The cost of refractories, then, for this furnace is about 20 cents per ton of steel with pig and scrap, and 40 cents where pig and ore are used.

When it is preferred to use natural combustible gas or vaporized petroleum, the gas producer outlet flue may be bricked up and the gas introduced into the flue, or the gas may be delivered into the producer, which should be hermetically closed and the flue opened, the producer being used as an expansion chamber when gas is introduced under high pressure. These kinds of fuel are fed in measured volume to the furnace, and are ignited in the flues leading from the producer to the furnace with measured volumes of heated air heated in the blast pipes, as hereinbefore described.

The gas producer should always be attached to the furnace to prevent stoppages from any failure in the gas supply, and to regulate the price of natural gas below the cost of the cheapest available coal and labor of fueling of the locality.

This furnace gives exceptional facilities for the production of steel castings, as the metal may be tapped from the hearth just as it is wanted, leaving the remainder hot in the furnace, which is desirable for small castings. It can be built of any required capacity ranging from $2\frac{1}{2}$ to $12\frac{1}{2}$ tons per cast.

THE FLAME PROCESS.

This invention is founded on the discovery that the purification of iron may be obtained by flame alone when combustible gases are supplied in the exact chemical proportions in which they are required for combustion, and brought together in such a manner that the different molecules which have to enter into combination may readily do so. This is accomplished by the arrangement of the furnace previously described, which produces a homogeneous flame in the connecting flues of the producer with first heating chamber, and by causing the inflamed gases to impinge on the iron, produces dissociation to their original elements, and thereby rapidly effects the purification of the iron. Pig iron exposed under these conditions below the melting point becomes decarbonized and partially dephosphorized without being melted, which, if continued long enough, will become oxide of iron, without any change in size or form; but for practical use it is more economical to melt the iron, and thus make homogeneous iron or cast steel, which may be poured or run from the hearth and cast into ingots, which roll direct, without blooming, to required shapes. This is done in one-fourth the time with flame alone, or in one-eighth the time when reagents are also used, that is required in the regenerative furnace, and all of the carbon, silicon, sulphur, and phosphorus may be removed, and the phosphorus and sulphur recovered as by-products, and the heat produced by the chemical reactions be used for heating uses.

Four patents were granted to me for flame processes in 1883, of which No. 283,483 is for the flame with basic reagents, with or without basic lined hearths. No. 283,484 is for the use of flame alone, without basic reagents, and with or without basic lined hearths. No. 284,550 is for annealing iron or steel exposed in this flame. No. 284,551 is for "purifying solid iron and steel, producing therefrom malleable iron or steel without fusion."

Further information may be obtained by addressing the author, Mills Building, New York, care of Chas. G. Francklyn.

PHOTOGRAPHY UPON WOOD

VARIOUS processes of direct photographing upon wood have been much used for some time past, which permit skillful engravers to perform their work directly, without the intermediation of a drawing.

In the *Bulletin de la Societe de Photographie*, Mr. E. Frewing describes the following method, which he says gives excellent results.

The wooden blocks are prepared as follows:

Preparation.

Gelatine.....	180 grains.
White soap.....	180 "
Water.....	21 fl. ounces.

The gelatine is allowed to soak in the water for a few hours, and is then dissolved in a water bath. Then the soap, cut into small pieces, is added, and the whole is stirred with a glass rod so as to make a perfect mixture. Next, powdered alum is added until the froth disappears, and the liquid is finally strained through muslin.

The block of wood is covered with this mixture and a little zinc white, and is afterward wiped off so as to leave but a very thin film. The operation is finished by a gentle rubbing, so as to render the film very even. After the film is dry, the following composition is applied with a badger's hair brush. This latter should be quite wide, since sometimes, if great care be not taken, and the operation be not performed quickly, lines are visible on the finished image. It will suffice to give one coat by passing the brush from one end to the other. After this the surface is allowed to dry.

Composition.

Albumen.....	13 fluid ounces.
Water.....	10 "
Sal ammoniac.....	270 grains.
Citric acid.....	75 "

The albumen is whipped to a froth, and then allowed to settle. It is the limpid portion that is used. The water is added, and then the sal ammoniac, and the whole is carefully stirred with a glass rod. Finally, the citric acid is added. When the block is dry, it is ready to be sensitized.

Sensitizing Solution.

Nitrate of silver.....	750 grains.
Distilled water.....	13 fluid ounces.

A small quantity of this liquid is poured upon the block and spread with a glass rod, and the excess is placed in a bottle, to be used again after filtration. When once dry, the block may be exposed under a negative. The print should be exactly of the tone desired, since the image loses nothing in the following operations. When the print is obtained, the wood is placed face downward for three minutes in a bowl full of very salt water.

This operation slightly weakens the image. The block is next washed under a stream of water, and the image is fixed in a saturated solution of hyposulphite of soda by placing the block face downward in a bowl

containing the liquid. After this the block is washed for about ten minutes under a stream of water, and is next dried, when it will be ready for the engraver. If desired, the image may be reversed by any of the methods generally used. In practice, this process will be found to be good, rapid, and simple, and to give fine results. It is well adapted for engraving on wood, in that it offers no perceptible layer, and that the image is clean and sharp.—*Le Genie Civil*.

FUEL CALORIMETRY.

By B. H. THWAITE, F.G.S., C.E., etc.

ALTHOUGH instruments for the precise value measurement of most of the agents of our industries have long been utilized, the heating value of the great natural source of power—coal—is rarely tested even by the largest consumers.

Occasionally quantitative analyses are obtained, but this method is expensive, and is neither so practically exact from a thermic estimation point of view, nor so useful, as a careful calorific estimation by actual combustion would be.

At present the different qualities of coals are known by the name of bests, seconds, etc., whereas a calorific

the combustion of fuel are deprived of the carbon dioxide and passed over cupric oxide for the estimation of the weight of carbon monoxide. But even this supplementary estimation does not allow of an absolutely exact correction to be made. Nevertheless, the arrangement of Favre and Silbermann's calorimeter reflects high credit on these distinguished chemists, but the complication and delicacy of the instrument render it unsuitable for ordinary fuel calorimetry.

Referring to the engravings, Fig. 1, which shows a section of Silbermann's ingenious calorimetric instrument, *a* is the combustion chamber of thin copper, silvered internally; the cover, *b*, allows the insertion of the platinum cage, *c*, in which the fuel to be tested is placed. The oxygen for supporting combustion is supplied to the fuel by means of the pipe, *d*.

The progress of combustion can be watched by means of the ignition tube, *e*, and reflector, *f*.

The products of combustion escape by means of the outlet tube, *g*, and their sensible heat, resulting from combustion, is absorbed in the passage of the gas through the copper coil condenser, *h*, finally escaping by means of the pipe, *p*. The whole of the parts enumerated are submerged in a thin copper vessel, *i*, silvered internally and filled with water, which is well circulated by means of the agitator, *j*.

estimation might show that the seconds, or even qualities more inferior, possessed a higher calorific efficiency than the firsts. By the utilization of fuel calorimetry, a user of coal would be able to ascertain exactly the financial value of the definite amount of heat energy of different fuels. He would also be able to compare the heat energy possessed by the fuel with that economically evolved in his steam generators. For the character of his fuel the user would not have to rely on the *ipse dixit* of his boiler firemen, who are not always proof against tempting bribes. If his steam generator was of the usual wasteful kind, he would realize the cost of the defect in a most telling manner. Consequently, fuel calorimetry would prove a strong inducement to the adoption of more perfect combustion arrangements, and thus aid the laudable objects of the Smoke Abatement Society. Dulong was the first to design a scientific calorimeter, in which the fuel was consumed in a current of oxygen. This instrument was greatly improved by Favre and Silbermann.

The disadvantage of Dulong's system is that the combustion absorbs a considerable period of time, and consequently requires a notable correction for re-cooling; besides, owing to the fact that unless the oxygen is applied by compression, the instability of carbon dioxide in the presence of carbon prevents the entire oxidation of the carbon, and part of the gases escape as carbon monoxide with a consequent loss of heat energy. Owing to the defects enumerated of the Dulong calorimeter, his, Dulong's, measurements are not so exact as one might desire.

In the ingenious and carefully designed apparatus of Messrs. Favre and Silbermann, the gases result from

This copper vessel, *i*, is placed in an external annular vessel, *k*, lined inside with swan's down, *l*, the annular space, *m*, being filled with water. Openings in the covers are provided for the insertion of thermometers. The ignition can be effected either with an electric spark, the combustion of a given length of fine iron wire, or by a fuse; and as soon as the ignition is effected, the supply of oxygen is commenced and continued until the fuel is entirely consumed. The difference of initial and final temperatures of water and the weight of the water are then noted, and the calorific estimation is thus attainable.

Mr. Lewis Thompson, M.R.C.S., designed some time ago an exceedingly ingenious apparatus by which he obtained the oxygen for fuel combustion from potassium chlorate and potassium nitrate intimately mixed with the fuel in a finely divided condition. The mixture is ignited with a fuse.

Ingenious as this process undoubtedly is, it nevertheless contains serious defects, inasmuch as the dissociation of the potassium chloride generates heat, and heat is, on the contrary, absorbed by the expansion of the oxygen from a solid to a gaseous condition to the normal atmospheric pressure, and the dissolution of the residual potassium chloride also absorbs heat, so that to arrive at accurate results considerable corrections have to be made.

Berthelot mentions that in the hands of Mr. Stohmann the solid oxygen arrangement has been greatly improved and increased in accuracy; indeed, the concurrence of the results of Mr. Stohmann's experiments with those obtained by Berthelot with his compressed oxygen apparatus are confirmatory of this.

Berthelot and his confrère Vieille mention the use of potassium perchlorate, intimately mixed with the fuel, the combustion to be effected in a confined atmosphere of oxygen. By this system the intervention of the heat of the dissolution of potassium chloride would be avoided, and combustion would have been effected at constant volume; but after serious consideration Messrs. Berthelot and Vieille decided to confine themselves to the use of oxygen *per se* in a gaseous form as the oxidizable agent in their calorimeter. In the use of gaseous oxygen the single difficulty to be overcome is the realization of the complete oxidation of the fuel without the production of a trace of carbon monoxide or of hydrocarbons. This difficulty has been successfully overcome by the use of pure oxygen compressed to about seven atmospheres, and with a weight of combustible such that the proportion of oxygen consumed does not surpass 30 or 40 per cent. of its initial quantity. The air is forced into the small combustion and strongly formed mortar-shaped vessel by means of a force pump.

Referring to Fig. 2, representing Berthelot's latest form of calorimeter, *a* is the special gaseous explosion or combustion bomb or cylinder of steel internally lined with platinum; *b*, a special screw-down cock, allows the oxygen to enter the bomb by the pipe, *c*, when it is compressed by means of a force pump to a pressure of seven atmospheres.

A special key is provided by which the head of the bomb can be rigidly forced on it. The fuel to be tested is placed in the platinum basket, *e*, suspended by thick platinum wire; the fuel is ignited by an electric current passed by the conductors, *f*. The combustion bomb is immersed in a platinum vessel, *g*, provided with a lid or cover, *h*, perforated to allow the insertion of a thermometer. The outside of the annular casing is lined with felt, *n*.

Berthelot's first experiments, embodied in his "Essai de Mécanique Chimique," were obtained with a different arrangement of combustion vessel, shown in Fig. 3. Into a vessel of glass, *a*, a tube, *b*, also of glass, led the oxygen for the combustion of the fuel, which was placed in a cage of platinum, *c*. The ignition was effected through a special corked opening, *d*, through which the fuel cage could also be passed; the products of combustion released their sensible heat in traversing the serpentine coil condenser, *e*, to the water in platinum vessel, *g*, the products of combustion finally escaping (for subsequent analysis if desired) by the pipe, *e*. The whole apparatus was placed in an ordinary external calorimetric vessel, as shown in Fig. 2.

The advantages obtained by this new arrangement are that the calorimetric measurement can be performed in from three to four minutes, while the actual combustion only occupies a few seconds. A very small quantity of water is required, so that the temperature attains the highest degree, and this increases the precision of measurement. The residuum is not, judging from critical analysis, found to contain any residual gases. The ignition is effected by the passage of an electric current through a platinum wire and to a platinum cage in which the fuel is placed.

With this instrument Messrs. Berthelot and Vieille have established the calorific value of the most important heat-generating hydrocarbon elements. The figures are given in the *Comptes Rendus* for May 31 last. The disadvantage of this exceedingly precise instrument is its cost, which is very high. This calorimeter can be obtained from M. Golas, of Rue St. Jacques, Paris, who makes Berthelot's splendid instruments of precision.

Mr. W. Thomson, F.C.S., of Manchester, has lately improved the Lewis Thompson calorimeter. He also utilizes gaseous in preference to solid oxygen, and applies this agent in a very simple manner; and so far as the author can judge, the instrument appears the most satisfactory for popular use, as it will be decidedly inexpensive. It may not be entirely free from the defect mentioned in the use of oxygen at atmospheric pressure, *i. e.*, the incompleteness of combustion; but for every practical purpose, the instrument is all that could be desired. Referring to Fig. 4, showing a section of the calorimetric apparatus designed by Professor William Thomson, F.C.S., *a* is the oxygen holder of galvanized iron and also internally black varnished.

The displacement of the oxygen is effected by means of water (under pressure or from an elevation) which enters the holder through the tap, *b*. The oxygen displaced escapes at the top of the large tap, *d*, from which it is led to the calorimetric apparatus by the India rubber tubing, *e*. The volume of oxygen displaced in holder is indicated by the gauge glass, *f*; the second glass tube, *g*, is intended to show the pressure of gas by the difference of levels in the two tubes.

The oxygen enters into the calorimeter combustion vessel, *h* (which is simply an inverted bell glass), by means of a brass tube, *i*, of a small caliber, and provided with a regulating tap, *j*. The fuel to be tested is placed in the platinum crucible, *k*, which is in its turn placed on a pipe-clay support resting on a spring framework, *l*, which is attached to the sides of the inverted bell glass, *h*. The latter is placed in a thin glass beaker, *m*, of a capacity of 2,000 c. c., filled with water, which of course cannot enter the inside of inverted bell glass until the tap, *j*, is opened and the oxygen tube disconnected.

The beaker is set on corks inside a bright tinned sheet iron outside vessel, *n*, which has in its side a glazed orifice, *o*; through this the progress of combustion can be watched. The water in the beaker can be well circulated by means of the agitators, *p*. The ignition fuse is prepared as follows: Two or three strands of lamp wick are soaked in a solution of potassic nitrate and dried.

The *modus operandi* when using the Thomson calorimetric apparatus is as follows:

One gramme of coal having been weighed, it is then placed in the platinum crucible; 2,000 c. c. of water are then poured into the beaker, and the temperature taken.

The crucible is now placed on a spring clip frame which is attached to the mouth of the bell glass; the ignition fuse is then lighted and the apparatus is then immersed in the water. The oxygen supply is commenced and continued until the completion of combustion. During the test the water should be well circulated by means of the agitators. The oxygen supply tube is pushed into the mouth of the crucible toward the termination of combustion, and a circular motion is given to the tube by the hand until the fixed carbon of the coal is entirely consumed.

The water in the beaker is now allowed to enter the inside of the bell glass, by which the heat from the crucible frame and oxygen supply pipe is abstracted, and after the water is well circulated the final temperature reading may be taken. The difference between the final and initial temperatures of the water represents, of course, the heat due to combustion; and without any deduction for recooling or for imperfect agents having to be taken into account, it will be seen that this process is adaptable for the use of unscientific persons.

The author suggests that the standard marketable or sale value of coal should be expressed in the weight of fuel in decimals of a pound required to raise 1 lb. of water to 212 deg. Fah. or 100 deg. Cent. from an initial temperature of 77 deg. Fah. or 25 deg. Cent.

An instrument such as that designed by Professor Thomson ought to be adopted as the standard calorimeter to be used. The general adoption of this fuel calorimetric system would undoubtedly conduce to greater economy in the use of fuel and in the prevention of smoke and fogs, and these desiderata would be attended with sanitary and other self-evident advantages.—*Engineering*.

AN ELECTRIC TACHOMETER.

THE need of an apparatus which will show at a glance the speed of a rotating shaft has been greatly

d, which is driven by a band from the shaft the speed of which is to be measured. Now when this armature is rotated within the field of the magnet, electric currents are formed in its body, just as in the case of a Gramme ring, except that here they circulate in the solid metal and not in insulated conductors. Within the copper ring there is mounted on the spindle, *h*, a soft iron bar, *g*, the section of which is shown in Fig. 3. This bar is constrained by the magnet, *b*, to take up an axial position between its poles, and to form a direct path for the lines of force between the poles, N and S. But immediately the ring, *c*, commences to revolve, another force is brought to bear on the bar. The currents in the copper tend to rotate the bar, *g*, on its axis, *h*, and thus it moves from its horizontal position until it finds a point at which the influence of the magnet is exactly balanced by that of the current. An arm on the spindle, *h*, carries a curved rack, *i*, which gears with a pinion on the index spindle, *b*, and thus the movement of the bar is greatly magnified upon the dial. The strength of the currents is proportional to the speed of rotation, and the divisions of the dial are uniform.

The accuracy of the indicators is not dependent (within limits) on the strength of the magnet, because the two forces acting upon the bar are derived from the same magnet, and vary together, decreasing together if the magnetic power should suffer any de-

THE ELECTRIC TACHOMETER.

emphasized since the introduction of electric lighting. Such an instrument has always been desirable, but until the last five years the demand was not urgent, and little effort was made to meet it. Recently, however, says *Engineering*, several tachometers or speed indicators have been brought out, and some have been illustrated and described in our columns. The latest invention of this sort is by Dr. T. Horn, of Leipsic, and is distinguished from all that have preceded it by its extreme simplicity. It is also peculiarly appropriate for use in an electric light installation, in that it is itself a simple form of dynamo machine. We illustrate its construction by the engravings above, the perspective view showing the indicator with the dial and index removed, and the other views giving details of its construction. A powerful horseshoe magnet, *b*, stands astride of an armature, *c*. This armature consists of a ring or pulley of copper (Fig. 4) mounted on a spindle,

terioration. There are no springs or weights in the instrument, and it contains nothing whatever which can get out of order, except the main bearings.

Although the chief demand for tachometers is for electric lighting purposes, yet they are useful for many other purposes, such as for showing the speed of locomotives, of cotton and lace mill engines, of marine engines, and of pumps. As the moving parts of the instrument we are describing are very light, it is exceedingly sensitive, and will at once disclose the faults of a bad governor. It is also made as a tachograph, and produces a diagram of speeds on a continuous ribbon of paper. Dr. Horn's tachometers have been used at the Colonial and Indian Exhibition, by Mr. W. H. Preece, at Woolwich Arsenal, and at various other establishments, and have given great satisfaction. The proprietors are James Thorne & Co., 85 Gracechurch Street.