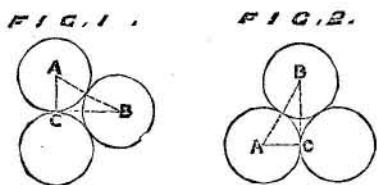


occupied is 1.812 to 6, or 80 per cent., as before. If the balls are 3 in. diameter, the percentage is the same. The distance apart of the rows is $\sqrt{3^2 - (1.5)^2} = 2.598$ in., and the space occupied by each ball is $3 \times (2.598)^2 = 20.25$ cubic inches. The solid sphere is $0.5236 \times 3^3 = 14.137$ cubic inches, leaving a space around each ball of $20.25 - 14.137 = 6.113$ cubic inches, and the ratio of the hollow space to the whole space is 6.113 to 20.25, or 80 per cent.

These may be compared with some recent trials of the proportions of sand and shingle at the Portsmouth Dockyard Extension works, given by Mr. C. Colson in a paper read at the Institution of Civil Engineers in February, 1881, where 15 samples of shingle of 1 cubic foot each, from various localities—viz., from Langston Harbor, Brown-down, and Portsmouth Harbor, were tried, and which showed that it required, on the average of the 15 samples from the above-named localities, 38.4 per cent. of sand to fill the interstices, or 2.630 parts of shingle to 1 of sand. There was 53.3 per cent. of sand in the material as procured and used in the dock walls and other parts of the work, or 1.875 of shingle to 1 of sand; but in the trials the quantity of sand was reduced to that which was sufficient only to fill the interstices of the shingle, with the above results. At the same time 26 trials were made of the quantity of cement required to fill the interstices of the sand for mortar, which showed a proportion of 36.4 parts of cement to 100 of sand, or 2.715 of sand to 1 of cement.

Mr. G. F. Deacon, of Liverpool, made some trials of concrete used in the foundations of roadways, given in a paper read by him at the Institution in April, 1879. The concrete consisted of 8 parts of broken stone, 6 parts of gravel, and 1 of cement, making a mass, when mixed and beaten together, of 11 parts of stone and gravel to 1 of set cement; from which it would seem, the cement being included in the 11 parts, that it required 3 parts of gravel (containing half a part of cement) to fill the interstices of the broken stone, there being in the produced mass 3 parts of gravel more than was sufficient to fill the interstices. The percentage of space of the interstices of the broken stone to the whole mass was thus 3 to 11, or 27.27 per cent.

When the quantity of sand and cement is considerably in excess of that required to fill the interstices of the larger material, as in this latter case and in the walls of the Portsmouth Dockyard Extension, it takes the form of a matrix in which are embedded the larger pieces of material, and thus becomes or resembles rubble masonry, such as is found in the old castle walls and Roman buildings, in which pieces



of rough stone are embedded in a coarse mortar. This is the form which concrete walls should take which are intended to retain water in a reservoir. Concrete has not hitherto been used to form a reservoir embankment entirely, but during the last few years it has been used to protect the puddle walls of earthen embankments.

In the Appendix, No. 7, of the third Report of the Rivers Commission, in 1867, Mr. Rawlinson recommended the use of concrete to protect the puddle in these words: "The cheapest material which can be safely used will be concrete, made of the best hydraulic lime, and laid thickly over the entire surface of the puddle trench. Concrete, or a thick bed of mortar, should, in fact, protect puddle from contact with rock, gravel, clay, or earth at every point."—*Building News*.

DESTRUCTIVE DISTILLATION.

By "OWEN MERRIMAN."

THAT "dividends are made in the retort house" is an oft-repeated assertion the truth of which is never disputed. For it needs no statistics to prove that, if economy is not observed in the production of the crude gas, the advantage lost cannot be regained in the subsequent processes of purification and distribution. Seeing that so much depends upon the operations conducted in the retort house, it is eminently desirable that the theory of these operations should be thoroughly understood. Chief among them is the carbonization or destructive distillation of coal.

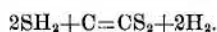
"Destructive distillation" is the term given to the application of heat to a substance without access of air, whereby the chemical compounds or combinations of elements of which the substance is composed are broken up and new products formed. Thus coal consists of the elements carbon, hydrogen, oxygen, and nitrogen, in a state or states of combination with each other (of which nothing definite is known), together with sulphur and mineral and earthy matter forming the ash. When submitted to the action of heat in a retort, the affinity which binds together the elements in the coal is relaxed, new combinations are formed, and the products which result are evolved in the state of vapor. The nature and composition of the ultimate products are dependent upon—(a) the condition of the coal; (b) the temperature to which it is submitted; and (c), in a less degree, on the pressure to which the evolved vapors are subjected in the retort.

(a) If the coal be wet, the temperature of the retort is at once reduced by the abstraction of the heat necessary to raise the water to a state of vapor; while if the temperature be regained before all the moisture is driven from the innermost portions of the coal, this water is decomposed by contact with the outside incandescent coal and the sides of the retort, its oxygen combining with carbon to form carbonic acid, and its hydrogen being set free. The amount and condition of the sulphur present in the coal necessarily influence the amount of sulphur impurities which will be contained in the gas, and likewise with the other constituents. The amount of nitrogen determines the ammonia, and the oxygen the carbonic oxides, while the hydrocarbons are given off in greater abundance and have an increased symbolic value, according as the coal contains much hydrogen—as is strikingly exemplified in the large yield and high quality of gas and tar from cannel coal.

Again, the ash, which is always present in coal, exercises a considerable influence in determining the yield of gas, by holding down the hydrocarbons and compelling recourse to a much higher temperature than would otherwise be necessary.

Another condition which has an important bearing upon the ultimate results of its distillation is the size of the pieces

and the thickness of the layer of coal in the retort. When coal is distilled in large lumps or in a thick layer, that on the outside loses its gas and becomes incandescent before the coal in the center has reached the temperature required for distillation. In consequence, when gas is evolved from this latter it must pass through an incandescent mass and be redistilled, losing its carbon and gaining in diluent gases, while any moisture is converted into hydrogen and carbonic acid, as before shown. The sulphur, too, which it may be giving off as sulphureted hydrogen, becomes, in contact with incandescent coke, bisulphide of carbon—



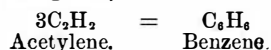
Whereas, when the coal is previously broken into small pieces and is in a thin layer, the heat penetrates more uniformly into the mass of coal, and the process of distillation is more quickly accomplished; but with this drawback—the heat acting upon a largely increased surface of coal, a greater abundance of vapors is immediately disengaged, requiring a considerable reserve of heat in the retort and furnace at the commencement of the charge to convert these vapors into permanent gas, otherwise a large proportion of liquid hydrocarbons will result.

(b) As we are ignorant of the manner in which the elements are combined in the coal, so are we in ignorance of the precise nature of the change which takes place on applying heat for the purpose of its destructive distillation. Whether this consists in the simple rearrangement of the elements to form new compounds or in the decomposition of definite formations already existing in the coal into less complex bodies is not certainly known, although observed facts seem to favor the latter hypothesis. Certain it is that the first result of the process is the production of complex hydrocarbons, which, undergoing a series of decompositions through a regular descending scale of gradations, would, if submitted to a sufficiently high temperature, result in their ultimate reduction to simple gases and elementary bodies. Were this the only effect produced it would be quite possible, by a regulation of the temperature, to cut short these decompositions at any required stage, and so to produce compounds of constant and uniform composition. But the reactions in the retort are far more complicated. Besides breaking up complex hydrocarbons into more simple ones, heat has the property of building up these same compounds by accretions of bodies possessing the same constituents in lesser density.

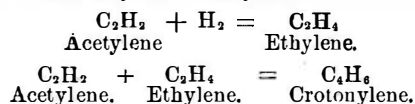
Thus, at the temperature of the electric arc, carbon and hydrogen unite to form acetylene, and oxygen and hydrogen to form water, and from these two bodies it is possible to build up nearly the whole series of hydrocarbon compounds. This synthetical action of heat in the process of distillation is known by the term "cumulative resolution." By its influence in conjunction with that of decomposition before described the great diversity of products formed during the distillation of coal is readily explained.

As examples of its operation take the following:

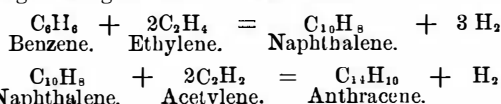
At a low temperature three molecules of acetylene unite to form benzene (the benzene being decomposed into acetylene again by a strong heat)—



When acetylene is heated with hydrogen ethylene is produced, and with ethylene crotonylene—

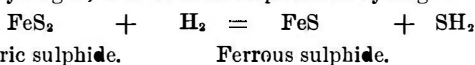


At a red heat benzene and ethylene combine to form naphthalene, and naphthalene and acetylene to form anthracene, hydrogen being evolved in both instances—



The consideration of these few instances will serve to explain why it is that while, with high heats, much hydrogen and other gases of low illuminating power are produced with very little benzene, they are always accompanied by a considerable proportion of naphthalene and other heavy hydrocarbons.

Not only the composition of the illuminants varies with the temperature at which the coal is distilled, but that of the other components of crude coal gas known as impurities. Thus, at a low temperature nearly the whole of the oxygen present in the coal passes off, combined with hydrogen, as water; whereas, at a high temperature, it is evolved, in combination with carbon, as carbonic acid or oxide. Sulphur usually exists in coal, combined with iron in the form of bisulphide of iron. When submitted to a moderate temperature, one equivalent of sulphur is liberated, which, taking up hydrogen, is evolved as sulphureted hydrogen—



This reaction probably goes on continuously from an early period of distillation. When the sulphureted hydrogen comes in contact with incandescent carbon, either existing on the sides of the retort or in the coal itself, it is converted into bisulphide of carbon, with evolution of hydrogen.

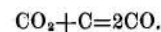
From this it would appear that the popular opinion which regards the production of this compound as taking place during the last stages of distillation is in the main correct, because at this period the coal, having been nearly exhausted of its gas, and having attained to a high temperature, presents a mass of incandescent carbon, over and through which the sulphureted hydrogen and any other vapors being evolved must pass. It is, however, probable that the deposited carbon on the sides of the retort affords the requisite conditions for its formation, to some extent at least, during the whole process.

With regard to the production of ammonia little is known. The most reasonable supposition is that it results from the decomposition of some compound of nitrogen existing in the coal, but whether its production is favored by one temperature rather than another, or whether it is continuously produced throughout the whole period of distillation, is a matter involved in doubt, and which calls for thorough investigation by intelligent research.

(c) The influence of pressure is chiefly important by reason of its tendency to prolong the stay of the vapors which are being evolved from the coal in the highly heated retort, and so to increase their liability to decomposition. For it is evident that, if an obstruction to the exit of these vapors be formed by means of an increased pressure, they must be

subjected to further heat until their tension is raised sufficiently to enable them to overcome the obstacle. The deteriorating effect upon the gas thus induced is strikingly shown by the deposits of carbon which are formed by the decomposition of hydrocarbon vapors in contact with the intensely heated surface of the retort. This action is aggravated by the mode in which the pressure is obtained or transmitted—the pulsatory motion of the gas passing through the liquid in the hydraulic main producing a backward and forward movement of the gas in the retort, involving constant friction against its surface.

There is one compound, however, which may with advantage be suffered to endure prolonged stay in the retort. This is carbonic acid, which, by contact with incandescent carbon, is converted into carbonic oxide, taking up carbon as follows:



By relieving the retort of pressure the process of fractional distillation is facilitated. Fractional distillation is the method of separating different substances in a mixture undergoing distillation, by taking advantage of the fact that they boil and pass over at different temperatures. According to Wanklyn, "The quantity of each ingredient which distills will be found by multiplying its tension at the boiling point of the mixture by its vapor density."

By this law we are enabled to account for the difficulty which is experienced in separating the light from the heavy vapors of one homologous series of hydrocarbons, because while the tension decreases with each increment of CH_2 , the density is correspondingly increased. By reducing the pressure on the retort, the difference between the tensions of the various vapors is increased, and the separation of the lighter ones is proportionately facilitated, leaving the heavier compounds longer subjected to the heat of the retort.

Such are some of the reactions involved in the destructive distillation of coal. Complicated and obscure they may oft-times be, but they act in obedience to unerring laws which, if we rightly understand, we shall be enabled to carry out the operations of the retort house with more intelligent satisfaction, as well as with greater certainty of success.—*Journal of Gas Lighting*.

PREPARATION OF NEUTRAL OXALATE OF POTASSIUM.*

By E. B. SHUTTLEWORTH.

THE rapid dry-plate processes in photography, which are at present exciting considerable attention among the more advanced classes of those engaged in the art, have created a demand for neutral potassium oxalate that cannot be supplied through the ordinary trade channels. The writer has frequently been asked for this salt, as doubtless have many of the readers of the *Journal*, and as the preparation is simple, involving no special apparatus, a few notes on the subject may prove opportune.

There are three oxalates of potassium known to chemists—the neutral salt to which this paper refers, and which contains two atoms of potassium to one molecule of acid; the *binoxalate*, the ordinary salt of sorrel of the drug stores, and that which is found in many plants containing one atom of potassium to one of acid; and the *quatroxalate*, a salt not frequently prepared or used, in which the proportion of potassium and acid are one to two.

The neutral salt is the only one used in photography. It crystallizes in rhombic prisms, is stable in the air, contains two molecules of water of crystallization which may be driven off by heat, and is soluble in about three times its weight of cold water.

It is evident that the easiest mode of preparing this salt is by neutralizing a solution of carbonate of potassium by oxalic acid. Some have recommended that the ordinary salt of sorrel, *sal acetosella*, be rendered neutral by the addition of the carbonate, but this is certainly a roundabout and expensive plan, not only as involving the use of more costly material, but unnecessary evaporation. The most expeditious method will be found to be as follows:

Dissolve a quantity—say one pound—of carbonate of potassium in an equal weight of cold water, decanting the clear solution from any undissolved sediment, if such should remain. This residue consists of potassium sulphate or silicate, and is commonly present in the ordinary salts of tartar of commerce. Put the clear solution in an enameled iron, porcelain, or Wedgwood dish, add a quantity of water equal to that first employed, and heat to the boiling point. Add carefully, and by small portions, avoiding mishap by effervescence, sufficient powdered oxalic acid to neutralize the carbonate, testing carefully toward the close with test paper. If necessary filter the solution while hot and set aside to crystallize. A fresh crop of crystals may, of course, be obtained by evaporating the mother liquor.

The quantity of oxalic acid required cannot be definitely stated, as both acid and carbonate are generally impure; but theoretically, 174 parts of carbonate should require 90 of acid, and produce 202 of neutral oxalate. The product will practically be always considerably less than this, seldom equalling more than the weight of the carbonate employed.

As has been stated, the neutral oxalate is soluble in about three times its weight of water, and as photographers use a saturated solution, there is no reason, if time be an object, why a liquor should not be prepared extemporaneously, or at least that the operation of crystallization might not be omitted.

I have found that the specific gravity of such a solution is, at ordinary temperatures, 1.220, and that ten ounces of the salt, when dissolved, measure twenty-six fluid ounces. Such a solution, except made with distilled water, will, of course, require filtering, as the lime present in ordinary water is precipitated as oxalate.

DETERMINATION OF POTASSIUM.

By L. L. DE KONINCK.

THE potassium is thrown down, with the ordinary precautions, by platinum chloride; the K_2PtCl_6 is collected on a filter, washed in alcohol, and immediately dissolved in boiling water. The solution is reduced hot by magnesium. All the chlorine of the chloro-platinate is obtained in the form of a soluble chloride and a black precipitate of reduced platinum. At the same time the magnesium decomposes the water, yielding hydrated magnesia with an escape of hydrogen. When the reduction is complete the mixture is filtered, and in the neutral solution the chlorine is determined in the usual manner with a standard solution of silver nitrate, using potassium chromate as indicator.

* From the *Canadian Pharmaceutical Journal*, August, 1881.