

ELECTRICAL SECTION.

(Stated meeting held Thursday, December 5, 1907.)

Process and Apparatus for the Production of Carbon Bi-Sulphide in the Electric Furnace.

BY EDWARD R. TAYLOR.

The application of electricity is fast revolutionizing many industries, and perhaps no other field is more inviting for this revolution than the chemical.

Many reactions require heat for their accomplishment, and also the materials of the reaction to be kept apart from combustion reactions and products. Retorts and crucibles have served for these separations, and are made of many different materials, oftentimes very expensive. Even this is not their worst defect. All are limited in size, and when it comes to a large production of any product so manufactured, it can only be had by multiplying these small retorts or crucibles.

Again, except in the case of platinum or other expensive materials, the life of these retorts or crucibles is very short, for they are subject both to the corrosion of the materials within them and the intense heat to which they must be subjected, to bring about the required reaction.

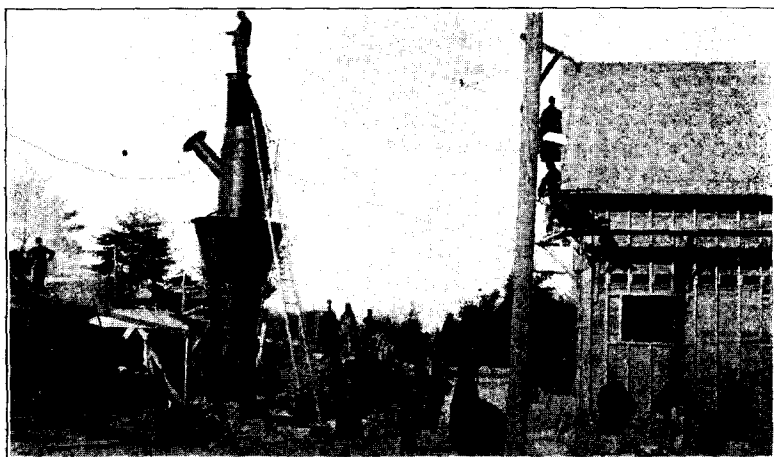
Oftentimes their cleaning is very troublesome and expensive. They are generally bad conductors of heat, and last and by no means least, they constitute a very wasteful application of heat.

From a manufacturer's point of view, their greatest defect is their limited size which leads to the multiplication of these retorts or crucibles for any larger production of goods. There is probably no one in all the past who has been obliged to use these who has not racked his brain for some way—I was going to say, out

of them. Well, let it stand—it probably conveys my meaning, if it is not strictly literal.

Being in the manufacture of bi-sulphide of carbon, which in retorts is one of the most disagreeable of all our manufactures, I, too, racked my brain, and am glad to say that I succeeded in racking it to good purpose. As I see it now, it seems to me peculiarly fortunate that this particular production should have been one of the first to get out of the retort. This feature will have our attention further on.

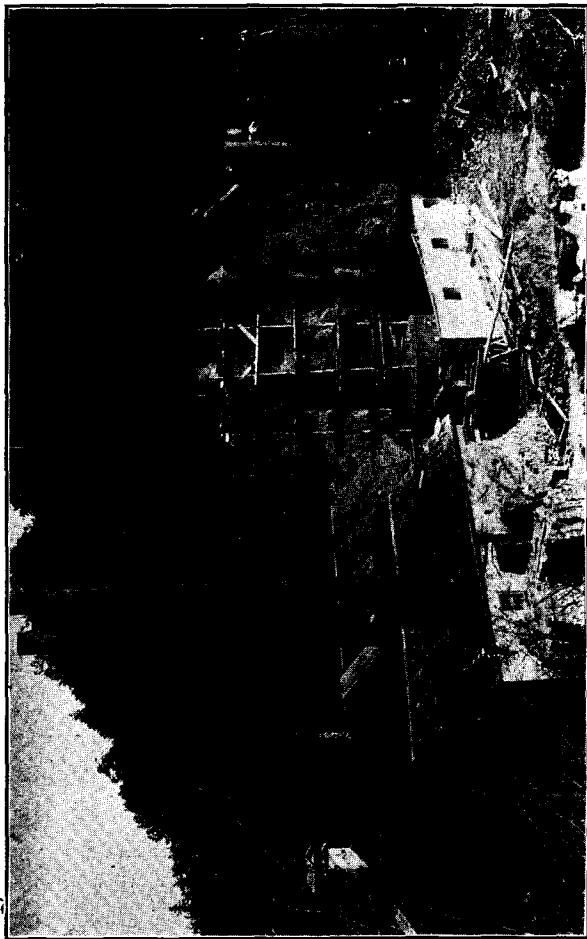
My first demonstration was made in Pittsburgh, in 1893,



First furnace 4 ft. diameter and 23 ft. high.

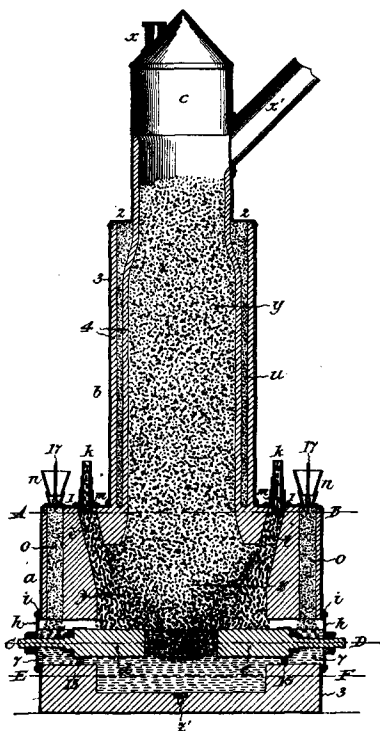
through the courtesy of our lamented Captain Alfred E. Hunt, of the Pittsburgh Reduction Company.

The first furnace for the industrial production of bi-sulphide of carbon was four feet in diameter and twenty-three feet high. It is illustrated here in the blue print and also by the lantern slide. Four feet in diameter was much smaller than my best judgment dictated, as I felt the heat would be too intense, and it did not afford sufficient room for the movement of the material. A vindication of this conviction came early. The sulphur was melted in the surrounding jacket, and while being hindered one time in feeding sulphur, the heat became intense and soon spoiled the shell of the furnace. Fortunately there was on the ground a



16 ft. x 41 ft. furnaces during construction.

still seven feet high and ten feet in diameter, and I at once determined to cut off the furnace, after supporting the upper part, and substitute this still for the lower part of the furnace. A large door and part of the side wall of the building had to be removed to get it into position. We were soon in shape again. That was a grand move and we had room in which to do something. While this enlargement was a great advance over the



Showing electrodes and chimneys for reinforcing
with broken carbons.

previous construction, we being able to make about 5,000 pounds per day with 100 horse power, we could run it but four or five weeks till it had to be shut down, cleaned out and electrodes renewed. This usually required three weeks, including time for it to cool off. This was money expense without income. The demonstration of the larger furnace was so overwhelmingly successful that the next construction was made sixteen feet in di-

ameter and forty-one feet high. This is the size of the furnaces now in use, and they have more than confirmed the advantages anticipated for them. We can run these furnaces more than a year before renewing the electrodes or cleaning out.

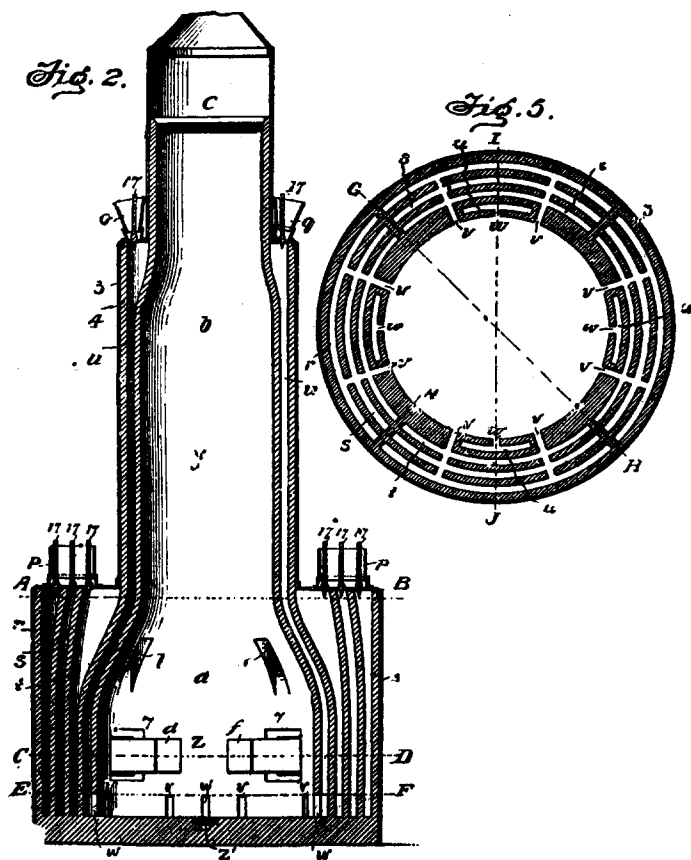
Each composite electrode in this furnace is composed of twenty-five carbons each 4" x 4" x 48" making a complete electrode twenty inches square and forty-eight inches long. We use two phase alternating current and four of these electrodes. In the center of the furnace they are about twelve inches apart. Chimneys above each of these electrodes are used to convey broken carbons down upon them and over their ends. Their action breaks up and diffuses the current, which instead of being of one or two arcs, is broken up into a multitude of little ones, but these probably disappear as the furnace heats up. This moderates the intensity of the heat, stops entirely the hissing of the current, so common in arc furnaces, and protects from excessive wear the main and more expensive electrodes, taking, so to speak, the brunt of the battle.

They also, if possible, serve a still more important purpose in regulating the current and saving the necessity of moving the electrodes through the walls of the furnace, which would be a very troublesome thing to do in a furnace filled with melted and vaporizing sulphur. This was a problem that presented very serious features in the early thought of a furnace for this purpose. The broken carbons also relieve the intense violence of the heat at the terminals. It will be appreciated that for low temperature work, like the manufacture of bi-sulphide of carbon, this is very essential. They also facilitate the starting and stopping of the furnace. Indeed the broken carbons are so valuable in this respect that we find we can stop and start at will, even when the furnace has become completely cold, and I cannot emphasize too highly the value of these broken carbons in a furnace of this construction.

By reason of these considerations, no furnace is more capable of abuse without harm than this. There is no noise, no violence, no sudden fluctuations in the passage of the current, and it never refuses to go.

Aluminum bars 6" wide and $\frac{5}{8}$ " thick (shown in the lantern slide), connect the insulated electrodes with the two Stanley in-

ductive type dynamos, which are of three hundred and thirty kilowatts capacity each, and usually run by water power, but we have an engine to help out in times of low water. The voltage varies between forty and sixty, according to conditions in the furnace, but there are no sudden fluctuations in voltage and the average is about fifty volts.



Showing electrodes and channels in the periphery for sulphur.

To charge the furnace sulphur is filled in up to the top of the electrodes and broken carbons are added, including the filling of the different chimneys over the several electrodes and the shaft of the furnace is filled with charcoal, and the periphery spaces of the furnace filled up with sulphur.

With the larger construction it is easy to feed the cold and crushed sulphur around the periphery of the furnace, allowing it to find its way in the melted state into the interior heat zone.

Being progressively raised in temperature as it approaches the zone of reaction, the level of the melted sulphur is regulated by the amount of current supplied to the furnace and the amount of cold sulphur fed into the periphery.

On combination of the sulphur vapor with the charcoal, the formed bi-sulphide of carbon rises through the charcoal above it, heating it as it progresses downward towards the reaction zone.

Thus in this furnace, the heat seeking to escape by radiation, is continuously borne back to the reaction zone by the incoming material.

So complete is this return, that when making bi-sulphide of carbon at the rate of fourteen thousand pounds per twenty-four hours with the room at 16°C. the outside shell of the furnace shows temperatures at different points ranging from twenty-three to sixty-four degrees as a maximum. With yet more power in the furnace, the production would be greater and these readings still lower.

This brings us back to a point referred to before, with reference to this particular production for this demonstration of the conservation of heat in the electric furnace.

The low melting point of sulphur very much facilitates the development of this idea, and to my mind it is difficult to overestimate the value of this return of heat to the zone of reaction.

My ideal for an electric furnace is one where the outer shell of the furnace is merely a jacket as cold as the surrounding atmosphere and mainly serving to keep gases from escaping, and to direct the flow of the interior materials, the real walls of the furnace being one or more of the reacting materials completely surrounding the reaction zone, and continuously bearing back to the inside heat as constantly endeavoring to escape.

Graphically it may be represented by, say an egg-shaped interior, surrounded with reacting material constantly approaching and returning heat that has escaped from the hot zone, but cannot make its way out of the furnace itself, thus using the heat produced for the definite reaction in hand; this incoming material being of such thickness as to completely absorb all radiant heat.

It is now well demonstrated that this is easily brought about in case of material not too difficultly fusible, and one need not hesitate to work this principle on materials having a melting point very much higher than that of sulphur, which as we have seen behaves most admirably, for in this with sufficient power we could carry almost to perfection the ideal conditions above indicated.

No form of combustion can really compass these conditions, but this is made possible by this form of electric furnace. A correct balance of power to the size of furnace and materials used, is the key to this ideal result. It is obvious that this principle is of



Completed works, showing railroad facilities, stills for refining storage tanks, etc.

wide application and without doubt will be in the future largely applied.

In most electric furnaces the gases have been of secondary or of no consideration. But not so with the manufacture of bi-sulphide of carbon. It is gaseous in the furnace as formed and it is the thing we are after. We may therefore follow it out of the furnace through the pipe at the top and on to the condenser, shown in the lantern slide of the works in construction, after which it is refined for market by distillation. The stills for this

purpose are shown in the foreground of lantern slide of the works after completion.

It is obvious that any gaseous product from such a furnace can also be saved and utilized even should it be a by-product and not a main product, as in this case; as for example carbonic oxide, which could well be used in gas engines. For such use it would be much more valuable than producer or blast-furnace gas, as it is not diluted with nitrogen.

The bi-sulphide of carbon being an endothermic compound absorbs heat in its formation, and being in the vapor state at its formation also has its latent heat of vaporization with it, as also the high temperature of its formation. These actions are constantly taking heat away from the heat zone, and as noted, distributing it to the charcoal coming down and to the sulphur coming in from the bottom and the sides. By these means a comparatively uniform temperature in the reaction zone similar to the uniform temperature of a liquid when it has reached its boiling point is maintained. Thus the work balances itself. There are no sudden fluctuations of current in the furnace except the fluctuations of power outside of it.

For other reactions and other products a different temperature would be the normal one just the same as different liquids maintain their boiling points. This uniformity of temperature, very low or very high, may be continuously maintained for months at a time.

Nothing cold ever reaches the heat zone of this furnace. Sulphur or charcoal completely envelopes the heat zone. With the continued progress of the charcoal and the sulphur towards the heat zone there is the continual increment of heat, so that when they do reach the interior of the furnace both are at a bright red heat, the charcoal in a glow—and the sulphur in a state of vapor. The combination is immediate and the compound hurries upward, heating the charcoal in its path, being pushed on irresistibly by the material behind it.

We can modify the conductivity of the furnace by the feeding of broken carbons and by the height at which we carry the melted sulphur. Indeed we can completely cut off the flow of current through the furnace by allowing the melted sulphur to raise sufficiently high above the terminals. So the maintenance of a suita-

ble level of melted sulphur is an important factor in the operation.

So easy is it to maintain these necessary conditions that my man in charge takes great delight in running it. Often he says to me, "I have no words to describe how nice and easy this furnace runs. It is rest to run it. It is like driving a gentle horse. It is a great satisfaction to run it. No trouble here. It is just pleasure. This furnace is just grand." He even exhibits affection for it when he says "this dear furnace." Thus I am greeted with expressions of pleasure day after day. Think of the maker of bi-sulphide of carbon evincing such satisfaction with his work as this. I venture the assertion that no other process of manufacture of bi-sulphide of carbon calls from the man who runs it any such expressions of pleasure.

In Sicily I saw a plant where they used forty-eight retorts for making 10,000 pounds of bi-sulphide of carbon in twenty-four hours, and required thirty-five men to run them. When you consider that every few days these retorts had to be opened from the top and the ashes spooned out, sulphurous acid coming up into the faces of the men, you can imagine how disagreeable it is to attend to such retorts, every individual one of which must have more attention than an electric furnace making more goods than the whole of them. We appreciate things by contrast.

This blue print illustrates the retorts formerly used by me in this manufacture. The opening at the bottom shows where we removed the ashes from the bottom of them every ten days or two weeks. This was done while they were hot, lost us about twelve hours in time and was very disagreeable, but nothing to compare with spooning them out as just referred to in the Sicily works.

With the electric furnace the cleaning out is done with a cold furnace about once a year with no trouble or inconvenience.

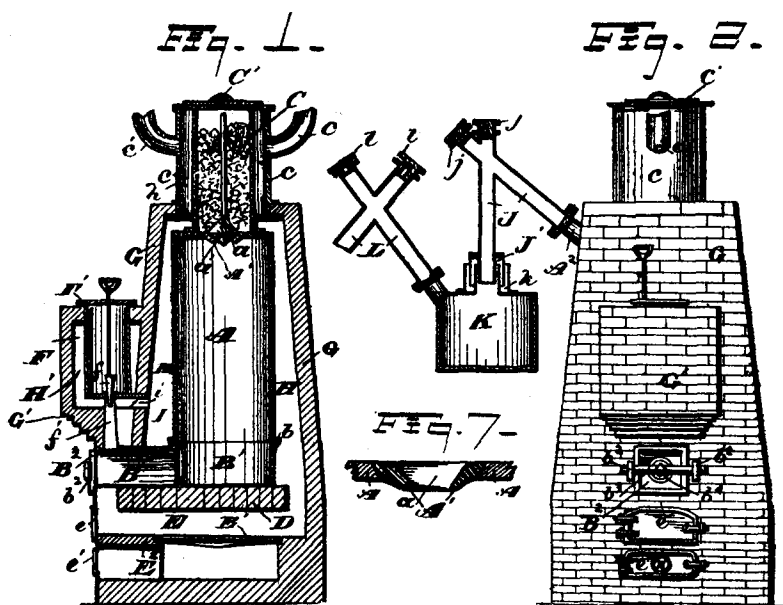
Just at this writing a telephone from the works saying, "Oh, it is fine, Mr. Taylor!" "You really do not take the comfort with these furnaces that I do."

This reminds me to say that we transformed an old paper mill into this chemical works—but the name "mill" will not leave it, so it comes to pass that I have the unique distinction of having a "chemical mill," whatever that may be.

When the furnace is in full operation, the charcoal is supplied through an opening at the top of the furnace to a hopper above a

bell similar to those used in blast furnaces. As often as there is room in the shaft below the bell the charger (holding about thirty-two bushels), is dumped and the charger refilled. In this place it becomes more or less heated, so it does not enter the furnace absolutely cold. A very strong endeavor was made to substitute coke for charcoal three years ago, but it was a failure and abandoned.

In like manner the sulphur is fed into the periphery from the hoppers above them, as often as is necessary to maintain the best working conditions, and it is very desirable that these conditions



Retorts formerly used for making bi-sulphide of carbon.

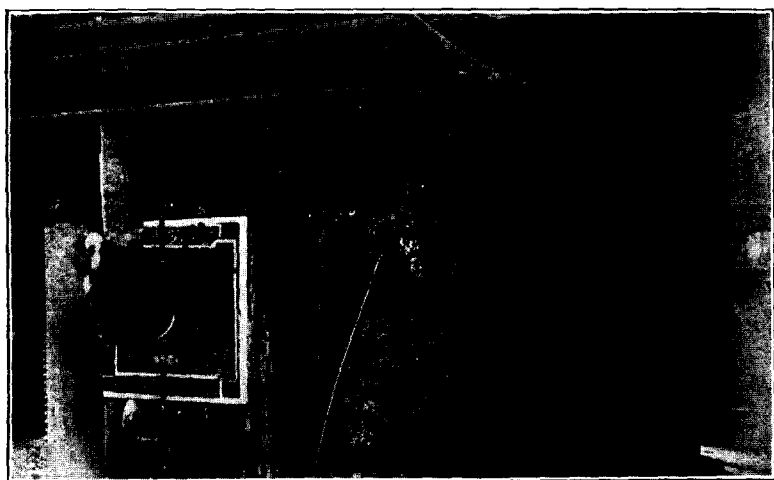
should be such as to keep these spaces full.

If the power is equal to the capacity of the furnace for producing goods, sulphur should be put in whenever there is room for it under all conditions.

As we are now working we can produce 14,000 pounds per twenty-four hours in one of these furnaces, but in so doing we are not able to keep the periphery of the furnace completely filled with sulphur to the top, which would be the ideal condition, had we sufficient power. This size of furnace is quite capable of pro-

ducing 25,000 pounds per twenty-four hours. It would be very interesting to note the temperature of the shell of the furnace with such a production. We always find the larger the production the more economical and the cooler the shell.

If on a production of 14,000 pounds the highest temperature of the shell is $64^{\circ}\text{C}.$, may we not expect that on a production of 25,000 pounds in the same furnace we may closely approach the ideal condition of having the outer shell at a temperature but little, if any, exceeding the temperature of the surrounding air? Is it not a condition devoutly to be wished and is this not in a direction in which we may ultimately expect success?



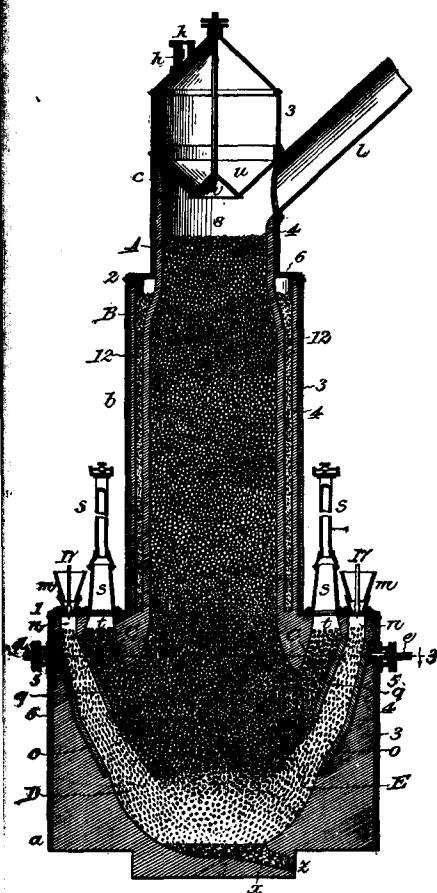
Showing electrode with packing gland-aluminum attachment, and insulated plate attached to furnace.

It may be interesting to trace the different intermediate connections between the carbon electrodes and the aluminum bars outside of the furnace.

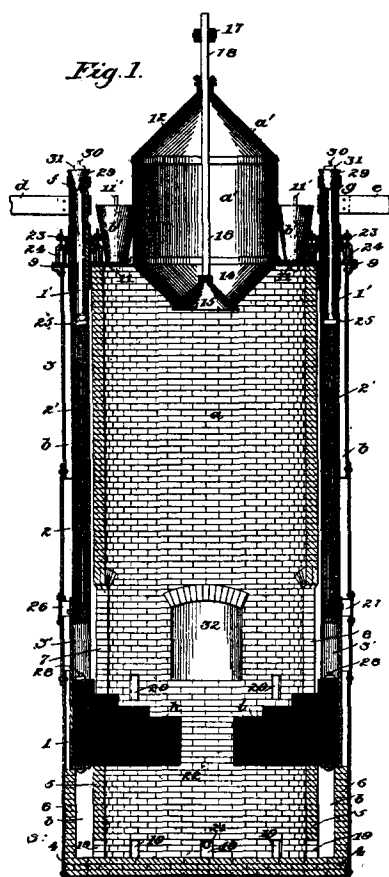
We have in this blue print shown a socket of iron into which the carbons are inserted,—another cylindrical casting attached to this socket passing out of the furnace through a plate insulated from the shell of the furnace and through a packing gland similar to that of the piston of an engine. This is made large and is packed with mica and asbestos paper. This is done so carefully and is so complete that the most delicate magneto will give no

ring when connected with the shell of the furnace and one of the iron terminals.

This other blue print shows another form of intermediary where a metal chimney or tube is lined with carbons through which broken carbons are supplied, and which descend and are



Showing self renewing electrodes of broken carbons and charging bell.



Smaller electric furnace showing electrodes and connections.

replaced from above as they wear away. They take current from the carbon lining of the conductor and carry it to the center and towards the bottom of the furnace.

They may be further reinforced by other broken carbons, being fed in through S, at a point farther into the furnace.

It is designed to so feed them that the weakest part of the circuit will always be near the bottom of the furnace. The conduits are passed through the shell of the furnace higher up on the shell but in a similar way to the other form of electrode. This arrangement makes a continuous self-renewing electrode, the weakest point in the circuit being where the two streams of broken carbons meet near the bottom of the furnace, the broken carbons taking all the wear.

Another form of intermediary electrode is shown in this blue print, which partakes of features of both forms of electrodes just described. In this, the carbon electrodes in the form of steps, are shown near the bottom of the furnace, and the intermediary is carried up in the form of a box to the top of the furnace, from whence it is connected with a cylindrical pipe which passes through a stuffing box through the top of the furnace to the exterior where it is connected with the aluminum bars to the dynamo. Through this cylinder broken carbons are fed down upon the carbons at the foot where they fall out and over the main carbon electrodes, reinforcing them and making them self-renewing and continuous. This form of electrode and furnace was devised that a comparatively small and really workable furnace might be obtained that would be thoroughly efficient.

The shell of the furnace is lined with asbestos, as are the others, inside of which is a lining of brick of smaller diameter, and leaving a space between its outside and the shell of the furnace. Into this periphery space is fed crushed sulphur, which is melted by the radial heat from the interior of the furnace, settles down and makes its way into and at the bottom through similar openings.

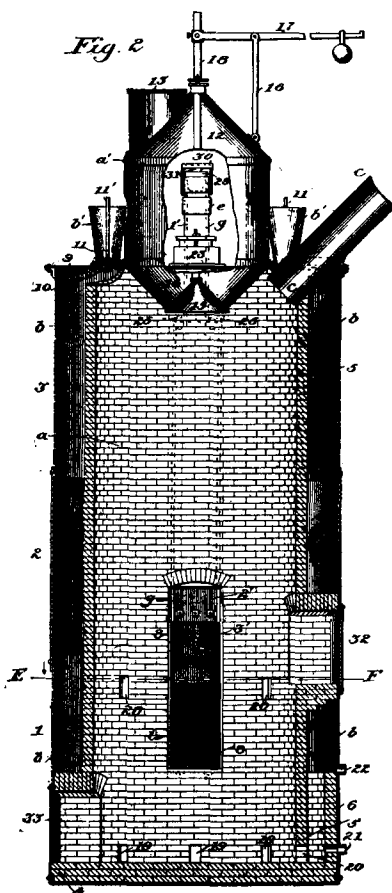
The charcoal is fed in through a hopper and bell as described in connection with other forms of construction.

This furnace is designed to be eight or ten feet in diameter and eighteen or twenty feet high, and will produce five thousand pounds per twenty-four hours with economy and satisfaction, while it could be pushed to a production of 10,000 pounds per twenty-four hours without trouble, with good advantage.

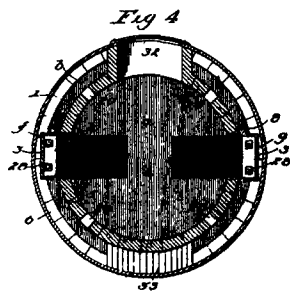
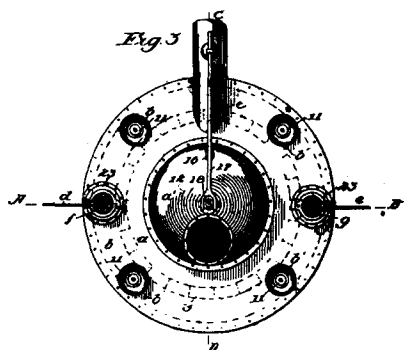
Two electrodes only are provided in this furnace, as a larger number would take up room more valuable for the materials of the reactions.

The broken carbons of course perform the same office as in the other construction.

The sockets which hold the main carbons are separate castings from that intermediary that connects with the outside of the fur-



Showing charging bell and sulphur space around the periphery.



Top view showing electrodes and connection periphery sulphur space.

nace, so if spoiled they can be detached and others supplied without the sacrifice of a large casting. Our experience is that these sockets can be used several times before they become so much injured as to require renewal.

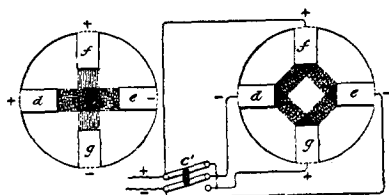
While this form was devised more especially for a compara-

tively small construction, there are principles in it that are very desirable in a large construction, and that will doubtless be so used.

With most electric furnaces the carbons figure up to a very heavy expense, but not so with these furnaces. The broken carbons are cheaper than the main carbons and are by this arrangement forced to the front, by means of which they take the wear and save the more expensive material.

To equip one of the large four-electrode furnaces with carbons costs one hundred and seventy-five dollars each time, but they last for a year or more without renewal, and make more than two million pounds of goods.

It will be seen that this combination of main and movable carbons in the interior of the furnace itself does away with the necessity of moving an electrode through the shell of the furnace from time to time and the insulation becomes permanent.



The four-electrode electrical furnace with two phase current to my mind presents many advantages. We usually pass the current through and through direct from one electrode to the other, but at any time when desired it can be changed to the adjacent electrode and then melt down or burn out any corners or pillars that may form and not be disposed to come down, thus any obstruction to the regular descent of the material may be removed. They also more completely centralize the heat in the hot zone of the furnace.

The electrodes are directly connected to the dynamo circuit without the intervention of transformers and the current regulated by the field and exciter rheostates with entire ease and satisfaction.

I doubt if the interior of the bi-sulphide of carbon furnace attains a temperature to exceed $1,000^{\circ}$, or at most $1,500^{\circ}$ Fahren-

heit, and I would be prepared to see measured any temperature between these points as the practically constant temperature of the interior.

May I make my meaning clear without pretending to be literal, by saying the boiling point of the reaction.

For electric furnace work this is a comparatively low temperature. With other materials for a given reaction either a lower or a higher temperature may be the constant temperature.

There is a question as to the possibility of running a furnace of this type that will constantly maintain a very high temperature in the interior if the reacting materials will not be driven out or cannot be removed in a state of fusion, until such high temperature is attained; and we have proof of this in the first furnace four feet in diameter before referred to when the outer steel shell was so near the melting point that one of my men before I knew what he intended to do took a steel punch about sixteen inches long and pushed it through the shell as easy as though it were butter. Instantly I said, "Leave that there." What a nice time we would have had if he had pulled it out.*

There is no question about the ready application of these principles to other manufactures, especially when one of the constituent materials employed has a low melting point and good fluidity, like sulphur; and we may expect in the near future such developments.

For solid materials of difficult fusibility many difficulties present themselves in a furnace of this sort, but I am not without hope that such materials will ultimately be successfully worked; but it will have to be on a very large scale if at all, for solid bodies must have room in which to move to fulfill the conditions required,—quite likely mechanical action may be required to supplement the force of gravity.

As illustrating such a possibility, please notice the suggestion of such an endeavor illustrated by the blue print.

Between the interior hot reaction zone and the shell of the furnace which by the absorption of heat as it progresses shall keep the outer shell of the furnace at practically the temperature of the

*This high temperature was caused by our failure to feed in sulphur, thus giving the heat nothing to do but to accumulate in the interior till it had become so intense as to heat the shell as indicated.

surrounding air; with sufficient power in these present furnaces I believe this ideal condition could be reached. With this attained it is clear that the same ideal conditions can be reached with materials having much higher melting point than sulphur, and the use of this form of furnace not only greatly extended to other manufactures, but the practical size of furnace very greatly increased.

In this connection it is very interesting to note the progressive enlargement of the blast furnace, and to remark that nine blast furnaces erected during the first six months of the present year have a combined capacity equal to the entire production of pig iron in the United States in the year 1886, and which in that year required four hundred furnaces to produce. Yet of these nine furnaces built this year two of them were of such a size that seven such furnaces would be capable of producing more than the entire production of 1886, with its four hundred furnaces, and the probable maximum of large blast furnaces in all probability has not yet been attained.

Probably the blast furnace is the most economical furnace constructed, but the heating of useless nitrogen and the loss of heat from its sides is of necessity very great. It offers no such opportunity to cut off radiant heat as does the electric furnace, and while the advantages of increasing the size of blast furnaces has been very pronounced, the advantages of enlargement in electric furnaces are many times greater. Yet it must be admitted that most electric furnaces so far constructed have been very uneconomical, and especially wasteful of radiant heat,—yet in spite of these limitations the electric furnace is continually working into new fields, and will without doubt ultimately reach a perfection quite beyond the most efficient blast furnace.

Heretofore the gases from the electric furnace has been generally neglected.

It is very easy to see that an electric furnace constructed on the principles I have described is capable of utilizing all of the gases produced, and as no nitrogen is introduced the gases will be much richer and more valuable either for use in the gas engine or as a source of heat.

In the discussion on my first paper before the American Electrochemical Society, President Richards was kind enough to say:

"I think it is well to know that this furnace of Mr. Taylor's
"has practically revolutionized the manufacture of carbon bi-sul-
"phide in this country, and the size of the furnace is a revelation
"of what may be expected in the size of electric furnaces in the
"future."

May I also quote from my second paper before the same soci-
ety at the first Niagara Falls meeting, *i. e.*: "In this connection
"I will say that with this construction of the furnace and an ade-
"quate source of electricity at my command, it would take less
"nerve on my part with my present experience, to construct an
"electric furnace that would dwarf the largest blast-furnaces
"in existence to-day, than it took to build the furnaces now in use,
"which are sixteen feet in diameter and forty-one feet high."

May I close this paper by quoting from a paper that I had the
honor to read before the International Congress of Applied
Chemistry at Berlin, in 1903, as follows:

"Having made provision for the movement and renewal of the
"electrodes in the interior of the furnace itself, the introduction of
"the conductor through the side or shell of the furnace (from
"which it is insulated) is not only comparatively simple, but is of
"a permanent character, and is shown at E in Fig 6. In this
"construction, provision is also made at S for either the reinforce-
"ment of these movable fragmentary electrodes, or for retarding
"their conductivity by the introduction of non-conductive mate-
"rial, or for the introduction of other material to be acted upon
"in the furnace. A tap hole is also provided for the removal of
"fused material.

"With these arrangements all the materials very gradually ap-
"proach the heat zone of the furnace, and having entered into
"combination under the best possible circumstances, the fused
"product or residue makes its passage downwards, and the gase-
"ous upwards, giving out heat as they go to the descending ma-
"terial, and finally making their escape to the condenser through
"the pipe shown at the top of the furnace.

"We have in this furnace the possibility of uniformly obtaining
"the most suitable temperature (very high, very low, or any-
"where between) for any given furnace reaction and maintaining
"the same without fluctuation for days, weeks, or even months to-

“gether, a feature that will be greatly appreciated by working
“chemists.

“All materials after having been once placed in the furnace
“feed uniformly by gravity and fusion, giving such unity to the
“whole as to give the best possible results from an economical point
“of view, and creating in the mind of the worker a feeling of
“great satisfaction, from the fact that troubles do not come to
“disturb him and he can readily see a good reason for every-
“thing he does. This encourages and stimulates his best endeav-
“or and he becomes an enthusiast rather than a drudge, and his
“labor a delight and pleasure.

“In most electric furnaces, more heat is wasted than is used.
“In the one herein described, the loss is reduced to a minimum.
“The whole operation takes place in a closed case protected from
“any excess of heat, and lasts for many years without any import-
“ant deterioration. The lining inside, after runs of many
“months, requires only trivial repairs that are easily made.
“When, therefore, to all of these considerations and others not
“enumerated, it can be added that there is practically no limit to
“the practicable size for such a furnace, except a market for the
“goods and an adequate supply of crude materials and electricity,
“its great advantages are obvious. We no longer need make bi-
“sulphide of carbon in thimbles of furnaces; but any manufacture
“it with ease in large quantities with an economy that ought to
“largely extend its uses.

“As an illustration of the great advantage of a large furnace,
“an earlier construction, ten feet in diameter and twenty-three
“feet high, could be run continuously but a month or five weeks
“at most, whereas, these sixteen by forty-one furnaces can be run
“for many months in succession, and a furnace that would dwarf
“the largest blast furnace in existence would probably offer cor-
“responding advantages, both in economy and ease of manipu-
“lation.

“We have made in this furnace fifteen thousand pounds in a
“single twenty-four hours, and with more electricity in the same
“furnace twenty-five thousand pounds can readily be made in that
“time.

“It may also be said that the larger the furnace the easier it
“can be worked, and it would seem that an operation that can be

"performed in a crucible, might be worked in this construction on "a scale almost bewildering to contemplate."

Coming now to our present gathering at the Franklin Institute, I may say, the market for bi-sulphide of carbon is a limited one and we cannot sell all we can make, and no larger furnace than those now in use would be justified under present conditions. But were the market for bi-sulphide of carbon as large and regular as the market for pig iron I would say the size of the future furnace need only be limited by the market for the goods and the amount of electricity available to put into it.

Book Notices.

NEW PUBLICATIONS.

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