If now the CO be burned to CO_2 , the sensible heat produced will be equal to $10,093 \times 2 = 20,186$ B. t. u. Total, 40,372 B. t. u.

But the quantity of heat absorbed in the gasification of the 2 pounds of carbon has disappeared as heat by its conversion into molecular work; and this is $5,642 \times 2 = 11,284$ B. t. u.

Net for 2 pounds of carbon, 29,088 B. t. u.

And for 1 pound of carbon burned to CO_2 , 14,544 B. t. u.

The loss of heat attending the formation and release to the air of CO, about 70 per cent., is serious; but the residual heat is subject to all the absolute losses at the chimney, by radiation and otherwise, and not more than one-sixth to one-fifth of the full heating power of the carbon is available.

Fortunately, this danger is not as great as it appears. Carbon monoxide can be formed very readily, and its formation can be as readily avoided. It has been demonstrated that only minute traces need ever be formed in any reasonably well-managed boiler furnace, while dampers are open and the fires are burning freely. While the fires are banked, the proportion of carbon burned to CO is large, although the actual quantity is relatively small. Bituminous coal suffers less loss from this cause than anthracite; on which account it is advantageous to use bituminous coal for banking anthracite fires. A crust is formed, beneath which the escaping CO is conducted to orifices through which it issues to burn like ordinary jets of gas. But dampers should be made to shut as tight as possible.

Combustion cannot be carried on with less than 20 pounds of atmospheric air for each pound of anthracite, and something more for bituminous coal, which usually has as much carbon as anthracite has, and 3 or 4 per cent. of hydrogen in addition. The time allowed for combustion, only 3 or 4 seconds, even with externally fired boilers, is too short to permit a more complete absorption of the oxygen than about one-half of that which entered through the grates and through the fire. No air should enter in any other way, and great care should be taken to prevent all leakage through brickwork and around doors and arch fronts.

The two things about a fire most important to be known are, first, the temperature of the escaping gases, and second, their composition, which, taken in connection with the weight and analysis of the coal burned, will give the quantity of the gases. No details of the process of analyzing the gases can be given here. The volumetric method, by the use of the Winckler apparatus, is easy and expeditious, and (in skillful hands) reasonably accurate. The gravimetric method, conducted by an expert chemist, gives the weight of coal burned as accurately as it can be weighed at the furnace door. Care must be taken to procure fair samples for analysis, as heterogeneous mixtures of gases exist at the same instant in boiler flues and chimneys.

REPAIRING BROKEN CRANK-SHAFTS.

Our illustration represents a novel and very effective method of repairing broken crank-shafts, invented by Mr. Henry Foster, Newburn Steel Works, Newcastle-on-Tyne.

It is well known, says *Engineering*, that the break-

ages of crank-shafts almost invariably occur at the angle formed by the junction of the crank-pin and crank-web, where the forging is most likely to be defective, and where the change of form of the shaft throws great local stresses on the material.

These breakages are evidently produced more by bending than by twisting strains, and on the slightest indication of fracture at the points mentioned, the shaft, although perfect in all other respects, has hitherto been condemned as useless, and another entirely new shaft substituted, involving considerable outlay, only to be repeated on another indication of flaw.

In the method which we illustrate, instead of throwing away the whole shaft, the fractured pin and webs are turned off, leaving a small boss at each end of the two parts of the shaft; upon these bosses there is fixed another crank-pin, A, together with its two crank-webs, B B, formed in one piece. The new cranks are shrunk on to the lengths of shaft forming the body of the crankshaft, and afterward further secured by means of keys. The end of each length of shaft, C C, at its junction with the crank-web, is left somewhat larger in diameter than the other part of the shaft, so as to enable the keys which secure the crank-webs to the body of the shaft to be driven in from the outside of the crank-webs in the direction of the arrows. A broken crank-shaft after being thus repaired is now working and giving perfect satisfaction where three new crank-shafts had previously broken.

The invention is not confined solely to the repairing of crank-shafts, but is applicable also to the manufacture of new crank-shafts, which, when thus made, are essentially built shafts without the disadvantage of having a large amount of unbalanced material at the crank-pin end of the webs. The crank-pin with its two webs in one piece is preferably made in one casting of special mild steel, while the other parts of the shaft are forged.

The Board of Trade have decided to approve of this shaft, "on condition that a surveyor of the Board of Trade should witness the testing of the pieces which are required to be cut from each shaft and each web and pin, for tensile strength, elongation, and bending, in accordance with the usual practice, and the results of the tests be submitted to the Board for approval";

and Lloyd's Committee have decided to approve of this shaft, "provided test-pieces cast on it be proved to have a tensile strength not exceeding 30 tons per square inch, and pieces $1\frac{1}{4}$ in. square permit of being bent cold through an angle of 90 deg. over a radius not exceeding $1\frac{1}{4}$ in., and the shaft when machined be found to be perfectly free from blow-holes, and in other respects to the satisfaction of the local engineer surveyor."

These conditions of test can be readily fulfilled by the material of which these crank-shafts are made.

THE WENHAM LIGHT.

AN interesting new lamp for the economical consumption of common gas has been invented by Mr. F. H. Wenham, C.E., and is in course of manufacture by the Wenham Patent Gas Lamp Company, and was shown in action at the Inventions Exhibition. The claims made by the company as to the economical advantages

FIG. 1.

of the lamp are, says *The Engineer*, exceedingly large, namely, that it increases the illuminating power of common gas from 200 to 400 per cent., and that, too, without charging the gas with additional hydrocarbons. In the Wenham lamp the gas is burnt downward instead of upward, and the common air is heated before it reaches the flame; as a gas flame consumes about fifteen times as much air as gas, care is taken to heat this air as much as possible before it comes into contact with the gas. The flame of the Wenham lamp has the form of a flat, horizontal ring, resembling a quoin in shape, but not so large when the lamp is of any ordinary size. The flame has no invisible or blue part to it, but over its whole area is intensely and equally luminous, and is more painful to the eyes than a gas flame to look at for any length of time, because of its brilliancy and its being richer in the rays of the blue end of the spectrum. There is little or no flickering with the flame, or variation in its form, but it is simply a steady, luminous ring.

The accompanying diagram, Fig. 1, represents the whole arrangement. In this cut A is the air inlet, and B the regenerator; the latter is somewhat massively made in iron, and takes up the heat from the gas-flame below to communicate it to the incoming air. A cylinder, C, conveys the heated air to the burner through perforated disks; D is the burner, E the flame, F the reflector, G the fastener of the ring, J, which carries the lamp-glass, K, and has a hinge at H. The chimney is at L, M is the gas supply pipe, and N the heat disperser.

It was necessary that the glass hemisphere, K K, should be light, and this was a difficulty, most of those

FIG. 2.

in the market being heavy, with a very thick glass rim at the top. Some of lighter form and better quality are made in Paris. The company so far has been using bowls of thin glass cut from the ends of flower shades, and fitted with an artificial rim invented and patented by Mr. Wenham; it consists of a band made of asbestos, cemented to the glass by silicate of soda.

A section of the burner is represented in Fig. 2. In this cut A is the porcelain burner, held in position by the ring, B. C is a perforated disk, and D a perforated button; E the stem supporting the button, F the gas way to the burner, G a perforated dome, H a ring secured by a bayonet lock, K the external cylinder, L the gas supply pipe, and M the flame. The gas issues in a horizontal curve from a ring of holes in the

burner. Mr. Wenham finds that to get the best light, the gas must issue in a series of streams rather than as a thin sheet; the air gets at it better. When the flame of this lamp is turned on so that little projections begin to appear at the outside edge of the ring of light, the arrangement is giving the maximum illumination.

The external appearance of the simplest form of the Wenham lamp is represented in Fig. 3, but it is, of course, made of various shapes and sizes, and with more or less attention to the requirements of the luxurious.

Mr. F. W. Hartley has photometrically tested the illuminating power of the flame of the lamp at 45 deg. from the vertical, and gives the following certificate of the results:

Lamps tested.	Gas burned per hour.	Total light obtained.	Light per cubic foot of gas.
	Cubic feet.	Candles.	Candles.
No. 1	6.4	55.00	8.60
" 2	12.9	122.50	9.50
" 3	15.2	171.00	11.40

Mr. Hartley remarks about the above figures that the vertical lighting power on the average of the tests was more than 50 per cent. greater than with angular lighting. The "total light" and "light per cubic foot" mean the light of standard sperm candles, and the figures gives the number of these which it would have been needful to burn at one time to produce a light equivalent to that of the Wenham lamp. The average amount of light yielded per cubic foot of gas burned from an average burner does not exceed, he says, the equivalent of 2.6 standard sperm candles.

FIG. 3.

Dr. John Hopkinson, F.R.S., and Mr. George Livesey have also tested the flame of the lamp photometrically; their results, given below, agree closely with those of Mr. Hartley:

Lamp.	Feet per hour.	Total light.	Equivalent per cubic foot.
		Candles.	Candles.
No. 1	6.4	54.1	8.5
" 2	12.8	121.6	9.4
" 3	15.1	173.9	11.4

In these tests, taken at 45 deg. from the vertical, reflectors were used. The same referees report that "at Mr. Wenham's express desire the experiments were made with the lamps complete with their reflectors, just as they would be used, and the light was tested both at the vertical and angularly at 45 deg." The average light directly under the lamps at the same distance from the flame was about 55 per cent. more than at 45 deg.

Some photometric tests of the economy of the Wenham light made in comparison with an ordinary gas flame under the same conditions in each case—that is to say, both without reflectors—would be of scientific interest. At the same time, the Wenham light is of unusual brilliancy, as any visitor to the exhibition may see at a glance.

THE INFLUENCE OF MAGNETISM UPON THE CHARACTER OF THE SPECTRAL LINES.

By CH. FIEVEZ.

FARADAY'S discovery (1846) of the rotation of the plane of polarization of light under the influence of magnetic forces made manifest the relation existing between polarized light, magnetism, and electricity.

The action of magnetism upon the electric spark while passing through highly rarefied gases was plainly shown by the researches of De la Rive and by the spectroscopic experiments of Trève, Daniel, Secchi, and Capron.

According to De la Rive and Daniel, this phenomenon obeys the laws of electro-dynamics, and the results observed, the increased luminous power of the spark and of its spectrum, are due to a local condensation of the gaseous medium. Secchi, on the other hand, ascribes them to the diamagnetism of the gases, *i. e.*, to a repulsion which the magnet exerts upon the rarefied gases occasioning a strong diminution of the gaseous surface in the section of the tube traversed, and thereby an elevation of temperature.

According to these physicists, the influence of magnetism upon a spark traversing rarefied gases depends merely in a change of the resistance of the gases thus traversed. Cazin has also concluded from Secchi's experiments that "there is no spectrum peculiar to magnetism, *i. e.*, that the magnet exerts no direct action upon the rays emanating from the source of light."

This inference, however, goes beyond the known facts, for nothing forbids us, on the other hand, to ascribe the increased luminosity of the spark and its spectrum to the action of the magnetism upon the luminous rays themselves.

However this may be, the question may be answered more accurately, even if perhaps not as yet finally, and that by means of experiments where magnetic forces may act upon the movement of light and heat without anything intermediate save ponderable matter. Magnetic experiments with flames fulfill these conditions.

The influence exerted by magnetism upon the direction of flames has long been observed, and it is known that all flames display the same phenomena in different degrees. It has only to be decided whether the magnetic action is confined to a change in the direction of the gaseous masses, or whether it extends to the luminous undulations themselves.

Although spectral analysis might decide this question, it is necessary to combine the most favorable conditions of magnetic intensity and of the dispersion of light in order that the spectral modifications produced may not escape observation.

The spectroscopic appliances of the Brussels Observatory, including a very powerful dispersion apparatus and a Faraday's electro-magnet constructed by Ruhmkorff, which is excited by a current of 50 amperes, enabled the author to attempt the solution of this question.

The oxyhydrogen flame of a small blast was driven horizontally upon a piece of charcoal saturated with soda placed between the conical keepers of the electro-magnet, which were at ten millimeters distance from each other. An image of the flames was thrown by a double objective upon the slit of the spectroscope. The quantity of oxygen introduced into the flame permitted the temperature to be regulated in such a manner

direction of the magnetic axis undergoes the same changes under the influence of magnetism as that of a flame perpendicular to this axis.—*Acad. de Bruxelles* [3], vol. ix. (1885).

COCOA-NUT FIBER.

It was Linnæus who first called the palms the "princes of the vegetable kingdom," but it has been reserved to writers of the present day to designate the cocoa-nut and the palmyra respectively the "prince of palms;" which of these two plants, however, is most entitled to the term it is difficult to say, for we read that the palmyra (*Borassus flabelliformis*) has been immortalized in a poem in the Tamil language, and though 801 uses of the palm have been thus recorded, the list is by no means exhausted. Whether it would be possible to enumerate so many uses for the cocoa-nut palm (*Cocos nucifera*) I have not been at the trouble to inquire, but I venture to believe that for sterling value as a commercial plant the cocoa-nut can compete any day with the palmyra, or any of its allies.

It would seem that with a plant so well known as this, and about which so much has been written, nothing now remains to be said. It is an old story to be told that the outer husk yields coir; that the inner hard shell can be, and is generally, carved into ornamental cups; that the kernel of the nut itself is edible when fresh, and that it yields large quantities of oil when dried. These are facts known to all who know a cocoa-nut when they see it, and what schoolboy is there who is not acquainted in some way with this

Islands; the quantity landed in the United Kingdom being about 12,000,000 yearly. Nearly all the nuts are imported in the husks or outer covering, from which, on arrival, they are stripped by men using two fine-pointed steel chisels, and who, by constant practice, became so skillful in the art that many are able to open 1,000 to 1,200 nuts per day. The nuts themselves after being removed from the husks are generally sold to wholesale fruit dealers, who, in turn, supply the retailers, costermongers and others, but they are likewise often sold under the hammer at public auction.

After removal from the husk they are sorted into seven sorts or varieties, known respectively as large milky, middle size, small, starters, milky growers, green, and dry. Those from Trinidad are the sweetest in flavor, and are mostly preferred by the manufacturing confectioners, biscuit-makers, and others, though the Ceylon nuts run them very close in quality. Cocoa-nuts are largely used in the North and West of England, and they are also in great demand at holiday times, at fairs, on racecourses, and such like gatherings in all parts of the kingdom. The husks, after the nuts have been cracked, are stacked in the yard in the open air, as shown in the engraving, until they are required for conversion into fibre; for this purpose they are first passed singly through a powerful "crusher," or "back-breaker," driven by steam power, with large revolving corrugated wheels, which flatten the husks, and, to a certain extent, make them more pliable; but after this severe pressure, so springy is the nature of the husk that, somewhat like a sponge, they immediately assume their original shape on emerging from the

COCOA-NUT FIBER MANUFACTORY.

that the spectral lines D_1 and D_2 could be made to appear at pleasure.

Under these conditions the sodium lines D_1 and D_2 , which prior to the passage of the magnetizing current were but narrow and not inverted, became immediately longer, broader, and more luminous as soon as the electro-magnet was set in action.

If the luminous lines D_1 and D_2 are already broad before the electro-magnet is brought into play, they become still broader, and are inverted (*i. e.*, there appears a black line in the center of the broad luminous band) during the transit of the magnetizing current.

If the bands are already expanded and inverted, the expansion both of the luminous band and of the black line increases considerably.

These phenomena, which immediately disappear on the interruption of the current, can also be observed, though with less intensity, in the red line of potassium or lithium, in the green line of thallium, etc., if a trace of these metals or of their salts is laid upon the charcoal.

If instead of the conical armatures of the electro-magnet we use flat ones, so that the entire length of the flame is between the armatures, the lines D_1 and D_2 , which are already extended and inverted, display a double inversion (*i. e.*, a shining line appears in the middle of the black line) when the electro-magnet is set in action.

These experiments, which demonstrate the influence of magnetism upon the luminous undulations without the intervention of the electric spark, show likewise that the phenomena which appear under the influence of magnetism are identical with those produced by an elevation of temperature.

The spectrum of a flame which coincides with the

familiar nut? But each one of its uses might be dilated upon, and to use an oft-repeated term, "volumes might be written" upon each; but our business at present is only with the husk, apparently a minor portion of the cocoa-nut, commercially considered. A glance at the engraving, however, will show that a large trade must be centered about these "unconsidered trifles," and that such is the case I shall endeavor to show by briefly recording what I saw on a visit to the cocoa-nut fiber works of Messrs. Chubb, Round & Co., situated in West Ferry Road, Millwall. This firm is one of, if not the largest importers and manufacturers of cocoa-nut fiber, and their stock of material, which is well shown in the engraving, is a very striking sight. The enormous heap of husks, which, indeed, is known in the locality as the "mountain," comes upon view immediately upon entering the premises, and one can scarcely, at first sight, realize the fact that the enormous pile is composed entirely of these apparently useless portions of the fruit. At the time of my visit this reserve stock of husks was estimated at considerably over a million and a half, and presented an appearance as shown in the engraving, which is from a photograph taken by Mr. John G. Horsey only a week or so previously. Before proceeding to describe the various processes through which the husks pass to convert them into marketable material, it will be well to say something about the nuts themselves.

Cocoa-nuts, or, as they are generally termed in the trade, coker-nuts, to distinguish them from the Theobroma cacao, which furnishes cocoa and chocolate, are shipped principally from Trinidad, Jamaica, Demerara, Tobago, several of the other Leeward Islands in the British West Indies, Ceylon, Belize (British Honduras), all round the coast of America, and the Fiji

crusher. They are then thrown into huge stone tanks, each holding many thousands, where they undergo several hours' steaming and soaking. Great care and skill are required to know how long to keep them in the tanks, husks from different countries requiring more or less time, according to circumstances, such as age, thickness of outer cuticle, substance of fiber, and other peculiarities known to the manufacturers. In the tanks the husks swell considerably, and have to be kept down by heavy pressure. One of the tanks filled with husks is shown in the center of the engraving.

After the husks are sufficiently soaked they are ready for the mills, which are technically known as "teasers" or "devils," and consist of cylinders or drums, each being studded on the outer circumference with about 3,000 fine or thick 3 inch steel teeth, specially tempered. The mills vary slightly, according to certain requirements. They are driven by steam, and revolve with great rapidity, requiring the utmost care and constant attention of the workmen. Each husk is divided longitudinally into thin pieces, and each piece is passed into the mill separately by the workman between two steel rollers, the workman retaining a firm grip of it so as not to allow it to pass out of his hands; but the few moments he holds it there the drum with its numerous steel teeth is revolving, and combing out the irregular fiber and refuse. After one-half of the slice of husk is thus cleaned the workman reverses it, passing in the other half. The continual feeding of these mills gives such strength of wrist and dexterity to the workmen that what appears a very dangerous operation is gone through with wonderful rapidity, and each slice of husk is passed through three of these mills in succession, occupying but a few seconds from the time that the crude husk is passed into the mill