedish door. To please my wife I bought her a box of Dutch confectionery and a French straw bonnet, and for my little girl a German toy. Here I found my wife playing German music on a French piano, with a French shade on the lamp. I took out my Italian violincello, and having applied some French risen to my new Leipsic bow, played for some time with her. Abruptly breaking off, I told her my adventures during the day in much the same language as above. She grew excited, being a Fair Trader, and assured me that, though men might have such experience, the case was different with women. I replied by reminding her that she got her bonnet, silk for dresses, trimmings, ribbons, lace, gloves, boots and most of her clothes from France, mantles from Germany, hair from Russia, and her teeth from America. We got to high words; so putting on my French boots and gloves, seizing my Malacca cane and my French felt hat, I left the house, hailed a hansnm with a pair of American wheels, and spent the rest of the evening at the French plays. Going home in an American tramcar I arrived to throw myself in an American chair, whence I noticed a great blot of ink on my French wall-paper. Ere retiring I partook of some Belgian rabbit, curried, washing it down with brandy and water, sweetened by French refined sugar. Finally I reposed on a bedstead of the same nationality."

"Getting up Steam" and "The wheels Moving," are the suggestive head-lines we notice in a daily paper. A little further inspection shows that they apply only to the political machine.

Electro-Plating with Iridium.—Some interresting results in electro-plating with this very unchangeable metal may shortly be looked for. It is almost absolutely indifferent to atmospheric influences, and, unlike platinum, it is susceptible of taking a very brilliant polish.

THE PROPER CONNECTIONS FOR STEAM PIPES.

We avail ourselves of the politeness of the Hartford Steam Boiler Inspection and Insurance Co. to reproduce from their monthly journal the accompanying illustrated article, conveying some sound advice respecting right and wrong ways of connecting the main steam pipe of boilers. The advice conveyed therein is well worth consideration:

After boilers are properly arranged and set up, the next important point to be considered is the arrangement of the main steam pipes and their connections, for unless these are properly designed and put up, much trouble is apt to ensue. The points to be considered, but which are very often neglected, is to provide for the effects of expansion, and also to make allowance for any settling of the boilers which may, and generally does, occur after they have been run a short time.

Fig. 1 shows a case where two boilers were improperly connected. Cast-iron tees were bolted to the nozzles, and connected by means of a cast iron pipe, which had an outlet on top, as shown, from which the steam pipe was led. It will be seen at once that the boilers were rigidly bound together by this arrangement. After a short time the tee on No. 2 cracked off, as shown at A; this was replaced with a new one, and soon afterward the pipe connecting the two boilers broke off at B. Both these breaks occurred while the boilers were in use, and of course resulted in their stoppage until the broken pieces could be renewed. The only strange thing in connection with the affair was the fact that the breaks did not occur the first time steam was gotten up.

Cast iron pipe should be used with caution for such purposes, as, from its brittle nature, accidents are liable to occur at any time. Wrought-iron pipe is better in every way, and should always be used. But in no case can the use of such connections as that shown in Fig. 1 be justified. Only a very inexperienced engineer would design such a connection, and no steam fitter should put it up without entering a strong protest against it. No provision whatever is made for the motion of the boilers due to expansion, or settling for the foundations or walls.

Figs. 2 and 3 show what we consider a properly designed arrangement of steam connections for a battery of boilers. Wrought-iron pipe is used. To the nozzles risers are attached by means of flanges, and from the upper ends of these risers pipes are led horizontally backwards into the main steam pipe. In this horizontal pipe, the stop valves, one to each boiler, are placed. These valves should have flanged ends, as shown, so that they may be easily removed, if repairs become necessary, without disturbing any other portion of the piping. The main steam pipe may be supported by means of long hangers from the roof of the boiler house, when practicable, or, if this cannot be done, it may be held up by posts which rest on the back wall of the boiler setting, or any other convenient place.

By this arrangement, it will be seen that the movements of the boilers, and the piping itself, are compensated for by the spring of the pipes, and no trouble will ever occur. The height of the risers should never be less than three feet, and when there are eight or ten boilers in one battery, they should be, if room permits, six to eight feet high, and the horizontal pipes leading to the main steam pipe should be ten to twelve feet or more. *Manufacturer and Builder.*

THE DAVEY SAFETY ENGINE.

The Davey Safety Engine, or Vacuum Motor, of which we present an engraving herewith, is an invention of Mr. Henry Davey, a mechanical engineer of prominence in England where he is well known as a manufacturer of hydraulic machinery. It possessses some remarkable features which will commend it strongly to all branches of industry where a small, cheap, and positively safe power is required. In principle it is quite unlike any of the steam, gas, hot air, or petroleum engines heretofore offered to the public, and a careful investigation of its merits, will gain it the preference in many cases. In this illustration the adaption of this engine to run printing presses is shown. It is a low-pressure condensing engine, in which a prssure of only one atmosphere is maintained in the boiler, which, as pressures are commonly spoken of, or shown on the steam gauge, is no pressure at all. Theboiler is of cast iron, the part above and back of the furnace being cast in partitions, which serve the purpose of flues, giving the necessary heating surface, and which are not likely to be burned out or destroyed, even if the boiler were fired without water. No

CONNECTIONS FOR STEAM PIPES.

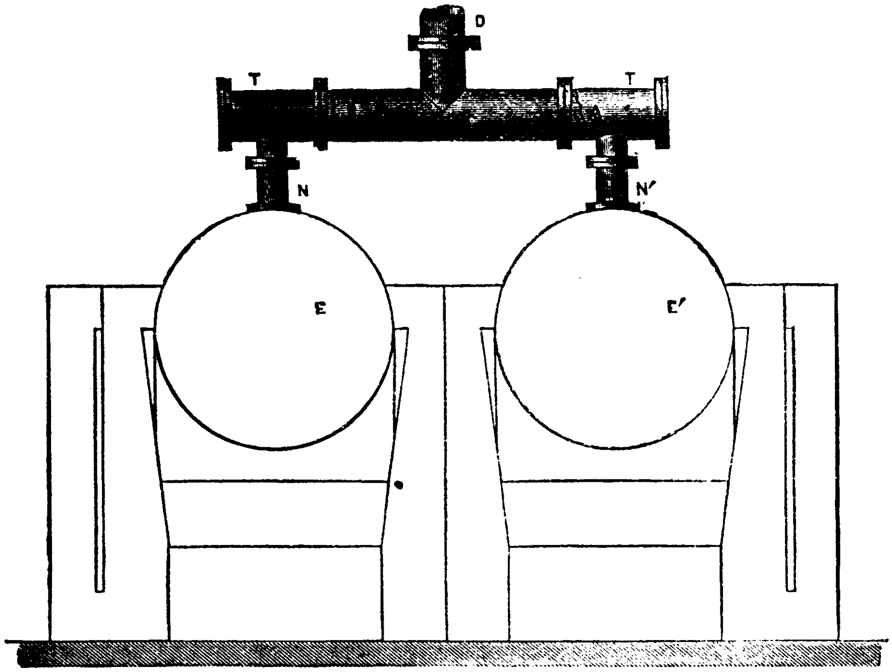


Fig. 1.

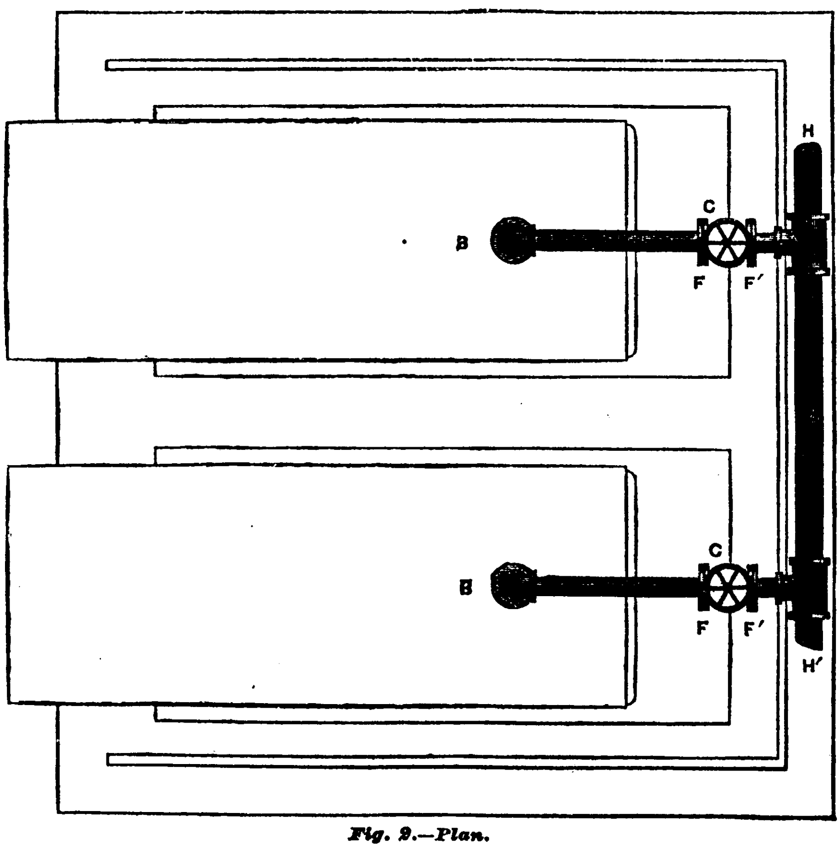


Fig. 2.—Plan.

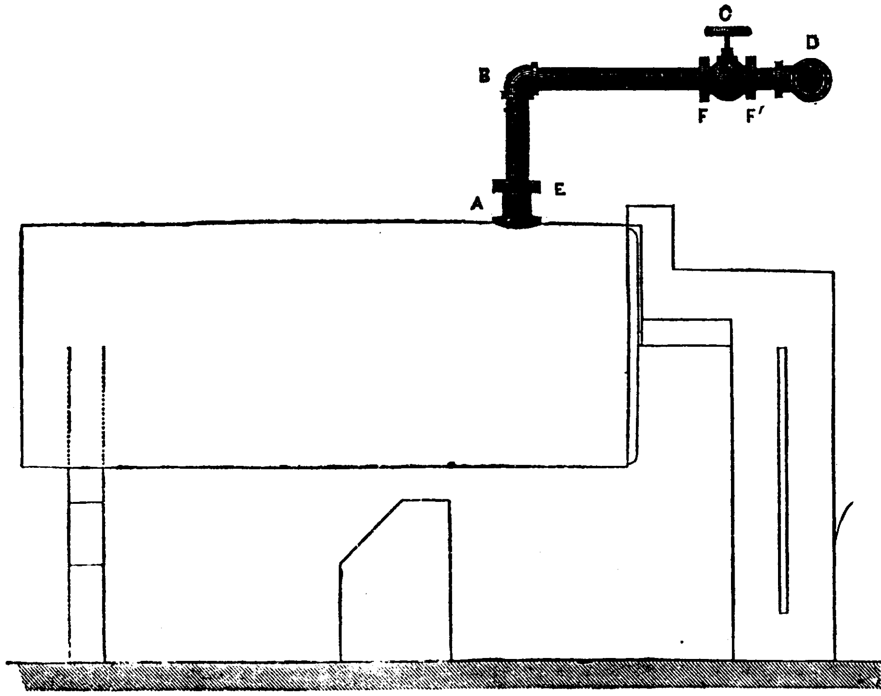
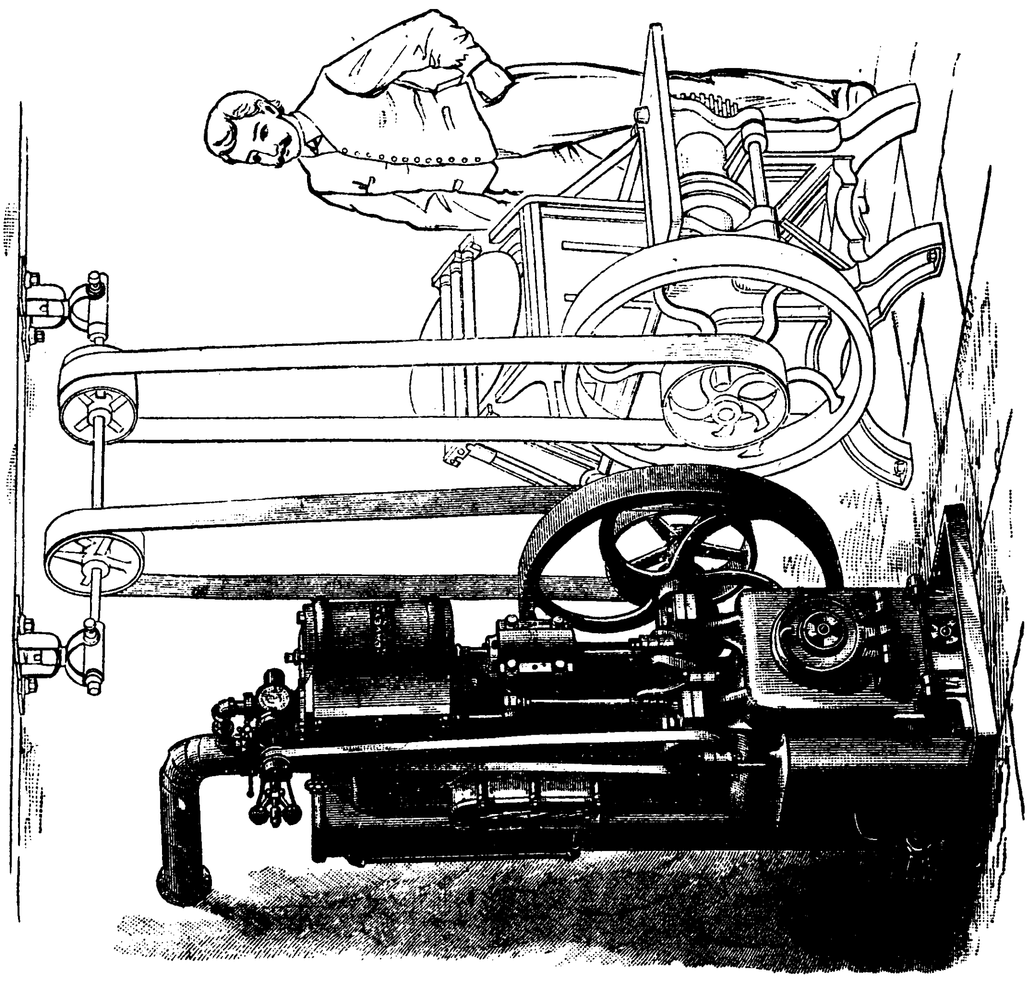


Fig. 3.—Side Elevation.



DAVEY SAFETY ENGINE.

safety valve is used, but a hole of larger diameter, covered by a plug laid loosely over it, prevents the accumulation of more than one-quarter of a pound gauge pressure. Ordinarily the pressure in the boiler is just sensibly less than that of the surrounding atmosphere, so that the plug is held down by the pressure of the latter. Practically however, the internal pressures are balanced so there is no pressure whatever tending to burst or collapse the boiler. The surface condenser is a casting open at the top, and provided with tubes in which the exhaust steam is condensed, the water and air being removed by a small, single-acting air-pump, of the plunger type. The top of the condenser is above the water level in the boiler, and the overflow from the condenser is at the top. The small head of water in the condenser (above the water level in the boiler) is utilized for feeding the boiler as follows: Connection is made between the top of the condenser and the water space in the boiler by means of a small pipe. In this pipe is a cock controlled by a float in the boiler. When the water falls in the boiler the cock is opened, the water running in by gravity. When the water rises the cock is closed. The water level is thus automatically maintained, without the use of a pump, or any attention from the attendant. A glass panel in the side of the boiler provides for observing the water level. The condensing water may be taken direct from the service pipes in cities, or where this is not practicable, a small pump driven by the engine may be used for circulating the water. When the engine is used for pumping water the water may be passed through the condenser. When water is scarce it may be used over and over by standing long enough to cool; or the condenser may be located directly in a tank of water. The engine is double-acting, with diameter of cylinder sufficient to give the rated power at a mean effective pressure of eight or ten pounds, which is easily maintained by the air pump. The cylinder is brass bushed, and the piston is of brass, no lubrication being required. The cylinder is steam jacketed around the body and at the ends. In general construction the engine does not differ materially from any small engine.

The speed is controlled by a sensitive governor, which responds as quickly to changes of load as if controlling steam of high pressure. The wearing parts are large doing away with the probability of causing trouble from heating. It is arranged to burn either hard or soft coal, wood or coke, and petroleum or common gas may be used by conducting pipes into the fire box. The manufacturers claim that when hard or soft coal or coke is used, the cost will not exceed one cent per horse power per hour. Although new in this country, these engines have already come considerably into use in Great Britain and France, published tests of their performance showing good economical results. They are suitable for all kinds of light work, including furnishing power for small electrict light plants, as in country residences, and seem to be particularly suited for households purposes, where their absolute safety will commend them.

CASTING AND FORGING.

A very general misapprehension exists in regard to the value of cast iron articles and the same description of articles forged from wrought iron. There is a mistaken idea, also, that it is less expensive to cast than to forge. This error is not confined to the unmechanical public, but it is shared by many mechanics; perhaps the possibilities and facilities of drop forging are not sufficiently understood; but it is true that many articles can be drop forged from tough wrought iron cheaper than they can be cast from brittle cast iron. The range of purely cast iron work is great—from a single casting of thirty or more tons to pieces that weigh less than a quarter of an ounce—and its cost varies from a price barely above that of the pig iron delivered to sixteen, eighteen, and even twenty cents a pound. But many small articles are cheaper forged than cast, and almost immeasurably superior. The cost and value of the forgings give them a superiority over the castings, especially when one pattern is required in large numbers. For each single casting or plate of castings a new mould is required; moulding costs money and requires jud ment if not skill, and even with the mechanical appliances for bench moulding the losses from defective casting are very great. But in drop forging the mould—dies—will do for hundreds, thousands, of pieces, and the percentage of loss by imperfection of work is very slight. Nor does plain drop forging require the highest grade of mechanical skill.

There are many small articles of common use in the market, some of them coming under the designation of tools—which, from a mistaken notion of cheap production and low price, are made from cast iron or from cast iron made malleable. Many of these could have been made from wrought iron, or at least from machinery steel, and sold at the same price for as large a profit; or with a few cents added to the price could have been sold at a greater profit. When cast iron thumbscrews with quarter inch shanks are put upon the market the folly of cast iron must have reached its limit.—*Scientific American.*

THE INTERNATIONAL YACHT RACE.

Probably no former event in the history of yacht racing has attracted so much attention as the trial for the championship between British and American yachts in the vicinity of New York during the week commencing Sept. 7. The arrangements for the contest were not made without a great deal of correspondence, extending through many months. The race was for the possession of the prize cup won by the yacht America, in a contest with a fleet of British yachts off Cowes, England, in 1851; and its having remained on this side of the Atlantic for the thirty-four succeeding years as a standing challenge for British yachtsmen, made the latter extremely cautious in their preparations for an effort to win back the cup this year. The New York Yacht Club has held the cup under a deed of gift from the original owners of the America, under the condition of its remaining a perpetual challenge cup, not being the property of any boat winning a match in which it is the prize, but of the club to which such boat belongs, and subject to future competition for its possession. The New York Club, therefore, invited all regular organizations of American yachtsmen to unite with them in preliminary trials, with the view of selecting the best American yacht to defend the cup against the British yacht Genesta, which had been chosen to compete for it as the best representative "all-around" yacht of the different British yacht clubs.

When the challenges for this race were issued, it was quickly concluded that there was no centerboard sloop in this country of sufficient length to match against the Genesta, whereupon the flag officers of the New York Club ordered such a one built, and about the same time some members of the Eastern Yacht Club also ordered another, both being centerboard sloops. Of these two yachts, the Puritan, of the Eastern Yacht Club, was selected to sail against the Genesta.

The Puritan is of wood, and was built at South Boston. Her dimensions are: 93 feet in length over all, 81 feet at the water line, 22 feet 7 inches extreme beam, and 8 feet draught. Mast, 78 feet long; topmast, 44 feet long; and bowsprit outboard, 38 feet; mainboon, 76 feet; gaff, 47 feet; and spinaker boom, 64 feet. All her spars are of Oregon pine. She was not selected for the trial until after a contest with the Priscilla, built by the New York yachtsmen, and minor changes in her sails, ballast, and some other details were being made up to within a few days of the race, every precaution being taken to have her in the best possible condition to creditably represent American yachting interests.

The Genesta, which has come over here to race for the cup, is owned by Sir Richard Sutton, of the Royal Yacht Club; she was designed by J. Beavor-Webb, and built on the Clyde, being of composite build, with steel frame and elm and teak planking. She is 96 feet long over all, 81 feet on the water line, 15 feet extreme beam, 11 feet 9 inches depth of hold, and 13 feet 6 inches draught.

The great difference in width and draught of the two yachts at once mark the broad distinction between the two classes of vessels, the Genesta being of the cutter, or "knife blade" style, while centerboard sloops like the Puritan are sometimes styled in yachting vernacular "skimming dishes.

The particulars of the Genesta's spars are given as follows: Masts from deck to hounds, 52 feet; topmast from fid to sheave 47 feet; extreme boom, 70 feet; gaff, 44 feet; bowsprit, outboard, 36 $\frac{6}{10}$ feet; spinaker boom, 64 feet; club of topsail, 42 feet. While the Genesta has not always been successful heretofore, she is to be credited with a long list of victories, under the most diverse conditions, since her first race, at the regatta of the New Thames Yacht Club, in the spring of 1884. Her passage across the Atlantic from Queenstown was made in twenty-four days under jury rig, that is, a mast and bowsprit two-thirds the length of her racing spars and a small mainsail. *Scientific American.*

NEW DREDGING ENGINES.

We present with this engraving representing a pair of dredge engines, recently built by the Lidgerwood Manufacturing Company, 96 Liberty street, New York for Ross & Sandford Jersey City, N. J. They are strong and powerful engines for their class, built for hard and steady duty, which are essential features in engines for such use.

The cylinders are 14″x18″, strongly geared to the drum as shown, the engines being mounted on a hollow bed plate, bolted together to make substantially a continuous bed. As will be noticed, the main shaft carrying the driving pinions is rigidly connected to the inner drum journals; this connection being next to the driving pinions and gears holds the gearing in proper position, avoiding the spreading of centers almost sure to occur when there is no such connection.

The winding drums are scored, and are provided with friction at each end. At the outer ends the wooden friction blocks are made fast to a disk, and at the inner ends to the large spur wheels. This double friction makes a powerful holding arrangement, requiring small motion to engage and disengage. The manner in which the wooden friction blocks are fitted and fasttened provides for the ready substitution of new ones at any time when it becomes necessary. All parts of these engines are simply arranged, so as to be little liable to get out of order, and to be kept in proper working condition by any one of ordinary intelligence and experience.

Ample arrangements are made for taking up lost motion, and the unusual length of connecting rods—seven cranks—makes the wear and strain on slides small.

As shown in the engravings the engines are spread sufficiently to permit the boiler to project up through the center space; they can be brought nearer together where some other location of boiler is desirable.—*Am. Mach.*

TECHNICAL EDUCATION FOR PLUMBER.

A meeting was recently held in the committee room, Guildhall under the presidency of Earl Fortesque, to consider certain recommendations of the Plumbers' Company, based upon resolution, passed at a conference of metropolitan and provincial plumbers, having for their object the improvement of plumbing work in dwelling-houses. A report which was read stated that the investigation conducted by the plumbers' company having made it clear that both among the masters and journeymen of the trade there was generally a distinct recognition of the fact that defective work was a serious evil to the trade as well as to the general public, they believed that it was now time to initiate and accept, on behalf of the trade, such regulations as might tend to secure more efficient work. They had therefore decided to recommend the establishment of a system of registration of plumbers in London and seven miles round. Further, that the persons registered should be able to satisfy the court by either of the following means: Evidence of present status in experience in the trade; examination by a board of examiners composed largely of practical plumbers appointed for the purpose; production of certificates of competency granted by the Plumbers' Company and the City of Guilds of London Institute. Indentures of apprenticeship will receive due consider ration.

Earl Fortescue said, as a veteran in the cause of sanitary reform, he had great pleasure in taking a prominent part in the movement, which he was persuaded would not only proove of great benefit to the public, but to all engaged in the trade. The public would gain very much, because by the system suggested they would have their work done by competent men. A long discussion ensued, in the course of which Mr George Shaw (master of the Company) said it was well known that there were many men engaged in the trade who knew nothing whatever about plumbing, and the result was that the public health suffered. Mr. P. Magnus, director of the City and Guilds Technical Institute) strongly urged the importance of technical instruction. He believed that the step which was about to be taken would result in the men being thorougly acquainted with their business. The recommendations were adopted, and the proceedings terminated.—*British Architect.*

A USEFUL cement, which hardens very quickly, is formed of litharge mixed with glycerine. It may be used for water and steam pipes, as well as for lining cisterns for petroleum oils.

CAR-COUPLERS AND AUTOMATIC BRAKES ON FREIGHT TRAINS.

If the recent tests of automatic car couplers shall bring about interest enough to induce railroad companies to agree upon the adoption of one or the other of those that were shown to be worthy of adoption, the result will have been entirely satisfactory. These tests showed that several of the couplers operated satisfactorily, and a short trial in actual service would settle all that is now unsettled. The number of men killed or disabled in coupling cars is frightfully large, and public opinion will in the end force the general use of automatic couplers.

It would show more humanity on the part of railroad managers if they moved with reasonable alacrity in the matter before being compelled to. But we have but little hope of their doing so unless they are stirred by pecuniary considerations, which is not likely. The history of railroads in his country shows that a consideration for human life, unless it costs something in money, seldom moves railroad corporations to action. Perhaps they are no worse in this respect, however, than other, large corporations.

Another thing equally deserving of attention is the use of automatic brakes on freight trains. Between getting squeezed to death coupling cars, and killed from falling off trains over which they must pass, the life of a freight brakeman is considerably less secure than that of a soldier in time of war. Earnest attention to the security of freight trainmen would result in a large saving of life; it is a fair matter for legislative attention.—*Am. Mach.*

AMERICAN LEATHER IN ENGLAND

Thomas Waller, the recently appointed United States Consul-General at London, has sent to Secretary Bayard an exaustive report on the leather and boot and shoe trade of Great Britain. He says 321,591 persons are engaged in working leather in England. Scotland and Wales. The estimated yearly production of hides in these three countries is 12,366,874. Nearly 7, 000 firms are engaged in the different branches of the leather trade in London and suburbs. "There is no doubt an unjust prejudice still existing against American leather; indeed for general use it has no standing in the English market. The steady increase in the American trade in leather here during the last four or five years, as statistics show, indicates, however, that American sole, upper, and patent leather is gradually growing in favor. The difference between English and American Leather almost entirely arises from the different system and processes of tanning.

A thorough investigation carefully made justifies the statement that American leather is only used in this country for waxed uppers and soles, and in rough, low priced, and inferior goods. Indeed it is the fashion of boot and shoe dealers to deny the use of American leather altogether whenever they can. Some of the objections to American leather may deserve consideration. They are as to its harshness, its wants of finish, and its red color. The enlargement of American trade in leather here mostly depends, first upon the readiness of our countrymen to acknowledge the faults of their production and to apply the remedy, and, second, upon their recognition of English prejudice, if it exists, and for the sake of trade, upon their willingness to humor it. The best way to cultivate and increase American trade in this country is to adapt American goods to this market and then depend upon established merchants and factors to sell and dispose of them.

London and its suburbs support 406 wholesale and 4,248 manufacturers and dealers in boots and shoes. This country is supplied with the latest American inventions in shoe machinery. The American boots and shoes are scarcely known in London. As Great Britain exports over half a million pairs of shoes over all imports, there is not an absolutely necessary demand for foreign shoes here Still France, Belgium, and Holland, send 120,000 pairs annually, while America send only 4,000. The practice of the French and Germans in sending experts here to investigate and report upon the trade, its needs, fancies, and prejudices, might be followed with profit. To succeed the American trade will have to offer this market the English form and style of shoe with American modifications."

NEW DREDGING MACHINE.