

Mr. Dorion conceived the idea of the utilization of the bed of the river, which is dry most of the time, as a filter for all the waters coming from the reduction works. A mile from the reduction works a well was dug, and the waters accumulated there. An electric pump pumped the water back, and thus the concentration could go on almost all the year without interruption. These two facts ought to increase the production considerably, if everything is managed skillfully.

During the year 1896 the cost of 1 ounce of fine silver can be stated as follows:

	Per Cent.
Cost in mining	\$0 391 or 36'0
Cost in milling	286 or 26'4
Cost in administrative expenses	075 6'9
Profit	333 30'7
	<hr/>
	\$1 085 100'0

THE FRANKLIN INSTITUTE.

Stated Meeting, September 21, 1898.

A NEW PROCESS OF COMBUSTION.

BY PAUL J. SCHLICHT,
Member of the Institute.

To the layman, combustion is a most perplexing and distressing problem. He seems to know by intuition that a large part of his coal-pile goes to waste up his furnace-chimney, and, while deploring the fact, is helpless against it. He has heard of the smoke-nuisance, and when he sees dense black clouds belching forth from countless chimneys he shakes his head and bemoans the terrible fuel losses. While his intuitive knowledge as to his house-furnace cannot be gainsaid by the expert, it is unfortunately defective when applied to that duskiess of the heavens produced by the thick carbon-laden breaths of factory-furnaces that defile the atmosphere of our manufacturing centres.

As a rule, the expert has given little thought or attention

to the stove and house-furnace, but he knows that those black out-breathings which to the layman are signs of such reckless waste are but of infinitesimal economic significance.

He can cite instances of evaporative performances that prove most satisfactory realizations of the calorific values of the fuels burned, and generally insists (at least such has been my experience) that in these well-designed plants substantial gains cannot be made by any improvements in combustion.

While this may be approximately true of some model plants where the most intelligent watchfulness and care are exercised and the fuel contains a high percentage of fixed carbon, it is not true when use is made of fuels whose composition is less favorable to the limitations of the ordinary process of combustion.

When the fuel contains too large a percentage of volatile matter the conversion of its energy into useful work ordinarily entails enormous losses. This is true more especially of those fuels that have hydrogen in excess of the quantity which will unite with their oxygen.

I am not aware that, in the industrial analyses of flue-gases, the losses due to the escape of combustible gases other than carbon-monoxide are taken into account. I know of instances of plants built in accordance with the best engineering practice where less than 40 per cent. efficiency has been realized in a clean boiler when such fuels have been used.

The stove and house-furnace and the industrial furnace are not in the same category.

In the former combustion is slow, in the latter generally rapid. Slow combustion in the stove and house-furnace is generally incomplete with the best fuels. Rapid combustion, except as to the volatile portions of fuels, is generally complete.

Incomplete and wasteful combustion in stoves and furnaces is due to insufficient and irregular air supply. In the industrial furnace an abundant air supply produces complete, even if in many instances, wasteful combustion with the best fuels and partially incomplete with others.

The fact that enormous losses occur in the burning of fuel in stoves and house-furnaces, and that in the best industrial plants the fuel energy is not adequately transformed into useful work, seems to me to offer abundant apology for my work in the field of combustion, which I will now endeavor to describe to you.

One of the objects of my process of combustion is to render available for useful work, in a simple manner, the greatest number of heat units in a given fuel, without material alteration of existing apparatus. It is especially with this phase of my invention that I desire mainly to occupy your attention.

The invention is based upon the fact, which I have discovered, that if a current of air is properly introduced into a chimney or flue through which hot products of combustion are escaping, the air current will flow in a direction contrary thereto, and, becoming heated in its contact therewith, will reach the sphere of combustion in a condition highly favorable to the union of its oxygen with all the combustible elements of the fuel.

In stoves, house-furnaces, and other slow-combustion apparatus, all of the air for combustion is supplied on the top of the bed of fuel. In industrial furnaces the desired rate of combustion determines the quantity of air to be admitted below the bed of fuel in addition to air supply on top.

In some instances the best results are obtained by closing, or nearly closing, the ash-pit door. In other instances, when a high rate of combustion is necessary, the resistance offered by the bed of fuel and the air pressure downward through the chimney or flue, so reduces the air pressure ordinarily exerted through the open ash-pit doors that no appreciably large air supply is furnished upward through the bed of fuel, but it is given a double air supply most favorable to high efficiencies.

In the ordinary process, combustion is most active over the grate bars, but its uniformity is constantly interfered with by the varying thickness of the bed of fuel and the gradual accumulation of ashes. In stoves and house-fur-

nances the losses from the escape of carbon-monoxide and other combustible gases up the chimney, in very large quantities, is the result of feeding the air for combustion upward under the grate bars, and through the bed of fuel. In industrial furnaces this upward draft generally results in the feeding of an excessive air supply, the losses due to which are known to those who have made a special study of the subject, and are now beginning to receive the attention they deserve by engineers generally. I will not refer to the breaking up of carbon-dioxide, about which much might be said.

The purpose of the house-furnace and heating stove is to maintain the temperature of rooms at a degree conducive to the comfort and health of their occupants. The purpose of the industrial furnace is generally to maintain a pressure of steam sufficient for power requirements.

An air supply adequate to thoroughly oxidize the combustible elements of the fuel would be inconsistent with the purpose of the heating stove and house-furnace, and would produce a great excess of heat, and require the burning up of a larger quantity of fuel than is now burned imperfectly to meet practical requirements. Moreover, to maintain fires it is necessary to shake down the ash daily so as to permit the air supply to reach the fuel. This produces, in mild weather, a temperature that is not conducive to the comfort or health of the occupants of rooms so heated.

By my process of combustion there is no solid and varying resistance to the air supply, as in the old process due to accumulations of ashes and varying thickness of fuel, but there is a constant supply of heated air that flows in contact with the combustion products, and which is regulated by the quantity of combustion products passing through the flue or chimney.

An evenness of temperature can at all times be maintained, labor is reduced, poisonous gases are converted into useful work, and the coal pile has been made often to last more than twice as long as ordinarily.

The feeding of air through the flue or chimney in regulated quantities on top of the bed of fuel in stoves and house-

furnaces by my process has secured some very remarkable results.

During mild weather the ashes have been allowed to accumulate for days, and a very small fire maintained on the surface thereof.

This has been done with a ten days' accumulation of ashes, an evenness of temperature and the burning of the fuel to clean ash with entire freedom from clinkers resulting therefrom.

In this process the combustion chamber is raised to a higher temperature than that attained in the ordinary process, and therefore when applied to hot-air furnaces previously incapable of furnishing warm air to all of the rooms of a house, the cold rooms have been successfully heated.

In addition to gains of from 25 per cent. to 50 per cent. in stoves and house-furnaces by the use of this invention, it has been found entirely practicable to use the smaller sizes of fuel, such as pea coal, instead of the more expensive furnace coal. As the calorific value of pea or any of the other sizes of small anthracite, when washed, is just as great as that of the larger sizes of coal, the burning of the former should give approximately as good results as the latter with my process, the saving in price of which should be added to the gain made by the burning of a smaller quantity of coal. Furthermore, the production of coal gas within and without the house is effectually prevented by this invention.

* * * * *

I believe that the most common sources of waste in industrial furnaces when the fuel is high in fixed carbon, are those due to excessive air supply and to the non-transmission of a portion of the heat of the gases through the boiler plates, the rate of flow of the gases, being more rapid than the rate of transmission through such plates. I effectually prevent such wastes in plants favorable to the proper application of my invention, besides bringing back waste heat to the combustion chamber. When the fuel is high in volatile matter, the additional gains by my system are

very large. I have realized gains as high as 40 per cent. in well-designed plants burning such fuels.

This latter gain was made at a plant where evaporative tests of two weeks' duration were confirmed by months of subsequent use of the system.

In industrial furnaces, where the draft has been insufficient to economically burn the smaller sizes of anthracite coals, I have realized large gains with my process in the burning of these cheaper fuels, burning them either alone or mixed with soft coal. I am well aware that with high chimneys and forced draft this can be done successfully, but I maintain that it can, in most cases, be done on a smaller investment and with a less deterioration of the boiler plant and greater economy by my system. Another great source of gain that has been realized with my process of combustion is the less frequent cleaning of boiler-furnace fires. At one large plant which had been run with the closest regard to economy, the services of two men were easily dispensed with.

Before describing my invention in detail, I desire to fortify myself by the testimony of others who have used my combustion process successfully, and who, when it was first presented to them, were skeptical, as you doubtless are, regarding the results I profess to be able to attain.*

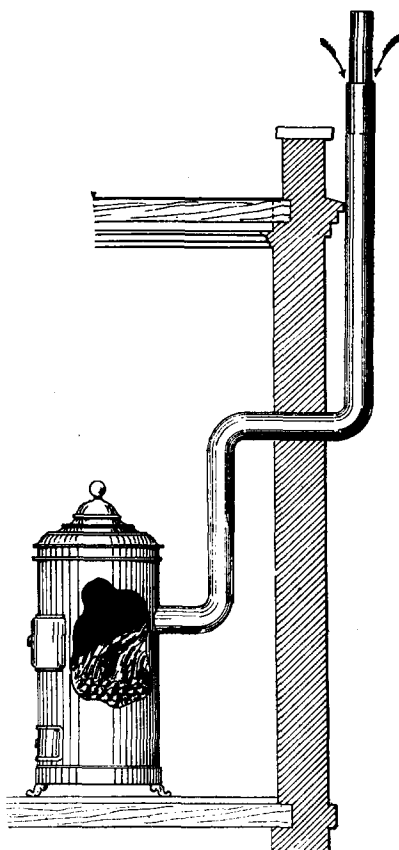
The accompanying illustration shows a stove similar to the one with which I made experiments of different kinds to test the efficacy of my induced downward draft. I carefully sealed up every crack and joint with asbestos cement, so that the air supply could only come through the chimney. The length of the smoke pipe was about 25 feet, including the bend, and I was able to burn the coal so as to give an even heat many times longer than would be possible by the ordinary process. The coal was burned to an impalpable powder. It was a fairly good quality of anthracite coal, but burning it in the ordinary way produced clinkers. The appearance of the fire was different from that of ordinary

* Mr. Schlicht here read extracts from letters from users of his combustion process confirmatory of his claims to economy, evenness of temperature, etc.

fires, a peculiar pulsatory action being observable and a much greater heat produced by the small quantity of coal on the grate. The temperature of the escaping products of combustion was very low and there was no carbon-monoxide in the products. I proved to my own satisfaction with this stove that a very low rate of combustion could be maintained without the production of carbon-monoxide. Roughly the experiment indicated several times greater efficiency than shown with the old process.

The annexed illustration shows the application of the Schlicht device to the furnace of Mr. Thomas G. Steward, now a member of the Board of Appeals of the United States Patent Office, but at the time of its application Chief Examiner of the Division of Stoves and Furnaces.

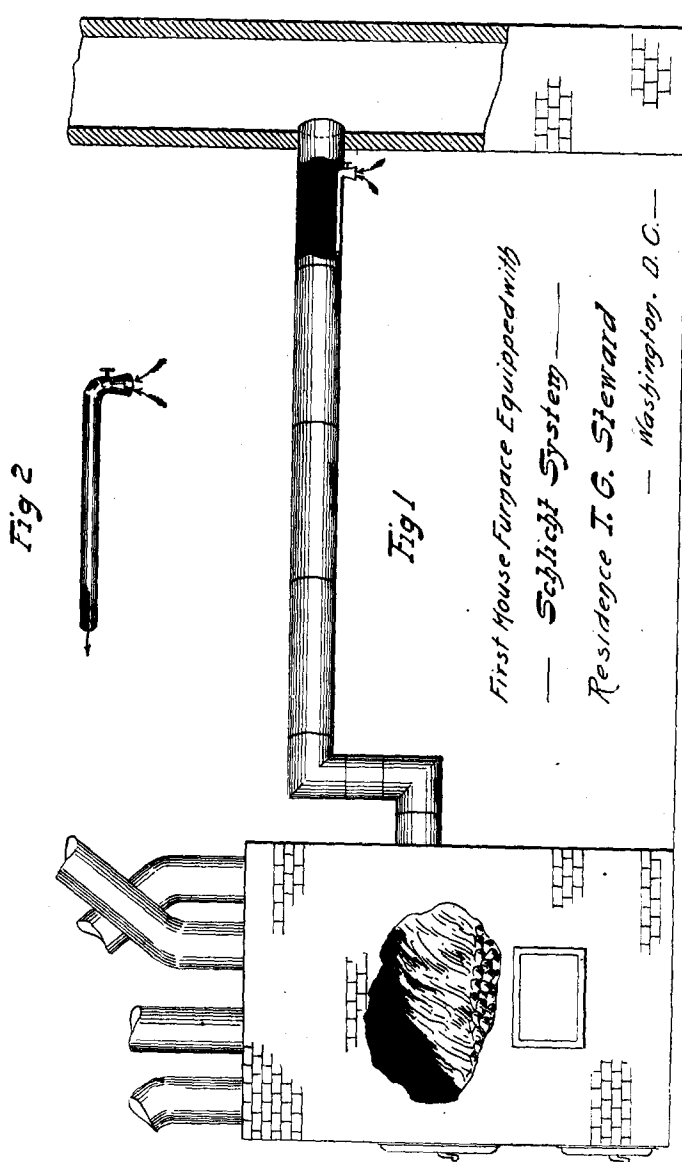
Mr. Steward experimented with my invention for months, not only to determine its value, but also to guide him in the allowance of my patent claims. He lived in a house which had the reputation of being a cold house, and which required the burning of a large amount of coal to render it habitable. Upon the application of my invention he was able to heat his house comfortably, and with a much smaller coal consumption than theretofore.



* * * *

When my application was first filed it was rejected on the ground of inoperativeness, the examiner denying that,

with the appliances shown, I could cause an air current to flow to the place of combustion. This fact I subsequently



proved by a practical demonstration in the basement of the Patent Office in the presence of the different examiners of

the division of stoves and furnaces. It was further verified by Mr. Steward's experiment with his own furnace. Since these early experiments, the appliances for furnaces have been greatly improved, but these early tests conclusively proved the correctness of the principle involved.

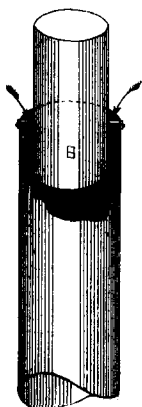
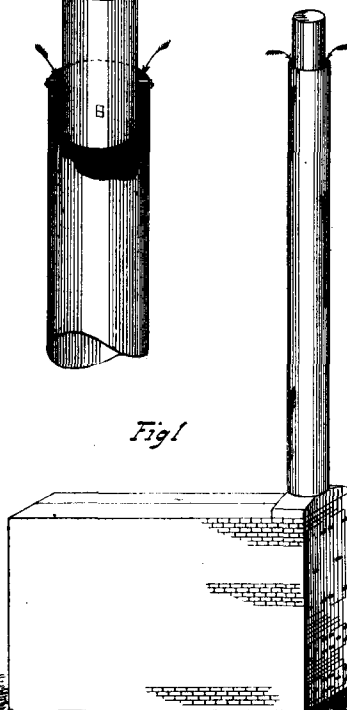
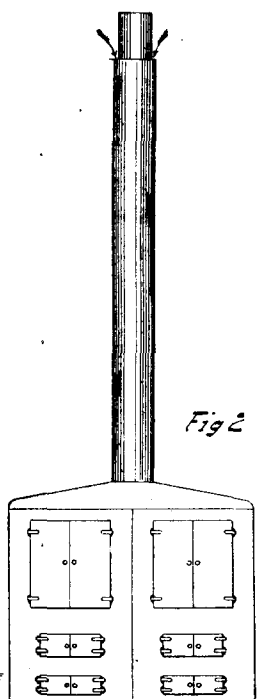
The air for combustion in industrial furnaces, as well as stoves and house-furnaces, as will be seen, may be admitted at the top of the chimney or through a flue leading to the same. The place for the admission of the air is determined by the conditions. In some instances they are such that the application to the chimney is the only feasible one, in others the application to the flue. The application to the top of the chimney secures contact with the current of escaping products of combustion throughout its entire length, giving the air abundant opportunity to be heated thereby.

One of the boiler-plants of the Barber Asphalt Paving Company (see accompanying illustration) typifies the conditions most favorable to the application of my invention at the top of the chimney of industrial boiler furnaces. Here the combustion products enter the chimney immediately after leaving the sphere of useful work, and its height and diameter are properly proportioned to the grate surface and to the quantity of coal burned per square foot of grate. If there were a separate chimney to each furnace, the results would be even more favorable, as the current of the combustion products from one boiler interferes somewhat with the current of combustion products from the other. If a less quantity of coal be burned per square foot of grate in one furnace than in the other, the quantity of air flowing into the combustion chamber will be proportionate to the combustion taking place therein. For example, if twice the amount of coal is being burned in one furnace than in the other, approximately twice the quantity of air will automatically flow to the combustion chamber of that furnace.

These two boilers are return tubular. For a part of the day the plant is run below and for the other portion, far beyond its rated capacity. It is while burning the largest

amount of coal per square foot of grate surface that the largest economy is effected. Evaporative tests with these boilers show the following results with "Sonman" bituminous coal :

	Without Schlicht Process.	With Schlicht Process.
Pounds water from and at 212° per pound of coal	10.79	12.96 and 12.68
Horse-power developed	166	188 and 172

Fig. 3*Fig 1**Fig 2*

Barber Asphalt Co.

PLAN B'

A test made to determine the efficiency of process with reference to time required to melt 250,000 pounds of crude asphalt showed: without Schlicht process, 20 hours; with

Schlicht process, 17 hours, and requiring a consumption of $8\frac{3}{4}$ per cent. less coal.

The amount of work done at this plant was greatly in excess of that done in previous evaporative tests.

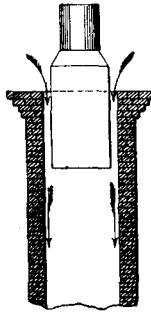
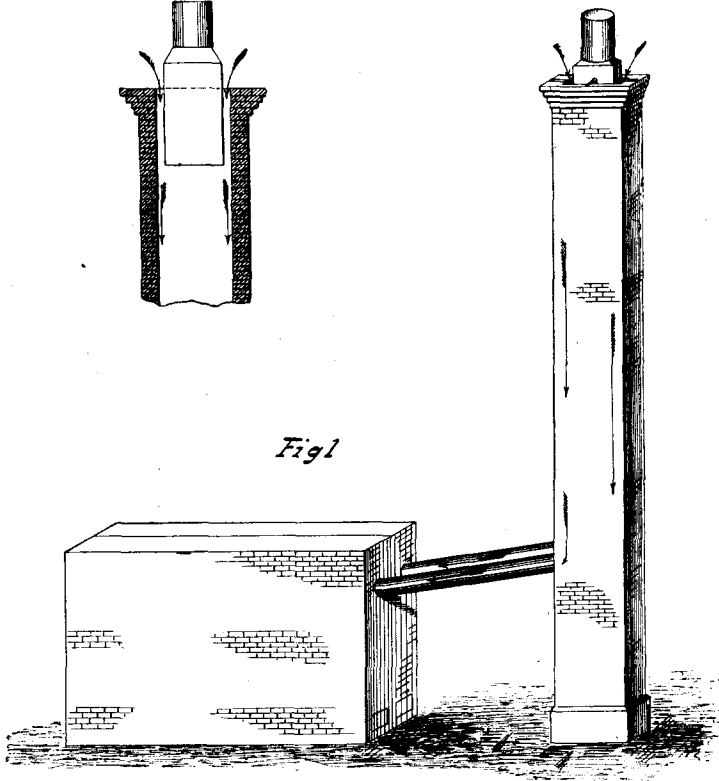
There are also Babcock & Wilcox's boilers at this plant, the equipment of which is at top of chimney.

The following illustration shows an early application of the Schlicht process to a steam plant. *Fig. 2* shows the appliance in the chimney. It consists of a square tube rounded at its top, occupying about 70 per cent. of the area of the chimney at its lower part, and much less at the top. The restriction of smoke area at the top was made because I found the chimney larger than the normal, considered with reference to its grate surface, and believed that such reduction of smoke outlet would prevent the too rapid outflow of gases which might otherwise not adequately heat the air fed through the chimney. Bituminous coal was and is burned at this plant, and they were troubled with the smoke nuisance. Immediately upon the application of the Schlicht device the color of the smoke changed from dense-black to a very light yellow, resembling wood smoke. * * *

Evaporative tests were made at this plant (a brewery), and showed variations with the rate of combustion. My compensation for the application of the process was determined by the lower cost for coal of each barrel of beer. From returns made by the brewing company, the cost of coal per barrel of beer up to June 1, 1898, for the previous year was \$0.0695, while previous to installation of the invention the cost of coal per barrel of beer was \$0.0855. This difference represents a saving of \$0.016 per barrel of beer. In these calculations the price of coal was made the same for both years, although the market price was less for the last year.

About this time the German Patent Office, doubting the statement in my application for a patent that I could cause air to flow down a chimney in contact with products of combustion escaping therefrom, requested me to furnish affidavits of reliable experts in corroboration of this fact. Accompanied by Professor Greenleaf, formerly of Columbia Col-

lege, and John J. Powers, I secured evidence of this fact in a very simple manner. Pieces of tissue paper were strung upon a string with a piece of wood fastened at its lower end. The string was let down the chimney close to its side and

Fig 2*Fig 1*

Eastern Brewing Co

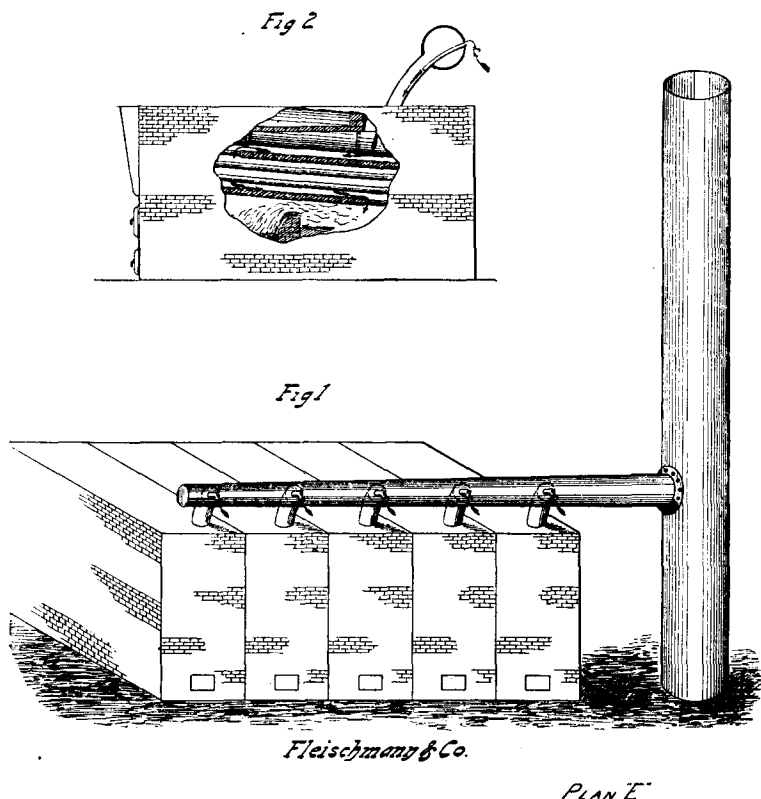
PLAN "A"

the papers strung upon it were drawn down in the manner that pieces of paper on a kite string are carried to the kite, known to boys as "telegraphing to the kite."

This plant was run for long periods with ash-pit doors shut, during which period combustion was intense. The

remark was made by the stoker that, "the draft was very strong."

This illustration shows the application to the boiler plant of Fleischmann & Co.'s distillery at Blissville, Long Island. *Fig. 1* represents the entire plant with air-feed devices applied to the flue of each boiler. In a preliminary test on one boiler the heat generated with my process was greatly

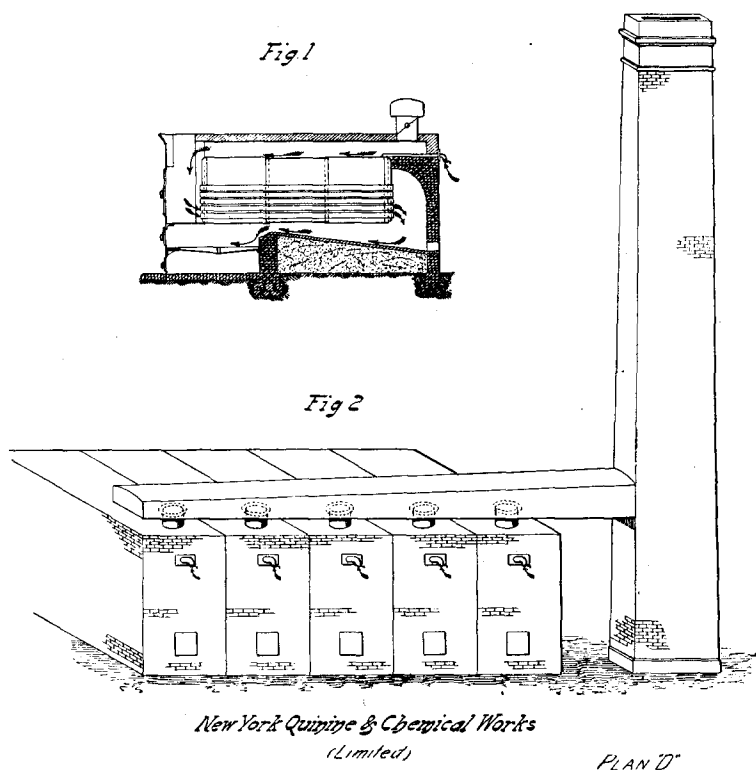


in excess of the absorptive capacity of the boiler and consequently the ratio of grate surface to heating surface was reduced, and 15 per cent. gain made. Before this was done the products of combustion were of a temperature sufficiently high to melt the pyrometer placed in the flue to determine temperature of flue-gases. In order to determine to what extent the reduction of grate surface was responsi-

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ble for the gain made the air-feed pipe was shut off and a test was made the old way which showed a lower evaporation, proving that the reduction of grate surface, while beneficial with the Schlicht process applied to a Heine boiler, was decidedly disadvantageous without it.

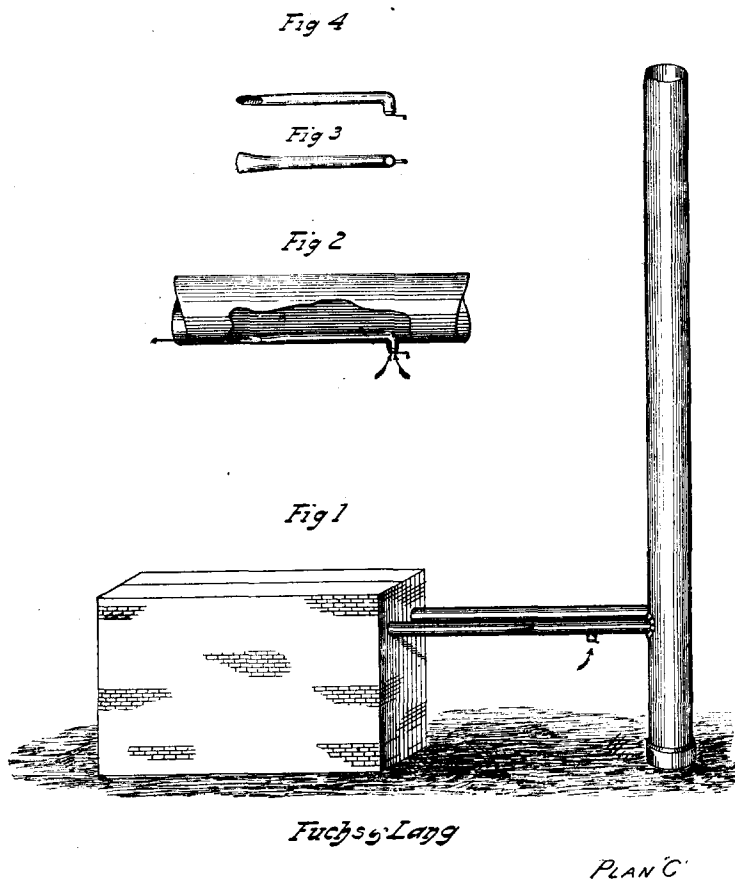
Mr. Jacob Blumer, the chemist and superintendent of the Blissville plant of Fleischmann & Co., carried on a great



number of careful experiments to determine the cost of a horse-power with different fuels and different boilers, under the direction of Mr. Charles Schlagenhauser, Superintendent of Manufacturing for Fleischmann & Co., an engineer of great sagacity and practical experience. I am permitted, on the authority of the latter, to state that independently of the gains shown by official evaporative tests there are so many other indisputable evidences of benefit that he cannot but

give the process his unqualified approval. Reduced coal bills, less ashes and refuse, greater uniformity of steam pressure, reduction of smoke, increased power when desired, are among these evidences.

Using "Coledale" bituminous coal an evaporative test showed: without the Schlicht system, an evaporation of



11.08 pounds of water per pound of coal from and at 212° . (The rate of combustion was 14 pounds per square foot of grate per hour.) With Schlicht process, evaporation was 12.19. Capacity test showed 8 per cent. better results than builders ever secured.

The illustration on page 370 shows the application to each boiler of the New York Quinine and Chemical Works, Limited. The air is introduced to each boiler as shown in *Fig. 1*.

Inferior coal was previously tried without success. Good results were produced with my process. Steadier steam pressure and greater boiler efficiency characterize boiler operations here. Very satisfactory economy is secured at this plant.

The illustration on page 371 shows application to flues leading from boilers of plant of Fuchs & Lang Manufacturing Company.

Tests were made with six parts of pea and dust, and one part of bituminous coal. The evaporation without process was 8.08 pounds of water; with process, 9.10. Evenness of steam pressure and high boiler efficiency characterized operations at this plant.

In consequence of lack of experience, difficulties with certain abnormally constructed plants were met with, but with the average boiler plants success has generally resulted from the application of the invention. To cite further details of successes and failures would tire you. To-day the commercial application of the process can be successfully made.

I beg to thank you for your courteous attention, and hope to be able in the near future to have something further to say that will interest you.

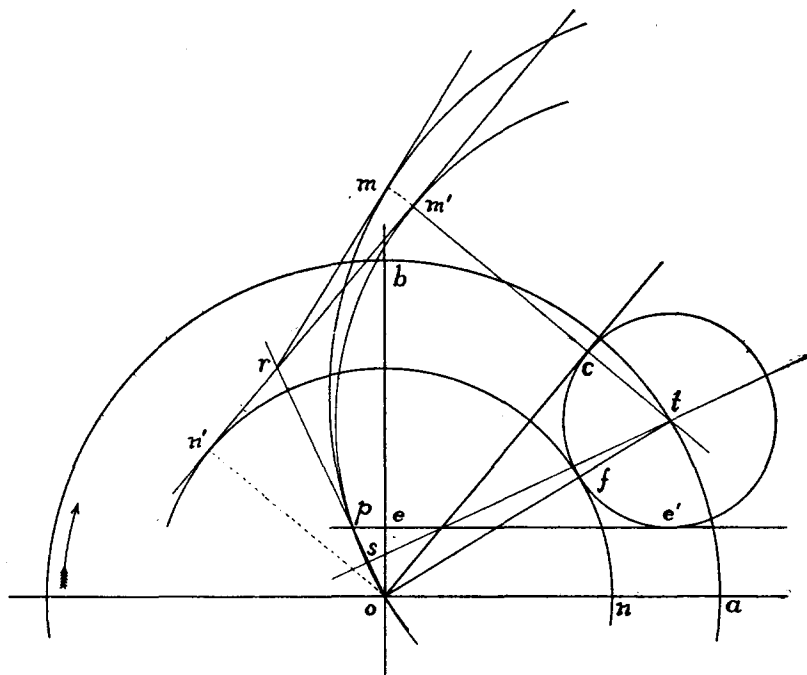
BILGRAM'S DIAGRAM AND THE SOLUTION OF
PROBLEMS INVOLVING LEAD.

BY MERRILL VAN G. SMITH.

Apropos of Professor Fox's recent article on the Zeuner Diagram, in which allusion is made to the approximate solution, by Bilgram's method, of one of the fundamental problems involving lead, the following is given to show that the same can be solved by a simple and exact construction.

The problem, which is that given as Problem IV in Professor Spangler's treatise on valve-gears and as Problem 15 in Professor Fox's article, is: Given the point of cut-off, lead and port-opening, to find the angular advance, lap and eccentricity.

Draw $o a$ and $o b$ at right angles, and lay off $o c$ to represent the position of the crank at cut-off. Draw $e e'$ parallel to $o a$, making $o e$ equal to the lead. With o as a center, describe the arc $n n'$ with the port-opening as a radius.



Draw $n' m'$ parallel to $o c$ and tangent to arc $n n'$. From o , let fall $o p$ perpendicular to $s t$, the bisector of the angle made by $o c$ and $e e'$. With a center on $s t$, draw any secant circle, as $o p m$, passing through o and p . From r , the point where $o p$, prolonged, intersects $n' m'$, draw $r m$ tangent to this secant circle. Lay off the distance $r m'$, on $n' m'$, equal to $r m$. Then, from m' , draw $m' t$ perpendicular to $n' m'$ and the point t , where this line intersects $s t$, will be the

center of a circle, which, with a radius equal to ct , will be tangent to ee' , nn' and oc . And, joining the centers o and t , of the circles $nf n'$ and $cf e'$, we have toa as the angle of advance, tf as the lap and ot as the eccentricity.

The proof the construction, in short, is:

The line $n'm'$, being parallel to oc , and tangent to the arc nn' , is distant from oc an amount equal to $on' = cm' = of$ = the port-opening. The line op , let fall from o perpendicular to st , the bisector of the angle made by oc and ee' , is divided into equal parts, os and sp . Any circle having its center on st , and passing through o , will pass through p . Circle opm is such a one; and, since or is a secant line, while rm is a tangent, we have $rp \times ro = rm^2$. But, rm' is equal to rm ; hence, $rp \times ro = rm^2 = rm'^2$. That is, a circle described through the points o , p and m' , will be tangent to rm' , which is $n'm'$, at the point m' . Such a circle must have its center on st , at the point where the perpendicular to the tangent at the point of tangency intersects st . The point t is the one thus found, and opm' is the auxiliary circle, which is here drawn only for purposes of proof. The line $m't$, being perpendicular to $n'm'$, is perpendicular to oc ; and the point c , where it intersects the latter, is one point of tangency of the circle sought to complete the diagram and solve our problem. A circle with its center at t , and a radius ct will be tangent to oc at c , and to ee' at e' . It will also be tangent to the arc $nf n'$ at f . For, $to = tm'$, being radii of the auxiliary circle opm' , and $fo = on' = cm'$; therefore, $tf = tc = te'$.

This solution will, in the number of its lines and the nature of their description, be found quite as simple as, if not somewhat more so than, the solution to the same problem given by either Professor Spangler or Professor Fox by means of Zeuner's diagram.