that after conferring together these committees should present their report to the Newcastle meeting, where a smaller committee might be appointed to confer with the Chemical Society, and the Society of Public Analysts, with a view to the furtherance of the solution of the questions we have this evening for discussion.

ON THE MANUFACTURE OF WHITE LEAD, AND GARDNER'S ELECTRIC WHITE LEAD.

BY J. CARTER BELL, A.R.S.M., F.I.C., &c., &c.

THE manufacture of white lead is a most ancient proceeding, and has been pursued with but little variation in the mode of manufacture for some hundreds of years. The Dutch seem to have been the originators of this method of making white lead, which is now so largely conducted in this and other countries.

In this process metallic lead is piled in stacks, and submitted to the action of acetic acid, watery vapour, air, and carbonic acid for some time, by which means the metallic lead becomes gradually converted into white lead.

This method is called the "Stack" or Dutch process.

The construction of a stack is a very simple and rude operation. Layers of dung or tan, or a mixture of the two, so arranged as to imbed a large number of earthenware pots, each containing some acetic acid. These pots are about 4 or 5 in. in diameter, and about 7 or 8 in. high; a coil of lead is placed in each pot, and buckles or gratings of lead supported on oaken bearers are laid across and on top of the pots; boards are laid to cover the whole, and form a floor.

The stack is composed of a number of such layers of pots, bearers and buckles or gratings, raised one upon another.

A stack chamber is a brick inclosure 10 or 12 ft. square, and 20 or 25 ft. high; such a chamber will contain about 70 tons of lead when stacked and piled. In a white lead factory several of these chambers are built side by side, and when they are in full operation a set of chambers will contain as much as 700 or 1000 tons of lead.

Only the purest kind of lead will be suitable for conversion in this stack process of making white lead, the common varieties being inadmissible. Messrs. Pontifex and Wood have kindly given me the following analyses of lead used for white lead making.

	Copper.	Antimony.	Iron.	Spelter.	Silver.	Lead.
A	0.00700	0.00180	0.00200	0.00080	0.00100	99.98130
B	0.07580	0.00320	0.00220	0.00320	0.00200	99.91320
C	0.00310	0.00160	0.00120	0.00070	0.00350	99.98420
D	0.05260	0.00710	0.00150	0.00180	0.00100	99.93270
E	0.00910	0.00210	0.00160	0.00100	0.00075	99.98515
F	0.02330	0.00580	0.00210	0.00180	0.00100	99.96570

The presence of silver, copper and iron in the lead would damage the colour of the white lead resulting, and other admixtures retard or prevent the progress of conversion.

In olden times horse dung was the only imbedding material used in the stack arrangement. This material when heated evolves gases which seriously interfere with the colour of the resulting corrosion. Dung has been almost superseded in this country by tanner's refuse; in Belgium dung is yet employed, and in some places a mixture of dung and tan.

Where dung is used, the process of corrosion of the lead goes on more quickly than when tan alone is employed, but the use of tan offers great advantages, especially this one: that it does not give off gases that damage the white lead.

The operation of charging and discharging these chambers is principally the work of women, and is most laborious and fatiguing.

In emptying the chambers and stripping the stacks the women are fully exposed to the heated gases which are yielded by the decomposing tan, and the heated and corroded lead. These gases, in themselves most injurious to health, are not to be compared in this respect to the dust which pervades the air and fills the chamber in which these women work.

When a stack is charged, the chamber containing it is enclosed. The tan or dung within soon commences heating, and the heat soon causes the acetic acid in the pots, and the water in the tan or dung to rise in vapour and penetrate the stack. Air is admitted to the stack through openings left for that purpose, and carbonic acid is evolved from the heated decomposing tan or dung, and this gas also penetrates the stack, and the process of converting blue lead into the white lead gradually proceeds, and the blue metal becomes corroded and incrustated with a white crust or covering.

As to the exact chemical changes and combinations proceeding in the working of a stack differences of opinion exist, but we may fairly conclude that the process resolves itself into this—first, the formation of sub-acetate of lead, which, decomposed by the agency of the carbonic acid gas, becomes reduced to the condition of normal acetate by loss of a portion of its basic oxide of lead. The reduced sub-acetate then again takes up an additional molecule of oxide of lead and is re-converted into its original subsalt state to be again attacked and reduced by the carbonic acid gas, and so on continually during the working of the stack.

It will be evident that the "nascent" state of the various substances engaged during the chemical changes which are proceeding in the stack is an important factor in this process, and must be taken into account in considering the philosophy of the operation.

It will also be evident that the mode of proceeding in white lead making by the stack process is most crude and clumsy, and a most uncertain method, one governed by rule of thumb, and by no element of certainty or science. White lead makers, as a rule, know nothing of the chemistry of their subject. This absence of chemical knowledge of the subject, by those who are engaged in this manufacture, may explain the curious circumstance that for hundreds of years this industry has been pursued in the same old-fashioned and uncertain way, and the stack, or Dutch process, still holds its ground and displays little or no advance in knowledge or improvements in its method of proceeding, even in the present age of precision in almost every branch of manufacture. The uncertainty of the stack process is shewn most clearly in this: That stacks may work and some do not work. In the latter case all the time and labour spent in forming the stacks, and all the acid they contained, is lost.

No amount of foresight will avail to determine beforehand which stack shall accomplish the conversion of its contained metallic lead, and which will not.

The stacks are generally allowed to remain in operation, after they are charged, three or four months; in this time it is presumed all profitable action in the stack has ceased. The temperature of the stack which had risen gradually from the normal temperature to 100° or 150° Fahr. will have gradually fallen, and this falling temperature is the indication that the corrosion of the lead in the stack has terminated.

After the three months' action of the stacks, they are stripped and pulled to pieces. Some will be found

to be done better than others, and one part of the same stack will be done more perfectly than another. The coating on the lead will also differ; some will be smooth, regular, and equal in formation, some will be rough and blistered, and very ununiform. The rough blistered casting is rejected as unfit for white lead making, the workmen call it "dross." The smooth laminated coating is the one preserved for the after manufacture. It is a curious fact connected with the consideration of the total want of educated guidance in these matters that prevails, that in all factories of this description some chambers are noted as always working well, and others are equally well known to always do their work the reverse of well. No one knows why! No one stays to seek the reason. The factory way goes on filling and emptying these white lead chambers whether the stacks be working well or no.

The incrustation that is most esteemed by the manufacturers of white lead in this old-fashioned way is a hard, china-like material, formed of thin deposits, layer upon layer, in a slow, continuous, regular way. It is at once conceivable that in the rough-and-ready manner of stack manufacture most irregular action must proceed.

It would be almost impossible for the contents of the pile or stack to be submitted to the same action of the gases throughout. Some part of the stack and its contents will be under more favourable conditions than another, hence the reason why, in practice, it is invariably found that some stacks, and some parts of a stack, work better than another. Under the microscope this good crust of white lead, the proper incrustation from which to prepare white lead, will be readily seen to consist of very thin coatings or layers of white lead, which have been slowly formed on the metallic lead and piled one upon another to the thickness of an eighth or a quarter of an inch. This formation constitutes the hard, china-like substance, which alone possesses the chemical constitution and the properties to form good white lead paint.

White lead makers, recognising this peculiar incrustation as the only one capable of fulfilling their desired purpose of making good white lead paint, do not even recognize any other as of any service for that purpose, be it good or bad. Such a material, if obtained, however good, would be outside their experience and beyond their philosophy. After the stacks have been stripped, the gratings or buckles with their adhering coating of white lead are moistened with water and are passed through crushing rollers to separate the unconverted lead, then the crust which has been detached is ground under heavy edge runners with water.

This detached crust of white lead will vary much in colour, it will be white in some parts, yellowish or greyish in others. These discolourations arise from various causes, but they are principally caused by the contact of the moist wood and tan. The white lead is now a rough crushed material, very hard, and requiring to be ground to the finest powder. It contains, also, small fragments of blue lead, which have passed the crushing rolls, and a quantity of acetate of lead. The presence of acetate of lead is always found in larger or smaller quantities, which vary with every operation, and which invariably accompany white lead produced in the stack.

To remove discolourations—to separate the fragments of metal and to dissolve out the acetate salt—much water and washing is employed. The material is ground with water under the heavy edge runner stones, it then proceeds to a series of horizontal mills, each succeeding mill set closer than its fellow, and is further and further ground to fineness with water. From these mills it runs as a milky liquid to a series of settling tanks where it is allowed to subside, and

the clear fluid run off to waste, or into tanks to be used over again. This waste water will now contain the colouring matter removed from the incrustation, and the principal portion of the acetate of lead which the incrustation previously contained, and any other soluble matters removed from the washed and ground material. The small fragments of lead which passed the crushing roll and edge runner mills will have been previously removed by subsidence in water.

The white lead deposited in the tanks is in some factories ladled out into skips and agitated by a "Dolly," which further enables the heavy powder to get free from the water in which it is entangled. The moist powder is next placed on trays or dishes, and is conveyed to the stove or drying chamber. Women always perform this work.

The drying or stoving room is a large enclosed space heated by a "Cockle" arrangement; rough scaffoldings are erected within this chamber on which women mount to stow the trays on shelves fitted for the purpose. The trays and their contents remain in the heated atmosphere of this chamber for two or three weeks, by which time they become dry and ready for removal, to be packed in lumps for certain markets, or ground to dry powder and packed in barrels for others.

Women are employed to fill and also to empty the drying or stoving chamber, and during this work they are fully exposed to its contaminating atmosphere. Hot and dry, and charged with fine dusty particles of white lead, it becomes a dangerous trap, and contaminates the blood of those engaged with its deadly poison. It is in this part of the manufacture that the principal damage to health occurs. This is the most laborious work; heat makes it very fatiguing, the atmosphere within this chamber being always much above the exterior air. Recent Government regulations have sought to curtail these and other evils in this manufacture. Women engaged in these stoves are ordered to wear overclothing, headdress and respirators; the general experience of their practice, notwithstanding Government regulations, is this: that they cannot work in them with ease and convenience, and more often wear the respirator around their necks than in front of nose and mouth. The excessive mortality in women who work in these stacks and stoving houses scarcely requires reassertion. Few, even of those who employ them, know the extent of the deadly operation. Recently, medical men have made public that cases are within their knowledge of children born already contaminated with lead poison. Woman labour should surely be restricted by Government enactments in all such deadly occupations.

We may sum up the whole matter as regards white lead making by the stack or Dutch method in a few brief words: It is a most tedious and uncertain operation: it is a most dangerous occupation for all concerned; it is founded upon no true principles of any kind; and of science its whole course is ignorant. White lead making is ruled by a "happy-go-lucky" philosophy. The representatives of this manufacture are completely ignorant of the scientific details relating to it, and hence we may not be surprised to find amongst them an enormous amount of ignorance and prejudice.

Good white lead will not differ materially in its composition by whatever process it may be made, but it may differ seriously in its physical character, and in its fitness to produce a substance adapted to the uses to which white lead paint is applied. Good white lead is a compound which contains hydrate and carbonate of the metal, in the proportions either of one molecule of hydrate of lead, combined with two of carbonate, or is made up of one molecule of hydrate, with three of carbonate of lead.

If we consider the first compound roughly

white lead will be made up of one part of hydrate over two parts of carbonate of lead.

The second compound roughly estimated

will be one part of hydrate, combined with three parts of carbonate of lead. The latter will be in the proportion of 75 per cent. of carbonate and 25 per cent. of hydrate of lead, and this represents the composition which has been assigned to good white lead by those most acquainted with the subject. The amount of hydrate contained in white lead should never exceed the proportion above named of 25 per cent., nor should its amount be much below the 25 per cent.

The hydrate contained in the substance serves to unite with the oil in the paint, it forms therewith a drying white and elastic varnish which embraces and holds the particles of white carbonate and prevents their subsidence and separation in the paint. There is a chemical action of a much more intimate character between the components of good white lead when mixed with oil which neither of the constituents of this compound can alone produce.

For instance, hydrate of lead and linseed oil produce a varnish-like substance semi-transparent and of no covering capability.

Carbonate of lead and linseed oil produce a compound which is opaque, but has no body or covering power and in which the white solid carbonate is held in feeble mechanical suspension. Neither of them constitute a paint, but when together as white lead they are mixed with oil combination takes place, and serviceable paint of good body and covering power and enduring quality is produced. Good white lead is a dense, perfectly amorphous powder of perfect whiteness possessed of great body and covering power when combined with oil. When mixed with linseed oil and used as paint it rapidly dries in the air and assumes a varnish-like, glossy, hard surface, and is capable when once dry of resisting the action of air and water for any length of time. It does not weep when laid on a surface with a brush, that is the oil does not separate from the solid material of the paint.

Attempts have been made to produce white lead quickly and cheaply by precipitating processes, but in all such methods the resulting compound is deficient in certain special qualities absolutely necessary to white lead proper and to its uses. The precipitated white lead is always of a crystalline structure and crystalline lead can never furnish a good body paint—no amount of pulverizing and grinding of this crystalline material will correct this defect in its nature, and deprive it of its crystalline form.

"Once a crystal always a crystal" has an especial application to this point of our philosophy. Pulverising a crystal will not alter its structure, but simply reduces the size of the crystals. Crystals of white lead are unable to effect the necessary combination with the oil and form the true varnish which white amorphous lead so readily produces. Paint made with the precipitated white lead lacks body and covering power, and this because of the absence of this chemical union with the oil.

The manufacture of white lead by process of precipitation, even were the resulting preparation suitable, does not correct the evils of the present method by Dutch or stack process of making white lead.

A solution of lead may be precipitated in a few minutes, but it cannot be made so quickly. The white lead after its precipitation has to be filtered, or separated, washed and dried, and ground to powder, which processes cannot occupy less time than a few weeks for completion.

Precipitated white lead has been made in France and Germany for some years, and it is now manufactured in those countries. It is now made in England by one patent process, but the product lacks certain qualities, and is consequently still open to the objections already noted.

Substitutes for white lead of a non-poisonous nature, or of such a nature as not to produce such deadly effects in their preparation or use as white lead does, have been proposed; their introduction has not, however, been a great success. I may mention some of these—Albissima silicate paint, patent white sulphide of zinc paint, and zinc white. They are known to us and are—

Ground silicates and oil and driers.
Oxychloride of lead.
Sulphide of zinc.
Oxide of zinc.

A mixture of sulphate, sulphide and oxide of zinc is a patent white made by subliming galena in an oxidizing furnace or hearth. This compound lacks body. All of these so-called substitutes are very inferior to white lead, not only as to quality but as to cost. They cannot compete with white lead. A committee of enquiry on these substitutes for white lead, reporting the result of their enquiry and examination, stated that they found that these were mostly prepared with varnishes before they were sold for use, and that in most instances were mixed with a large quantity of driers, and that the drier invariably was a compound of lead. The principal consumption of white lead is for paint; to produce this paint it is ground with oil in varying proportions, about 8 or 15 per cent. This produces the ordinary white lead in oil, and is worth from £19 to £20 a ton, but often more than this amount.

Dry powdered white lead is chiefly made for and used by grinders and mixers, who combine with it a variety of other cheaper materials—chalk, clay, sulphate of lime, and sulphate of baryta, but principal use is made of chalk and barytes. These are mixed with the white lead, and then the mixture is ground with oil and formed into paint, sold under various names according to quality, thus: guaranteed white lead—firsts, seconds, thirds, and fourths, the proportion of white lead diminishing, and that of the adulterant increasing as we descend from the pure material. Guaranteed and best white lead is not pure, and does not mean pure white lead. Pure white lead can be purchased at some makers, but its price, if pure, can never fall below £19 or £20 per ton. To sophisticate white lead, and produce the various inferiors named, dry powdered white lead is needed as a starting point, and for this purpose principally arises the necessity for its production. If ground in oil the adulterants cannot be properly incorporated with it. Dry white lead is used for nothing else that could ever give rise to any great demand for it. We have already observed that the production of this dry and powdered white lead, is the most dangerous proceeding connected with this industry. Grinding in oil is unattended with any important consequence to the health and comfort of those employed. A serious drawback to the "stack" production, the china-like incrustation to which reference has already been made, is that it requires crushing, grinding, washing, and drying, and a second course of dry grinding after it is dried; the most objectionable step in its preparation.

Could the corrosion of the blue lead be effected in such a way as to prevent any discolouration of the material by the tan and wood—could the corrosion be so produced as to be easily separated from the buckle or grating on which it has been formed—could this separation be so effected as to prevent the

breaking up of the lead skeleton, and the presence of small pieces of metal in the detached crust of white lead, two principal reasons for washing and drying are removed. There is yet another consideration, that is the presence of acetate of lead, always found in varying quantities in the incrustation produced, and remaining at the close of the operation and conversion. To remove this, careful washing, and after stoving and drying, must be accomplished. The amount of this salt present is found to differ with each operation, and in various portions of the same make. The washing out of the acetate is never perfect, and it involves a large amount of labour.

Opinions differ as to the effect of this acetate if allowed to remain in the product. White lead makers on the "stack" principle aver that it should and must be washed out lest it should damage the qualities of the paint. This is questionable, and not one can produce practical evidence of its being the cause of any damage if still contained in white lead. Facts seem to deny its harmfulness in this respect inasmuch as the best prepared samples, those washed and dried, from the most careful makers, will be found upon analysis to contain more or less of acetate of lead. A large proportion of this salt in white lead may not be beneficial for many reasons, but a small percentage can do no harm, nay, for many purposes it may be good. There is no substance used for driers for white lead that is more esteemed than this acetate of lead, commonly known as "sugar of lead."

A small amount of this salt present in white lead would communicate drying properties, and this alone is what it could do. Granting that we can discover a method of producing white lead of amorphous character of good density, free from all discolouration, free from all particles of metallic lead, and free from but a small percentage of acetate of lead, then washing will not be needed. Stoving and drying become unnecessary. The work of women, their deadly occupation, so burdensome to the operatives, and to all with whom they are concerned, is done away with. Let us again call to remembrance that this work attendant upon washing and drying white lead cannot be pursued for any length of time, that lead colic, palsy, falling hands, and paralysis, the concomitants to breathing and handling white lead soon overtake the workers, that these symptoms are rapidly followed by premature decay and death. We surely shall hail with delight any method of remedying these grievous evils!

Such a process as that which I have characterised as being needful is invented, and it is my pleasing task to describe this plan to you this evening. It is Gardner's patent process for producing electric white lead. As the name implies, Professor Gardner calls electric power to his aid, and by its means good amorphous white lead can be produced in 14 days. No washing or drying are necessary. No women are engaged in the manufacture, and but few men. The white lead thus produced by the aid of electricity is deposited in a peculiar state of disintegration, it is perfectly amorphous and non-crystalline, of the purest quality, its density is 5.8. When ground in oil and made into paint it possesses great body and a covering power inferior to no other paint, if not superior to them all.

Painters who have used the paint, practical men, and amongst these we may observe coach painters, have pronounced its excellence and superiority to the best ordinary white lead paint.

By this electrical process of manufacture, not only is the time consumed in the making and in the preparation of this material greatly shortened, but the cost of preparation is reduced, and added to this is the important fact, the vital factor in our con-

sideration. The labour of women is unnecessary! No lives are sacrificed to its working requirements.

Professor E. V. Gardner, who has been for some years occupying his attention with the subject of white lead making, with a view especially to remedying its existing evils, has invented his electrical chamber process of manufacture, and an entirely new course of after treatment. He has for the last seven or eight years been more or less occupied perfecting his conception, and accommodating it to the practical and commercial claims.

Chamber processes are not new, there have been several patents enrolled for making white lead in closed chambers, but none have proved commercially convenient, or practically successful in their adaptations, and none have survived to the present time so far as I can ascertain.

In Germany white lead is made in chambers in the present day. The lead in gratings or sheets is supported on wooden rods, saddle fashion, the chamber is then filled and its contents are then submitted to currents of acetic acid vapour, air, steam, and carbonic acid gas; the time needful for conversion is six or seven weeks. The after steps in the separation of the incrustation, and its preparation for trade purposes are much the same as in the "stack" product preparation. It is washed, stoved, dried, and ground. The white lead made on the German plan does not differ in any material degree, save it be in price, from the best English commodity. We may assume that the washing and drying in Germany consumes a like period of time to that process in English works, viz: two or three weeks. We then see that the German plan of making white lead cannot be perfected in less than eight or ten weeks time from the commencement of the corroding action in the chamber. Let us compare these facts and the efficiency of the different plans I have described.

The time required to complete the corrosion in the stack is at least 14 or 16 weeks.

The Gardner's electric process requires for the same purpose only 14 days. As to point of time the German plan excels the stack, and can be carried out in one half the time required in the stack method of conversion. The Gardner's electrical method excels the German, and can be perfected in one-third the time needed for the German chamber operation, and one-sixth the time required by the stack.

These figures open out a most important matter when we regard the capital invested and lying dormant in stack lead works.

We will particularise this Gardner's electrical plan of working.

It is well known that we have in electricity a most powerful agent by which to effect the chemical combination of various substances on the one hand, or on the other, by its means to break up and disrupt a chemical compound. Professor Gardner's main principle of action in his new process to which we now refer is founded upon these facts, and he takes advantage of electrical power to cause the combination of the lead with the necessary elements to build up white lead in his chambers. He either employs electrical discharges to energise and render active in their chemical affinities the various materials engaged, or he so disposes of them as to form an electric galvanic combination in the chamber. In the latter arrangement the chamber and its contents represent a gas battery on an extensive scale. In practice he prefers the latter plan; it is more simple, more manageable in the hands of the ordinary workmen. The original plan was to have graphite or graphitic carbon plates or supports for the buckles or gratings of lead within the converting chamber. These carbon plates and the lead to be converted,

were so placed as to form a collection of galvanic "couples" or "pairs," and in this condition were submitted to the gases entering the chamber from without. It will be understood that various modes of arrangement would occur without departing from the principle concerned.

In practice this method answered very well, but presently a difficulty arose; not only were the graphitic carbon or graphitic plates expensive, but they were easily broken, and became friable in use. Carbon plates of an especial kind were manufactured to meet these failures and remedy these defects, not without success, but still open to objection. In looking round for some substitute to replace the carbon two points were to be kept in view, to seek some electro-negative to lead like unto the carbon, and some electro-conductive like unto it, and some material that would bear rough handling, such as workmen give, and be practically convenient in its adaptation to a working chamber.

Gold or platinum would excel in these particulars, but there are considerations which debar their use. Pure tin presented itself and tin was tried with great success. Tin would at first be thought, on account of its close electrical relationship to lead, far from favourable to the purpose. Graphite or carbon would appear far more suitable. Practice pronounced the tin to act as efficiently as carbon. This may at first seem contradictory and strange, but if we consider that while the carbon is certainly more highly electro-negative to lead than tin, yet the tin is the more conductive, and offers the less resistance to the electric current of the two, in this manner the tin compensates by its conductive power all it may lack, as compared with carbon, in electrical energy when coupled up with lead.

Tin plate is now used as the electric-negative element in the chamber of the Gardner plan. Tin plate means pure tin, Ingot tin is rolled out into plates, the bottom of the chamber is covered with this pure tin plate, so are the bearers and the shelves, or supports which are to hold the lead during its conversion. Tin pipes and tin fittings which resist the action of acetic acid, are also used to conduct the gases to the chamber to carry on the converting operation, and to preserve the product from any source of discolouration.

When a chamber is prepared for the converting operation, the whole of the lead it contains will be in metallic communication with the tin supports, and these with the tin covered bottom of the chamber.

The chamber when working is kept at a certain temperature by a steam coil beneath the floor of the chamber. The process is simple. The lead buckles or gratings are placed on tin covered stands, somewhat in form and make like unto a dinner-wagon. The whole is hauled up and dipped into a bath of acetic acid and acetate of lead; it there remains for one or two minutes, it is then hauled out, drained and lifted bodily through the top into the chamber. Other stands filled with buckles are so dipped and so placed till the space of the chamber is fully occupied.

This dipping cleanses the surface of the metal, and when it is exposed to the air it is speedily coated with a hydrated oxide of lead. This is the first step in the process of conversion. The chamber when filled is closed, and its temperature brought to about a 100° Fahr., then vapour of acetic acid and vapour of water and air are supplied from without to the interior of the chamber. This is continued for 15 or 20 hours. The lead buckles within the chamber will now possess a whitish coating consisting of subhydrate and subacetate of lead, and they will present a uniform colour. Carbonic acid generated in any convenient manner is next passed

into the acid generator, it mixes with the other gases and vapours, and with them goes on its way to supply the chamber. Speedily the action of the carbonic acid is observed, the surface lead becomes quite white and presents the appearance of a snow shower having fallen within the chamber. The formation of white lead is now speedily effected. This treatment is continued throughout the space of 13 days; at the end of this time the supply of acetic acid vapour is stopped, and the supply of air, steam and carbonic acid continued, according as it is desired to obtain white lead rich in oxide or in carbonate.

After a short further period steam and air only are sent into the chamber, which is varied in temperature to 120° or 130° Fahr., and lastly the steam supply is stopped, air alone enters the chamber, which is kept heated by the coils beneath the floor. The contents of the chamber are now in a dry state, and the operation is terminated.

It will occur to most of us that these terminal proceedings amount in effect to a convenient method of washing and drying the white lead while it is still attached to the parent lead, and this it is in fact.

The contents of the converting chamber are lifted out through the opened top, and the buckles or gratings with their crust of white lead are turned into the agitator. This agitator is an iron cage revolving inside a closed chamber of the same material. During the revolution of this cylinder or cage the contained lead gratings fall from side to side, and the incrustation on their surfaces becomes detached and broken up. It falls in this broken state through the bars of the cage or cylinder into a receptacle beneath. The denuded buckles or gratings are retained in the cylinder and are removed. These gratings or buckles are cast of such a thickness as to withstand two or three converting operations in the chamber before they are recast.

This crude white lead is carried by an elevator, or it falls into the hopper of a pair of granite crushing rolls, also enclosed, and from these it passes into the mixer or incorporator from which it can be removed in a dry state or mixed with oil.

The incrustation of white lead will be found upon examination to be possessed of some peculiarities, the result of the electrical action which has been going on within the chamber. It is quite white; it falls from the lead buckle or grating which it coats; if the grating be struck against a piece of wood, with but a slight blow, it is easily friable, and can be rubbed to the finest powder between the thumb and finger, or on the palm of the hand.

Now, we may explain as we conceive the philosophy of its production in this state of disintegration.

We know that a feeble and prolonged current of electricity will in time deposit metals from their solutions in a crystalline condition, and that if we quicken the current of electricity and cause it more energetically to act on the same solution, we can precipitate the metal from that solution in a state of powder.

It is to similar action of electricity as that to which we last refer that we ascribe the formation of the crust on the gratings of lead in the non-adhered and disintegrated condition in which it is produced, and by reason of which it is so easily detached from the lead and broken up to powder. No edge runner grinding, such as is required by the stack process, is in this case necessary.

The crude white lead and crushed material, whether in a dry state, or incorporated with oil, is finished and ground in a granite roller paint mill, from which it issues as dry white lead, or as white lead in oil.

Paint made from this electric white lead has been sent to America, to France, to Belgium, to Germany

for trial, and has also been largely tested in this country by painters, engineers, and others unacquainted with its precise nature, and it has been productive of good results.

Of its density, body and covering point, there can be no doubt, and never once have these qualities been called in question.

The cost of the manufacture of white lead by the stack process is about £3 to £3 10s. per ton, by the German method the cost is about the same as by the stack. By Gardner's electric process the cost of conversion is 10s. a ton. To this 10s. must be added the cost of labour expended in preparation, an item which cannot be well estimated on the present limited scale of manufacture; it could not exceed an additional 15s. a ton. This would bring the cost of manufacture of electric white lead to 25s. a ton.

In this electric process inferior lead can be operated upon with success. Brands of that metal, such as white lead makers, by the stack method, dare not employ, may be successfully converted in an electric chamber, and with fair results as to the quantity and quality of the white lead produced.

By the use of the Gardner's electric process it would appear that we not only preserve health but save lives; we not only save time but interest on large capitals, which lie idle for long periods at a time, but we can economize and simplify the whole manufacture and preparation of white lead, divesting it of all its present cumbersome and unhealthy stages. Gardner's process, we believe, must take a prominent position as one of the most necessary, valuable, and scientific inventions of modern times.

ON JAPANESE CAMPHOR—ITS PREPARATION, EXPERIMENTS AND ANALYSES OF THE CAMPHOR OIL.

BY H. OISHI.

(COMMUNICATED BY T. TAKAMATSA.)

Laurus Camphora, or Kusunoki, as it is called in Japan, grows mainly in those provinces in the islands Shikoku and Kinshin, which have the southern sea coast. It also grows abundantly in the province of Kishu.

The amount of camphor varies according to the age of the tree. That of a hundred years old is tolerably

flange at the top. Over this flange a wooden tub A is placed, which is somewhat narrowed at the top, being 1ft. 6in. in the upper, and 2ft. 10in. in the lower diameter, and 4ft. in height. The tub has a false bottom for the passage of steam from the boiler beneath. The upper part of the tub is connected with a condensing apparatus by means of a wooden or bamboo pipe D. The condenser is a flat rectangular wooden vessel (a), which is surrounded with another one (c) containing cold water. Over (a) is placed still another trough (b) of the same dimensions, into which water is supplied to cool the vessel (a) at the top. After the trough (b) has been filled with water, the latter flows into (c) by means of a small pipe attached to it, as shewn in the figure. In order to expose a large surface to the vapours, the condensing trough (a) is fitted internally with a number of vertical partitions, which are open at alternate ends, so that the vapours may travel along the partitions in the trough from one end to the other. The boiler is filled with water, and 120kg. of chopped pieces of the wood are introduced into the tub, which is then closed with a cover, cemented with clay, so as to make it air-tight. Firing is then begun; the steam passes into the tub, and thus carries the vapours of camphor and oil into the condenser, in which the camphor solidifies, and is mixed with the oil and condensed water. After twenty-four hours the charge is taken out from the tub, and new pieces of the wood are introduced, and distillation is conducted as before. The water in the boiler must be supplied from time to time. The exhausted wood is dried and used as fuel. The camphor and oil accumulated in the trough are taken out in five or ten days, and they are separated from each other by filtration. The yield of the camphor and oil varies greatly in different seasons. Thus much more solid camphor is obtained in winter than in summer, while the reverse is the case with the oil. In summer from 120kg. of the wood, 2.4kg., or 2% of the solid camphor are obtained in one day, whilst in winter, from the same amount of the wood, 3kg., or 2.5% of camphor are obtainable at the same time.

The amount of the oil obtained in ten days, i.e., from 10 charges or 1200kg. of the wood in summer is about 18 litres, while in winter it amounts only to 5-7 litres. The price of the solid camphor is at present about 1s. 1d. per kilo.

The oil contains a considerable amount of camphor

rich in camphor. In order to extract the camphor, such a tree is selected; the trunk and large stems are cut into small pieces, and subjected to distillation with steam.

An iron boiler of 3ft. in diameter is placed over a small furnace C. The boiler is provided with an iron

in solution, which is separated by a simple distillation and cooling. By this means about 20% of the camphor can be obtained from the oil. The author subjected the original oil to fractional distillation, and examined different fractions separately. That part of the oil which distilled between 180°-