# YEAR BOOK

OF THE

# American Iron and Steel Institute

## 1916

MAY MEETING - - - NEW YORK
OCTOBER MEETING - - - ST. LOUIS

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# FOREWORD

This is the sixth Year Book of the American Iron and Steel Institute.

The first Year Book gave the proceedings of the International meeting which began in New York on Friday, October 14, 1910, and was continued in Buffalo, Chicago, Pittsburgh and Washington.

In 1911 the Institute held no general meetings.

The second Year Book gave the proceedings of the two general meetings held in 1912, the May meeting in New York and the October meeting in Pittsburgh.

The third Year Book gave the proceedings of the two general meetings held in 1913, the May meeting in New York and the October meeting in Chicago.

The fourth Year Book gave the proceedings of the two general meetings held in 1914, the May meeting in New York and the October meeting in Birmingham.

The fifth Year Book gave the proceedings of the two general meetings held in 1915, the May meeting in New York and the October meeting in Cleveland.

The present volume contains the proceedings of the two general meetings held in 1916, the May meeting in New York and October meeting in St. Louis.

James T. McCleary,
*Secretary.*

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# AMERICAN IRON AND STEEL INSTITUTE

## TENTH GENERAL MEETING

NEW YORK, MAY 26 AND 27, 1916

The Tenth General Meeting of the American Iron and Steel Institute was held at the Waldorf-Astoria Hotel, New York City, on Friday and Saturday, May 26 and 27, 1916.

Following the usual practice, three sessions were held on Friday, all in the Grand Ball Room. The forenoon and afternoon sessions were devoted entirely to the reading and discussion of papers. The evening session included the annual dinner. As usual, the papers, discussions and addresses covered questions of metallurgy, of business and welfare work.

On Friday the Secretary had a temporary office near the Grand Ball Room, where members registered for the meeting and were provided with identification buttons and with programs.

The paper read by Mr. William H. Childs on By-Products Recovered in the Manufacture of Coke was printed in advance. Mr. Lowenstein's paper at the evening session on the Construction of the Hell Gate Bridge was illustrated by stereopticon views, some of which have been reproduced in this volume.

At the noon recess on Friday, the members of the Institute were its guest at a buffet luncheon. During this recess, also, the Directors held a Board Meeting.

The attendance was the largest of any meeting thus far held.

On the next page will be found the program of the Friday sessions, at all of which the President of the Institute, Judge Gary, presided.

## FORENOON SESSION, 10.00 A. M.

Address by the President.............................. ELBERT H. GARY

By-Products Recovered in the Manufacture of Coke.... WILLIAM H. CHILDS
President, The Barrett Company, New York.
(Illustrated.)

Discussion.................................. WILLIAM H. BLAUVELT
Consulting Engineer, Semet-Solvay Company, Syracuse, N. Y.

The Electric Furnace in Steel Manufacture............. JOHN A. MATHEWS
President, Halcomb Steel Company, Syracuse, N. Y.

Discussion.......................................... LESLIE E. HOWARD
Metallurgist, Simonds Manufacturing Company, Lockport, N. Y.

Discussion.......................................... WILLIAM G. KRANZ
Vice-President, The National Malleable Casting Company, Cleveland, Ohio.

Discussion.......................................... CARL H. BOOTH
Treasurer, Snyder Electric Furnace Company, Chicago, Ill.

## AFTERNOON SESSION, 2.00 P. M.

Rail Manufacture.......................................... JOHN S. UNGER
Manager, Central Research Bureau, Carnegie Steel Company, Pittsburgh, Pa.

Discussion.......................................... HERBERT C. RYDING
Assistant to Vice-President and General Manager, Tennessee Coal, Iron & Railroad Company, Birmingham, Ala.

The Distribution of Raw Materials in the Blast Furnace
GEORGE W. VREELAND
Superintendent of Blast Furnaces, Carnegie Steel Company, Mingo Junction, Ohio.

Discussion.......................................... ARTHUR J. BOYNTON
Superintendent of Blast Furnaces, National Tube Company, Lorain, Ohio.

Discussion.......................................... RALPH C. GLAZIER
Superintendent of Blast Furnaces, Cambria Steel Company, Johnstown, Pa.

Discussion.......................................... JACOB C. BARRETT
Superintendent of Blast Furnaces, Carnegie Steel Company, Youngstown, Ohio.

Discussion.......................................... HENRY S. BRAMAN
Superintendent Blast Furnaces and Steel Department, The Youngstown Sheet and Tube Company, Youngstown, Ohio.

Discussion.......................................... KARL L. LANDGREBE
Superintendent of Blast Furnaces, Tennessee Coal, Iron & Railroad Company, Ensley, Ala.

## EVENING SESSION, 7.00 P. M.

ANNUAL DINNER

Cooperation and Efficiency in Developing Our Foreign Trade
EDWARD N. HURLEY
Vice-Chairman, Federal Trade Commission, Washington, D. C.

The Hell Gate Bridge.................................. JACOB LOWENSTEIN
Engineer, American Bridge Company, New York.
(Illustrated.)

Impromptu Remarks in Response to Call of the President.

Remarks by the President.............................. ELBERT H. GARY

# ADDRESS OF THE PRESIDENT

ELBERT H. GARY

Chairman, United States Steel Corporation, New York.

Gentlemen, it is a great pleasure to welcome so many distinguished men to our annual meeting. I think we have reason to feel proud of the success which this Institute has reached. Steel men have many reasons for congratulations. It has become fashionable to be a steel maker. We hear very little of criticism or of abuse concerning the steel people or their line of industry at the present time. I think the time is opportune for saying something that I believe we are particularly interested in, and that we have heretofore refrained from saying because we were afraid our words might fall on barren soil. And so I am going to be bold enough to-day to express some opinions that I think are justified and will be received by the public without any disposition to antagonize them. My theme is Public Sentiment. If at any time you fail to hear what I say and will notify me, I will try to speak a little louder.

## PUBLIC SENTIMENT.

Public sentiment represents the concensus of opinion entertained by the people of a community, a state, a nation or the entire world. It is ascertained from the public press, the platform, the pulpit and especially from the man or woman in the office, the shop, the factory, the hotel, the elevator, the private house, including the salon and the kitchen, and other places where language is spoken or written. Time and pains are required to ascertain the status or trend of public sentiment and we may be mistaken in our conclusion relative to it, but if we listen, read and inquire and consider carefully the results we may learn what the majority of the people believe and desire concerning any important subject in which they are particularly interested.

Public sentiment is not always right and reasonable; it may be wrong, temporarily at least, as determined by subsequent events. It is sometimes influenced by prejudice or passion; but after the facts are known and understood and time for consideration has been permitted, when minds are cool and undisturbed, there is generally reached an equilibrium that is just and wise. Often changes of opinion occur in time to remedy wrongs committed; sometimes too late. The power and force of public sentiment cannot be overestimated. It is subtle and refined though sometimes brutal and demonstrative. When vitalized it is irresistible and overwhelming even before it is crystallized into statutory enactment. It is not usually cyclonic but rather steam-rolleric. It has enthroned and dethroned kings. It has created and overthrown nations. It has established laws and nullified or abrogated them. It has precipitated wars and terminated them; and it will do it again. We may properly use our influence to change or modify it when we believe it is based on lack of knowledge or reason and therefore wrong in principle; and we may use every honorable means to create a public sentiment that is sound and righteous; but we do well when we heed its admonitions and we would make a grave mistake if we ignored or defied it. We must remember that we would likely be wrong if we were in opposition to clear and settled public sentiment.

There are now confronting the people of this country certain momentous questions. They involve life, liberty and happiness. They are under discussion by the most talented writers and speakers and they are in the thoughts and mouths of the multitudes. It is likely opportunity will be given to the voters to give expression to their views in the near future relating to some of these questions. It will be attempted in this address to state what is believed to be the general sentiment concerning the subjects to be referred to—that is, the opinions of the majority of the citizens of the United States at the present time.

### Business Success.

The first and fundamental essential to the welfare and happiness of all the people of this country is the economic conditions, though there are other things just as important to be considered. Prosperity should be fostered; business success, large business as well as small, should be protected, encouraged and assisted in every honest way. Men, women and children, first of everything, demand food, raiment and shelter. They smile upon those who favor the utilization of every proper means to increase business success and they frown upon those who would retard or interrupt it. They have listened to the speeches of the demagogue; they have witnessed the attacks made upon legitimate business; they have seen it investigated by unscrupulous or incompetent men; they have seen it hampered and hindered and at times almost paralyzed and they have heard it and those who conducted it, misrepresented and sometimes abused, and they have become tired and disgusted. The large majority have a friendly feeling toward business success, large or small, so long as it is decently and fairly conducted. The leading men throughout the land do not hesitate to publicly announce their inclination to protect and promote the business interests of the country and they will do what they can to make this practical, for they know there is a general sentiment to sustain them. Whether there has been a decided change in this respect or instead the real opinions of men have become visualized it is not necessary to discuss. Business interests, if and when deserving, may expect hereafter to receive due consideration and fair treatment by the public.

The business fraternity embraces the ones who provide capital or have charge of a business and those who are designated as employes or wage-earners. Both strive for the success of a given enterprise and the results affect the personal welfare of each. Their interests are identical so far as disaster or success to the enterprise is involved though efforts are not infrequently made from unworthy motives by outsiders to create an impression to the contrary.

We have in this country perhaps two-fifths of the gold of all the nations. The American dollar is considered the international standard; its exchange commands a premium in respect to most other countries. We have nearly one-third the wealth of them all. We have a decided advantage in farm and mineral production and it is constantly increasing. In resources, income, climate and other natural advantages we are greatly favored. Now, while we have the kindliest and friendliest wishes for all other countries, we believe that we should first protect and advance the interests of our own citizens, of all classes, nationalities and conditions and then assist our neighbors across the seas, wherever they may be, as our means and liberality may permit. We are naturally approaching, and may reach and retain, the leading position amongst the nations of the world in many, if not most, of all the things that make for the health and happiness of the inhabitants and the stability of the nation. We are entitled to claim and we will insist upon full benefit of all the advantages which Heaven has bestowed upon us. It is high time for every one to understand that a large majority of the people of the United States are going to insist upon the utilization of every facility to protect and to honorably further the interests of their own country.

We believe thoroughly in the regulation and restraint of business in such a way as to prevent harm and injury to the public interest; but we do not agree that the proper way to prevent harm is to destroy the agencies which may be and generally are utilized for the promotion of good. There has in the past been too much complaint and too much action that was based on mere theory. As a nation we are becoming wiser and more practical. We acknowledge that the power to accomplish good may and often does involve the opportunity to do harm; therefore we would restrain the latter and encourage the former. We recognize that business success is desirable and worthy of support and we would give it encouragement by the adoption of necessary and proper laws and by governmental assistance; but we would pass and enforce such laws for regulation and restraint as would prohibit uses that are improper and results that are unjust. The Government and the business men should work in harmony with reference to these matters.

Nothing I have said is intended as a modification of previous utterances bearing upon the obligation of business men, particularly those connected with large interests and possessed of the power incident to wealth to manage their affairs in accordance with public opinion, the laws of the land and the principles of right and justice. I commend you all for what you have stood for and accomplished in this respect and I adjure you to be steadfast and persistent to the end in your endeavor to maintain the reputation you have established.

### Protective Laws.

In connection with the conservation of our wealth and prosperity there must be considered the question of adequate and proper legal protection to American industries. We are a nation of producers as distinguished from a nation of consumers. Our national resources and conditions place us in this position and give us this advantage. The producers include the owners whose interests are represented by stocks in corporations or otherwise and by those who, as employes, perform the larger portion of the manual labor. Many of the latter are holders of corporate stock but the large majority are not. However, all are interested exactly alike. Together they are in normal times in competition, severe even though good natured, with the producers of other countries. As to many products, some of the other countries can produce at a lower cost than we can produce, based on the past and present scale of wages for labor. The labor of this country is thus brought into direct competition with the labor of other countries. It is well known that wages in the leading foreign countries have been about one-half the amount paid here for similar services and that in some countries, such as China, it is many times lower. Many foreigners have heretofore been in competition with us in selling to non-producing countries and they have also dumped their surplus stocks here in times of depression, at prices even below our costs and sometimes below their own. The articles sold in competition with us include large numbers of manufactured products and also raw products, such as wool, cotton, fruits, etc. Many of you have seen lemons by the millions, grown in California, going to waste because imported lemons were selling there at prices less than the cost of picking, boxing and shipping. Most of the foreign producing countries have in force tariff laws that fully protect their industries; and probably all will hereafter have similar laws; such are the indications as published in the daily press. Besides many of the governments furnish aid to their industries in many ways not necessary to mention at this time. After the war is over the contending nations will be impoverished and in great need of business and money. They will produce as much as possible and their facilities are generally unimpaired. They will sell wherever they can find a market and at low prices if necessary, including this country if we are not protected against them; and we cannot sell in their countries because they are and will be protected against us. We have for many months last past been secure by reason of the well known conditions of war, but if we carry our minds back to the circumstances existing shortly prior to the war we know what we may expect after the close, unless there is a change in our laws. From the time the present tariff laws came into force, in October, 1913, until some time after the war was started the effect upon our business was very bad. It was almost desperate with many. The prices of foreign surplus products dumped into our markets, though not large in volume as to some items, were so low that we were compelled to put our prices down to about cost and, in instances, below. Many were operating at a loss. We were going from bad to worse. Except for the war and war orders, wages would necessarily have been materially reduced and even then many employers would have been compelled to suspend. We know by sad experience that unless our tariff laws are changed so as to protect our business and place us on a parity with our foreign competitors, the large majority of producers will suffer, that business will be depressed, that the number of idle mills and cars and men will be increased and that wages will be lowered. We have seen these conditions before and there is reason to fear that they may be worse than ever unless our tariff laws are improved.

It may be observed by way of diversion (for general public sentiment may not have become focused on the subject) that it is not of first importance to consider the forms or details to be adopted. There should be included in the laws features which will furnish reasonable and adequate protection to American industries and also the necessary revenue for Government purposes; a plan for reciprocity or reciprocal negotiations and relations with other countries so that all conditions, changes and emergencies can be met and solved for the benefit of all concerned; and the amounts of tariffs applicable to various commodities should be carefully, logically and scientifically ascertained, and necessary, fair and reasonable protection—no more and no less—thus afforded. If these amounts are to be reported upon by a commission, competent and disinterested, the report should be made to the Ways and Means Committee for consideration and report to the House of Representatives. The party in power perhaps ought to have the right of final decision, especially as long as the tariff is made a party issue and submitted to the vote of the people at large. By the method suggested it seems probable there would be removed the struggle between different localities to secure advantages for one place or one industry over another, which has heretofore resulted in unsatisfactory rates, in some cases.

The principle of protection to industry by means of tariff laws has built up the commerce and the wealth of this country and other producing countries that have had a surplus for export. Its value has been demonstrated. As between nations, it is simply a safe, sound, business proposition. So long as one country maintains it others similarly circumstanced must do likewise in order to protect the interests of the large majority, including particularly the great aggregate of workmen. A benefit to the majority in the end advances the interests of even the minority, so closely connected and interdependent are the interests of each. When our competitors in other leading countries are ready to adopt the laws of free trade for our commodities it will be soon enough for us to favorably consider similar action. If we were to have free trade throughout the world, we could probably take care of ourselves in any contest for the disposal of what we have for sale. In view of conditions as they exist in normal times, it is not logical to place or to leave the United States in a position of disadvantage when we have the opportunity to establish a parity. The doctrine of America first, which is a patriotic one, applies with peculiar force to the idea of sufficient protection to American industries. This means not a prohibitive tariff, but one large enough to permit continued success in competition with the outside world.

## Merchant Marine.

Apropos of the subject already discussed is the question of transportation facilities on the high seas. Our export business is large and increasing. The total exports for March of this year were $411,476,638 in value, an increase of $114,864,786 over March, 1915. The total for the nine months ending March 31st was $2,997,172,472, an increase of $1,066,094,603 over the total for the same period of the preceding year.

The markets of the world are multiplying in number and increasing in importance. We are hoping for, nay expecting, open ports in every country. Some of the foreign countries are non-producers of many of the commodities we produce in abundance and they must be supplied by others. We have not heretofore had our proportionate share of this trade. It is good business, the prices are fair and yield some profit and it brings money to this country in substantial amounts. Its beneficial effects upon industry, upon capital and labor is of much consequence. One reason for the limited amount of our export business in the past is found in the lack of ships owned, controlled and operated by Americans. We have been more or less subjected to the domination of foreigners having the ownership or control of ships and who are interested directly or indirectly, in business competing with us; and we have labored under great disadvantage by reason of foreign laws that aided foreign owned and operated ships or domestic laws that added to the burdens and costs of the operation of American ships. Here again our government agencies have, in effect, antagonized the business interests of the country. When the present wars are ended these conditions will be even worse than they have ever been before unless there are adopted laws or amendments that will place our merchant marine practically on an equality with that of other nations. American capital will supply ships if our laws properly protect the investment. We may hope to see some existing laws repealed and other necessary and proper laws enacted, for the subject has received more attention and study during the last two years than it had received for decades before.

## Desire for Peace.

We are in favor of peace for our nation; not at any price, but we would if necessary, pay liberally for it. We would fight any other nation but only defensively. We would fight with all our ability and vigor in defense of our country, our lives, our property and our sacred honor. However, we do not wish for war and we believe it is not necessary to engage in it with any European nation or nations. The horrors of war are appreciated, though they cannot be completely portrayed. The full extent of the suffering and misery caused by it is fully realized only by those who are brought into close personal contact with it; but we know it is a terrible thing and we are sure it should not be allowed if it can be prevented. Moreover, if it becomes necessary to engage in a contest with any of the principal European countries we are unprepared to fight, even in self defense, and it would take much time and money to prepare. The large majority of the people of the United States are determined we shall not become involved in serious trouble with any European country and they do not look with favor upon any suggestion that proposes it, except as a last resort. It seems perfectly clear and certain that any candidate for office who entertains a contrary opinion is doomed to defeat.

So anxious are our people to avoid trouble and to maintain a peace footing, they are willing to submit, temporarily and until the minds of hot heads have had time to become cool and collected, to many acts seemingly unfriendly and even to sneers and insults, before they will assume an offensive attitude and run the risk of precipitating a war unnecessarily. This is a strong statement, but it represents the real attitude of a large majority of our people. They sincerely believe we shall get through and come out of the apparent shadows of doubt and distrust, the clouds of gloom that at times have been very black and threatening, without war and with the respect and confidence of all the European nations. We desire to have our administration at Washington maintain a strictly neutral attitude concerning the belligerent nations. We know it is for the interest of the United States to have the friendship of all other nations; and we are ready to return it. When the war is over—and may a merciful Providence speed the day—we wish to be on terms of intimate and cordial relations with them all, for we, as well as they, will be benefited and made happier thereby.

We do not approve of suggestions occasionally made in the Congress of the United States, or elsewhere, that there is imminent danger of trouble with Japan, for we understand that conflict is sometimes brought about by insinuations and insults. It is neither desirable nor necessary to have any serious controversy with Japan. Except as the result of mutual arrangement we wish for nothing they possess and we believe they seek nothing that belongs to us. We would not oppose any legitimate effort on their part to progress in competition with us and the same disposition may be expected of them. They have shown wonderful capacity and skill in developing their resources and in expanding their commercial interests and we admire them for it. We have no feeling of envy or covetousness and the same is true of them. In fact the feeling of the great majority and indeed practically all of the American people towards all other nations and nationalities is one of genuine and sincere friendship. We can and will be of service to them and they can be of service to us. The more they prosper, the richer they become, the more influence and power they possess, the better it will be for us, if we are alive to our duties, our obligations and our opportunities. The great future advancement of all the nations of the world in every worthy particular will result from friendly co-operation—a desire and effort to be of service, every one to all others.

The thoughts of the multitudes are looking forward to the time and opportunity for the firm establishment of a basis for permanent peace, a condition which will prevent prolonged international conflict. Our country would, if possible, exert an influence in this direction and it may be practicable if we avoid unnecessary controversy, if we are reasonable and patient and constantly give evidence of a Christian spirit. We may be considerate and conciliatory without yielding our honor or lowering our self respect. It is no stultification to offer the olive branch even if insulted.

## Preparedness.

It is not certain that there is a universal demand throughout this country for complete military preparation proportioned to its population and wealth; but it is certain that there are large and increasing numbers who are awake to the necessities of prompt, diligent and persistent efforts in this direction; and as the subject is discussed and considered and it is fully comprehended that the only purpose of those who are most emphatic in their insistence that there must be no delay in completing a sufficient military strength on land and sea is to secure peace, there will be little opposition to the measures proposed for the accomplishment of these objects.

The arguments in favor of a navy at least as good and as strong as that of any other nation and the adoption of provisions for the training, organization, equipment and quick mobilization of an army, even up to a million or more men, are sound and convincing. It is always possible we may be forced to fight in defense of our country, our lives, our honor, our property and property interests, though it seems to be unlikely at present. If war should be thrust upon us and we were unprepared we would properly be charged with suicidal tendencies. We could find no sufficient justifications or excuse. We would have invited attack. We would have neglected the ordinary prudence that the instincts of nature demand of every one possessed of common understanding. We know by the experience of the past that men sometimes get down to the level of wild beasts, with all the term implies, and that under such circumstances no reason or fairness or mercy is shown.

## Cost of Preparation

The cost of providing and maintaining a sufficient army and navy will be large, but small in comparison with the cost of war if one should be forced upon us because of a state of unpreparedness. When we read that the money expended for war purposes by a single European belligerent nation amounts to $25,000,000 per day, it is seen that any estimate of the cost of military preparation and maintenance is insignificant in comparison. As a mere matter of economy it is quite probable there would be saved billions of dollars by expending hundreds of thousands for military purposes. Withholding appropriations needed for purposes of preparing and keeping prepared for defense would be a false economy. It would be comparable to a refusal to make the necessary outlay for a good and sufficient lock to the doors of a house containing valuables and located in a burglar-infested district, or one that might be so infested by reason of the fact that protection was insufficient. Besides, if the United States is to assume and maintain the important position among nations that has been thrust upon her, she must be possessed of the same elements of power and strength that others have. She must be prepared to protect her commerce on the seas, which, let us hope, may equal that of any other single country. She must be ready to support other nations in the insistence that the ports of all foreign friendly nations shall remain free and open to all. And even more important to consider, we would be able to exert a powerful influence in aiding and even compelling international peace. If there shall be effected a basis for the settlement by arbitration of all international disputes and the enforcement of the decrees entered by a competent, disinterested court, as we so much desire and expect, then the permanency of this court, as well as its creation, will depend largely upon the strength of this, the leading country, from a military as well as a financial standpoint. There are many ways of economizing and in properly reducing the expenses of government in other directions. Many of the annual appropriations and expenditures which it has been customary to make during the last few years could be omitted without detriment to the progress of the country and some with positive benefit. This subject was adverted to at the last annual meeting of this Institute.

### General Observations

There is no questions of politics involved in what has been said, notwithstanding persons of different political parties may entertain different opinions concerning some of the points discussed. It is believed a strong and dominant public sentiment will bring about: first, a regard for honest business success, beneficial to all the people of this country, and necessary laws and administration of laws to promote and protect it; second, the maintenance of permanent peace, industrial as well as social; and third, a sufficient preparedness to insure both.

### Business Conditions

The steel industry is good—better than ever before. There have recently been publications to the effect that there is a falling off in new orders and this may be true to a slight extent, but the daily bookings generally are larger in volume than the total producing capacity, and as the unfinished orders on hand are sufficient to keep the mills busy for the remainder of this calendar year and a large portion of 1917, there is not much, if any, cause for concern on the part of manufacturers for the next twelve months at least. We could hope that we had been permitted to continue co-operation on a basis that would have influenced greater stability in prices, higher in times of depression and lower in times of great activity, for it would have been satisfactory and beneficial to both producer and consumer and to their employes; but circumstances, over which we had no control, brought about a change in this particular. Public sentiment may bring about a restoration of the former and better methods. Who can tell? We know, at least, that conditions in our industry are infinitely better than they were fifteen years ago or more. Whatever happens we may continue to entertain the same feeling of respect and esteem for each other that has characterized our intercourse these many years. I count it a pleasure as well as an honor to be associated with the members of this Institute, and I am grateful for your confidence and support. (Applause.)

We shall now have the pleasure of listening to a paper, "By-products Recovered in the Manufacture of Coke," by Mr. William H. Childs, President, The Barrett Company, New York, whom I take pleasure in introducing.

# BY-PRODUCTS RECOVERED IN THE MANUFACTURE OF COKE.

WILLIAM HAMLIN CHILDS
President, The Barrett Company, New York

We are told that in the year 1771 a chemist named Stauf, who lived in the forest near Saarbrucken, Germany, treated bituminous coal in ovens on a hill over a burning mine and obtained oil, pitch, coke, soot, and even a lump of sal-ammoniac. The great German writer and thinker, Goethe, paid a visit to Stauf there and bestowed on him the title of "Coal Philosopher." Goethe describes his visit as follows:

"Ready and glad to pour his complaints into a human ear, the lean, decrepit little man, with a shoe on one foot and a slipper on the other and with stockings hanging down and repeatedly pulled up in vain, dragged himself up the mountain to where the pitch house stood, which he had built himself, and now with grief saw falling to ruins. Here was found a connected row of ovens in which coal was to be freed from sulphur and made fit for use in the iron works; but at the same time they wished also to recover the oil and pitch, and indeed did not want to lose even the lamp black, so that all failed together on account of the many ends in view. During the lifetime of the former prince the business had been carried on in an amateur spirit, and in hope. Now they asked for the immediate use, which was not easy to show."*

Stauf seems to have been the first to recover by-products from coal, but the title of "Kohlenphilosoph" and a place in history was about all he got in return.

The by-product industry has progressed since his day. We are not content with his limited list of products, nor with his modest compensation. I have not heard that any by-product oven operators have received the title of "Coal Philosopher," but to judge from the number of new by-product ovens now being undertaken, they consider that returns are sufficiently encouraging.

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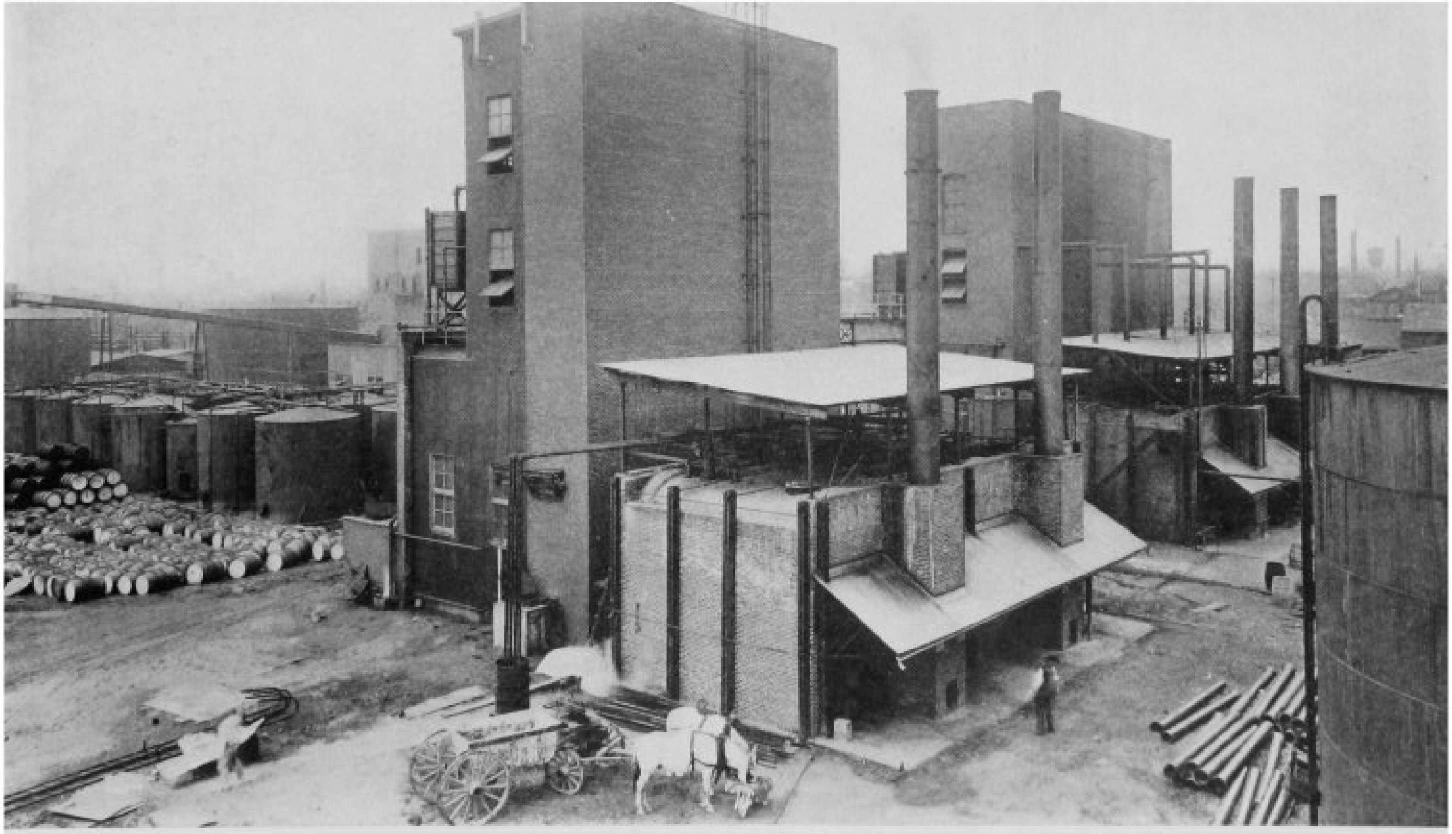
* Goethe's Autobiography. Book 10.



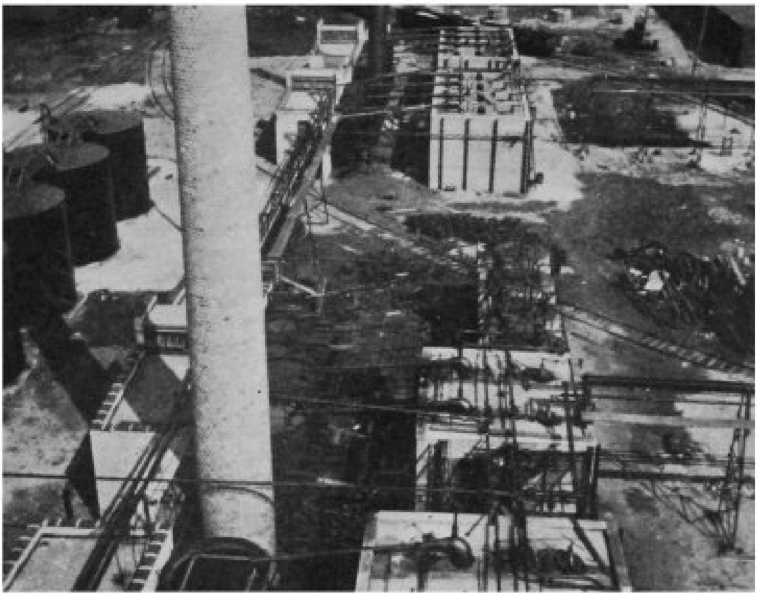
Light Oil Stills

There is one passage of that account, however, that deserves closer attention, namely, the statement that "all failed together on account of the many ends in view." In that the keen eye of the visitor summed up what has been the greatest obstacle to the progress of the industry of coal distillation ever since the days of Stauf. It produces not only one article or one type of article alone, but four or five, all radically different one from the other, different in their uses and disposed of in different channels. The relative quantities of the by-products from metallurgical coke cannot be varied to any extent; and in most cases the demand for coke, the main product, absolutely governs the output of the others. Continuous operation is essential to profits, hence a continuous market for the by-products as well as the main product must be secured. Where these requisites have been overlooked or minimized, embarrassment or disaster have not been slow to follow. The recognition of these difficulties is one of the chief reasons for the seemingly slow progress the by-product oven has made in this and in other countries.

## Development Not Uniform Here and Abroad

As we are all aware, the English and German development of coal by-products began earlier than in this country and hence has progressed further. In England the growth and extension of the coal gas works put sufficient quantities of coal by-products on the market to bring about commercial exploitation of their simpler derivatives before it was done elsewhere. In Germany, however, the commercial development, as distinct from that of theoretical chemistry, has waited on the growth of the by-product coke ovens. Germany came into the field later than England, but her broad and persistent methods of research and their application have carried her ahead in many lines, particularly those generally included under the title of coal-tar chemistry.

In the United States the industry may be said to have waited for its larger development on the advent of the by-product coke-oven. Coal gas plants were established and operated in the United States and the primary by-products were recovered and worked up, but the quantities were relatively small and the business was carried on in a number of isolated establishments. Extension was hindered by the long distances between the several points of production and between them and the prospective markets. More-



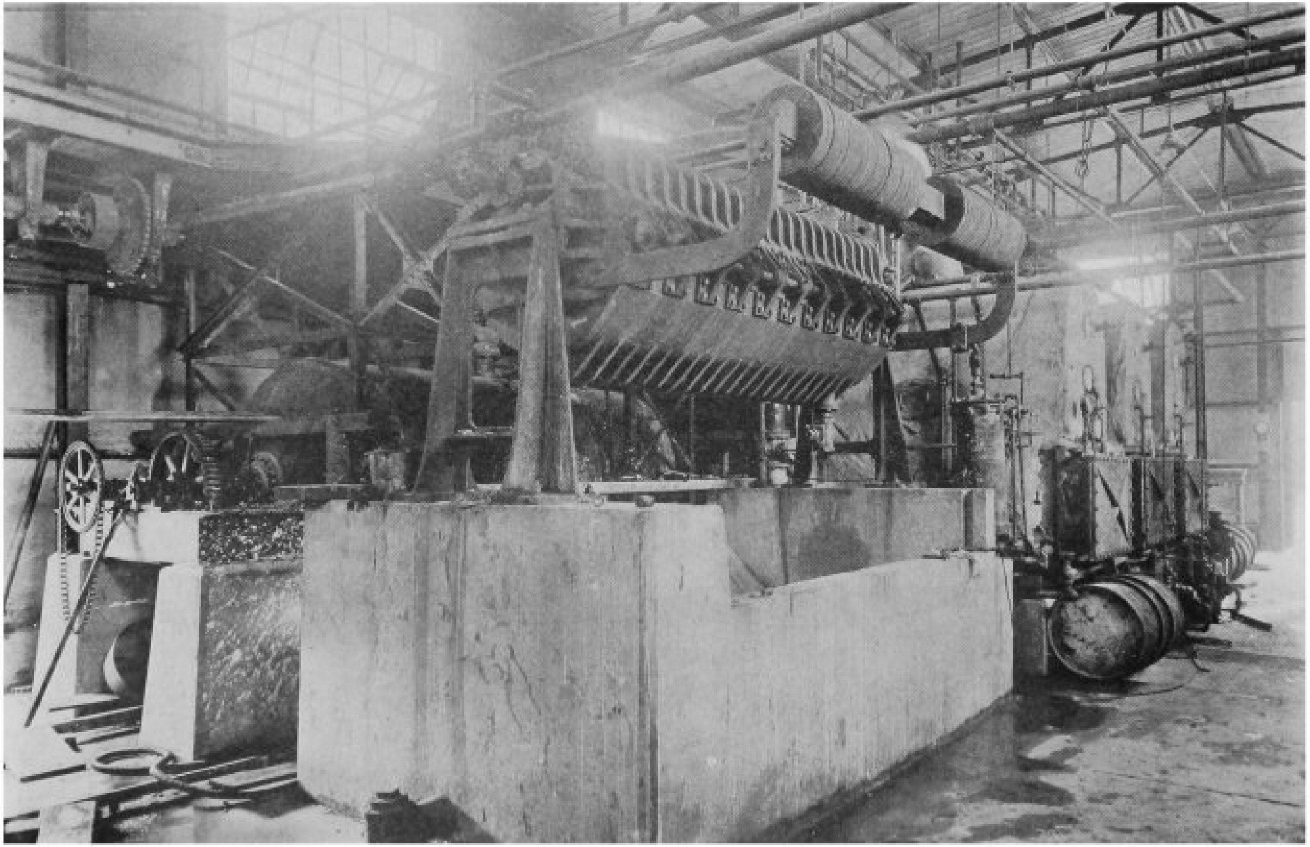
Bird's-eye View of Tar Stills

over, carburetted water gas was very popular and cheap, and for many years promised a larger development than coal gas. With the by-product coke-oven came the carbonization of large quantities of coal at one plant, corresponding quantities of by-products and a basis for an industry.

The development of this industry in the different countries has proceeded in general along the lines of least resistance and of greatest opportunity. The results have not been identical by any means. In Germany, for instance, certain conditions favored the development of the higher coal-tar chemistry, and in this direction a detailed, laborious and highly scientific structure was built up. On the other hand, practically all the pitch made in Germany, or indeed in Europe, is intended for fuel purposes, whereas in the United States the use of the softer grades of pitch have been carefully developed. A further illustration of this is in the use of gas. In the United States coke-oven gas has been used for general city purposes since 1899 with success and increasing favor. In spite of her extensive by-product coke-oven industry, Germany did not do this until 1910, but laid great emphasis on the use of oven gas in gas engines for electric power development. In this direction, in turn, the United States has remained behind. Many other such points of difference might be cited.

It should be recognized in this connection that for some years past practically all the coke made in Germany has been with by-product recovery. Aside from the normal expansion of the iron industry and the additional coke capacity needed for it, or an extended use of coke for general fuel purposes, made possible by present war measures, the German by-product recovery has reached its maximum. No large increments of tar and ammonia have been expected from this source for some time. This fact has doubtless played an important part in the German progress toward more refined chemical products. In England this condition is approached, but in the United States matters are very different. Based on the maximum Government figures for 1912–13, the coal carbonization for coke and gas was about 73,000,000 tons. Of this only 19,000,000 tons, or 29 per cent., was with by-product recovery. In other words, it is possible for the present by-product recovery to be increased three-fold without figuring on any increase in the iron and steel production.

That this prospect is by no means an idle vision is testified to by plans now on foot in the construction of by-product ovens. At present writing, new ovens to the number of 2,600 are under contract and will probably be completed by the end of 1917, and others are in prospect. The bearing of this fact on the future position of the by-



Filter Press in Phenol Plant. (See page 59.)

product market is a matter that must be reckoned with in due course.

From the point of view of those who rate highly the ability of the country to maintain itself in war or in peace, the development of our resources in this direction is a cause for congratulation. Germany and England have both found their coal by-product industries of vital importance to them in the present crisis, not only because they are essential to the steel industry but also because they are the great source of benzol, toluol, phenol and other chemicals used in the manufacture of explosives. Not only this, but in our case they are the only operating native source of combined nitrogen, from which nitric acid, so absolutely necessary in making explosives, can be made. The only alternatives are the round-about and costly method of atmospheric nitrogen fixation, or the importation of Chilean nitrate, the last of which might be cut off in time of war. These facts are but little known to the general public or apparently to the members of Congress.

As the title of this paper covers specifically the by-products of coke making, I shall not devote any space to coke, more particularly as I would be speaking as an outsider to an audience largely composed of specialists in that line.

In order to deal with the subject systematically, it will be necessary for me to take up the various primary by-products by themselves, these being in order: Ammonia. Gas, Benzol, Cyanogen and Tar.

## Ammonia

The recovery of ammonia in coking operations does not offer the possibility for as attractive a selling price as does the gas, nor for such an astonishing range of products as does the tar. It more than compensates, however, for these shortcomings in the uniformity and excellence of its returns. This is as it should be. Ammonia is important in chemical manufacture, in refrigeration and, as already mentioned, as a source of nitric acid for explosives manufacture in war time, but its great field is as an agricultural fertilizer.

This use lies at the very basis of our national prosperity and is continuing in peace or in war. A four-foot vein of coal will yield enough sulphate of ammonia to fertilize the land lying above it for 1,000 years.

To be more specific, coal contains from 1 per cent. to $1\frac{1}{2}$ per cent. of nitrogen. At the minimum figures this should yield 80 pounds of sulphate of ammonia per net ton of coal, whereas the usual yield in by-product ovens is one-fourth as much or a little more. This is due to the unfortunate fact that when coal is distilled, the nitrogen is distributed among the products of distillation, the bulk of it, usually more than half, remaining in the coke. The remainder goes into the tar, or into cyanogen, or as ammonia into the liquor and gas, there being also a possibility of loss as free nitrogen by ammonia dissociation. The distribution varies with the coal, a high nitrogen content not necessarily meaning a high ammonia yield.

Many attempts have been made, mostly in gas retort practice, to increase the yield of ammonia from coal, in view of the large amount of nitrogen retained in the coke. The most promising of them seems to be the mixing of a little less than 2 per cent. of caustic lime with the coal to be carbonized. Results for a year at an English gas works showed a gain of 1.68 pounds of sulphate of ammonia per net ton coal, the operations being benefited rather than otherwise.

The usual method of ammonia recovery in gas works and in the first by-product coke plants was as weak ammonia liquor, obtained by washing the gas with water. In some of these earlier gas plants this liquor was sold to chemical establishments on the basis of the tons of coal carbonized, or even on the basis of the "ounce strength", an inaccurate test now happily obsolete, depending on the number of ounces of free sulphuric acid required to neutralize a gallon of liquor. These methods have now given place to the more equitable chemical test for actual $NH_3$ present, whether the product is liquor or sulphate.

The treatment of the ammonia liquor consists in distilling it in a column with direct steam, which drives off the free ammonia, lime being added to a lower portion of the still to free the fixed ammonia, and again distilling, in the same operation. The exit ammonia vapor, mixed with steam, is cooled sufficiently to yield the strength of liquor desired, and passes to the condenser if strong crude liquor is to be made, or to the saturator if sulphate is to be the product. There it encounters dilute sulphuric acid, and the sulphate of ammonia is formed and crystallizes out. The salt is removed from the saturator, washed and dried, usually in centrifugal machines. and is ready to bag for market. The strong crude liquor, which usually contains 15 to 22 per cent. $NH_3$, is shipped as such in tank cars.

The latest coke oven plants have adopted what is known as the semi-direct or direct methods of ammonia recovery, in which the gas from the ovens, freed from tar, is led directly into the dilute sulphuric acid, the production of sulphate thus being accomplished without the intervention of washing water or redistillation. In the semi-direct system, which is much used in this country, the preliminary removal of tar involves the production of a certain amount of ammonia liquor, which can be treated in a still and returned to the oven gas before it enters the saturator, or can be made into crude strong liquor. This process is called semi-direct as all the ammonia is not made directly into sulphate. A direct system, in which no liquor is made, has also been developed and placed in operation in this country.

The sulphate of ammonia produced by either the old or new methods does not differ materially. The usual test is 25 per cent. $NH_3$, which, compared with 25.8 per cent., the chemically pure article, is a high degree of purity for a commercial product. A well-made sulphate will have from 0.8 to 1.5 per cent. moisture, and under 0.5 per cent. of free acid. The latter is easily controlled by using a slightly ammoniacal water for final washing in the centrifugal. A low free acid test is a great advantage, as the bags in which the sulphate is shipped last better.

Some of the German plants put out a dried and ground sulphate, which, being entirely deprived of moisture by kiln drying, tests over 25.25 per cent. $NH_3$ and brings a slightly higher price. A corresponding grade is made in this country. It has a great advantage over other nitrogenous chemicals used for fertilizers in its fine mechanical condition, which makes it spread evenly by hand or in a grain drill or spreader. It is a question for serious consideration whether it would not be a wise measure to treat all the sulphate made in this way, in order to set a high standard in view of possible German competition after the war.

Several methods have been proposed for making use of the sulphur in the gas to make sulphate of ammonia, rather than to resort to acid purchased from outside. Among these are the processes of Burkheiser and of Feld. The latter seems to offer a prospect of success, though the alterations in the usual methods of gas treatment are quite radical. It has not been tried in coke-oven work in this country as yet, although a modified form is in operation at the Central Union Gas Works in New York City and a plant is being installed at Chester, Pa.

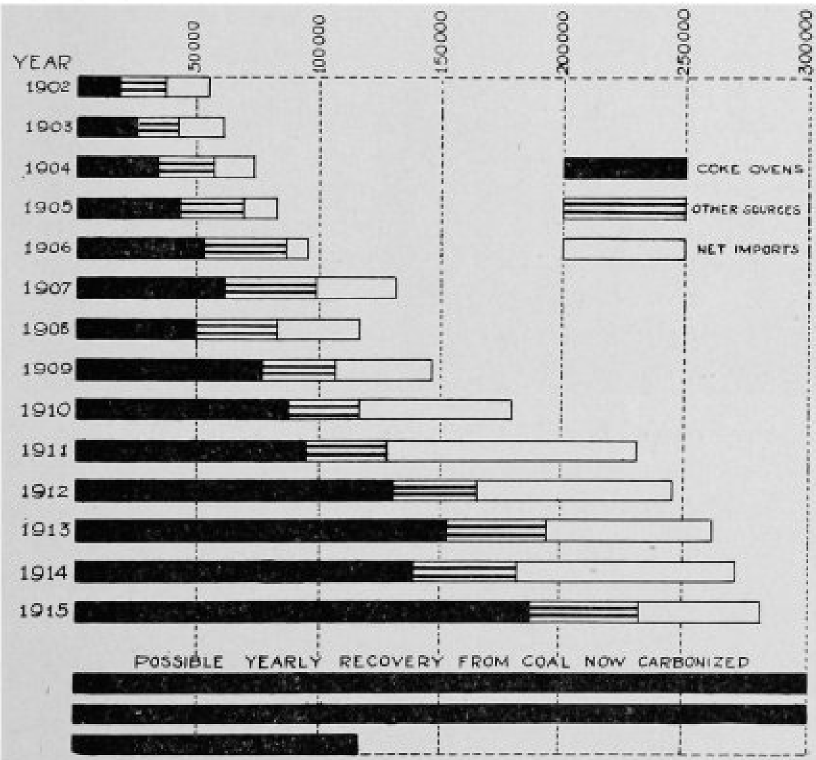
Mention has been made by some of the German technical journals of the use of gypsum (natural calcium sulphate) in place of sulphuric acid in making sulphate of ammonia. Details are not known, the process having never found much technical use because of the low yield. It would not be surprising, however, if it should become known later that Germany has used this process, or a modification of it, to produce ammonium sulphate and even sulphuric acid itself under the stress of war conditions.

Other developments in Germany are also of interest, both from a commercial and technical point of view. We know that Germany has had to increase her synthetic ammonia and cyanamid plants very heavily in order to obtain nitric acid for use in making explosives. The German cyanamid capacity is now said to be 500,000 tons per annum, and that of the Haber plant, at Ludwigshafen-on-Rhine, 300,000 tons of sulphate of ammonia, this being equivalent to 800,000 tons of sulphate of ammonia, and an increase of at least 500,000 tons over previous capacity. In order to induce private capital to build these plants, the Government has established a nitrogen monopoly, to continue in force after the cessation of hostilities. While the terms of this arrangement are not known, it is highly probable that any relief that they can get by shipping their surplus product into this country will be taken advantage of.

The production, importation and consumption of sulphate of ammonia and equivalent in the United States for the last five years have been as follows:

| | Production[1] Net Tons | Net Imports Net Tons | Consumption Net Tons |
|---|---|---|---|
| 1911 | 127,000 | 103,427 | 230,427 |
| 1912 | 165,000 | 81,089 | 246,089 |
| 1913 | 195,000 | 67,024 | 262,024 |
| 1914 | 183,000 | 89,158 | 272,158 |
| 1915 | 220,000 | 60,045 | 280,045 |

(1) For detailed figures of Sulphate of Ammonia production see special pamphlet, which will be sent on request.




United States Production, Net Imports and Consumption of Sulphate of Ammonia and Sulphate Equivalent, together with estimate of the amount recoverable annually from the coal now made into coke. Net ton = 2,000 pounds.


Cotton Fertilized with Sulphate of Ammonia


Oats Fertilized with 200 Pounds Sulphate of Ammonia per Acre

Timothy Hay, Top Dressed with 113 Pounds Sulphate of Ammonia per Acre

The prospects are that with the full operation of the existing plants, and those that will come into operation before the year is out, the production for 1916 will exceed that for 1915 by 30,000 or 40,000 tons. With upwards of 2,600 new ovens under construction, it is highly probable that the years 1917 and 1918 will register successive large additions. It is not out of the way to estimate the sulphate of ammonia capacity of the country at the end of 1917 as 375,000 tons.

The price record of sulphate of ammonia, together with that of nitrate of soda and the equivalent cost of one pound of nitrogen in each, is given in the accompanying insert diagram. According to these figures the price of the nitrogen in sulphate of ammonia has largely remained at the higher level of the two for some years past. Whether, in the face of the increased production, this record will be continued, of course, cannot be predicted.

Sulphate of ammonia is extensively used in ready-mixed fertilizers, which is the form generally purchased by the American farmer. These usually contain acid phosphate and potash, together with sulphate of ammonia, tankage, cotton-seed meal, etc. Sulphate of ammonia is dry in its nature, and makes an excellent mixture as far as mechanical condition goes, with the added advantage that it does not react with the other fertilizer chemicals to cause loss of nitrogen or reversion of the acid phosphate, both of which points are claimed against nitrate of soda. The nitrogen in sulphate of ammonia is quick to act, is not easily leached out of the soil, and it continues its action over a considerable period, so that the growing plant is carried along to maturity without setback. Its only disadvantage is the tendency to exhaust the lime in the soil. While this point is apt to be urged by Agricultural Experiment Station men, it is really of minor importance because the actual amount of sulphate of ammonia in the usual fertilizer application is small, and its nitrogen is relatively so much more beneficial to the growth of the crop. The liming of the soil, which of course overcomes all objection, is urgently recommended by all Experiment Station advisers, and in large areas of the

Eastern States is practically the foundation of profitable agriculture. On the other hand, in some soils, as in those of Southern California and parts of Texas, which tend to excess of alkali, the action of sulphate of ammonia is peculiarly beneficial. In some soils sulphur is lacking, so that the sulphur in sulphate of ammonia actually acts as a plant food.

In order to deal with such matters as these effectively, it became necessary for The Barrett Company to have an Agricultural Department, and for the past six years propaganda has been carried on for the introduction and proper use of sulphate of ammonia. Agricultural branch offices in charge of trained men have been maintained in the South at Athens, Ga., and in the Middle West at Medina, Ohio. Work is also being done in Virginia, California and elsewhere. These offices are devoted entirely to propaganda work. Three general lines are followed, namely: (1) To keep in touch with the Experiment Station and Government officials, and to see that due attention is given to sulphate of ammonia on its own merits, wherever opportunity may offer. (2) Actual co-operative experiments with farmers on their own land, using sulphate of ammonia. Hundreds of such experiments are carried on yearly, on all kinds of crops. (3) General publicity work, bulletins, advertising, etc.

The actual demand for sulphate of ammonia depends, of course, on the demand for fertilizers in general, which in turn is affected by agricultural conditions. The consumption of fertilizer in 1914 is estimated at 7,631,000 tons, which at $20.00 per ton would be over $150,000,000. For the year 1913 it was 6,780,000 tons. Estimates for 1915 are not yet at hand, but it is doubtful whether the 1914 figures will be exceeded. It is of interest to note in this connection that the large consumption of fertilizer is in the South Atlantic States—Georgia, the Carolinas and Alabama—while the main production of sulphate of ammonia, aside from the Birmingham district, seems likely to be in the Chicago-Pittsburgh region. This involves a considerable rail haul to the point of consumption. The Western grain states, which would naturally draw from Chicago, have not come to use fertilizer to any extent. When the demand for fertilizer develops there, as it will in time, the production will be at an advantageous position relative to other sources of supply.

The secondary products of ammonia are usually derived from the crude liquor.

Aqua ammonia and anhydrous ammonia are used in refrigeration. The crude liquor is purified by redistillation and scrubbing with lime, charcoal, bone-black, etc., and absorbed in water for aqua, or liquefied in a compressor for anhydrous. Aqua is diluted for use as household ammonia. Some anhydrous is made from sulphate instead of from liquor, the object being to make a very pure article without excessive purification costs.

Ammonium chloride, sal-ammoniac, $NH_4Cl$. This is largely used in electric batteries, as a flux in galvanizing, and in chemistry and the arts. Commercial test is 31.5 per cent. $NH_3$. It is made from sulphate by heating with common salt, or by absorbing ammonia gas in hydrochloric acid.

Ammonium bicarbonate, or acid ammonium carbonate, $NH_4HCO_3$. It is made by the action of purified $NH_3$ gas and carbonic acid, $CO_2$. The commercial test is 99.9 per cent. pure, or 21.5 per cent. $NH_3$. It is used to reduce the amount of yeast used in baking crackers, etc.

Ammonium nitrate, $NH_4NO_3$. This is made by the action of $NH_3$, ammonia, on nitric acid. The commercial test is 99 per cent. pure. It is used extensively in the manufacture of smokeless powder.

Mention has been made of the use of ammonia in making nitric acid for explosives in war. This process rests on the original invention of Ostwald (U. S. patent 858904, 1907), in which ammonia and air are passed through a heated tube in the presence of a catalyzer, as platinum sponge, the ammonia being oxidized to nitric acid.

The original process did not work out successfully in practice, but later experiments, with different catalyzers, appear to have given more satisfaction, although but little was done in a commercial way.

Under stress of war conditions, large amounts of nitric acid have been produced by this method in Germany. It has also been used to supply the place of nitrate of soda in sulphuric acid chambers.

Several different forms of the process have been developed by the several investigators, but so far as information is at hand none has been placed in operation in this country, although descriptions have been published from time to time in the technical press. The principle appears to be the same, in that in one type pure ammonia gas and air in the right proportions are brought into contact with a catalyzer electrically heated to about 700 degrees C., the product being nitric acid and water. This must be concentrated in order to obtain acid of the proper strength for nitrification purposes.

One of the obstacles is the necessity of thoroughly purifying the ammonia gas in order to avoid poisoning the catalyzer, but this, it is stated, may be greatly facilitated by using ammonium chloride, or presumably ammonium sulphate, in place of ammonia liquor.

For further details see *Metallurgical and Chemical Engineering,* Vol. XI, pp. 438–476, 1913; Vol. XIV, p. 425, 1916; *Metall. u. Erz.,* Vol. XIII, p. 21.

## GAS

Coke-oven gas is, in a way, the joker among the cards in the by-product coke man's hand. It may be worth a great deal for illuminating purposes, or it may be worth only its fuel value as against coal under steam boilers. In the first instance it brings from the consumer, let us say, about 60 cents per thousand cubic feet, or, allowing for purification and distribution, about 30 cents net. For fuel under boilers the usual price is about 4 cents per thousand, depending on the price of the coal it displaces. Modern coking practice easily recovers 6,000 cubic feet of surplus gas per ton of coal carbonized. At 30 cents this would be $1.80 per ton of coal, as against a credit of 24 cents which would be the other extreme. Where a new plant is under consideration there is an ample reward here for wise planning and successful negotiation. Unfortunately, success in finding such a market for the gas is in many cases a difficult matter, the reasons usually being the existence of a regular supply of natural gas, or the lack of cities of sufficient size within piping distance to make the arrangement mutually profitable.

The amount of coke-oven gas that is available in making by-product coke for a modern blast furnace is very large, and its relation to the consuming power of the usual city is not generally appreciated. For example, a modern plant of say 40 ovens, which is about the minimum and corresponds to a 400-ton furnace, would produce about 3¼ million feet of gas per day. This under ordinary circumstances would supply a city of at least 150,000 inhabitants. There are only 26 cities of this size in the United States east of the Rocky Mountains, and all of these are supplied with gas, some of them with coke-oven gas. There are already upwards of 46 by-product coke-oven plants in existence, and some under construction. A list of the places supplied wholly or in part with coke-oven gas, together with the price of gas, is given in the table on page 42.

It has frequently been possible to supply a group of two or more towns from a single by-product oven plant, as in the case of the plant at Camden, N. J., which also supplies Trenton, Plainfield, New Brunswick, Gloucester, Burlington and other towns, through high-pressure transmission lines, or the plant at Joliet, Ill., which also serves Aurora, Elgin and La Grange, Ill.

A fair typical analysis of rich gas from coal of 30 per cent. volatile matter would be as follows:

| | Per Cent. |
|---|---|
| Methane | 31 |
| Hydrogen | 48 |
| Illuminants | 5 |
| Carbon monoxide | 6 |
| Carbon dioxide | 4 |
| Oxygen | 0.5 |
| Nitrogen | 5.5 |
| | 100.0 |

## CITIES AND TOWNS IN THE UNITED STATES OF 5,000 OR MORE INHABITANTS, USING COKE-OVEN GAS.[1]

| Manufacturing or Distributing Co.[2] and Points Supplied.[3] | Location | Net Price[4] |
|---|---|---|
| Birmingham-Tuscaloosa R. R. & Utilities Co. — Tuscaloosa, Ala. | Tuscaloosa, Ala. | $0.90 |
| Coal Products Manufacturing Co. — Joliet, Aurora, Elgin, La Grange, Ill. | Joliet, Ill. | 0.90 |
| North Shore Gas Co. — Waukegan, Ill. | Waukegan, Ill. | 1.00 |
| Citizens' Gas Co. — Indianapolis, Ind. | Indianapolis, Ind. | 1.00 |
| Linton Gas Co. — Linton, Ind. | Linton, Ind. | 1.00 |
| Maryland Steel Co. — Baltimore, Md. | Sparrows Point, Md. | 0.75 |
| New England Gas & Coke Co. — Boston and suburbs; Milton, Charleston, Quincy, Mass. | Boston, Mass. | 0.80 |
| Detroit City Gas Co. — Detroit, Wyandotte, Mich. | Detroit, Mich. | 0.85 |
| La Clede Gas Light Co. — St. Louis and suburbs. | St. Louis, Mo. | 0.80 |
| Zenith Furnace Co. — Duluth, Minn; Superior, Wis. | Duluth, Minn. | 0.75 Dul.<br>1.00 Sup. |
| Camden Coke Co. — Camden, Gloucester, Trenton, Burlington, No. Plainfield, Somerville, New Brunswick, So. Amboy, N. J. | Camden, N. J. | 0.90 |
| Empire Coke Co. — Geneva, Auburn, Newark, N. Y. | Geneva, N. Y. | Fuel, 1.00<br>Light, 1.25 |
| Hamilton-Otto Coke Co. — Hamilton, Ohio. | Hamilton, Ohio. | 0.30 |
| Philadelphia & Suburban Gas & Electric Co. — Chester, Darby, Pa. | Chester, Pa. | 1.00 |
| Harrisburg Gas Co. — Harrisburg, Steelton, Middletown, Pa. | Harrisburg, Pa. | 1.00 |
| Allegheny By-Product Coke-Oven Co. — McKeesport, Pa. | McKeesport, Pa. | 0.22½ |
| Chattanooga Gas Co. — Chattanooga, Tenn. | Chattanooga, Tenn. | 1.00 |
| Seattle Lighting Co. — Seattle, Wash. | Seattle, Wash. | 1.00 |
| Milwaukee Coke & Gas Co. — Milwaukee, West Allis, Wis. | Milwaukee, Wis. | 0.75 |

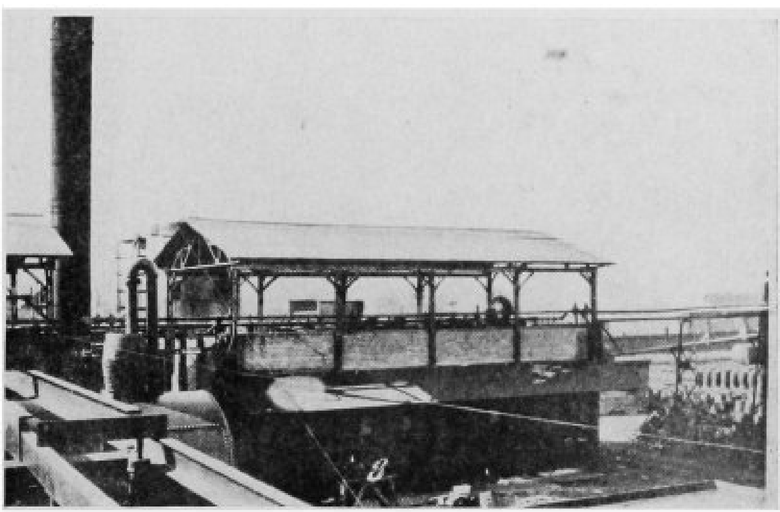
[1]. Statistics from Brown's Directory of American Gas Companies for 1916.

[2]. Total number of manufacturing or distributing companies listed, 19.

[3]. Total number of cities or towns listed, 40.

[4]. Prices are net for first supply to consumer. Gross prices are generally 10 cents in advance of the net where the latter is $1.00 or over, and 5 cents in advance of the net where latter is below $1.00.

The calorific power of the gas will average between 580 and 620 British Thermal Units per cubit foot and the candle power from 12 to 16. The lean or oven heating gas has in the neighborhood of 500 to 580 British Thermal Units. As the coking period has decreased to between 16 and 20 hours in the latest ovens, the heat efficiency of the oven has increased, and with it the amount of surplus gas, but as the rich fraction is taken over a longer time the quality of the gas is necessarily somewhat lower. As stated above, it is usual to estimate 11,000 cubic feet of gas from a ton of coal, of which 5,000 or less will be required for coking and 6,000 feet or more will be available surplus. Authentic reports are at hand which show a yield from a recent coke-oven plant of over 12,000 cubic feet of gas per net ton of coal, containing less than 5½ per cent. of carbonic acid and nitrogen. Of this gas less than 40 per cent. of the heat value was used in coking, so that the surplus corresponded to 7,200 cubic feet. The coal was a mixture of 40 per cent. low volatile and 60 per cent. high volatile coal, which would average about 30 per cent. volatile. The total amount of heat lost in waste gases and radiation at this plant was less than 4½ per cent. of the total heat in the coal.



Battery of Four Tar Stills

A large number of uses have been found for coke-oven gas around steel plants, aside from steam raising, as in open-hearth steel furnaces, soaking pits, drying ladles, heating furnaces, etc. There is also a wide field, though not a particularly high priced one, where natural gas for industrial purposes is failing. One important use, namely, for power development in gas engines, has not received the attention in this country that it has in Europe. So far as information is available, the only large gas engine installation using coke-oven gas in this country is at Lebanon, Pa., where four 1,200 h.p. engines using gas from the Semet-Solvay plant there develop electrical power for operating the Cornwall Ore Banks. According to published data, gas engines aggregating over 200,000 h.p. for operation with coke-oven gas have been installed in Europe by three of the principal builders since the year 1904. A guarantee of 1 h.p. per hour with 27 cubic feet of average gas is not considered out of the way, which would mean about 200 h.p. hours per ton of coal, or for each modern coke-oven the capacity to produce 125 h.p. continuously, as long as it is in operation. A battery of 80 ovens would yield 10,000 h.p.

While it is realized that various practical difficulties lie in the way before such results may be arrived at, there is good reason to think that they have been overcome by others, and that the prospect is by no means a hopeless one.

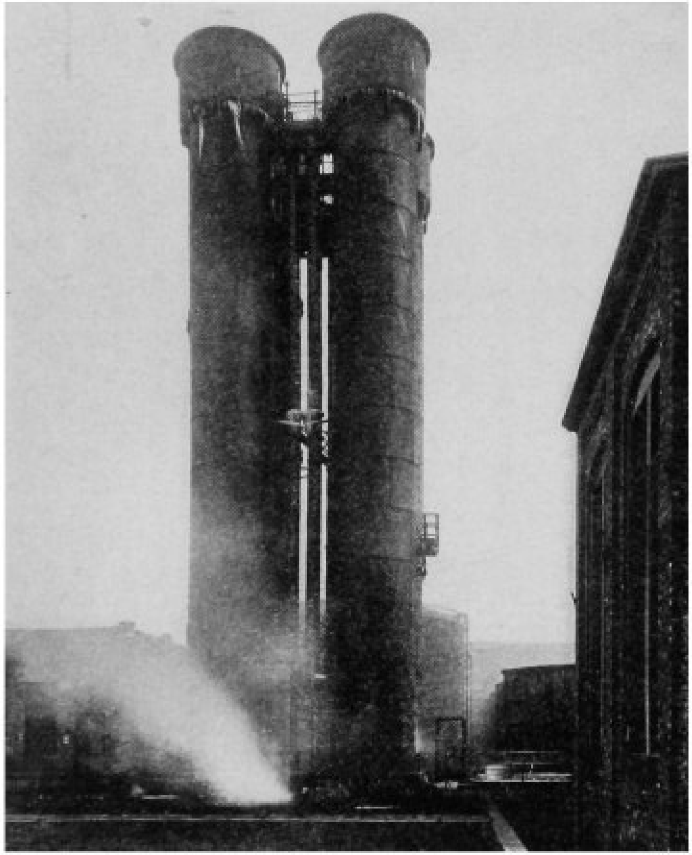
## Benzol, Toluol and Xylol

The recovery of benzol, together with its homologues, toluol and xylol, is more properly dealt with in connection with the gas than with the tar, as by far the larger portion of these oils is found in the gas, although chemically they are classed with the coal tar derivatives. There is, of course, no exact proportion, but a recovery of 2½ gallons of light oil from the gas from one ton of coal carbonized is common, while the corresponding fraction of the tar would probably be less than one-tenth of a gallon.

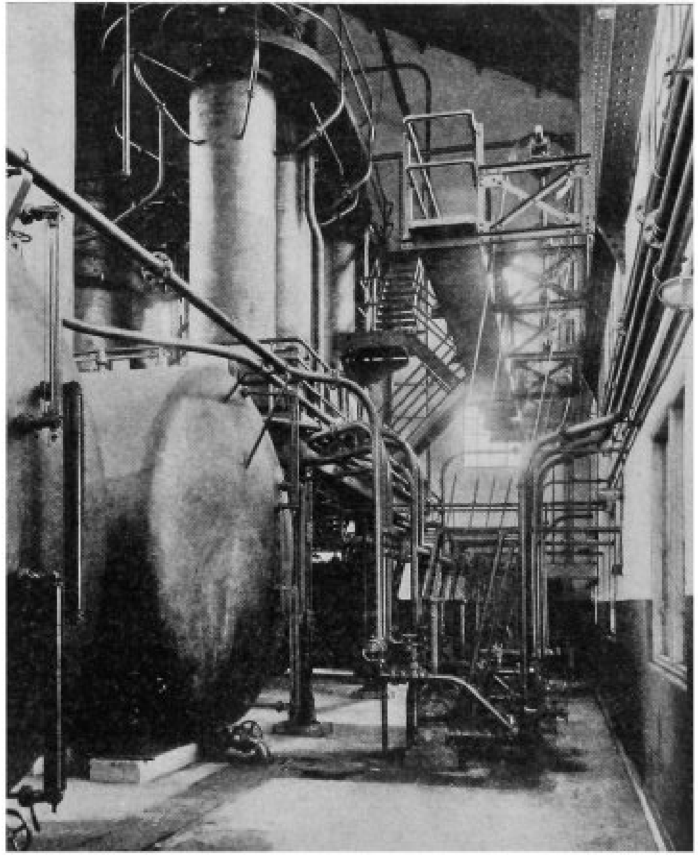
The actual recovery of benzol is a relatively simple matter. It is based upon the property of certain high boiling oils to absorb the crude benzol vapors from the gas, and to yield them up again when heated to a temperature below their own boiling point. The oils employed for this washing are the so-called petroleum "straw" and tar creosote oils. English practice prefers a tar creosote oil distilling from 220° to 250° C., although heavier oils distilling from 250° to 300° are also used. All the American benzol plants use the petroleum straw oil because it is cheaper than coal-tar oils and the benzol can be more sharply separated from it in the type of continuous still used.

The washing of oven gas with oil for benzol is practically parallel to the washing with water to recover ammonia, the guiding principle being to bring the gas into intimate contact with a maximum surface of the cool washing liquid. The benzolized oil passes from the washer through a preliminary heater to the still, where the benzol vapors are driven off by a combination of direct and indirect steam. The exit oil is cooled and returned to the benzol washers, while the benzol vapors pass to the condenser and are delivered as light oil. This contains possibly 10 to 15 per cent. toluol, and 45 to 55 per cent. benzol, with small amounts of xylol and naphthaline. From this crude light oil the refined products are obtained by successive distillation and by treatment with the sulphuric acid and alkali. Benzol is usually made as 50 per cent., 90 per cent. and 100 per cent. grades, the percentages referring to the amount that will distill over at 100° C., not to actual purity. For pure benzol the specification requires that 100 per cent. shall distill over within a range of 2° C., within which range shall be the true boiling point of benzol.

Benzol recovery has long been a part of regular condensinghouse practice in Germany. As but little of the German coke-oven gas is used for illuminating purposes, the loss of candlepower due to benzol removal is of little importance, and the loss of heating value only amounts to 3½ to 4½ per cent. The large amounts of benzol so recovered have furnished not only the raw material for that portion of the chemical and dyestuff industry, but also the larger quantity used for gas enrichment, solvents and motor fuel.



Benzol Scrubbers



Benzol Stills

In the United States most of the coke-oven plants that make illuminating gas have until recently found a good market for their benzol by leaving it in the gas to increase its candle-power. But even where the gas was used exclusively for fuel the operators have been slow to install benzol recovery plants because of the limited demand in chemical manufacture, and the low price of gasoline, which now occupies the field as a motor fuel. Up to the time that the European war began, benzol recovery was confined to the plants of one organization, although several others had recently made contracts for benzol installations.

Until the war demands for benzol and toluol arose, their chief uses in this country were as solvents for rubber, in paints and varnishes, paint and varnish removers, grease extraction, imitation leather, and as a basis for making other chemicals, as anilin, benzoic acid, saccharin, etc. With the outbreak of war, a complete change has come over the benzol situation. This country found itself with a growing demand for benzol and toluol derivatives, and at the same time deprived of any outside source of supply.

Toluol, the basis of trinitrotoluol, or T.N.T., now the most fashionable explosive in European war circles, jumped from 30 cents a gallon to $4.50 or upwards. Benzol, in moderate but increasing demand at 25 cents a gallon, suddenly climbed to 80 cents as the basis of synthetic phenol, an essential in making picric acid, and for the manufacture of anilin oil — an important factor in the dyestuff industry.

Accordingly, benzol recovery plants were installed right and left, as rapidly as they could be constructed, and are now in operation or contemplated at nearly all of the by-product coke plants. The estimated figures for the production of light oils from gas washing, so far as they are obtainable, indicate that in 1914 about 6,000,000 gallons were made, and in 1915 about 14,000,000 gallons. For the year 1916, if all the existing works and those expected to come into operation are kept in service, it is expected that the output will exceed 22,000,000 gallons. If we assume that all the metallurgical coke now used was made with benzol recovery, the quantity of refined benzol available would be upwards of 100,000,000 gallons per year. Under such circumstances it would have to be used as a motor fuel, on the same basis as gasoline. The gasoline consumption of the United States is estimated at over 1,000,000,000 gallons, so that even if the present maximum recovery of benzol were made, the total would equal only 10 per cent. of the gasoline now used. To put it differently, on the average consumption of 450 gallons per car per year, the maximum benzol recovery would serve for 222,000 cars. There were two million motor cars licensed in the United States in 1915, over 500,000 more than in 1914. An increase of a million is confidently predicted in 1916, which would take care of four times the maximum benzol production figured above. There is, therefore, ample room for any benzol surplus in immediate prospect. As a motor fuel 90 per cent. benzol is actually 20 to 25 per cent. more efficient per gallon than gasoline, a statement that has been demonstrated by numerous tests on the road, the only difference in operation being a slight adjustment of the carburetor. A mixture of gasoline and benzol can be used without carburetor adjustment, and with both convenience and economy.

## Cyanogen

The gas from the by-product coke ovens or gas retorts usually contains hydrocyanic acid, $HCN$, either in the form of the acid itself or as ammonium cyanid, its presence being usually attributed to the breaking down of ammonia on exposure to heated coke or other heated surfaces. The iron oxide purifier removes a variable amount of cyanogen, $CN$, from the gas, the spent oxide being sometimes purchased from gas works when the cyanogen content justifies it and worked up into yellow prussiate of potash or some equivalent form.

The direct removal of cyanogen from coal gas may be accomplished by any one of several methods, among which are the Bueb, the Davis-Neill, the Feld, etc. The former is perhaps the best known and is in operation at the Astoria works of the Consolidated Gas Company. Its product is an insoluble cyanid sludge, ammonium ferro-ferrocyanid, which is sold on the basis of its cyanid content calculated as yellow prussiate of potash. As present prices for sodium salts are very materially lower than those for potash, the sodium ferrocyanid is made. Owing to the use of a ferrous sulphate solution as the medium for absorbing the cyanogen from the gas, the ferrocyanid is the usual form of recovery.

Until recently there have been few gas works or coke-oven plants recovering cyanids from their gas in this country. Late developments indicate, however, that several new plants are about to begin operations. Under normal market conditions there is probably little profit to be obtained from its recovery from coal gas.

The normal price of prussiate of potash before the war was 9 and 10 cents a pound; owing to war conditions, the present price is about 60 cents.

Estimating the cyanogen in the gas at 1 pound per net ton of coal carbonized, equivalent to about 2.6 pounds of yellow prussiate of potash, the output of a modern plant of 80 by-product ovens would be about 3,000 pounds of prussiate per day or 1,000,000 pounds per year.

The accompanying figures of production and imports indicate that, up to the outbreak of the war, consumption had, if anything, decreased.

Both ferrocyanids are used for the manufacture of the ferricyanids or red prussiates, and in the manufacture of colors, more particularly Prussian Blue, in case-hardening iron, and when purified, in photography and as chemical reagents. It is possible to transform potassium or sodium ferrocyanid into the simple potassium or sodium cyanid, used in the extraction of gold from ore, but so far as is known this transformation is no longer carried on commercially.

## FERROCYANIDS OF POTASSIUM AND SODIUM

(Yellow Prussiates of Potash and Soda)

From Official Sources

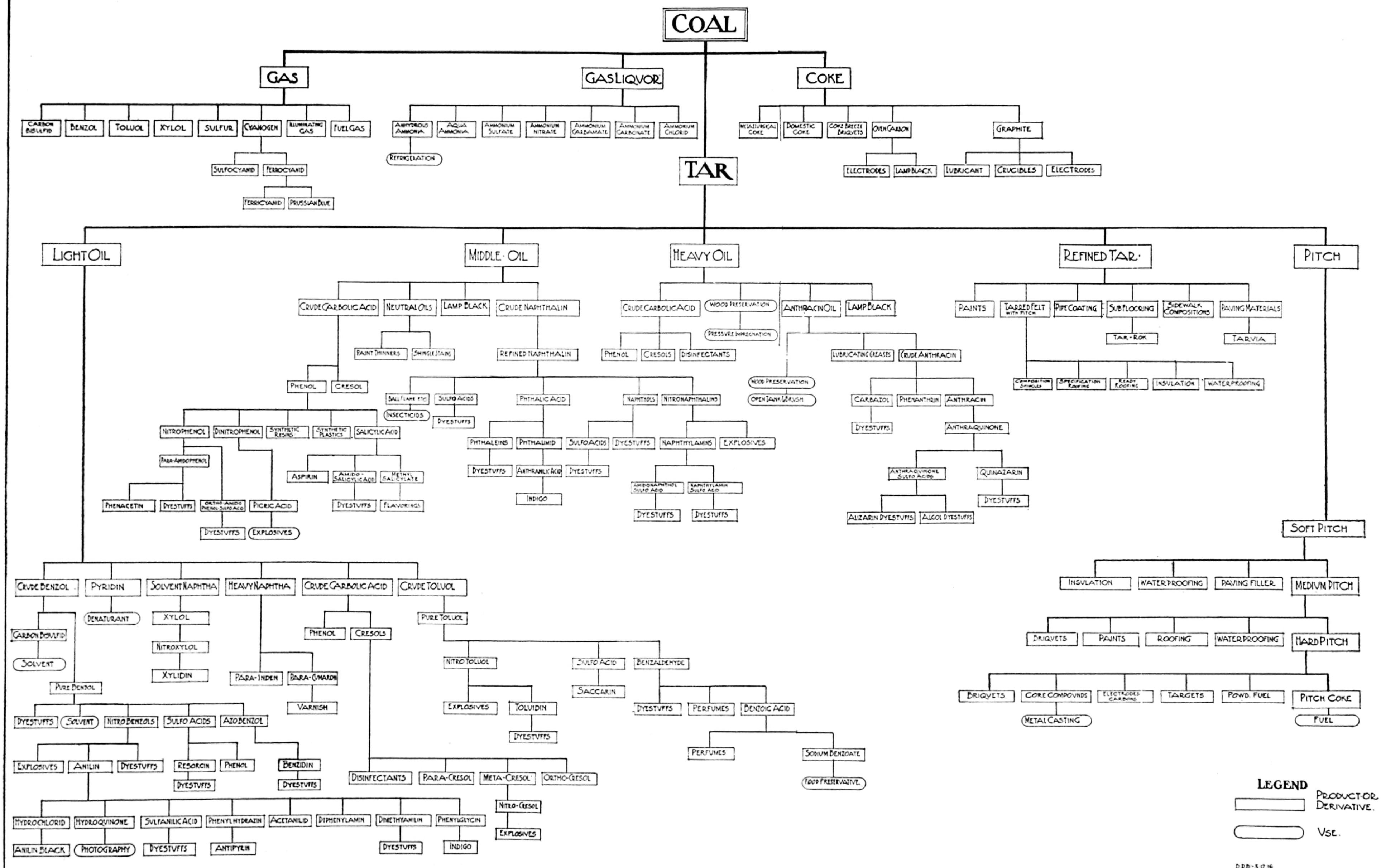
| Year | U. S. Production | | U. S. Imports | | |
|---|---|---|---|---|---|
| | Pounds | Value | Pounds | Value | |
| 1899 | 6,140,406 | $993,514 | 1,809,089 | $204,974 | Sodium ferrocyanid not reported |
| 1900 | 6,165,407 | 994,014 | 1,771,394 | 224,274 | |
| 1903 | ........ | ...... | 2,263,219 | 189,601 | |
| 1904 | 5,027,264 | 683,277 | 3,592,146 | 292,874 | |
| 1907 | .... ... | ..... | 3,602,202 | 324,254 | |
| 1908 | ........ | ...... | 2,535,073 | 217,719 | |
| 1909 | 3,510,208 | 463,983 | 3,716,445 | 302,624 | |
| 1910 | .... | ... | 3,630,711 | 306,591 | |
| 1911 | ..... | | 2,973,974 | 247,555 | |
| 1912 | .... | | 3,719,105 | 293,949 | |
| 1913 | ..... | | 4,699,777 | 427,777 | |
| 1914 | .... | .. | 5,373,937 | 531,154 | |

## Tar

Although the by-product oven is now the most important source of coal-tar, and as we have already stated the broader development of the tar industry awaited the advent of by-product coking, it is important to record that a very substantial industry had arisen, having gas-works tar as its raw material and having roofing materials as its principal products. The coal-tar industry in the United States has passed through two stages and is now entering upon a third epoch.

In the first stage, from 1857 when tar was first distilled at Buffalo by Samuel Warren, until about the beginning of the present century, tar distilling necessarily followed "rule of thumb" methods and progressed in volume of material handled rather in improvement of processes or development of new products and new markets. Great

# DIAGRAM OF THE PRODVCTS DERIVED FROM COAL AND SOME OF THEIR VSES



credit is due the pioneers in the industry for building up during this period a substantial business, particularly in the line of roofing material. They laid the foundations and at the same time outstripped in methods and in volume of business the roofing branch of the tar industry in all European countries. It is also important to note that during this epoch, in the year 1887, the H. W. Jayne Chemical Company, Philadelphia, was established for the production of naphthaline, refined carbolic acid, benzol and nitrobenzol. This was the beginning of the plant that in 1896 became the Chemical Department of The Barrett Company.

The second stage of the industry, comprising roughly the first decade of this century, was a period of engineering development attended by such progress along chemical lines as was necessary to the working out of largely increased production on the one hand, and more exacting demands from consumers on the other hand. The technical specification, as applied to paving, roofing and waterproofing materials, to creosote oil, to crude as well as to refined products, became an important factor. Laboratory control of products was inaugurated, requiring in many instances the working out of new methods for testing and analysis. In 1900 our Company had, outside the chemical department, perhaps four or five chemists in its employ. In 1915 we had over fifty. I need not tell the makers of iron and steel products that during this decade and a half, large producers have had to spend much time and money in co-operative work on standards for methods and materials. The tar industry has been no exception, and our representatives are serving on committees in many scientific and technical societies. During this second stage, development of refined chemical products progressed to such extent as any demand or encouragement for these products existed, and one important product, anilin oil, was established successfully in the face of unfair German competition.

We are now entering into the third stage of development. The searchlight of newspaper and popular magazine attention has been thrown upon coal-tar, although it must be said that this naturally dark subject has not been highly illumined by the rays from that quarter. Coal-tar began to be regarded as a sort of Aladdin's lamp, and for many months it was no uncommon thing to receive inquiries for "50,000 gallons of tar a day" from respectable and previously conservative manufacturers of cast-iron pipe, sewing machines or porcelain bathtubs, who contemplated going into toluol at $4.50 per gallon as a profitable side-line.

The tremendous demand for certain coal derivatives, notably benzol, toluol and phenol for the production of explosives, and the effect of this demand on the erection of benzol recovery plants at existing coke-oven plants, has already been referred to.

Less tangible and less sharply defined, but not less insistent and perhaps even more significant in its relation to the future of the tar industry, is the demand for "intermediates" for the production of synthetic dyes and drugs. In this direction, some substantial progress has already been made and much research work is now in progress.

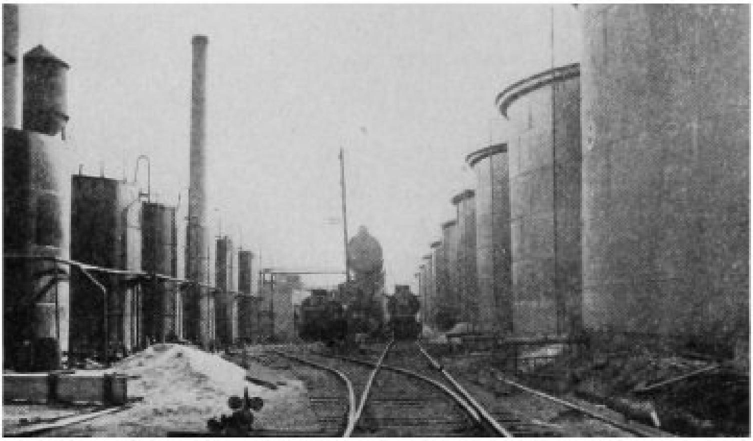
What will be the future of the synthetic dyestuff industry in the United States? This question cannot be answered to-day, but a few observations may be set down.

The manufacture of a limited number of coal-tar colors on a very considerable scale is to-day in progress. Most of these dyes are produced by companies already engaged in the business before the European War commenced. There can be no doubt that these established companies will continue to produce dyes on a larger scale than before, and their requirements for intermediate products, heretofore imported from Germany, will be met by American tar distillers. Many new concerns are starting to make dyes. Some no doubt will fail, and others may continue. The answer to the broader problem: Will the United States become independent of European dyes?, depends upon two things: first, a reasonable measure of tariff protection, including an anti-dumping provision; second, a comprehensive scheme for co-operative effort on the part of the manufacturers. In other words, we cannot, without pulling together, hope to surpass the compact organization existing in Germany. It must be remembered that Germany's great success in coal-tar dyes did not come when she was able to supply her entire home consumption, but when she was able to dominate the world's markets.

Even assuming the greatest possible success in the establishment of permanent chemical industries based on coal-tar derivatives, the importance of this from the standpoint of the tar distiller is greatly over-estimated by all but those having full knowledge of the situation. The portion of tar that can be used in making synthetic dyes and chemicals is only ten per cent. of its whole composition. I cannot over-emphasize the fact that the continued growth of the tar industry, and its ability to take care of the largely increased supplies that are already in sight, depends entirely upon the disposal, at profitable returns, of the two principal items that constitute the great bulk of the product of tar distillation, viz.: pitch and creosote oil.

In attempting a brief outline of the tar industry as now practiced in this country, it is necessary at the outset to refer to the several kinds of coal-tar with which the distillers have to deal. The total United States production of coal-tar in 1915 was approximately 180,000,000 gallons, of which 140,000,000 was from by-product ovens and 40,000,000 from gas works. The production of gas-works tar has not materially increased during recent years, on account of the popularity of water-gas. The latter has perhaps reached or passed its zenith. and the vertical retort is coming into favor. We have, therefore, three distinct types of tar: first, that from horizontal gas retorts, which may be expected to gradually diminish in quantity; second, that from by-product ovens, which it is estimated will reach 250,000,000 gallons in 1917; and third, a much smaller but gradually increasing amount of vertical retort tar.

These three kinds of tar differ widely in characteristics. The difference may be roughly expressed by saying that horizontal or old-fashioned gas works tar is the heaviest, most viscous and contains a lower percentage of oils and more pitch. It also contains the highest percentage of suspended or "free" carbon—the portion of tar insoluble in benzol. Coke-oven tar occupies an intermediate posi-



Crude Tar Storage Tanks

Spreading Tarvia on Wearing Course

Mixing and Spreading Pitch and Sand Filler on Belgian Block Pavements tion. It is usually lighter and contains more oils and less pitch than horizontal gas-works tar. Its free carbon content is lower. Vertical retort gas-works tar is lighter, less viscous and contains more oils and less pitch than coke-oven tar, and is also lower in suspended carbon.

These tars differ also in chemical constituents as well as in physical characteristics. All contain benzol and its homologues, phenols and cresols, naphthaline, anthracine and bases of the pyridine type, but in widely varying degree.

Wide variation in physical and chemical composition also occurs between tars produced in different types of coke-ovens; and in any given type of oven or retort a change in the time or temperature of coking is reflected by changes in the character of the tar. In fact, the composition and properties of tar depend as much upon conditions of carbonization as upon the kind of coal from which it is derived.

In the following table are shown analyses of tars from the several types of by-product coke-oven and, for comparison, a number of gas-works tars, including the old and new type of horizontal retorts as well as inclined and vertical retorts.

| Tests | Coke-Oven Tars | | | Gas-Works Tars | | | |
|---|---|---|---|---|---|---|---|
| | No. 1 Type A | No. 2 Type B | No. 3 Type C | No. 4 Horizontal (Old) | No. 5 Horizontal (New) | No. 6 Inclined Retort | No. 7 Vertical Retort |
| Specific gravity at 60° F. | 1.178 | 1.173 | 1.187 | 1.254 | 1.218 | 1.198 | 1.154 |
| Water, per cent. | 1.0 | 1.3 | 2.3 | 2.8 | 5.2 | 3.3 | 3.6 |
| Free carbon (insoluble in benzol) per cent. by weight | 7.6 | 4.3 | 10.4 | 29.8 | 21.6 | 19.9 | 3.7 |
| Viscosity, Engler at 212° F., 100 cc. (seconds) | 76 | 30 | 37 | 273 | 103 | 89 | 30 |
| Light oil (to 400° F.) per cent. (crude benzol, toluol, solvents, etc.) | 5.3 | 1.8 | 1.4 | 2.0 | 3.3 | 4.1 | 3.7 |
| 100% Middle and creosote oil (to soft pitch), per cent. | 20.8 | 35.0 | 24.0 | 18.7 | 21.1 | 22.1 | 30.2 |
| Soft pitch (including loss), per cent. | 73.9 | 63.2 | 74.6 | 79.3 | 75.6 | 73.8 | 61.2 |
| Tar acids (phenols, cresols, etc.), per cent. on tar | 5.0 | 1.1 | 0.34 | 1.6 | 2.9 | 5.2 | 7.2 |

The effect of different conditions of carbonization on tars from the same coal is shown by comparing tar No. 5 with tar No. 6, and by comparing tar No. 6 with tar No. 7.

This difference in tars extends not only to the yield of refined products, such as benzol, phenol and naphthaline, but materially influences the value of the heavy oils and pitch. In order to meet specifications controlling the sale of products, it is generally necessary to combine two or more tars before distilling. Thus the problems of the tar distiller are rendered more complex by each new type of gas-retort or coke-oven that is introduced, and by each change in coking time or temperature at existing plants.

To cite a definite instance: A few years ago there was a general tendency to reduce the time of coking, with consequent increase of oven heats. This resulted in depriving a number of important tars of practically their entire content of tar acids. These bodies are the source of carbolic acid and of all the disinfecting or antiseptic compounds derived from tar. They also play an important part in the preservative value of creosote oil used for treating timbers. The importance of this to the tar distiller can be readily appreciated.

The quality of tar may never be the controlling factor in deciding the type of oven or gas-retort, or even in determining the heats and time of coking; nevertheless, some consideration of this phase may be worthy of the attention of coke-oven operators.

The reduction or disappearance of valuable constituents means, of course, that the tar is really worth less than before. In the past, such conditions have not influenced the price of tar. Doubtless the time will come when the real value of each tar, based on its composition, will affect the price.

There are at present about fifty distilling plants located in the United States. Many are naturally in the large cities, where the greatest demand exists for the road surfacing materials, paving pitch and roofing, that constitute the largest items of tonnage. Another reason for having tar-distilling plants located in large cities is the exacting service required in the delivery of road tars and paving pitch, in which hundreds of motor-driven tank trucks are engaged. Hence, freights from gas or coke-oven works are often 25 to 40 per cent. of the value of the tar at shipping point.

The transportation, handling through plant, dehydration and mechanical features of tar distilling would require a separate paper. Over 1,200 tank cars are now engaged in the transportation of tar and tar products, and on the Atlantic Coast there are about 20 barges of 25,000 to 300,000 gallons capacity. At one of the larger plants there are fifty storage tanks of 1,000 to 20,000 barrels capacity.

There are few if any proper uses for crude tar, both by reason of its varying character and because the presence of water and ammonia is objectionable in practically all cases. However, crude tar can be successfully burned in the same manner as heavy petroleum distillates and residues. At this point it may be well to say that tar itself as well as any of the crude fractions obtained from it, can replace petroleum fuel oils in steam plants, metallurgical furnaces, etc., whenever the relative value of the products makes burning a good economic policy. Tar oils have

Digging Out Finished Lumps of Naphthaline

been successfully used in engines of the Diesel type in this country and abroad. In Germany tar oils are apparently the preferred fuel for these engines. Coke-oven tars average about 16,500 B.T.U. value, and the heavy distillates 17,000.

The first step in tar distillation is dehydration, and this is one of the most expensive and troublesome. Dehydration may be accomplished in the tar still, but more approved practice favors heating in thin films under partial vacuum. Special apparatus for continuous dehydration is now in use at several works in this country.

The tar stills in general use are of the horizontal type. European practice favors the vertical type still, and it is used to some extent in the United States. Continuous distillation has been tried in Europe and in this country with varying degrees of success, but encouraging results are lately being obtained here in this direction. Further development in designing apparatus for distillation will engage the attention of the engineers in this industry as in the larger field of petroleum distillation, where new apparatus and processes are being patented almost daily.

The horizontal still is of cylindrical form, set in brick, and usually has a protecting arch under the still bottom. Gaseous, liquid or solid fuel can be readily adapted for firing. Steam or air agitation is generally used, and sometimes vacuum may be employed to advantage.

The vapors are condensed in a long worm, usually arranged as a rectangular coil in an open tank. Means for heating the condensing water must be provided. The condensate is collected in small tanks, which provide means for observation and measurement of the oils. From these the several fractions are discharged into receiving tanks, and thence pumped to storage.

In running to pitch, three to five fractions are taken, depending on the requirements for the pitch and on the desired uses of the oils. These fractions are often as follows:

1. Light oil or crude naphtha.
2. Carbolic or middle oil.
3. Heavy or creosote oil.
4. Anthracine oil.
5. Residue, distilled tar or pitch.

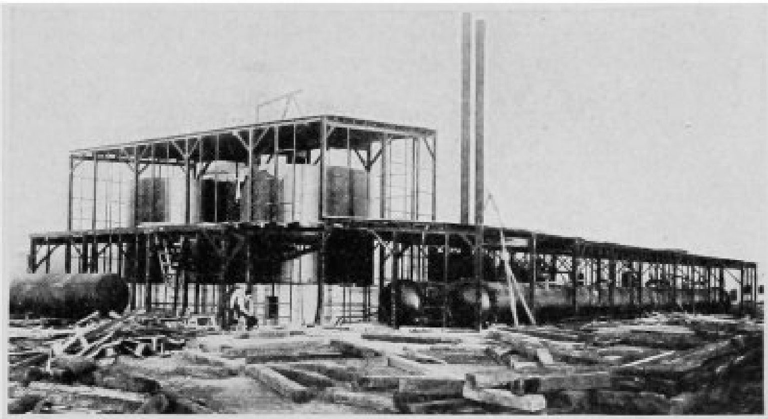
1—*Light Oil:* This fraction comprises the entire distillate lighter than water, up to a vapor temperature of about 400° F., and from it, by redistilling and washing the products, benzol and toluol may sometimes be obtained in small amounts. Solvent naphtha and heavy naphtha, and small amounts of phenol and cresols, are derived from light oil. This light oil fraction varies from less than 1 per cent. to 3 or 4 per cent. Coke-oven tars are usually very deficient in light oil compared with gas-works tars.

2—*Carbolic or Middle Oil:* This varies from 5 to 15 per cent., being usually cut at such a point as will include most of the tar acids and naphthaline. The oil is cooled to remove naphthaline and may be sold as a crude disinfectant, or the tar acids may be extracted by treatment with caustic soda and liberated by sulphuric acid or carbon dioxide. From the crude tar acids, phenol and cresols can be isolated. The phenol (carbolic acid) content of tar seldom exceeds 0.25 per cent. Naphthaline, which can be recovered from this fraction and the succeeding one, may amount to 5 to 7 per cent.

Certain fractions of the middle oil have lately found use in ore concentration by the flotation process. This is a new and comparatively unexplored field from the oil producers' standpoint, though almost every type of mineral and vegetable oil is being experimented with. The tar oils that have so far met with most favor are liquid fractions of comparatively high tar acid content.

3—*Creosote Oil:* This often comprises the fraction distilling from the middle oil to the end of the distillation. It is sometimes cooled for removal of naphthaline. It contains some cresols, which may be removed by means similar to those employed in treating fraction 2. This fraction is taken largely for wood preservation and has to be run so as to meet the varying requirements of that industry.

The creosote oil fraction, depending on the hardness of pitch made, varies from 15 to 35 per cent. of the tar. Without the use of creosote oil for wood preservation, it is doubtful if the industry of tar distilling could have been successful. The amount of oil used for treating timber annually has increased from 50 million gallons in 1908 to 100 million gallons in 1914. Of this, nearly two-thirds has been imported from Europe; but for three or four years past the relative consumption of domestic creosote has been increasing. About 80 per cent. of the creosote oil used in treating timber goes to preserve railroad crossties. Only 30 per cent. of the ties used per year are treated, although the economic value of treated ties is acknowledged. Piling



Timber Creosoting Plant

takes about 5 per cent., paving blocks 5 per cent. and construction timber 7 per cent. of the oil used. Obviously, this field is capable of great development. The importation of creosote oil from Europe and the conservative estimate placed by engineers on increased life of timber when treated, tend to prevent the price of creosote from exceeding a pretty definite level.

The requirements of the wood-preserving industry are often very exacting as to the tests that the oil has to meet, and tars have to be carefully studied by the distiller in order to produce creosote oils that meet the requirements of the consumers.

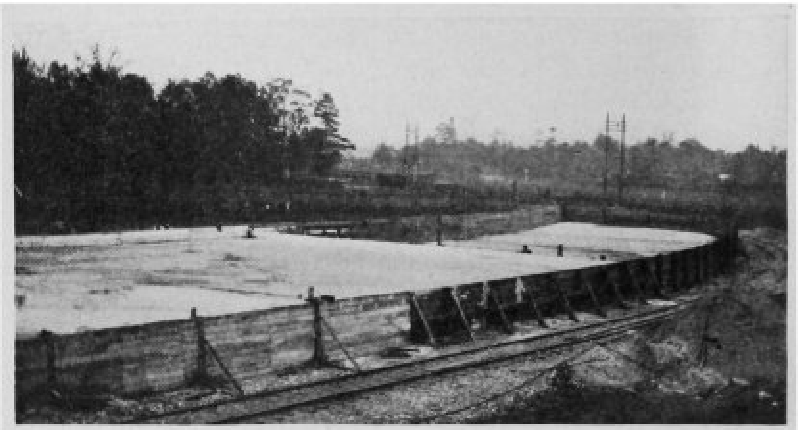
4—*Anthracine Oil:* This yields anthracine, which after purifying becomes the source of alizarin, an important product in dyestuff manufacture. Pure anthracine may amount to 0.2 per cent. of tar. In the past there has not been any demand for anthracine in the United States, except for a brief period twenty years ago, when some crude anthracine was exported. The production of anthracine for domestic alizarin manufacture is now practically assured. Unless a separate heavy fraction is desired, fractions (3) and (4) are often taken as one.

5—*Distilled Tar or Pitch:* The residue left in the still varies (depending on the amount of oil distilled off) from a viscous, semi-solid material to pitch hard enough for grinding. The point for stopping distillation is often determined by the consistency of pitch desired. Pitch comprises from 50 to 80 per cent. of the tar, depending on the character of tar and the hardness of the pitch.

Its uses are varied. Long experience in some fields and scientific research in others has determined what physical and chemical properties are desirable in pitches for each important use. In order to produce pitch meeting these requirements, the tar distiller has especially to study, select and combine tars of different quality.

It is in the development of soft and medium pitches that the American tar distiller has far surpassed the achievements of his European contemporaries. We have extended the use of pitch into much wider fields, and in addition to that we have devoted infinitely more care to the production of pitches meeting the special requirements of each purpose. Large sums of money have been expended, not only on advertising such uses for pitch as the specification roof and road tar, but on the technical development of these products, and on educating the architects and engineers upon whose decision the choice of materials depends. It was frankly admitted by the delegates from England, France and Germany at the International Road Congress in London in 1913, that in technical work on the use of bituminous materials in road construction, American chemists and engineers were far in the lead.

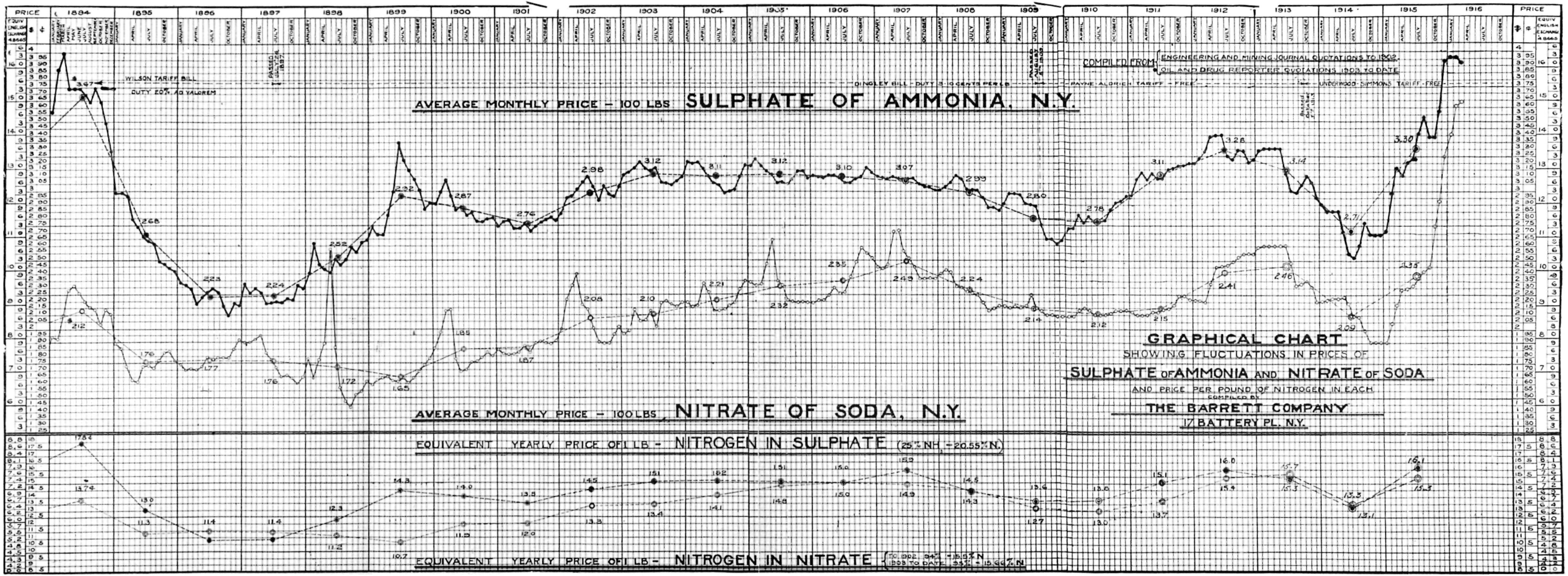
Mention of the uses of distilled tars must include saturant for roofing felts, coatings for iron and steel pipes, surface treatment of roads by hot or cold application. The soft pitches are used as a filler in block pavements and for waterproofing walls below grade. Medium pitches for roofing, saturating fibrous materials, and as a binder in briquetting fuel. Harder pitches go into the manufacture of electric carbons, sealing and insulating compounds, core compounds, foundry facings and clay pigeons.



"Bay" of Hard Pitch

Pitch for most of the foregoing purposes has to be run within very closely controlled limits of consistency, usually specified by a "melting-point test," which has come to be widely used.

The tremendous increase in the output of coal-tar from new and enlarged by-product coke-oven plants has made it imperative to find new uses for pitch. One rather promising outlet for very hard pitch is as pulverized fuel, where, in some cases, for metallurgical work, it can compete advantageously with fuel oil. Hard pitch normally contains less than ½ of 1 per cent. ash and only about ⅓ to ½ of 1 per cent. sulphur. For these reasons it can be used where pulverized coal would be out of the question on account of much higher ash and sulphur content. Work on another pitch outlet was started by our engineers nearly a year and a half ago, in the line of mixing with coke breeze or non-coking coals to supply the cementing properties necessary for satisfactory coking. It is very interesting to note, by frequent references in the English gas journals within the past few months, that the surplus of pitch in England has caused experiments to be made there along this line.


GRAPHICAL CHART
SHOWING FLUCTUATIONS IN PRICES OF
SULPHATE OF AMMONIA AND NITRATE OF SODA
AND PRICE PER POUND OF NITROGEN IN EACH
COMPILED BY
THE BARRETT COMPANY
17 BATTERY PL. N.Y.
AVERAGE MONTHLY PRICE - 100 LBS SULPHATE OF AMMONIA, N.Y.
AVERAGE MONTHLY PRICE - 100 LBS NITRATE OF SODA, N.Y.
EQUIVALENT YEARLY PRICE OF 1 LB - NITROGEN IN SULPHATE (25% NH₃ - 20.55% N)
EQUIVALENT YEARLY PRICE OF 1 LB - NITROGEN IN NITRATE
COMPILED FROM ENGINEERING AND MINING JOURNAL QUOTATIONS TO 1902
OIL AND DRUG REPORTER QUOTATIONS 1903 TO DATE
WILSON TARIFF BILL
DUTY 20% AD VALOREM
DINGLEY BILL - DUTY 3-10 CENTS PER LB
PAYNE ALDRICH TARIFF - FREE
UNDERWOOD-SIMMONS TARIFF - FREE
PRICE
1894
1895
1896
1897
1898
1899
1900
1901
1902
1903
1904
1905
1906
1907
1908
1909
1910
1911
1912
1913
1914
1915
1916

It is significant that an editorial in a recent issue of the *Gas World* (London), in which this problem was discussed, was entitled "The Burden of Pitch." This, then, sums up the tar problem: 8 to 10 per cent. of relatively high-priced refined products, of which our growing synthetic chemical industries will absorb a proportion yet to be determined, and which we will market in competition with European products; 25 to 30 per cent. of heavy oils (creosote, etc.), for which a ready market exists, with definite price limits; and 50 to 70 per cent. of "The Burden of Pitch."

## Conclusions

(1) The by-product coke-oven industry is entering a period of rapid development. The by-product industries must expand to keep pace with it.

(2) This expansion must take place on lines adapted to our own conditions and to the large volume of materials involved. We may learn from foreign experience, but we must not be content to copy their methods.

(3) The great outlet for ammonia is in agriculture, in which direction there seems ample room for development, though it may come slowly and need fostering.

(4) The future field for gas is in an increased use for general city and industrial service, made possible by more widely extended distribution systems and by replacement of natural gas shortages, also in generating power by means of gas engines.

(5) There is an ample supply of benzol, toluol and homologues now recovered for our present domestic consumption of solvents, chemical derivatives and explosives. After the present abnormal conditions are past, the surplus will find ready use as motor fuel.

(6) New uses for tar must be found for an increased production of 100 per cent. within two or three years, unless it is to be used as fuel. Refined derivatives, including phenol, cresols, naphthaline and intermediates, will be produced in sufficient amount to meet the demands of the color, drug and chemical manufacturers. The degree of

development in this direction depends on the action of the Government with regard to protective measures and upon the co-operative effort of the industries involved.

The increased amount of creosote oil will tend to keep the price at such a level that European producers will seek to find outlets at home for their surplus.

The outlook for pitch is exceedingly problematical. Although new uses may be confidently looked for, it seems inevitable that a large proportion of pitch must find its outlet in the fuel field.

(7) The by-product coke-oven, besides being an integral part of our steel industries, is our main source of benzol, toluol and phenol for munitions and the wide range of chemicals of scarcely less importance. It is also our only operating native source of combined nitrogen for nitric acid, and the only possible one outside of the costly processes for fixing atmospheric nitrogen. These facts should be recognized by the Government and co-operation for national defense should be established.

To illustrate what I have been saying, we will now have some moving pictures. (Applause.)

(Some of these pictures are reproduced herewith.)

CHAIRMAN GARY: We shall now have the pleasure of hearing a brief discussion of Mr. Childs' paper by Mr. W. H. Blauvelt, of Syracuse, New York.

# BY-PRODUCTS RECOVERED IN THE MANUFACTURE OF COKE

Discussion by William Hutton Blauvelt

Consulting Engineer, Semet-Solvay Company, Syracuse, N. Y.

The development of the retort oven, or the by-product oven as it is usually called in this country, has shown that it has a number of advantages over the bee-hive oven in the production of metallurgical coke. Some of these are: A greater regularity of the product, a better physical structure and a better control of quality, owing to the ease with which coals are mixed and the ability to regulate the oven heats to suit the coal used, higher yields of coke from a given coal, etc. The iron-master has become familiar with all these advantages, and of late years by-product coke has taken a first place in the foundry trade and is rapidly obtaining the same reputation for blast furnace use. But the by-products are still rather an uncertain quantity in the minds of many users of by-product coke, and even to some of those who own by-product plants, notwithstanding the fact that by-product ovens are already in operation or in course of construction at so many of our prominent iron and steel plants. So Mr. Childs' paper is a very timely one, and I am sure it will have an important place in the Transactions of the Institute.

Mr. Childs has covered his subject so thoroughly that he has left little for those coming after him, but I want to emphasize a few points of interest to the members of the Institute.

## Ammonia

As Mr. Childs has pointed out, ammonia is perhaps the most important by-product, both on account of its value per ton of coke produced, and on account of its importance in the industries; and a study of its market possibilities is important to every coke maker. America has been very prodigal of the fertility of its virgin soil, but our yields per acre have already fallen much below those of Europe, and the day of the general use of artificial fertilizers is rapidly drawing closer. Mr. Childs has mentioned a use of ammonia, namely, the manufacture of nitric acid which war conditions have brought forcibly to our attention. He says very truly that sulphate of ammonia is at present the only operating source of combined nitrogen in this country. As the by-product oven replaces the bee-hive in the manufacture of coke, the supply of sulphate of ammonia will increase accordingly, and it may before many years be much more than the 375,000 tons which Mr. Childs gives as the probable production of next year. This amount of sulphate is equivalent to about 587,000 tons of nitric acid of ordinary 40° strength.

Even in the emergency of war conditions a certain considerable amount of ammonia must be retained for refrigerating purposes for preserving our food supply. One of the leading authorities in refrigeration work estimates the annual consumption for this purpose to be the equivalent of 14,000 tons of sulphate. It is entirely possible, in case of emergency, to withdraw temporarily the sulphate of ammonia ordinarily used for agricultural purposes. It is clear that we have here potentially a very large supply of available nitric acid. Before any large investments are made for plants to produce nitric acid by fixation from the atmosphere, it would seem important that thorough investigation of the relation between the possible requirements and the available supply of nitric acid from present native sources should be made by competent authorities. Such investigation could perhaps best be made by the War Department, with the full co-operation and assistance of the by-product coke producers of the country.

## Surplus Gas

While most of the by-products from coke-making may be sold in the open market as recovered at the condensing plant, the surplus gas must, in general, be utilized at or near the point of production, since the cost of delivery to any distant point reduces seriously its value at the ovens. Often the most satisfactory customer for the gas is the owner's own works, since, for example, a contract for delivering gas for use in a municipality entails responsibility for continuous service, and the necessity for meeting the wide seasonal variations in consumption is often embarrassing, especially to a plant that is operated for the purpose of supplying the coke needs of a blast-furnace plant. When a blast furnace goes out for re-lining, or on account of commercial conditions, with a consequent reduction of coke requirements amounting to perhaps 50 per cent., or even 100 per cent., the contract for gas to be delivered to a city is a heavy burden. Moreover, candle-power requirements are still maintained in many of our states for all gas sold for domestic purposes, notwithstanding the almost entire disappearance of the flat-flame burner, which is the only place where candle-power has any real value. The maintenance of 16 or 18 candle-power in oven gas through all the varying conditions of temperature and pressure of domestic distribution requires special preparation of the gas and a constant study of service conditions. Probably the prevalence of water gas in America has caused us to lag behind Europe in the abolition of candle-power requirements; but, although our legislatures move slowly, a number of states have already either much reduced or abolished candle-power specifications, so that we may have hope of their general disappearance.

Utilization of coke-oven gas in steel works has developed rapidly in the last few years. At first it was burned largely under boilers, where its value was very small, as it replaced coal or coke breeze, and the calorific energy in coal is utilized more efficiently, and at less cost, in boilers than in almost any other manufacturing operation. As the supply became more reliable the gas came into use for soaking pits and heating furnaces; and within the last two years it has been thoroughly worked out for the open-hearth furnace, so that there are now at least three well-known plants where oven-gas is used alone in open-hearth furnaces with entire satisfaction, and with a larger daily tonnage of product than with the usual producer gas fuel. In cases where the gas has been stripped of its benzol, it has been found advisable to replace the luminous quality of the gas with a small amount of tar sprayed into the gas. This restores perfectly the radiating qualities of the flame and makes even the stripped gas an entirely satisfactory open-hearth fuel. Of course, on account of its methane content, oven-gas is not preheated for steel furnace work. Oven-gas is also used for open-hearth work mixed with producer gas; and in England and on the Continent a good deal of successful work has been done in using a combination of coke-oven and blast-furnace gas both in the steel furnaces and for gas engines. This mixture of gases in controlled percentages makes it practicable to maintain a very uniform calorific value, which is especially advantageous in gas-engine work. I have not noted any reports of the successful use of coke-oven gas alone in open-hearth furnaces in Europe, although many experiments have been made, mostly with mixed gases.

## Benzol

No product of the distillation of coal has attracted as much attention of late as benzol and its homologues. The public has received a large mass of misinformation, especially through certain articles in the public press, regarding the production in the United States of colors and dyes. These publications have given very many people the impression that the reason for our having no dye industry was the lack of raw materials, probably because no one investigated the subject. Even our statisticians seem to have entirely overlooked the fact that this country has been for years producing millions of gallons of benzol and the other raw materials available for the dye and color industry. Careful estimates from the best data obtainable show that in the year 1914, for example, before any of the recent large construction of benzol-recovery plants was in operation, there was produced an amount of benzol quite sufficient, if it had all been applied to these purposes, to furnish all the colors and dyes used in America which have benzol as their source; and our tar distillers have stood ready to furnish all the naphthalene, anthracene and other materials besides benzol that are employed in making colors, at very moderate prices. For years, for lack of a better market, millions of gallons of benzol have been employed in enriching illuminating gas, when the enrichment could have been easily obtained from other sources; and there was practically no market for naphthalene and anthracene for color-making purposes. Of course, with the very large increase in production of benzol from plants recently started or in course of construction, it is clear that there is ample raw material for any possible expansion of color-making in this country; and it is clear that after war conditions have disappeared a large amount of benzol will go into motor fuel. The fact that a large percentage of the total benzol production will be obtained from the plants controlled by members of this Institute makes this portion of Mr. Childs' paper of live interest to us all. It is satisfactory to note that, while the ignorance regarding the supply of raw materials for an American color and dye industry was almost universal at the opening of the war, those whose business it is to know have in most cases become fully alive to the situation.

To show the ignorance on such subjects, in a town down South there is a plant in which benzol has been recovered for some twelve years. When Mr. Edison's great inventions were published in the papers, covering his manufacture of benzol and carbolic acid, the Chamber of Commerce in this town held a meeting and voted funds to a committee to come North, meet Mr. Edison, and see if it was not practicable to introduce this manufacture into the coke-oven plant which was in the suburbs of their town. Fortunately, however, before the committee had departed and spent the money, they found out that this manufacture had been in progress already for twelve years. That is not a peculiar condition at all, but it just illustrates the lack of knowledge that the public has had on all these general subjects.

It is now easy to obtain accurate information regarding the possibilities of the industry and the conditions which must be met. Our members have one responsibility, however, which must not be overlooked. Proper legislation is necessary to prevent unfair competition from the other side of the water, and to protect the large investments already made here to secure a color industry to this country by the utilization of these important by-products, thereby preventing the paralysis of our great textile industries. And it is the duty of each of us to see that our representatives in Congress are fully informed of our views on this subject. In the dye-making countries of Europe it is recognized that combination, not competition, is the life of trade; and American manufacturers who combine their brains and resources to carry out the development of a great industry must not be regarded as criminals under our law, while in European countries they are encouraged, and, in fact, are almost compelled to combine for the best good of the industry and the nation. American manufacturers have the money and the will, and American chemists the brains and the knowledge, and while the great color industry cannot be developed in America over night, we have all the factors here that are required for success, if properly combined and fostered. The color industry itself is represented by relatively small values. Some one has said that the total value of all dyes and colors used annually in the United States is less than the amount paid for candy sold by the Woolworth stores. But some of the most important industries in this country are vitally dependent upon artificial colors. From a Government report we learn that there are over 14,000 establishments which are absolutely dependent upon dyes and colors. These establishments employ about 1,400,000 employees, and over $3,000,000,000 capital. It is estimated that over 2,000,000 working men and women are occupied in industries which are directly dependent upon the use of artificial colors.

Referring again to the use of benzol for motor fuel, Mr. Childs has shown the probability of a large amount of benzol being available for this purpose. Considerable propaganda work will, however, have to be done before this fuel can come into general use for motors, since it is hard to convince the general public of the advantage of even the slightest change in any practice to which they have been accustomed. One producer of benzol has been experimenting for six or eight years on its use for motor fuel, with very satisfactory results. I have operated my own car on it regularly for about four years and find it distinctly superior to gasoline. Automobile makers are recognizing the necessity of improving or modifying their carburetors to permit the satisfactory use of a wider range of petroleum distillates than has heretofore been possible, on account of the enormous increase in the demand for motor fuel as compared with the gasoline supply, and this fact will doubtless make it easier to develop the general use of benzol for motors. At present a slight readjustment of the air supply is necessary on most carburetors in changing from gasoline to benzol.

### Pitch

Under the phrase "the burden of pitch," Mr. Childs refers to the difficulty of providing a suitable market for the large amount of pitch that will be produced from the coal tar obtained from the by-product oven plants when the present period of expansion has brought the product up to 250,000,000 gallons or more per annum. Considerable experimenting has been done both in this country and in England looking to the mixing of hard pitch with coal with a view to converting it into coke. While these experiments have not been brought to a conclusion, they seem to promise success. So far as I know, no coke containing pitch as part of the coal mixture has as yet been tried in the blast furnace, but the indications are that all the pitch produced from the tar made by the coking plants may be mixed with the coal without disadvantage to the coke, and in the case of many coals, with material benefit. If these indications are confirmed by further tests, it will only remain to show that the pitch can be used at an appropriate price in order to remove "the burden of pitch" as an obstacle in the path of tar distillation.

Mr. Childs' paper shows very clearly the importance of the by-products to the manufacturer of coke and to the industries of our nation. As we obtain a clearer knowledge of the value of the returns from the by-products, and their relation to the cost of making coke, we shall realize more fully the importance of these products to the members of our Institute. With the rising costs of coal and labor, the owner of the coke plant must study most carefully the returns from these by-products and be ready to assist in developing their best markets in order to continue to realize the lowest possible costs of coke. (Applause.)

Chairman Gary: Opportunity is now afforded for informal discussion of Mr. Childs' paper. (After a pause): There being no further discussion, we will now have the pleasure of listening to a paper on the Electric Furnace in Steel Manufacture, by Dr. John A. Mathews, President, Halcomb Steel Company, Syracuse, New York.

# THE ELECTRIC FURNACE IN STEEL MANUFACTURE.

JOHN A. MATHEWS

President, Halcomb Steel Company, Syracuse, N. Y.

It may be a surprise to many to learn how nearly the commercial introduction of electric steel coincides with the beginning of the twentieth century. In fact, it antedates the new century by three days, according to Dr. H. Goldschmidt, who is my authority for stating that on December 28, 1900, the first carload of electric steel was delivered by Heroult to Messrs. Schneider & Co., Creusot, France. The shipment consisted of nearly 9,000 kilos of steel bars.

In the last years of the nineteenth century much experimenting with electric furnaces was going on and many processes were perfected and patented all over the industrial world. Sales of the product may have been made earlier than the one recorded, either by Heroult or the other inventors, but they have not been made a matter of public record. Kjellin's furnace at Gysinge was first operated in March, 1900, while Captain Stassano, Girod, Harmet, Keller and others were very active during the closing years of the nineteenth century.

## SIR WILLIAM SIEMENS, PIONEER.

The different processes have been described so often that I will not take up your time by repetition of these details. Electro-metallurgy may be said to date from Sir William Siemens' experiments. He constructed and operated an arc furnace and patented it in 1878. In this furnace he melted iron, steel and other metals, and his remarks before the Society of Telegraph Engineers in 1880 are truly prophetic and are worth recalling because we have of late seen his prophesy fulfilled. After some theoretical consideration of the power required to melt steel and a comparison of the same with the very expensive coke melting furnaces used in Sheffield, which require from two and one-half to three tons of coke per ton of product, he concluded that

"the electric furnace may be, therefore, considered as being more economical than the ordinary air furnace and would, barring some incidental losses not included in the calculation, be, as regards economy of fuel, nearly equal to the regenerative gas furnace. It has, however, the following advantages in its favor:

1st. That the degree of temperature is theoretically unlimited.

2nd. That fusion is effected in a perfectly neutral atmosphere.

3rd. That the operation can be carried on in a laboratory without much preparation, and under the eye of the operator.

4th. That the limit of heat practically attainable with the use of ordinary refractory materials is very high, because in the electric furnace the fusing material is at a higher temperature than the crucible, whereas in ordinary fusion the temperature of the crucible exceeds that of the material fused within it."

## Slow Development of Electro-Metallurgy.

Notwithstanding Siemens' words, electro-metallurgy did not develop along iron and steel lines, but progress was made in other branches of the art, and to this pioneer work Americans have contributed richly. We need only recall the work of Cowles Brothers in 1885 and Hall in 1886 on aluminum; Colby in 1887 invented the electric induction furnace; Acheson produced carborundum in 1893 and artificial graphite in 1895; Willson in 1893 produced calcium carbide; and the manufacture of ferro-alloys, especially of silicon and chromium, early received attention in the United States. I mention these early achievements because they make more conspicuous our neglect of electric furnaces for steel making.

European engineers were working along similar lines to those that engaged the American workers from 1885, but I will not presume to discuss questions of priority which have been in dispute between the geniuses of our own and other nations. The rapid rise and decline of the carbide industry in Europe had something to do with directing the attention of European inventors to the problem of utilizing existing hydro-electric plants no longer needed for carbide manufacture. Smelting and refining of ores and alloys followed, and France, Italy and Sweden produced a group of inventors whose brilliant achievements have merited recognition from the whole iron and steel trade. To Germany and Austria belongs the credit of having first adopted commercially the inventions of others; and to the United States belongs the somewhat doubtful honor of having overtaken and passed all other nations in the introduction of electric steel furnaces. England has been particularly backward in introducing electric furnaces to replace her very expensive crucible steel process, although rapid changes have taken place there within the past two years. It seems as though the too-enthusiastic claims of the inventors and their representatives in the early days had injured their cause in England, and their conservatism in adopting electric methods seems to be reflected in the remark of Sir Robert Hadfield, made some ten years ago, that "unfortunately there seems to be fixed in the minds of some of those exploiting such processes the idea that all steel now made is radically of bad quality."

In sharp contrast with the initial backwardness of both England and the United States is the example of our northern neighbor. The Canadian Government early recognized the possibilities of electric smelting, and as early as 1903, under instructions from the Minister of the Interior, Dr. Eugene Haanel—an erstwhile Syracusan, by the way—organized the commission which investigated the then state of the art in Europe, and made its valuable report in 1904. The work of the commission was followed up in Canada by direct experiments upon smelting many of their native ores.

### The Halcomb Steel Company, American Pioneer.

The Halcomb Steel Company first made electric steel on a commercial scale in the Western Hemisphere, and we have just entered upon our second decade of electric steel production. To be exact, our furnace was first operated on April 5, 1906, and we are beginning our second decade with the original furnace still in operation, while a three-ton Snyder furnace—a purely American type—was installed during 1915, and a six-ton Heroult furnace is now being erected. We take considerable pride in this priority of adoption, and it is a source of satisfaction to have witnessed the progress of the process at home and abroad and to have seen the judgment of the founders of the Halcomb Steel Company abundantly confirmed by large numbers of steel makers the world over, even by the big brother of us all, the United States Steel Corporation.

Five years after our installation was made there were only three other furnaces in the United States in steel works. The second installation was at the Firth-Sterling Steel Company, and the third and fourth were by the Illinois Steel Company and by the American Steel & Wire Company at Worcester. The last two furnaces were of fifteen tons capacity and, at the time, were the largest that had been built. Furnaces have now been built of from twenty to thirty tons capacity.

### Types and Uses of Electric Furnaces.

In the earliest types of furnaces almost every system of utilizing the electric current for heating was employed, and no strictly new types have been developed since, although many mechanical and electrical modifications have been made. Many of these bear new names although they do not constitute radically new processes. The types electrically considered are: (a) Pure arc furnaces, illustrated by the Stassano and, more recently, Rennerfelt processes; (b) arc-resistance furnaces, illustrated by the Heroult and the later Girod, Gronwall and Snyder types; (c) pure resistance furnaces, such as the Keller, Harmet and Heroult pig-iron furnaces, by the Gin process and the earlier Girod crucible furnace, and (d) induction furnaces, such as the Kjellin-Colby and its later modification, the Roechling-Rodenhauser type.

Metallurgically considered, electric furnaces have been put to several distinct uses in the iron industry: (a) for making pig-iron, (b) for making steel direct from the ore,

(c) for refining steel previously made in the open-hearth or Bessemer, (d) for making steel by melting cold scrap with or without the use of pig or ore, (e) for manufacturing ferro-alloys, (f) for melting ferro-alloys to be used as additions, and (g) for melting pig-iron for malleable castings. The steel produced by b, c, or d may be put into ingots or castings.

### Comparison of Processes Difficult.

It is not our purpose to criticise the various processes that have been developed. Many of them are commercially successful, but there are so many variables entering into the matter that no one can fairly compare them except, perhaps, in one or more particulars. For example, the current consumption can be readily compared, and we hear much about this or that furnace showing low current-consumption per ton. Unless furnaces compared are operating under similar conditions and on a similar product, the figures are quite valueless. In melting a similar quality, one furnace may take more current than another simply because the melter kills his steel more perfectly. A few extra kilowatts makes the difference between well and poorly made steel.

Beside current-consumption, other variables are life of roofs, bottoms, side-walls and electrodes. First cost of furnaces and quality of construction, and, from the power-house point of view, simplicity and cost of electrical equipment, must be considered, and this involves questions of phases, frequency, voltage and power-factor. When all elements are considered, together with ease of operation, we see that it is no simple matter to give off-hand judgment as to what furnace to use. I mention this because I am so frequently asked this question, and I notice a considerable tendency upon the part of those with no electrical furnace experience at all to install relatively new and untried processes rather than those that have unquestionably proven their merits.

The time has passed when the electric current itself is supposed to confer any mysterious benefits upon the product, but its function is just as stated by Siemens thirty-five years ago, namely, to "effect such reactions and decompositions as require for their accomplishment an intense degree of heat, coupled with freedom from such disturbing influences as are inseparable from a furnace worked by the combustion of carbonaceous materials."

Various claims, however, are made for processes depending upon whether the current passes through the bath horizontally or vertically or is merely radiated upon the surface. Mixing or circulation in the bath is supposed to be especially facilitated by whichever process the speaker happens to be interested in. At the temperatures involved, molecular mobility is very great, and solution and diffusion take place satisfactorily if only the total heat available is sufficient to maintain the entire contents of the bath perfectly fluid. Aside from this condition, it is my judgment that excessive agitation of the bath by the current is just about as desirable as "agitation" elsewhere in the plant among employees.

The condition for perfect melting described by Siemens has best been met for a hundred and sixty years by the crucible process, which has been held in highest esteem where quality is considered. Crucible steel production, after a century of supremacy, was given a setback for ordinary uses by the invention of Bessemer steel, and a little later the crucible industry was again assailed by the Siemens-Martin product, particularly after the advent of the basic process. Neither of those processes give a product that competes with crucible steel where highest quality is demanded, and the venerable crucible process thrives notwithstanding these earlier rivals.

### Electric and Crucible Results Compared.

With the advent of electric furnaces we have a rival which claims to make steel equal to the best crucible steel. It is interesting to note that the inventors recognized the superior character of the crucible product so frankly. Equally frankly I can say, after ten years' experience, that I think they were right; nevertheless, we are building four new crucible furnaces at the present moment.

When I say that the electric furnace can produce steel equal to crucible steel, I mean that conditions in the furnace are such that the metal in the ladle, ready to pour, is in approximately the same condition as well-melted crucible steel. The quality of the finished product, however, depends upon the use of equally good methods of handling the ingot in cogging, rolling, annealing and inspecting that are customary in handling fine tool steel.

The point is that each process has its particular field, and while some crucible tonnage may be diverted to electric steel, yet it is more likely that electric steel will find its market in the most exacting requirements of steel for structural and tensile purposes, such as have come about almost simultaneously with the processes themselves, namely, for automobile and aeroplane parts. Crucible steels for these purposes are scarcely commercial because of the difficulties attendant upon making very low or medium carbon alloy steels by that method, and the tonnage demand is far beyond what could be met by crucible steels.

Our own experience shows that the electric furnace was opportunely invented to meet a new demand rather than to replace an old process. Our demand for crucible products has not decreased, but the reverse; and while each and every grade that we manufacture can be and has been successfully produced in one or both of our electrical processes, the fact remains that they are better adapted to the production of relatively low carbon alloy steels.

## Electric Process Requires Skill.

The pioneer work that we have done in introducing electric steels into this country has had the effect of creating new standards of value for alloy products and, indirectly, has brought about a general improvement in the quality of open-hearth steels upon the part of mills specializing in these products. Of this there can be no doubt.

The recent activity—epidemic, we might call it—of electric furnace installations calls for some comment and caution. Mr. James H. Gray published in the *Iron Age* of January 6, 1916, an interesting summary of the world's installations. It is noticeable that many of these are going into plants not formerly engaged in steel making at all, and this, in conjunction with the hesitancy of established plants to adopt electric melting, leads one to look for a reason. It is in part due, I fear, to the activity of power companies in looking for desirable business; but while the electric furnace load is generally desirable, it can only remain so if the plants of the users are successful. On the part of those who have recently made these installations, I fear there may be some misapprehension as to just what an electric furnace will do. It is not an automatic machine guaranteed to produce steel of crucible quality by merely throwing on a switch. It requires at least as much skill as any other existing process, and the number of those possessing this skill is limited. I believe we will pass through a period of reaction and dissatisfaction with electric products while many of the new furnaces are in the experimental stage.

## Adaptability of Electric Processes.

To one who has been interested in electric steel from its earliest days, it is interesting to observe the change in attitude toward the actual carrying out of the processes and the feasibility of establishing them in widely scattered districts. We formerly thought, and were repeatedly told, that it would be impracticable to utilize electrical energy to do the original melting, that only in most-favored localities could these processes be operated at all, and then only for making the highest-grade products. In accordance with the prevailing idea, our initial installation consisted of a single-phase four-ton electric fed by a twenty-ton Wellman-Seaver tilting basic open-hearth furnace. At that time four tons was as large a furnace as had been made, and nothing but single-phase current had been used. The initial installation of Richard Lindenberg, in Germany, was practically identical and started operating at almost the same time. The current was used for refining only, and our furnace was not suitable for cold melting, although a few heats have been so made. One of these is of peculiar historic interest because our charge consisted of electric pig iron, made in the Canadian experiments under the direction of Dr. Haanel. The particular pig iron used was made from roasted pyrrhotite ores and was described by Dr. Haanel in 1906 in the "Preliminary Report on the Smelting of Canadian Iron Ores by the Electro-Thermic Process." Some of this material was later smelted by us in March, 1909, under the supervision of Mr. Ernest Humbert, who furnished me the following analyses of the iron used:

| Ni. | Cu. | Si. | S. | P. |
|---|---|---|---|---|
| 4.35 | .72 | 2.95 | .020 | .030 |
| 3.13 | .80 | 2.31 | .013 | .023 |
| 4.15 | .82 | 2.39 | .012 | .027 |

The heat made from this iron gave the following analysis and represents the first steel made in the Western Hemisphere direct from the ore in two operations, both of which employed electric furnaces of the Heroult type:

| | |
|---|---|
| C....... | 0.44 |
| Si....... | 0.034 |
| Mn..... | 0.50 |
| P... ... | 0.013 |
| S....... | 0.013 |
| Ni.... | 3.62 |
| Cu...... | 0.48 |

The high copper content led us to test this heat very thoroughly. The results were published by the writer in the "Proceedings of the American Society for Testing Materials," Vol. X, 1910, and need not be repeated other than to say that the physical characteristics were very good indeed and showed no harmful effects of the copper present.

Of the later installations of electric furnaces, probably one-half are intended to melt and refine cold charges, even in localities not especially favored as regards power rates. However, there has been a very general decrease in wholesale power rates during the last few years, and this applies to steam as well as hydro-electric sources of power. Rates below one cent per kilowatt may be had in very many localities for large quantities of power steadily used.

### Changes in Electrical Equipment.

The most marked change in the electrical equipment of furnaces consists in the larger quantity of power deemed necessary for a given size of furnace. In our original furnace we have 550 KVA. for a four-ton furnace. To-day the United States Steel Corporation recommends 900 KVA. for a furnace of this size. Some of the older six-ton furnaces have from 900 to 1,000 KVA. available; 1,200 KVA. is now standard, and one furnace is to have 1,500 KVA. The Snyder furnace has 800 KVA. available for a three-ton furnace, and the Heroult furnaces, as installed in this country, are now equipped with 750 KVA. for this capacity. It has been found that increased power during the melting-down stage is very desirable and brings about a saving in total kilowatts expended. After the melting is complete excessive power is detrimental to the heat itself and very destructive of roofs and linings.

It is possible to make electric steel chemically purer than by any other process. Phosphorus with us rarely exceeds 0.010 per cent., and sulphur in carbon heats will average still lower, while in alloy heats the sulphur rarely exceeds 0.015 per cent. This is true of both the Heroult and Snyder product; in fact, I have seen eight consecutive heats showing sulphur and phosphorus below 0.010 per cent. In the case of sulphur, we view this not so much as of itself important, but as an indication of the success in attaining a reducing and deoxidizing condition during the operation. In the case of both low and high carbon heats of a great variety of compositions, we have split many ingots in two and have never seen a cavity or blow-hole, either subcutaneous or deep-seated, even so large as a pinhead. This is no positive guarantee that unsound ingots may not result even with electric steel, and the approved methods of pipe prevention must be emloyed, together with every possible care in melting and pouring.

Even with the use of all these precautions, the same results cannot be obtained in open-hearth and Bessemer steel, owing to the oxidizing conditions of operation.

### Timeliness of Electric Process.

This shows how timely was the invention and development of electrical processes simultaneously with the advent of the automobile and aeroplane. New requirements for materials of construction came into being along with them, and it is in meeting these requirements the electric furnace finds its best application. In the construction of automobiles and aeroplanes, it is little short of criminal to use any materials but the best when human life is at stake and when safety cannot be had by merely increasing the weight of vital parts. In our ten years' experience in introducing electric alloy steels, I can safely say that a large part of our business came from those who had had a more or less unsatisfactory experience with other grades of steel, and we have furnished much steel for racing cars to those who did not use it in their general product, but who thus displayed both a sense of added responsibility commensurate with the requirements and a recognition of the merits of electric steel.

An advantage of the electric product scarcely anticipated by Siemens is the ability to control the composition within narrower limits than are possible in open-hearth practice. This is especially noticeable in the use of the more easily oxidizable metals, such as silicon, manganese, chromium and vanadium. This is an advantage in several ways: First, less excess alloy needs to be added to the heat to ensure the proper amount in the finished steel. Second, the quantity of solid metallic oxides in the steel, or to be eliminated from the steel, is thereby reduced. And, third, the more nearly composition can be controlled the more certain will be the results of heat-treatment.

Both the maker and the user of the steel are the gainers by reason of the above characteristics, as well as by the fact that all alloy additions may be made in the furnace itself rather than in the ladle, thereby removing danger from lack of homogeneity.

Not only in automobiles and aeroplanes, but in many other ways, electric steel will give a good account of itself here, as it has done abroad, for military and naval purposes. But I cannot discuss that lest I be deemed an alarmist, or a member of the munitions trust, or in some way identified with those evil influences stalking abroad in the land. We do not and have not engaged in the manufacture of munitions or steel for munitions at our mill, although guilty, perhaps, of furnishing small amounts to our own arsenals and navy yards in years gone by. Our facilities and products are at our nation's service whenever a constructive policy of preparation for either peace or war is determined upon.

## American Growth and Status

In 1910 there were 10 electric furnaces in the United States and 104 elsewhere in the world. In 1913, 19 against 121; in 1915, 41 against 172; while at present there are no less than 100 either operating or under construction as against probably 250 elsewhere.

The furnaces already installed in this country, or now being built, represent the utilization of between 125,000 and 135,000 electrical horse-power and will be capable of a tonnage output of between 1,000,000 and 1,100,000 tons of ingots or castings per annum. The Heroult system represents at least 70% of this electrical energy and tonnage output.

The recent announcement of electric furnace development in the plants of the United States Steel Corporation is deserving of especial mention here because of the magnitude of the installations. At the Duquesne Works of the Carnegie Steel Company, a 20-ton Heroult furnace is now under construction, which will operate on liquid open-hearth metal from any of their 32 open-hearth furnaces at that plant. It is estimated this furnace will produce about 200 tons of ingots per day of 24 hours.

At the South Chicago Works of the Illinois Steel Company, where a 15-ton furnace has been in operation for several years, three additional electric furnaces, two of 20 tons and one of 15 tons' capacity, are now under construction. These furnaces will receive liquid open-hearth metal from the duplex plant, consisting of three 200-ton rolling open-hearth furnaces and two 25-ton Bessemer converters, which is also under construction at these works. This installation, when completed, it is estimated will produce 800 tons of Electric Steel ingots per day and will represent by far the largest electric furnace installation in the world. The details of this will doubtless be made the subject of a separate communication from those most intimately associated with this development.

If preparation ever becomes a reality, we shall not have to apologize for our quality in comparison with any industrial or warring rival—at least so far as the product of privately owned plants is concerned; and, in the tonnage capacity of electric furnaces installed, we now take first place among steel-making nations, as we also do in Bessemer, open-hearth and crucible steel production. (Applause.)

CHAIRMAN GARY: Discussions of Dr. Mathews' paper have been prepared by Mr. Leslie E. Howard, Metallurgist of the Simonds Manufacturing Company, Lockport, New York, and by Mr. William G. Kranz, Vice-President of the National Malleable Casting Company, Cleveland, Ohio. As neither of these gentlemen is present, and as we are a little behind with our program, their discussions will be inserted in the Year Book without being read. We will now hear a brief discussion of Dr. Mathews' paper by Mr. Carl H. Booth, Treasurer of the Snyder Electric Furnace Company, Chicago, Illinois.

# ELECTRIC FURNACE IN STEEL MANUFACTURE

DISCUSSION BY LESLIE E. HOWARD

Metallurgist, Simonds Manufacturing Company, Lockport, N. Y.

Dr. Mathews has covered the electric furnace as applied to steel manufacture so thoroughly in his able paper, that there is very little that I can add, excepting, perhaps, to make stronger some of Dr. Mathews' comments.

Our experience has been entirely with small furnaces of the conducting hearth type. In 1910 we put down at the Chicago plant of the Simonds Manufacturing Company what we believe to be the first Girod furnace in this country, this being of half-ton capacity and single-phase. This was moved to Lockport in the early part of 1911 and was used entirely on experimental work and the production of special steels, some of which we have not been able to make successfully in the crucible furnace.

Some two years ago this Girod furnace was replaced by a furnace designed and built by ourselves, this being along the lines of the original Siemens furnace, having but one bottom electrode, this being welded by oxy-acetylene to the shell and the conductors so arranged that the shell forms part of the conductor to the bottom electrode. This furnace is of one-ton capacity and has operated very successfully indeed, and has also been used in producing high-grade carbon steel as well as alloy steels. We mention this as showing that our experience has been entirely with these small furnaces, and our comments will necessarily be considered with this in mind.

I thoroughly believe, as stated by Dr. Mathews, that steel equal to crucible steel can and is being produced every day by electric furnaces. But our experience, limited though it is, has convinced me that to do this we must follow very closely crucible steel practice in the choosing of melting stock, in the care taken in melting, especially during the killing period, and, of course, in the extreme care taken in pouring and subsequent handling of the ingots.

I was glad to see Dr. Mathews bring out the point that high-grade steel cannot be made of any or every thing in the way of steel scrap. Personally I don't believe this is possible to do; or if so, the extra furnace cost in the way of extra refining would offset the difference in cost of the melting stock.

We are also firmly of the opinion that a certain amount of new iron should be added, to even high-grade scrap if quality steel is to be produced. The writer has had occasion to talk with several Sheffield melters and metallurgists, and they will tell you over there that to get "body" and "life" in their steel, they are obliged to us liberal quantities of new iron, this holding good whether the steel is made by the crucible or other process.

In American crucible practice, it is, of course, well known that liberal additions of puddled iron, either Swedish or American, give crucible steel increased physical properties for the same analyses. And having in mind that the puddling process is about as crude an operation as we have in our iron and steel metallurgy, the writer cannot see why the same proportionate amounts of high-grade pig-iron combined with good scrap, and all melted and refined in the electric furnace, will not make steel equal to crucible quality.

The point which I wish to make is that the reduction and refining of the pig-iron addition will be carried out under very much better conditions in the electric furnace than in the puddling furnace. Our experience along these lines has been conclusive to the extent that we have installed and are now running a 6-ton, three-phase Heroult furnace and we have every reason to feel that results from this installation will be as successful as has been the results of the small furnaces. We do feel, however, that there is a limit to the size of the heat that can be properly worked in an electric furnace and get quality steel, especially when dealing with high carbon steels, and we are awaiting with some interest results from our new six-ton furnace along these lines.

# THE ELECTRIC FURNACE IN STEEL MANUFACTURE

DISCUSSION BY WILLIAM G. KRANZ

Vice-President, The National Malleable Casting Company, Cleveland, Ohio

Dr. Mathews' paper covers the subject very thoroughly and leaves very little for discussion. One cannot but be impressed with the rapid growth in the production of steel in the electric furnace, when you consider the development that has taken place in less than sixteen years with the capacity of furnaces installed and building of over 1,000,000 tons per year. We are acquainted with large figures these days, but we must not forget that the first million is by far the most difficult to acquire. In my judgment the next period of sixteen years will show a much greater rate of progress than the past.

In 1912 The National Malleable Castings Company installed a six-ton Heroult furnace at its Sharon Works for the production of a special steel, and during the past few months a second furnace of the same type has been added. The electric furnace was found to be much better adapted for this purpose than the open-hearth.

Dr. Mathews mentioned the melting of pig-iron for malleable iron purposes. This use of the electric furnace is yet in its infancy. There has been some experimenting along this line with gratifying results thus far, and I look for considerable development in the near future not only in the manufacture of malleable iron but also in the manufacture of iron castings such as chill rolls, car wheels, etc., where uniformity and exacting analysis are required.

Not only has the electric furnace come at an opportune time to take care of the automobile and aeroplane industry, as referred to, but it will set higher standards of quality which will spur the ingenuity of the steel maker to improve the quality of Bessemer and open-hearth materials, and thus the electric furnace should be heralded as a beneficial acquisition to the entire steel industry.

# THE ELECTRIC FURNACE IN STEEL MANUFACTURE

DISCUSSION BY CARL H. BOOTH

Treasurer, Snyder Electric Furnace Company, Chicago.

In discussing electric furnaces with prospective users, we have always held that any type of electric furnace, properly designed and constructed, if operated with sufficient metallurgical skill, could be used to make the highest grade of steel. Dr. Mathews has developed this thought with special emphasis upon the necessity of having skilled handling, which we consider a matter of first importance. Many an electric furnace has been condemned because of improper handling on the part of operators.

But we have always gone one step further and urged that, in the last analysis, the question of the cost of operation is equally important. This is especially true if the electric furnace is to have any wide application in the manufacture of the commoner grades of steel, which at present are made by the Bessemer converter and open hearth processes. It is also equally important to have low cost of operation if electric furnaces are to stay in the business when the manufacture of steel again returns to a normal basis, and when the net profit made is frequently measured by a dollar a ton. To secure high efficiency and low cost operation, we believe that furnaces should be built of relatively small holding capacity, should be high powered, and use but one electrode.

Snyder furnaces to-day, melting and refining cold material on a basic bottom, are making from six to twelve heats in twenty-four hours, depending on the grade of steel made and the methods used for handling the metal. It is not at all uncommon to melt down an entire charge of cold scrap in one hour and a half, and we have many records where the actual melting has been done in an hour and ten minutes.

This quick melting ability in an electric furnace makes unnecessary and expensive the use of other furnaces, such as the open hearth or Bessemer, to do either the preliminary melting or a part of the refining. We believe that the developments of the future will be in the direction of doing all the work in the electric furnace, except in cases where hot blast furnace or mixer metal is available as raw material for use direct in the electric furnace.

Dr. Mathews has also pointed out the decided advantage which the electric furnace has, due to its neutral atmosphere and its ability to make steel chemically purer than by any other process. It is quite evident that if the entire steel-making operation is carried on in the electric furnace considerably less deoxidizing and alloy additions will be required for cleaning the steel and removing oxides, nitrides, and occluded gases.

We are designing at this time an electric furnace of approximately twelve tons capacity, which will have a daily output of 100 tons of steel, melting and refining cold scrap on a basic bottom. The steel made would have an analysis equal to the best low-carbon open-hearth steel, and the operating cost promises to be low enough to compare favorably with an open-hearth furnace having a daily output of 100 tons. (Applause.)

CHAIRMAN GARY: Opportunity is now afforded for informal discussion of this paper. We will be very glad to have volunteers. There are young men here, I am sure, who have decided opinions on this subject and we would like to hear from them. We will be glad to have them tell us when and how we are going to adopt the electric smelting of iron ore. (After a pause): There being no volunteers, we will now hear the announcements of the Secretary, after which we will adjourn until two o'clock.

MR. McCLEARY: The luncheon will be served in the Astor Gallery, the location of which you all know. The Directors' Meeting will be held in the State Apartment on this floor, over on the 33d Street side of the building.

## AFTERNOON SESSION

During the noon recess the members of the Institute were its guests at a buffet luncheon. During this recess, also, the Directors of the Institute held their regular monthly meeting. At this meeting, St. Louis was selected as the place for the next October meeting of the Institute, and the following officers were re-elected for the ensuing Institute year: Elbert H. Gary, President; Powell Stackhouse, First Vice-President; Willis L. King, Second Vice-President; Charles M. Schwab, Third Vice-President; Edward Bailey, Treasurer; James T. McCleary, Secretary.

At two o'clock the Institute was again called to order, Judge Gary in the chair.

President Gary: One of the valuable features of these meetings is the opportunity afforded to our members to meet socially during the recesses. At these times men who conduct much of their business with each other by correspondence have the opportunity to sit down together and talk over matters of mutual interest. It is, therefore, not to be wondered at that after the noon recess our members are a little slow in coming into the room where the meeting is being held. They know, too, that the papers will be published both in the trade journals and in our own Year Book, so that they can study these papers at their leisure. Indeed, that is the fundamental and permanent value of the papers. They are too full of meat to be digested by simply hearing them read. The comments I have heard about these papers from year to year have without exception been most favorable. Still it is a courtesy we owe to those who read the papers to be in our places to hear them, and I will ask the Secretary to announce to those in the lobbies that the meeting has been called to order and that the reading of papers is about to begin. (After a pause, during which the room filled up): It is my pleasure to introduce Dr. John S. Unger, Manager of the Central Research Bureau of the Carnegie Steel Company, Pittsburgh, who will speak on the subject of Rail Manufacture. (Applause.)

# RAIL MANUFACTURE

JOHN S. UNGER

Manager, Central Research Bureau, Carnegie Steel Co., Pittsburgh, Pa.

The amount of money expended annually for steel rails in the United States during the past five years has averaged over eighty millions of dollars. The rail industry ranks third in tonnage among the steel products and constitutes about 12 per cent. of all the steel rolled into finished material.

Its universal use has made it familiar to everyone, consequently it is better known to the public than almost any other large steel product.

Owing to the severe demands made of the rail, a great deal of time has been given to investigating it by both the producer and the user. The rail manufacturer has been engaged for years in making studies and investigations looking towards rail improvement, beginning with the manufacture of the steel and through all the subsequent operations to the finished rail. In addition, they have thrown their works open to a representative engineer of a prominent railroad society, who has made many investigations at almost every rail mill in the country.

Such co-operative work must result in a better knowledge of factors entering into rail manufacture. To be of the greatest service, such information must be supplemented by studies of the use and maintenance of the rail in actual service.

In studying the rail problem, one is impressed with the great number of rail sections. Standards have been prepared and adopted by engineering societies, but they are used by few railroads, the larger railway systems having their own sections. In the same weight of rail, one finds the extremes from a thin, flat head, deep web, thin flange, to a round head, short web and thick flange. Why are sections changed, even if they have shown by service that they will give reasonably good results?

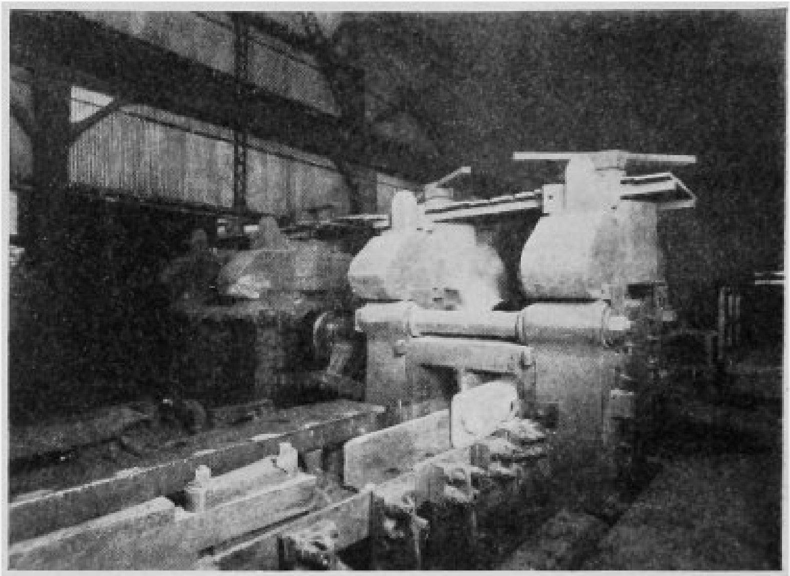
In spite of the futile efforts of societies to decrease the number of sections, they have grown. Take a standard weight, say 85 pounds. This has been used long enough and on enough railroads to determine what is a good section. If a number of sections of this weight give equally good results, the natural conclusions are that all are good and differences in section is unimportant, or all are bad and the best has not been discovered. A decided economy could be effected by having few sections, as the cost of rolls and changes necessary to produce different sections is an important one.

Another view of the effects of so many sections is presented in the case of a railroad operating cars on a flat-head rail. The wheels wear to fit the head. When these cars are hauled over another road with a round-head rail the point of contact of wheel and rail is at center of head. On the other hand, if cars from the latter road be used on the flat-head rail of the first road, the wheel bears on each side of the head of rail, concentrating the wear and stress at an entirely different point.

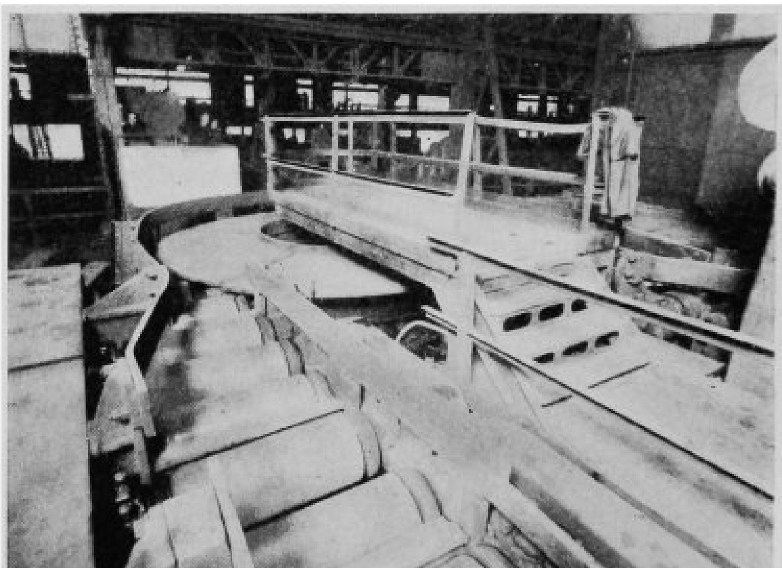
Another important consideration in the manufacture of rails is the large number of specifications. As a whole, there is very little difference among them, except that some carry more restrictions than others. Is it not possible for the railroads to harmonize their specifications for rails? This should result in a common specification to cover all rails. If this could be done, it would be one step in the right direction.

In the use of the rail, the primary considerations are safety, durability and cost. The severity of modern railroad service necessitates that every effort be made to insure safety and to produce more durable rails. Heavier rails are necessary to meet these severe conditions.

The heavier rail is an improvement when it is not merely an added weight of 5 to 10 pounds per yard, which is one-third of that per foot, but a pronounced increase in size. Weight in rails, except as it affects cost, is not objectionable, as it is not a moving load.



48-inch two-high non-reversing blooming mill.



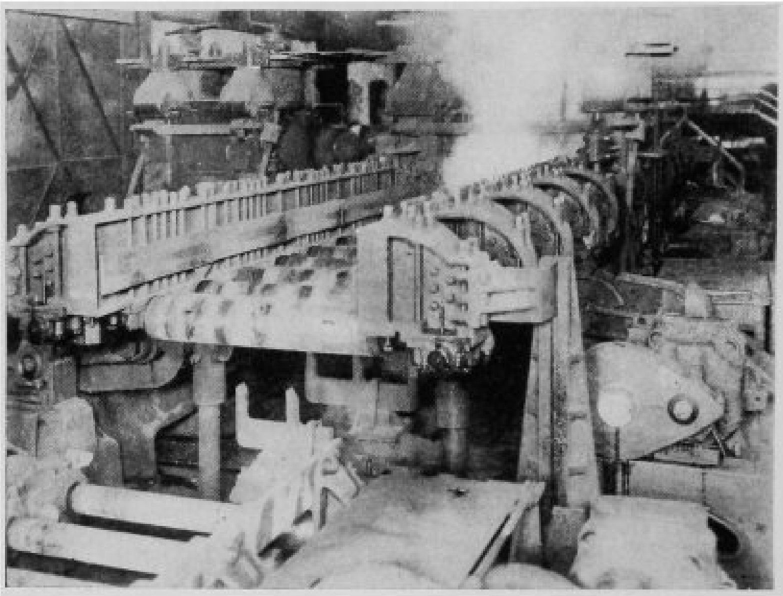
Turn-table and return, 48-inch blooming mill.

The impression is that heavy rails lack ductility, but this is true in a comparative sense only. A heavy rail cannot be bent to the same extent as a light rail. A rerolled 30-pound rail will stand more bending than the 100-pound rail from which it has been rolled, even though the finishing temperatures were the same. This is to be expected, as a similar condition exists when any article of steel is compared with one of heavier section made from the same steel. A piece of wire can be bent more than a 3-inch axle, both of the same steel.

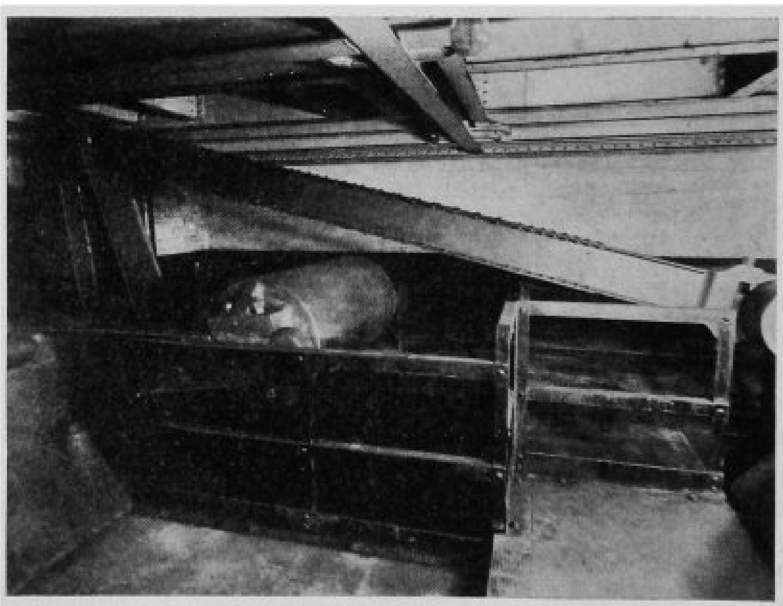
There is a growing tendency at the present time on some railroads to install heavier rails. One railroad has rails of 135 pounds in service on its fast passenger tracks, and another system has recently placed a large order for 130-pound rails. Some of the very heavy rail sections have not proven to be quite as satisfactory as was expected at the beginning of their use, but later experiments with some modifications in section have given satisfactory results. It would be idle to predict where weight in rails may end, but a 200-pound rail is a future probability.

A new rail mill at the Edgar Thomson Works, at Bessemer, Pa., was completed early in the present year. This mill is capable of rolling rails up to 150 pounds per yard and will be able to supply any demand for heavier rails for some time to come.

In looking towards possible rail betterment, this plant is using an ingot 23½ inches square, instead of the smaller ingot used by many of the older mills. The ingot is bloomed at the beginning in a tandem two-high, non-reversing, 48-inch mill with two passes in each stand. The ingot first goes through a pass in the first stand, then is turned 90 degrees and given a pass in the second stand. It is then returned to the first stand by a turn-table and carrier, again turned 90 degrees, given another pass, turned again and given a last pass in the second stand, thus rolling the ingot on all sides, turning at every pass before being sent to the three-high, 40-inch, reversing, blooming mill, which completes the blooming. The bloom is then sheared, re-heated and rolled on the rail mill.



40-inch three-high reversing blooming mill tables.



Underground counterbalance for mill table.

The advantages of the preliminary blooming lies in the large fillets used in the rolls, avoiding any tearing at the corners of the ingot, the very slow rolling speed employed giving a kneading action to the plastic surface of the ingot, and the rolling on all sides working all surfaces of the metal equally.

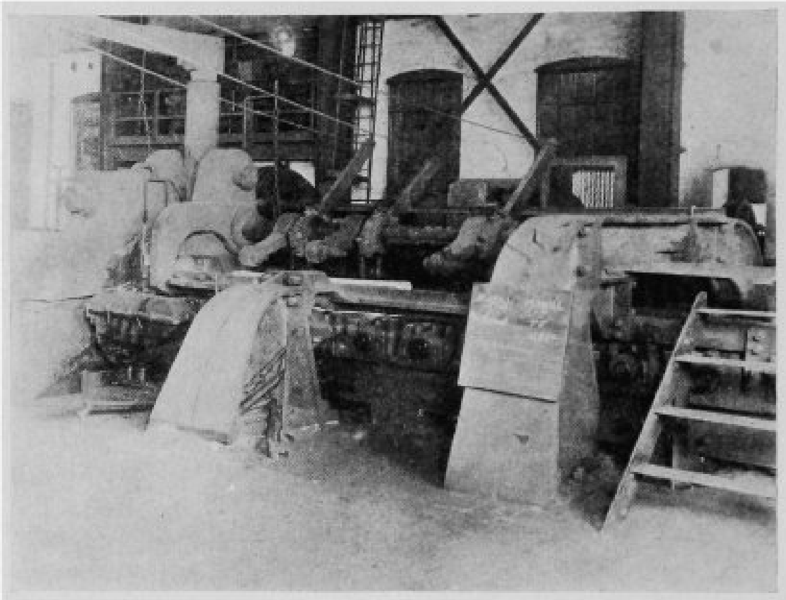
This mill has been rolling rails of 130 pounds for almost a month. To give some idea of the quality of these heavy rails, not a single rail has failed in any of the mechanical tests made at this works to date.

Numerous other features of this mill are particularly noteworthy, among them being commodious underground passages to the mill machinery and to the soaking pits. This permits of readily making changes in the mill equipment when such are necessary.

The investigations of the rail manufacturer has not only covered the manufacture of rails, but also some of the causes of rail failures. I do not believe a rail-testing machine can be built which will exactly imitate service conditions. The vibration and loading might be imitated, but to imitate the speed at which they are applied would be difficult, if not impossible.

In studying rail failures, a study should be made of some of the causes which may assist in producing them. Bad gauging of track, worn wheel-tread and flanges, flat spots on wheels, poor trucks, poor sub-grade, insufficient ballast, improper counterbalance on engine, bad ties and insufficient area of contact between wheel and rail should be considered. Rail maintenance and condition of rolling stock exercise an important influence. Rails rarely break on trestles, crane runways or bridges. When failures occur at these points, they are due to crushing or split heads, which are noticeable and can be removed before an accident occurs.

In an accident, a broken rail may show better quality than the adjoining or opposite rails which did not break, but it failed. The question might be asked here, When is a rail a good rail? Rail failures are few when compared with the number of rails used annually, and would not be considered serious in most of the ordinary articles made of



Bloom shear.

steel. As rail breakage is of such consequence that it cannot be disregarded, can the rail not be made strong enough or so supported that it will not break?

Rail failures are greatly dependent on climate and locality. A railroad official of a road in the northwest claimed he could examine his monthly record of broken wheels and rails and determine the date and at what point on the road they had extremely cold weather.

This statement is borne out in drop-testing rails at temperatures from 50 to 100 degrees below zero, Fahrenheit, which showed a pronounced falling off in resistance to shock. In these tests, the added effects of a frozen roadbed could not be studied.

Another western road had two and a half times as many rail failures annually per mile of track on one portion in which the sub-grade was largely clay, as compared with another portion of track on a sandy, porous sub-grade, the traffic and rail section being the same in each case. An official of this road stated: "These facts seem to confirm the statement 'there are indications that rail failures are a question of geography!'"

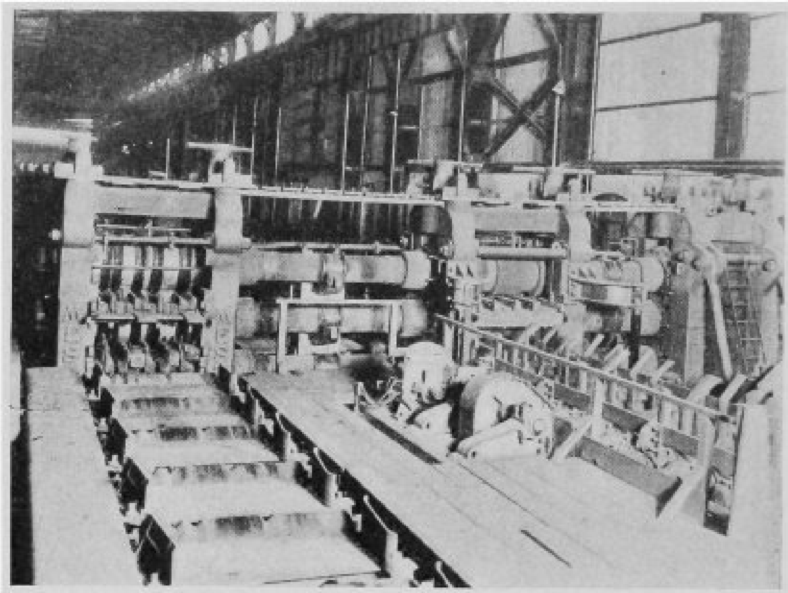
An experiment under my supervision verifies this statement. I found a piece of track about 500 feet long in which rails, splices and fastenings failed much more rapidly than in the track on either side. The track was perfectly straight, the fill for sub-grade of the same material, the rails, ties and ballast alike. No apparent reason could be found for the difference in performance until it was pointed out that the railroad crossed an old, abandoned canal bed, where the ground had remained soft and swampy for years.

Transverse fissures appear as a new rail disease. Apparently composition is not responsible for their occurrence, as they are found in both segregated and unsegregated rails, and from every part of the ingot. Lack of ductility of the steel cannot be charged against it, as of 102 rails removed for transverse fissures, more than one-half had an elongation of over 10 per cent., while one of the rails giving only seven months' service had 14 per cent. elongation.

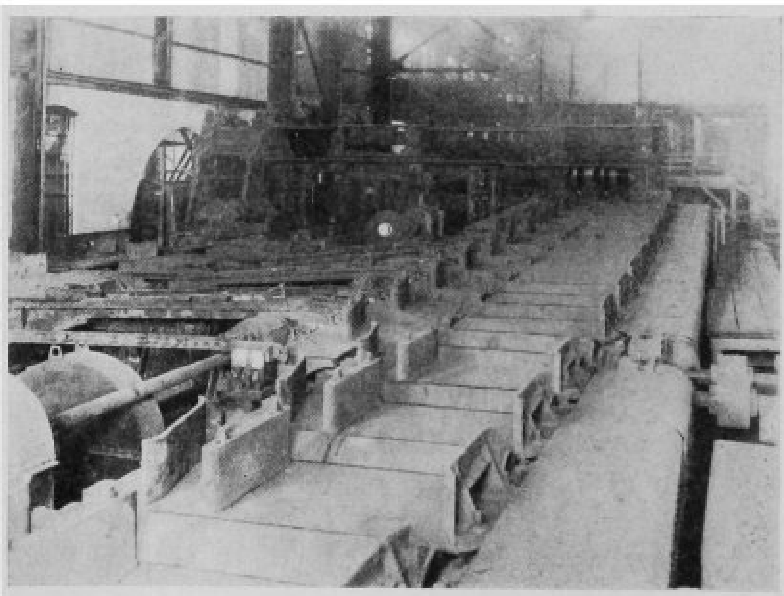
From incomplete investigations made, transverse fissures appear to be a kind of detailed fracture, the result of a combination of cold rolling or working of the metal in service and vibration of the rail. The results so far indicate they may be produced on a new or worn rail at any point desired. If this can be proven, the answer is obvious. A rail must be so strong or so well supported that it cannot vibrate. I have made many inquiries, but have not heard of a case of a transverse fissure on a well-supported rail, as on a bridge. Some engineers go so far as to recommend that a rail be laid on a longitudinal girder to support it.

The service demanded of the rail by the modern railroad is necessarily severe. Safety must be the primary consideration. The engineer designs the modern bridge, building or engineering structure much heavier than formerly to provide for the increased demand made upon it.

Rail durability can be obtained by several methods. Alloy steels, of which manganese steel is a good example, is one method, but its cost, except for special locations, as yards, switches, terminals or congested traffic points, is



First and second set roughing rolls, rail mill.



Transfer table, rail mill.

prohibitive. Heat-treated rails of alloy or carbon steels have shown less wear in the few service tests made to date, and is another example of possible improvement in rail durability.

Rail improvement will be made. This result will probably be reached by using the best steel obtainable, an increase in size of section and the best possible maintenance. A combination of these factors should lead to a settlement of the rail question. (Applause.)

President Gary: This paper will now be discussed by Mr. H. C. Ryding, of Birmingham, Alabama.

# RAIL MANUFACTURE

DISCUSSION BY HERBERT C. RYDING

Assistant to Vice-President and General Manager, Tennessee Coal, Iron & Railroad Company, Birmingham, Ala.

Dr. Unger, in his paper, informs you the rail industry ranks third in tonnage among steel products and that only 12 per cent. of the steel produced is put into rails. If it were possible, it would be very interesting to know what proportion of the total work done by all the steel produced is borne by this small proportion of 12 per cent. going into rails. Whatever it is, it is very large; and it is still increasing and at such a rate, by reason of heavier loads and more of them, together with greater speeds, that both the manufacturers and the railroads have devoted themselves earnestly to the task of improving the quality and section of rails to meet this growth of more severe conditions of service.

For economic reasons the railroads have within recent years doubled the loading capacity of cars; and it is very natural, since the carrying capacity of railroad tracks have not also been doubled, that weaknesses in certain parts of the track should develop. The rail as a part of the track has, therefore, become a problem, and manufacturers are interested not only in their process of producing rails but are also vitally interested in conditions surrounding the rails made by them when put into the track.

To get the best results, the railroads must give as much attention and care to track conditions as the manufacturer now gives to every process through which the material passes up to the finished rail. It is not only true that the manufacturers are giving decidedly more attention to and exercising more care in every process through which the rail passes, but it is also true that the railroads are diligently at work in caring for and improving track conditions, all of which are showing a gratifying reduction in the number of accidents occurring and rails failing in service.

At the works with which I am connected, we have co-operated with the American Railway Engineering Association representative in making some very interesting investigations in the process of blooming the steel, results of which have all been published.

The rail manufacturers in this country to-day are working to a very large number of rail specifications, some varying very radically from others in certain respects; but generally the differences are not so great as to make it impossible from which to frame a common specification, acceptable to both the railroads and the manufacturers. This should be done and would to a great extent provide a common ground on which to still further devise ways and means for rail betterment.

With increasing loads, there has been a growing tendency to use heavier sections of rails; but the adoption of heavier rail sections has not been as rapid as the development of the heavier equipment.

Rails are now being rolled up to 130 pounds per yard, but they have not been in use sufficiently long to obtain reliable data as to their wearing qualities compared with lighter sections used under the same conditions of traffic.

This gradual increase in the weight of rails has been productive of a great number of rail sections being used; and from time to time efforts have been made to standardize series of rail sections, as was done by the American Society of Civil Engineers and the American Railway Association. In addition to the above well known rails, a great many railroads have designed and used for many years sections of their own, thus increasing the number of sections of rails to the point where it seems well-nigh impossible to decide upon a standard type of rail.

The form of the rail is an important consideration. I have for some time felt that the heads have been too wide. So much so that in some instances where the wheels have worn to fit a rail having a narrow head, these same wheels running over rails with wider heads, bear only on the false flanges on the outer sides of the heads of these rails. To illustrate, take the 100-pound A. S. C. E. rail. The width across the top of the head is 2¾ inches. The effect of this width, in conjunction with the usual bevelled tread of the wheels, is to throw the entire load on the top inside corner of the head, and until this part of the rail wears down the load continues to be carried to one side of the head, and is therefore not carried centrally on the rail.

In the case of a new 90-pound A. R. A. type A rail, with the treads of the wheels bevelled one in 24, the nearest point of contact of the wheel on the rail is 7-10 inch away from the center of the head. In structural work, the load is always carried centrally on a girder. If the load were carried to one side, as in the case of rails, the girder would have to be made materially stronger. What is true of a structural girder is true of a rail which is also a girder. A modification, therefore, in the shape of the heads of rails as made to-day can, I think, be made to serve a very useful purpose. In the case of the 100-pound A. S. C. E. rail, the present width of the head can be maintained at the bottom so as not to decrease the fish-plate bearing. The sides of heads can be made to incline inwardly 7½ degrees, making the width across the top of the head 9-32 inch less than at present, and the metal displaced from the sides added to the top of the head, increasing its depth 7-64 or nearly ⅛ of an inch, and the total height of the rail an equal amount.

The effect of such changes will be to strengthen the rail as a girder, stiffen the head, more nearly centralize the load on the rail, and will not increase its weight. In the case of the 100-pound A. R. A. type B rail, the same changes would increase the depth of the head 3-32 inch and the height of the rail an equal amount.

In addition to changes in the form of the rail, the weight per yard will also have to be increased and to what extent this should be done will entirely depend upon the conclusion to be reached by the work of investigation now being done by both the railroads and the manufacturers.

The railroads are demanding a steel rail more uniform in physical qualities. Steel showing any evidence of piping or segregation is not considered suitable for the purpose. The manufacturers are studying ways and means of reducing these objectionable features to a minimum and decided progress is being made.

Other causes of failure, such as transverse fissures, are receiving very careful study. This particular cause of rail failure has received the attention of the rail manufacturers and metallurgists for the past two years, and still to-day we are without a satisfactory explanation of the causes producing them. Changes in the present methods of making rails will, as heretofore, suggest themselves.

The rail will undoubtedly be improved, but on account of the very great importance of the work required of rails these changes will come slowly, but none the less surely. (Applause.)

President Gary: Opportunity is now afforded for informal discussion of Dr. Unger's paper. Any volunteers? (After a pause): If not, we will call on Mr. George W. Vreeland, of Mingo Junction, Ohio, to speak on the Distribution of Materials in the Blast Furnace. The discussion of this paper will be opened by Mr. A. J. Boynton, of Lorain, Ohio.

# THE DISTRIBUTION OF RAW MATERIALS IN THE BLAST FURNACE

George W. Vreeland

Superintendent of Blast Furnaces, Mingo and Bellaire Works,
Carnegie Steel Company, Mingo Junction, Ohio

The proper distribution of the raw materials in the blast furnace has been the subject of more thought and study than any other factor of furnace operation. This is evidenced by the large amount of literature on the subject and the number of devices patented, all striving for what is looked upon as perfect distribution. That the time and thought given to this subject have been productive of good results is absolutely beyond question, but the necessity of a still more efficient distribution continues to occupy the minds of blast furnace managers and engineers, and, no doubt, will continue to do so until the perfect or ideal condition is attained, or that point is reached beyond which it will be impracticable to go.

To faulty distribution can be attributed, as frequently as any other single cause, the bad practice and short life of our blast furnaces. We have numerous conspicuous instances where faulty distribution has injured the physical condition of the furnace to such an extent that it has been necessary to blow the furnace out after a very short and troublesome campaign. Many patents have been taken out, innumerable designs have been made, many working models have been constructed and the distribution with miniature charges has been observed, all of which promised good results; but many a hope has been shattered when a supposedly perfect top failed under actual operating conditions.

The longer and more efficient life of the present day furnace furnishes proof of the fact that the efforts to secure a better distribution have been rewarded. On our large furnaces, with their big tonnages, the errors of faulty distribution are more evident than on the smaller furnaces, due to the more rapid rate of driving; but that these errors exist on the small hand-filled furnaces, even with the most approved methods of charging, cannot be denied. Up to the present time, however, no change in the distributing equipment has produced such uniformly good results as to lead to its general adoption, nor has any one top shown conspicuous superiority over all others.

The variety of furnace tops now in use (some stationary, and others rotating in divers ways), the stationary and movable deflecting rings, the numerous ways of placing the raw material (ore, coke and stone) on the bells and in the furnace, all have their advocates, with data to substantiate their claims. The equations of the blast furnace have so many variables and so few constants that almost any one can solve the equations for the particular variable for which he is looking, and apparently prove his opinion to be correct.

The changes and improvements that have been made to effect the better distribution of raw materials in the furnace can be more fully understood and appreciated by a brief description of the various methods used in their chronological order.

## The Early Charging Arrangements

During the middle ages, when the shaft furnace first appears as a matter of record, the ore, fuel and flux were, no doubt, simply dumped into the top of the furnace, air was blown into the bottom and iron produced. Fuel cost and the many economic questions that the present day manager has constantly before him were not considered.

The very early furnaces, especially in this country, were usually built close to a hill. Nature, with the forests on the hillside and the ore in the hills, determined the site. This location eliminated the problem of elevating the material to the top of the furnace.

The first method of filling a furnace of which we have any record is described in an excerpt from a publication of the year 1686. It consisted simply of "the throwing in of a basket of ore and a basket of charcoal." In the "History of the Iron and Steel Industry of Great Britain," Abraham

Darby is given the credit of being the first man to operate a blast furnace successfully, using coke as a fuel, and he states that he watched the filling of the furnace for six days and six nights, having no regular sleep and taking his meals at the furnace top. This was about 1735, and from his close attention to the filling it might be inferred that the methods of distribution fell into disrepute at an early date.

It appears that during the early years the top or mouth of the furnace was of very small diameter, as we read that the Blendare Furnace, Pontypool, Wales, had an accident which caused the inner portion of the lining near the top to give way, thereby increasing the diameter of the top from 3 feet to 9 feet. Operation was continued, however, and the accidental increasing of the diameter to 9 feet resulted in much cooler top gases and better furnace practice. This must have been considered a marked improvement, as when the furnace was rebuilt the diameter of the mouth was increased to 10 feet. This led to a similar change on all furnaces operating at that time. It may be inferred that this marked the beginning of circumferential charging.

From copies of old prints we find that previous to the "cup and cone" arrangement, furnaces were equipped with a tunnel head, consisting of a stone or brick structure encircling the mouth of the furnace. This, in my opinion, was primarily intended to act as a conductor of the gases, but it must also have served as an aid to the better distribution of the raw material, as we find that this structure was provided with openings of sufficient height and width through which the raw materials were dumped. I understand that a few years ago several furnaces in the Cleveland district, of the customary bell and hopper type, were still equipped with these tunnel heads, but of steel plate construction; and the gas was taken through off-takes at the periphery. After the introduction of the hot blast, quite a number of devices were tried to take the gas off centrally; and provisions were also made for the better distribution of the materials.

The bell and hopper arrangement was introduced into Wales in 1850. In his book "Iron and Steel," Dr. Percy states that when the closed top was first introduced an inferior grade of iron was made in some instances; and he informs us of an experiment which was made in which it was found that upon the installation of the "cup and cone" on a furnace that had previously produced gray iron, nothing but white iron could be produced even with increased fuel. This created some temporary prejudice against the closed top.

Later, after the general adoption of the closed top furnace, a great number of patents were granted on devices for the distribution of materials. The most of these, however, were used at a time when the chemical and physical properties of the raw materials were entirely different from those we find today. Several of these tops had a central gas off-take and were intended to distribute the finer portions of the materials in the center of the furnace to prevent the direct pull of the gas, which might have happened had the coarser materials been dumped in the center of the furnace. In order to get satisfactory penetration and to produce the quality of iron desired at that time, which, of course, was much different from the quality desired today, the diameter of the hearth was small.

These various tops were all designed with the view of distributing the materials to the best advantage under conditions as they were at that time. Foremost among them were the Baumann bell and hopper, the Durham, the Baumann-Firestone and the Witherbee double bell. These various tops have been so well described that I will not go into detail here, especially since they are not in use in this country. The main points of difference were the number of concentric rings of material formed in the furnace. I understand that excellent results were attained with some of these devices and that modified designs are still in use on the lumpy ores in Germany. But on our fine ores of the present day they are impracticable.

## Changes Resulting from Advent of Mesaba Ores

The single bell and hopper with hand-filling remained in general use, with no great change in its general design and no attempt made to charge the furnace by mechanical means, until all other parts of the furnace had been developed to such an extent that it was almost impossible to keep the furnace full. With the advent of the Mesaba ores and the attendant dangers to top fillers due to slipping, many efforts were made to substitute some mechanical means of charging the furnace, but these methods were so crude that they were temporarily abandoned. In some cases the skip was removed and the furnace again filled by hand, which system allowed greater flexibility in the arrangement of the materials on the bell. There are several mechanically filled furnaces, however, which survived this period, one of which is now in operation at Steubenville, Ohio. This furnace is equipped with the Fayette Brown skip hoist, built in 1885, with an orange-peel opening for the receiving hopper, which is square. The No. 1 Lucy Furnace, the skip on which was built in 1884–5, is also in operation at the present time.

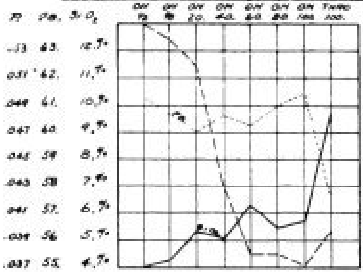
At this period the value of the gas which escaped while lowering the bell was more fully appreciated, and a number of devices were in use to prevent this waste, such as iron lids on the bell rod, which were so placed that the furnace hopper would be covered when the bell had reached the lowest point of its travel.

With the advent of the skip hoist the question of the proper distribution of the lumps and fines presented itself. If the skip hoist with its many attendant advantages was to stay, some mechanical means must be devised for doing what had been easy of accomplishment under the hand-filling system. The evil effects of improper distribution were too many and too serious to be neglected.

With poor distribution, the results on the furnace would not be quite so bad were the chemical constituents of the fine and coarse materials approximately the same; but poor physical distribution is always accompanied by poor chemical distribution. I will not attempt to discuss the question of thorough screening of coke and stone at this time, but it is the universal opinion of furnace operators that these two materials should be as free from dust and foreign material

## ORE-A

GRAPHIC ANALYSIS OF SIFTINGS.

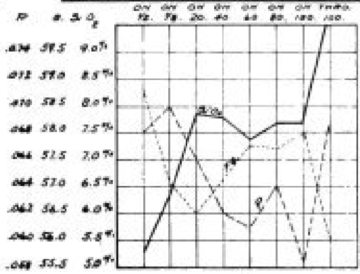


SIEVE TEST.

| | On ½ | On ¼ | On 20. | On 40. | On 60. | On 80. | On 100. | Thro. 100. |
|---|---|---|---|---|---|---|---|---|
| | % 29.06 | % 19.82 | % 8.65 | % 9.62 | % 14.78 | % 0.98 | % 1.16 | % 16.44 |
| $SiO_2$ | 4.00 | 4.20 | 5.30 | 5.46 | 6.35 | 5.85 | 5.70 | 9.80 |

## ORE-B

GRAPHIC ANALYSIS OF SIFTINGS

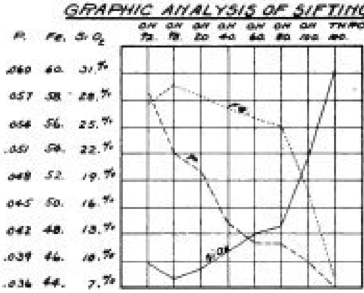


SIEVE TEST.

| | On ½. | On ¼. | On 20. | On 40. | On 60. | On 80. | On 100. | Thro. 100. |
|---|---|---|---|---|---|---|---|---|
| | % 23.81 | % 39.35 | % 16.74 | % 8.65 | % 3.70 | % 1.31 | % 1.00 | % 5.54 |
| $SiO_2$ | 5.19 | 6.37 | 7.86 | 7.74 | 7.45 | 7.48 | 7.64 | 9.80 |

## ORE-C

GRAPHIC ANALYSIS OF SIFTINGS

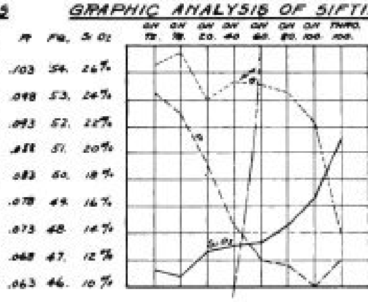


SIEVE TEST.

| | On ½. | On ¼. | On 20. | On 40. | On 60. | On 80. | On 100. | Thro. 100. |
|---|---|---|---|---|---|---|---|---|
| | % 26.17 | % 23.86 | % 11.31 | % 11.43 | % 9.25 | % 3.53 | % 3.63 | % 10.98 |
| $SiO_2$ | 9.80 | 7.13 | 9.34 | 11.49 | 16.44 | 13.93 | 21.34 | 31.48 |

## ORE-D

GRAPHIC ANALYSIS OF SIFTINGS

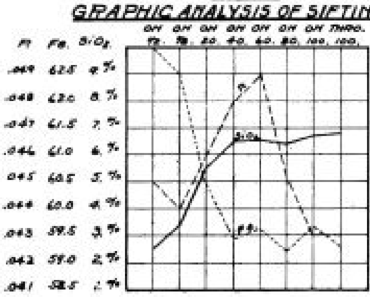


SIEVE TEST.

| | On ½. | On ¼. | On 20 | On 40. | On 60. | On 80. | On 100. | Thro. 100. |
|---|---|---|---|---|---|---|---|---|
| | % 32.12 | % 23.30 | % 12.12 | % 8.83 | % 4.98 | % 3.42 | % 2.48 | % 10.69 |
| $SiO_2$ | 11.33 | 10.76 | 18.12 | 13.49 | 13.48 | 16.09 | 16.31 | 21.30 |

## ORE-E

GRAPHIC ANALYSIS OF SIFTINGS.

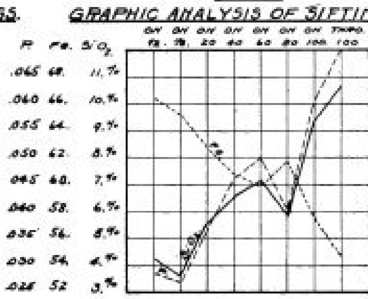


SIEVE TEST.

| | On ½. | On ¼. | On 20. | On 40. | On 60. | On 80. | On 100. | Thro. 100. |
|---|---|---|---|---|---|---|---|---|
| | % 33.81 | % 28.87 | % 7.27 | % 9.15 | % 1.88 | % 3.44 | % 4.98 | % 11.79 |
| $SiO_2$ | 2.43 | 3.34 | 5.63 | 6.46 | 6.56 | 6.47 | 6.74 | 6.93 |

## ORE-F

GRAPHIC ANALYSIS OF SIFTINGS



SIEVE TEST.

| | On ½. | On ¼. | On 20. | On 40. | On 60. | On 80 | On 100. | Thro. 100. |
|---|---|---|---|---|---|---|---|---|
| | % 13.80 | % 43.30 | % 17.90 | % 7.30 | % 4.30 | % 0.30 | % 8.80 | % 2.80 |
| $SiO_2$ | 4.27 | 3.64 | 5.68 | 6.48 | 7.14 | 5.87 | 9.24 | 10.67 |

CHARTS A TO F.

as it is commercially possible to make them. The treatment and preparation of the raw materials are receiving more attention at the present time than ever before, and we should not undo some of the work that is being done along this line through faulty and improperly designed furnace tops. By a study of the six diagrams on the opposite page, which represent five Mesaba ores (A, B, C, D and E) and one very excellent Old Range ore (F), it is readily seen that the percentage of silica in the fines of all these ores is several times as much as it is in the coarser material. That this same variation in analyses occurs in the stone and coke is shown by a brief glance at the table of sieve tests:

### Sieve Tests and Analysis of Limestone

These analyses are direct from the cars:

| | | | | | |
|---|---|---|---|---|---|
| Total weight of stone in No. 1 car | 106,731# | ....... | No. 2 car | 108,785# | ...... |
| Stone above 1¼ inches | 85,042# | 79.70% | | 86,789# | 79.8% |
| Stone thru 1¼ inch and on ½ inch | 11,974# | 11.20% | | 15,031# | 13.8% |
| Stone thru ½ inch | 9,711# | 9.10% | | 6,963# | 6.4% |

Analyses of stone from the above cars:

| | Through 1¼ inch and on ½ inch | Through ½ inch |
|---|---|---|
| $SiO^2$ No. 1 car | 3.83% | 12.24% |
| CaO | 51.87% | 44.75% |
| MgO | .35% | .73% |
| Sul. | .062% | .071% |
| $SiO^2$ No. 2 car | 3.06% | 10.29% |
| CaO | 52.57% | 46.36% |
| MgO | .52% | .47% |
| Sul. | .065% | .093% |

A sieve test was run on all the stone from this last car, passing thru the ½″ and an analysis made of each size with the following results. This was not the worst result obtained, but I am taking this to show conditions we do meet. From one of the cars 11.08 per cent. of the stone passed through the ½″ and gave an analysis of 11.23 per cent. Silica, 41.39 per cent. CaO, .46 per cent. MgO, and .118 per cent Sul.

| | Per Cent. on Sieve | Per Cent. $SiO^2$ | Per Cent. $AL^2O^3$ | Phos. | $FE^2O^3$ | CaO. | MgO. | Sul. |
|---|---|---|---|---|---|---|---|---|
| ⅛ inch...... | 84.71 | 4.09 | 1.92 | .024 | 2.90 | 50.45 | .61 | .075 |
| 20.......... | 6.73 | 8.01 | 3.23 | .040 | 11.51 | 43.44 | .45 | .108 |
| 40.......... | 3.34 | 10.04 | 3.69 | .050 | 26.90 | 32.59 | .44 | .076 |
| 60.......... | 1.08 | 10.41 | 5.77 | .061 | 32.23 | 26.23 | .45 | .135 |
| 80.......... | .72 | 13.52 | 4.49 | .069 | 33.23 | 24.22 | .41 | .082 |
| 100.......... | .36 | 18.09 | 6.84 | .072 | 36.40 | 20.79 | .45 | .139 |
| Pan.......... | 3.06 | 14.73 | 6.38 | .077 | 32.66 | 20.89 | .51 | .131 |

## Analysis of Connellsville Coke and Coke Ash

| | Tests Number | Ash | $SiO^2$ | Sul. | P. | Vol. Matter | Fixed. "C" | Avail. "C"* |
|---|---|---|---|---|---|---|---|---|
| Coke "A".. | 5. | 9.13 | 4.49 | .678 | .010 | 1.45 | 88.51 | 83.17 |
| Dust....... | | 29.19 | 11.83 | 1.054 | .016 | 4.22 | 65.63 | 49.40 |
| Coke "B".. | 5. | 11.53 | 5.84 | .944 | .016 | 1.10 | 86.48 | 79.67 |
| Dust....... | | 22.90 | 11.47 | 1.472 | .021 | 1.73 | 71.67 | 58.44 |
| Coke "C".. | 1. | 9.17 | 4.75 | .721 | .009 | 1.98 | 87.85 | 82.46 |
| Dust....... | | 19.23 | 9.25 | .800 | .014 | 5.14 | 72.63 | 61.85 |
| Coke "D".. | 7. | 11.52 | 5.70 | .953 | .013 | 1.38 | 87.22 | 80.41 |
| Dust....... | | 24.36 | 10.48 | 1.277 | .022 | 3.50 | 72.14 | 58.54 |
| Coke "E".. | 7. | 11.47 | 5.99 | .839 | .010 | 2.16 | 86.37 | 79.78 |
| Dust....... | | 23.99 | 12.61 | 1.890 | .018 | 4.96 | 71.05 | 56.94 |
| Coke "F".. | 7. | 12.18 | 6.16 | .885 | .011 | 1.11 | 87.00 | 79.86 |
| Dust....... | | 26.33 | 13.13 | 1.085 | .015 | 3.47 | 70.20 | 55.45 |

* Available Carbon—Total fixed Carbon minus that necessary to take care of ash and sulphur of coke; also bases to form slag.

## Results of Bad Distribution, and the Remedy

If the materials charged into the blast furnace were uniform in size and chemical analyses, and if, particularly, the ores were always of the same consistentcy as regards moisture, the problem of proper distribution would be easily solved. It is my opinion that ideal distribution, under present conditions, is attained when the materials comprised in any one charge of the furnace burden are so deposited in the furnace that physically and chemically any one sector is the exact counterpart of any other sector, and on any horizontal plane a sector of material shows the maximum fines at the periphery, and a diminution of fines and a corresponding increase of lumps towards the center of the furnace.

Faulty distribution may take a form wherein an excess of the coarser materials is thrown to the walls and an excess of fines deposited toward the center, which is usually repeated with every bell dumped. Under such conditions the ascending gases will follow the lines of least resistance, and as the coarser materials are more easily penetrable, the gases, because of their tremendous reducing power and their high speed of travel, and by reason of the scouring action of the dust which they carry in ascending through the vertical ring, will cut the lining. If this is not promptly observed and corrected, economical operation is out of the question. This has been very closely watched, especially in later years, and often checked in time by the adjustment of one or more of the factors of distribution, resulting in better operation and longer life of the furnace. Such changes as these, wherein an attempt is made to correct some of the inherent defects of a faulty distribution, is dependent upon the closeness of observation of the operator, and when the effects of bad distribution manifest themselves, changes can be made which may correct the evil, but usually after many trials and disappointments.

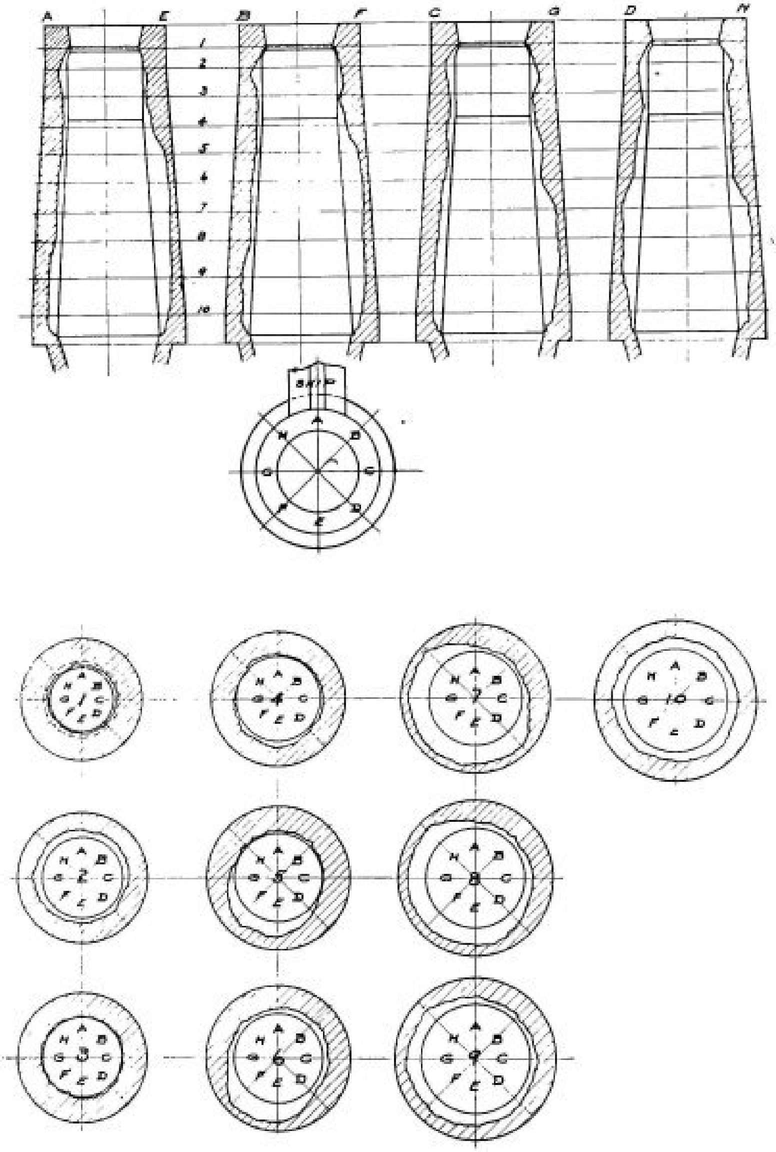
In some cases the order of charging the materials has been changed, speed and angle of dump of the skip changed, and often where certain tuyeres showed the greatest activity and an excessive quantity of coarser materials, one or more of these very active tuyeres have been plugged, thus reducing the activity of that portion of the furnace. This latter course is only a makeshift measure and is merely an attempt to take care of a faulty distribution by an unequal wind distribution. It is but choosing the less of two evils. Under such conditions the bosh above the plugged tuyere or tuyeres will become inactive and allow an accumulation of half reduced ore, coke and stone, which in a short time becomes too heavy, slips into the hearth and chills the iron there in proportion to the amount precipitated. Also, when such faulty distribution exists, the coarse materials in the charge reach the tuyeres in a high state of reduction; and the finer materials, which offer more resistance to the reducing gases, reach this zone in such a condition that the reduction must be completed by solid carbon, which means a tremendous endothermic action. Finer stone, with lower fluxing efficiency, and finer coke with lower calorific value, invariably accompany the finer ores. Thus at that portion of the furnace where we require the greatest amount of carbon to carry on the direct reduction and produce heat, we are not supplied with the agents for meeting the conditions.

In a case where it has been established that it is impossible to get a uniform distribution, we must make every effort to get as close to it as the equipment and the materials will permit; and the furnace will have to be burdened in such a manner as to give assurance that the sections of the furnace giving trouble are supplied with the amount of fuel necessary to furnish the heat and reducing power (and also sufficient porosity in that section) to make an acceptable grade of iron. This is extravagant and wasteful and is adopted only as a last resort.

Faulty distribution increases the amount of flue dust more than any other cause, due in some measure to the vertical shearing action between the sides with the high and low percentages of fines. This in turn causes an irregular descent of the charge, thus creating a disturbance which permits the gases to pick up the finer materials and carry them into the flues. It also increases the top temperature, which is an indication of uneconomical operation.

Should faulty distribution deposit too much fine material at the walls of the furnace, or in a ring concentric with the periphery of the furnace, evils equally as serious as those mentioned above but of a different nature result. It will be readily seen from this, then, that only as the distribution approaches the ideal, can the blast furnace approach the efficiency of which it is capable.

The effects of poor distribution on the furnace lining are very clearly shown in Figs. A and B. Here are seen the lines as they actually exist in a furnace which admittedly suffered from a serious segregation of the lumps and fines, due to an improper design of the top.



Figures A and B.

The question as to what are the main factors that have contributed to the more economical and efficient practice of the last few years has been frequently asked. As many and varied claims have been put forth, this is a most difficult question to answer. In my opinion, among the many other essential improvements, proper credit must be given to the better adjustment of the flexible factors of distribution, such as the dumping angle of the skip relative to the center line of the furnace, speed of dumping, changes in the receiving hopper and skip, changes in the order of charging the material, the order of dumping both on the small and large bell, changes in the size and angle of the large bell, and other factors with which blast furnace operators are familiar. The better mechanical preparation of the raw materials, through screening of the coke and stone and better mixing of the ores in the ore region, also contributed. These latter not only assist in the mechanical feature of distribution but in the proper chemical distribution as well, as is shown by the analyses of materials referred to elsewhere. I believe that the tendency of today to increase the diameter of the hearth and steepen the angle of the bosh, while not eliminating entirely the evils of poor distribution, tends in a great measure to counteract them. Beyond a doubt, the bosh conditions have been improved, and this helps considerably in the more regular descent of the material and prevents excessive accumulation of the fine materials on the walls of the furnace.

## A Brief Description of Modern Methods of Filling

Three requirements have to be met to secure good distribution: First, proper distribution of the fine and coarse materials in the receiving throat and hopper; second, proper distribution of the materials on the big bell; and third, proper distribution of the materials in the furnace. The first is the keynote of good distribution and presents the greatest difficulties at the present time.

With the use of manual labor on the furnace top, good distribution is easily obtained. In hand-filling the buggies always go to the top in the same sequence, i. e. the first or leading buggy always containing the same ore, likewise the second, third, etc. As the top of the furnace is always divided off into an even number of spaces (generally six spaces), each charge can be easily rotated with reference to the charge below by simply advancing the ore buggies one space in the circumference of the hopper. By this method, any irregularities—such as dumping an extra buggy, or the ore overlapping on dumping the last two buggies of an eight-buggy charge—are taken care of after six rounds or charges are lowered into the furnace.

So far as the distribution of raw materials is concerned, hand-filling has always been considered very nearly perfect. But to obtain large tonnage output a radical change had to be made, and the high labor cost in hand-filling warrants a heavy investment in equipment for the large production. The mechanically filled furnace was the natural sequence. The early skip-filled furnaces were built without much thought to distribution. The life of the lining was consequently very short and the campaign very troublesome. In many cases the skips were simply placed on old furnaces that had done good work with hand-filling. This usually developed a poor working furnace and the skip-filling was blamed. Operators and engineers attacked the problem with the result that various designs of furnace tops were brought out, among them the following:

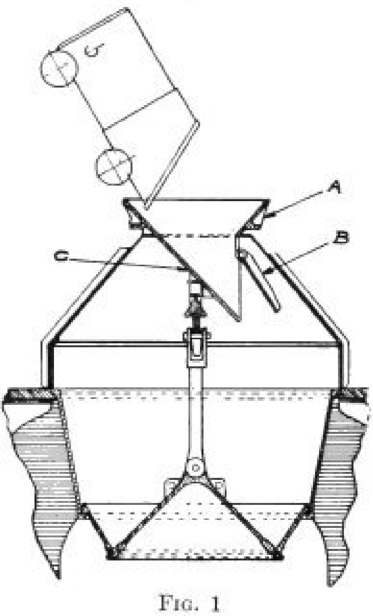


Fig. 1

*Brown Top.*—One of the earliest designs to prevent bad distribution caused by skip filling was the Brown rotating top. In this the attempt was made to follow the hand-filling method as closely as possible. This top (Fig. 1) has a spout C, with gas seal B in the form of a flap door at the lower end to prevent the escape of the gas when the bell is lowered. The door is operated by the flow of material to the big bell. The receiving hopper A and spout C rest on ball-bearings and are rotated together, either by the operation of the skip car or independently, a predetermined number of degrees, slightly less than 90 degrees. By this method a series of piles are placed around the big bell, each pile representing a skip load.

One of the objections to this top is the location and form of the material deposited on the large bell, depending on the position of the spout relative to the skip. If the spout is pointing directly opposite the skip incline, the speed of the ore leaving the skip and down the spout will throw the ore considerably further away from the center of the bell than when the spout is pointing directly under the skip. With the spout in the last-named position, a direct reversal of the flow of the ore must take place, with consequently reduced speed, and in an intermediate position we will have the fault varying between these two extremes. Various methods have been tried to overcome this fault, but none has worked out satisfactorily; and although it approaches the hand-filling method, the fundamental trouble mentioned above has not been removed.

*Straight Double Bell Top.*—This consists of a receiving hopper into which the skip or skips dump (depending on whether the furnace has a single or a double skip), and a barrel, either straight or slightly tapered, with a small bell fitting it at the lower end. Under the small bell is the large bell closing the top of the furnace. These are the fundamentals of a straight double-bell top; but there are many points that must be kept in view in designing a top of this description, as they all have considerable influence on the final distribution desired. Some of the fundamental points are: First, the size and shape of the skip car; second, speed of dumping; third, angle of dumping; fourth, facilities for regulating the dumping position, and maintaining it at an exact point after this has been determined, even with varying loads and ore conditions; fifth, shape of receiving hopper; sixth, dumping close to the center line on both axes, so that the lumps and fines will not segregate to separate points in the barrel; and, seventh, the barrel should be of such diameter (not exceeding 5 feet as a maximum) and of such a length as to hold one full skip of coke.

With these points in view, a top can be built that will do good work; but, as a general proposition, the most successful straight double-bell top, of which we have numerous examples in this country, are the result of the continual altering and changing over a number of years. The weak points are noted and eliminated as the opportunity affords, until the materials are distributed correctly on the bell. Local conditions will not permit such change in many cases without radical alterations; and often the installation of a rotating top will straighten out a bad distribution and correct errors that cannot be corrected in any other way without complete rebuilding of the top of the furnace and the skip incline.

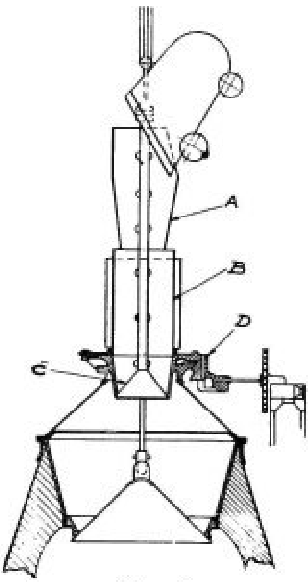



Fig. 2

*McKee Revolving Top.* — The McKee revolving top (Fig. 2) is a well-designed straight, double bell top, with the additional feature that the barrel is not connected to the receiving hopper but, with the small bell, rests on ball-bearings and is revolved by a train of gears direct-connected to a motor or by cable to a drum with a motor at the bottom of the furnace. The small bell and barrel are revolved around the center line of the furnace, so that any errors of distribution on the small bell can be spread and equalized over the entire circumference.

The method of operating the top varies considerably. Some operators revolve each skip load of a six-skip charge through an angle of 60 degrees with reference to the load immediately preceding. Others deposit a complete charge on the bell from the hopper in its original position and then revolve the top through an angle of 60 degrees before dumping the materials of the succeeding charge. In either case the cycle is completed in six successive movements of the top.

With the highly developed automatic electric control, the rotation of the top in either of the desired cycles is taken out of the skip operator's hand, being operated in connection with the skip. Thus the top must be revolved in the predetermined cycle if the skip is operated.

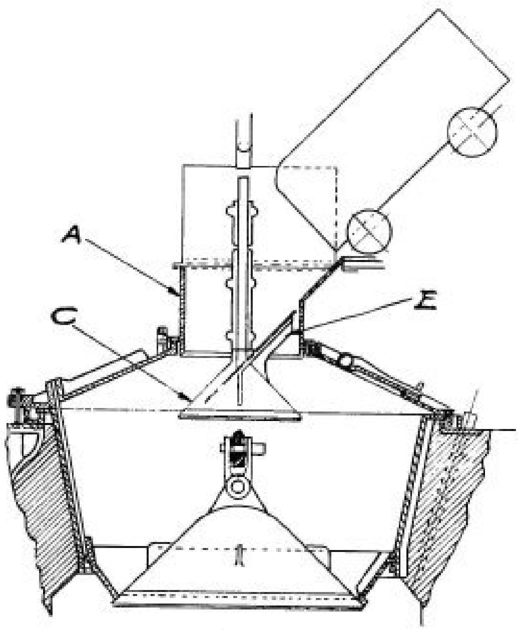



Fig. 3

*Baker-Neuman Revolving Top.*—This top (Fig. 3) consists of a revolving hopper, A, with a small bell, C, on which is attached deflecting plate B. The small bell, with the deflecting plate, is revolved 87 degrees and 30 minutes as the bell is raised. This rotation is accomplished by means of a rifle barrel arrangement at the upper part of the small bell rod.

The skip load is dumped on the large bell with the deflecting plate and small bell in the lowered position, the principal function of the small bell being to act as a gas seal when the large bell is lowered. This top has a tendency to put the raw stock in piles, but not as distinctively as the Brown top.

*Kennedy Top.*—This top resembles the McKee top in many particulars, and is rotated by a cylinder on top or by means of ropes attached to driving mechanism at the bottom.

*Neeland Top.*—I have left the discussion of this top until the last because, although it was one of the first tops designed for the mechanical filling of a blast furnace, I regard it as a most excellent filling system. The four original furnaces at Duquesne were for several years the only furnaces in this country equipped with this system.

About ten years ago the good qualities of this top began to be appreciated and a number of furnaces have since been so equipped, many of them varying somewhat from the original but not in principle. The improvements have been due to modern conditions as it must be remembered that this top is twenty years old.

The Neeland system (Fig. 4) consists of a cylindrical bucket with a bell in the bottom to which there is attached a stem by means of which the bucket is carried to the top of the furnace and placed on the gas seal. The material in the bucket is deposited on the big bell by lowering the bell in the bottom of the bucket. After the bucket is emptied the bell is drawn up and then taken down the incline and deposited on the scale car (as originally built), or placed on a turntable (Forbes-Parkes modification) or held at the bottom permanently attached to the trolley by means of a swivel, as at the Youngstown Sheet and Tube Company's furnaces.

It was noticed at Duquesne that as the ore flowed from the chutes into the bucket there was an unequal distribution of the lumps and fines, which resulted in the cutting of the furnace lining at some point. To remedy this the scale cars were equipped with revolving tables on which the buckets were set and are revolved continuously while the ore is flowing, or revolved a certain number of degrees after the bucket is full. By thus revolving the bucket, the lumps and fines are uniformly distributed, as has been shown by many tests.

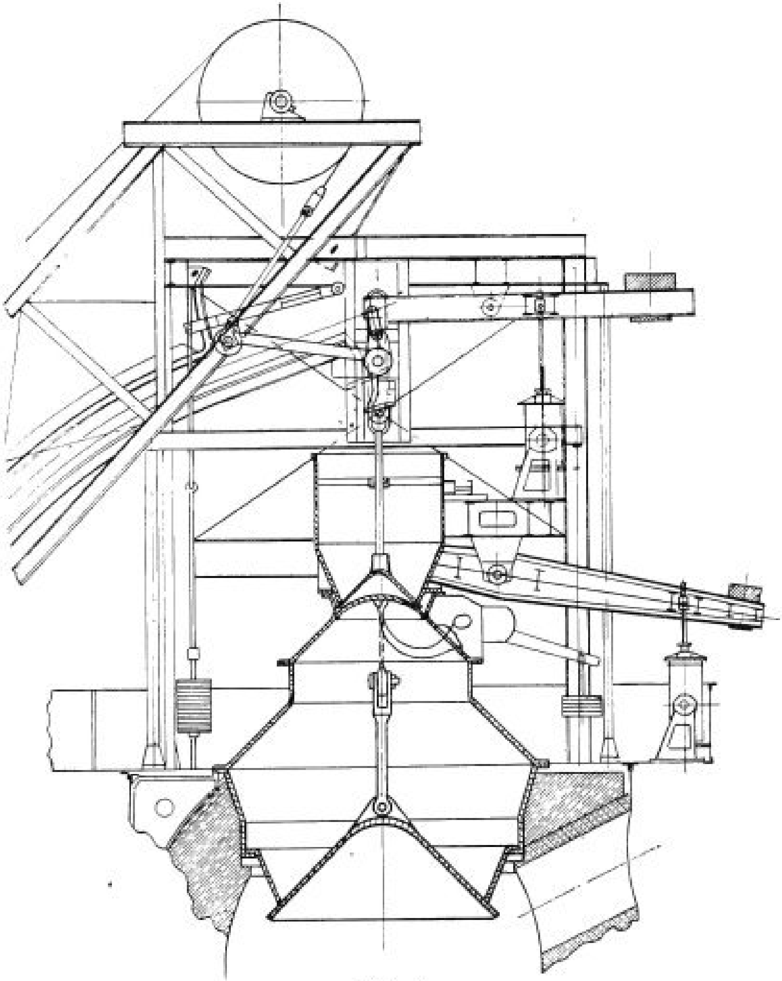


Fig. 4

A further modification of the original scheme is to discharge the charge from the larry car into the bucket as it hangs on the trolley and then rotate the bucket a certain number of degrees. The rotation is accomplished by means of a rack attached to a hydraulic cylinder meshing into a pinion in the stem of the bucket before the bucket goes to the top.

The great advantage of this system is that all the mechanical and electrical devices used to revolve the charge are located at the bottom of the furnace, away from the heat and dust, and are continually under the eye of the operator.

These brief descriptions cover the tops generally used in this country. The selection and design must be left to the furnace management, and they must be governed by the local conditions, with the two main requirements kept in view: First, as nearly perfect distribution of the lumps and fines around the big bell as it is possible to attain (and it is not so important that this equal distribution should obtain with every charge as it is that it shall be attained over a certain number of charges); and second, that continuous operation of the device is essential. No charging apparatus should be installed that will cause numerous and costly delays for repairs and adjustment.

A rotating top is a most desirable refinement, but it is not a cure for all the "ills and ails" to which a blast furnace is subject. It will go far, however, toward ironing out and smoothing over some of the troubles of poor distribution and leave the operator's mind comparatively free to take up other pressing questions which may confront him.

## Distribution on the Large Bell and in the Furnace.

After the small bell has been lowered and the contents deposited on the large bell, no change in circumferential distribution can take place; but the question presents itself as to the quantity of the various materials and the disposition of them vertically on the large bell, also the cycle of lowering the charge into the furnace. There also enters the problem of what might be termed as radial distribution.

A study of the actual charges of raw materials, starting with the drawing of the ore and stone from the bins into the larry cars, dumping them into the skip buggy, then on the small bell, then on the large bell and finally into the furnace, has produced varied and interesting results.

A few years ago it was possible to obtain very good results with a thick stratum of ore and a corresponding thick stratum of coke; but as the percentage of Mesaba ores increased their fineness increased also, and the Old Range ores deteriorated physically or disappeared entirely, and we were left with our iron-bearing material forming a dense layer or ring in the furnace and no lumps to afford the freer passage of the ascending gases. That the increase in the physical fineness of the ores has brought about necessary changes in the methods of charging the furnace, as well as changes in the lines, is shown by the records of furnaces made years ago when the very best Old Range ores were used with about 30 to 35 per cent. of the best Mesaba ores.

From the practice on the Duquesne furnaces in the years 1897–8–9, according to Mr. Diehl's figures given in his discussion of Mr. Brassert's paper on blast furnaces, read before this Institute in 1915, we find that these furnaces produced 502 tons of pig iron with 1,979 lbs. of coke per ton, with a stove temperature of 948 degrees and a yield of about 60 per cent. The lines of these furnaces were not modern, in that they did not have the large hearth and the steep angle bosh, but that was unnecessary with the grade of materials used. As the percentage of Mesaba increased and the theoretical yield decreased, our furnace practice showed a marked falling off, as is shown in the following table, which is the average of a large number of furnaces in this country using Lake ores, taken from Mr. Brassert's paper mentioned above:

| Year | Per Cent. Mesaba | Lbs. Coke per ton Iron |
|---|---|---|
| 1902 | 42.8 | 2,155 |
| 1903 | 50.3 | 2,191 |
| 1904 | 55.0 | 2,239 |
| 1905 | 61.0 | 2,275 |
| 1906 | 65.2 | 2,345 |
| 1907 | 68.7 | 2,365 |

During the period above mentioned, general improvements in the furnace plants were under way, such as increasing the stove capacity, purifying the gases, steepening the boshes, and many other changes for the better and more regular operation of the furnace. These improvements produced remarkable results in the economical production of pig iron, through greater yield, better coke practice and lower cost, even in the face of theoretical yields averaging considerably lower than that of the ores ten years earlier.

But, with all the mechanical improvements in the methods of charging and better preparation and selection of the raw materials, too much importance cannot be given to the question of the actual manner of preparing the charge before it goes into the furnace and to its delivery into the furnace proper.

The large charge of 14,000 to 16,000 lbs. of coke and 30,000 to 35,000 lbs. of ore, with the necessary amount of stone, forms thick heavy layers of each material; and although the coke does not offer much resistance to the gas, the heavy layers of ore, especially that part thrown towards the center of the furnace, prevents the free ascent of the gases. The gases in their ascent, following the paths of least resistance, cause imperfect and incomplete reduction of the ores in the denser part of the charge. This condition can be overcome only by direct carbon reduction in the lower part of the furnace.

To remedy this the charge is often split in two, thereby cutting the layers in half, which gives us a ring of ore of maximum thickness near the walls, tapering off gradually towards the center, where the lumps have a tendency to roll. This method has been demonstrated to be an improvement over the large charge, but a condition may arise wherein we have too much ore close to the walls, and too much coke towards the center. This would cause the center to travel too fast with respect to the materials close to the walls and result in greater loss in flue dust.

With the results for the years 1902 to 1907 before us, during which period the percentage of fine Mesaba ores was on the increase, it is readily seen that our general blast furnace practice was going backward. Many changes were made in design, equipment and practice. Among other problems attacked the question of filling received considerable attention. During that period the thick strata of materials were used quite extensively. Practice demands that a certain amount of ore must be deposited close to the furnace wall to prevent too much gas following this path. If the theory is correct that a more intimate mixture of the ore, coke and stone would permit of a better reduction of the ore, because of the more intimate contact of the ore and the gas, due to the more uniform distribution of the gas, then the proposition resolves itself into the adoption of a system whereby we get the requisite amount of ore against the wall, and the remainder of the ore, coke and stone intimately mixed and uniformly distributed over the entire area.

This system of charging was effected by filling and operating the bell as follows—assuming for illustration, a 15,000 lb. coke charge:

7,500 lbs. coke on large bell—Dump same into furnace.
½ stone and ½ ore on large bell—Dump same into furnace.
7,500 lbs. coke, ½ stone and ½ ore on large bell }—Dump same into furnace.

The first section gives us a thin layer of coke practically uniform in thickness over the entire area of the furnace, with the ore and stone intimately mixed and deposited close to the walls, some of the lumps rolling towards the center. In the second section, the coke is placed on the large bell and the ore and stone intimately mixed on top of it; and, upon lowering the bell to deposit the charge, it is observed that only a small part of the coke leaves the bell before the ore and stone begin to break through and mix with the coke falling from the large bell into the furnace. As this section lies in the furnace, it is found that we have a very thorough mixture of ore, coke and stone throughout the entire layer.

That this method of filling and distribution in the furnace is satisfactory is proved by the work of one of our Mingo furnaces for the year 1915:

| | |
|---|---|
| Average tonnage per day... | 534.4 tons. |
| Average coke per ton, Pig Iron............ .... | 1,994 tons. |
| Average loss.... .... .... | 2.29 per cent. |
| Blast temperature..... ... | 891 degrees Fahr. |

The blast temperature of 891 degrees Fahrenheit is particularly noticeable, it being all the stoves will produce; and when we compare this furnace with other furnaces working similar raw materials with stoves capable of giving an average temperature of 1,200 degrees Fahrenheit, we must give some credit to the filling method described.

A proof that this method of charging is conducive to good results is this: On changing to the thick coke and ore layer, we were unable with the same burden to maintain our hearth temperatures with the heat at our command; and not even in the face of a 10 per cent. reduction in the ore burden did the temperature return. On changing the filling back to the other method, the furnace returned to its normal condition as soon as the charge reached the tuyeres. This was done on two separate occasions with the same results.

Many methods of placing the materials on the large bell and depositing them in the furnace are now in use and I have experimented with a large number of them; but the method described above has given very satisfactory results over a long period of time and may prove of value to other operators under similar conditions, especially where a large percentage of fine ores are used.

## Large Bell.

The almost universal use of the large bell, without distributors of any kind, has standardized its dimensions for furnaces of various stock lines and those using Lake ores. After a careful examination of a large number of furnaces, it was found that the diameter of the bell is generally 4 feet less than the diameter of the furnace stock line, although there are a few cases where this difference in diameter is somewhat less, but the above seems to be the accepted figure on large furnaces with 15 feet to 17 feet stock lines.

The angle of the bell in many cases has been increased from 45 degrees, the standard for many years, to as high as 53 degrees, and the entire surface machined. This has been done in order that the wet and sticky ores will clear the bell and spread in a uniform stratum over its entire circumference. If the ore leaves the bell in an uneven stream after the lowering of the bell is started, it will cause the bell to swing, and the materials still to leave the bell will disturb the distribution and the lay of the raw materials in the furnace.

## Distribution Below the Large Bell.

*Killeen Distributing Ring.*—The Killeen stationary distributor consists of a tapered cast steel ring, about 6 feet

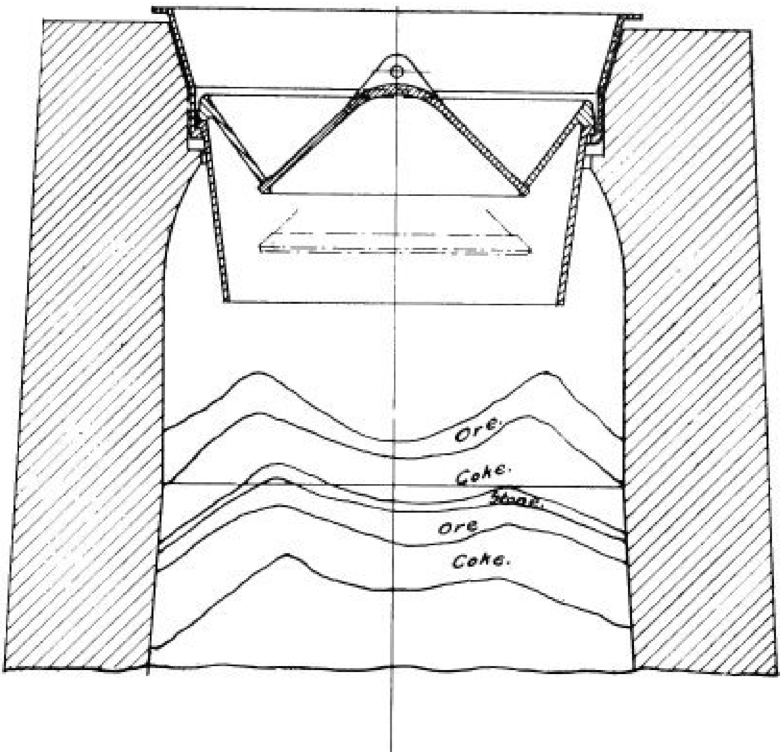



Fig. 5

6 inches long and 11 feet to 11 feet 6 inches in diameter at the smaller or lower end. The large bell is reduced to about 9 feet 6 inches in diameter. These dimensions apply to furnaces with a top 16 feet to 17 feet in diameter. The material leaves the large bell, strikes the distributor and is

deposited in a ring, as illustrated in Fig. 5. This gives a ring with the maximum fines, the apex of which is about 3 feet away from the wall, the coarser materials rolling to the center and wall.

The idea in designing this distributing ring was to throw the coarser materials closer to the walls, affording an easier passage of the gases, thereby maintaining cleaner walls. During the time of the lower percentage of Mesaba and higher percentage of coarser ores, this ring produced results that compared very favorably with those obtained on furnaces using the large bell and no ring. As the Lake ores increased in fines, however, furnaces equipped with the Killeen distributor experienced more and more trouble with high pressures and irregular movement of the stock with resultant high coke and low tonnages. It was readily seen that though our walls were kept comparatively clean we were unable to force the air and gases through the heavy mass of iron-bearing material so far away from the tuyeres. The physical conditions of the ores finally reached that point where it was almost impossible to keep the furnace moving and it was necessary to go to the large bell.

Below is a comparative statement showing the results obtained on a furnace with a Killeen Distributing Ring and the same furnace without the distributor but with a 12 foot bell—11 months' operation in both cases:

| | Tons per Day | Lbs. Coke per Ton Iron |
|---|---|---|
| With Killeen distributor........... | 497.7 | 2,240 |
| Without Killeen distributor........ | 531.1 | 2,029 |

This type of ring served one good purpose in that it protected the stock line of the furnace, but operating conditions were such that we could not afford to pay the price for this protection.

*McDonald Distributing Ring.*—This distributor (Fig. 6) differs from the Killeen in that the large bell is of standard diameter, the same as would be used without the distributor, and the distributing ring is raised or lowered as desired. The usual method of operating this type of top is to keep the distributor in the upper position clear of any materials as it leaves the bell for three or more charges. The distributor is then lowered and the succeeding charge is dropped into the furnace.

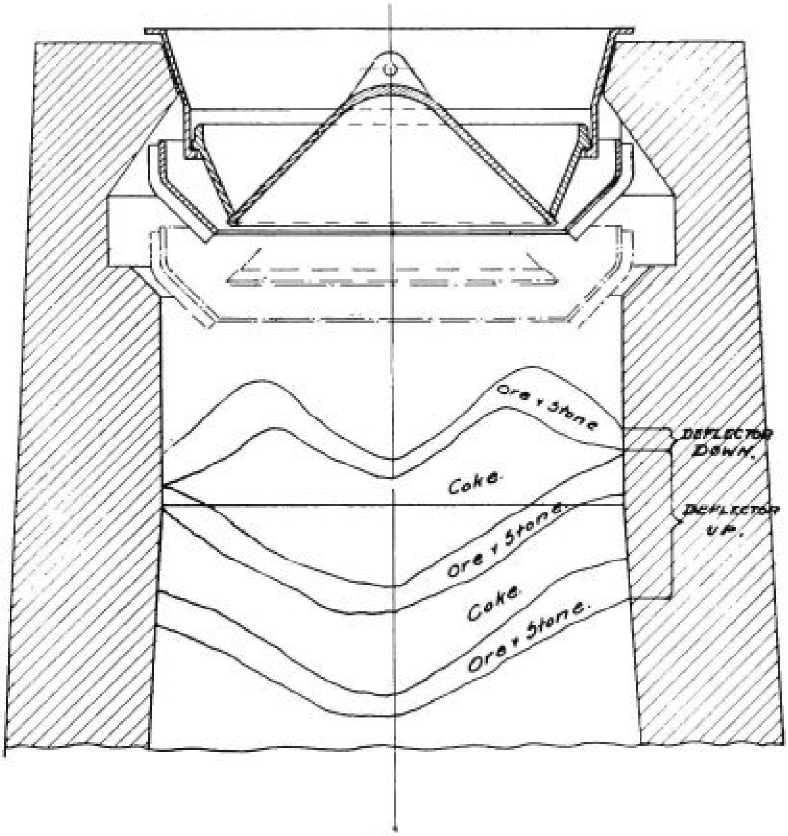



FIG. 6

Having a movable distributor, the operator can throw the fines toward the wall from the large bell, the distributor being in the upper position and out of the path of the raw material; or, by lowering the distributor, the operator can throw the major portion of the coke to the center of the furnace, with the fines and most of the ore away from the wall.

*Slick Distributing Ring.*—One of the latest developments in distributing rings below the large bell is the one designed by E. E. Slick, as shown in Fig. 7. This distributing ring is permanently set in the furnace top and combines some of

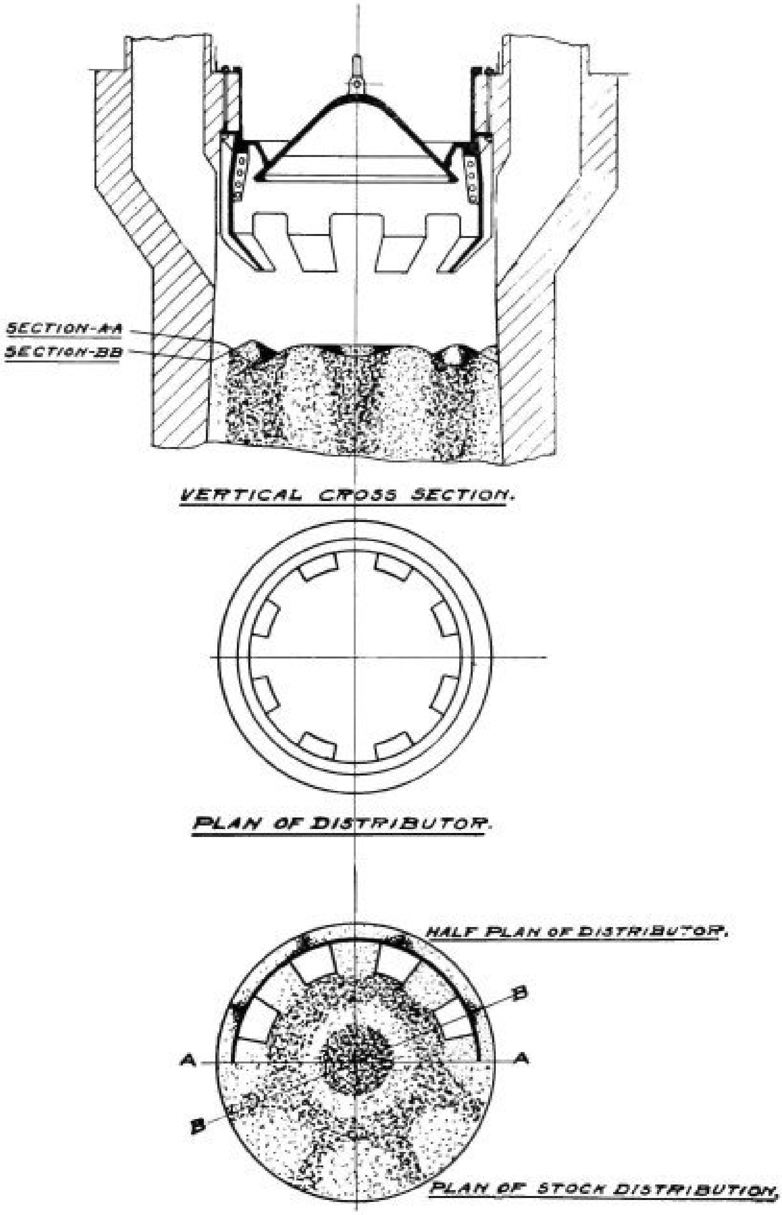



FIG. 7

the features of the Killeen and McDonald rings, with the further and radical development that the lower portion of the ring consists of a number of fingers equally spaced, with the lower end projecting inwardly.

As the material leaves the large bell, those portions which impinge upon the fingers are deflected toward the center of the furnace, the portions which pass between the fingers continue in their travel outwardly towards the wall of the furnace, and that which impinges against the upper portion of the straight ring or skirt drops more or less vertically.

In this way the charge is deposited in the furnace so as to form a number of vertical columns of finer material. These columns are formed by the separation of the coarser portions of the charge which roll down from each of the small mounds formed on the surface at the stock line.

This design permits of a relatively uniform ascent of the gas, due to the lines of greater porosity surrounding the denser columns of fine materials, and also tends to give a more intimate mixture of the raw materials over the entire area with a certain percentage of fines close to the walls, which latter condition we have found is so necessary for our operation. The use of the Slick distributing ring has shown some meritorious results.

As such excellent work is being done on furnaces without a distributing device below the large bell, their necessity is not apparent, at least under our present conditions.

## Economic Importance of Improved Blast Furnace Operation.

So much for the technical and present-day aspect of this problem of distribution, the importance of which will not be underestimated by any furnace operator. Smooth operating, quality of product, minimum labor cost, low fuel consumption, high yield and large tonnages, are all matters of prime importance today. But no paper on this subject would be complete that did not at least touch on that great economic problem wherein the practice of today has its direct bearing on the problems of tomorrow. I refer to the conservation of our natural resources, and particularly to the conservation of those raw materials connected with the iron and steel industry.

Nature has bountifully endowed us. The largest and richest coal and ore deposits have been given into our keeping for our own use in this generation and as trustee for future generations. If we are to discharge that obligation conscientiously, we should see to it that in this, our generation, all metallurgical processes and operations shall be so conducted that waste and loss in raw materials are reduced to that point which, based on our ability, is the lowest practical limit.

The estimated amount of iron ore to be brought down from the Lake Superior region this year reaches the enormous figure of 66,000,000 gross tons, practically all of which is to be used for the production of pig iron. If by more perfect distribution of our raw materials in the blast furnace and with other improvements that could be effected in many furnaces, an increase of only one-half of one per cent. of the metallic yield should be effected over this entire quantity of Lake ore, it would mean that 610,000 tons of ore could be reserved annually for the future.

As the more perfect distribution reduces our metallic loss, so does it reduce the coke consumption, as they go hand in hand; and if we could reduce our coke consumption for the smelting of this quantity of ore by 5 per cent., we would save 1,750,000 tons of coke, with 2,500,000 tons of coal left in the mines for future generations to use.

The thought of effecting an increase of one-half of one per cent. in yield and 100 lbs. of coke per ton seems small when we talk of them in our every day practice, but in the aggregate they amount to large figures.

If we convert the 610,000 tons of ore and the 1,750,000 tons of coke into dollars and reconvert this money into labor, where the larger part of the cost originated, we can appreciate not only the loss of the raw material but the enormous economic loss represented by labor.

# THE DISTRIBUTION OF MATERIALS IN THE BLAST FURNACE

Discussion by Arthur J. Boynton

Superintendent of Blast Furnaces, National Tube Company, Lorain, Ohio

I wish to base my discussion of Mr. Vreeland's practical and interesting paper on three of his statements, as follows:

> The equations of the blast furnace have so many variables and so few constants that almost any one can solve the equation for the particular variable for which he is looking and apparently prove it to be correct.
>
> A top can be built that will do good work; but, as a general proposition, the most successful double-bell tops, of which we have numerous examples in this country, are the result of continual altering and changing over a number of years. The weak points are noted and eliminated as opportunity affords, until the materials are distributed correctly on the bell.
>
> A rotating top is a most desirable refinement, but it is not a cure for all the "ills and ails" to which a blast furnace is subject. It will go far, however, toward ironing out and smoothing over some of the troubles of poor distribution, and leave the operator's mind comparatively free to take up other pressing questions which may confront him.

I have not time to discuss the matter of radial distribution below the main bell further than to say that definite and positive knowledge as to what this should be and why, is, from the nature of the case, almost impossible to obtain. The problem of circumferential distribution, as Mr. Vreeland defines it, although complex enough, is much more easily capable of scientific solution, and I wish to speak of means of accomplishing this end.

## Many Variables; Few Constants

Amplifying Mr. Vreeland's statement with regard to the tendency of all blast furnace men, and probably all other men, to solve an equation for a particular variable, especially when in trouble, I think it is true that the matter of distribution—that is, distribution about the main bell—has been complicated by the presence of other influences, some of which are generally appreciated and one to which, so far as I know, little reference has been made.

Thus, the tendency of an insufficient number or insufficient area of downcomers has been generally supposed to cause enough loss of fine coke and fine ore at a point under the downcomers to cause hot working at these points.

The remedy for this condition, which consists in increasing the area of the furnace at the level of the offtakes, and increasing their number and årea and their angle with the horizontal, is well understood and has been applied to many furnaces.

There existed, also, and still exists, the problem of what is called "wind distribution." To a considerable extent, this was only a resultant of bad stock distribution, since an overburdened or finely burdened section of the furnace will not take its due share of wind. Wind distribution, as Mr. Vreeland has said, is affected by plugging or reducing the size of certain tuyeres, which was formerly often done to prevent break-outs at the tapping hole. Stronger hearth jackets have largely prevented the necessity for this practice, excepting as a result of bad stock distribution.

Wind distribution is apparently little affected by the drop in pressure around the bustle-pipe. I have attached a differential gauge to the bustle-pipe of a furnace immediately over the blast inlet and on the side opposite and have never found more than two-tenths of an inch of mercury difference in the static pressure.

Experiments which we have recently made with regard to the difference in temperature of blast in the tuyere stock immediately under the blast inlet and that opposite, in three different furnaces whose stoves are supplied with washed gas, showed a practically constant drop of nearly 50 degrees Fahr. from one side to the other. Just what the effect of such a constant difference in temperature may be is, like everything that goes on in the blast furnace, a matter of speculation.

I believe, however, that the hotter blast tends to premature melting, and to increased wind on the side next the blast inlet. If this difference happens to aggravate an error in stock distribution, the contour of the stock column is very possibly affected so that the hot side is low, with a tendency for coarse coke to remain close to the hot side, thus making the effect cumulative, in which case there will be very one-sided working and rapid destruction of the lining. The remedy for this condition lies in the use of insulating brick in the bustle-pipe, for which there is apparently a more important reason here than at the hot-blast main or stoves, or possibly in the use of a tapered bustle-pipe, which will decrease the surface of the pipe relatively to the amount of air flowing. These pipes were formerly tapered by dust in the pipe, and the clear pipe following the advent of washed gas has doubtless increased the radiation, which high blast temperature also increases.

When all these variables existed to a greater degree than they now do, there grew up certain rules for locating downcomers, hot blast inlets, tapping holes and skip hoist with reference to each other about the circumference of the furnace. These rules were formulated by men of experience and good judgment, and were no doubt correct for the conditions as they existed locally and temporarily. They would not, however, apply where one variable was changed, consciously or unconsciously, and much grief was occasioned by borrowing a rule without sufficient understanding of the reasons for its existence.

So long, then, as these other variables exist, the problem of stock distribution is complicated by their presence, and a top developed, as Mr. Vreeland says, by "continual altering and changing over a number of years," can only be correct with reference to all these variables as they exist, and is very possibly incorrect from the standpoint of distribution alone.

I wish to urge the importance of elimination of the other variables mentioned, in order that the study of the more complex matter of distribution may be done with more intelligence and more certainty, believing that so long as we are able to observe only the resultant of several interreacting causes, we have no sound basis for success.

## Some Experiments Epitomized

The study of means of distribution cannot be carried to any very satisfactory conclusion by means of the small scale models mentioned by Mr. Vreeland. Certain of the grosser errors can be identified and corrected by this means but a full-scale model is required for anything approaching accuracy. I have had the opportunity to study distribution with such a model and wish to state certain conclusions, as follows:

1. Observations of bulk distribution on the main bell may seem practically correct when there is marked difference in weight and in segregation of coarse and fine material in the different quadrants, so much so that no experiments on distribution are of much value without weighing and screening.

2. Repetition of the experiments without change to the model showed practically constant results, so long as the character of the material did not change.

3. Slight changes in the model produced very considerable effect on the distribution.

4. A shape of receiving hopper which will be practically correct for ore alone, or for coke and stone alone, can be designed, but we were not able to design a hopper which was correct for both classes of materials, and the receiving hopper which resulted from these experiments was in the nature of a compromise.

5. With any given receiving hopper the distribution is influenced by the angle, speed and path of dumping of the skip car, and especially by variations in moisture in the stock.

6. Judging by the experimental distribution, and by the performance of the furnaces, marked segregation of fine coke and fine stone into one quadrant of the furnace will make this quadrant work colder than others more heavily burdened but free from this segregation.

After a series of campaigns under the top resulting from these experiments, we have installed the McKee revolving distributor on the three furnaces last out of blast, and I have been asked to amplify Mr. Vreeland's reference to this top.

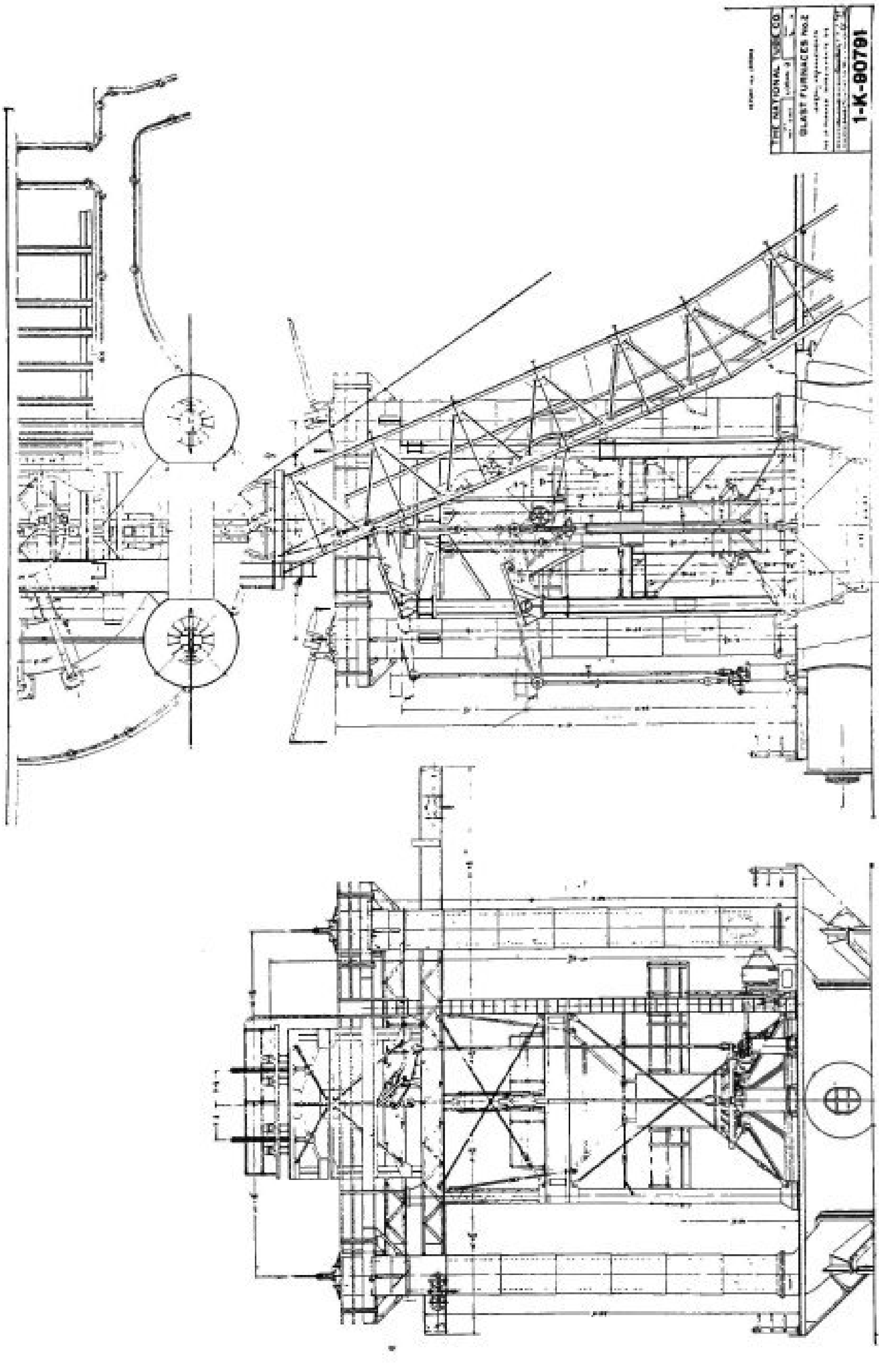
As the name is generally used it has been somewhat confusing, because it has been applied not only to a complete design of top, but also to a peculiar method of rotation which can be applied to any standard double-bell top. It is of this system and method of rotation that I wish to speak, rather than of the details of design which apply to all double-bell tops.

As Mr. Vreeland has stated, the number of points and cycle of operations may vary, but the usual practice with this top is now to rotate through an angle of 60 degrees and multiples of this angle, and to handle a complete charge with each arc of rotation. The skip loads of material forming the first charge are successively dumped and held on the small bell and lowered onto the main bell with no rotation. The succeeding charge is handled in the same way, excepting that the throat of the furnace and the small bell are rotated 60 degrees after receiving each skip load and before it is dumped onto the main bell. The skip loads of the next charge are rotated through 120 degrees, and so on until the sixth charge, with each skip rotated through 300 degrees, completes the cycle.

The effect is as though the furnace itself were rotated, or as though the bin system and skip bridge were rotated about the furnace 60 degrees after each charge.

The scheme is based on the observed fact that most of the errors of distribution are constant in their tendency if not in their extent, and that many which vary at different times are constant or nearly so at any given time.

Thus, the segregation of coarse and fine material due to a definite shape of bin and larry car will exhibit a constant tendency to appear at some one point in the furnace. The tendency may be more or less marked, according to moisture, frost, etc., in the stock, but its extent will be nearly the same at any given time. There will always be




General view of McKee distributor.

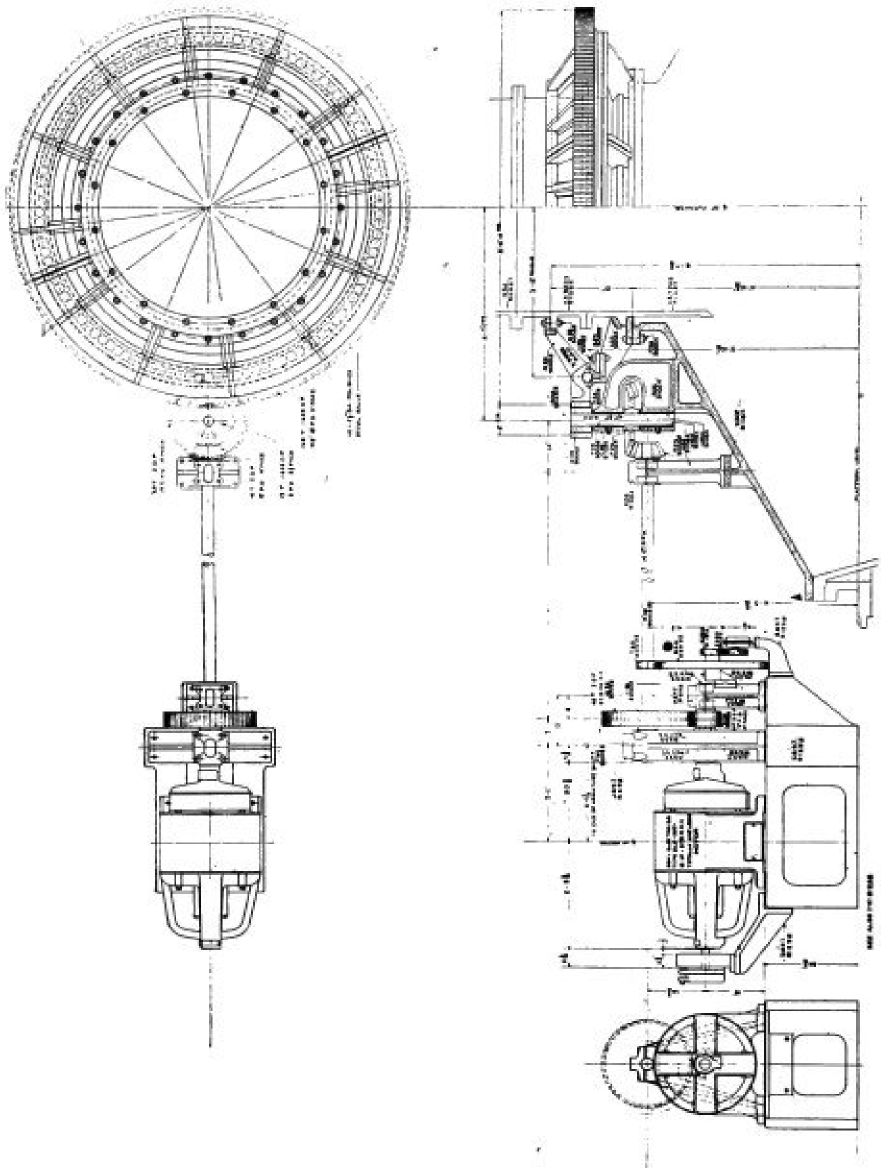
a tendency toward excess of one material or another at some point in the furnace, due to the shape of any given receiving hopper, which tendency may be greater or less as it is influenced by the angle of dumping of the skip car. The length of the cables controlling this angle may vary appreciably within twenty-four hours, but it is practically constant during any given cycle of operation.

This class of errors, therefore, can be largely corrected by a revolving top operating upon the principle described above.

I have appended two drawings, one showing a general view of the McKee distributor as applied to a furnace top at Lorain Works, and the other a detailed assembly showing the mechanism used to rotate the throat or barrel, and have given below additional details as to the installation and operation.

To the much-discussed question as to whether it is necessary and advisable to complicate furnace construction and operation by the installation of revolving tops, there are two answers: First, that mechanical and electrical progress, not only in building the rotating mechanism, but also the furnace itself, have made the complication almost inappreciably small; and second, that modern progress is not satisfied with any distribution short of the very best obtainable. The investigator who has gone through the costly and cumbersome experiments necessary to approximately good distribution in a stationary top is forced to admit that its limit is far from perfection, that his good distribution becomes poor distribution by a change from dry stock to wet, and that the variables due to weather and condition of stock which are most hopeless with a stationary top, are those which rotation easily corrects. The idea that stationary distribution is good enough will shortly disappear, unless it can be shown that distribution is better without rotation than with it, an argument which so far I have never heard.

Good distribution requires, therefore, in my opinion, first the elimination of other errors which may be confused with those of distribution; second, the experimental develop-



Mechanism used to rotate barrel of McKee distributor.

ment of a good stationary top, and, third, the refinement of the distribution thus obtained by rotation as described.

### Details of Installation

In addition to the parts shown, the installation includes a ball race at the top of the small bell tube and a magnetic control for automatic rotation. This control is located on the ground level, usually in the skip engine house, can be built for any number of points of distribution and skip loads per charge, and, as long as this cycle is followed, is entirely automatic. By throwing out the automatic control, hand control may be substituted. Rotation is started by contact made by a nut on a lead screw which revolves with the skip engine, contact being made when the engine reaches the end of its travel.

A dash pot in the system may be set to allow any required number of seconds to elapse between the completion of travel of the skip and the beginning of rotation, in order to clear the skip car of material before rotation starts. The skip car is free to run as in ordinary operation. Rotation is stopped by a limit switch geared to the drive on the top of the furnace, and by a magnetic brake on the motor shaft. Regulation of angle of revolution is practically correct. Five wires from the ground level to the top are required, three to the motor and two to the limit switch. The outside wiring is therefore very simple. The amount of attention required is that usually given to such switchboards, repairs are light and interruptions to service infrequent and of short duration. The drive and rotating parts require no attention except oiling. The ball races are arranged to clear themselves of dirt, and where cut steel gears are employed the wear is very slight. In our experience, therefore, the operation of the top presents no difficulties. (Applause.)

Vice-President King: Mr. Glazier, of Johnstown, and Messrs. Barrett and Braman, of Youngstown, not being here, their discussions will be printed in the Year Book without being read. We will now hear a discussion of the paper by Mr. Karl L. Landgrebe, of Ensley, Alabama.

# THE DISTRIBUTION OF RAW MATERIALS IN THE BLAST FURNACE

DISCUSSION BY RALPH C. GLAZIER

Superintendent, Blast Furnaces, Cambria Steel Company, Johnstown, Pa.

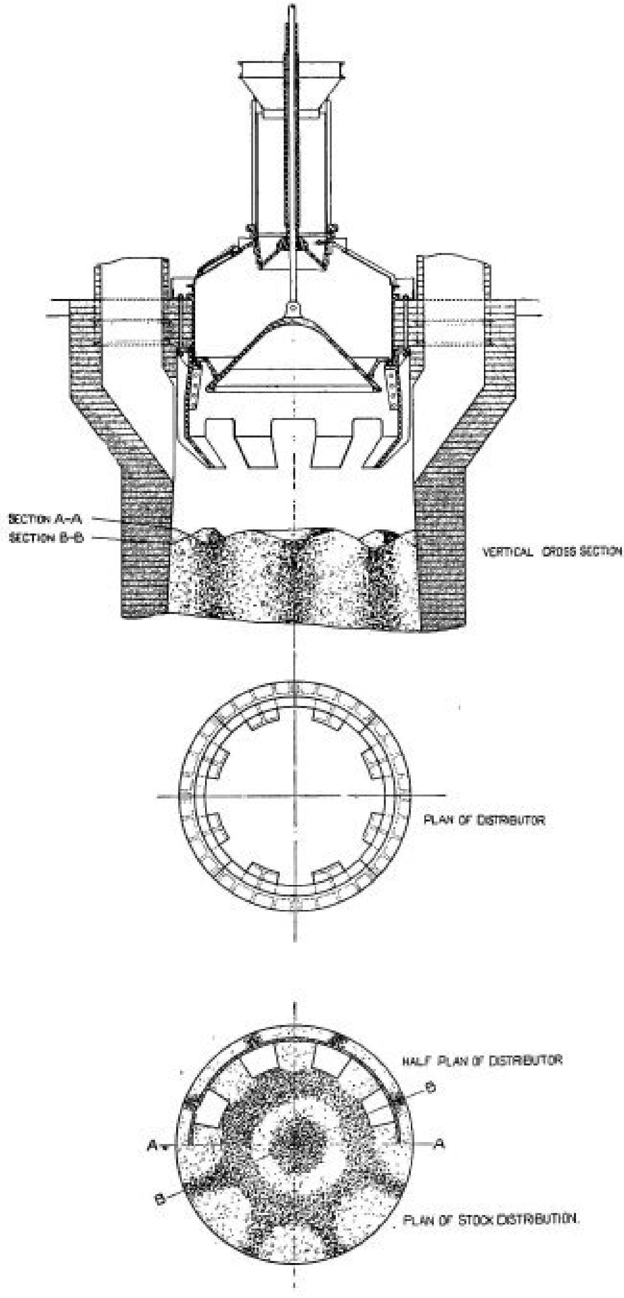
In Mr. Vreeland's paper on the Distribution of Raw Materials in the Blast Furnace he makes the statement that "Faulty distribution increases the amount of flue dust more than any other cause." To minimize flue dust production it is necessary that the stock should settle in such a way as to permit a relatively uniform ascent of the gases. To accomplish this, the charge of ore should be distributed in the furnace so as to avoid the formation of concentric rings and provide a large and regular number of porous portions, with a proper percentage of fines along the wall.

To obtain this distribution, Mr. Edwin E. Slick, Vice-President and General Manager of Cambria Steel Company, designed and had installed on one of the blast furnaces at Johnstown, Pa., a distributing ring which was placed in the furnace-top under the large bell. It proved so successful that the seven other furnaces were immediately similarly equipped.

The drawings herewith illustrate quite clearly the construction, which in essence is as follows:

Surrounding the main charging bell is a depending skirt formed of cast steel, the upper part of which is approximately cylindrical, while the lower portion has a number of depending fingers spaced apart, with their lower ends projecting inwardly. The general arrangement of the distributor is shown in cross-section, including the principal upper parts of the blast furnace, illustrating the distributing bell and hopper, the charging bell and hopper and the distributor arranged around the charging bell. The illustration also shows a separate plan of the distributor and a half plan of the distributor with a plan of the stock distribution.

As the charging bell is lowered, the stock slides down




SLICK BLAST FURNACE DISTRIBUTOR AND STOCK DISTRIBUTION the surface of the bell and portions of the same impinge against the distributor. Those portions which impinge upon the fingers are deflected toward the center of the furnace, while those portions which pass between the fingers continue in their travel outwardly toward the walls of the furnace, and those which impinge against the upper portion of the skirt of the distributor drop more directly downward. In this way the charge is deposited so as to form a large number of upright columns in the furnace, equal to the number of fingers and spaces in the distributor, which columns of stock are separated by the line of cleavage formed of the coarser portions of the charge which roll down each of the slight surface mounds.

This arrangement of stock permits a uniform ascent of the gases, with the result that smelting irregularities are eliminated and a regular settling of the stock is accomplished. This insures the avoidance of operating difficulties by practically eliminating hanging and slips. The reduced velocity of the gas, due to its relatively uniform distribution through the stock column, minimizes the amount of friction and results in a decreased production of flue dust.

The actual production of flue dust since the installation of this distributor is less than half of that made formerly, and the amount of fine Mesaba ores which can be used is greater. For the same reason the blast pressures, top temperatures and coke consumption are lower, with consequent further economies and ease of operation.

The following table gives results obtained on two furnaces similarly equipped except for the Slick distributor:

| Usual Bell and Hopper, no Distributor No. 4 Furnace, Six Months, January to June, 1914 | | Usual Bell and Hopper, with Slick Distributor No. 5 Furnace, March, April and May, 1915 | |
|---|---|---|---|
| Ore Used | Per Cent. | Ore Used | Per Cent. |
| Mesaba | 44.5 | Mesaba | 49.8 |
| Mesaba (Mahoning) | 10.5 | Mesaba (Beaver) | 44.0 |
| Old Range | 42.2 | Old Range | .... |
| Flue Dust | 2.8 | Flue Dust | 6.2 |
| | 100.0 | | 100.0 |
| Flue dust produced per ore charged | 8.02 | Flue dust produced per ore charged | 3.65 |

Prior to the use of the Slick distributor, as this table shows, the charge consisted of more than 42 per cent. of old range ores, in order to obviate, as far as possible, the slips and excessive production of flue dust. After the Slick distributor was installed the old range ores were discontinued in the case shown and 100 per cent. of fine materials were used, composing the iron-bearing portion of the charge. This included 49.8 per cent. of miscellaneous fine grain Mesaba Ores, 44 per cent. of Mesaba Beaver Ore, which is very fine, showing 15 per cent. through a 100-mesh sieve, with other fines in proportion, together with 6.2 per cent. of flue dust. Despite this fine mixture the flue dust production was less than half.

That the results shown on No. 5 Furnace in the preceding table have also been achieved on the other furnaces at Johnstown, since they were equipped with the Slick distributor, is shown by the fact that the flue dust production on Cambria Steel Company furnaces for the first four months of 1916 is 153 pounds per ton metal produced or about 3.6 per cent. of the ore charged. The decreased amount of dust not only shows a marked saving in the yield of mixture but aids in the operation and lessens repairs and maintenance of stoves and boilers when unwashed gas is used.

Briefly, then, the use of the Slick distributor has given us smoother-working furnaces and enabled us to use an increased percentage of Mesaba ores, while reducing the proportion of flue dust and decreasing the coke consumption. This distributor is the subject of pending patents.

# DISTRIBUTION OF RAW MATERIALS IN THE BLAST FURNACE

DISCUSSION BY JACOB C. BARRETT

Superintendent of Blast Furnaces, Carnegie Steel Company, Youngstown, Ohio

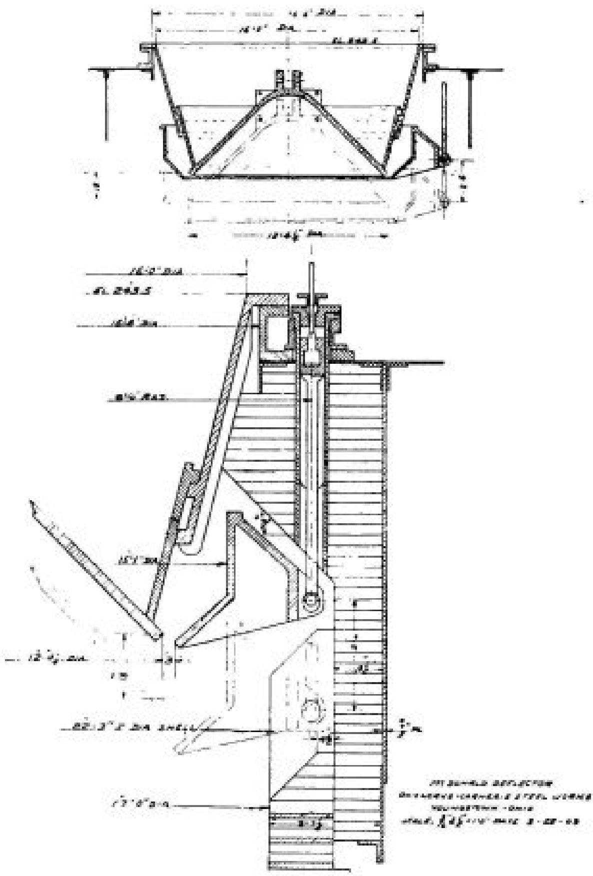
The matter of distribution of stock in the blast furnace is of great importance, and the proper distribution in the furnace has much to do with its economy.

There are many phases in operating a blast furnace which have an allied relation to distribution for its success, such as lines of the furnace, relative size of the big bell and stock line, quality of coke—its size and amount of breeze in it—condition of lining, method of charging, and fineness of ores. The furnace which has the above conditions right, with the stock uniform and evenly distributed on the big bell, which in turn deposits the stock with an even stock line in the furnace, has a satisfactory condition under which to operate.

In the handling of ores there is a tendency for the fine and coarse to segregate. As the ore is drawn from the bins to scale car, and from scale car to skip. and as skip car turns over into the receiving hopper, the coarse has a tendency to take a position different from the fine. To overcome this irregularity, the revolving hopper was developed so as to deposit these little irregularities equally about the furnace. The stock deposited into the furnace from the big bell of the ordinary blast furnace takes a fixed position, namely, like an inverted cone—the fine material next to the wall and usually quite compact, the center of the furnace depressed and the large pieces rolling into the center. The rare and open center has the larger portion of the coke and makes a passage of the least resistance to the gas, which naturally would produce a rich gas. To get some work from this rich gas, stock could be directed into this flume of open stock.

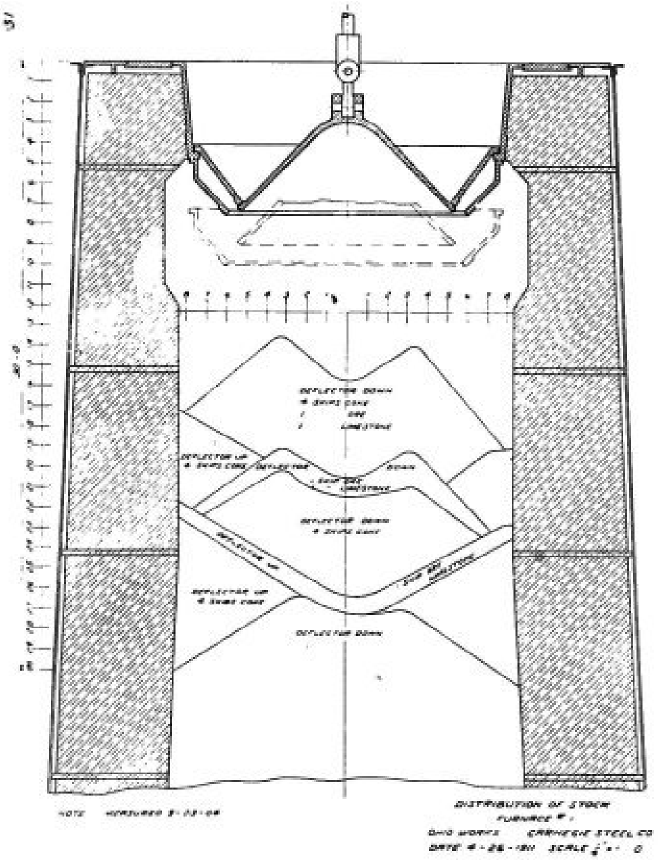
## The McDonald Distributor

The McDonald distributor serves for the purpose of deflecting the stock towards the center of the furnace at your will. This distributor is a movable one and when not in use hangs behind the hopper and hopper extension.



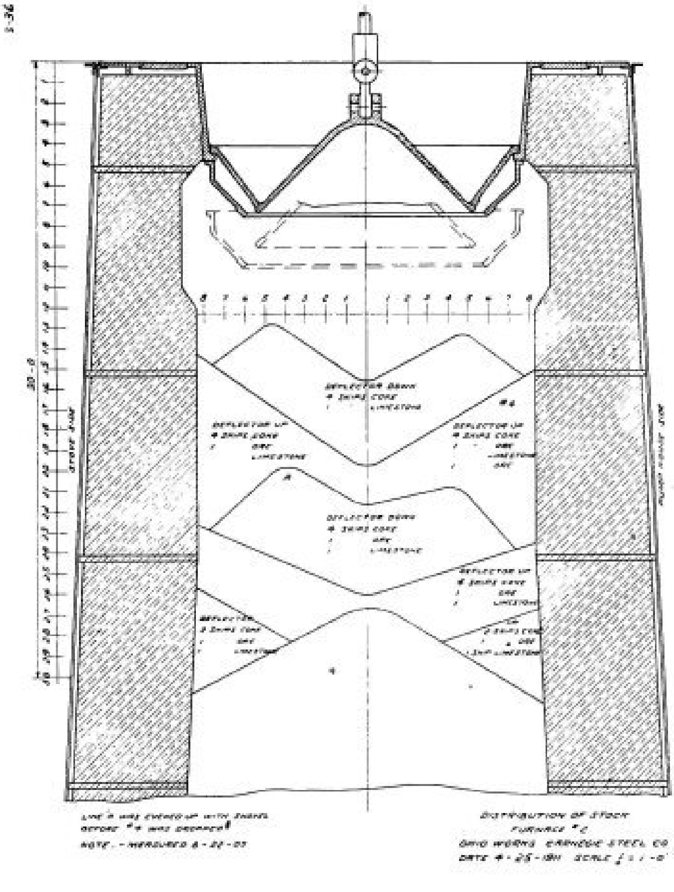
From Mr. Vreeland's paper I quote as follows:

The large charge of 14,000 to 16,000 pounds of coke and 30,000 to 35,000 pounds of ore with the necessary amount of stone forms thick, heavy layers of each material, and although the coke does not offer much resistance to the gas, the heavy layers of ore, especially that part thrown towards the center of the furnace, prevents the free ascent of the gases. The gases in their ascent, following the path of least resistance, cause imperfect and incomplete reduction of the ores in the denser part of the charge. This condition can be overcome only by direct carbon reduction in the lower part of the furnace.




To remedy this the charge is often split in two, thereby cutting the layers in half, which gives us a ring of ore of maximum thickness near the walls, tapering off gradually towards the center, where the lumps have a tendency to roll. This method has been demonstrated to be an improvement over the large charge, but a condition may arise wherein we have too much ore close to the walls and too much coke towards the center. This would cause the center to travel too fast with respect to the materials close to the walls and result in greater loss in flue dust.

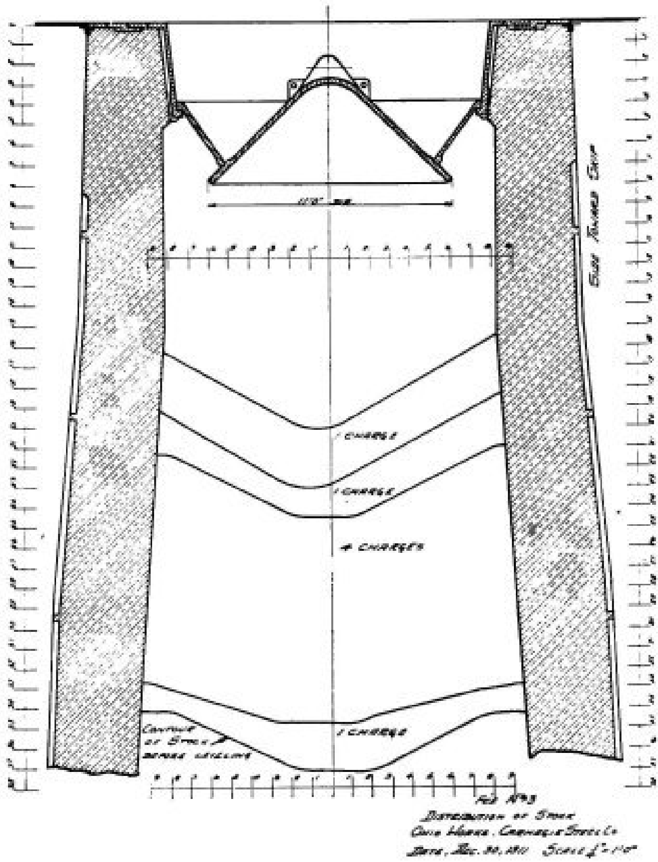
These conditions, as stated by Mr. Vreeland, are remedied by the use of a distributor as we use it at the Ohio Works, Carnegie Steel Company. Our method has always been to use a large ore charge, 28,000 to 32,000 pounds. The coke, ore and stone are deposited on the big bell as follows: 2



skips coke, 1 skip ore, 2 skips coke, 1 skip ore, 1 skip stone —7 in all, and lowered into the furnace as a mixed charge. The repose of the ore and coke in the furnace is quite different. The ore has a higher angle than the coke, and the center of the furnace no doubt travels faster, if for no other reason than friction on the walls, and draws the stock towards the center. The general use of the distributor is:

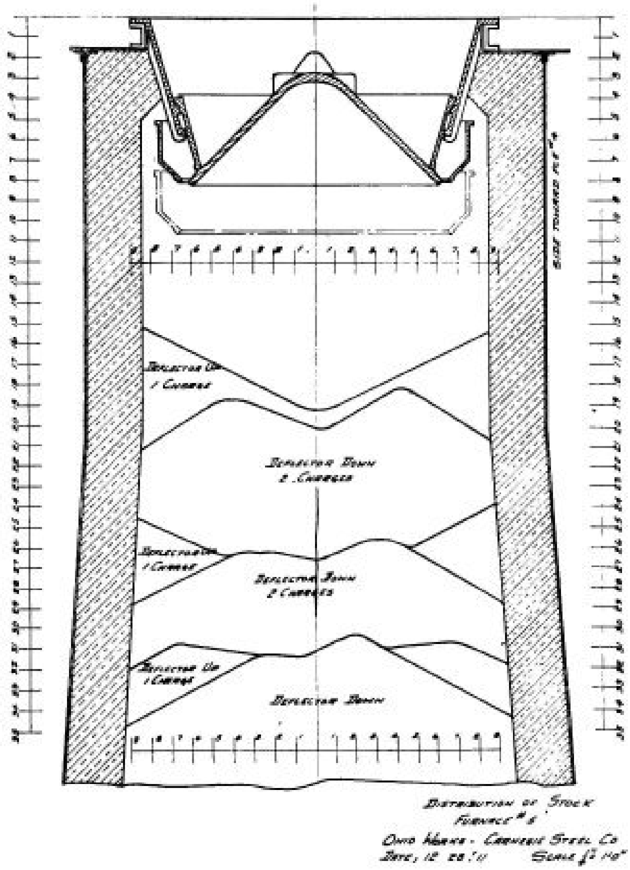
Two charges of stock with the distributor up, discharging against the furnace wall, and then one charge with the distributor down, deflecting towards the center.

Our experience is that coke breeze and limestone dust are detrimental to the furnace operations, and by the use




of the distributor we are enabled to throw, in the two-up and one-down operation of the distributor, two of the limestone skips to the center, making the charge 2 stone, 3 coke, 2 ore, and the two charges going on the side making one charge 1 stone, 4 coke, 2 ore, and the other charge no stone, 5 coke, 2 ore. This thins out the fines on the side of the furnace and allows more gas to get to the side.

Another beneficial effect is when the furnace is clogged up and gives the appearance of being built up on the bosh. By charging the furnace with the distributor up for one charge and then down for one charge, it is possible to put in the center the charge made up of 2 stone, 3 coke and 2




ore, and to the side of the furnace a charge made up of no stone, 5 coke and 2 ore. In this charging for a period you put all of the stone in the center and extra coke to side, allowing more freedom of gas to the sides and an opportunity to clean up the furnace.

Five of our six furnaces are equipped with a McDonald distributor, and I hereby submit the operation of all furnaces since the last blow-in, or since the last repair, until April 1, 1916. No. 3 furnace is the one not equipped with a distributor:

| | *No. 1* | *No. 2* | *No. 3* |
|---|---|---|---|
| Blown in............. | 3/9/15<br>4/1/16 | 7/22/14<br>4/1/16 | 2/18/14<br>1/14/16 |
| Length of Service..... | 1 yr., 22 days | 1 yr., 7 mos., 9 days | 1 yr., 10 mos., 26 days |
| Coke................. | 1,907 | 1,982 | 2,236 |
| Average tons per day.. | 570 | 544 | 485 |
| | *No. 4* | *No. 5* | *No. 6* |
| Blown in............. | 2/1/15<br>4/1/16 | 1/25/15<br>4/1/16 | 2/1/14<br>4/1/16 |
| Length of Service..... | 1 yr., 2 mos. | 1 yr., 2 mos., 6 days | 2 yrs., 2 mos. |
| Coke................. | 2,198 | 2,104 | 2,143 |
| Average tons per day.. | 523 | 529 | 497 |

No. 3 blown out to repair stock line, 1/14/16.

No. 5 from date of repairing stock line.

Special.—This includes coke dust, which averages about 50 pounds per ton of iron and does not go into the furnace.

This distributor has served a useful purpose in our operations by distributing the stock in a way that gives economy. It is used on normal or standard sized bells and flexible to all kinds of filling. Two features must not be overlooked. One feature is the use of water on the stock, by which it is possible to keep the gas temperature about 300 degrees. In any method of filling, omission of the water will allow the temperature to go high and vitiate any uniform distribution by allowing the excess dust to blow over. The other feature is a perfect condition of the stock line which, if lost, upsets all other distributions and economies.

With a good uniform distribution of the stock when it is placed on the big bell, and the proper deflection of the stock in the furnace, a low temperature of the top gases and a good stock line, it was possible in the period January 1, 1909, to January 1, 1916, to make an actual tonnage of iron with the use of raw flue dust (used 881,670 tons raw dust and produced 529,779 tons) of 6,008,556 tons, whereas the available tonnage of iron without the use of surplus dust was 5,959,231, a gain of 49,325 tons. This showing looks like a good step toward conservation of materials and labor.

# THE DISTRIBUTION OF RAW MATERIALS IN THE BLAST FURNACE

DISCUSSION BY HENRY S. BRAMAN

Superintendent Blast Furnaces and Steel Department, The Youngstown Sheet and Tube Company, Youngstown, Ohio

Mr. Vreeland's paper has been well worth the author's effort and I cannot help but feel, as he does, that proper distribution is one of the most vital questions which confronts the present blast furnace man. Poor distribution with its attendant irregular furnace operation, as well as the subsequent undue relining made necessary, is too well known for further elaboration. The few remarks which follow are more or less a digression from the main issue of the paper under discussion, but having been requested to say something concerning the Neeland Top I feel that they will not be out of place.

## NEELAND TOP

Small bell and slide seal. The Neeland Top which we have is practically the standard type except for one or two changes which we found it advisable to make in order to give us somewhat better results. The small counter-weighted bell which was used as a gas seal has been replaced by a box seal, this seal being an ordinary steel plate slide which is operated by an oil cylinder. The slide is pushed over the top opening of the furnace during the periods when the large bell is lowered and acts as a perfect seal in this position. The small counter-weighted bell often retained lumps of stock which would wedge between the bell itself and the seal, which of course would not give a perfect seal. Owing to the design of this bell it was necessary for it to travel in an arc which at one point only was centrally located in reference to the furnace. Even slight variations of this bell caused considerable unevenness in the stock distribution of the large bell. Any over or under travel of the bell in the bucket would consequently throw the small bell out of line and hence give uneven distribution. If the bucket, in being placed on top of the furnace, should vary its speed slightly the small bell would receive such a blow as to make it rebound with considerable force.

## Bucket Carriage

Another change was made in our layout when we adopted a parallelogram skip carriage which gave us a perfect line motion, keeping the bell rod in a vertical position during the entire travel of the skip and also during the dumping. A turn-buckle adjustment was incorporated in the design which gave absolute control over the placement of the bucket on top of the furnace and also allowed easy adjustment which would entirely correct any faulty distribution which might come from the wear and tear on the skip carriage.

## Revolving Bucket

At the skip hole we have a rack which is worked by an hydraulic cylinder which turns the pinion on the bucket through 120 degrees each way, thus giving three points for dumping which aids considerably in distributing the coarse and fine materials. The operation of this turning is very simple. The bucket is first turned to the left through 120 degrees, then it is taken to the top of the furnace and discharged. The next bucket is turned to the right 120 degrees. The third operation requires no turning, thus giving a point between the first and second turning, which in all makes three points equally spaced.

## Stock Line Plates

No matter how much care is taken and how perfect the distribution on the large bell, it is quite possible to undo all the good efforts in the final distribution of the stock by having uneven surfaces on the stock line. Many different constructions have been used and some of the common ones are as follows: Cast-iron bricks, laid alternately with hard-burned bricks; hard-burned firebricks alone; cast-iron angles laid in firebricks; plain cast-iron wearing plates, and water cooled cast-iron wearing plates. Of the different constructions, we use the water-cooled cast-iron plates and find that in most cases the cast-iron plates outlive the furnace lining and hence give a surface which can absolutely be depended upon.

## Changes in Filling

Poor coke, irregular ore, dirty limestone, etc., all have their effect on furnace operation and cannot be entirely overcome by perfect distribution or any one way of filling. After filling one way for some time, six weeks or so, we have found the furnace works sluggishly and somewhat irregularly, due no doubt to channelling of the gases, which has been directed by the filling and that certain portions of the charge become stagnant. At this time a change of filling will allow new channels to be formed and a general cleaning up is apparent.

For example, our standard method of filling is very much the same as that mentioned by Mr. Vreeland, or

Skip Coke, Lower Bell,
Skip Ore, Lower Bell.
Skip Coke, Lower Bell,
Skip Ore and Stone, Lower Bell.

This filling gives very good results for about six weeks, at the end of which we notice a certain degree of sluggishness in the working of the furnace. We then fill as follows:

Skip Coke,
Skip Ore, Lower Bell,
Skip Coke,
Skip Ore and Stone, Lower Bell.

After five days, or as soon as the cleaning up ceases somewhat, we again go back to the standard filling and find that the furnace travels with renewed activity.

### Inspection of Large Bell

Inspection of our distribution on top by our operatives is another instance where the human element is quite as essential as a perfect automatic mechanism itself. Through the clean out and inspection doors on top of the furnaces our men are able to observe and measure stock distribution on top of the large bell. Occasionally sticky ores adhere to the bell and are not discharged upon lowering. Furnace rounds coming on top are therefore deflected in their course and unless frequent inspection trips are made, much trouble will be experienced.

In conclusion, we consider the distribution of raw materials in the blast furnaces as one of the most important phases in furnace practice and accordingly we devote considerable time to what we think a proper execution.

# THE DISTRIBUTION OF RAW MATERIALS IN THE BLAST FURNACE


Discussion by Karl L. Landgrebe

Superintendent of Blast Furnaces, Tennessee Coal, Iron and Railroad Company, Ensley, Ala.


The development of the present stage of the distributing top at the Ensley blast furnaces started with the Brown top as outlined in Mr. Vreeland's paper. Reproduction of the general arrangement drawing of the original Brown top is shown (Fig. 1). The spout was revolved 89 degrees, between dumps of the skips, through a series of mitre gears driven from the shaft of one of the top cable sheaves. The method of sealing the gas when the large bell was lowered was by means of a flap-door closing the end of the spout in all positions except the closed position of the bell (Fig. 2). This door was held open when bell was closed through a simple arrangement of bell cranks and levers operated from the top of the beam from which the bell was suspended.

The second stage of the development is shown in Fig. 3. Here the change was principally mechanical in that the method of driving the distributor spout eliminated the complicated and troublesome gears of the old Brown distributor. The distribution of materials was affected because the revolving arc of the spout was changed from 89 to 64 degrees.

Since the method of driving this distributor is essentially the same as that employed on our latest tops at Ensley, we will describe now, more or less in detail, its mechanical features:

Reciprocating motion is obtained from a throw crank (A) on the end of the shaft of one of the top sheave wheels. This motion is transmitted through rocker arms (B) and connecting rods (C) to crossheads (D). Fitted into the crossheads are pawls (E), which engage the teeth of a circular rack (F) at points 180 degrees apart. The throw cranks are so arranged that the crossheads and pawls travel

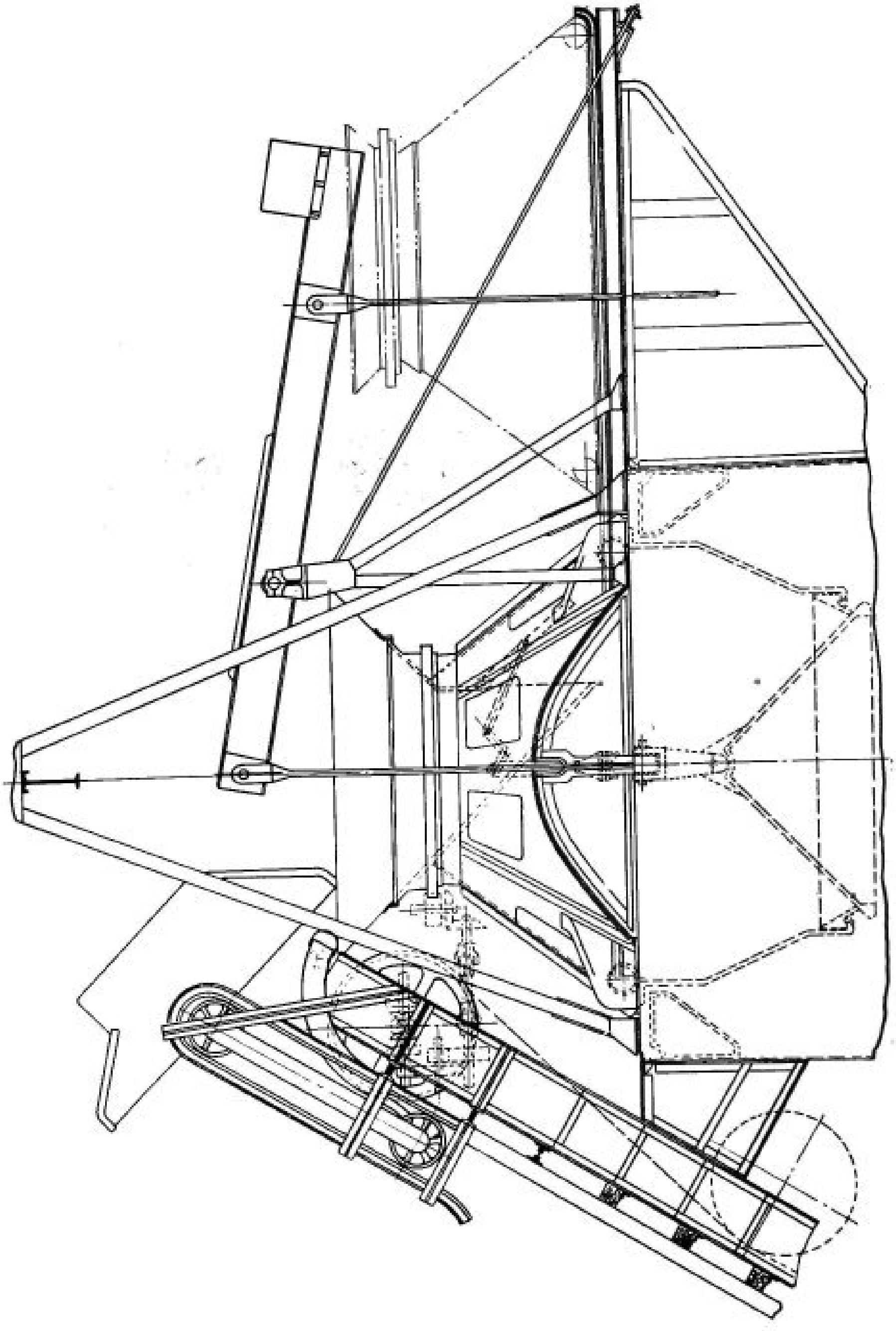


FIG. 1.—General arrangement of original Brown top.

in unison, so that only one pawl is engaged and doing work at one time. This feature eliminates all shock and jar to the top. The travel of the crosshead, of course, determines the number of teeth of the circular rack engaged each stroke, which in turn determines the length of the revolving arc of the spout. Various features are included to prevent or counteract wear, so that it may be known that the top is rightly performing its function.

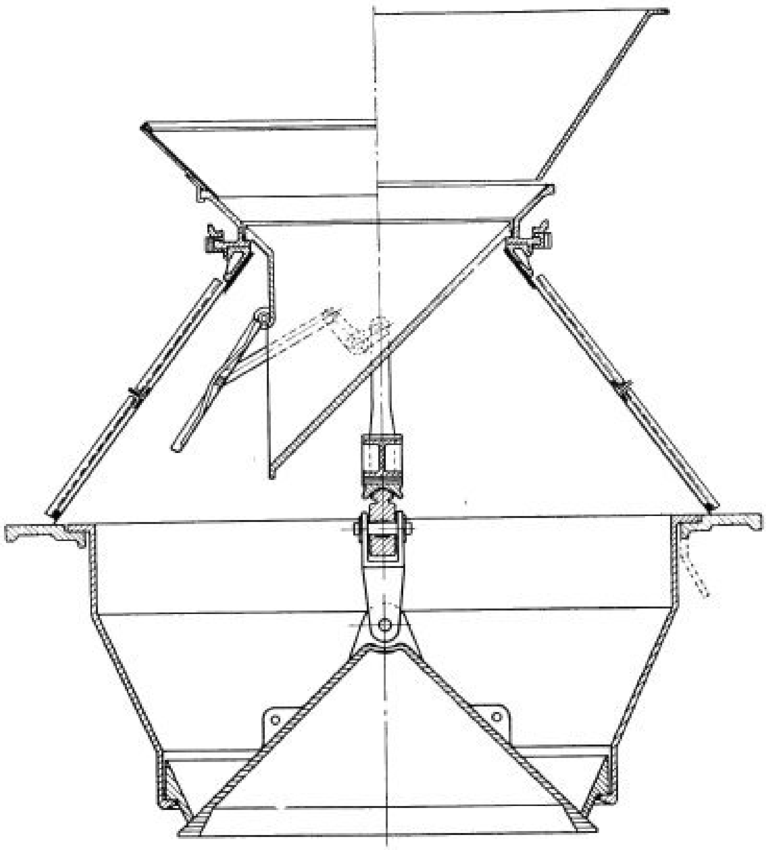


FIG. 2.—Showing flap-door for sealing gas, Brown top.

This Brown top had objectionable features to be overcome. First, the difficulty of keeping the top gas-tight, as the door covering the end of the spout was continually

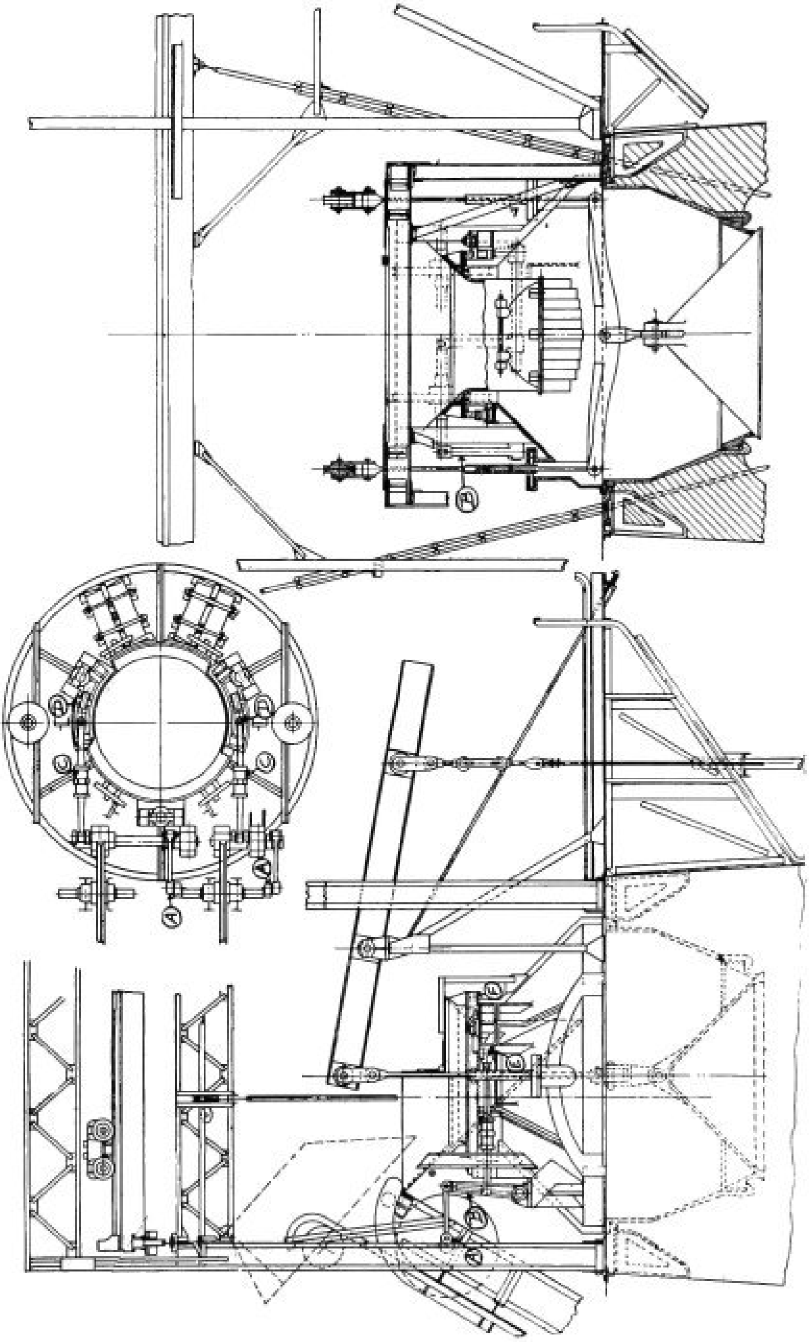


FIG. 3.—Showing second stage of development of Brown top.

wearing out and considerable quantities of gas was wasted when the big bell was lowered. Second, the objection pointed out by Mr. Vreeland, that the varying deposition of materials on the bell, depending upon the relative location of spout and line of flow of materials dumping from the skip cars. Third, the crossbeam supporting large bell was detrimental to good distribution, for it deflected the stock away from points on the large bell directly under this beam, and as this beam was stationary, the voids occurred always in the same places.

The third stage in the development of the Ensley top successfully removed the second and third objections, but did not make the top gas-tight. Uniform deposition of materials around the big bell regardless of position of spout in relation to the skip car was accomplished by placing above the distributor spout a small bell (Fig. 4), which brings to rest the charge from the skip cars before it is passed through the spout and on to the big bell. There were no interferences between distributor spout and bell to obstruct free flow of the stock. In this stage, the revolving portion of the top included spout (G) and rack cone (F) as far up as dividing line "XY." When the large bell was completely filled and ready to lower, the small bell was closed, thus sealing the gas from the furnace as long as everything was tight below the little bell. However, it was found that the rack cone wore and opened a space between the revolving and stationary parts, so that gas was again wasted every time the large bell was lowered.

The final stage of the top is shown in Fig. 5. Here the revolving portion of the top was extended up to little bell seat and the little bell supported on a ball race to prevent binding when running the skip while the little bell was closed. The whole top was divided vertically to facilitate changing bell or hopper.

Furnaces Nos. 2 and 3 at Ensley were the first furnaces to be equipped with this modified Brown top. This arrangement was patented by Mr. F. H. Crockard, Vice-President of our company. This type of top has given remarkable results, as can be seen from the following figures.

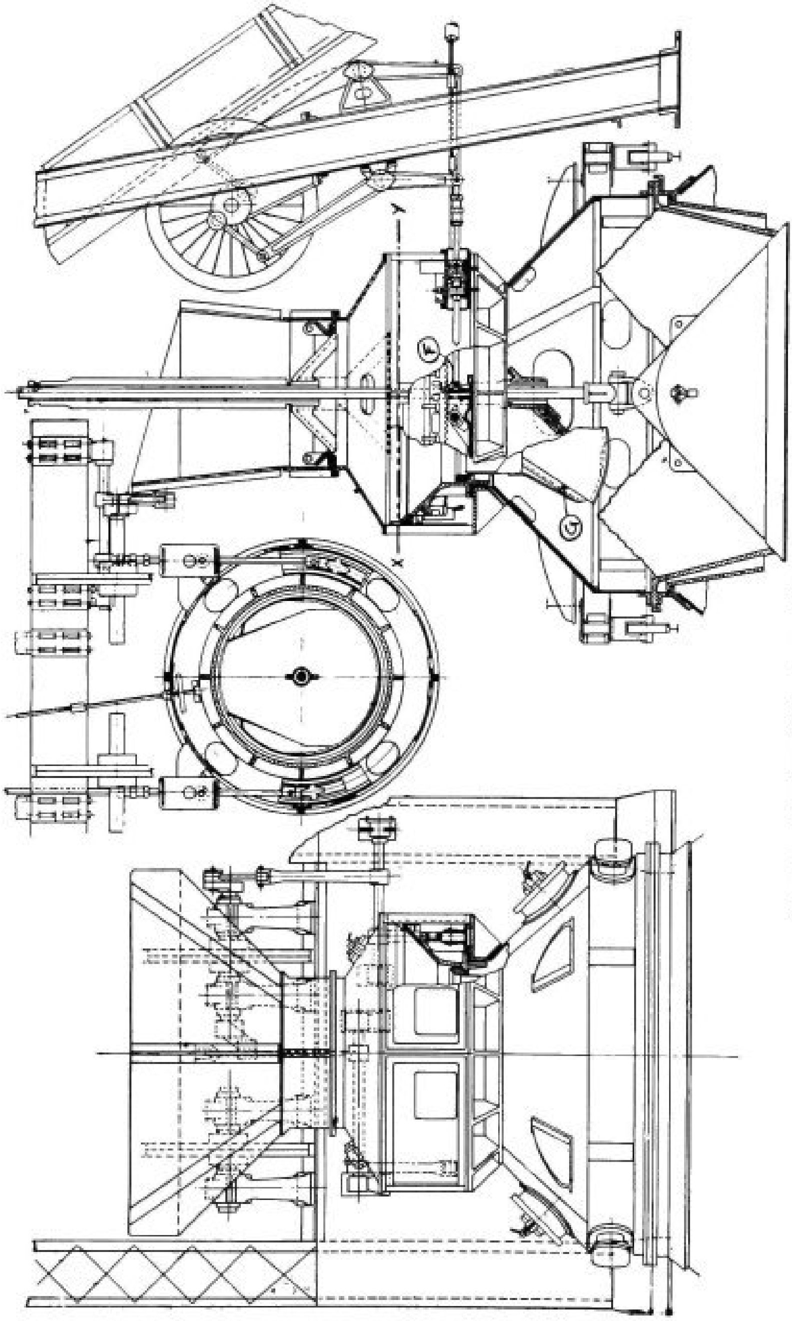


FIG. 4.—Showing third stage of Brown or early top.

Number 3 Furnace was put in blast July 20, 1909, and has produced to May 1, 1916, 912,735 tons of basic and foundry iron, the tonnage of raw materials consumed in producing this tonnage being:

| Materials | Gross Tons |
|---|---|
| Hard red ore | 2,029,920 |
| Soft red ore | 1,225 |
| Brown ore | 334,588 |
| Manganese ore | 1,029 |
| Pyrites cinder | 50 |
| Slags | 32,382 |
| Scrap | 40,400 |
| Dolomite (stone) | 250,559 |
| Coke | 1,152,209 |
| Total | 3,842,362 |

This furnace has not shown any signs of a hot spot or any indications that the lining above the mantle is any the worse for all this material having passed through it, and except for a weak bosh, looks good for some time to come.

Number 2 Furnace was put in blast February 5, 1910, and up to May 1, 1916, has produced 883,443 tons of basic and foundry iron, the tonnage of raw materials consumed in producing this tonnage being:

| Materials | Gross Tons |
|---|---|
| Hard red ore | 1,990,945 |
| Soft red ore | 1,260 |
| Brown ore | 302,655 |
| Manganese ore | 1,303 |
| Pyrites cinder | 551 |
| Slags | 34,904 |
| Scrap | 37,254 |
| Dolomite (stone) | 220,384 |
| Coke | 1,106,498 |
| Total | 3,695,754 |

This furnace also looks good for some time to come, and we hope that it will establish a new record for tonnage made on a lining, notwithstanding the fact that our ore mixtures have a theoretical yield of only approximately 39 per cent.

We believe these total tonnages of raw materials charged

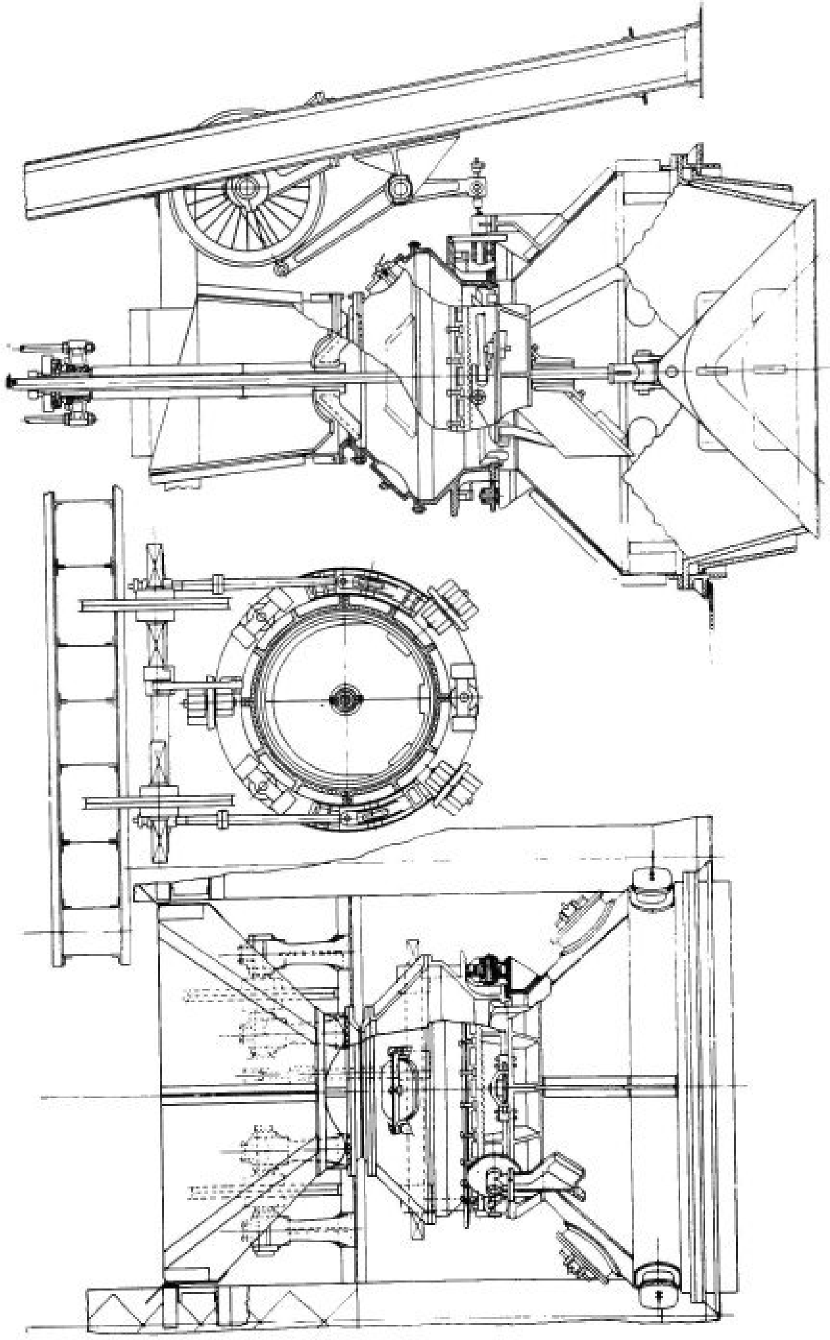


FIG. 5.—Fourth and present stage of Brown or early top.

are as great, if not greater, than any tonnages ever charged into a blast furnace in this country during a campaign. The record of these two furnaces has been remarkable, and I do not know of any two furnaces built on identical lines and using the same materials that have given the same uniform performance over such a period of time that these two furnaces have. The performance of these two furnaces with this type of top has proven that the fault Mr. Vreeland mentions concerning this type of top has been very satisfactorily overcome. From observations made of the distribution of the stock on the large bell and in the furnace, before blowing in any furnace equipped with this modified top, we are certain that there is obtained as near an ideal filling as is possible with any mechanical blast furnace top. Using a large bell having a diameter 4 feet less than stock line, the materials lodge ideally in the furnace, with a maximum of fines at the wall and a diminution of fines and a corresponding increase in lumps toward the center of the furnace.

As further proof of the value of the good distribution obtained, I would call attention to the work on Nos. 4 and 5 Furnaces before, as compared with that after the present tops were installed:

Record for the Month Following the Month of Blowing In.

| Furnace | Blown In | Avg. Daily Tonnage | Avg. Coke Consumption | Type of Top |
|---|---|---|---|---|
| No. 5....... | 9–2 –09 | 311.0 | 3190 | Original Brown |
| No. 5....... | 7–8 –11 | 317.3 | 2859 | " " |
| No. 5....... | 7–10–15 | 332.7 | 2604 | New type |
| No. 4....... | 6–6 –07 | 183.9 | 3331 | Old style modified Brown |
| No. 4....... | 1–1 –13 | 386.1 | 2542 | " " " |
| No. 4....... | 4–4 –16 | 410.4 | 2250 | New style |

In the preparation of raw materials for the blast furnaces after mining, sizing is the most important operation, although in the case of brown ore it is necessary to wash, screen and pick the ore, as it occurs in irregular masses imbedded in clay, sand, loam and gravel.

The standard set-up for crushing hard red ores is as follows:

| | Pounds | Percentage |
|---|---|---|
| Weight of ore passing through ¼" screen.......... | 803 | 36% |
| " " " " " ½" " .......... | 198 | 9% |
| " " " " " 1" " .......... | 334 | 15% |
| " " " " " 1½" " .......... | 577 | 26% |
| " " " " " 2" " .......... | 237 | 10% |
| " " " " " 2½" " .......... | 71 | 3% |
| " " " " " 3" " .......... | 20 | 1% |
| " " " " over 3" " .......... | 00 | 0% |
| | 2,240 | 100% |

| | |
|---|---|
| Largest piece of ore not passing through the ¼" screen but going through the ½" screen.......................... | 1⅛" x ½" x ⅜" |
| Largest piece of ore not passing through the ½" screen but going through the 1" screen.......................... | 1½" x ¾" x ⅝" |
| Largest piece of ore not passing through the 1" screen but going through the 1½" screen.......................... | 2⅜" x 1¼" x 1" |
| Largest piece of ore not passing through 1½" screen but going through the 2" screen.......................... | 3¼" x 1⅝" x 1⅛" |
| Largest piece of ore not passing through the 2" screen but going through the 2½" screen.......................... | 4½" x 2⅛" x 1⅛" |
| Largest piece of ore not passing through the 2½" screen but going through the 3" screen.......................... | 5¼" x 3" x 1¼" |

On all the material that is being crushed, at least one of the dimensions is 1¼" or less.

Dolomite for furnace flux is mined from a pit about 100 feet in depth. The broken stone is elevated to a pocket by skips working in balance, then run through a No. 8 Gates gyratory crusher, reducing the product to go through a 4-inch ring. All crushed stone passes over a grizzly screen taking out all fines from one-half inch down. These fines are then washed in revolving screens, taking out all dust and fine material, the washed product going to the steel plant.

The mining of brown ore is done by both hand and steam shovel. All of the ore-bearing material is passed through a log washer, where the ore is separated from the foreign material by washing, screening and picking. Sixty per cent. of the ore passes through a 2½-inch ring. All lump ore is separated by a grizzly screen, when it is run through a No. 8 Gates gyratory crusher, reducing the lumps to pass through a 5-inch ring. The fine and crushed lump ore is mixed while being loaded into railroad cars, which insures a uniform product.

The analyses of all raw materials used at the Ensley furnaces are as follows:

| Material | Iron | Silica | Alum'a | Lime | Mag-nesia | Man-ganese | Phos. | Water |
|---|---|---|---|---|---|---|---|---|
| Hard ore—Muscoda No. 1.... | 33.42 | 10.80 | 3.17 | 20.08 | ..... | .16 | .16 | .40 |
| " " " " 2.... | 33.78 | 10.17 | 3.12 | 20.31 | ..... | .16 | .29 | .35 |
| " " " " 4.... | 34.23 | 10.59 | 3.13 | 19.62 | ..... | .16 | .29 | .34 |
| " " " " 5.... | 34.49 | 10.55 | 3.13 | 19.44 | ..... | .16 | .30 | .34 |
| " " " " 6.... | 34.90 | 9.97 | 3.00 | 19.58 | ..... | .16 | .31 | .31 |
| " " " " 6 SP. | 35.49 | 9.83 | 2.86 | 19.31 | ..... | .16 | .31 | .36 |
| " " " " 6½.. | 32.76 | 17.66 | 3.10 | 16.34 | ..... | .18 | .31 | .40 |
| " " —Fossil No. 7........ | 36.42 | 11.71 | 2.83 | 17.51 | ..... | .17 | .33 | .31 |
| " " " " 6 SP... | 36.40 | 11.90 | 2.73 | 17.44 | ..... | .18 | .33 | .33 |
| " " " " 8........ | 36.29 | 13.23 | 2.93 | 16.61 | ..... | .17 | .34 | .30 |
| " " " " 9........ | 36.64 | 13.39 | 2.77 | 16.29 | ..... | .16 | .33 | .28 |
| " " " " 10...... | 37.52 | 12.74 | 2.71 | 16.07 | ..... | .17 | .34 | .27 |
| " " —Ishkooda No. 11... | 36.60 | 16.73 | 2.98 | 14.44 | ..... | .18 | .37 | .49 |
| " " " " 12... | 37.27 | 16.76 | 2.94 | 14.03 | ..... | .17 | .38 | .55 |
| " " " " 13... | 36.39 | 16.61 | 2.97 | 14.97 | ..... | .21 | .37 | .49 |
| Brown ore—Champion......... | 52.72 | 9.92 | 2.79 | ..... | ..... | 1.16 | .35 | 6.04 |
| " " —Martaban......... | 48.22 | 15.62 | 3.08 | ..... | ..... | .78 | .31 | 7.33 |
| " " —Giles............. | 50.21 | 12.99 | 2.85 | ..... | ..... | .87 | .32 | 6.29 |
| Dolomite—Ketona.............. | .14 | .41 | .28 | 31.51 | 20.19 | .... | ... | .... |
| Converter slag.................. | 28.28 | 50.06 | ..... | ..... | ..... | 7.46 | ... | .... |

| Material | $H_2O$ | V.M. | F.C. | Ash | Sul. | Phos. |
|---|---|---|---|---|---|---|
| By-product coke......... | 2.78 | .89 | 90.88 | 8.22 | 1.14 | .039 |
| | $Fe_2O_3$ | $SiO_2$ | $Al_2O_3$ | CaO | MgO | $P_2O_5$ |
| Coke ash............... | 1.68 | 3.45 | 2.56 | 0.19 | 0.10 | 0.09 |

From the foregoing it can be seen that the mixture is a fairly open one, showing a minimum of fines.

The raw materials are grouped in the stock bins, so as to make them easily accessible according to the percentage used and also with the point in view to separate the ores according to their chemical characteristics so that the larry car operator can have no possible excuse for having drawn the wrong material. This having been accomplished, the next step is to plan the distribution of the charge which has been decided on, for the kind of iron which has to be made. As before stated, the spout of the distributor revolves 64 degrees while the skip car travels once from skip pit to top. It is possible to fill the stock in a great many combinations, depending upon the number of skips of coke, ore and stone used to constitute a charge. We have tried all the practical combinations to prove out the best one. Although realizing the ideal at all times, we were hampered to a great extent by the stock-house equipment, which consists of two sets of bins paralleling each other, one of wood and one of steel construction. This equipment prevented us from making the coke charge less than 12,000 pounds and still keep the furnaces filled so as to get the proper reduction of the stock column. Our standard coke unit is therefore usually 12,000 pounds. Every mixture is planned on a concentric circle chart (Fig. 6) laid off in degrees corresponding to the travel of the spout of the

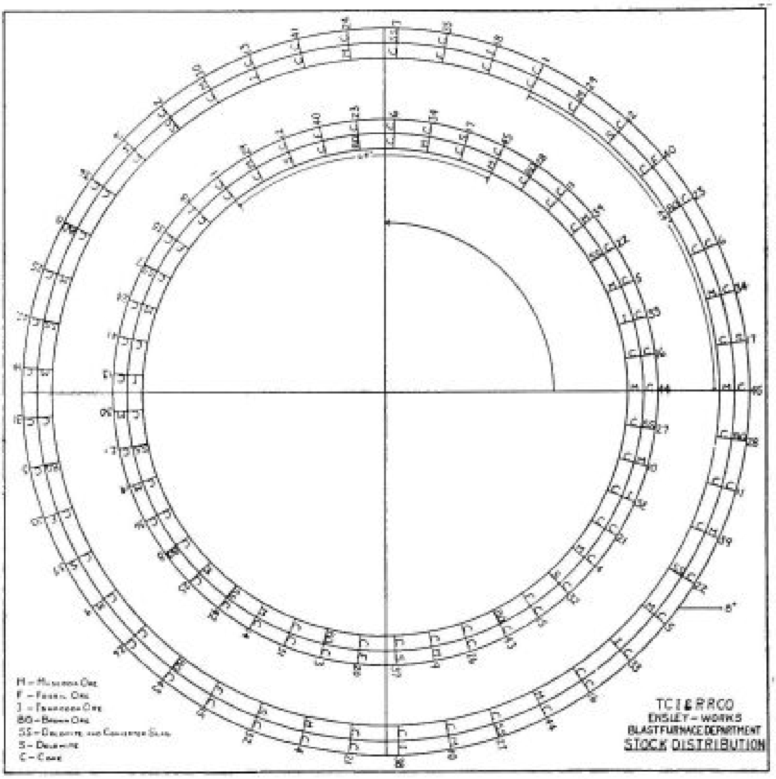



Fig. 6.—Concentric circle chart controlling mixture.

mechanical top. A complete cycle is then mapped out and the position of the raw materials are changed until we get the best possible distribution of all materials in each sector of the furnace. You will notice in following the position of the raw materials that the ores, slags and stone are uniformly spaced. For every six trips of the skip there is an overlap of 24 degrees more than a complete circle, and as 10 skips constitute one charge, it thus takes 9 charges of coke, stone and ore, or 90 trips of the skip, to bring the spout back to its original starting point. With certain ore mixtures it sometimes happens that a given ore is not absolutely uniformly distributed as far as each sector is concerned when a cycle is completed. To prevent the recurrence of this error, the second cycle is started 64 degrees in advance of the first by moving skip car empty for one trip. This is shown by inner circle on insert (Fig. 6). By doing this, all grades of materials are charged into the furnace in such a manner as to form a uniform spiral column. After deciding the method of filling a given mixture, complete information is furnished the stockhouse foreman as follows:

*Burden Change*
*Furnace No.*................ *Date,*............................191....

| Mixture | Pounds per Charge | | Per cent. | Scale Beams | | |
|---|---|---|---|---|---|---|
| | From | To | | No. | Weight | Combination |
| Muscoda....... | 12,750 | 13,050 | 48.2 | 1 | 5,000 | 1 and 2 hard ore. |
| Fossil......... | 4,250 | 4,350 | 16.1 | 2 | 3,700 | 1 and 2 brown ore. |
| Ishkooda...... | 4,250 | 4,350 | 16.1 | 3 | ....... | ....................... |
| Brown ore..... | 4,250 | 4,350 | 16.2 | 4 | 1,700 | Stone. |
| Converter slag. | 900 | 900 | 3.4 | 5 | 1,800 | Slag 1st and 3rd charges. |
| Total burden... | 26,400 | 27,000 | 100.0 | 6 | 2,000 | Coke (6 skips). |
| Stone......... | 1,700 | 1,700 | Burden ratio 2.25 | | | |
| Coke unit...... | 12,000 | 12,000 | Time of change. | | | |

The above slip shows the stockhouse foreman what weights to carry on his scale beams, together with the weights of the various materials in each charge, set forth clearly so that he has all data before him for checking purposes. Accompanying the change of burden slip is a filling slip which clearly shows the stockhouse foreman where to place each grade of ore in the filling. He, in turn, makes the necessary change on filling boards, which are conveniently placed at each skip pit for the larry and skip car operators:

| Charges | Filling | | | | | | |
|---|---|---|---|---|---|---|---|
| 1 | 6 Coke | Dump Bell | Dolomite and Converters Slag | Brown Ore | Muscoda | Muscoda | Dump Bell |
| 2 | 6 Coke | Dump Bell | Dolomite | Ishkooda | Muscoda | Fossil | Dump Bell |
| 3 | 6 Coke | Dump Bell | Dolomite and Converters Slag | Brown Ore | Muscoda | Muscoda | Dump Bell |
| 4 | 6 Coke | Dump Bell | Dolomite | Ishkooda | Muscoda | Fossil | Dump Bell |

Although it is of the greatest importance to design a furnace top to get the best results as far as distribution is concerned, it is just as important to familiarize the stock-house crews with the construction of the type of top in use and the reason for putting in the stock in the rotation ordered, and also dumping the small and large bell at certain intervals. I have always found it to be the best practice with any kind of top to handle each material according to its physical and chemical characteristics in the larry and skip car by itself. In this way the coke, stone and each individual ore is filled by itself, and it also obviates large errors which are liable to be made in weighing small quantities of silicious or special ores representing a small percentage of each charge. Scrap is another material which should be properly charged, and this is done at Ensley by having a man called a "scrapper" place as near as possible an equal amount in each skip load of coke, ore and stone which goes into the furnace. In this way every sector of the furnace will get the beneficial effect of the scrap without any undue wearing on any particular section of the brick lining.

The other changes in blast furnace construction mentioned by Mr. Vreeland in his paper, such as enlargement of the hearth, steepening of the bosh, large bell having a diameter four feet less than the stock line. a permanent stock-line armor, etc., have received their proper attention at the Ensley plant and have had a part in improving the practice, but we attribute the major portion of the improved practice to the latest type of mechanical revolving top, as described. (Applause.)

VICE-PRESIDENT KING: I see before me many men who have to do with the operation of blast furnaces, and I feel sure that their time has been very well spent here in listening to these papers. If there is anyone here who cares to discuss these papers informally, an opportunity is now presented. (After a pause): In the absence of further discussion, the Secretary has some announcements to make, after which we will stand adjourned until this evening.

MR. MCCLEARY: The evening session will be held in this room. We ought to assemble in the Astor Gallery by 7:00 o'clock, and be seated at the tables here not later than 7:30. The program for the evening is very interesting and may be a little long, so it is very important that we begin early.

Please bring your banquet tickets. Of course, we are glad to do everything that we can to make it pleasant for you, so we will have a surplus of banquet tickets at the door. You are all known to us and if you should forget your ticket we will have one ready for you. The purpose of having the tickets is to facilitate adjustment of accounts with the hotel for the banquet, so in justice to the hotel management it is necessary that each person participating in the banquet should be accounted for by ticket.

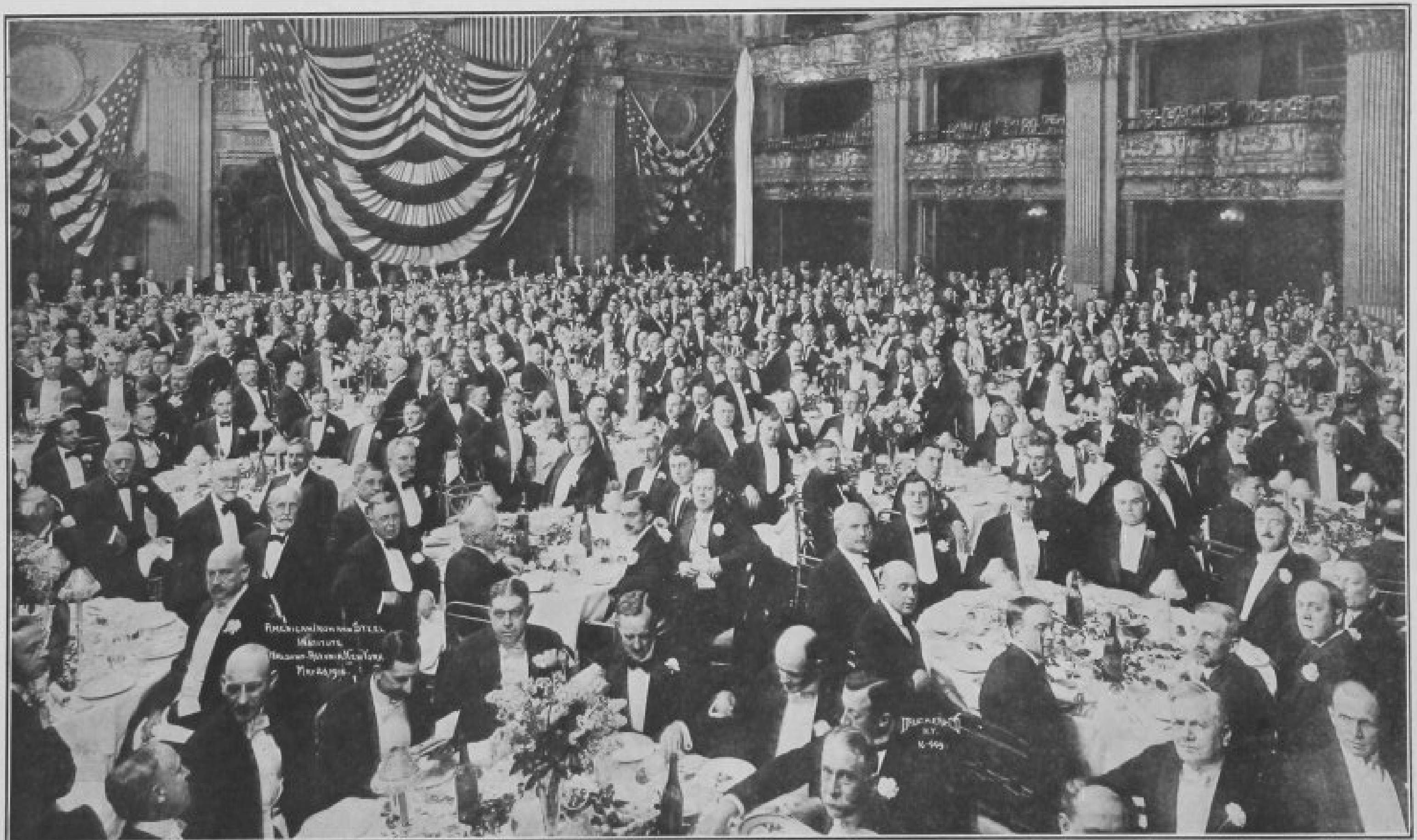
We are endeavoring to eliminate the giving of tips at our banquets, not because of the amounts of money involved, but because we do not like the practice, deeming it unfair both to the banqueters and to the waiters. For your information in this connection I may say that Judge Gary always authorizes including in the voucher covering our banquet bill an additional sum for the waiters. The management of this hotel is co-operating with us in the effort to eliminate entirely this tipping practice at our banquets, and I would be glad to have you report to me any case in which the waiter may start a plate around the table. (Applause.)

It was nearly midnight last night when we completed the seating arrangements. They are not entirely satisfactory to us and probably will not be to you, though we have done everything possible to make them so. You are all such busy men and many of you live so far from our places of meeting that it is difficult for you to decide until shortly before the meeting whether or not it will be practicable for you to attend it. We appreciate this fact and do not ask for decision until the latest moment that will give us time to make up the seating lists. Experience has shown that in order to give you the best possible result in the seating arrangements, it will be necessary for us to have a little more time. Preliminary to our next meeting we shall probably ask you to send us your acceptances at least one week prior to the meeting.

In relation to the matter of requests of members to be seated at table together, we find that these requests sometimes conflict, some members being desired at two or more tables. In such cases we make the best adjustment that seems practicable.

Many members have asked, "Can't we obtain the official Institute button in solid gold?" The buttons distributed complimentary to the members at the registration office are all rolled gold and will last for many years. In order to meet the wishes of those who desire solid gold buttons, we have had them made in two grades, 14-carat and 18-carat. This is one of the 18-carat buttons that I have in the lapel of my coat. By ordering these in quantity we have obtained especially favorable prices, that for the 14-carat button being $2 each, and that for the 18-carat button $4 each. Members may have them at the prices named. Of course we are all too busy to distribute any of the buttons now, but if you will send me your check from home for the kind of button you wish I will send it to you promptly.

VICE-PRESIDENT KING: We are in recess until seven o'clock this evening.



PART OF THE MEMBERS AND GUESTS WHO PARTICIPATED IN THE INSTITUTE DINNER, WALDORF-ASTORIA, NEW YORK, MAY 26, 1916

## EVENING SESSION

The annual dinner of the Institute was held in the Grand Ball Room of the Waldorf-Astoria. Judge Gary, President of the Institute, acted as Toastmaster.

After the dinner had been partaken of, Judge Gary called the meeting to order and said:

Several years ago, this country was making such great progress in business matters that for a time there seemed to be a clash between business interests, particularly big business interests, and a large portion of the general public represented in official circles. As a result there were those who advocated the destruction of big business in order to prevent what seemed to be a possible harm. On the other hand, some of those who represented large business interests voluntarily offered to subscribe to a policy which would enable the government, through its proper agencies, to regulate if not control, within certain limits, business and business organizations. There were many who criticised that attitude and urged that the proposed solution was impracticable and would result in the government itself taking absolute charge and control of business with results which would probably prove to be disastrous.

Gentlemen, I submit to you that the answer to that criticism is found in the extraordinary conditions which we see this evening in this magnificent presence, and in the founding of a Federal Trade Commission, which is supposed to have an influence in regulating, or rather in assisting business to progress in a normal and proper way, and in the further fact that a representative of that governmental commission is here this evening to speak to the gentlemen present upon the subject of co-operation and efficiency in developing our foreign trade. This gentleman, occupying the high position to which he has been called, is no more opposed to the violation of law, and is just as much in favor of the administration of law, as even the Supreme Court of the United States, and yet, in the occupancy of that high position, he is recognized as a conservative and constructive force, ready, willing and anxious to do everything reasonable and proper in assisting you and me to carry on our affairs with the completest success. What more could a fair-minded business man ask than that?

It is my very great pleasure to introduce the Honorable Edward N. Hurley, Vice-Chairman of the Federal Trade Commission of the United States. (Applause.)

# CO-OPERATION AND EFFICIENCY IN DEVELOPING OUR FOREIGN TRADE

Edward N. Hurley

Vice-Chairman, Federal Trade Commission, Washington, D. C.

According to an old story, King Midas was at one time showing his golden treasures and the vaults built for their safe-keeping to the philosopher Solon. Solon was greatly impressed by the stores of gold and the strength of the vaults, but prophetically observed: "Midas, the man who has possession of the iron of the world will some day be master of all your gold."

We have moved a long way toward the fulfillment of Solon's prophecy. The American Iron and Steel Institute is evidence of it. I feel highly honored by your invitation to address you. Your Institute has already done much to put in practice the principles which I believe lie at the foundation of all successful business; and, being the greatest association in the greatest industry in the world, it has an importance not confined merely to its members and to the iron and steel trade, but its influence affects vitally our national life and international commerce.

## Iron and Steel Industry of the World

We can learn many things in this country which will assist us in developing foreign trade from the organization and efficiency of the iron and steel industry in the great industrial countries of Europe. In Europe this industry illustrates the effectiveness of co-operation, first between business men, second between business men and government. I feel that we should study its methods both because it is one of our most formidable competitors in foreign markets and because it will suggest to us methods for meeting this competition successfully.

## Italian Iron and Steel Industry

Only within comparatively recent years and since the introduction of foreign capital, has industrial organization in the form of cartels and syndicates developed in Italy. Among the better-organized industries is that of iron and steel. In April, 1911, the six leading Italian iron and steel manufacturers combined and formed a syndicate known as the "Ferro et Acciaio" (Iron and Steel). The syndicate agreement was made for 12 years, and the Ilva Company, located at Genoa, was named to act as the common selling agency until December 31, 1922. The companies in this syndicate represented a total capital of $26,800,000.

## French Iron and Steel Industry

The French iron and steel industry is one of the most highly organized industries in France. Of the various syndicates of iron and steel producers in France, the Comptoir de Longwy is the largest and best organized. It combines 18 important firms. In 1909 its syndicate-contract was extended for 20 years. Each month it fixes the prices of coke and raw iron. It produces about seven-tenths of the annual production of pig-iron in France. In the interests of foreign trade, it has established a special export organization, which handles exclusively all the export business of its members.

## Belgian Iron and Steel Industry

Nearly all of the leading Belgian industries are exporting industries and long ago pooled their forces and combined for the purpose of promoting their export trade. The steel manufacturers have a syndicate which is organized along the same line as the steel syndicate of Germany, with which it has an agreement concerning Class "A" products. It sells its products exclusively through a common selling agency located at Brussels. About three-fourths of its products are exported. In practically every branch of the Belgian iron and steel industry there are smaller cartels and syndicates through which the manufacturers work jointly for their common interest. It is said that the success of Belgium export trade is in a large measure due to organization and co-operation among industrial producers.

## British Iron and Steel Industry

A well-known English economist in a recent discussion of organization and combinations among British iron and steel producers, said: "In all the recent amalgamations *the main desire* has been to increase the power of resisting American competition, and the opportunity has been taken of raising fresh capital from the public for the purpose of extending works and modernizing plants."

Although there is a tendency among British iron and steel manufacturers toward merging small with large concerns (as in the case of Bolckow, Vaughan & Co.; Guest, Keen & Nettlefolds; Vickers' Sons & Maxim; Sir W. Armstrong, and Maitworth & Co.), numerous combinations and trade associations also exist for controlling prices and production and combating foreign competition.

Among the larger combinations of steel producers are the Scotch Steel Makers' Association and the North of England Makers. Both of these divide territory and fix prices. Other similar organizations are the National Galvanized Steel Makers' Association, the Tin-Plate Bar Combine, the South Wales Siemens Steel Makers' Association. The manufacturers of galvanized plates, which constitute one of the chief items of English steel exports, are also organized. As illustrative of the extent to which the British iron and steel trade has been syndicated, I may mention the fact that the greater part of the annual output of ship and boiler plates, galvanized plates, tin-plate bars and rails, amounting to about 3 to 3½ million tons, is controlled by combinations of manufacturers.

## German Iron and Steel Industry

The German steel industry has few, if any, equals in effective organization. It offers a typical example of how efficient industrial organization and co-operation, assisted by government, may succeed in building up a large national industry, shipping its products to all parts of the world.

The German Steel Syndicate ("Stahlwerksverband") comprises 31 leading steel concerns, including the well-known Krupp Company. It controls about 90 per cent. of Germany's total steel production. In 1913 its production amounted to 6,339,000 tons.

In the production and distribution of Class "A" products (half products, railway line material and bar iron), the syndicate has an almost absolute monopoly; in the case of Class "B" products it controls the production but not the distribution. It has standardized the class "A" products, and maintains a large technical bureau for testing the products of its members, and, if possible, to increase uniformity and to improve quality.

The syndicate maintains close relations with dealers' associations, and has been instrumental in the formation of a number of them. It has also organized its wholesale dealers in foreign countries.

The total volume of business controlled by the syndicate amounts to more than a billion marks a year. Its expenses of distribution and administration have been reduced materially, so that it now averages only 7 cents per ton of crude steel.

All orders placed with the syndicate are distributed among its members according to their shares of participation, but due consideration is given to the geographical location of the plant desired by the customer.

The control or common selling agency of the syndicate is located in Düsseldorf. In connection with it a special clearing house for the export trade is maintained. In order to promote and regulate systematically the export trade and to equalize some disadvantages under which the German export industry is said to be placed, the syndicate, through the Düsseldorf office, computes, regulates and pays export bounties which have averaged from 10 to 15 marks per ton of steel half-products during the past 10 years. In this way it expended from 1904 to 1908 a total of 17 million marks.

## Advantages of Syndicates from Economic Standpoint

Business men, economists and statesmen of the leading commercial nations of Europe practically agree that where industries are efficiently managed and under proper governmental regulation, the cartel and syndicate have proven their desirability from an economic point of view, and have enabled these nations to hold a dominant position in the world's markets. German and French writers point with pride to the success achieved by their respective iron and steel syndicates, and the present German Minister of Finance, Dr. Helfferich, stated a short while ago that the cartel organization has been the acme of German industrial enterprise during the past 25 years.

European iron and steel producers have repeatedly called attention to the fact that their system of co-operation has enabled them to prevent *or at least tide over periods of business depression and industrial crisis.*

Official government investigations in several European countries make it clear that cartels have succeeded in reducing both the cost of production and the selling expenses, which permits the consumer to purchase the finished product at a lower figure. In the case of the French Comptoir de Longwy, co-operation in selling has reduced selling expenses to from 3 to 4 cents per ton. It is maintained that the cartel organization also enables manufacturers to equalize supply and demand, to adapt their prices to demand, and to regulate the prices of their products in accordance with the cost of raw materials.

## American Supremacy in Iron and Steel

In a report to the Chamberlain Tariff Commission of England, Mr. J. Stephan Jeans, Secretary of the British Iron Trade Association, said: "All other things being approximately equal, the country that produces the cheapest pig-iron should in the long run be the master of the iron trade situation." It is my belief that if the cost sheets of the iron and steel industries in the countries which have been mentioned were compared with those of the United States, the comparison would show that pig-iron is produced in this country as cheaply as in any country of the world. I believe that, not merely in natural resources, but in management and organization, the American iron and steel industry is in a position to meet the severest competition of its foreign competitors, and in the end to conquer the iron and steel markets of the world.

## Our Government and Business

Has our Government done its part? Has it assisted and encouraged business in a consistent and constructive way? If we are to succeed in the markets of the world, it must do as other governments have been doing for many years. I doubt whether the European iron and steel industries could have achieved success in foreign markets without the active assistance of their governments. When compared with the attitude of those governments and, of late, of the Japanese Government, the attitude of the American Government toward our industries presents a striking contrast.

For several decades our Government has worked out through the Interstate Commerce Commission a constructive program for the railroads of the country. It has also made effective through the Agricultural Department measures likewise helpful to the farmer. In these cases it has approached the problems in the spirit of co-operation and the results have been beneficial to all.

The Government's attitude toward business, however, presents again a contrast. The trouble has really been one of point of view. Government action has usually been negative; always scattered and seldom constructive.

## The Wrong Remedy

Unfortunately, our business men and our Government have been losing valuable time during the past 15 years in trying to settle our economic and business problems, not by co-operation, not by any scientific method which will bring about results beneficial to our people as a whole, but by resorting to the courts. I know business has been sick, and business has undoubtedly been in a large measure to blame for its illness, but, instead of sending for a doctor who could prescribe a remedy that would give practical and permanent relief, the Government sent for lawyers, and you know the result.

A wrong feeling has existed in this country as to the proper relations between Government and business. Even when I went to Washington I had the feeling that business men did not want to co-operate with the Government, but I learned very quickly that they are all eager to co-operate, and willing to do everything in their power that the Government desires.

We are talking a great deal these days about mobilizing our industries and co-operating for industrial preparedness. We have been floundering about for many years with no definite plan; in fact, the first step has hardly been taken toward solving our industrial problems and toward attaining the result which we all know is absolutely necessary. Co-operation requires the interest and good-will of both sides. Business men are anxious to co-operate with our Government. It is now the duty of the Government to lend its active constructive aid, and it is the earnest desire of the Federal Trade Commission to do everything in its power to help foster American industries. (Applause.)

## Federal Trade Commission and Definite Steps Forward

The Federal Trade Commission is endeavoring to-day to work out a comprehensive, constructive solution of our business problems. We have taken definite steps toward getting at the real facts of industry from manufacturers. Within a few months we hope to be able to give manufacturers first-hand information about their business. I am satisfied from this investigation that the business men of the country are anxious and willing to co-operate with the Commission. I know it. We are in receipt of thousands of letters expressing their appreciation of our efforts. In preparing this Report on Industries, we have sent out many thousands of forms, and the percentage of firms objecting to filling them out is almost negligible. This in itself is evidence of their willingness to do their part and assures us of a basis of fact upon which we can co-operate.

### Present Attitude of Department of Justice

The Chamber of Commerce of the United States has a Federal Trade Committee, of which Mr. Harry A. Wheeler, of Chicago, is Chairman. Last autumn the Attorney-General of the United States, after a number of conferences with this committee, issued a statement defining the attitude of the Government in anti-trust cases, which has been reassuring to business men and dispelled some uncertainty which had been said to exist. He stated that no court proceeding is ever instituted by the Department of Justice until after a most exhaustive investigation, in the course of which the parties complained against are given full opportunity to be heard. He stated further, in substance, that in admittedly doubtful cases, where the parties acted in good faith, no criminal action at all would be brought, and that even no civil proceedings would be started without first giving the parties an opportunity to abandon the course of conduct regarded by the Department as illegal.

### Trade Association: Machinery of Co-operation

Co-operation is the watchword of the era upon which we are entering—co-operation between employer and employee, among business men, and between Government and business. Trade associations and similar organizations are perhaps the chief media through which this co-operation can be made effective. Their field of activity should be extended and their work made more efficient.

There are about 6,500 commercial, industrial and trading organizations in this country. These include 2,500 chambers of commerce, commercial clubs, boards of trade and similar promotive business organizations; a thousand manufacturing and mercantile associations of a general character, comprising business concerns in a number of different industries, such as state manufacturers' associations, credit associations, etc., and about 3,000 trade associations—groups of business men in particular manufacturing, mining or mercantile industries.

The commercial club, the board of trade, the chamber of commerce, attempt to bring together business men of all lines for the many kinds of co-operative endeavor so necessary for the progress of a business community. The general manufacturers' and merchants' association fills a similar need for the broad manufacturing or mercantile field, while trade associations consist of concerns in particular industries, and include manufacturing, mercantile and producing associations; national and even international associations.

## Bettering Business Methods

The activities of all of these business organizations are manifold, and the business done by their members runs into the billions. These groups of associated business men are putting forth special efforts to improve systems of cost accounting, bettering their processes of manufacture, standardizing their output, obtaining credit information, and endeavoring to advance the welfare of their employees, and are bound to be most important factors in our country's development in the course of the next few years.

Special commendation should be given to associations that are endeavoring to build up industry in these constructive ways. Successful production and successful merchandising require many steps in the process of changing the form of the raw materials, and putting the product on the market at a figure adequate to cover the cost of production and the cost of selling, and net some profit to the producer, without charging the consumer an excessive price; and neither the individual manufacturer nor the Government alone can work out the many serious economic and business problems involved so successfully as can a group of associated producers laboring together in co-operation. These associations, when conducted intelligently and rationally, with the thought of bringing about improved business conditions, will make it possible for our industries to compete in price and quality in the markets of the world.

### Bettering Conditions of Labor

The question of giving to our workmen continuous employment, so that they may average longer periods of prosperity, can be solved and other plans for their welfare can be worked out, through trade associations. As we have grown in manufacturing capacity we have come to realize that our employees are one of the most important parts of a successful establishment. That management is successful which is not only efficient in working out economies in production, but which also has the real interests of its employees at heart and which is anxious to have as many of its employees stockholders as possible, and which also realizes that without the hearty co-operation and enthusiasm of their men the best results cannot be obtained. Many corporations and firms, particularly those in the iron and steel industry, are now raising salaries and wages without the request from their employees. These benefits are commendable and should be supplemented by movements for the general welfare, planned and put into effect by our trade associations.

### Trade Associations and Government

Business and government can co-operate through trade associations better than in any other way. The Federal Trade Commission's report on industries will furnish associations with facts and figures, not now available, which will enable them to assist in developing and stabilizing their industries. We talk much nowadays about industrial preparedness and the mobilizing of our industries in case of war. This can be accomplished through trade associations more quickly than in any other way. In the countries of Europe these associations, in co-operation with the governments, have been important factors in improving industrial conditions and particularly in extending foreign trade.

There should be a greater degree of organization and of mutual helpfulness in all lines of trade and industry, so that American business may be welded into a commercial and industrial whole, the part of the Government being to co-operate with business men, on request, to bring about the results that will benefit business and hence promote our national welfare.

### Views of President Wilson

President Wilson's views on trade associations may be of particular interest to you. In a letter addressed to me, under date of May 12, 1916, he says in part:

"Your suggestion that trade associations, associations of retail and wholesale merchants, commercial clubs, boards of trade, manufacturers' associations, credit associations and other similar organizations should be encouraged in every feasible way by the Government, seems to me a very wise one. To furnish them with data and comprehensive information, in order that they may more easily accomplish the result that they are organized for, is a proper and useful government function. These associations, when organized for the purpose of improving conditions in their particular industry, such as unifying cost accounting and book-keeping methods, should meet with the approval of every man interested in the business progress of the country."

### A Model Association

I regard the American Iron and Steel Institute in many respects as a model trade association. For practically half a century this Institute and its predecessor, the American Iron and Steel Association, have worked for the betterment of your industry. This Institute's committee on welfare work has assisted in improving the conditions of your workmen. Its committee on improvement in methods has been a great factor in promoting the technical advance of your industry. Its committee on foreign relations has given you a broad, comprehensive view of foreign trade. Its Year Book and statistical reports, nowhere surpassed for completeness and accuracy, have kept you informed on the technical and industrial development of your industry. In short, it has been the organization through which you have co-operated for your mutual improvement, and I know that it will continue a powerful factor in the further progress of your great industry.

### Standardizing Products and Processes

The standardization of products and processes has been extensively developed in the iron and steel industry both in Europe and in this country. Standard specifications for structural and boiler steel, steel rails, concrete re-enforcement bars, etc., have been agreed upon. Your Institute has done excellent work in this direction, and of itself and in co-operation with engineering societies and industrial experts I know it will do much more.

Economy in production and continuity of operation are both served by judicious standardization. Better materials and more efficient workmanship are made possible by it. It reduces costs. The consuming public also shares the benefit by not having to pay for a wide and unnecessary variety of products and materials. As standardization has been one of the results of co-operation in the past, it should continue to be one of the ends of co-operation in the future.

### Uniformity in Accounting Methods

The subject of more uniformity in cost finding is at present receiving the careful attention of many manufacturers and trade associations. A number of trade associations are in this way achieving marked success in strengthening their industries. It is being demonstrated that a knowledge of cost determined by a uniform practice can improve trade conditions to a remarkable degree. By a uniform practice I mean a common classification of costs, both manufacturing and selling, a uniform method of distributing overhead expense, and a uniform method of providing for depreciation with rates more or less standardized. Where this condition exists, production statistics which are comparable, and which will inform and guide the whole industry, are obtainable. Manufacturers can then talk the same language and will be in a position to profit by each others' experience, to conduct their plants more efficiently, and to establish prices more intelligently.

### Accounting in Iron and Steel Industry

The excellent financial condition in which the iron and steel industry is to-day, is due in a marked degree to the attention iron and steel manufacturers have given to the important questions of business policy. Perhaps foremost among these is the importance of knowing definitely your true costs of manufacture and of distribution. I doubt if there is another industry in the United States where conditions in this respect are as satisfactory; where the destinies of the industry have been so wisely safeguarded by adequate provisions for exhaustion of capital, both of plant and natural resources; and where so much attention has been paid to a study of operating conditions for the purpose of increasing efficiency and of lowering costs.

It is gratifying to know that practically all iron and steel manufacturers are recording and classifying their costs on a substantially uniform basis, are distributing their overhead expense by the same methods, and are adequately providing for depreciation and exhaustion.

A preliminary study of industry generally, made by the Federal Trade Commission, has revealed the fact that only a very small percentage of the manufacturers of the country make any charge for depreciation of plant or of equipment, and that their products were priced and their profits determined before reckoning this vital and important item. A manufacturer who figures his profits without adequately providing for depreciation and who pays dividends on that basis is paying dividends out of capital and not out of profits.

### Example of Dangers of Lack of Adequate Accounting Methods

Take two manufacturers, say Jones and Brown. They are in the same line of business and bank with the same banker. Jones keeps an accurate cost accounting system, charges off liberally for depreciation on his buildings, machinery, etc. He charges his jigs, tools, dies and patterns against the cost of operation every month or, at least, every quarter. His overhead is distributed equally and fairly. He quotes a fair price on his product and his customers recognize that they are getting value received. He has a large bank account and is considered a conservative and substantial business man. Brown, his competitor, on the contrary, does not keep a cost accounting system; does not charge off for depreciation except a small amount at the end of each year. Brown maintains that his buildings and machinery are as good as they were twenty years ago. He charges his jigs, tools, dies and patterns to capital account and considers them valuable assets. He figures that he has been quite liberal when charging off ten per cent. for depreciation on these items at the end of the year. He is a heavy borrower at the bank and the banker is probably loaning him money that Jones, his competitor, has on deposit. This furnishes Brown working capital, to do what? To continue to run his business in a slip-shod, slovenly manner, to cut prices and ruin the industry in which they are both engaged.

Ignorant competition is most dangerous to the development and success of our country. The Clayton Act and the Federal Trade Commission Act have no control over this menace. It is estimated that ninety per cent. of the manufacturers and merchants in Germany know absolutely what their goods cost to manufacture and sell. If you compare our figures, which show, according to estimates, that only 10 per cent. of our manufacturers and merchants know what it costs to manufacture and sell their products, you have the answer as to why Germany has been so successful in developing such a high standard of efficiency in manufacturing and distributing their products not only in Germany but in the markets of the world.

It is a fact well understood among business men that the general demoralization in a large number of industries has been caused by firms who cut prices, not knowing what their goods actually cost to manufacture; the cost of selling also, which is equally important, is almost wholly lost sight of. Are the officers of the companies who are cutting prices right and left, irrespective of their costs, *fair to their customers, stockholders or competitors?*

*Quality and service* are becoming greater factors in the field of merchandising. Long after the price of a product is forgotten the *quality of that product is remembered.*

The fact that you steel manufacturers know definitely your costs and whether or not a given price is profitable has enabled you to escape many of the pitfalls of manufacturers of other lines. Adequate and reliable information about your business has saved your industry a great deal of the unintelligent and destructive competition that arises in lines where manufacturers do not know their true costs of production and where many of them price their products arbitrarily.

## Accounting Essential to Progress

Government has complained about business. Business men have complained of the attitude of the Government toward business. Whatever justification there may have been in the past for such complaints, to-day there is a better understanding between Government and business. Since better business methods usually begin with better methods of cost accounting, scientific cost keeping becomes in a very definite sense the basis of our prosperity. The Government, through the Federal Trade Commission, by recommending the subject of costs to the business men of the country at this time, and offering to aid in the actual development of proper cost systems, is endeavoring to do a constructive piece of work which is of the greatest importance. The problems of credit and finance, of foreign trade and unfair methods of competition, and of labor and capital—all will begin to solve themselves once the subject of costs receives on every hand the attention it rightly deserves.

### Benefits to the Public

So rapid has been the expansion of American business during the last year that the public are unable to realize the vast advantage it will be to the nation as a whole. This business expansion is placing the United States in the forefront among exporting nations and giving it a control of the financing and producing forces of the world which other nations have spent many decades in building up. This prosperity is an advantage not merely to those businesses which are benefiting directly, but to the great masses of the American people who are employed in these industries, or who benefit indirectly by everything which increases national prosperity. Do we realize the importance of our position? Are we doing all that we should to increase efficiency in production, to standardize our products and processes, and to perfect our selling organizations?

### Foreign Commerce Should Be Reciprocal

I need hardly point out that commerce, if it is to be permanent, must include buying as well as selling. It must be reciprocal. We must be prepared to purchase raw and finished materials from the countries we sell to. With the growth of our export trade must go the growth of our imports. Ships which leave our ports laden with our manufactured goods should return with full cargoes of the products of the countries with which we trade. In the very nature of things our trade expansion has for its complement the trade expansion of those peoples to whom we sell.

### Foreign Trade Opportunities

The present European war has given us an unprecedented opportunity for developing our export trade. When peace is again restored we will, for a while at least, be the leading export nation of the world; whether we retain this supremacy will depend largely upon the efficiency of our merchandising and industrial organization and the co-operation of our Government with business. These opportunities for trade exist in Latin America, in the Orient, in Russia, and elsewhere. Let me particularly mention the opportunities to be found in Russia. Russia exports hides and skins, carpet wools, vegetable fibre, and makes a specialty of exporting flax, furs and licorice root. At the present time our leading exports to Russia are agricultural implements, raw cotton, machinery, locomotives, cars and copper.

The present war and many reforms, such as the abolition of the sale of vodka, have proven of great financial benefit to the Russian people as a whole, of which there are 170,000,000. Even a slight increase in the consuming power of this large population will mean in the aggregate a vast increase in trade opportunities.

Before the war 30 per cent. of the products purchased by Russia from the United States, and 20 per cent. of the products purchased by the United States from Russia, were handled through German commission houses in Berlin. We now have an opportunity to increase our trade. Buying and selling direct with Russia will save commissions, reduce the costs, and bring the business men of Russia and the United States in closer contact. American business has no greater trade opportunity to-day than the one presented by the Russian Empire.

## After the War, What?

We frequently hear about how the trade of the different countries is going to be regulated after the war. There is no question but that many new economic conditions will be presented, not only by the nations at war, but by our own and other neutral countries.

After the war England, France, Russia, Italy, Belgium and their dependencies will, without a doubt, form a co-operative trade compact whereby they will agree to purchase from and sell to each other every possible commodity manufactured or produced by them. This will be for the purpose of protecting their manufactured products and their natural resources, and to co-ordinate their shipping and financial interests.

England in the past developed a large foreign trade through financing foreign enterprises, and for many years the business men of that country obtained their orders through London bankers. This required little, if any, trading or merchandising skill on the part of these manufacturers and merchants to secure business.

### Efficiency in Selling Organizations

On account of the advantages which the investment of English capital in foreign countries gave to English business men, they did not develop a well-organized selling force. When Germany went after foreign trade about 25 years ago, England felt that because of her great financial strength her business men were secure. You know what happened.

The German manufacturers and merchants, realizing that to be efficient they must run their factories to the maximum, which means every day in the year, and realizing that they could not sell all the products which they could produce in the home markets, started after the foreign trade which England had controlled for so many years. Aided by the German Government, they put salesmen in the field in almost every country in the world, and in a few years they were considered the only rivals of England. This was all brought about by thorough and efficient manufacturing and selling organizations.

### Co-operative Selling Agency in Foreign Trade

Nowhere is co-operation among business men, and between them and government, more essential than in the development of our foreign trade. The success of our European competitors is evidence enough of this. We have reached the point where, under normal conditions, we must have foreign markets for our surplus manufactured products. The American people, including every day laborer, every clerk, every mechanic, every farmer and every business man, large and small, is heartily in favor of Congress removing the doubt which now exists in the interpretation of the anti-trust laws when applied to organizations co-operating to further our export trade. Such relief will make it possible for us to obtain our share of foreign business, so that our factories may run continuously and keep our workmen permanently employed.

Competition is the same the world over, and it will be particularly keen when the business of peace is resumed among the nations. America's chance at the trade of the world will be helped beyond what it was before by reason of a new, even start with the others in the race, but we must be prepared to match systematized industry against the effective systematized industries of our competitors. We must meet conditions as they exist.

If our business men are to be factors in the world's markets they must receive encouragement to do as our foreign rivals are doing, and the Federal Trade Commission has recommended to Congress that a bill be passed giving the American manufacturer the legal right to form a co-operating selling agency in export trade. (Applause.)

The Federal Trade Commission does not believe that Congress intended by the anti-trust laws to prevent Americans from co-operating in export trade for the purpose of competing effectively with foreigners, where such co-operation does not restrain trade within the United States and where no attempt is made to hinder American competitors from securing their due share of the trade. It is not reasonable to suppose that Congress meant to obstruct the development of our foreign commerce by forbidding the use, in export trade, of methods of organization which do not operate to the prejudice of the American public, are lawful in the countries where the trade is to be carried on, and are necessary if Americans are to meet competitors there on equal terms.

By its investigation the Commission, however, has established the fact that doubt as to the application of the anti-trust laws to export trade now prevents concerted action by American business men in export trade, even among producers of non-competing goods. In view of this fact and of the conviction that co-operation should be encouraged in export trade among competitors as well as non-competitors, the Commission recommended the enactment of declaratory and permissive legislation to remove this doubt.

We feel that we would fail of our duty if we did not urge the pressing need of such action immediately. If American business men are to make the most of the great opportunities now before them, are to build securely in foreign trade, and are to avoid disaster in the shock of the stern and determined competition that will doubtless follow the war, they must at once perfect the organization demanded by the conditions of international trade.

## National Competition

Competition in foreign markets is national. Foreign countries such as England, Germany and France present in markets like those of Latin America a united front. One does not hear of the competition of individual concerns but, for example, of German competition and English competition. Each country pools its governmental and commercial forces and goes forward into foreign markets in a united effort to capture those markets against the business forces of other countries. Competition from our foreign rivals must therefore be met by bringing together in a co-operative way our national forces—governmental, industrial, financial and commercial. American manufacturers must cease to think selfishly or even provincially; they must think nationally and internationally. If we are to be factors in the world's markets, our vision must be broadened; we must cease to think merely of local conditions. United, then, in the spirit of co-operation and with the support of our Government, there is every reason to believe that we will succeed against all comers in the great markets of the world. (Hearty applause.)

Chairman Gary: To quote from Bret Harte or some contemporary: "Do I sleep, do I dream, or are there visions about me?" (Laughter.) I can close my eyes and can easily imagine I am attending one of the Gary dinners.

The reason is that there is occupying this high political office at Washington, not a politician, but a competent, skillful, experienced business man and a real statesman. I call upon you to witness that what has been suggested in this very able address was the real disposition and offer of the leading iron and steel industries of this country long ago to co-operate with the government of the United States, if that could be made possible. And I make the statement here that there was never held a Gary dinner without furnishing to the Department of Justice and other governmental officials the substance of all that took place at those meetings.

And I would like to ask one question: If co-operation is good and wise and valuable and proper and for the best interests of this country with respect to export business, why isn't it good principle to apply it with reference to domestic business? (Applause.)

Gentlemen, this is an epoch. This is a wonderful performance. The gentleman who has spoken represents not alone the government of the United States, he represents the general sentiment of the people of the United States.

One more suggestion: the steel manufacturers of this country, represented here to-night, must never for a moment forget that they are a substantial part of the people of this country; they have the same obligations of loyalty and the same duties to perform with respect to their influence upon the public and their treatment of others that any others connected with the different interests may have, and we must be certain from day to day that we are loyal in every respect in supporting the laws of this country and the sentiment of the people of the United States. (Applause.)

It is now my pleasure to introduce Mr. Jacob Loewenstein, Engineer of the American Bridge Company of New York, who will speak on the subject of "The Hell Gate Bridge." I believe his address is to be illustrated. Mr. Loewenstein.

THE COMPLETED BRIDGE AND ITS APPROACHES

The New York Connecting Railroad is the joint undertaking of the Pennsylvania and the New York, New Haven & Hartford Railroads. It will serve as a connecting link between these railroads and make possible the journey from New England to points in the West and South without change of cars. The track branches from the main line of the New Haven Railroad near New Rochelle, passes through the Bronx, crosses Randall's and Ward's Islands and connects with the Sunnyside Yards of the Pennsylvania Railroad System. At the Sunnyside Yards the freight tracks will connect with the present Manhattan Beach line to Bay Ridge. A ferry will carry the freight from this point to Greenville, New Jersey. A material saving in time over the present ferriage is thus brought about. At some future time, no doubt, a tunnel will afford direct connection between the two shores. The entire cost of the project, including the right of way, will be about $30,000,000.

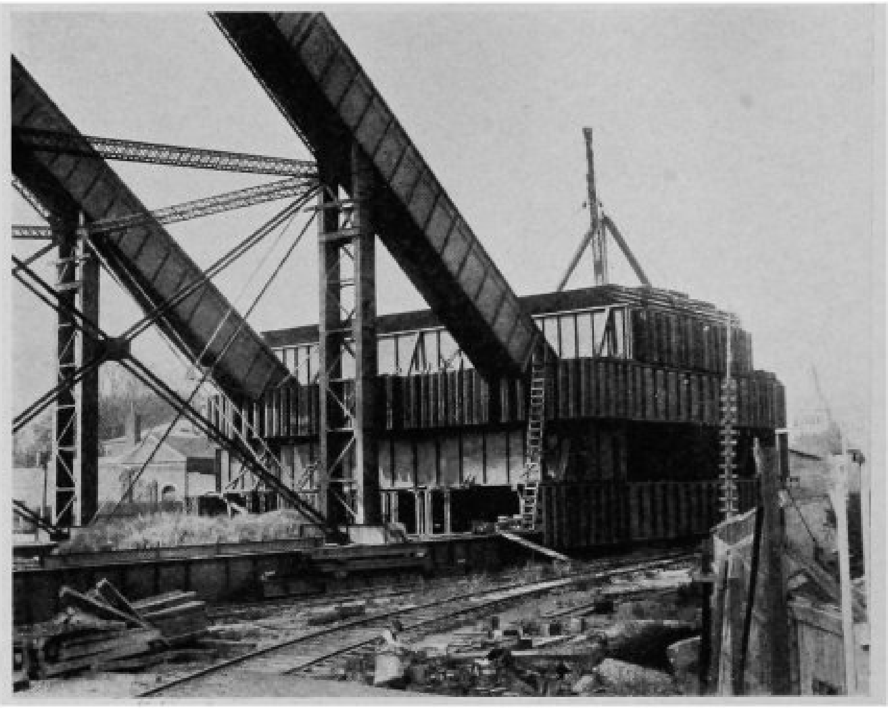
# HELL GATE BRIDGE

Jacob Loewenstein
Engineer, American Bridge Company, New York

It is a great honor to appear here this evening to give you a short account of the erection of this most wonderful bridge at Hell Gate. This engineering enterprise was undertaken jointly by the Pennsylvania and the New York, New Haven and Hartford Railroads. When finished it will be possible for the traveler leaving New England to journey through New York to points in the South and West without change of cars. (Mr. Loewenstein continued his lecture with the aid of a screen. Lights were put out.)

The most interesting part of the undertaking is the steel arch known as the Hell Gate Bridge, which spans the East


Section of Arch Truss temporarily assembled in Ambridge Yard to insure members connecting properly when erected in field.

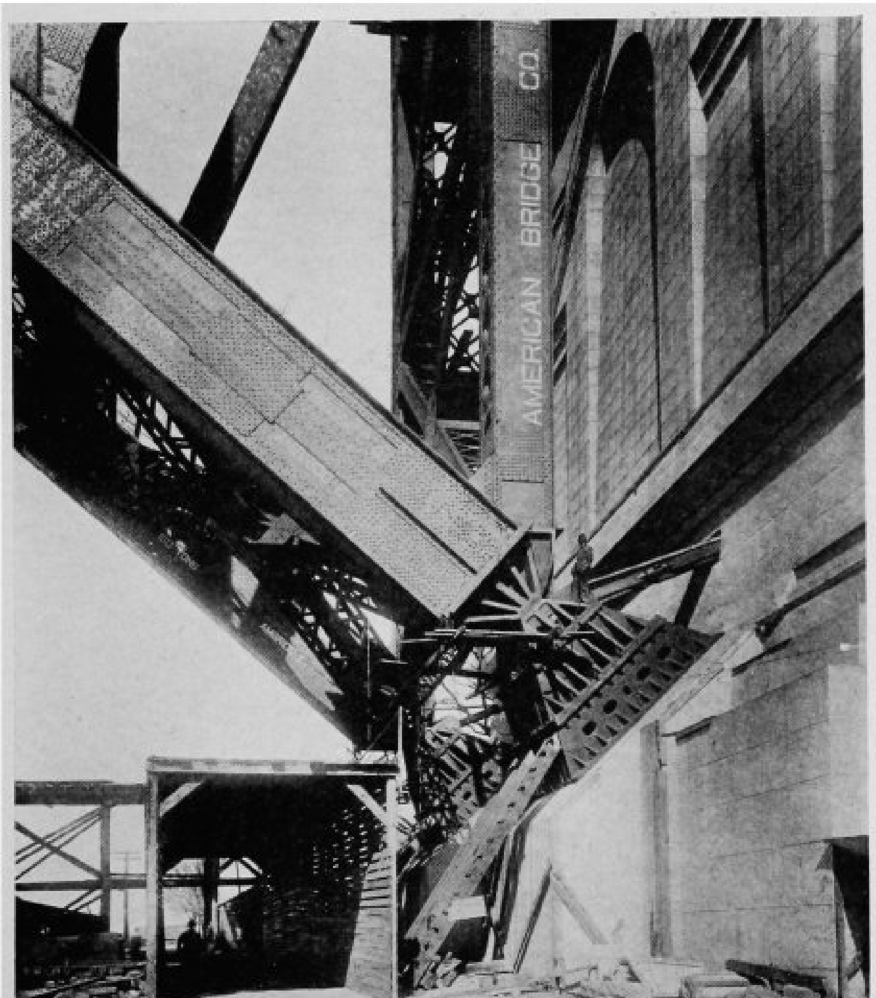


Lower end of back stay and counterweight composed of girders and I beams to be used finally in the Approach Viaducts.

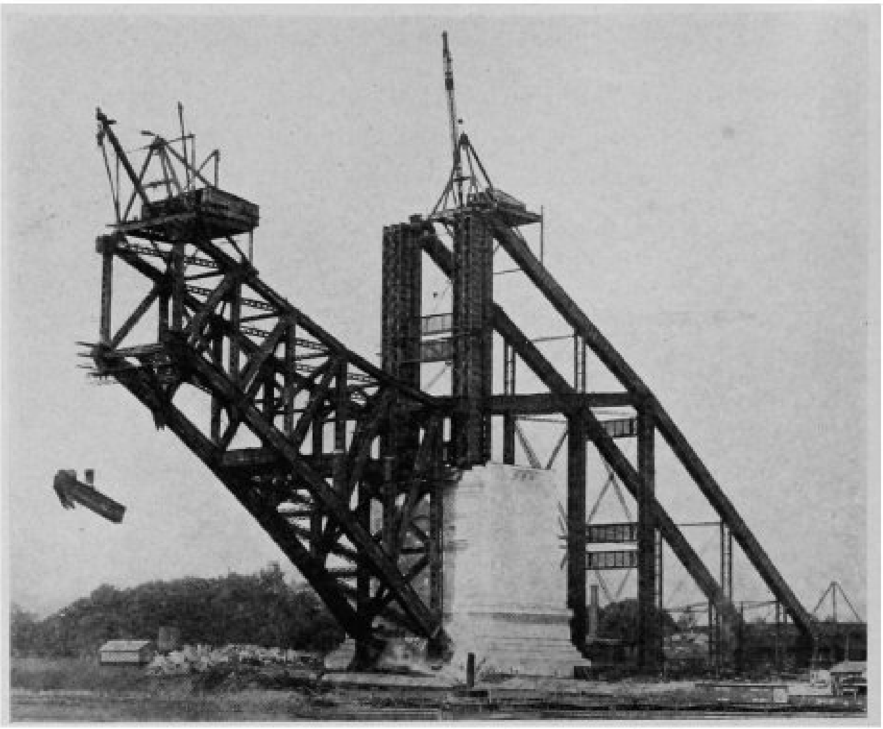
Back stay nearing completion composed of girders of the approach spans and stringers of arch spans. Note railing used for tower bracing. The back stay traveler is erecting the arch traveler.

River between Ward's Island and Long Island at "Hell Gate." The bridge is a four-track structure and its dimensions are as follows:

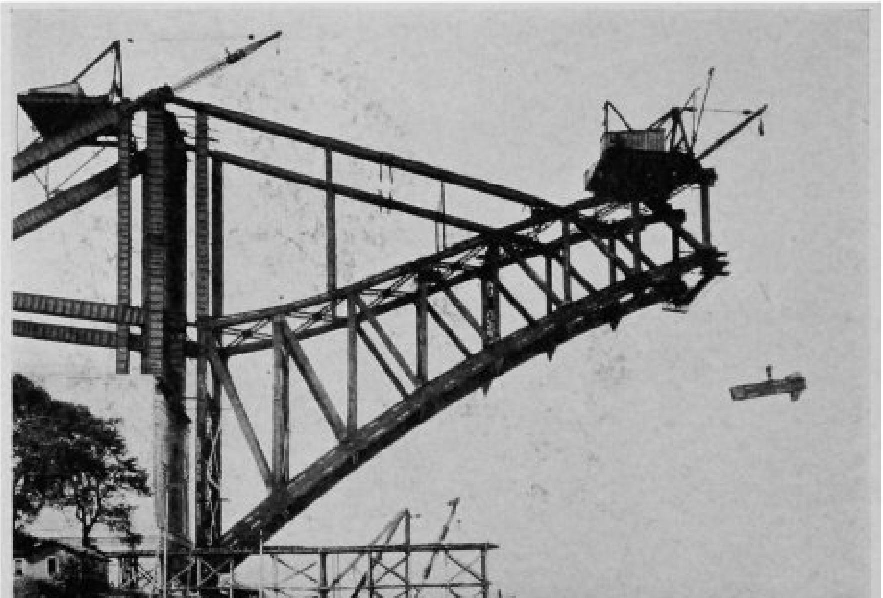
| | |
|---|---|
| Span Length | 977′ 6″ center to center of bearings. |
| Depth | 260′ 2¾″ from bearing at piers to the center line of top chord. |
| Width | 60′ center to center of trusses. |
| | 90′ over all—four tracks and two walks. |
| Clear Height | 135′ above mean high water. |
| Extreme Height | 307′ 6″ above mean high water. |




Heaviest piece of bottom chord in place; also showing the arch shoes, each composed of four layers of castings (13 sections). Note tie to pier in order to hold shoes in place during erection.



Five panels of the arch erected lifting a section of bottom chord with gussets attached. Arch held to back stay by lower tie. Note cages at end for use of workmen.



Seven panels erected. Arch held by upper tie, lower tie disconnected.

The steel used in the bridge and viaducts on either side was divided into four classes:

1. Hard steel, used for the arch span.
2. Structural steel, used for other rolled material.
3. Rivet steel, used for rivets.
4. Cast steel, used for shoes for the main arch and girder shoes on the viaduct.

The steel was required to meet the following chemical and physical specifications:

| | Phosphorus Maximum Per Cent. | | Sulphur Maximum | Manganese and Carbon |
|---|---|---|---|---|
| | Basic | Acid | | |
| Hard Steel | 0.04 | 0.06 | 0.05 | To be recorded |
| Structural Steel | 0.04 | 0.06 | 0.05 | To be recorded |
| Rivet Steel | 0.04 | 0.04 | 0.04 | To be recorded |
| Cast Steel | 0.05 | 0.08 | 0.05 | To be recorded |

HARD STEEL: *Ultimate tensile strength*, 66,000 to 76,000 lbs. per square inch (71,000 desired).

*Yield point* determined by first drop of beam, maximum speed 2″ per minute = 38,000 lbs. per square inch, minimum.

On retest elastic limit as determined by dividers = 36,000 lbs. per square inch, minimum.

*Elongation*, 1,400,000 divided by ultimate strength for thickness up to ¾″ with a decrease of one per cent. for each increase of ⅛″ thickness above ¾″.

Minimum elongation to be 16% for 2″ maximum thickness of plate and 15% for thickness above 2″.

*Cold Bending Test*, 180° around a pin of double the thickness of the test piece for material up to and including ¾″; 180° around a pin three times the thickness of test piece over ¾″ up to and including 2″.

*Character of Fracture*, silky.

STRUCTURAL STEEL: *Ultimate strength*. 62,000 to 70,000 lbs. per square inch (66,000 desired).

*Yield point* as determined by first drop of beam, maximum speed of 2″ per minute = 35,000 lbs. per square inch, minimum.

On retest elastic limit as determined by dividers = 33,000 lbs. per square inch, minimum.

*Elongation*, 22% in 8″.

*Fracture*, silky.

*Cold Bending Test*, 180° around a pin the thickness of test piece.

RIVET STEEL: *Ultimate strength*, 50,000 to 58,000 lbs. per square inch.

*Elastic limit*, minimum, 28,000.

*Elongation*, 28% in 8″.

*Cold Bending Test*. 180° flat.

*Fracture*. Silky.

CAST STEEL ANNEALED; *Ultimate strength*. 65,000 lbs. per square inch, minimum.

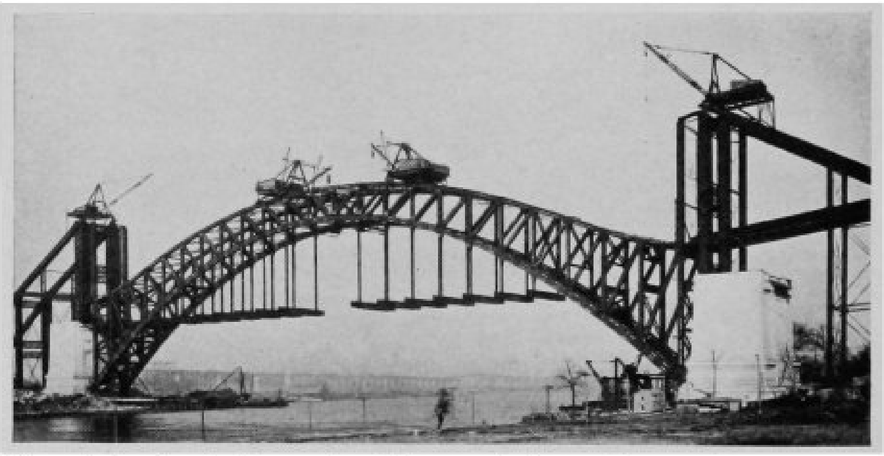
*Elastic limit*. 33,000 lbs., minimum.

*Elongation*, 20% in 2″.

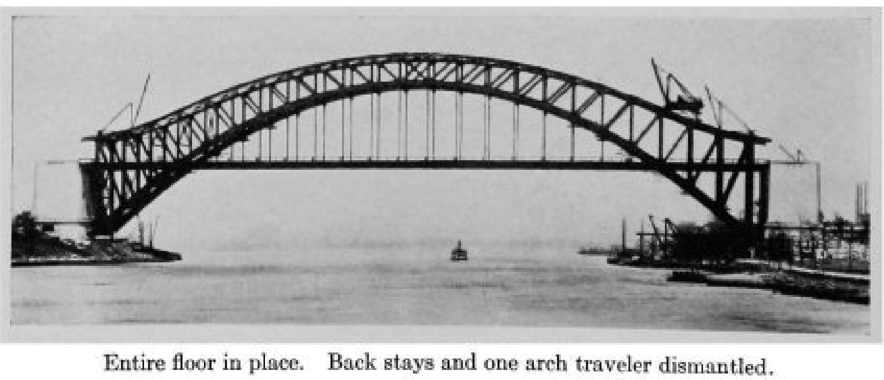
*Cold Bending Test*, 90° around pin diameter 3 times thickness of test piece.

*Fracture*, silky or fine granular.

All but center panel of arch in place. Note part of approach viaduct in the background.



The arch closed and self-supporting. The upper back stay tie removed and the floor-beams mostly in place.



Entire floor in place. Back stays and one arch traveler dismantled.

A large element of the fabrication and erection costs was due to mill limitations. The maximum plates rolled were not large enough for the webs of the bottom chords. This necessitated splicing in every panel both longitudinally and transversely. The 8 x 8 angles used were the largest size obtainable, but better results could have been reached by using 10 x 10 or 12 x 12 if such sizes had been rolled. Ingenious though expensive details were used to keep gusset plates within obtainable widths and lengths. On account of the inability of straightening large gussets, special care was taken in rolling and cooling to see that they were straight and true. This was absolutely necessary to insure members entering properly in the field.

In shop fabrication, consideration had to be given to the ease with which parts could be handled as well as riveted together. In the arrangement of details, confined spaces were eliminated wherever possible, in order to safeguard the workers against fumes from paint while hot rivets were being driven. The weight of the heaviest piece handled in the shop (the first bottom chord) was 150 tons. Rivets of $1\frac{1}{4}$ inches in diameter were used for fastening pieces together, some rivets having as much as 10″ grip. The metal was all drilled. To insure an accurate fit in the field, the trusses were assembled in the yard, and connections carefully reamed and marked, so that the pieces could again be put together without difficulty. The only new equipment added to the shop to facilitate fabrication was a planer for finishing the ends of the large chords, and a 150-ton gantry for assembling trusses in the yard.

The question of shipment received due consideration. On account of the weight of the individual pieces, the Pennsylvania Railroad Company was obliged to construct special cars to carry them. Some members, owing to their depth, had to be shipped to the site by a roundabout way in order not to exceed existing car clearances.

The most important consideration in the development of the plans was the question of erection. On account of a swift current and the necessity of keeping the channel open for navigation, the structure could not be erected by supporting it directly on falsework. The bridge was erected from each end toward the center, anchoring the ends by temporary means on the shores. When the two ends met at the middle, adjustment and connection were made by the use of four enormous jacks that gradually lowered the halves into position.

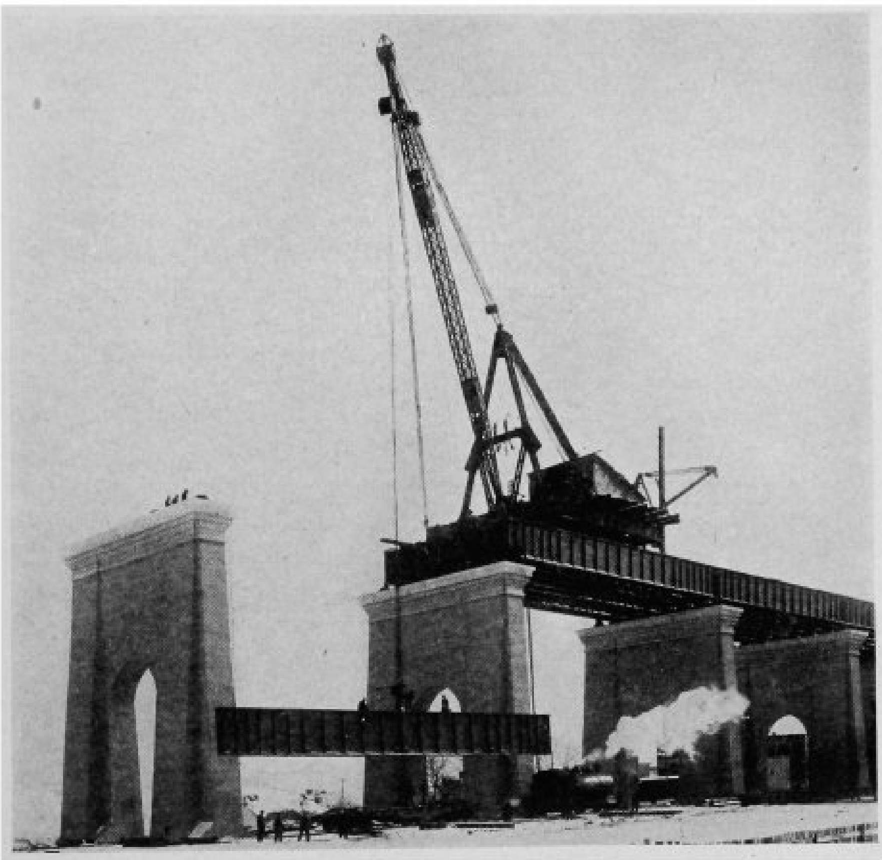
The noteworthy features of what has been termed the boldest erection scheme on record were:

1. The unique method in which the permanent material from bridge and viaduct was used for erection purposes. About 85 per cent. of the entire temporary erection material was later placed into the permanent structure. To this scheme can be largely ascribed the success of the American Bridge Company in securing the contract.
2. The exclusive use of steel for all temporary supports. The omission of all timber reduced the fire hazard.
3. The use of working cages for safeguarding the men.
4. The accuracy with which the entire back anchorage and arch were fabricated and erected.

Below is a tabulation of some of the important factors regarding the bridge:

| | |
|---|---|
| Heaviest piece lifted, first bottom chord with gussets attached | 180 tons |
| Weight of one complete cast steel shoe, made up of 13 pieces | 250 tons |
| Capacity of each jack for adjusting connection at center as well as releasing stress in the temporary material supporting the arch | 2,400 tons |
| (These jacks were tested up to 3,000 tons before being used.) | |
| Weight of one erection traveler for arch | 315 tons |
| Weight of steel in bridge | 20,000 tons |
| Weight of steel in viaduct (American Bridge Company contract) | 22,000 tons |
| Weight of temporary material required to support the arms while projected over the river | 14,000 tons |
| Weight of bridge per lineal foot, including complete track | 26 tons |
| Carrying capacity of bridge per lineal foot | 12 tons |

In presenting this paper, the writer calls the attention of the members of the American Iron and Steel Institute to the new field of bridge construction that could be opened by rolling larger pieces of material. An improvement could be made not only with regard to the size but also with regard to the carrying capacity of steel. The Hell Gate Bridge, the largest of its kind in the world as well as the heaviest bridge per lineal foot, could then be exceeded. The carrying capacity is only one-half of its own weight. Though this is far greater than any other large bridge, it is still far from being ideal. (Applause.)



Back stay traveler being used to erect viaduct approach.

## IMPROMPTU REMARKS IN RESPONSE TO CALL OF THE PRESIDENT

THE CHAIRMAN: We now come to the part of our program which provides for impromptu speeches. We will call first upon Mr. Charles F. Rand, President of the Spanish-American Iron Company and of the United Engineering Society, New York.

MR. RAND: Mr. Chairman and Gentlemen: The success of the American Iron and Steel Institute is so great that it overshadows other similar work; yet I think you may be interested here in something of the work that is now being done by the American Institute of Mining Engineers, the American Institute of Electrical Engineers, the American Society of Civil Engineers, and through the instrumentality of these united engineering societies.

The United Engineering Society was formed by the American Institute of Mining Engineers, American Institute of Electrical Engineers and American Society of Mechanical Engineers in the year 1903 to hold the legal title to part of their property and to act for them in certain matters.

Through a gift from Andrew Carnegie of $1,000,000 and a loan from him of $500,000, the Societies were able to build the great Engineering Societies' Building in West Thirty-ninth street, New York. The loan has been repaid with interest, and endownment funds now represent $2,000,000, all free and clear. The Engineering Foundation is a fund established for engineering research, started with a contribution of $200,000 by Ambrose Swasey, of Cleveland, Ohio.

The total membership of the Mining, Mechanical and Electrical Institutes is 21,000, and the membership of associate societies is 23,000, making a grand total of 44,000 engineers who now have their headquarters in this building.

The American Society of Civil Engineers, although originally invited to participate, did not do so because of having a home of their own, but it is expected that they will accept a recent renewal invitation to become an additional Founder society and make this their permanent home.

The Library contains 52,000 bound volumes and 10,000 unbound volumes. The Library of the Civil Engineers contains 25,000 bound volumes and 46,000 unbound volumes. When combined these libraries will constitute the most complete engineering collection in the world. It is a free public library. Plans have been made to make this Library a general information bureau on applied science, to furnish references on technical literature to any person, to make abstracts or copies, translate between all languages, and furnish photographic copies of maps, diagrams, tables, etc. At present the societies can only afford to spend about $15,000 per year for the conduct of the Library. Plans have been made which contemplate the expenditure of $50,000 per year, part to be paid by the societies and part from the income from endowments which it is hoped will soon be obtained.

The Bureau of Engineering Information is expected to be of great assistance to engineers having problems in mining, metallurgy, hydraulics, electricity or unique mechanical problems. It is at present being conducted in a modest way, but in its final form any one may send his engineering problems to this library and receive very good service. For instance, a man is inquiring about tin mining in China, or tin mining anywhere in the world. He writes to the library, where the subject is looked up and the information desired by him collated and sent on. Or a man may have a difficult, or complex, or scientific problem before him. He has no knowledge that it has ever been done before. He will probably find in the library that some other man has already met and solved that particular problem and written about it, and thus he is saved considerable time and trouble.

Gentlemen, I am very grateful to you for having permitted me to call your attention to this subject and the work that is being done by the Engineering Society. (Applause.)

The Chairman: Mr. Charles C. Cluff, of the Carnegie Steel Company. Please come forward to the platform so we can all see you.

Mr. Cluff: Gentlemen: You may recall, at the meeting of this Institute last fall, in Cleveland, one of our members connected with the selling end stated that he did not remember any papers having been read from the sales department. It is my privilege to be connected with that department, and this fact is, perhaps, the reason why our Secretary, Mr. McCleary, notified me next morning that I might be called upon at this meeting to make some "impromptu" remarks and advised me to prepare myself accordingly.

Under the present prosperous conditions ruling in the steel business, with mills making records practically each month in the matter of output, thus reducing costs so that the position of the operating official is about all that could be desired, perhaps it has not occurred to some of us here to-night just what the sales manager's position is under such congested conditions.

Let me say seriously these are very trying times for the sales manager, as he stands between the buyer, who is pressing for deliveries, and the mill, which is unable to make them satisfactorily to anyone. He is really a "Commercial Ambassador," that is, an envoy extraordinary between the customer and the mill, charged to execute certain negotiations to the advantage of both. This certainly requires considerable tact and diplomacy upon the part of the sales manager in order that the result may not militate against his company in the loss of the customer's business when the time comes again, as it surely will, that said business will be badly needed. The sales manager must be fair to his company as well as to the customer, but at the same time use his influence to see that the latter is receiving his fair proportion of the tonnage shipped. He must also be willing to listen to all the complaints and troubles that the customer desires to pour into his ear personally, and, without being able to help him pacify him by showing him why his position is unreasonable, and sympathize with him generally, but send him away remaining a customer.

There are, however, many bright spots in the sales manager's life. Prominent among these sources of satisfaction is the pleasure he feels when he has obtained for his company reasonable prices according to the market, and at the same time has taken care of the customer in such a way that the satisfaction is mutual. There is also the personal equation, the friends one makes based upon integrity, confidence and fair dealing. It has been my pleasure and privilege to serve under the President of this Institute for the past twenty years, during which I have tried to emulate to the best of my ability his spirit of fairness and justice. I thank you. (Applause.)

THE CHAIRMAN: I call upon Mr. James Gayley, President of the Ore Reclamation Company. Mr. Gayley.

MR. GAYLEY: Gentlemen: In these days people are showing their interest in preparedness by parades, and men are arranging to attend training camps, and women are training for hospital service in preparation for military purposes. There is also preparation being made by private organization and capital for expanding our foreign trade, and there is a program to prepare industries for war; but I wish to direct your attention to some features in preparation for competition which I think are fundamental.

We have been told that France was retrograding; that England was unprogressive and her manufacturing was in a rut, but the war has awakened them. We behold to-day compact, highly efficient nations working out their destiny with a single purpose and in a most masterly way. It may be true that the English nation has been slow moving and deliberate, but the war has changed all that. You know when supreme trial overtakes an acquaintance whom till then we conceived we knew, how the man's nature changed past knowledge or belief.

So we have seen these nations transformed beyond our every conception. In those countries to-day all forces work outward to the front, like a chain of buckets toward a conflagration; everybody has his or her bucket, little or big, and nobody disputes how they shall be used.

It is thought that the nations at war will be so burdened with debt that any progress will be hindered for a long time, and that so many men have been killed or injured that it will cripple their industries and we will be advantaged accordingly. I doubt that advantage to be anything but a temporary one. Our national debt is about $10 per capita, and if the war lasts until the end of the year, the average per capita debt of the nations at war will be at least twenty times as great as ours; but England's debt per capita was much greater after the Napoleonic wars a century ago.

That those nations will be seriously crippled in men, I doubt very much. They are densely and over-populated and a diminution may work little harm from a manufacturing standpoint. Many have been and will be killed, and many more will be wounded, but back of the men at the front engaged in war activities are vast armies of men being prepared by thorough training for war, who will be most effective in the time of peace.

The chief dependence to-day of a nation at war is on the physical fitness of the individual. And with a nation trained into physical fitness, that fitness translated into times of peace makes the nation far more efficient in manufacturing and business.

The warring nations have also learned the necessity of economy—the spirit of patience and the advantage of co-operation which will be continued in times of peace.

England, a non-military nation, has learned a lesson from German efficiency and profited by it, and after the war ends will carry that efficiency into manufacturing and every branch of trade. If I mistake not, Germany will count as her greatest loss in the years to come that through the disclosures she has made of the value of efficiency and organization, which will be adopted by other nations, she has built up an enduring force of competition against her in trade and in every form of national endeavor.

What are we doing to keep pace with these nations that have been rejuvenated through a war which has awakened them as never before?

We have in national thought traveled along conservative lines, as an inheritance of our ancestry. We have been lulled into a sense of security by reason of our supposed isolation by oceans, and we have aimed to be neutral. Nature has endowed this country with rich raw material and fertile soil. The climate gives the people energy, and by the expenditure of that energy on raw material in mines and furnaces, and by cultivating the soil, great wealth has been produced, which makes a people complacent. May not this complacency as to the future bring it about that the warring nations will become the younger nations of the world, and we one of the older nations? For the age of a nation, as reckoned to-day, is not in its life's history alone, nor its abundance of relics of the past, which Matthew Arnold pronounced "but the trumpery of a thousand years," while the youthfulness of a nation is determined by its progressiveness and efficiency. (Applause.)

We have seen Germany's efficiency in war, and we know what it is in manufacturing and in trade, and her efficiency will continue. Here is a nation not blessed with rich raw material as compared with this country, but they have applied to their problems 75 years of technical education and scientific training, thorough and highly specialized and organized in its efforts. The military training has made the men physically fit, and the application of physical energy under direction of trained specialists has created an efficient Germany in all lines of manufacturing and national work.

Can we think that the Allies, having learned so much from German efficiency in war, will not follow out her German efficiency in times of peace, after the period of reconstruction is ended?

There is much that we can do as individuals in furthering the work of preparedness to meet competition. Most of our higher institutions of learning are supported through individual benefaction. To every man who has won wealth there is no greater opportunity to expend his wealth for the good of his country and erect an enduring monument for himself, than to freely endow departments of institutions providing a technical education; in establishing schools for research work to better use and to economize raw material, expanding the work now carried on by some corporations; in establishing schools of commerce and international finance, and industrial schools in manufacturing centers. Back of all this, and in order to make the individual thoroughly fit for the nation's work, there should be a compulsory system of physical and military training in our schools and educational institutions as a certain step toward efficiency.

Military training in schools is much misunderstood. It is not a preparation for defense alone. There is a distinction between a nation prepared and a nation in constant readiness for transition to war. It is an education in the duties of the citizen to the state, and to impress upon the young men that a part of their efforts is for the benefit of the nation and not all of it for themselves.

It is not the "old school" method of bending the will by blind, unreasoning obedience, but to use the individual will in concerted action which is the basis of efficiency; and, besides, it brings the individual to manhood physically fit for the duties of life. We need to train our young men in highly specialized lines, supplementing it with physical efficiency and directing it by intelligent organization. (Applause.)

The Chairman: I have the pleasure of introducing to you Mr. William S. Pilling, of Pilling & Crane, Philadelphia.

Mr. Pilling: Gentlemen: This business of public speaking I find is viewed from very different angles. In traveling through Virginia some years ago on a special train, we were delayed and the train finally became very late. Among the party were two trustees of the University of Pennsylvania, an ironmaster and a lawyer. When it became evident that the connection for Philadelphia could not be made, one of them, the ironmaster, said: "I must get out and send a telegram. I am due to make an address to-night in Philadelphia and I cannot keep my appointment." He sent off his telegram, and the other trustee, a lawyer, said: "Well, this is rather awkward for me, too." "Well, what is the matter?" I said, "Do you have to make an address?" "No, worse than that," he said, "I have to listen to one."

A couple of years ago I was leaving the Institute dinner about midnight to get a half-past twelve train, and down at the revolving door on 34th street I saw Uncle Joe Butler just going out. "Why," I said, "Mr. Butler, I never knew you to go home so early." "Yes," he said, "I am going home. They didn't call upon me for a speech, and I am going to take the first train for Youngstown." (Laughter.)

Now, when I got my two weeks' notice that I was to deliver an impromptu address, as no doubt did the other men, I immediately sat down to dictate a declination. Public speaking is not in my line. And then a vision of our President came before me. I remembered what he had said about co-operation and that every member of this Institute when called upon must do his duty and do no shirking. So I tore up my letter of declination and here I am.

Then I thought, well, what shall I talk about? Everything on Heaven and earth and beneath the earth has been discussed here. Then an observation came to mind, and I wondered whether the same thought had come to the other members of the Institute, and that is this: Have you ever noticed the number of lawyers that attend these dinners? I doubt whether any convention of lawyers has as many iron men as we have lawyers. Of course, we are glad to have them. As the song says, they are jolly good fellows, and they are good talkers—talking is one of their strong points. But I have wondered whether there is some hidden or mysterious reason why these lawyers attend these meetings.

In Philadelphia, where I come from, that is, the City of Brotherly Competition, there was, years ago, not only competition, but rivalry and even feuds which grew into bitter quarrels between our railroad systems. Many of us can remember how the Pennsylvania and the Reading opposed anything which the other wanted to do. About that time a new Archbishop came to Philadelphia and took up his residence there, and many of the prominent citizens tendered him a reception and dinner. The chairman of the meeting, in introducing the guest, said he thought that it was proper that he should explain the personality of some of the people present. So he said: "Your Grace, you will notice that we have here the president of our greatest railroad. When the chairman of the invitation committee asked this gentleman if he would be present he seemed to hesitate. He said: 'Well, I'll tell you; I never go out to any of these public meetings any longer unless I am attended by my counsel. You know the intense feeling there is now between the railroads, and if it is permissible for my counsel to be present, I should be very glad to meet the Archbishop.' " The chairman said: 'Certainly. We are going to invite him, and he will surely be there.' 'Then,' said the chairman, 'we went to the president of another railroad and we asked him if he would come and meet the Archbishop, and we were rather surprised when he made the same sort of reply—that he did not want to go out to meet the other railroad men unless his counsel was with him, and whenever we invited the railroad president we were careful to send an invitation to his counsel.' Then turning to the Archbishop, he said: "Now, I am going to ask these railroad men to honor you and do a favor and pleasure to me. I am going to insist that every one of them shall give you a free pass, an annual pass, and promise to renew it as long as they live, over the entire system. And your Grace," he said, "in return for that, I want you to assure each one of these gentlemen a sure, direct passage to Paradise when their time will come." The Archbishop arose very slowly, with a very thoughtful expression on his face, and with some hesitation said: "Well I am quite ready to issue direct transportation to Paradise to all of these railroad presidents. But," he said, "I do not like to separate them from their counsel." (Laughter.)

Now, some of us belong to the class of smaller manufacturers. Many of us represent what are to us important industries, but small industries compared to many of the great ones which are represented here. And in concluding these rather scattering remarks, I want to pay a tribute to the membership of this Institute. I feel quite certain that many of us felt a little apprehensive years ago as we saw these great corporations being formed, not one but many, some, of course, greater than others, and in our minds we wondered what might become of the smaller companies and the individual operator. We have rejoiced to learn, to know as the result of experience, that these big corporations are controlled and managed by big men, men of liberal views, of broad minds and of real friendship; and I know that I voice the thought of a large number of my companions of the smaller companies when I say that we now feel safer in the hands of our big competitors than we used to feel in the hands of our little competitors, and none of us feel that when we come here we have to be protected by our counsel. (Applause.)

THE CHAIRMAN: Mr. Robert J. Mercur, President of the Standard Iron Company, Montreal, Canada.

MR. MERCUR: Mr. Chairman, Ladies and Gentlemen: We in Canada consider it a great honor to belong to the American Iron and Steel Institute and to have the opportunity of acquiring the valuable information and advice to be heard at every meeting of the Institute. In numbers, if not in area, we are the small brother of our southern neighbor. I think I can also say, without being accused of flattery, that the remarks we have the privilege of hearing from our President, Judge Gary, are a constant inspiration to us in the conduct of our business. The motto of the Institute, "Right Makes Might," so thoroughly exemplified in both his words and his actions, is particularly appreciated in this terrible crisis of international affairs when so many of our brethren and allies are giving up their time, fortunes and lives to maintain this principle for the benefit of the world. We feel justly proud of the showing the Dominion of Canada is making and the sound position and progress of our iron and steel industries.

As the welfare work that is being carried on so vigorously and successfully by different members of the Institute appeals to all of us, I think you will be interested in learning of one item of welfare work that is now being carried on in Canada, and that is the Patriotic Fund, which provides for the wives, children and dependents of all our enlisted soldiers. The total already reached is over $10,000,000, made up entirely by voluntary subscriptions.

The distribution of this $10,000,000 is handled in a very systematic and businesslike way. It is not dealt with as a charity, but as money justly due the wives and dependents of the soldiers. Further, it only supplements two other amounts regularly received by the soldiers' dependents, one being the portion of the government pay assigned by the soldier to his family, and the other being the government allowance, or separation money, which averages about $20 per month per family.

The personal touch is added by the individual families being visited by voluntary women workers, and particular attention is paid to hygienic and sanitary conditions. Special arrangements for medical services are made in the case of the children, and special attention is given to any affection of the eyes, ears, nose, throat, etc. It is interesting to note how the general hygienic conditions of so many families have improved since this work has been carried on.

In addition to this, the Red Cross Society and the Belgian and other Special Relief Associations are doing noble work.

You read much of war these days, and we are watching with interest the awakening of your nation to the necessary preparedness. Up in Canada we have prepared, for we are at war. The air is full of the sounds of the bugle and the drum; everywhere the eye meets khaki-clad soldiers; and with the two hundred thousand gone, one hundred thousand now going and two hundred thousand more promised, one understands that war is a very real thing to Canada, and that she is nobly undertaking her share of the fight for human liberty.

While we are determined, with our Allies, to carry the war forward to a successful conclusion, we cannot help but wish that the days elapsing until the end of the war could be given as exactly as our friend Penton gives in his daily issue the days still to elapse before your much-wished-for change in the United States is accomplished.

James H. Hare, the Veteran War Correspondent of *Leslie's Weekly*, who has been in the war area since August, 1914, sums up the situation as follows:

"This war is like a Poker Game. The Central Powers, thanks to good hands in the form of long years of preparedness, cleaned up a few pots at the beginning of the game and quite naturally are getting cold feet and would be happy to quit. But the Allies are forcing them to sit in and play the game out, and, believe me the Allies are going to clean up everything. That is as certain as anything human can be."

I thank you gentlemen. (Applause).

THE CHAIRMAN: Mr. J. V. W. Reynders, Vice-President of the Pennsylvania Steel Company, Steelton, Pa.

MR. REYNDERS: Mr. President, Members of the Institute and Guests: When the Secretary wrote to me, as I presume he did to all these other impromptu speakers, it was stipulated that my time would be limited to five or eight minutes. I had a further understanding with Mr. McCleary that I would yield enough of my time to make up for the excess taken up by my predecessors, and on the basis of that computation my speech came to an end an hour and a half ago (Laughter), a fact which I am sure is as gratifying to me as it is to you. Nevertheless, one or two observations are necessary on the score of propriety.

I am constantly impressed with the fact that one always learns something in coming to these meetings. I was particularly interested to observe the moving pictures thrown upon the screen illustrating the erection of the Hell Gate Bridge, because I happened to be the second lowest bidder on the work. At the time in question, three or four years ago, the steel business was at a low ebb. We put our bid down to a point where we were quite sure that no one could go much lower and make any money. Notwithstanding this, we were underbid by a good many hundred thousands of dollars—I won't tell you how many hundreds of thousands—and the reason of it all has now become perfectly evident in so far that we had failed to take into account the possibilities of moving-picture photography. (Laughter.) The facility with which we have seen these huge members, weighing over a hundred tons, placed into position, and the incredibly short time required to make the center adjustment, has certainly reduced to a minimum the most expensive and uncertain element of cost in the construction of long-span bridges. It only goes to show how the American Bridge Company manages to keep just a little ahead of the rest of us. (Laughter.)

This constant demonstration of superiority makes one feel toward this company like the Irish woman did toward the English. About a year ago, you will remember, an engagement took place in the North Sea, in the course of which a number of retreating German ships were sunk by the British fleet. During the progress of the engagement a young Irish seaman, under heroic circumstances, saved the life of his superior officer, and as a result won the Victoria Cross. As he was a poor man, it was felt that the giving of the Victoria Cross should be supplemented by some substantial evidence of the appreciation of his countrymen, and accordingly the sum of one hundred pounds was subscribed in London to be presented to his poor mother in Ireland. The committee that was selected to make the presentation in person sought out and located the old woman some miles outside of Dublin in a small hovel, and brought her out into the open air. Ranged in front of her, in the full glory of top hats and frock coats, they delivered their address, and, after recounting the heroic deeds of her son, presented the purse of money. Thereupon the mother got up and said: "Well, gentlemen, it's a fine story ye've bin tellin' me of me boy Dennis. Dennis was ever a fightin' lad. Wherever there was any fightin' goin' on, Dennis was there, an' me not knowin' half the time what Dennis was fightin' about. And I'm sure I don't know now what all the excitement is about, but I only hope to God somebody will lick hell out them damned English." (Laughter.)

I must encroach just a few moments more upon your time and patience. The two outstanding events of this annual meeting, it seems to me, are two addresses, the one delivered by our President this morning, and the other tonight by the Vice-Chairman of the Federal Trade Commission. Judge Gary gave expression to the legitimate hopes of American business men, while Mr. Hurley has given to this Institute the first welcome glimpse of the realization of those hopes. (Applause.)

I have listened to Judge Gary on many previous occasions, perhaps on every prominent occasion connected with the American Iron and Steel Institute. I have heard him give utterance to expressions of optimism when he seemed to be the only optimist in the room, not omitting the man at my right, who invented optimism—Charles M. Schwab. (Applause.)

It is therefore gratifying to the Judge's many friends that an occasion has presented itself when the facts require no straining of the imagination. The courageous foresight with which he directed the building of new works and the constant enlargement of old ones in periods when the demands of the country seemed to be inadequate to existing capacity, has been vindicated, and the seal of undisputed success has been impressed upon the greatest commercial undertaking in the world's history. (Applause.)

The recent chain of circumstances which has advanced the prosperous development of industrial enterprises in the United States, so that the normal progress of ten years has been crowded into two, is, however, a story of which only the first chapter has been written. Even as appeared in Mr. Loewenstein's paper, there is always apt to be a "Ford" in the ointment, nowadays.

Europe is paying to America a ransom for its future. In the natural course of things we were perhaps entitled to have our turn. We paid our ransom to Europe during the Civil War, and in many financial and industrial wars since then, but the figures are bigger now than has been the case at any time in the past.

The sudden acquisition of great wealth is apt to be as fruitful of harm as of good, and only the future can demonstrate whether America, having been placed in a new and strong position, will know how to retain its advantage and to use its changed circumstances as stepping stones to that permanent "place in the sun" which is agreeable no less to democracies than to kings.

There is no grave danger, in my opinion, that our newly attained wealth will be snatched from us bodily by some European nation long of soldiers, battleships and guns, and short of money and credit. While it is essential that we provide ourselves with the means of protection against the wielding of a national jimmy in the hands of some unfriendly power, the actual process of relieving us of our surplus wealth will, in all probability, be more subtle. Judge Gary, in his admirable analysis of this morning, has summarized the dangers against which we must take preventive measures.

The problem of safeguarding the biggest market in the world from the dumping of goods produced under circumstances which we regard as inadequate to our national standards of living, is still active and will be until, as the Judge has indicated, universal free trade becomes a reality. Our wages have risen in the last twelve months to a level which, taken in conjunction with the almost complete absence of tariff protection, constitutes an active danger, which public men, irrespective of party, must take into consideration. Any moment may disclose to us the startling news that active hostilities in Europe have ceased, and it may well be that in an incredibly short space of time a new war for world prominence in trade will have begun, which may find us as unprepared in the first prerequisite of victorious warfare, the exclusion of the enemy from our own territory, as was France and Belgium. Speaking in military terms, when this trade war starts we will have to "dig in." It is not the protection of the Chinese wall that we want, but a tariff trench at least deep enough to enable us to avoid the high explosive effect of ten-cent labor directed against our industries paying twenty-five cents an hour. (Applause.)

The second commercial danger-point referred to by Judge Gary is our lack of ownership of vessels. It is a mistake to imagine that ocean transportation can be purchased over the counter. The existence of a merchant marine is intimately interwoven with the development of our export trade, and the control of the return cargoes is often an essential element in the distribution of our finished products. At the present time we have contrived to create laws which make it impossible for Americans to carry on ocean transportation within ten per cent. of the cost of operating foreign ships, and as long as this condition continues our commerce will be paying tribute to foreign ship owners.

In the matter of commercial co-operation, we are again at a disadvantage compared with the nations of Europe. Our merchants and manufacturers are placed in the position of having to fight single-handed the organized industries of competing nations. We have become accustomed to regulation of business, and so long as the purpose of regulation is to keep business on the move in the right direction, it will be welcomed by all reasonable men.

Ten years ago there practically was no such thing as regulation of street traffic in New York. To-day the traffic has increased to such an extent that regulation has become an imperative necessity. No one thinks of the traffic squad except as a helpful instrument in keeping the traffic moving. If the result of the regulation were to choke the traffic for even the briefest space of time, the traffic squad would not be tolerated for an instant.

And so it is with the Government attitude toward industry. We have had a long period of readjustment and experimenting. The country has gained much and lost much. There is an old French proverb which says: "It is not necessary to eat the whole of an egg to know it is bad." The time is now close at hand when, from an industrial point of view, it will no longer be American against American, the West against the East, or the North against the South. It will be America against the world in trade and in commerce. Not necessarily, let me say, in a cold-blooded spirit of antagonism, but it will be a competition nevertheless carried on by full-size men with full-size brains, able to gauge the difference between a full house and an uncompleted flush. It will be a national game, in fact, with the thinking done on national lines, and with the stakes going to the nation that knows how to play the cards. (Applause.)

It will be a very simple thing for us to win in such a situation, provided we can act as a nation with the same effective unity of purpose which Americans display individually. We have the natural resources and the advantage of geographical position.

If the Secretary of Commerce, and the members of the Federal Trade Commission, as well as the committees of Congress, will all put themselves in the attitude of traffic policemen striving to keep trade moving forward, and will courageously advocate that American business men be given reasonable latitude in their efforts to develop foreign fields of commerce, approaching all of the questions which have been touched upon as fundamental elements of national growth and not as sounding boards in political campaigns, America will enter upon a phase of development the outcome of which no optimist, not even our worthy President, can overstate. (Applause.)

THE CHAIRMAN: Mr. George P. Early, of the American Sheet and Tin Plate Company, Pittsburgh.

MR. EARLY: Mr. Chairman, Ladies and Gentlemen: I am very grateful that it never gets late in New York. But really you have heard so many excellent addresses and the hour is really so late that out of charity I feel that I ought not to speak to you. But unfortunately for you charity not only begins at home, but it is not, as Mr. Bryan says, a paramount trait of my character.

Upon occasions of this kind I have often wished that I had the genius of oratory of an old colored minister down at Lynchburg, Va. He could get up at any time, at any place, and make a snappy extemporaneous speech—really extemporaneous that would please everybody. He had no education, and some one asked him one day how he did it. The colored minister answered, "I tell you, boss, it is just like this: In the first place I tells 'em what I's goin' to tell 'em; then I tells 'em; and then I tells 'em what I told 'em."

I often wished that I had the complacent assurance of the Western orator who had been elected mayor of his little village. He was a man who made great pretensions of literary attainment, deep reading, travel, broad culture, and when he was elected they gave him a banquet, and in delivering his speech, he did it something like this: "Mr. Toastmaster and fellow citizens: I am profoundly sensible of the distinguished honor which you have conferred upon me by electing me mayor of our beautiful little city, and I want to assure you, my fellow citizens, that it shall be my most earnest purpose to give you the best civic government that you have ever had. And I want to take advantage of this occasion to say that I prize my victory the more because of the high-class citizenship represented by my opponent. It is true that our press said a great many harsh and adverse things about him, and I want to take advantage of this occasion now to publicly disavow them, for as Shakespeare says in his Paradise Lost, a man's a man for all of that." (Laughter.)

And that reminds me of a fellow who had a great desire to be an orator who was afflicted with stuttering and a friend said, "Why don't you go to Doctor So-and-So. He is a specialist and he will fix you up all right." He said, "B-b-y j-j-j-ing, I think I will just s-s-see him." So he goes to the doctor and the doctor looks at him and says, "You stutter, do you?" He said, "Y-y-y-es s-s-sir." "Well," the doctor said, "Do you always stutter." "N-n-o, s-i-r, only when I t-t-t-ry to t-t-t-alk." Well," the doctor said, "we will fix you up all right." And so the doctor worked with him, and got him so that in a little while he was able to say without stuttering, "Peter Piper picked a peck of pickled peppers," and thought he was going to be able to dismiss him and charge him a good stiff fee. So he told the man he was cured, and the man said, "W-why, D-d-d-octer, I-I-I don't th-th-think I am cured yet." The doctor said, "Why you can say Peter Piper picked a peck of pickled peppers, without stuttering." "I know t-t-hat, D-d-d-octer, b-b-ut it's a d-d-darn hard th-th-th-ing to in-tr-o-d-d-d-uce into a con-con-v-v-ers-s-s-s-ation." (Laughter.)

You have all heard a great deal about the optimism of Mr. Schwab. I knew a man out in Ohio that would make Mr. Schwab look like a pessimist. Nothing could faze him. One year all of his neighbors had very bountiful crops, and he had almost a complete failure, and his neighbors came to him, sympathizing, and saying, "Why, John, isn't this too bad that you have got such a poor crop this year. We can't understand it. You have had the same sunshine, the same germinating quality of seed, you have plowed the same as as we have, you had the same industry, yet your crops are a failure and we have bountiful crops. We are all sorry for you." "Oh, well," the fellow said, "I wouldn't worry about that. In fact we had so big a crop last year and we had so much in the barn that really if we had a big crop this year we wouldn't know what to with it." (Laughter.) A few years later his house burnt down, the old homestead, couldn't be replaced, no insurance, and some of his sympathizing neighbors came and said, "John, isn't this too bad that your house has burnt down and all the contents and no insurance." "Well," he said, "I don't know. It seems the law of physics that when material gets afire it will burn unless it is put out, and I don't see how I could stop it. To tell you the truth, mother and I have sat around during the winter trying to entertain one another. This house didn't suit us and we have been planning a house that would suit us, and I think we will build such a house," and they did. (Laughter.) Three or four years later they had big crops and a big bank balance and one evening the old lady says, "Pop, we are getting pretty old. We haven't many years to live. I would just like to go to the big city, New York, see the Brooklyn Bridge, the elevated railroads, Wall Street and all the other sights there." He said, "Mother, after harvest we will just go," and so they went. And they were having a good time and seeing things. As the old fellow tried to cross Herald Square and Sixth Avenue, a car struck him and cut off both his feet. He was bunged up pretty badly, but with the aid of skillful surgery and a good constitution he pulled through. Then he was taken back to Ohio, and the neighbors came in and said, "John, isn't this too bad, both feet off, and you were always able to do a good day's work; now you are a cripple for life, isn't it too bad." "Well," he said, "I don't know. My feet were always kind of cold anyhow." (Laughter.)

I want to say a serious word to-night. While the greatest tragedy of all time is being enacted across the Atlantic, I believe that in our own country the spirit of the brotherhood of man is becoming more and more a dominating feature in our industrial and commercial life. There are more humanity and philanthropy, more courtesy and gentility, in business to-day than ever before. Why, business is now regarded as an honorable vocation, because it is being conducted along lines of Christian co-operation and not upon the basis of cruel competition. The fact that all men and those who are dependent upon them have a right to exist, and not be crushed by heartless competition, is being generally recognized. No matter how large a concern may be, it must recognize by fair methods of dealing the rights of the smallest concern in this land to live; and that small concern should know that, if it expects to expand and grow, it should give equally fair treatment to the larger concern. The sentiment of fraternity and fellowship is growing more and more every day, and with most wholesome effect. Manufacturers and the distributors of their products as well as the users of them are getting together in associations and conventions for the purpose of having a better mutual understanding. But the most encouraging sign of the times is the recognition of the fact, as evidenced by the splendid welfare work done in the last three or four years, that we all realize that the well-being of society and the safety of life and property depend upon our treatment of men as human beings with affections, sentiments, hopes and aspirations, and not as unfeeling and inanimate mechanisms. And when men receive such just consideration they should show their appreciation by fidelity to duty, by loyalty of service, by respect for law and order and by due regard for the rights and property of their fellow men. (Applause.)

The Chairman: And they generally do.

By the unanimous vote of the directors of this Institute to-day, our next October meeting will be held in the City of St. Louis. We have received urgent invitations by telegram from the Governor of the State, the Mayor and many of the leading bankers and other business men of that city, and we have been urgently and personally and persistently solicited by Mr. Clarence H. Howard, who is the President of the Commonwealth Steel Company and the President of the

St. Louis Citizens League, a fine, great, big successful business organization, and we are going to ask Mr. Howard to say just a word to us at this time. (Applause.)

MR. HOWARD: Ladies and Gentlemen: St. Louis feels highly honored in having been selected as the place for holding the autumn meeting of the American Iron and Steel Institute next October. As president of the Business Men's League of St. Louis I take great pleasure in extending to each and every one of you a very hearty invitation to attend that meeting. We will guarantee to give you a royal welcome.

St. Louis is the fourth largest city in North America. It is one of the great financial and commercial centers of the world. The St. Louis district, the city and its suburbs on both sides of the river, has a population of more than a million. It has 3,500 factories, employing nearly 150,000 people. It has a capital investment therein of over $400,000,000, and its manufactured products exceed $500,000,000 annually. St. Louis is nearer the center of population and area than any other large city of the United States, so it is accessible to all members of the Institute. It is a city well worth seeing, whether considered in relation to its past, its present or its future. On a March day in 1803, three flags waved over St. Louis, when the Spanish governor ceded Louisiana back to France, and the French tricolor promptly thereafter fluttered down to make way for Old Glory. The Mississippi River flowing by will recall memories of Mark Twain. In St. Louis General Grant once lived, as did his great antagonist, General Lee. General Sherman is buried in Calvary Cemetery.

To-day St. Louis appeals to the business world as the center of territory of vast potentiality of production and consumption. The attention of the Institute is particularly called to the fact that St. Louis is the largest producing center of steel castings in the United States.

Proud of her past and her present, St. Louis has every reason to look hopefully toward the future. Situated at the heart of the continent, she has the energy of the North and the hospitality of the South, the culture of the East and the vision of the West. St. Louis is proud of the fact that she is to be honored by the first meeting of this great association to be held west of the Mississippi River, and will prove herself worthy of the honor. Our October climate is delightful, and our hotel accommodations are ample and excellent. You will leave St. Louis with regret but with pleasant memories. Come one, come all. (Applause.)

THE CHAIRMAN: This is the end of the program as outlined by the Committee. What is your pleasure now?

(Cries of "Schwab, Schwab.")

THE CHAIRMAN: We never give Mr. Schwab an opportunity to prepare. I always promise I won't call upon him if the crowd won't insist upon it. Mr. Schwab. (Applause.)

MR. SCHWAB: Mr. Chairman and Gentlemen: Being called upon by this distinguished audience every year for a few remarks reminds me of a mistake I made in having made a humorous speech to you a few years ago. I am very much in the position of the soldier that was decorated with medals from one shoulder to the other, and I thought of him as a great hero. Naturally, I wanted to know what he had received all these medals for, and he told me: "That large medal that you see on my left, which was the first, I received by mistake." "And how did you get the others?" I asked. "I got all the others because I had that one." (Laughter.)

We are in a period of great prosperity. A man came into our office recently and said, "Mr. Schwab, do you want to buy some steel?" "What is the price?" "Four hundred and fifty dollars a share." "No, I don't want the stock. I want steel." "Well, steel is worth more than the stock." And that is the condition that we are in.

I wonder if any of us ever expected, anticipated or dreamed that we would see any such state of affairs as we see to-day. Yet with all my pessimism, compared with my friend from Ohio, I am obliged to say that many of the many predictions which I have made—and some of them have come true because I have made so many—I have predicted that we would some time see such a boom and such prosperity as we have never dreamed of. In talking with Judge Gary, how well do I remember Mr. Morgan asking me, "Do you believe that this great corporation will ever earn seventy million dollars a year?" and I said, "Yes, Mr. Morgan, you will see it earn two hundred million dollars." And it is with great pleasure that I have seen that prediction come to pass. It has been the pioneer, it has been the leader, it has been the protector and it has been the standard that has helped us all to get along and shape this business in the manner in which it ought to be shaped. Boys, may this prosperity continue. (Applause.)

I was delighted beyond measure to hear the address made by Mr. Hurley, one of the most significant, one of the most wonderful and one of the most hopeful that I have heard in many days. It reminds me of the time when we talked of other things than funny stories, and I want to say one thing about Hurley's appointment. It reminds me of the man who was entertaining a lot of English friends on a hunting expedition and when it was through—he was a big strapping fellow from the West—he was invited to go abroad and return their visit. He accepted the invitation and they gave a dinner in his honor. At the dinner they placed him at the table with the dignitaries. Indeed, they placed him next to a Grand Duchess. He was much flustered and didn't know what to say. Finally he turned to her and said, "Madam, I don't know what to say to a duchess, but by thunder you look good to me." (Applause.)

So we feel about Hurley. He knows what he is talking about. He has been in competition with me, and I know that he knows what he is talking about. And I know that he knows what manufacturing is, and that he knows what the manufacturers need. We have reached the time when men with the ability and knowledge that Mr. Hurley has will have to help make our business and our country prosperous and successful. (Applause.)

At a dinner here the other night I had the pleasure of sitting beside the Secretary of War, and he said that preparedness in this country meant the preparedness of the industries of the country, and it was my pleasure to say to him: "Mr. Secretary, you are entirely right, and if it is ever necessary to act for preparedness, the industry which we represent, the iron and steel industry, will show men of the greatest loyalty, men of the greatest progressiveness and as true Americans as any industry in the United States. But, Mr. Secretary, while I agree with you that the industries of this country should stand by the government, on the other hand the government should stand by the industries of this country." (Applause.)

Now, my speech was to be just a few general remarks, so I can't say anything about Willis King, and my old friend Jim Campbell sits up there in the gallery with his wife. But I see the ladies wearing flowers and smiling happily, which is another evidence of prosperity. And when the ladies are wearing flowers and are smiling and happy, then the men are happy and smiling. And so with one more story I will conclude.

I wanted to go abroad very badly; I wanted to see the war in the trenches, but my wife was opposed to it. Finally I promised I would not go without her consent. But I thought I would try to persuade her to let me go. So I said, "I wonder if the weather is nice on the ocean." And I kept hinting around, and I watched her to see if it met with any response, with a favorable response, but she didn't seem to warm up one little bit. Finally, leaning across the table, she said, "If you want any real war, you can get all you want right here at home." (Laughter.)

So it is right here with our business itself. We can get all we want right here at home. Let us husband our resources. It won't be smooth sailing all the time. We are in the greatest business in the United States, we are the greatest people, we are the greatest friends, we are the jolliest party, and we are the greatest organization in the United States, and long life to the American Iron and Steel Institute. (Applause.)

THE CHAIRMAN: Have you any others in mind that you wish to hear?

(Cries of "Farrell, Farrell.")

THE CHAIRMAN: Mr. Farrell is called for. We shall be glad to have a few closing words from him. Mr. Farrell. (Applause.)

MR. FARRELL: Mr. Chairman and Gentlemen: While I appreciate the friendly spirit that has prompted you to call on me, I cannot allow myself at this late hour to detain you more than a very few minutes. I desire simply, on behalf of the General Committee on Arrangements, to thank and congratulate the gentlemen who contributed the papers at to-day's session, the tenth general meeting of the American Iron and Steel Institute, and those who participated in their discussion. I take pleasure in saying that these papers measure up to the Institute's standard, which is as high a compliment as can be paid.

The papers read at these meetings and the discussions thereon deservedly rank very high in the literature of the industry. Already five volumes of these papers and discussions have been published by the Institute and occupy an honored place in public and college libraries, in the libraries of the various companies and in those of the members of the Institute. The papers and discussions had here to-day will constitute the first part of the sixth volume; the second part will be composed of papers and discussions to be read at the St. Louis meeting next October. The Committee on Arrangements has already begun preparations for that meeting. We trust that in making up the program we shall continue to have the hearty co-operation of the members.

We feel sure that the St. Louis meeting is going to be a great success. Friday, October 27th, will be devoted to the literary part of the program, closing with the banquet in the evening. Saturday will be devoted to seeing the industrial and residential sections of St. Louis and its suburbs. As Mr. Howard has indicated, St. Louis is a city well worth visiting, whether considered from the standpoint of its great business enterprise or from that of its historic and scenic attractiveness. We feel confident that St. Louis will extend to the Institute the hearty welcome promised on her behalf by Mr. Howard.

I am not inclined to tell stories, but in closing I'll venture to tell just one. As I entered the room this evening I encountered a gentleman who asked me if the business boom had been arrested. To which I replied, "If the business boom has been arrested, you may be sure that its trial won't take place for another twelve or eighteen months." (Applause.)

The Chairman: On account of the lateness of the hour, I waive my usual closing remarks. The meeting stands adjourned.

# OCTOBER MEETING

## SAINT LOUIS, MISSOURI

OCTOBER 27 AND 28, 1916


SEMI-ANNUAL DINNER OF THE AMERICAN IRON AND STEEL INSTITUTE IN THE DINING ROOM OF THE MISSOURI ATHLETIC ASSOCIATION, ST. LOUIS, ON FRIDAY EVENING, OCTOBER 27, 1916

# AMERICAN IRON AND STEEL INSTITUTE

## ELEVENTH GENERAL MEETING

St. Louis, Missouri, October 27 and 28, 1916

The Eleventh General Meeting of the American Iron and Steel Institute was held in St. Louis, Missouri, on Friday and Saturday, October 27 and 28, 1916. The day sessions on the 27th, for the reading and discussion of papers, were held at the Planters' Hotel. During the noon recess the members were the guests of the Institute at luncheon, and the Board of Directors held its usual meeting.

The banquet on the evening of the 27th was held at the club house of the Missouri Athletic Association. The principal feature of the banquet was the presentation to President Gary of a testimonial of the high regard in which he is held by the members of the Institute. The fund for the purchase of this beautiful testimonial was made up by small subscriptions of uniform size from all the members of the Institute, so that it is a general expression of affectionate admiration, not simply the tribute of a few of the Judge's immediate friends, who would, if selfish, gladly have subscribed the entire amount.

On Saturday the Institute members were the guests of St. Louis, whose leading citizens vied with each other in the courtesies to the Institute. In the forenoon the members were taken by special train to and through the great industrial section on the east side of the Mississippi River and were the luncheon guests of the Commonwealth Steel Company after they had enjoyed the privilege of visiting that company's admirable plant. In the afternoon, having returned to St. Louis by the special train, the members were taken for automobile drives around the residential sections of the city. St. Louis not only showed herself a city of great business enterprises and wonderfully attractive homes, but also lived up to her high reputation as a hostess.

## FORENOON SESSION, 10.00 A. M.

Address by the President.................................Elbert H. Gary
Chairman, United States Steel Corporation, New York.

St. Louis and Its Industries.........................Clarence H. Howard
President, Business Men's League, St. Louis, Mo.

The Duplex Process of the Lackawanna Steel Company, George B. Waterhouse
Metallographist, Lackawanna Steel Company, Buffalo, N. Y.

Discussion.......................................Quincy Bent
General Manager, Bethlehem Steel Company, Steelton, Pa.

Discussion................................Theodore W. Robinson
First Vice-President, Illinois Steel Company, Chicago, Ill.

## AFTERNOON SESSION, 2.00 P. M.

Pulverized Coal as a Fuel for Metallurgical Furnaces....James W. Fuller
President, Fuller Engineering Company, Allentown, Pa.

Discussion.....................................Nat. C. Harrison
General Superintendent, Atlantic Steel Company, Atlanta, Ga.

Discussion...................................William E. Snyder
Mechanical Engineer, American Steel and Wire Company, Pittsburgh, Pa.

Discussion..................................Joseph P. Kittredge
Superintendent, National Malleable Castings Company, Sharon, Pa.

Discussion....................................William A. James
Chief Engineer, Lackawanna Steel Company, Buffalo, N. Y.

The Iron Ores of the Adirondack Region............Frank S. Witherbee
President, Witherbee, Sherman and Company, Port Henry, N. Y.

Discussion...................................Frank E. Bachman
Formerly Manager, MacIntyre Iron Company, Port Henry, N. Y.

Discussion..............................John L. W. Birkinbine
Consulting Mining and Hydraulic Engineer, Philadelphia, Pa.

Progress in Hot Blast Stove Design.................. Arthur J. Boynton
Superintendent of Blast Furnaces, The National Tube Co., Lorain, Ohio.

Discussion.......................................Rufus J. Wysor
Superintendent, Blast Furnace Dept., Bethlehem Steel Company, So. Bethlehem, Pa.

Discussion.....................................Edward B. Cook
Ore and Blast Furnace Dept., Pickands, Mather and Company, Cleveland, Ohio

## EVENING SESSION, 7.00 P. M.

### Semi-Annual Dinner

Impromptu Remarks in Response to the Call of the President

Presentation of Testimonial to Judge Gary and Responses Thereto

Closing Remarks by the President

# ADDRESS OF THE PRESIDENT

Elbert H. Gary

Chairman, United States Steel Corporation, New York

Again it is my privilege to welcome to the semi-annual meeting of the Institute a very large number of its members. We have reason to be proud of the progress which the Institute is making. It has established for itself a reputation which is widespread and of great influence. I think all of us may congratulate ourselves that we are members of an institution which stands so well and whose opinions are received generally throughout the country with so much favor. I feel certain that we have yet much to do to secure all we are entitled to, but with the persistent course we are pursuing we are certain to secure for ourselves the benefits which we expected when the institution was organized.

To the citizens of St. Louis, for the very generous hospitality extended to this Institute, I beg to express in behalf of the Institute our most grateful appreciation. One of the distinguished editors of the city has stated that the keys of the city are turned over to you during your visit, and I am sure you have a keen appreciation of this kindness. Many of the members came here as strangers to the city, but they have been received within the gates and no longer are they strangers but they feel that they are among friends. For this kindness we extend our thanks over and over again.

We feel like congratulating the city on what she is and what she has done and what she is certain to do. With the progress, persistency and probity for which she stands, this city, located substantially in the center of the United States, is destined to be one of the greatest and most successful cities of the world. (Applause.) You know as well as I, gentlemen of the Institute, that at the beginning we felt St. Louis was a long way for some of the members of the Institute to come. But after receiving the generous and most cordial appeals from leading citizens of the state, from the Governor down, added to by the stubborn persistency of that most persistent of all men, Mr. Howard, we finally yielded, and are very glad we did. One thing I promised the members of the Institute, based on long experience, that if we came to St. Louis during the month of October there were ninety-nine chances out of a hundred that we would have splendid weather, and my promise has been fulfilled. We are glad to be here, glad we selected this location and we are proud of this sister city. (Applause.)

At the last meeting of the directors of the Institute, before the summer vacation, a member suggested that, at the October meeting, I give some account of my visit to the Orient, and therefore he properly may be charged with the responsibility of the President's remarks on this occasion.

I left New York on July 3rd for Toronto, and from thence proceeded via the Canadian Pacific Railroad to Vancouver; sailed on the *Empress of Asia* July 13th; arrived at Yokohama July 24th (dropping one day at the 180th meridian and picking it up again on the return trip), and from there went on same steamer to Manila, arriving July 31st. I left Manila on another ship (Japanese) August 7th for Hong Kong, overtaking the *Empress of Asia*, which had preceded the Japanese ship, and sailed for Shanghai. From there I went through portions of China (visiting Peking, Soochow, Nanking and various other places in the eastern and northern part) to Mukden, in Manchuria; Seoul, in Korea, and then across the Japan Sea or Strait of Korea to Shimonoseki, in Japan, arriving August 29th. I remained in Japan until September 14th, when I embarked on the *Empress of Russia* for Victoria, B. C., arriving September 23rd. I visited the principal cities in Japan and motored considerably through the country, as I also did in China and the Philippines, wherever practicable. The journey, taken as a whole, was long, rather warm and somewhat tiresome, as I expected it would be, but it was all interesting and enjoyable and a trip to be recommended, even in the summer months. The accommodations for the traveler are generally good and in many respects are excellent.

This brief outline has been given because I am hoping many of my hearers will be inclined to inquire into the details and then to personally inspect this fascinating portion of the Earth situated on the opposite side of the Globe from your habitation. I will later suggest reasons for my wish.

There are many phases of Oriental life and customs, of natural and artificial beauty, of contrasts between the old and new civilizations, all of which attract and interest the student and charm the traveler; but it is not my purpose to attempt at this time to do more than glance at some of the general features of the different countries mentioned, in which it seems to me you, as business men, are especially concerned. I was diligent and impartial in the endeavor to ascertain facts that appeared to have a bearing upon your interests and mine in the affairs and conditions of these nations respectively. I saw as much of the countries and as many of the people as the limit of time permitted. Posing only as a member of the business fraternity, I received from foreigners everywhere the most hospitable and generous treatment and the frankest expression of sentiment toward the people of the United States. Also our diplomatic representatives, without exception, were courteous, helpful and hospitable; they are rendering faithful and efficient service.

## The Philippines.

The Philippine Islands, with proper development and modern practice, are capable of supporting comfortably ten times, or more, the number of people now living within their territory. There can be produced everything indigenous to semi-tropical latitudes, and many things to better advantage than on any other lands within the same proximity to the equator. Hemp, tobacco, sugar, rice, cocoanut oils, coffee, fruits, vegetables, grains, choicest timber and multitudes of other valuable products can be raised in as large or larger abundance than in any other country, with comparatively slight exception. The natural requisites, including moisture, water-power and particularly richness of soil, are all sufficient. The climate is equable and excellent. In the summer, it is warm during the middle of the day, but the nights are agreeable, and, on the whole, the temperature seemed to me very much better than the average. No doubt the records will show favorably by comparison. The Filipinos, as a race, are a fine people, intelligent, of good disposition and possessed of capacity for success. I met large numbers of them, confined perhaps to the better educated classes, but nevertheless representative. With opportunity, example and precept they will take a desirable place in the ranks of progressive and worthy citizens.

When the United States paid nearly $20,000,000 to Spain, the owner, for the title to the Philippine Islands, she acquired a territory possessed of all the essentials for building up a rich, healthful and desirable extension of its dominions as a valuable and necessary supplement to the immense productive capacity which she already possessed; and it was inhabited by a people who, by nature, would readily become loyal and faithful citizens of our country. When the United States, by mere chance, or as the result of an overruling Providence, became responsible for the future welfare of the inhabitants of the Islands and for the conditions which might directly and seriously affect other countries, especially those in proximity, there was much in the condition of the people to be deplored. The masses were ignorant; perhaps purposely deprived of education; and they were subjected to tyranny and cruelty. They were poor, unhealthy, diseased, overtaxed and wretched. They were more or less at war with each other and with their Government. Every influence, every tendency, was bad. They had no hope for the future. Intelligent happiness was neither a reminiscence nor even an aspiration. Because of the diseases prevalent, both the people and their beasts of burden were a menace to the outside world. The Filipinos were not blamable for this situation; they deserved a better fate.

The United States was a good Samaritan. The splendid men who were duly appointed by our country, including both military and civil representatives, with fortitude and judgment and human instincts took up and carried on the work of renovating and rejuvenating this conglomerate of physical and moral corruption, which had developed without the fault or the understanding of the people themselves. The results of their efforts will stand for all time to come as a monument to the generous, humane and intelligent policy of an enlightened and unselfish nation, unless something shall be done in the future to counteract or neutralize the results of the course which has been pursued. All those who have represented the United States in bringing about the wonderful changes in the Philippine Islands are entitled to the highest commendation. Their work has not been fully appreciated by the average citizen of this country.

There has been established a sound and exemplary government. The laws are wisely and justly administered by able and impartial judges; modern and commodious hospitals have been built and are in charge of competent, practical and humane doctors and nurses; plagues and dreadful contagious and infectious diseases have been largely stamped out; model schools, special and common, have been established, and they are filled with eager and industrious Filipinos taught in the English language. Good roads have been built; agriculture, horticulture and forestry have been improved; means and methods for civilization and for modern practical results have been taught, though, of course, much remains to be done.

There has been a general cleaning up, and the best results of experience in other up-to-date countries are being applied so far as possible. Filipinos understand and appreciate what has been done, and they are a grateful people. Of course, the large majority are referred to. There are always exceptions. All this has cost and is costing large sums of money, but emphasis should be given to the fact that, with the exception of the money paid for maintaining the army and navy, which is no more than it would be if stationed elsewhere, the total expense of making the improvements and changes adverted to and maintaining the same, as well as the expenses of administration, including the civil government, courts of law, salaries of appointees of the United States Government, schools, hospitals and everything else of the kind, are and, from the start, have been paid from the treasury of the Philippine Government.

Without the protection and assistance of the United States, without the experienced talent of representatives sent from here, without the added energy, skill and invested capital of Americans, if the Filipinos were again left to themselves, they would be unable to make the progress in the development of the resources of the country which is possible and desirable, and the future of the Islands would be uncertain. They would not long be permitted to drift towards old conditions so as to be a menace to the health of neighboring nations particularly interested, for the latter would interfere and probably take possession and control.

The United States assumed a moral obligation to the Filipinos and to other nations when she took charge of these islands. She could not shirk it if she wished to do so.

Moreover, if the Filipinos desire it, as I believe they do, and if the United States, as I think a majority of the citizens wish, shall decide to have the Philippine Islands remain permanently a part of the territory of the United States, it would result in great financial benefit to the Islands and their inhabitants and also to the United States; and all other nations would approve. Considering the interests of the Filipinos and the Americans both, it would be a grave mistake to sever the relations now existing between them.

There cannot be properly developed the immense natural resources of the country and the resulting business, with adequate facilities for conducting the same, without large amounts of capital, and it is impossible to secure these unless and until there shall be permanently established a government which is satisfactory and will not be assailed. If the United States should abandon the Islands, capital already invested would be withdrawn, in part at least, and additional investments would be discontinued. The Americans in the Philippines who have done and are doing much to advance the pecuniary interests of the Archipelago, as well as the natives themselves, understand and openly recognize the fatal results to the Islands if they should lose our support.

## China.

During the last few decades, at least, China has not kept pace with others in the progressive march of nations. Possessed by nature with extraordinary opportunities, she has nevertheless been retroactive in disposition and, to some extent, has been exploited for the benefit of others. With a population of 400,000,000 and a territory almost as large as Russia, containing the richest and most productive soil, a variety of climate which permits the growth and maturity of the principal grains and fruits, and with an abundance of the richest minerals, she has, notwithstanding, become poor in cash resources; and the normal and necessary development of the country for the proper utilization of the national assets has been neglected, if not ignored. Consequently, in the consideration of questions relating to economic expansion, and in other respects, China has, for a long time, been well nigh helpless. It would not be useful, nor does time permit, to discuss the reasons for these conditions. Many of them are well known. It is sufficient to say that China, with her natural facilities, has the opportunity of becoming one of the greatest and most prosperous of nations.

Apparently, the leading Chinese statesmen, the most intelligent and most influential citizens and the best thinkers are keenly alive to the situation and are earnestly solicitous for the immediate future of China. The present Governmental Administration and the Parliament as well are devoting their talent and energy to ascertain and apply a solution for the problems which interfere with the growth and strength of their country. They realize that there is needed a new constitution which will establish a concentrated, unified, though democratic, government; a new and modern financial system which will be satisfactory to the financiers throughout the world; an adequate, thoroughly trained and fully equipped military force for defensive purposes; and the adoption of a systematic plan for the development of the whole country for the benefit and for the promotion of the welfare of the whole population. The leaders are frank and outspoken in declaring the desirability of a government such as I have indicated; and they appreciate also the necessity of having the friendship and assistance of all other nations. They know that under these conditions and with this attitude on their part, and not otherwise, they may expect to establish a credit which will secure the loans necessary to reorganize the affairs of government, and will put to practical use the instrumentalities for providing the money which is now lacking.

The present Government is an honest, unselfish, capable, industrious and harmonious organization. There are statesmen in China of high intelligence and qualifications. It should be only a question of time when the internal strifes, that are prevalent and have done so much to obstruct and retard legitimate growth and prosperity, will have ceased; when the peoples of the different provinces will be pacified and possessed of a spirit of genuine loyalty and patriotism. This is what is especially needed in China, and this is what will be experienced when there is a clear and general understanding of the motives of those now in governmental control.

China is now in a transition stage of activity. For a single and simple instance, the visitor to Shanghai may see from his hotel window, within a space of two hundred by seventy-five feet, the jinrikisha, the sedan chair, the wheelbarrow (carrying a large load of freight or passengers), a cart drawn by a caribou or water buffalo, a donkey or pony cart used as a passenger vehicle, a bicycle, an automobile, an electric train; and nationalities and costumes of a great variety of patterns and styles.

One of the principal things needed in China is first-class railroads. We know by experience what they are and do for a new country. There are provinces with immense acreages of the most fertile soil and a population of scores of millions, that have no pretension of reasonable facilities for getting to purchasing or consuming markets. If there can be established the basis of credit as already suggested, and as now seems probable, it is to be hoped American capitalists will participate in further loans which will permit the rapid extension of railroad lines, for this will tend to correspondingly increase the volume of general business between the two countries. The people of China who are well posted are desirous of maintaining the most cordial and intimate relations with the business concerns of the United States. Formerly China desired to be left alone. She wanted to be exclusive and seclusive. She claimed to be self-contained, and really thought it was wise to live unto herself alone. That belief and attitude are becoming changed as a nation. She now wishes the open door policy to prevail. The national latch string is out for all other nations. Indeed, in some instances, those in authority have been too willing to grant concessions. Permanent concessions of territory at Shanghai, Peking, Hankow, Hongkong and other places have been granted to various foreign countries who still own and occupy the same. The United States was formerly included in the list, but I think we have released and abandoned all that were ever given to us.

The people are becoming familiar with the habits and methods of other peoples. They are entering educational institutions in other countries and they are learning the English language. True it is that large numbers in outlying provinces are ignorant concerning the language or ways or even existence of foreigners, but all those in control of national or provincial affairs are well advised and they welcome every opportunity to learn and to assimilate. Especially does China need and desire the sympathy and neighborly support of the people of the United States. Here is a great field for operation on the part of American business men which can be cultivated without injury or objection on the part of any other nation and with decided benefit to China herself. I could wish that in some respects the conditions in the United States which now exist, resulting, I think, from political agitation, might be modified.

The Chinaman is naturally strong, diligent, industrious, economical, honest and intelligent. He is a good farmer and a shrewd merchant. He would like to be a good and loyal citizen, and it is only because he has been imposed upon or has misunderstood the facts that he appears to have been at times unreasonable or disloyal. He is a force in the world that must be considered, and it is wise to influence him honestly and practically in the right direction whenever the opportunity is afforded. Where Chinese blood is mixed with the Hawaiian or Filipino it has raised the standard of intelligent manhood, so far as I have observed.

There are men listening to me who will live to see China a great and prosperous nation; rich, powerful and progressive; better than she ever was in her palmiest days; one of the best creditors of and debtors to other countries; and at peace with all the world. I hope and trust she is just now making a successful start in this direction. I have for her the same kindly feeling which so many of her best people undoubtedly entertain toward the United States. She will, some time, have the power to do harm, but instead she may be a force for international peace, progress and prosperity.

Throughout the country and in the cities and villages there is much to surprise and charm the visitor. There may be seen uncleanliness in many places and crowded habitations to the extent of danger to health, but in other places it is decidedly different in appearance. For illustration, there is a striking contrast between Canton or Soochow, on the one hand, and Peking, on the other. The latter has an abundance of open space.

Scattered over the farms throughout the country are innumerable mounds of earth resembling, from a distance, cocks of hay. These are graves of the dead. They are of different sizes, depending upon the prominence or lack of prominence of the departed, and perhaps some other considerations. As ancestry is worshiped and the spirits of the deceased believed to visit, if not abide near, the graves, one can understand why, for years, the Chinese objected to the disturbance of the lands resulting from the building of railroads.

The use of opium is diminishing and will disappear in the comparatively near future.

Many books have been and more will be written on China; but to understand and appreciate, one should personally observe.

I have endeavored to excite your interest only in some of the practical things that ordinarily engage the attention of business men. We should know the country and its people better from the standpoint of our own interests.

## JAPAN.

Japan is a vigorous, progressive, prosperous nation. Representatives have temporarily resided in foreign countries, including England, Germany and the United States, for the purpose of studying the languages, customs, methods, improvements and facilities for advancement and for defense; and on their reports, from time to time, the Japanese people have adopted and assimilated what they consider to be the best features of enlightened civilization shown in the different countries. They are highly intelligent, determined, adaptable, very industrious and, above everything else, superbly loyal to their emperor and to their nation. The ordinary citizen lives for his country and is just as willing to die for it. There are no internal strifes; on the contrary, there is a harmonious whole. They present to the outside world a united front. This is as it ought to be in every nation. It gives a solidarity of power that is invincible.

It may therefore be seen why Japan has taken a leading position amongst the nations of the world, contrasting in a striking manner with her place sixty years ago. Rice is the principal, though not the only, crop grown in Japan. As the Islands are mountainous and not fertile, it is probable at least fifty per cent. is not cultivated. The fish industry is large and profitable. In farming, mining, manufacturing, merchandising, and with respect to her schools, hospitals, courts, prisons, temples, means of transportation, military training and strength and, generally, in the possession of modern equipment and administration of public and private affairs, Japan excels, and already may be considered a model government in many particulars.

Japan has grown and is growing with her strength. She has, with Korea, Formosa and other island territory recently acquired, 259,671 square miles and a population of 72,000,000, as compared with 37,000,000 in 1872. Besides all this, she is now increasing in wealth and in the near future will, I believe, be considered rich, unless her present policy shall be abandoned. Her financiers, her business men and her statesmen deservedly rank high. They are far-seeing and they are conservative. The wonderful natural beauties and artistic development and display I cannot take time to describe.

I am disposed just now to discuss briefly before you questions which, as a business man, I was free to speak about in my intercourse with Japanese acquaintances. Because I was open and sincere, and especially as I was an American, independent of any political obligation to consider questions of diplomacy, I met willing and attentive listeners and cordial greetings.

For some time there have been suggestions, in public and in private, in the United States and in Japan as well, that, for numerous reasons not necessary to recall, there was possibility, if not likelihood, of active hostility between these two countries. Whenever either Government has decided to provide an additional warship, some one in the other country has been prompt in charging that this meant preparation for war between these two nations.

I said repeatedly, on my own responsibility, making no claim except that I believed I could accurately represent public sentiment, that a large majority of the people of the United States did not desire, but would deplore and stubbornly oppose, war with Japan, except in self-defense, and that they were of the opinion there is not now nor will be any cause for serious trouble or disagreement; that there need be no conflict of opinion which could not be finally and satisfactorily settled by mutual negotiation and consideration. I also expressed the belief that our governmental administration is and would be inclined toward this most desirable exercise of authority. To all this I am sure this large company of representative business men will heartily subscribe. I would repeat and emphasize the sentiments thus expressed. (Applause.)

And now, gentlemen, I am here to say to you in words just as emphatic, and in a belief no less absolute, that the leading and controlling men of Japan are equally anxious to have a continuance, permanently, of the peaceable and friendly relations now existing between these two countries. That there may be exceptions may go without saying; it would be usual and need excite no surprise nor fear if such is the fact. Still I have no positive information on which to base this conjecture. I had good opportunity to ascertain the real situation, though my visit to Japan was comparatively short. The most prominent and influential men in Japan are outspoken in their profession of friendship for the United States and her citizens. They refer with sentiments of gratitude to Commodore Perry's visit in 1853, to them, apparently hostile at that time. They now consider this action as friendly and as the beginning of the growth of a great and prosperous nation. They speak of the benefit Japan has received and is receiving from the United States, educationally and otherwise. They claim to have received the largest benefit in economic lines by visits to and intercourse with Americans. They refer with satisfaction to the large and increasing trade relations. And, without stopping to enumerate, they speak of our people as their friends and advisors, now and always, as fair and generous and pacificatory in policy and practice; as a model government, whose friendly interest they court.

If you suggest these men may have dealt simply in diplomacy, so-called, or in diplomatic language, I answer, they gave me no reason to think so; I secured their confidence as I gave them mine. They do not hesitate to advance the reasons for peace and the objections to trouble. They realize that the geographical locations of these two countries should make them practically allies although acting independently and in their individual capacities and interests. And, from the business standpoint, the Japanese manufacturers, merchants and financiers are desirous of co-operating with those in the United States, to the fullest extent, in protecting and promoting the welfare of both and at the same time benefiting those in other countries with whom both of us may be conducting business. They understand and appreciate the spirit of co-operation which has actuated the men engaged in our lines of business, and they would be pleased to consider with us all legitimate plans for the application of this principle. While it is a difficult problem, requiring patience, skill and tact, still I believe we may be able to work out methods which will benefit all concerned. It is well worth trying. International conditions are peculiar. They are complicated and will be worse. Every one interested in international commerce should make careful survey of existing facts for purposes of future explorations and developments. There are many practical problems to consider, and their solution will require time and thought; but we will find the Japanese business men ready to take them up in a fair, reasonable and intelligent manner. (Applause.)

## What Japan Wishes in China.

The subject of Japan's intentions toward China and her possessions is a mooted question in many foreign quarters. From considerable inquiry and study, I conclude Japan sincerely desires that China shall proceed and succeed in the directions I have indicated; that she shall become firmly established as a sound, peaceful, progressive, prosperous and rich government, with free and open seaports, transacting an increasing business of every kind, within the limits of her capabilities, with any country or all countries outside her domains, on a fair, just and profitable basis.

I am confident Japan would like China for a continuous, permanent, friendly, profitable and satisfied customer, with no political, social or financial difficulties, internal or international. I think we may expect to see, before long, efforts on the part of the Japanese people to cultivate cordial business relations with those in China. I know there are important and influential men in Japan who will actively advocate this course. I am also of the opinion, founded on conversations, that the Japanese will be glad to consult with Americans concerning financial, commercial and even political questions relating to China. Japan and China both wish for close and intimate relations with the United States, and are willing to discuss and determine all matters affecting the rights and interests of any, with the purpose of doing justice to themselves and all other nations. The more our statesmen study these questions, the more clearly it will appear there need be no irreconcilable differences of opinion.

## Korea.

Korea, as you know, has again become a part of Japan. The name has been changed to Chosen, which is the same word in the Japanese language. It is a fine country, with people of good appearance, disposition and physical and mental ability, fully equal to the average. Under Japanese methods, conditions and appearances are rapidly improving. The Koreans seem to be satisfied with the governmental change. They have more respect for the present administration than they entertained towards former ones, and they believe their prosperity is increasing and will continue to increase. It seems probable there will be a gradual and complete amalgamation of the two races, and, if so, it will be beneficial to both.

## Our Business Men Should Visit the Orient.

Now, I would urge all of you, who find it practicable, to visit the Far East. Go during the autumn or early spring months, if convenient, but do not hesitate to make the journey during the summer time. You owe it to yourselves, to the business interests you represent and to your country to come into close relations with the people of these far distant lands. While they are far away, if measured by miles, yet in point of time they are growing nearer, by reason of improvements in transportation; and the trip is enjoyable. You may be assured there are innumerable features in each of the countries intensely attractive and in many respects different from what you have ever seen. While I was somewhat fatigued at times, I continued in good health and I have every reason to congratulate myself on having had the opportunity to see these countries and to meet so many agreeable people. If you decide to do so, you likewise will be glad to have made the journey.

More and more of our business men should come into close contact with the people of Japan, China and the Philippines. It will be of benefit to all. There is much to see and to learn. Many misunderstandings have arisen and some still exist. They can and should be removed. It is as true as it is old, that human nature is about the same the world over. We in the United States are not possessed of all the virtues. We are just as likely to be wrong in judgment and conclusion as others. Indeed, we have often been wrong. If some of our leaders in Congress had been better posted, it is possible that many ill-advised speeches would not have been delivered. At any rate, I strongly urge that as many of our citizens as find it possible take the time to personally and impartially inquire into the facts which bear upon the relations of the United States with other countries. There is always danger of unsettled disagreements if parties conduct their communications at arm's length. If they converse "eye to eye and face to face," even nations are much more likely to avoid conflict and to settle disputes without doing an injustice to any. If we are looking for trouble we can usually find it; and if we are looking for harmony it is, as a rule, equally easy to procure.

If any one conected with our government will spend a few months, or less time, in Japan, with an honest intention and effort to ascertain the sentiment of the large majority of the controlling elements, I verily believe such a one will be convinced Japan is not desirous of trouble with the United States, but, on the contrary, earnestly desires our friendship and co-operation in every worthy ambition.

## Business Conditions.

Following my usual custom, I will conclude with a few words regarding business conditions.

It is well known that the steel business in this country is better than ever before. Our concern is only for the future. Many believe there will be a continuance of large business for many months or years after the war closes; others think there will be a material recession. No one can certainly foretell. I have heretofore expressed opinions on the subject which have been published. Obviously the wise man will husband his resources, keep within safe limits and avoid over-extension. It is better to be prudent and make less profits, than to become reckless or extravagant at the risk of calamity. With large bank balances, we are independent and secure; with large indebtedness to the banks which we could not readily pay, we would be in danger of bankruptcy, depending upon future business conditions. All this we know by the experience of the past. As we cannot read the future, we should exercise caution and be prepared for unfavorable changes.

Whenever the war shall close, the business of this country will be confronted with new conditions. The purchasing power of the whole world will have been very greatly reduced. Foreign countries who are now buying our products, because compelled, will withdraw their patronage in a large measure. Other non-producing countries will find their financial resources and credits lessened. More than this, foreign producers, in great need, will strive more diligently than ever to supply the countries that are financially able to pay, and at prices based upon cheap labor and low cost, as they have a perfect right to do.

Our producers, including our wage earners, will find themselves in commercial antagonism with the most persistent and difficult competition ever experienced, unless this shall be prevented by laws that are reasonable and sufficient. Most of the foreign producing countries, and quite likely all of them, will be thoroughly protected by tariff provisions, and we should be on a parity with them in this respect.

I firmly believe, if the present unprotective tariff laws remain unchanged, we shall probably meet with competition from foreign sources after the war closes which will adversely, and perhaps disastrously, affect American industry and American labor. Conditions will be even worse than they were between October 1, 1913, and the beginning of the war. If the laws shall be amended and adequate protection to American producers and their workmen is afforded, we may expect satisfactory business conditions for some time to come. (Applause.)

I see on the program this notice, which you probably have observed: Informal discussion of the President's remarks under the five-minute rule. Now, gentlemen, you are cordially invited, in fact you are urged, to discuss this paper. Probably nothing would be of more interest to a large number here than to hear some of you discuss this paper.

(After a pause.)

When St. Louis was first mentioned as the place of our next meeting, all of you knew that the people of this city were industrious, but many were unaware of the fact that there were located here any industries of particular interest to steel men. Therefore, the committee on arrangements has deemed it only fair to give the most ambitious, and perhaps I might say the most optimistic, citizen of St. Louis an opportunity to say what he could about the industries of this city. I have the pleasure of introducing Mr. Clarence H. Howard, President of the Business Men's League of St. Louis and of the Commonwealth Steel Company.

# ST. LOUIS AND ITS INDUSTRIES

Clarence H. Howard

President of the Business Men's League and of the Commonwealth Steel Company, St. Louis, Mo.

The general committee on arrangements for this meeting has invited me to tell you something of St. Louis and her industries. Before doing that I want to express the great pleasure and honor that I feel in having, at your last May meeting in New York, extended to you, in behalf of our entire city and state, an invitation to hold this October meeting in St. Louis. We then promised to endeavor to provide you everything that goes to make up a well rounded-out meeting. To-day's program has been arranged by the Institute committee. The program for to-morrow has been arranged by the St. Louis committee.

At ten o'clock to-morrow morning a special train will leave the Union Station for a trip about the industrial district of St. Louis, both sides of the river, and the Commonwealth Steel Company extends to you all a very cordial invitation to luncheon after an inspection of the plant. At the train at ten o'clock you will find plenty of cars, plenty of service, and when we get to the plant, plenty to eat. For the afternoon we have arranged automobile trips to show you our fine residential sections. In behalf of all our citizens I cordially extend to you the right hand of fellowship through our gates of welcome into the hearts of our people. (Applause.)

My subject, "St. Louis and Its Industries," is an inspiring one, not only because of the present status of our city, but also because of its remarkable opportunities and resources, industrially and otherwise. It seems that the country has come to realize that industrial growth and improvement are inseparable from civic excellence. The investment of some of the fruit of industry in better homes and living conditions, parks, public recreation, etc., is a guaranty of the growth and success of a community, for it indicates recognition of the human element; and, other things being equal, industries will locate where these conditions are the best. We hope that before you gentlemen return to your homes you will realize the advantages and opportunities of St. Louis in all these respects.

Perhaps no other American city has a more romantic history than St. Louis. It was settled as a trading post in 1764 by Pierre Laclede Liguest under a grant from the French governor general at New Orleans, and was chartered as a city in 1823. It was subsequently under Spanish rule, and on a March day in 1803, when the Spanish government ceded Louisiana back to France, three flags floated over St. Louis: the Spanish colors were lowered in favor of the French, which were immediately replaced by Old Glory. In commemoration of the Louisiana Purchase, which was afterwards divided into thirteen states, St. Louis, in 1904, successfully conducted an international exposition which was probably the greatest ever produced. The exposition site covered 1,240 acres, partly in beautiful Forest Park, and 250 acres of its area were under roof. The cost, not including individual exhibits, was $42,500,000.

Going further back in our history, it is interesting to know that the forgotten race of Mound Builders chose this community for their remarkable earthworks, which have given St. Louis its side name of "Mound City." Archæologists have pronounced these mounds among the very interesting and most ancient works of man.

One of our esteemed fellow members from Rochester recently presented me with a most interesting old volume regarding St. Louis published in the early 50's. It sets forth most forcibly the advantages and immense possibilities of St. Louis as the great manufacturing and distributing center of the country. An article regarding railroads indicates some concern in the fifties as to the extent this comparatively new means of transportation would affect the traffic of the waterways. The problem of the country in this respect now seems to be reversed.

St. Louis is the center of the fertile valley of the greatest river in the world, and when the Federal Government deepens the channel and confines the Mississippi to its banks, something like 15,000,000 acres of the most productive soil on the globe will be added to this valley, this being three-fourths of the twenty million acres in the Mississippi drainage basin. These 15,000,000 acres are not swamps, but are available for cultivation, which the owners are willing to undertake at their own expense as soon as overflows are prevented. If this acreage were devoted to cotton raising, our crop of 16,000,000 bales would be increased to 23,000,000 bales. The value of this seven-million-bale increase would be about $500,000,000. Cotton is mentioned merely as an illustration, for naturally the crops of this acreage would be widely diversified. This means a very great addition to the country's present yield of agricultural products, and a saving of millions of dollars annually in loss of property, railroad washouts, etc., due to floods, and, above all, a great saving of life. Ten railroad systems sustained a loss of $6,250,000 during the floods of 1912 and 1913. This increased productivity will also mean more commodities to be distributed by the railroads, and as St. Louis will be in effect a seaport with outlets to the Gulf of Mexico and the Great Lakes, the 26 railroads centering here will handle a vast additional tonnage to and from all points of the compass.

### St. Louis Ranks Fourth in Manufactures.

You are probably aware that St. Louis, the metropolis of the Mississippi Valley, ranks fourth in the United States in manufactures, fourth in population, and is located near the center of the country geographically and as to population.

Considering St. Louis from the standpoint of its iron and steel interests, I wish to say that our citizens deeply appreciate the recognition evidenced by the Institute deciding to meet here, this being the first time you have come as far west as the Mississippi River. You will be interested to know that 35 years ago a convention assembling here was welcomed to the "City of the Iron Crown," which title was well merited. Iron ore in Missouri was found so pure that much of it was not smelted but was forged directly from the ore. Eighty years ago, in 1836, Featherstonbaugh, the mineral expert of that generation, reported to Congress that Missouri ore was 70 per cent. iron, and he stated that a single locality in this state offered iron ore equal to all the resources of Sweden. Another expert, C. A. Zietz, reported in 1837 that horseshoes, knife blades and hatchets were made in blacksmith shops directly from Missouri ore.

Sixty-five years ago you could have seen a man named Palm in a St. Louis foundry building locomotives for use on a railroad west of the Mississippi before there was railroad connection eastward to the Atlantic Coast.

Forty years ago the iron ore production of Missouri was $10,000,000 a year, and it was said and believed that this state had enough ore "to run 100 furnaces 1,000 years." To-day the various iron and steel industries in the St. Louis district, which includes both sides of the river, use more than 350,000 tons of pig iron annually, only a small percentage of which is made here. There are still vast mineral resources in Missouri, and within easy reach are the great coal fields of Illinois, and we also have direct connection with the electric power furnished by the great hydro-electric plant at Keokuk dam.

At present 60,000 horse-power from Keokuk is consumed in St. Louis by our street railways company and our electric light and power company. Everyone is familiar with this wonderful power plant. The wires from Keokuk to St. Louis, which are strung on steel towers, transmit 100,000 volts at a low amperage which is then stepped down to a lower voltage and higher amperage. Fuel and power in St. Louis are very cheap in comparison with other industrial centers.

Recognizing the wisdom of diversifying its industries rather than depending upon a few of Missouri's natural resources, St. Louis branched out in various manufacturing lines, of which one result was that while our iron ore production has decreased in the last few years, our manufacture, consumption, and distribution of iron and steel products have enormously increased.

### Good Relations Between Capital and Labor

Another important point industrially is the uniformly good relation which has been sustained between labor and capital in this district. We have some misunderstandings, but they result in a truer sense of fellowship and are made stepping-stones to broader and higher achievements. St. Louis has in abundance the essentials to successful industry, namely, labor supply, access to raw materials, cheap fuel and power, and adequate transportation.

The 26 railroads centering at St. Louis include most of the transcontinental trunk lines, and St. Louis is the headquarters of several of the large systems, such as the Missouri Pacific-Iron Mountain system, Wabash Railroad, Missouri, Kansas & Texas Railway, St. Louis Southwestern Railroad, St. Louis & San Francisco Railroad, etc.

St. Louis Union Station and terminals have been pronounced models of efficiency by terminal commissions from other large cities. The tracks of the passenger train shed accommodate 32 trains side by side, and those tracks have a capacity of 360 80-foot passenger-train cars. All baggage is handled through a subway with an elevator to the platform beside each train. During the year ending June 30, 1916, the Terminal Association handled in and out of Union Station over 105,000 passenger trains and 561,000 passenger cars. During the same period they handled across the Mississippi River 1,216,000 freight cars and interchanged with connections 3,518,000 freight cars. The Terminal Association employs 4,427 people and owns 154 locomotives. Their electro-pneumatic interlocking system, with 344 levers, is the largest in the world.

### A Few Figures Regarding St. Louis Industries.

The iron and steel and allied products of the St. Louis District, based upon official reports, are about $80,000,000, including such items as boilers, foundry and machine-shop products, structural iron, stoves, ranges, wire goods, cutlery and tools, agricultural implements, etc. The capacity of the car-building plants in St. Louis and adjoining districts makes this the largest railroad and street-car manufacturing center in the country. St. Louis would also be a splendid location for a locomotive plant. Our large capacity of cast steel products would conveniently and economically provide such a plant with material, and being so centrally located at the converging point of such a large number of railroads, deliveries and distribution could be made most efficiently and economically as compared with locomotive plants less centrally and conveniently located.

St. Louis is a Federal Reserve city, with bank deposits of more than $350,000,000, and has always been regarded as a financial Gibraltar.

"The City of the Iron Crown" of a third of a century ago has learned to diversify its industries and has become the center of cheap fuel and of prosperous agriculture. St. Louis iron and steel products are only a part of the total yearly output of its industries. According to government figures, St. Louis has invested $407,000,000 in 3,500 industries, employing 150,000 people, and our total manufactured product is valued at $550,000,000 annually.

### Some Things in Which St. Louis Leads.

St. Louis manufactures $65,000,000 worth of shoes annually.

Is the largest shoe distributing center.

Has the largest woodenware house in America.

Is the largest horse and mule market in the world.

Makes more street and railroad cars than any other place.

Leads in the manufacture of stoves, ranges, and furnaces.

Holds first place in the output of American-made chemicals.

Is the largest hardwood lumber market of America.

Has the largest hardware house in this country.

Is the largest inland coffee distributing center.

Is the largest fur market in the world.

Another item which will particularly interest the American Iron and Steel Institute is that the St. Louis district's five large cast steel plants make it the largest open-hearth cast-steel market of its kind in the country. These foundries have a capacity of about 300,000 tons a year of finished product and consume 1,500,000 tons of raw material.

## St. Louis as a City to Live In.

Now, grant me the pleasure of telling you something about St. Louis as a home city. I have lived here a great many years, but, until my election as president of our leading commercial organization, my civic conscience had not awakened to realize how fortunate I was in the selection of my home city.

St. Louis weather averages as good as that of any other American city, and better than most of them. Spring and autumn here are our most pleasant seasons. Recently *Collier's Weekly* contained two splendid editorials about St. Louis, showing, among other things, that our infant death-rate (which is considered the acid-test for healthfulness) was lower than that of any other large American city. These editorials also referred to St. Louis as a pioneer in such things as municipal playgrounds, free swimming pools, golf courses, chaperoned public dances, and other public recreations. Last year more than 5,000,000 people availed themselves of these public recreation features. From the standpoint of efficiency and architecture our 120 public schools are unexcelled anywhere, and are attended by 120,000 pupils. And, by the way, we will very soon vote a $3,500,000 bond-issue for the improvement and extension of our public schools.

An automobile ride around our residence district will convince you that St. Louis well deserves its title, "The City of Beautiful Homes." Three hundred and twenty-seven out of each 1,000 new dwellings are built for owners' occupancy.

Among our educational institutions are two universities of national reputation—Washington University and St. Louis University.

Our beautiful Art Museum, where you are all welcome, is located in Forest Park, a natural park containing about 1,400 acres, and the largest of our 51 parks. The Art Museum and the beautiful Jefferson Memorial building—the latter located at one of the entrances to Forest Park—are permanent reminders of the Louisiana Purchase Exposition, heretofore mentioned.

The Art Museum overlooks a natural amphitheatre where St. Louis produced recently the Pageant and Masque of St. Louis, which was witnessed by the largest audience that has ever viewed a single spectacle. The total in attendance at the five performances was 697,000. The third performance was witnessed by 197,000 people.

Another place of interest to which we are invited is the log cabin home of General Grant, who once sold wood for a living in St. Louis. This cabin and the farm surrounding it were purchased and are being adequately cared for by one of our prominent citizens.

As I have previously said to you gentlemen, you will like St. Louis and the friendly spirit and cordial neighborliness of St. Louis people. The culture of the East, the energy of the North, the hospitality of the South, the vision of the West—these are all embodied and blended in this cosmopolitan metropolis of the Mississippi Valley. (Applause.)

Vice-President King: Judge Gary has asked me to relieve him temporarily as Chairman.

We will now proceed to the first of the formal papers, "The Duplex Process" of the Lackawanna Steel Company, by George B. Waterhouse.

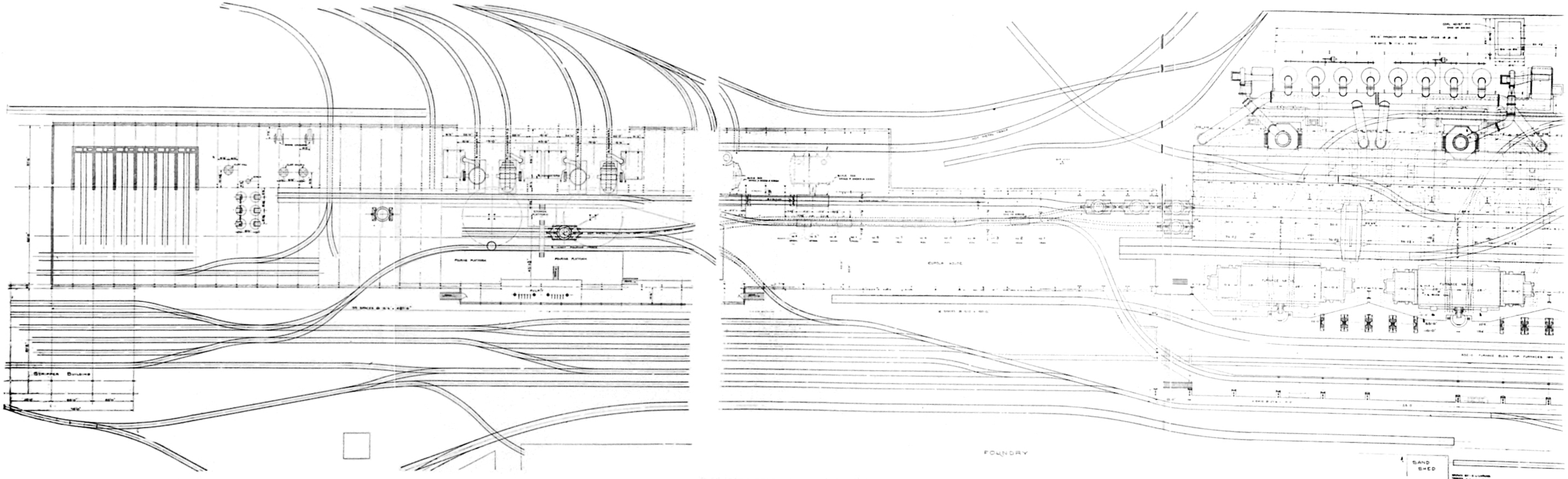



FIG. 1—GENERAL PLAN OF PLANT

# THE DUPLEX PROCESS OF THE LACKAWANNA STEEL COMPANY

George B. Waterhouse

Metallographist, Lackawanna Steel Company, Buffalo

The duplex process is commonly understood by steel men to be a combination of the acid Bessemer and the basic open-hearth processes. The tonnage of steel ingots made by this process has very rapidly increased during the last five or six years, so that a study of the duplex process, as worked out to meet American conditions, is most interesting. It is the aim of this paper to help in this study by giving a brief and clear description of the process in use at the Lackawanna Steel Co., Lackawanna, N. Y., and to give also an idea of the results obtained.

## Description of Plant

The plan, Fig. 1, shows the lay-out of the plant. The acid Bessemer department was already in existence when duplexing was decided upon. It contained the two mixers shown, of 250 and 300 tons capacity respectively, four 12-ton converters and twelve cupolas. Eight of these were for melting iron, and four smaller ones for melting the spiegel mixture used when making rail or high-carbon steel. The position of these various parts of the Bessemer plant is clearly shown in the plan. After careful consideration of the various possible locations, the open hearth was placed directly north of the old Bessemer plant. Two large tilting furnaces were built, shown on the plan as furnaces Nos. 15 and 16. This arrangement makes a comparatively short haul for the blown metal between the converters and the open-hearth furnaces. The iron cupolas Nos. 1, 2 and 3, nearest to the open hearth, were remodeled for the melting of spiegel mixture, and a scale was installed opposite No. 2, as shown in the plan. Since then cupola No. 4 has also been altered

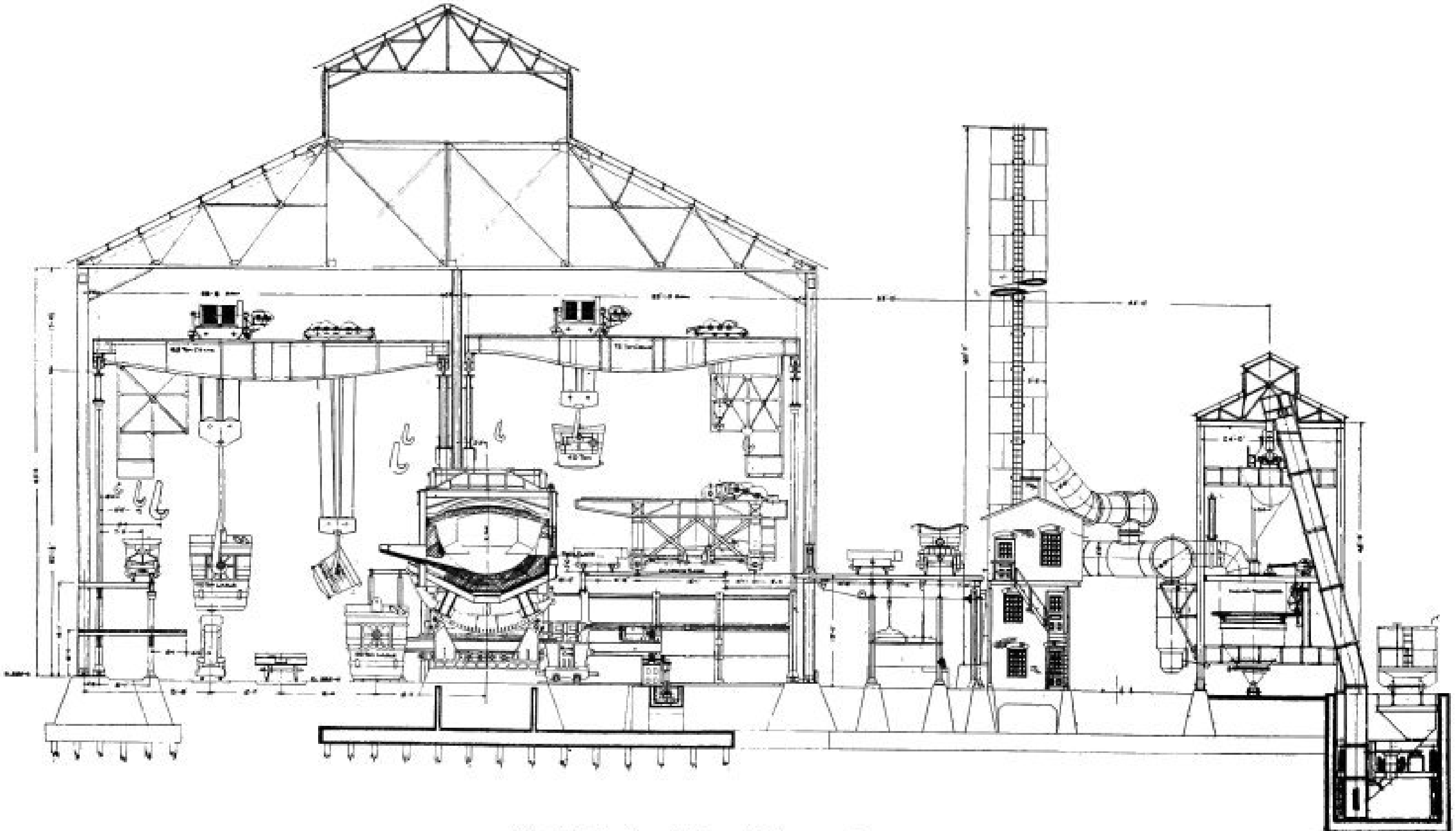


FIG. 2—Sectional View of Furnace Plant.

for the same purpose, and, like the other three, it taps into a ladle standing on the same scale. The transfer track for the blown metal extends far enough into the Bessemer plant so that all four vessels can be used to blow metal for duplexing. The plan also clearly shows the position of the checkers, the reversing valves, the flues, the chimney stacks, the Hughes gas producers, four per furnace, the gas mains, and the waste heat boilers. Also at the extreme left may be seen the stripper building.

The open-hearth plant is very massive and strong. Extremely heavy construction has been used for the building, furnaces, and machinery, in order to ensure as far as possible against delays or shut downs due to breakage. The building, housing the two tilting furnaces, is of steel throughout and is 352 feet long by 124 feet wide. It has since been enlarged to take care of eight stationary 100-ton furnaces, and is now 1038′ 2″ long by 124 feet wide. The massive construction is particularly noticeable in the case of the crane runway girders, which have a length of 110 feet, a depth of 12 feet, and weigh about 115 tons each. They may be seen in several of the half-tone illustrations. The extreme length is necessary in order to span the tilting furnaces, which are themselves very long and which are placed along the line of the center columns of the building. This location is shown in the plan, Fig. 1, but is more clearly brought out in the sectional view, Fig. 2, which gives the relation of the furnace, building, and equipment. The crane runway girders are protected, over the furnace proper, by steel shields suspended below the bottom chords.

The metal from the Bessemer plant is brought in the transfer ladle to the open-hearth plant. It is hoisted to the charging floor level by a crane of 75 tons capacity, having an auxiliary trolley of 25 tons. The span is clearly shown in Fig. 2 and is 55′ 10″. For handling the cold material there is a high-type charging machine. The pit side is served by two 165-ton cranes of 58′ 8″ span, each with an auxiliary trolley of 35 tons capacity. These 35-ton trolleys are also equipped with a 5-ton auxiliary hoist, which is used for tilting the spiegel ladle. At the extreme left of Fig. 2 may be seen the pouring platform, and above it the track along which the spiegel ladle comes from the cupolas. The elevation of this track above the floor level saves valuable floor space. The roof trusses span the entire width of the building, so that no roof load is carried on the center columns or

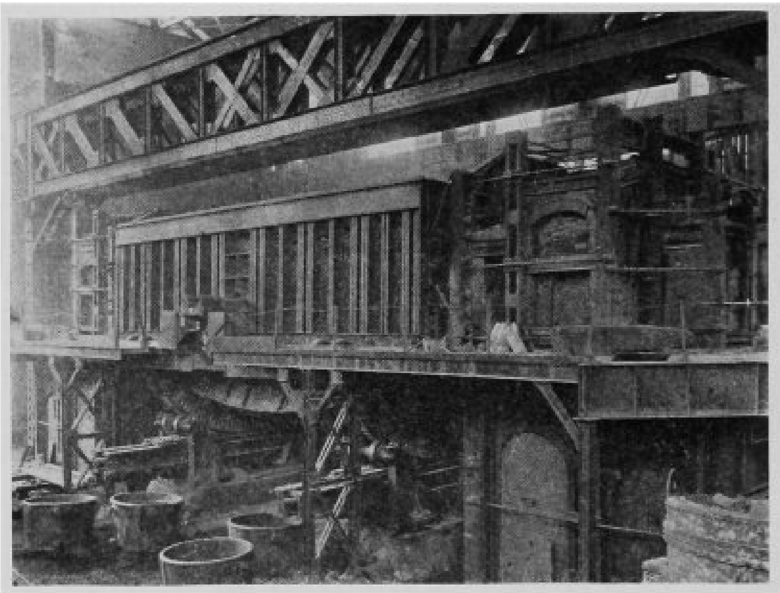


FIG. 3—Pouring Side of Furnace.

the crane girders, and vibration is not communicated to the roof. A platform for the convenience and safety of the crane operators is provided along the entire side of the building. This platform is level with the floor of the operator's cage, so that he can step directly from the cage to the platform at any point along the runway. The ventilation feature is rather simple, consisting of the usual louvre type of monitor so frequent on mill buildings. It is clearly shown in Fig. 2, where it may be noticed that its size is greater than the average. The width is 41 feet and the height 12 feet from the base of the posts to the bottom chord of the truss.

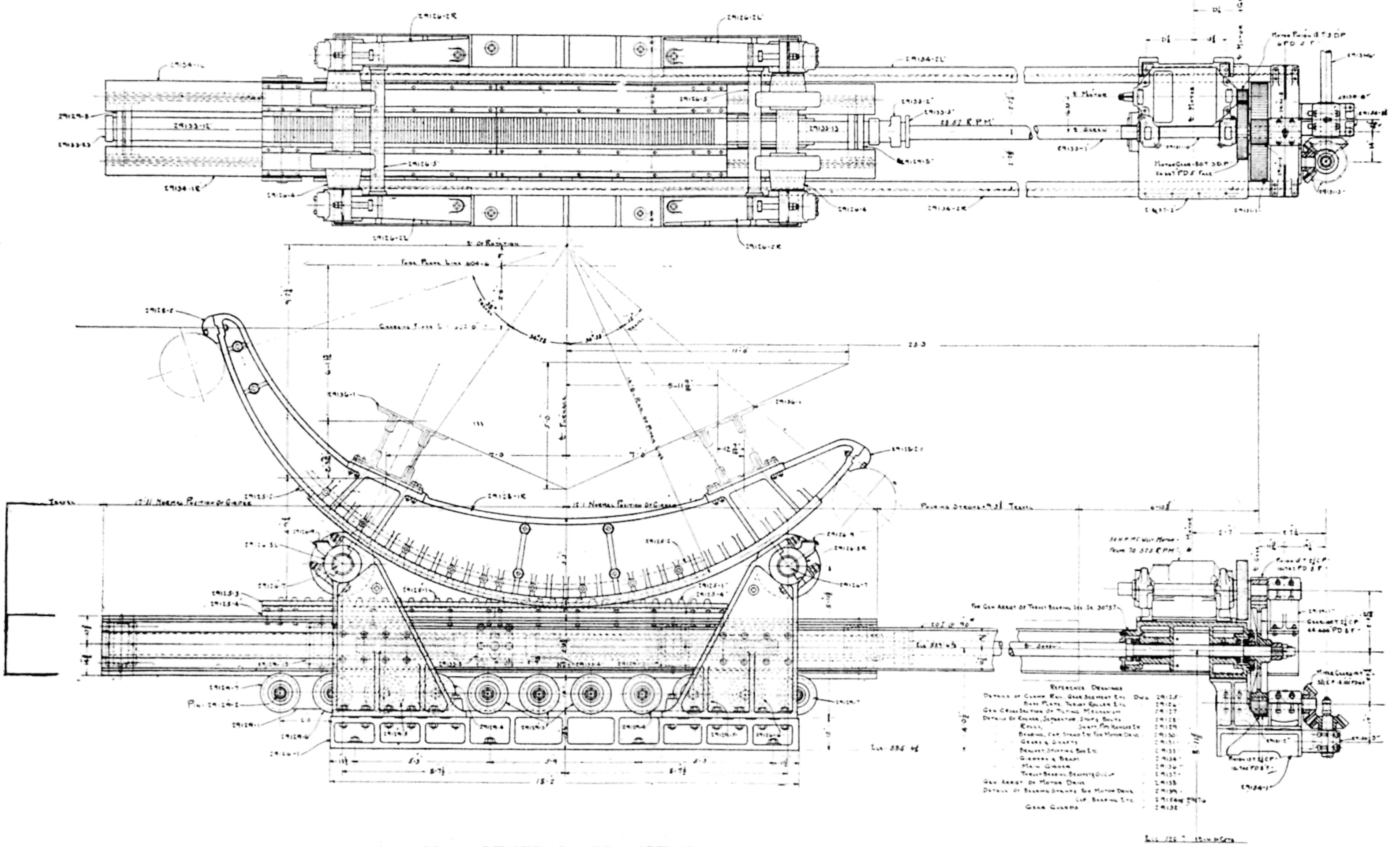


FIG. 4—GENERAL ARRANGEMENT OF TILTING MECHANISM.

The furnaces themselves are, of course, the most important part of the open hearth plant, and there are many interesting features in their construction. In common with the rest of the plant, they were designed and built by the Lackawanna Steel Company, and are of massive construction. The framework consists of heavy beams and channels, suitably tied together and braced. This framework rests upon two heavy box girders, shown clearly in the sectional drawing, Fig. 2, and extending from one rocker casting to the other. These castings are set 30′ 6″, center to center, and rest on heavy "I" beam girders, which support the entire weight of the tilting portion of the furnace, including the bath of metal. Fig. 3, which is a photograph of the pouring side of one of the furnaces, shows clearly these girders and their relation to the rocker castings. The girders also form a part of the tilting mechanism and are supported on a series of steel rollers mounted in a massive base casting. This is brought out in Figs. 2 and 3, but is better seen in Fig. 4, which gives the general arrangement of the tilting mechanism. The tilting or rotation of the furnace is accomplished by means of a rack bolted on the "I" beam girders, which meshes with a gear segment bolted to the rocker castings. The rack is moved by a steel screw journaled between the "I" beams, and held by self-aligning thrust bearings of the ball type, so that no lengthwise motion of the screw can take place. The screws, one for each "I" beam girder, are each driven by a 50 H.P. motor, and are cross connected by shafting below the floor level in order to ensure equal movement of each rocker casting, and avoid harmful twisting stresses in the structure and brickwork of the furnace. The furnace may be tilted in either direction, the extremes being 38 deg. travel from the vertical when pouring, and 15 deg. travel toward the charging side when removing slag. The center line of the ports has been made the center of rotation of the furnace, which results in the stationary ports and those in the tilting portion of the furnace always maintaining their proper relation to each other. Cold air is prevented from striking the ports or entering the furnace.

Each furnace has a hearth 13 feet wide by 40 feet long, and is 50 feet long over the chill plates. On the charging side there are seven doors, as shown in Fig. 5, which is from a photograph of the charging side of the furnaces. At the center of the furnace there is a door 2′ 6″ by 2′ 11″. On

FIG. 5—Charging Side of Furnaces.

each side are two doors 3 feet by 3′ 6″, those next to the center being equipped with a tapping spout. Also on each side there is a smaller door, near the ports, 2 feet by 2′ 4″. Blair water-cooled ports are used, and great care has been used in the construction of the ports so that when the furnace is heated up there is a minimum of clearance between the stationary ports and the tilting part of the furnace, greatly reducing the amount of cold air entering the furnace. The slag pockets and regenerator chambers are of ample proportions, and the binding is unusually heavy and well tied together. The construction of the ports, slag pockets, connecting flues and checkers is shown in

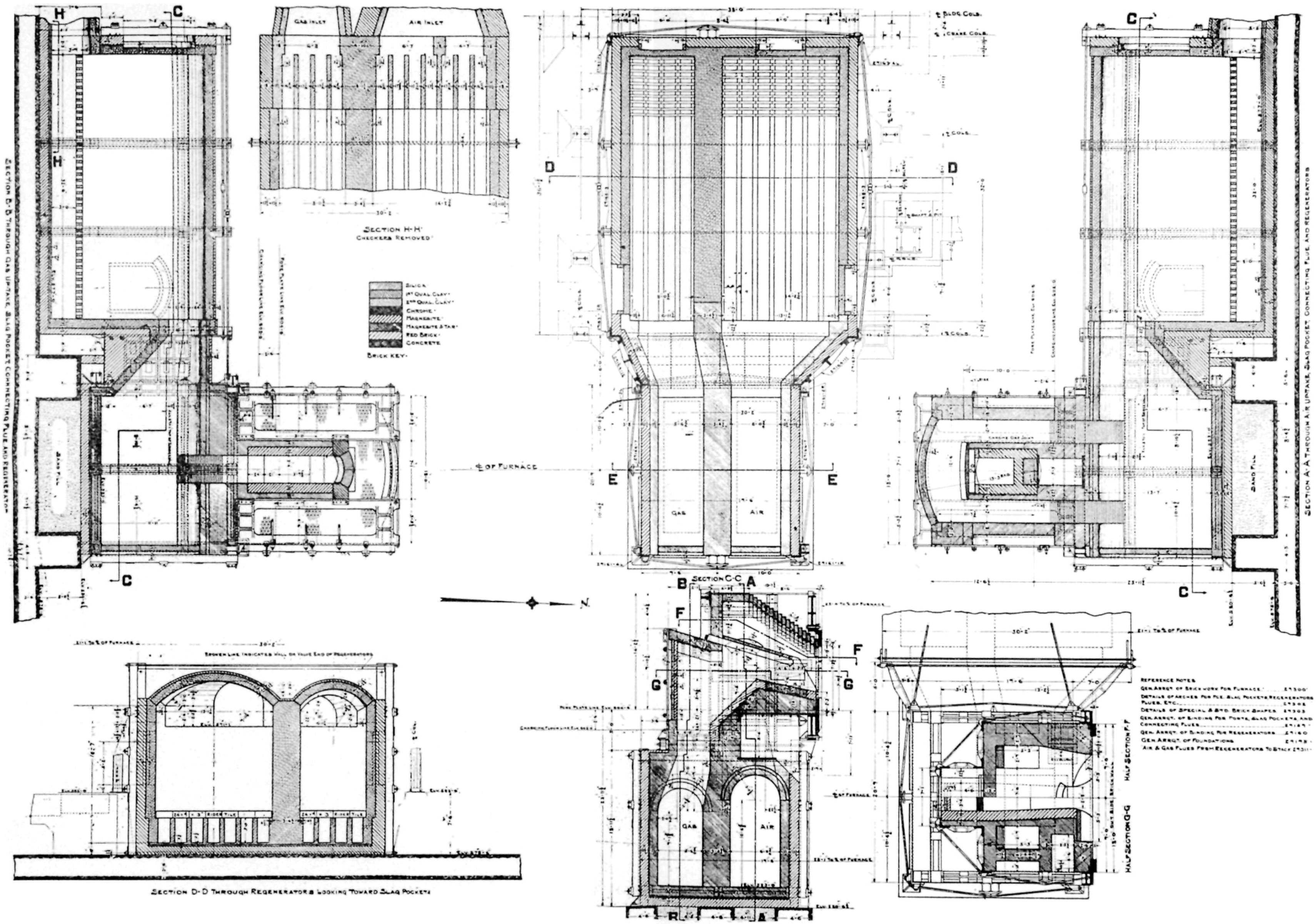



FIG. 6—GENERAL ARRANGEMENT OF PORTS, CHECKERS, ETC.

Fig. 6, the checker volume for each end of the furnace being 5388 and 3084 cu. ft. for air and gas, respectively.

For each furnace there is a self-supporting steel stack, shown in Figs. 1 and 2, 180 feet high, and 7 feet diameter inside the lining. The gas and air reversing valves are water-cooled and water-sealed, and of the same design as

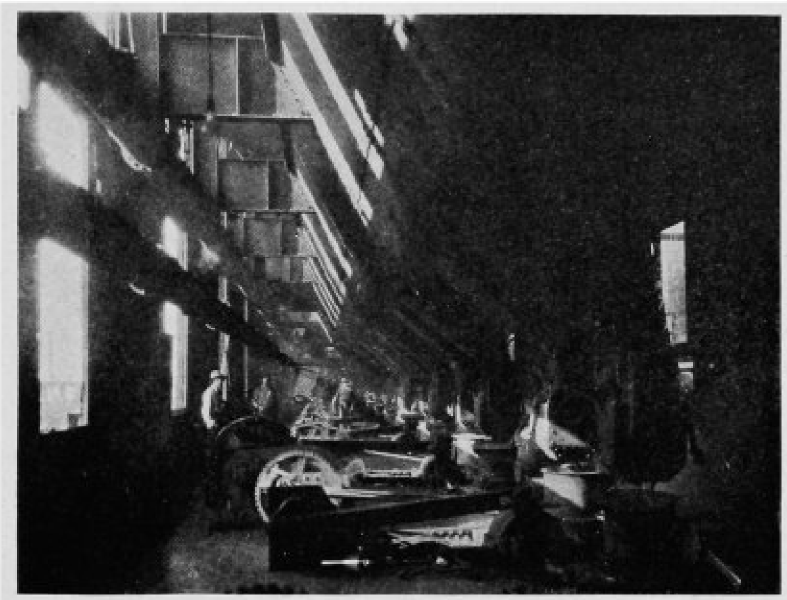


Fig. 7—Hughes Gas Producers.

used on all the Lackawanna Steel Company furnaces. They are 36-inch diameter for the gas, and 48-inch diameter for the air. The fuel for the furnaces is furnished by Hughes self-cleansing mechanical producers, four for each furnace, a photograph of which is given in Fig. 7.

## Description of Process

The process may be said to last for a week, for each week-end the tilting furnace is thoroughly drained, the bottom and slag line made up, the ports cleaned and repaired, and everything made ready for the week's campaign. During

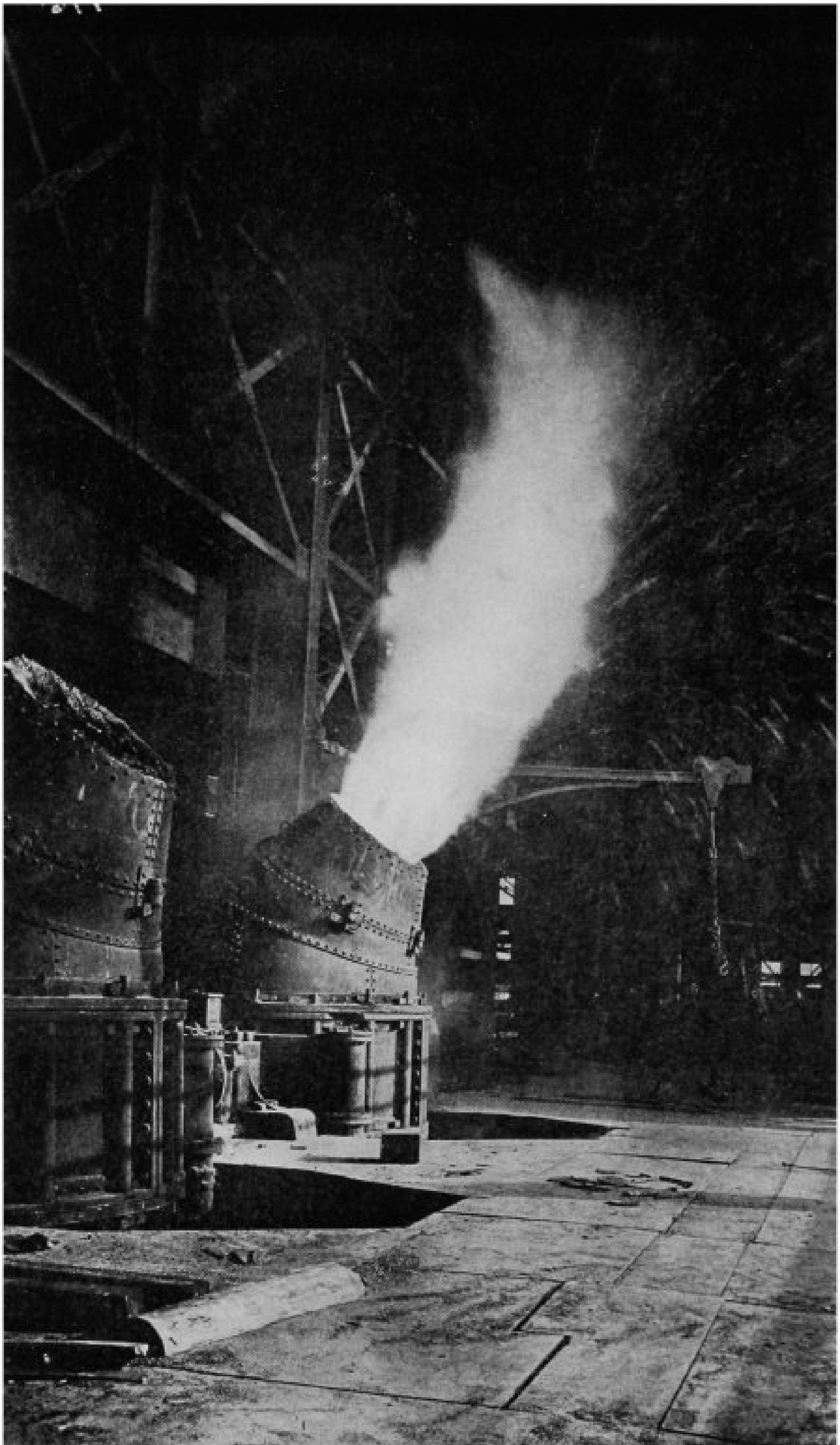


FIG. 8—Blowing Metal in Converter.

this interval the front and back walls are seen to, and such minor repairs made as are found necessary and there is time for. About 6 p.m. Sunday, the gas being once more on the the furnace after burning out the flues, the work of preparing the slag is begun. Four boxes of burnt lime and three of roll scale are charged and melted down. These amounts are then repeated, and when again molten the same amounts are again charged, the total being 12 boxes of lime, and 8 to 9 boxes of roll scale. The average weight of a box of burnt lime is 2000 lbs. and of a box of roll scale 3000 lbs. Considerable care is given by the melter to the preparation of a good slag, for the success of the process (as in all open hearth work) depends on the slag. At midnight, or shortly afterwards, the metal is ordered from the Bessemer department. An average analysis of the mixer metal, is:

| | |
|---|---|
| Total Carbon | 3.70 per cent. |
| Silicon | 1.50 " " |
| Manganese | .65 " " |
| Sulphur | .045 " " |
| Phosphorus | .360 " " |

The weight of this metal taken for a Bessemer heat is 28,200 lbs., less the weight of scrap used in the converter. Two Bessemer heats, blown in different vessels, are poured into the transfer ladle and taken to the tilting furnaces. When starting up, the first ladle contains metal blown down to about 0.40 per cent. carbon, to give a little action in the furnace. This first ladle is poured into the open hearth furnace about 12.45 a.m. It is followed by two ladles of "soft" metal, that is metal blown down to 0.05 per cent. to 0.07 per cent. carbon, and then by a "high" ladle, or a "kicker." This ladle contains metal blown down to 1.5 per cent. to 2.0 per cent. carbon, and when it is charged into the open hearth there is a vigorous reaction. The metal and slag are thoroughly mixed together, and during this reaction the phosphorus is largely removed from the metal bath to the slag. When this reaction has subsided, two more "soft" ladles and a "high" are charged. Then, if the bath is found to be low in carbon, another "high" ladle is given; while if

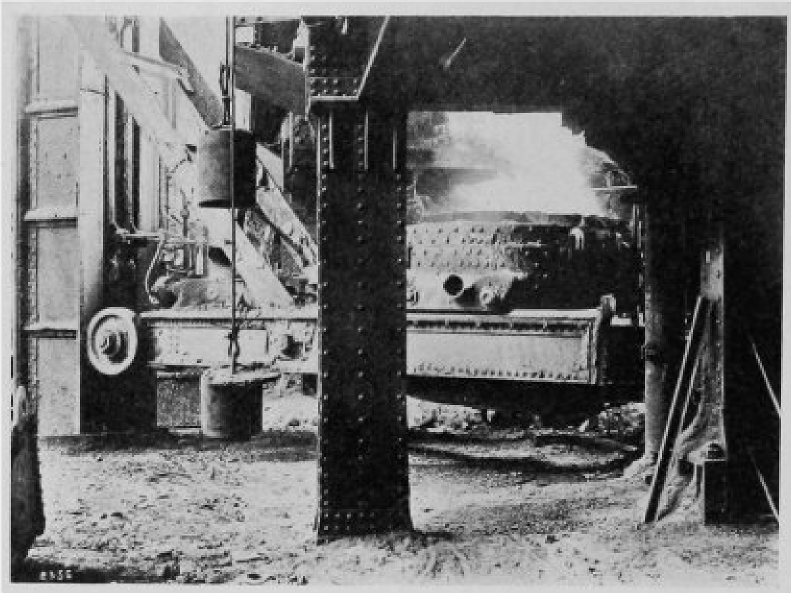


FIG. 9—Pouring Blown Metal into Casting Ladle.

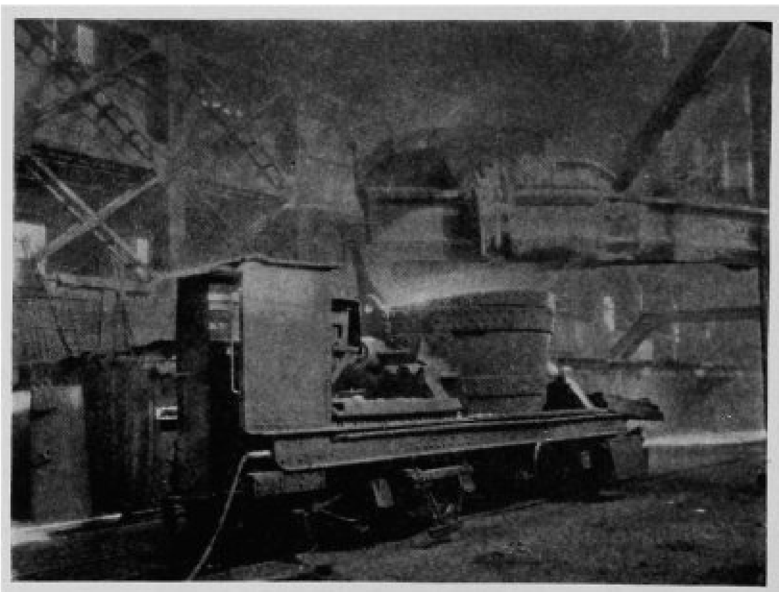


FIG. 10—Pouring into Transfer Ladle.

high in carbon another "soft" ladle is charged. In this way a bath of metal of 190 to 200 tons is produced. The charge is then worked down like an ordinary basic open hearth heat until ready for tapping, which is usually at about 3.30 a.m.

After the heat is tapped, which operation will be described a little later, there is a bath of about 100 tons of metal with 0.15 per cent. carbon still in the furnace, covered with the tapping slag. Two boxes of lime and two boxes of scale are charged, and burnt dolomite used along the slag line, around the doors, etc., as found necessary. Then three "soft" ladles of blown metal are charged, and two more boxes of lime, followed by the "high" ladle or "kicker." During the reaction the furnace is tilted slightly forward and slag allowed to flow from the front of the furnace through the slag spouts. As mentioned before, these are under the doors directly on each side of the center door. The slag falls into the slag cars standing on the tracks shown in Fig. 1. Practically all the slag taken from the furnace is removed in this way, for when tapping a heat only enough is taken to properly cover the metal in the ladle. When the reaction is over, another box of lime is generally charged and the bath worked in the usual way. Very often another box of lime is spread over the slag shortly before tapping, so that five to six boxes of lime are used per heat, but as a rule only the two boxes of scale. After the heat is tapped this procedure is repeated, enough slag being taken from the front of the furnace, at the time of the reaction, to maintain a constant and proper volume of slag in the furnace. A typical analysis of this slag, together with that of the other materials is given in Tables 1 and 2 below. The average time from tapping one heat to tapping the next, for 8,073 heats, was 2 hrs. 53 mins.

About 80 per cent. of the steel made in the tilting furnaces is recarburised in the ladle with molten spiegel mixture. The rest is made with the usual additions of ferro-manganese, ferro-silicon, etc. When the bath is ready for tapping the tap hole is opened and plugged with wet sacking. The furnace is then tilted for pouring. Before the sacking is burnt through, the slag is up along the back wall so that clean metal

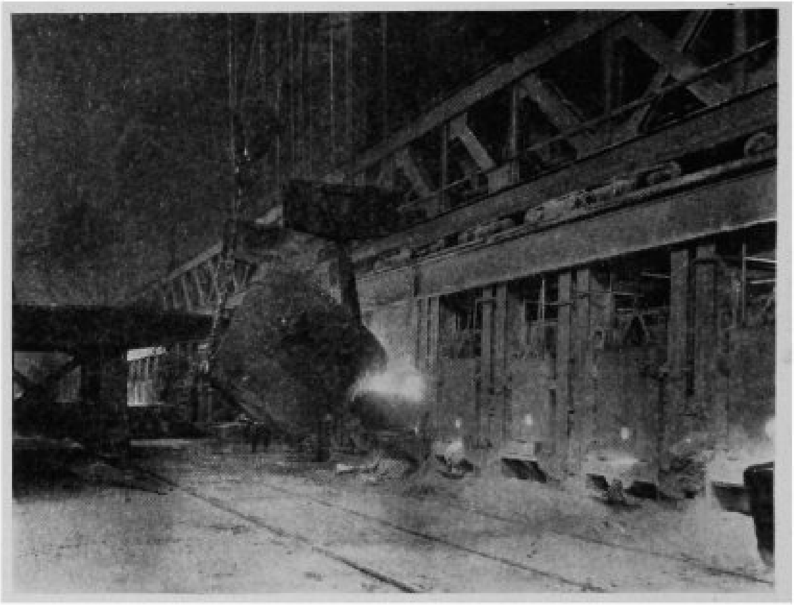


FIG. 11—Pouring Blown Metal into Open-hearth Furnace.

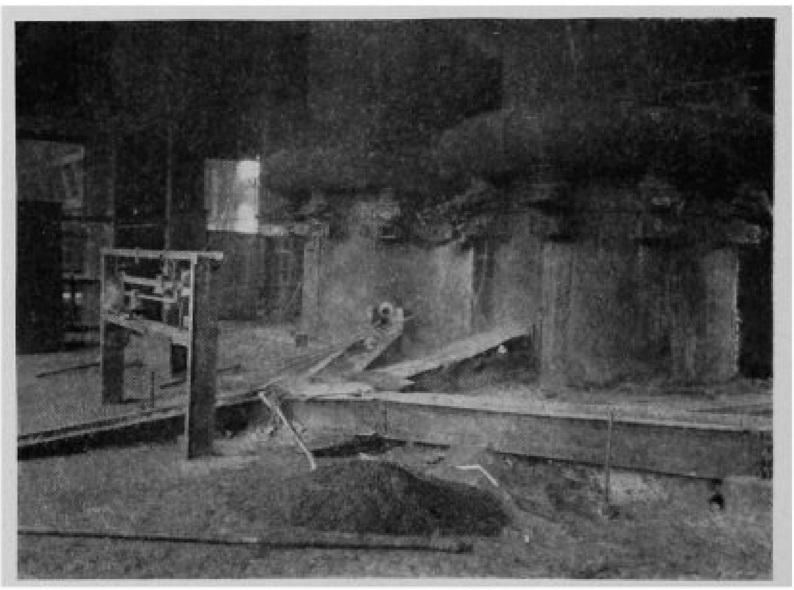


FIG. 12—Spiegel Cupolas.

comes from the furnace. As mentioned before, only enough slag is drawn off to properly cover the steel in the ladle. The 100-ton pouring ladle is held in place in the large hooks of the 165-ton crane, and when the bottom of the ladle is well covered with metal the molten spiegel mixture is also poured into the ladle. The molten spiegel comes from the spiegel cupolas along the track above the pouring platform, and the spiegel ladle is handled by the 35-ton trolley of the 165-ton pouring crane. When making rails the weight of spiegel mixture varies from 25,000 to 28,000 lbs., depending on the specification to be met, and the weight of the heat is about 100 tons, the average for 8,073 heats being 102.7 gross tons of ingots.

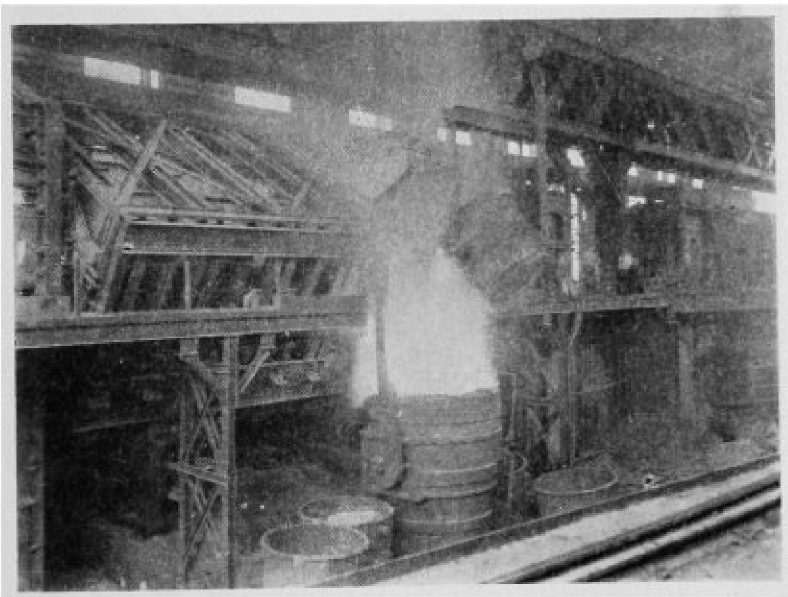


FIG. 13—Tapping Furnace and Recarburizing.

The operations described above may be again briefly outlined with the help of illustrations. Fig. 8, shows the operation of blowing the mixer metal in the Bessemer converter, and Fig. 9, the pouring of the blown metal into the casting ladle. The hydraulic crane carrying the casting ladle is swung around, and the metal poured through a three inch nozzle into the transfer ladle. This is shown in Fig. 10, and is an important part of the process, for in this way practically all the Bessemer slag is held back and does not enter the open hearth furnace. Fig. 10 shows the construction of the electric transfer car. As mentioned before, this transfer ladle holds two Bessemer heats. The transfer ladle, with its charge covered with coke breeze, is taken to the open hearth, hoisted by the 75-ton charging crane and poured into the furnace, as shown in Fig. 11.

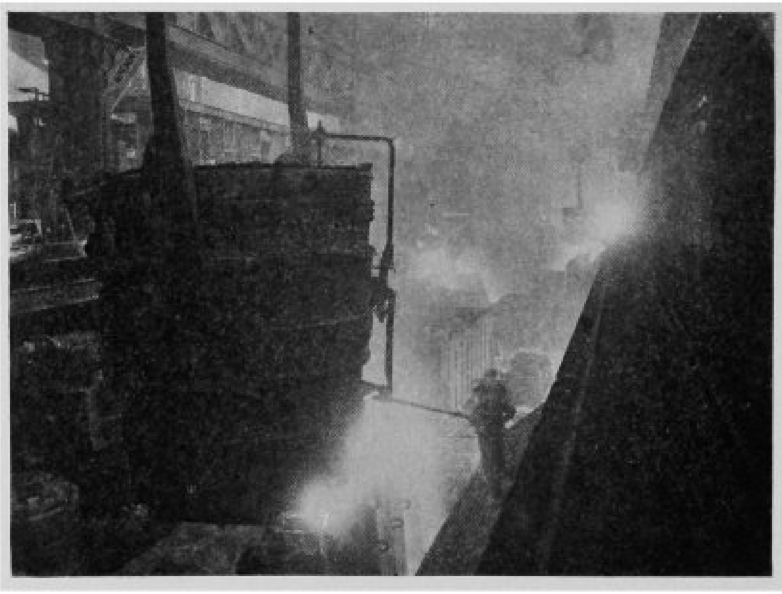


FIG. 14—Pouring Ingots.

Two of the spiegel cupolas and the scale are shown in Fig. 12, while Fig. 13 shows the tapping of the furnace and the pouring of the recarburiser into the ladle. The pouring of the ingots is shown in Fig. 14, where the spiegel track above the pouring platform may be clearly seen at the right.

In Tables 1 and 2 are given typical analyses of the materials used, together with an average slag analysis. The iron ore is occasionally used in order to get the slag into good condition, and the analysis of spiegel mixture given is one used when making rails.

TABLE I.

| | Burnt Lime | Burnt Dolomite | Burnt Magnesite | Fluor Spar | Roll Scale | Lump Magnetite | Slag |
|---|---|---|---|---|---|---|---|
| | Per Cent. | Per Cent. | Per Cent. | Per Cent. | Per Cent. | Per Cent. | Per Cent. |
| Silica | 2.10 | .45 | 4.10 | 3.44 | 1.75 | 5.15 | 6.50 |
| Alumina | .95 | .75 | 2.30 | 1.40 | ..... | 1.42 | 1.02 |
| Lime | 85.00 | 58.30 | 3.25 | ..... | ..... | 4.70 | 43.47 |
| Magnesia | 11.05 | 39.24 | 83.98 | ..... | ..... | .72 | 8.64 |
| Ferrous Oxide | ..... | ..... | ..... | ..... | ..... | ..... | 21.55 |
| Ferric Oxide | ..... | ..... | 6.70 | ..... | ..... | ..... | 6.85 |
| Total Iron | ..... | ..... | ..... | ..... | 70.00 | 61.00 | 21.77 |
| Manganese | ..... | ..... | ..... | ..... | .40 | .16 | 1.01 |
| Calcium Carbonate | ..... | ..... | ..... | 6.87 | ..... | ..... | ..... |
| Magnesium Carbonate | ..... | ..... | ..... | .53 | ..... | ..... | ..... |
| Calcium Fluoride | ..... | ..... | ..... | 86.57 | ..... | ..... | ..... |
| Phosphorus | ..... | ..... | ..... | ..... | .025 | 1.44 | 3.13 |
| Loss on Ignition | 1.05 | ..... | ..... | ..... | ..... | ..... | ..... |

TABLE II.

| | Molten Spiegel | Ferro Manganese | Ferro Silicon | Ferro Phosphorus |
|---|---|---|---|---|
| | Per Cent. | Per Cent. | Per Cent. | Per Cent. |
| Carbon | 4.30 | 7.00 | .15 | .17 |
| Manganese | 6.00 | 79.50 | ..... | .15 |
| Sulphur | .02 | ..... | ..... | .65 |
| Phosphorus | .08 | .20 | .05 | 18.70 |
| Silicon | 1.25 | 1.00 | 49.50 | .39 |
| Iron | ..... | 12.30 | 49.00 | 77.00 |
| Aluminum | ..... | ..... | .30 | ..... |

About midnight on Saturday the furnace is drained. The bath is worked down so that after the heat is tapped there are not more than 40 to 60 tons in the furnace. Then, as soon as a ladle and crane can be obtained, this metal is tapped and is made into a structural or soft steel heat with the proper additions of ferro-manganese, etc.

## Results Obtained

In Table 3, are given the tonnages obtained each month, the number of turns worked since the furnaces were started to the end of August, 1916. The total for the two furnaces is 8073 heats with a total tonnage of good ingots amounting to 830,230 gross tons. This gives an average of 102.7 gross tons per heat. It will be noticed that the best monthly tonnage for the two furnaces was the large total of 50071 gross tons in December, 1915, and the best tonnage for a single furnace was as high as 30272 gross tons for No. 15 in June, 1915. The average number of heats per turn for each furnace is 4.14, and the average time from tapping one heat to tapping the next is 2 hrs. 53 mins. The average tonnage of good ingots per furnace for each turn is 427.6 gross tons.

TABLE III.

| Year | Month | Furnace No. 15 | | | Furnace No. 16 | | | Total Tonnage |
|---|---|---|---|---|---|---|---|---|
| | | Turns | Heats | Tonnage | Turns | Heats | Tonnage | |
| 1913 | May | 5½ | 9 | 841 | ...... | ...... | ...... | 841 |
| | June | 49 | 201 | 18,964 | ...... | ...... | ...... | 18,964 |
| | July | 54 | 223 | 22,168 | 19½ | 69 | 6,863 | 29,031 |
| | August | 54 | 227 | 22,705 | 50 | 199 | 19,736 | 42,441 |
| | September | 52 | 199 | 20,069 | 52 | 197 | 19,647 | 39,716 |
| | October | 5½ | 21 | 2,170 | 52 | 189 | 18,960 | 21,130 |
| | November | ...... | ...... | ...... | 31 | 102 | 10,030 | 10,030 |
| 1915 | April | 34 | 132 | 13,056 | ...... | ...... | ...... | 13,056 |
| | May | 51 | 243 | 25,418 | ...... | ...... | ...... | 25,418 |
| | June | 52½ | 284 | 30,272 | ...... | ...... | ...... | 30,272 |
| | July | 35 | 179 | 18,870 | 31 | 150 | 15,568 | 34,438 |
| | August | 53 | 220 | 23,138 | 54 | 218 | 22,539 | 45,677 |
| | September | 54 | 242 | 25,252 | 27 | 94 | 9,739 | 34,991 |
| | October | 54½ | 212 | 22,115 | 50½ | 190 | 19,247 | 41,362 |
| | November | 53½ | 231 | 24,480 | 53½ | 221 | 23,012 | 47,492 |
| | December | 55½ | 245 | 25,693 | 55½ | 236 | 24,378 | 50,071 |
| 1916 | January | 40 | 166 | 17,302 | 54 | 222 | 22,852 | 40,154 |
| | February | 51½ | 228 | 23,695 | 51½ | 226 | 23,402 | 47,367 |
| | March | 55½ | 244 | 25,710 | 41 | 170 | 17,611 | 43,321 |
| | April | 52 | 218 | 22,690 | 52 | 218 | 22,572 | 45,262 |
| | May | 54½ | 228 | 23,772 | 54½ | 229 | 23,789 | 47,561 |
| | June | 52½ | 225 | 23,387 | 52½ | 218 | 22,653 | 46,040 |
| | July | 29½ | 111 | 11,234 | 52½ | 196 | 19,798 | 31,032 |
| | August | 54½ | 225 | 22,790 | 54½ | 216 | 21,773 | 44,563 |
| | Total.... | 1,053 | 4,513 | 466,061 | 888½ | 3,560 | 364,169 | 830,230 |

In order to give an idea of the life of the furnace, a short history of each of them may be given. The first heat was tapped from No. 15 furnace May 29, 1913, and it was run until October 5, 1913, being then shut down on account of business depression and repairs. Eight hundred and eighty heats had been tapped. A new roof was built, ten courses of new brick placed in the air checkers and six courses in the gas checkers. The furnace was started again April 12, 1915. On July 16th it was shut down for a new roof and checkers after 838 heats on the roof, 1718 heats on the checkers. Fourteen turns were lost. Nothing more than minor repairs were then necessary until January, 1916, when the furnace was down for a new roof after 1212 heats on the old one. Fourteen turns were lost. The last repairs were made in July, 1916, consisting of a new roof and checkers after 1303 heats on the roof, and 4233 on the checkers. This repair took 23 turns.

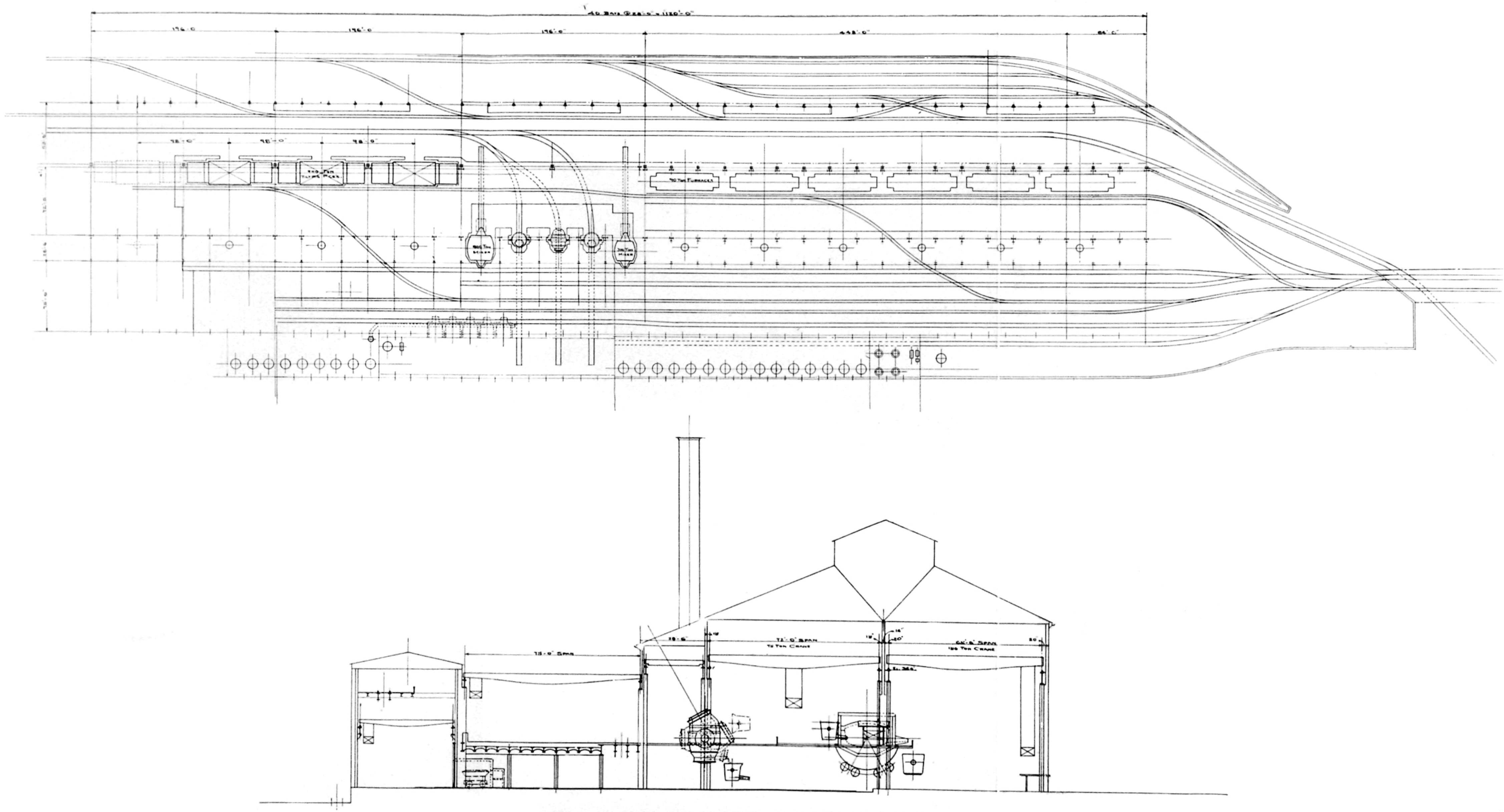
No. 16 furnace was started July 22, 1913, and shut down November 22, 1913, due to business depression. A new roof was built after 720 heats on the old one. It was started July 6, 1915, and ran until September 19th, when a new roof and checkers were put in. The heats on the old roof were 499, and 1219 heats on the checkers. Twenty-seven turns were lost. The next shut down was March 20, 1916, when a new roof was built after 1239 heats on the old one. Fourteen and a half turns were lost.

The standing at the end of August, 1916, for Furnace No. 15 was 280 heats on the roof and checkers, 4513 on the ports and slag pockets; and for Furnace No. 16, 1102 heats on the roof, 2833 heats on the checkers, and 3560 heats on the ports and slag pockets.

In regard to the quality of the steel made it has hardly been thought necessary to give long tables of heat analyses and the results of physical tests. All the steel has been made to specification, and many of the specifications have been of the most rigid character. It is not too much to say that the steel has fully met all the requirements and has proved to be very uniform from one heat to another.

Vice-President King: Under the five-minute rule there will be a discussion of this paper. First is by Quincy Bent of the Bethlehem Steel Company. He is absent and has asked Mr. McCleary to read his paper, which he will now do.

MR. MCCLEARY: Mr. Bent is a very loyal member of the Institute and would have been here had it been possible, but he has just been placed in charge of the great steel plant of the Bethlehem Company of Steelton, Pennsylvania. In these busy times he cannot leave and has asked me to read his paper.




PLAN AND ELEVATION OF STEELTON DUPLEX OPEN HEARTH

# THE DUPLEX PROCESS OF STEEL MAKING

DISCUSSION BY QUINCY BENT

General Manager, Bethlehem Steel Company's plant, Steelton, Pa.

In Dr. Waterhouse's paper we have a very comprehensive description of the Lackawanna Steel Company's duplex plant and its method of operation. They are, indeed, to be congratulated upon the results which have been obtained.

As the details of construction of the Steelton Plant have been accurately set forth in a previous technical article—*Iron Age*, September 10, 1914, and *Iron Trade Review*, September 17, 1914—I append herewith only a general plan and elevation sketch to show the plant as it exists to-day.

It will be noted that there is a marked similarity in the open-hearth furnace construction. The methods of operation of the two plants are likewise similar, save for a very few details, the principal features of difference from the Lackawanna installation being the size and location of the Bessemer vessels, the over-head crane transportation method from the Bessemer to the open hearth, and the use of bottom side-tap ladles direct from the converters for the elimination of the Bessemer slag.

All duplex processes in general are efforts toward the same end, namely, to divide the work of making steel from iron into two parts—(1) decarburize and desiliconize, and (2) dephosphorize, desulphurize and refine—assigning the first task to the Bessemer converter, which meets the conditions most admirably, and the second to the basic open-hearth furnace, where again the requirements are most advantageously provided.

The details of apparatus and variations of method are, of course, numerous, depending upon individual preference, local conditions and plant facilities.

There are, however, several important features which should be present in the ideal duplex installation:

First, an ample supply of molten pig iron, sufficiently high in heat-producing elements to assure warm blows, with or without the addition of a small amount of scrap.

Second, a fair reservoir of hot metal providing a good mixture of iron as it is produced by the various blast furnaces.

Third, a close proximity of mixers, converters and open-hearth furnaces, with ample means for rapid and regular transportation between the three divisions.

Fourth, converters of as large a capacity as practical—25 or 30 tons—three of which can be blown simultaneously.

Fifth, crane and ladle capacity to collect these three heats and transfer them as a unit to the open-hearth furnace.

Sixth, proper means for preventing the Bessemer slag from entering the open-hearth furnace, and facilities for the disposal of this slag.

Seventh, large tilting open-hearth furnaces of 200–250-tons capacity, tapping from 90 to 110 tons per heat.

Eighth, provision for recarburizing heats in the steel ladle.

Ninth, ample pit room and teeming facilities to handle the open-hearth output.

As to the production per unit of installation, the most rapid work of course is accomplished by the use of 100 per cent. hot metal, and on this basis one 200-ton open-hearth furnace can produce from 800 to 1,000 tons of ingots per day, provided no delays are encountered in the elimination of phosphorus and sulphur. From this point of maximum production to minimum production using the straight pig and scrap process at the rate of two heats, or 200 tons per day, is a varying productivity range depending upon the percentage of scrap used in the open hearth.

The actual percentage of scrap used in these large tilting furnaces will always be governed by commercial conditions, and much thought should be taken to consider carefully the value of the furnace output, the cost of blown metal and the price of scrap.

The cost of plant per ton of ingots, embracing *additional* blast-furnace capacity, Bessemer and open hearth, will be fully as great as the cost of stationary open-hearth furnaces per ton of ingots, but the duplex plant will possess a greater flexibility, permitting of maximum output in prosperous times, and still providing economical operation in periods of restricted product.

Obviously the most profitable location for such a plant is where the production of molten pig iron is on a low-cost basis as compared with the normal price of melting scrap.

Vice-President King: We will now have a short discussion of the paper by Theodore W. Robinson, First Vice-President of the Illinois Steel Company, Chicago.

# THE DUPLEX PROCESS OF STEEL MAKING


Discussion by Theodore W. Robinson

First Vice-President, Illinois Steel Company, Chicago, Illinois.


Dr. Waterhouse's paper is a valuable contribution to the literature of American steel practice. While primarily a description of the duplex plant and process as used at the Lackawanna works, it covers the fundamentals of a development in this country already important, and one that is destined to command greater consideration as time goes on.

The term "duplex process" is an elastic one. In the United States, it may be considered as specifically applied to the primary refining of pig iron in the acid Bessemer converter, with a secondary and final refining of the blown metal in the basic open-hearth furnace, either of the fixed or tilting type.

In 1876—forty years ago—this country produced a little over 500,000 tons of steel. Nearly 90 per cent. was Bessemer, and only 19,000 tons were open hearth. In 1906, thirty years later, our steel production had risen forty-eight fold, to over 23,000,000 tons. Eleven million tons were open hearth, and 12,250,000 tons were Bessemer.

The year 1906 marks the peak of Bessemer steel production in the United States, and will undoubtedly go down in our annals as the zenith of an invention that has perhaps done more for the rapid development of the American continent than any other industrial device. Since then, the decline of Bessemer steel in this country has been slow but certain, and open hearth has increased by leaps and bounds. Of the 32,000,000 tons of steel produced by our mills last year, 8,225,000 tons were Bessemer, and 23,500,000 tons were open hearth. Why such a change? Primarily, this marvelous transformation in method is the American steel master's answer to the demand for steel of higher quality. In response to this demand, the comparatively complex and expensive open-hearth process slowly grew through metallurgical stress and financial strain. Spurred by decreasing Bessemer ore reserves, and assisted by mechanical invention and metallurgical discovery, its development in recent years has been rapid.

But the tides of industry, like the ebb and flow of the sea, necessitate equilibrium. Change spells disturbance, and readjustment there had to be when the open hearth rose and the Bessemer fell. The result is the duplex process with its balancing influence on scrap consumption, a process which last year produced over 1,750,000 tons of steel in this country. It may be that the installation cost of the duplex process is slightly less per ton of product than the straight open-hearth melting process. It may also be that the operating cost of the duplex process is somewhat less, at least in some districts. But the underlying cause of the growth of the duplex process is its independence of a steel scrap supply.

Scrap or its equivalent is an economic necessity for the straight open-hearth process. It is perhaps reasonable to assume that of our ingot production, 20 to 25 per cent. is discarded as scrap in the process of manufacture. Probably 7,000,000 tons of our steel production last year went to the melting furnace. To this must be added the reclaim from the nation's scrap pile. While the combined amount is large, our scrap supply is to-day relatively smaller than when the Bessemer converter was dominant with its small scrap consumption. Blown metal may be considered essentially as molten scrap, and the duplex process is an important factor in maintaining the equilibrium of our scrap supply.

At the South Chicago plant of the Illinois Steel Company, several years' experience with Bessemer-blown metal in stationary open-hearth furnaces helped to demonstrate the advantages of the duplex process. At the Gary works there will soon be completed a plant consisting of two 25-ton acid Bessemer converters and two tilting open-hearth furnaces, each with a hearth area along the metal line of 46′x 14′. This plant may be rated as having a capacity of about 600,000 tons of steel per annum. At the South Chicago works a similar duplex plant is under construction, with the exception that three tilting furnaces are provided instead of two. Two of these furnaces, with a nominal capacity of 600,000 tons per year, will be used for duplex open-hearth steel. The third furnace will serve as an adjunct to two auxiliary 20-ton electric furnaces.

The installations of the duplex process in the United States have thus far been chiefly confined to plants already established. The process, as generally practiced in this country, may be divided into (a) the practice of adding blown metal from an acid Bessemer converter into an open-hearth furnace in which there has been left a residual bath of finished steel, as is the case at Lackawanna, and (b) the practice of adding blown metal to an open-hearth furnace where only the preliminary oxides with or without scrap additions have been prepared, and where the heat, when finished, is completely tapped. The methods are interchangeable, and the adoption of one or the other is subject to local conditions. When a residual bath is used, it is not customary to use scrap on account of slowing down the process. When complete individual heats are made, scrap is sometimes used.

Dr. Waterhouse speaks of the use of a "kicker" of partly blown metal. The practice of mixing partly blown metal with full blown metal in the open-hearth furnace is an important element in the satisfactory working of the process on account of the deoxidizing effects of the carbon and the mechanical agitation that ensues. Where only full-blown metal is used, similar results may be obtained by recarburizing the blown metal with molten pig iron between the Bessemer and the open hearth; or, as was usually the case with the stationary furnaces at South Chicago, by mixing full-blown metal and molten pig iron in the open-hearth furnace.

Dr. Waterhouse's paper refers to the satisfactory quality of duplex steel made at Lackawanna. Poor steel can be made by any standard process, and inversely, good steel can be made by any standard process. For the highest requirements, open-hearth steel, generically speaking, is better than Bessemer. And by the same token, electric and crucible steel are better than open-hearth. Yet Bessemer steel lends itself particularly well for certain purposes. The metallurgy of steel is not an exact science, and every steel man knows that whether as measured by chemical analysis, mechanical structure, or physical test, it is difficult at times to differentiate between steel made by one process or another.

It is proper to record that, as with our other standard methods of manufacture, we are indebted to Europe for the original development of the duplex process. In Europe, however, the duplex process has been often a combination of the basic Bessemer and the open hearth, instead of, as with us, a combination of the acid Bessemer and the open hearth.

More or less prejudice has existed in respect to the quality of some of the duplex open-hearth steel made in Europe. In this connection, however, it is interesting to recall that at one time there was a good deal of prejudice concerning the quality of straight open-hearth basic steel. But prejudice then, as often now, proved to be but an opinion formed without such a fair consideration of the truth as was necessary for a just determination.

I cannot vouch for the facts in respect to European duplex steel, but if there has been discrimination, it may perhaps be accounted for by the use of the relatively highly oxidized blown metal from the Bessemer converter. The truth probably is that any such adverse opinion as may exist is due rather to individual poor practice than to any inherent defect in the duplex process. Certainly the high quality of American duplex steel tends to substantiate such a conclusion. (Applause.)

Thereupon, the meeting was adjourned for luncheon.

## AFTERNOON SESSION

President Gary: The next paper is entitled, "Pulverized Coal as a Fuel for Metallurgical Furnaces," prepared by Mr. James W. Fuller. I understand in Mr. Fuller's absence this paper is to be read by Mr. J. H. Schuler, of Mr. Fuller's Company.

# PULVERIZED COAL AS A HIGHLY EFFICIENT FUEL FOR METALLURGICAL FURNACES

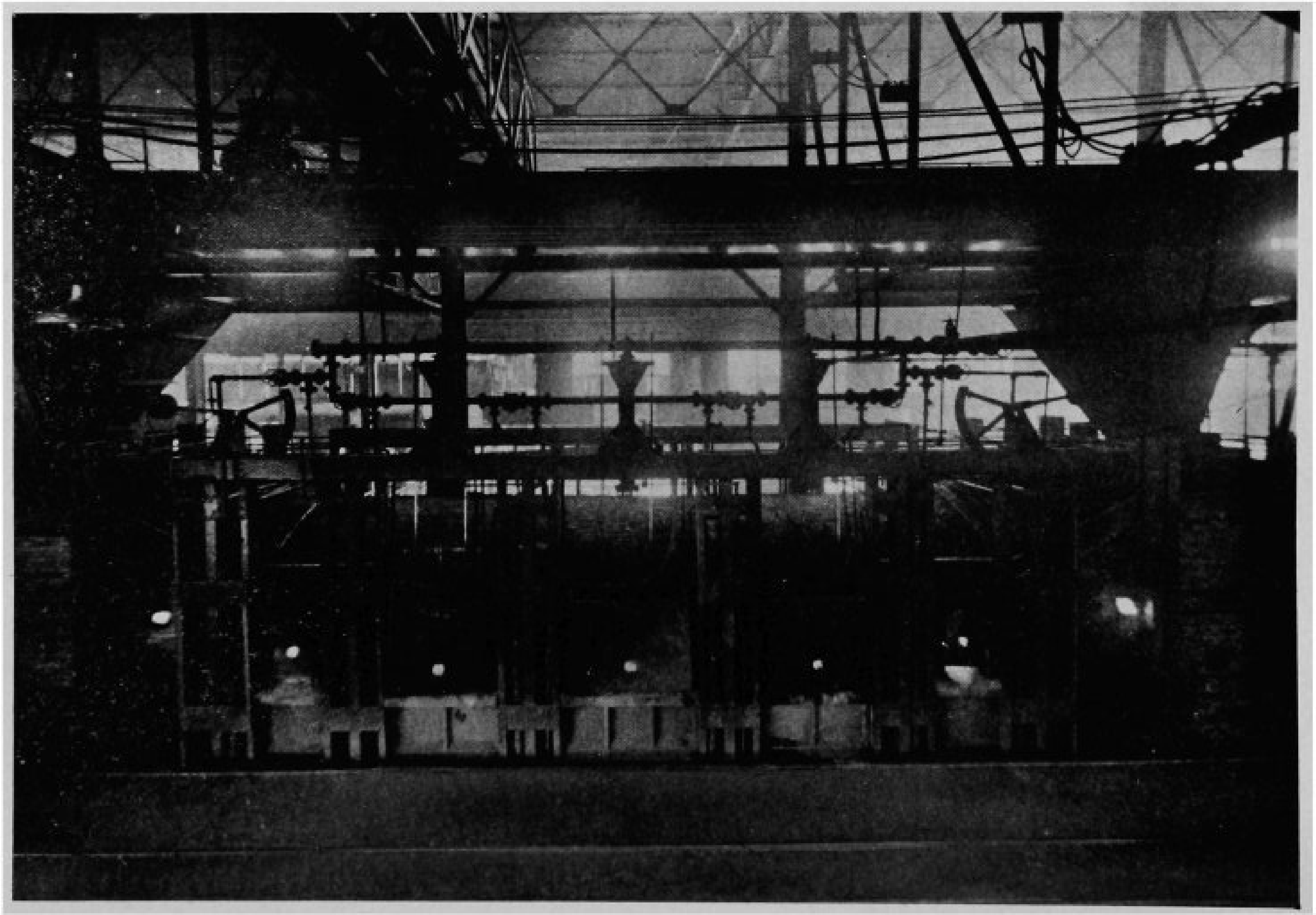
JAMES WHEELER FULLER

President, Fuller Engineering Company, Allentown, Pa.

The development and use of pulverized coal in this country has been primarily due to its application in the cement industry and its gradual application to other types of metallurgical furnaces. Marked economies, and in some cases increased productions, have been obtained from this fuel and within the last few years it has been applied very successfully to various kinds of heating furnaces, including forging, continuous heating, busheling, puddling and open-hearth furnaces. Pulverized coal is being used on continuous heating furnaces with very gratifying results. It is also being used as a fuel for soaking pits and promises to be used more extensively on this type of heating furnaces in the future.

One of the first applications of pulverized coal to the various types of metallurgical furnaces was made by the American Iron & Steel Manufacturing Company at Lebanon, Pa., at whose plant this form of fuel was successfully applied to heating, busheling, and puddling furnaces, this being practically the first attempt to apply it to the iron and steel industry. Taking into consideration the knowledge obtained from the experience at the above-mentioned plant, and also that obtained from other installations, it has been found that furnaces can be successfully operated by various methods of applying this fuel. Each type of metallurgical furnace presents different requirements as to the kind of burners to be used.

Probably the greatest recent development in its use has been as a fuel for open-hearth furnaces. The advantages expected to be gained from the use of pulverized coal as a fuel for open-hearth furnaces from observations of its use up to date are as follows:



View of 50-ton Open Hearth Furnace, Using Pulverized Coal, Showing Lines at Each End of the Furnace.

A more regular supply of heat to the furnace, as it is much easier to burn powdered fuel to gas than it is to gasify coal in the ordinary gas producer. In other words, the gas is of a more even chemical composition, and all the heat units are consumed in the furnace, which should result in a greater number of heats per week.

Open-hearth furnaces are in operation using powdered fuel with very low fuel consumption equal to the best producer gas practice, and much better than the average of the older plants in this country.

Coal can be pulverized and delivered to the furnace for approximately 35 cents per ton as compared to 60 cents per ton for gas producers.

It is possible to obtain, by the use of pulverized coal, as large a production of steel as by the use of fuel oil, and the substitution of pulverized coal for producer gas in most instances gives an increase in production which may amount to between 10 and 40 per cent. according to the nature of the practice.

Less cost of pulverized coal installations as compared with gas producers.

It is believed that there will be 1 per cent. to 2 per cent. less oxidation in pig iron and scrap in melting down a heat. This is brought about by minimizing the amount of free oxygen used in burning powdered fuel as compared with oil; and we also believe that there will be less oxidation in melting down a heat with powdered fuel as compared with producer gas, but are unable at this time to state just what this figure will be.

The furnace conditions are under more accurate control of the operator. It is believed that there will be less sulphur taken up in melting the heat down with powdered fuel with a coal containing, say, 1 per cent. sulphur than there will be with producer gas made from the same coal. The life of the furnace refractories is lengthened.

The disposition of the ash formed from powdered fuel in the furnace has been practically taken care of by specially constructing the furnace, and by pulverizing the coal to a great degree of fineness, thereby producing ash which is almost an impalpable powder which passes through the furnace and the major portion goes up the stack. The port construction has been so improved that it is not necessary to shut down the furnace during the week. The ash is removed over Sunday.

### Pulverized Coal as a Fuel for Open-Hearth Furnaces.

Pulverized coal presents many advantages over producer or natural gas and oil as a fuel for open-hearth and other melting furnaces. The chief advantages are reliability of operation and economy in fuel consumption together with

Bin, feeder, and burner used on a 50-ton Open Hearth Furnace, using pulverized coal.

increased production, due to a shorter period of time taken for melting down an open-hearth charge and then the high uniform temperature maintained, which facilitates the usual working of the charge, which greatly decreases the working time of the furnaces. It also has other advantages, one of which is that by using pulverized coal as a fuel for open-hearth furnaces, the design and construction of the furnace is very much simplified.

## Conditions Covering Its Use.

The best coal for use in open-hearth practice is a bituminous coal as high in volatile matter as possible and preferably low in ash. A coal having the following analysis is now giving excellent results:

| | | |
|---|---|---|
| Moisture | 1.64 | per cent. |
| Volatile | 34.42 | " " |
| Carbon | 57.84 | " " |
| Ash | 6.10 | " " |
| Total | 100.00 | " " |
| Sulphur | | 1.36 |
| B. T. U.'s | | 14,200 |

If a few important requirements are taken care of, it is possible to use a coal containing more sulphur and ash than shown above.

Coals containing more than the above quantities of sulphur and ash will tend to increase the length of time required per heat and will also necessitate more frequent cleaning out of the slag pockets and checkers. The use of coals containing a high percentage of sulphur depends entirely upon the degree of fineness to which the coal is pulverized and the efficiency of the burner used, as immediate and complete combustion is dependent upon the fineness of the coal.

Requirements of pulverization for open-hearth work are more stringent than for other types of furnaces. First, it is necessary to have coal ground so that 95–97 per cent. will pass 100 mesh and at least 70 or, better, 75 per cent. passes through 300 mesh. A great deal depends upon this fineness.

The elimination of sulphur, lower oxidation losses and the increased life of the checker work are directly proportional to the efficiency of combustion which is to so great an extent dependent upon this degree of fineness. The coal containing the highest percentage of impalpable powder is more suitable for this work, as it can be burned with greater efficiency, thereby nearly approaching a gaseous condition within the furnace.

## Oxidation.

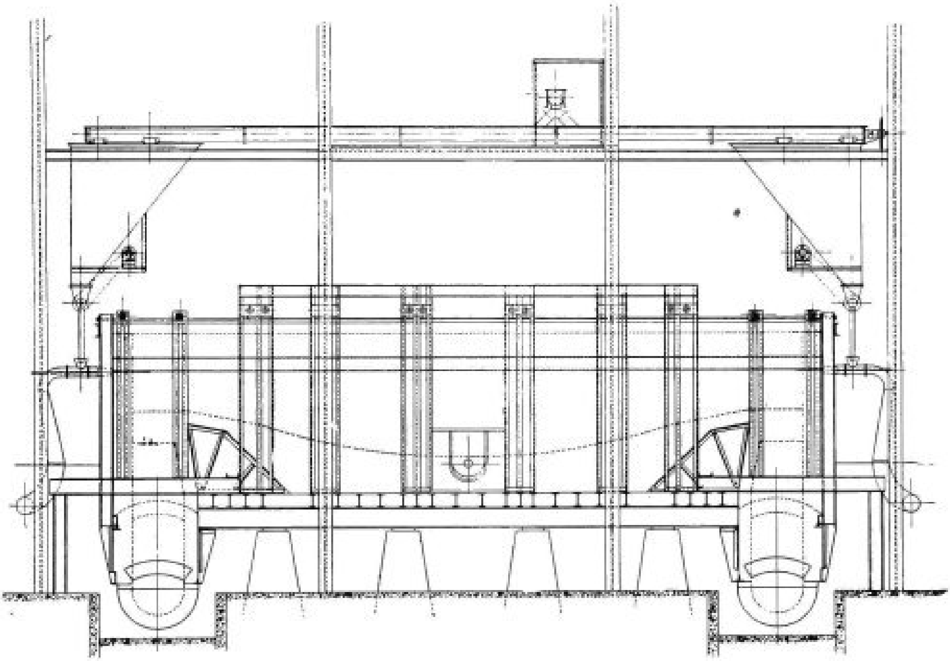
Unless the coal is pulverized to a very high degree of fineness and the efficiency of the burner is high, combustion will not be complete before the gases come in contact with the metal in the bath. This would cause excessive oxidation loss as there would be, with incomplete combustion, free oxygen in these gases which very readily attacks the charge at the temperature within the furnace at this period of operation. It has been shown that by having combustion complete immediately after the fuel enters the furnace and minimizing free oxygen in the gases when they come in contact with the metal in the bath, oxidation losses are reduced from 1 to 3 per cent. below the average practice of other fuels.

## Desulphurization.

The most important point depending upon complete combustion is to keep the sulphur in the fuel from going into the charge. Sulphur as it enters the furnace is mechanically mixed with the coal in pyrite form, and unless combustion is immediately completed so that all the sulphur is burned to sulphur dioxide ($SO_2$) and is allowed to pass out the stack with other waste gases, it is apt to combine with the iron, which is very undesirable, as it requires additional time to remove it from the charge before tapping the heat.

## Physical Conditions.

It has been found that for high furnace efficiency the velocity of the gases must not be very great. With high velocities the coal is not entirely consumed before the gases leave the furnace and a great deal of its heating value is lost in the outgoing gases, aside from the increased amount of trouble experienced due to the unburned or fused particles of carbon and ash being carried over into the regenerator chamber, causing the checkers to become clogged up after a short time. It must be remembered that it takes a

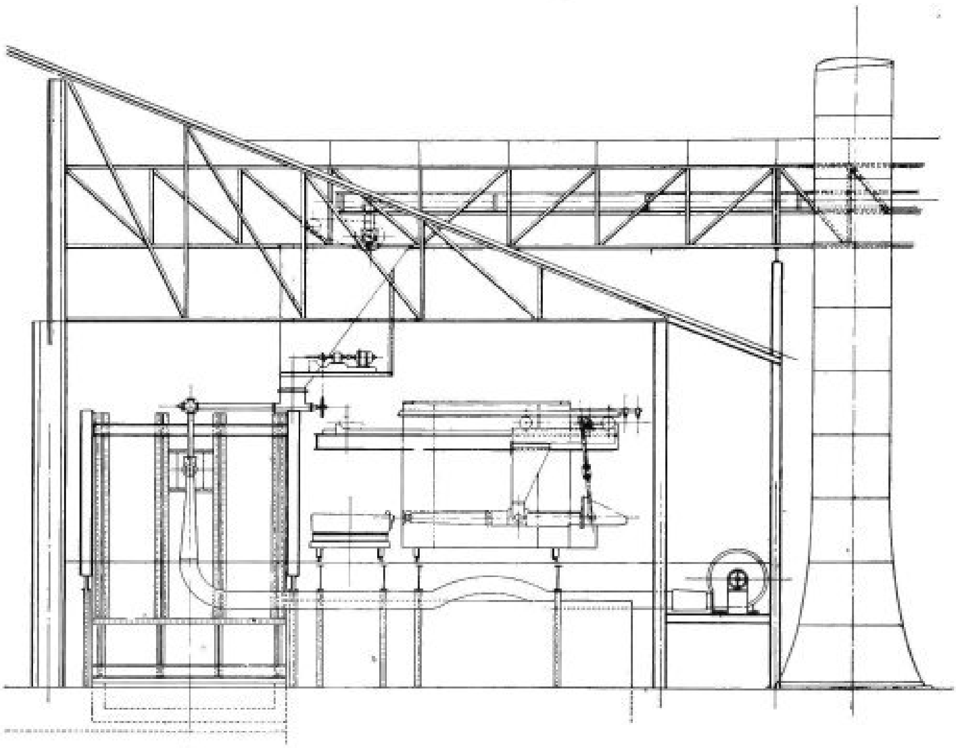


Side View of 50-ton Open Hearth Furnace designed for using powdered coal, showing bins, feeders, and burners. Also showing the simple construction of the furnace.

large amount of air for the complete combustion of one pound of the average coal and that in the open-hearth furnaces there will be approximately seven expansions, which makes the volume of waste gases very great, and in order to travel these gases at a velocity not to exceed 35 feet per second, the furnace and flue areas must be ample in order to travel these gases at that velocity. High velocities are detrimental also to the furnace refractories.

## Checkers.

In order to obtain a maximum number of heats before rebuilding the checker work in the regenerative chambers, it is very essential to provide means for easy cleaning out of these chambers. Another item of great importance is to



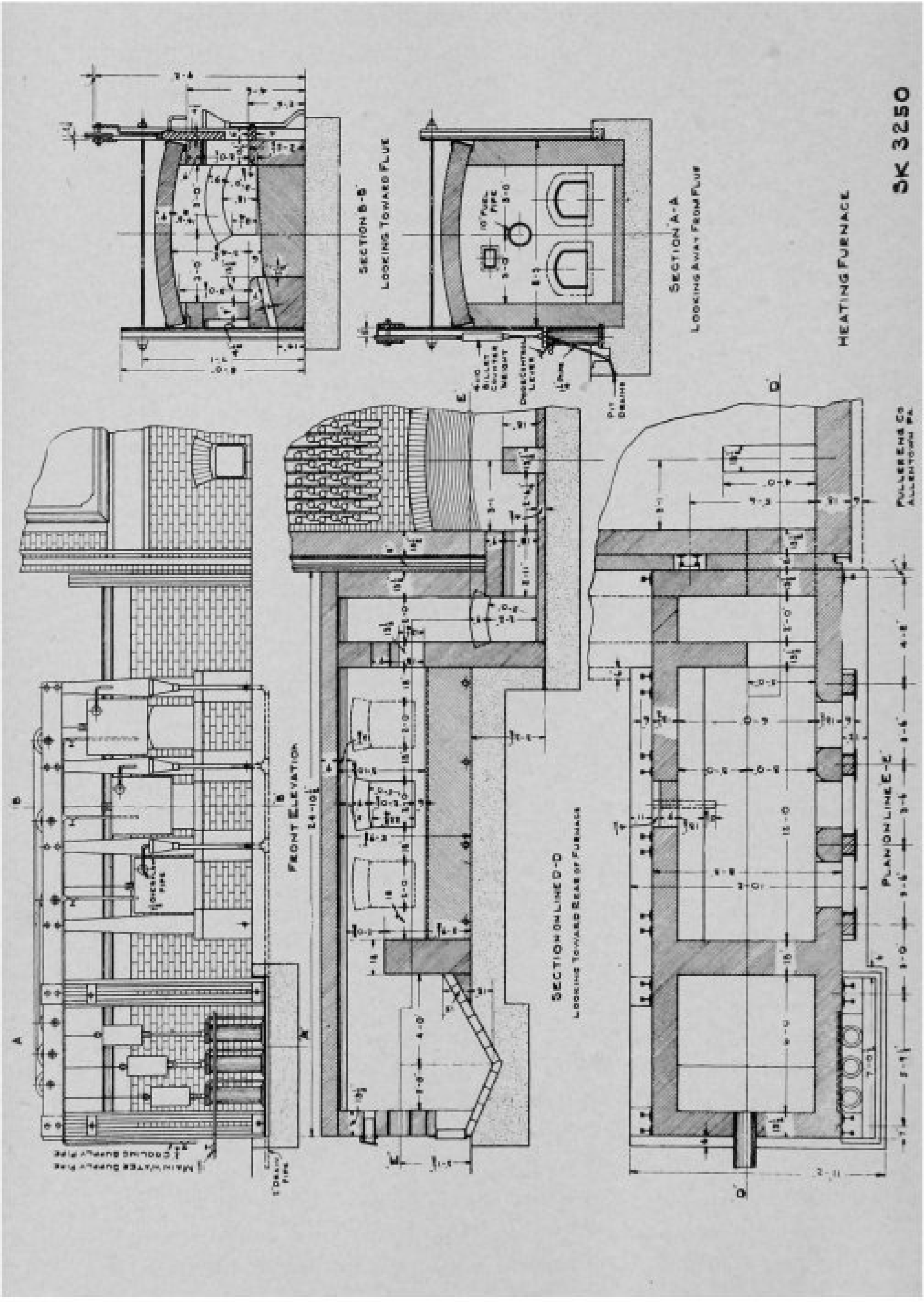
End View of 50-ton Open Hearth showing position of bins, feeder, and air piping to burner.

have a removable slag pocket or its equivalent placed between the furnace and regenerative chambers, so that all of the heavier and fused particles of carbon, ash and slag which may be in the flue gases will be removed before they reach the checker work in the regenerative chambers. This has been accomplished in several plants, and every week-end these slag pockets are removed and new ones put in their place in less than 40 minutes per furnace. It is also well to remember that in designing the slag pockets of a furnace, it is an advantage to give the gases a centrifugal motion on their way to the regenerative chambers, so as to facilitate the removal of the heavier particles which might do considerable harm if allowed to pass on to the regenerative chambers. This provision can be readily installed on most all types of open-hearth furnaces, and where it is not possible to use removable slag pockets some means, which will be nearly as efficient, can be provided for cleaning out this portion of the furnace.

Now, in reference to regenerative chambers, they should be of ample size to afford sufficient surfaces for the gases to come in contact with, on their passage through them, at the same time remembering that with powdered coal as fuel the most satisfactory checker brick to use is a regenerative tile having dimensions of 21″ x 9″ x 3″, these tiles to be laid in such a way as to form a vertical flue having openings of at least 6″ x 9″, or, better, 9″ x 11″.

Another feature is to have these regenerative checkers carried on rider walls at least 24″, better 30″, from the bottom of the chamber, and means provided to run a hoe into these rider walls and rake out any accumulation of dust that will settle out from the gases while passing through the checkers. It has been found that by installing the above ideas in the design of the furnace equipment, it is possible to rake out all of the ash accumulation in rider walls, as same is not fused but merely very fine accumulation of ash. When freshly deposited this ash is very fine and loose, but upon remaining in the rider walls for any length of time it soon absorbs moisture from the incoming air, which causes it to cake and makes it quite hard to completely remove.

In reference to the regenerator tiles themselves, it is good policy to provide means of blowing the accumulation of ash and soot off the top courses between each heat, or at least once a day, thus allowing it to settle through the checker into the rider walls, from where it can be easily removed. It is also advantageous to provide small doors or openings along the side of the regenerator chambers, so




Side Door Heating Furnace using pulverized coal as fuel. A waste heat boiler is used in connection with this furnace that after a run of 150 to 160 heats it will be possible to remove the first one or two courses of regenerator tiles by the use of peel. In this way it is possible without the replacement of these tiles to operate the furnace for another run of the same number of heats, as it has been shown that the deposit is only on the upper course of tile. This can be accomplished in a few hours, thereby keeping the delays in operation at a minimum.

If possible, it is an advantage to allow 90 cubic feet of regenerative chamber per ton of steel per heat, remembering that no gas regenerators are required when using pulverized coal as a fuel for open-hearth furnaces. However, very satisfactory results have been obtained from only 60 cubic feet, but it must be remembered that when you use a large tile as I have spoken of, you do not have as much regenerative surface per unit volume as when a 9″ checker tile is used.

It is important that the slag pockets be constructed in such a way as to take out practically all of the fused and heavier particles which are in the flue gases. In that way the life of the upper course of the checkers is greatly lengthened. It has been found that the nature of this deposit is such that it builds up upon itself very readily, while it does not form a good bond with the checker tile themselves, and when making replacements can be easily knocked off of the tiles, leaving them practically as good as when first installed.

In order to minimize troubles from the checkers clogging up, it is very essential that the furnace gases do not travel at a high velocity, and in this way the velocity is sufficiently low to allow all of the heavier particles to settle out of the gases before they have a chance to do any harm, and will at the same time allow a large percentage of the ash to go out of the stack, facilitating to a great extent the removal of the ash. It must be remembered that the regeneration of air for combustion is not a necessity in obtaining the high temperatures required, but is done for the sake of economy, so that by removing, as stated above, the upper course of the checkers, you may increase your coal consumption per ton of product a few pounds, but to counteract this increased fuel consumption you have an increased number of heats per furnace run, which more than makes up for the time lost in replacing these tiles.

## Description of Plant and Apparatus for Pulverizing Coal.

Referring to figure No. 1, which is a general arrangement drawing of an ideal small pulverized coal plant, it will be seen that the raw coal is received in a track hopper from the bottom of which it is discharged on to a belt of pan conveyor, delivering same either directly to the boot of an elevator or through a pair of crushing rolls, in case run of mine coal is to be used. This elevator raises the coal and discharges it into a bin placed above the feed end of a rotary drier, through which the coal passes while the moisture is being removed, and is discharged from the drier directly into an elevator, which elevates and discharges the dried, crushed coal into a storage bin above the pulverizer mill. From this bin it is fed through a spout into the feed hopper of the pulverizer. The powdered coal is discharged from the pulverizer into an elevator, which elevates it and delivers it into an overhead screw conveyor which delivers the coal to the individual furnace bins.

## Preliminary Preparation of the Coal.

The following stages are required to reduce the coal from lump to the pulverized form:

First—Eliminating the tramp iron from the coal by means of magnetic separators.

Coal as delivered to the milling plant always contains an astonishing amount of tramp iron in the form of bolts, nuts, rivets, nails, bar iron, railroad spikes, mule shoes, etc. Any of these materials entering the crusher or pulverizer might result in damage to the machine, with consequent delays in operation.

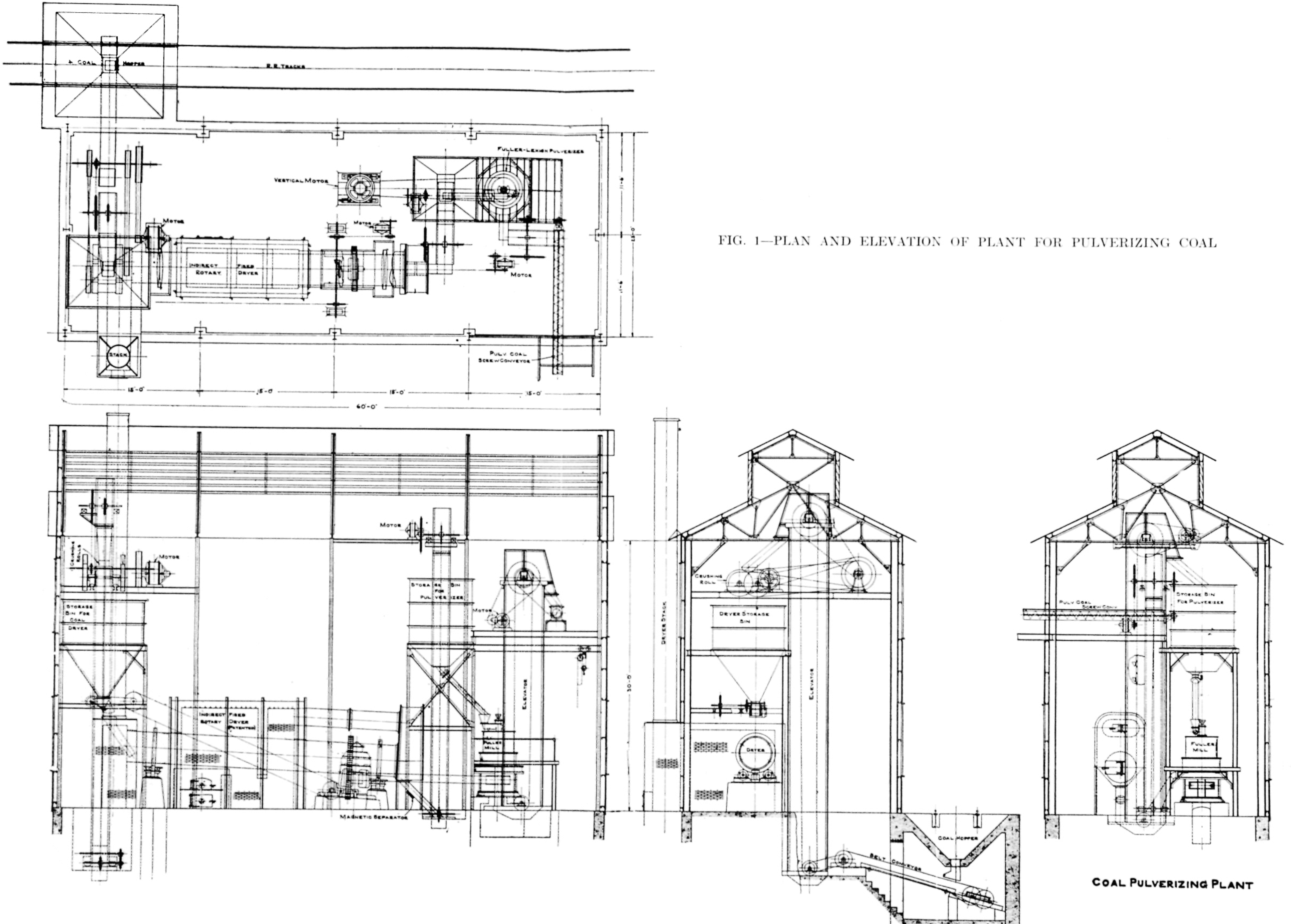
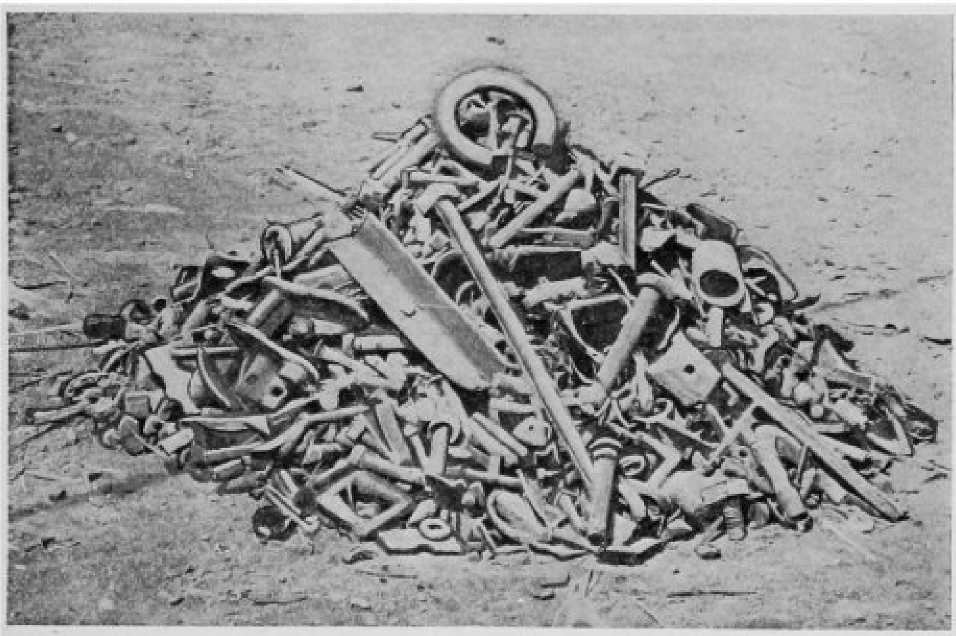



FIG. 1—PLAN AND ELEVATION OF PLANT FOR PULVERIZING COAL

This foreign material can be entirely eliminated by the use of a magnetic separator located at some point ahead of the crusher. Magnetic separators may be either of the stationary lifting type or revolving pulley type. The stationary lifting type of magnetic separator is generally placed in the bottom of a chute through which the material passes.



Iron Caught with 12-inch Cutler-Hammer Lifting Magnet, placed in chute back of coal dryer, face up; i.e., the magnet installed face up in the bottom of the chute, between November 20, 1913, and July 16, 1914. The close view was taken to get a good idea of the kind of iron usually found in coal. The quantity was about one barrel.

Any tramp iron passing through this chute and over the magnetic field is firmly held to the magnetized part of the chute and should be removed periodically by the operator in charge of this equipment. The pulley type of magnetic separator consists of a pulley revolving about a magnet. This pulley serves as a head wheel of the belt conveyor. When the material passes over the above pulley which contains the magnet, the magnetic material, consisting of tramp iron, is attracted and held firmly against the belt and remains in contact with the belt until it leaves the magnetized zone, which is at some point beyond the under side of the magnetic pulley. The tramp iron drops from the belt after it leaves the pulley and is delivered to suitable boxes by means of a chute, the coal continuing on its course.

## Crushing.

The coal as received should be reduced in one operation to a proper size for pulverizing, type of crusher depending upon condition of coal.

A mixed feed containing all of the various particles resulting from reducing the material so that it will pass through a 1″ ring is almost satisfactory feed. For example: When crushing to the 1″ ring size, the run of the crusher will contain 1″, ¾″, ½″, ¼″ and ⅛″ particles together with some dust. This feed when delivered to the pulverizer mill is distributed uniformly in the grinding zone, rendering the grinding elements most efficient and producing the best results.

## Drying.

In order to obtain a product having a high percentage of impalpable powder, coal fed to the pulverizer mill should not contain more than one per cent. of free moisture. Coal should be dried by mechanical means—air drying, either in open or closed storage, will not be satisfactory. Bituminous coal often contains 10–12 per cent. of free moisture when it arrives at the plant in rainy weather, and this moisture must be driven off before going into pulverizer in order to obtain the maximum thermal efficiency from the fuel. One type of drier usually installed in coal milling plants is the indirect fired rotary drier illustrated in figure 2 and figure 2-A and is described as follows:

The indirect fired rotary coal drier consists of an axially inclined cylindrical shell equipped with suitable rollers and gearing to permit the shell being rotated on its longi-

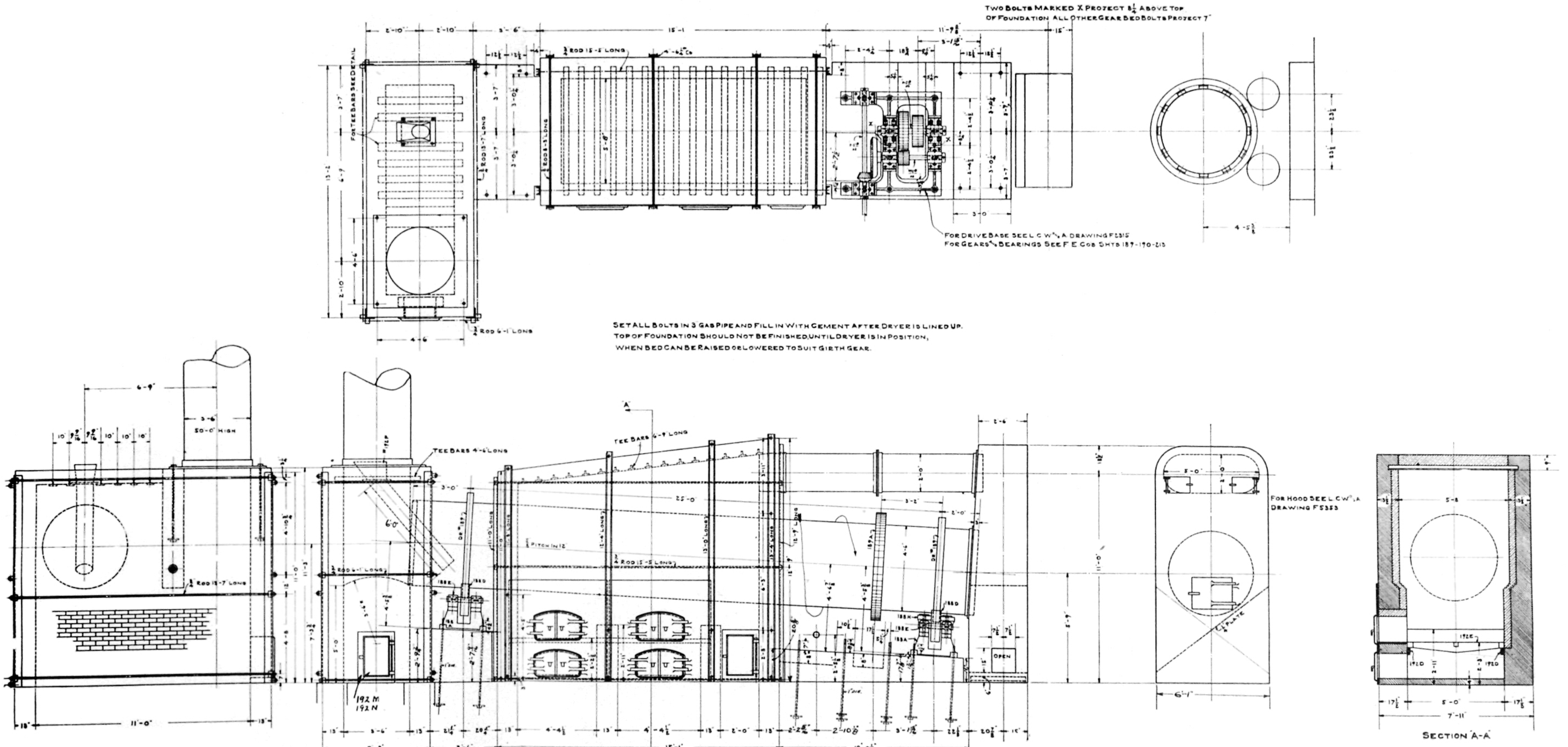



FIG. 2-A—DRAWING OF INDIRECT FIRED ROTARY DRIER

tudinal axis. The higher end of the drier shell terminates in a brick housing, which serves to support the stack which is supplied, to discharge the products of combustion from the furnaces and the vapor given off by the drying of the coal. The lower end of the shell terminates in a steel hood. The furnace for heating the drier is placed between the stack chamber and the hood, with a connection from it into the

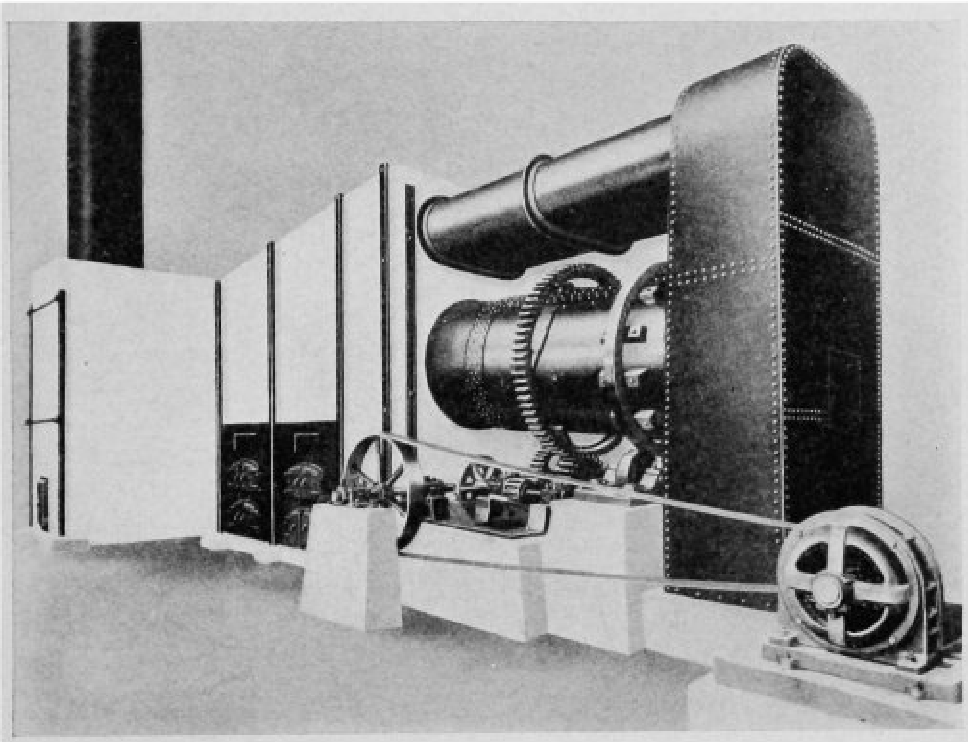


FIG. 2.—Indirect Fired Rotary Coal Drier.

hood. This furnace may be provided with one or two sets of grates, depending upon the size of the drier. The furnace is provided with a large combustion chamber through which the cylindrical shell passes. The entire furnace is built of brick and the walls are securely bound together by means of buck stays and tie rods.

The moist coal is fed into the drying shell by means of a cradle or swinging feeder which can be regulated to discharge a given amount of coal per hour (Fig. 3), through a feed spout located in the stack chamber. This spout enters the drier shell and delivers the coal close to the bottom of the shell. A series of longitudinal shelves fastened to the inside of the shell lifts the coal and drops it through the current

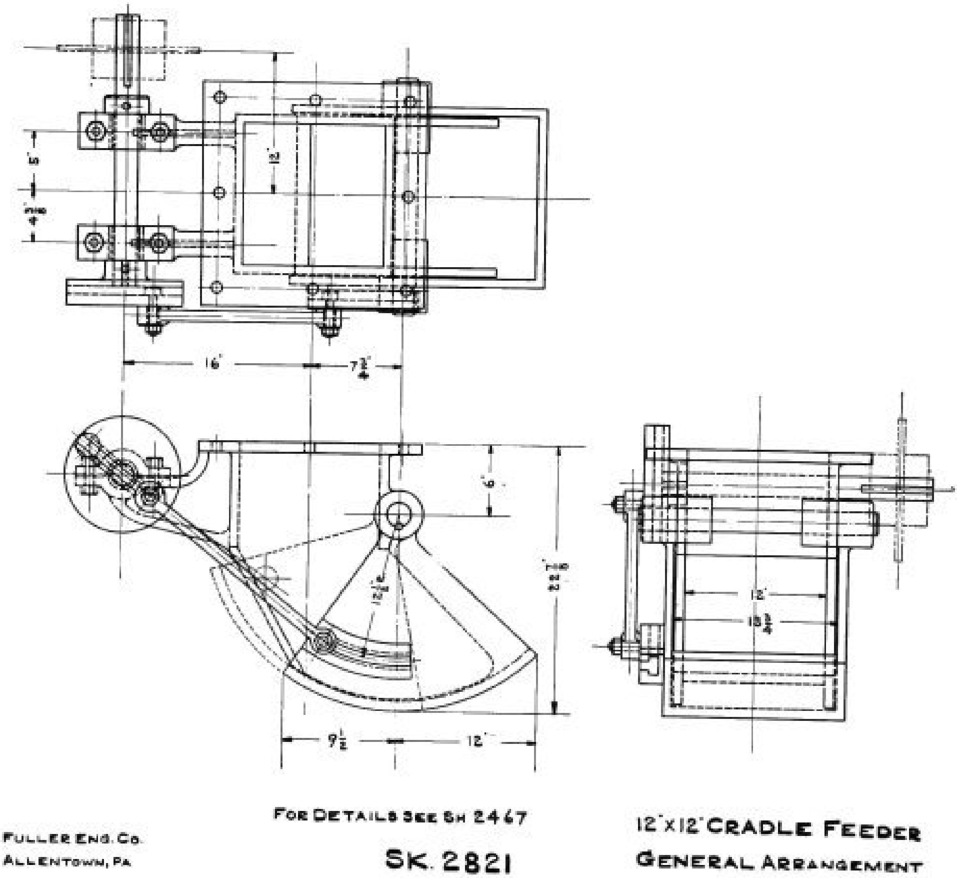



FIG. 3.—General Arrangement of Cradle Feeder.

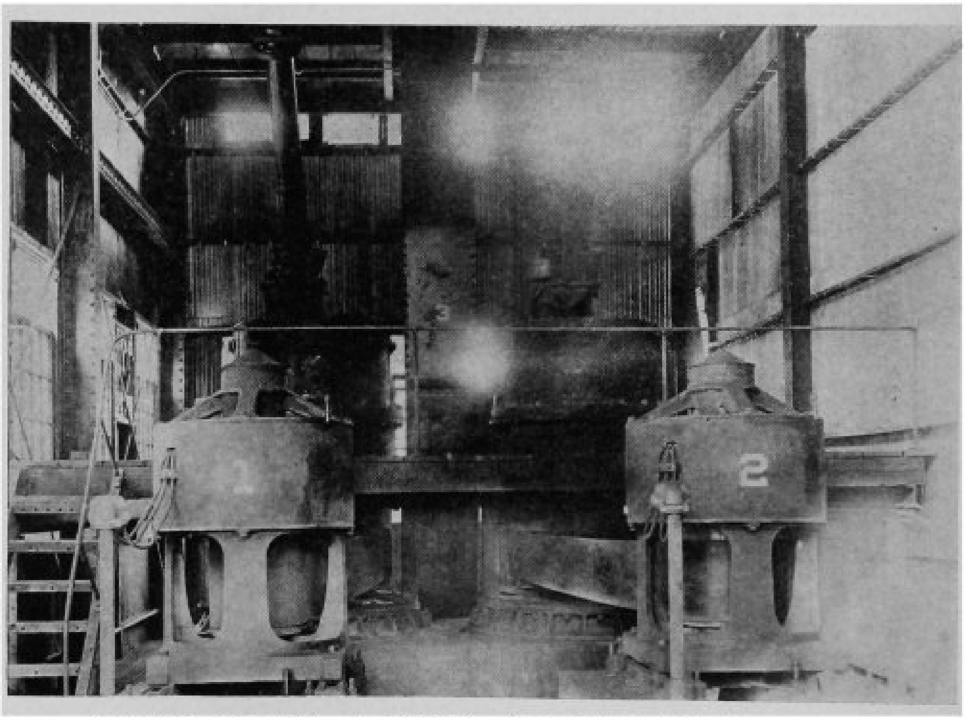
of heated air passing through the inside of the drier shell. As the revolving shell of the drier is slightly inclined, towards the discharge end, the coal travels the entire length of the shell and is finally discharged perfectly dry from the lower end of the drier. The hot gases from the furnace fire circulated freely around the outside of the drier shell, passing through the combustion chamber of the furnace. They then leave the combustion chamber through the horizontal breeching and enter the top of the hood at the lower end of the drier. From this hood the hot gases flow through the interior of the drier shell, removing the moisture which has been driven off from the coal and then escaping to the atmosphere through the stack.

The indirect fired rotary coal drier allows no flame to come in direct contact with the coal being dried, and there is practically no possibility of the coal taking fire during its progress through the drier shell. No fans are used in connection with this type of drier, as the stack draft is sufficient to move the gases at the required velocity.

## Pulverizing.

In order to obtain high efficiency of combustion, powdered coal should be reduced to a fineness so that at least 95 per cent. will pass a sieve of 100 meshes to the linear inch, 85 per cent. passing a sieve of 200 meshes to the linear inch, and at the same time have as much as possible pass a sieve having 300 meshes per linear inch. The greater the degree of fineness, the higher the efficiency of combustion as a gaseous condition is being approached. There are a number of designs of pulverizing machines of merit on the market, such as ball, tube, and roller mills. The major portion of the coal pulverized for fuel purposes is pulverized on a mill of the ball type, which is described as follows:

The material to be reduced is fed to the mill from an overhead bin by means of a feeder mounted on top of the mill. This feeder is driven directly from the mill shaft by means of a belt running on a pair of three-step cones, which permits the operator to regulate the amount of material entering the mill. In addition, the hopper of the feeder is provided with a slide, which permits the operator to increase or decrease the amount of material entering the feeder hopper. The material leaving the feeder enters the pulverizing zone of the mill in such a way as to insure proper and uniform distribution. The pulverizing element consists of four unattached steel balls which roll in a stationary, horizontal, concave-shape grinding ring. The balls are propelled around the grinding ring by means of four pushers attached to four equidistant horizontal arms, forming a portion of the yoke, which is keyed direct to the mill shaft. The material discharged by the feeder falls between the balls and the grinding ring in a uniform and continuous stream, and is reduced to the desired fineness in one operation.




2-42 Fuller-Lehigh Pulverizer Mills driven by Westinghouse Verticle Motors in the coal plant of the M. K. & T. R. R. at Parsons, Kansas.

The fan discharge mills are fitted with two sets of fans. One of these fans operates in the separating chamber immediately above the pulverizing zone, whereas the other fan operates in the fan housing directly below the pulverizing zone. The upper fan lifts the fine particles of pulverized coal from the grinding zone into the chamber above the grinding zone, where these fine particles are held in suspension. The fan in the chamber directly above the grinding zone is composed of two sets of blades. The lower set of fan blades raise the pulverized coal from the grinding zone while the upper set of blades throw the coal tangently against the finishing screen, which completely surrounds the mill at this section. The material after passing through the finishing screen is drawn into lower fan housing, from where it is all discharged through a spout by means of the action of the lower fan. All the material discharged from the mill is finished product and requires no subsequent screening. The operation is such as to keep the screen perfectly clean and thereby allowing the mill to handle material containing a considerable amount of moisture without unduly affecting the efficiency of the machine.

When the mill is in operation, it is continually handling only a limited amount of material at any one time, and inasmuch as the crushing force is being applied to only a limited amount of material, the power required to operate the machine is reduced to a minimum and it is furthermore applied directly to the material being pulverized, the result being that the product will contain a high percentage of impalpable powder.

## Conveying.

There are two systems used for conveying pulverized coal in successful application at the present time. One system conveys coal pneumatically to each furnace. This system consists of a storage bin to the bottom of which is attached a feeding device which feeds coal uniformly into the discharge side of an ordinary pressure blower, the blower supplying air with which the coal is blown through a system of closed pipes with taps taking the coal off and delivering same to the furnace burners. The surplus coal and air which is not required at the furnace is returned into a cyclone collector, which is located over the pulverized coal bin, where the coal is separated from the air and returned to this storage bin, the air being returned in turn to the fan, thereby eliminating loss of coal which might otherwise go into the atmosphere. This system has been used with successful results and finds its best application in plants where a small amount of coal is delivered to a large number of small furnaces. It has several points in its favor, namely, it is economically constructed and the depreciation is very slight.

By the other system and the one which is in practically universal use in plants grinding a considerable amount of the total tonnage of coal pulverized, the coal is delivered to a bin near each furnace by means of screw conveyors in dust-tight, steel troughs. This system has proven to be very positive and economical from both standpoints of power consumed and maintenance of equipment, and is highly efficient. Pulverized coal in large amounts should be handled by means of dustproof elevators and screw conveyors, The coal leaving the pulverizers is light and possesses some of the qualities of the fluid, thereby requiring only a nominal amount of power for its distribution in screw conveyors, due to the ease with which it flows along when slightly agitated.

## Pulverized Coal Bins.

Pulverized coal bins located at each furnace should have a capacity proportional to the service and hold a supply in excess of the amount required during the intervals when the grinding is not going on. Thus the mills may supply in ten hours all that the furnaces may use in twenty-four hours by making provisions therefore. These bins should be so constructed as to be dust-proof and of such a design that no trouble will be experienced from the coal becoming caked or hanging up on its way through the bin to the feeding device.

## Feeders.

It is essential that the feed of the pulverized coal to the burner be under absolute control of the furnace operator and be positive at all times. Too much emphasis cannot be laid upon this point. If the feed of pulverized coal to the burner is not absolutely regular and positive, the efficiency of combustion will be very materially lowered and puffing at the furnace will take place, which, of course, is very undesirable. If the feed is not positive at all times a regularly uniform condition cannot be obtained in the furnace. There are many different types of feeders on the market, each one having its respective good and bad features. It is always desirable to have a feeder as simple in construction and operation as possible, and to use a minimum amount of power in performing its function. A type of feeder which is very widely used and has proven to give excellent results in a large number of installations is illustrated in Figure 4.

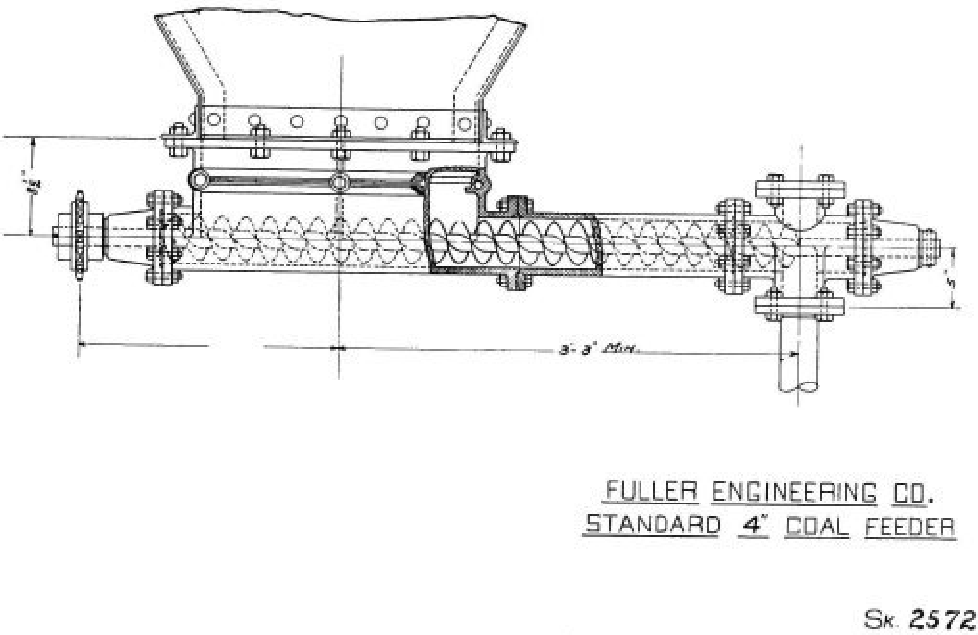



Fig. 4.—Pulverized Coal Feeding Mechanism.

The pulverized coal feeder in Figure 4 is provided with a long screw conveyor mounted in a substantial housing. The coal enters the feeder through a large hopper, which is fastened to the bottom of the storage bin containing the supply of pulverized coal for the furnace. It is very important to have a large hopper, so that at all times the screw conveyor will be surrounded with pulverized coal, thereby insuring a uniform feed.

The feeder hopper is provided with slide gates to permit shutting off the supply of fuel when desired. The housing in which the feeder screw revolves is bored to a neat fit to suit the feeder screw to prevent any flushing of the pulverized coal which might take place if the screw did not closely fit the section of the feeder housing through which it passes.

Pulverized coal is somewhat like a fluid in nature, as stated above, and for that reason it is necessary to provide positive screw feeding devices not merely to feed the coal but to retard the coal and insure a uniform feed. The pulverized coal feeder may be driven by means of a variable speed motor or by means of variable speed transmission. The power required to operate the feeder screw is nominal, a 1½ H.P. motor furnishes sufficient power to drive a 5″ feeder which has a capacity of 2,600 pounds of pulverized coal per hour when operated at 60 R.P.M.

## Burners.

The same as said of feeders may be said of pulverized coal burners—there are many different kinds of burners in use in various plants and, in fact, nearly every different plant uses a burner different from others in some features of design. Several types of pulverized coal burners have been found to give very good results under different conditions. The nature of the furnace to which the pulverized coal is to be applied determines the type of burner best suitable for it. Figure 5 shows a pulverized coal burner from which excellent results have been obtained.

It will be noted that the pulverized coal is discharged from the feeding device into pipe "A" which drops the coal into the burner. Air from a fan at a few ounces pressure enters from the pipe "B" and produces an injector action which draws the coal and air into the burner through the opening "C." It also induces air at "D" the amount of which is controlled by a cone fitted over the air pipe and arranged so it can be moved back and forth, controlling the amount of air admitted. The coal mixed with the air passes into the furnace as shown on the drawing. Any additional air required for combustion is induced at the point

"E" and such air is controlled by a sliding cone similar to the one at the point "D." This burner is very efficient in its operation and required less air from the fan than is the case with most burners. The burner above described is adopted for use on heating, puddling and boiler furnaces.

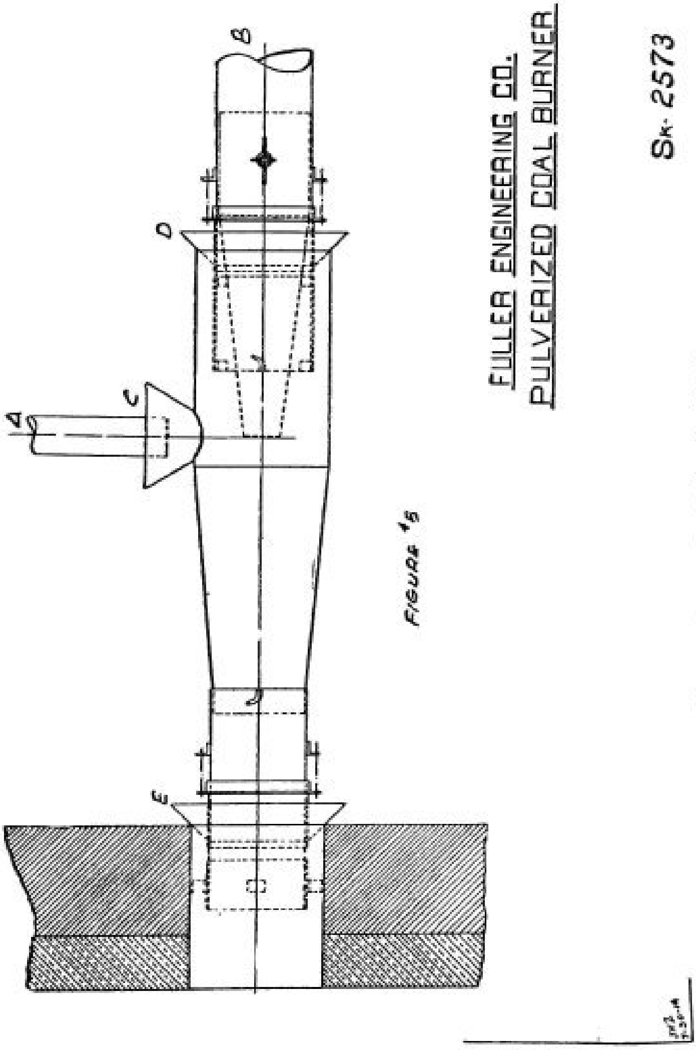



FIG. 5.—Burner for Pulverized Coal.

A burner which is being successfully used for firing open-hearth furnaces is shown in Fig. 6. It will be seen that pulverized coal enters this burner in much the same way as it entered the burner previously described.

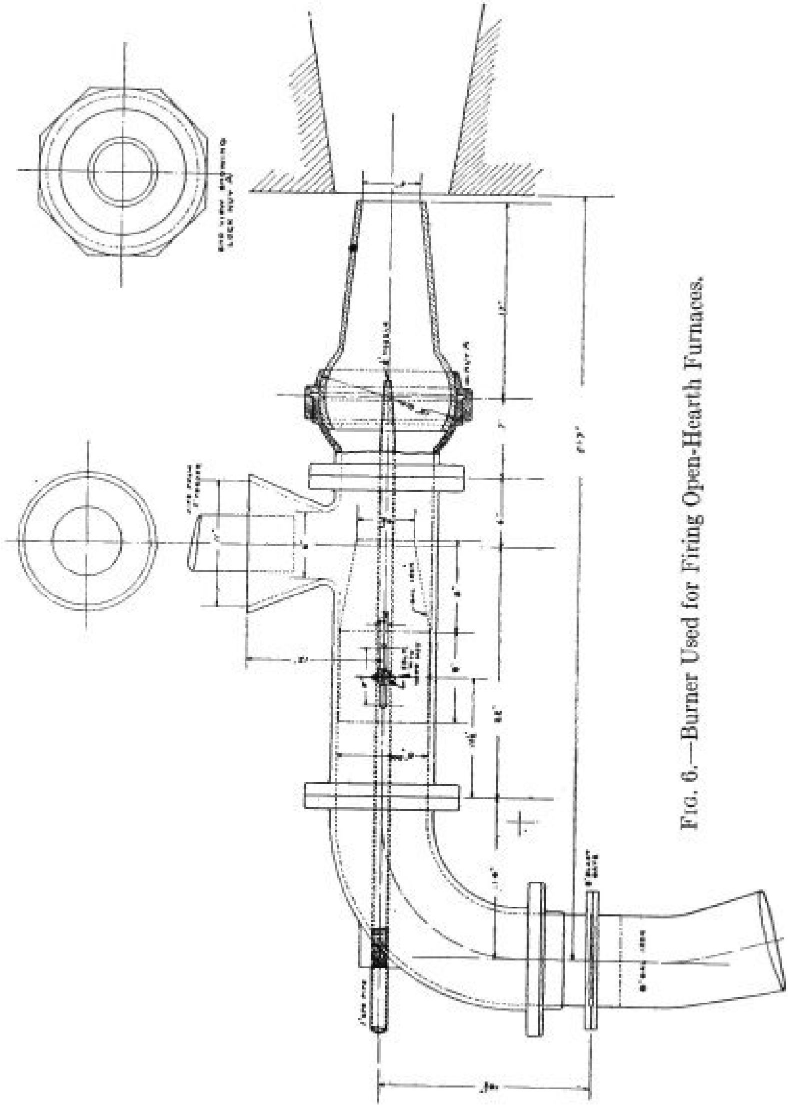


Fig. 6.—Burner Used for Firing Open-Hearth Furnaces.

The volume air, which is between 20 and 30 per cent. of air required for combustion, is supplied from a fan and is controlled by a blast gate inserted in the line as will be noted. This air carries the coal into the furnace. In the nozzle of this burner is inserted a jet of compressed air which serves not to increase the velocity of the coal and air entering the furnace but merely to properly mix the coal and air so that each individual particle of coal is independently suspended in air. When these conditions exist, the proper amount of air for combustion, of which between 70 and 80 per cent. is supplied through the regenerator or recuperator of the furnaces, can instantly surround each particle of coal thereby producing ideal conditions for immediate and complete combustion of the coal. It will be noted that this burner is supplied with a nozzle which is flexible so that the flame can be directed to any part of the furnace desired. This burner is generally used in connection with open-hearth and other types of melting furnaces. This is due to the fact that the nature of the flame can be made less oxidizing and can be directed upon any piece of material in the furnace to be melted. The length of the flame can be controlled to a great extent by varying the two different pressures of air. This is a considerable advantage in the rapid melting of an open-hearth charge, with less oxidation losses, than would normally occur under the same conditions with most other fuels.

In conclusion, in view of the foregoing, I am of the opinion that pulverized coal will be very extensively used in the future as a fuel for metallurgical furnaces. (Applause.)

THE PRESIDENT: Discussion by Mr. N. C. Harrison, of the Atlanta Steel Company, Atlanta, Georgia.

# PULVERIZED COAL AS A FUEL FOR METALLURGICAL FURNACES

DISCUSSION BY NAT. C. HARRISON

General Superintendent, Atlantic Steel Company, Atlanta, Georgia.

Colonel Fuller's paper, as just read, is very good, and covers the use of the fuel very thoroughly, and from my experience with pulverized coal on a 50-ton Basic Open-Hearth furnace, I believe most of his statements are correct.

Some of the essential features for the successful operation of this fuel are as follows:

First: Coal must contain 32 per cent. or above of volatile matter, and preferably below 8 per cent. of ash.

Second: Fine pulverization of coal is necessary to eliminate the sulphur element in coal and to secure complete combustion before reaching the bath.

Third: A regular uniform feed of coal to the furnace is necessary in order to secure most efficient and economical heat results.

Fourth: Proper design of burners using both volume and high pressure air are necessary, and also proper design and location of bins. These bins should be so constructed that the coal in same will not arch and should be located far enough away from the heat to prevent coking.

The question of properly designed checkers and slag pockets is also of vital importance as the tendency for an open-hearth furnace using pulverized coal is for the checkers and slag pockets to fill up with ash, iron and silica oxide much quicker than a producer gas furnace. To handle this accumulation the furnace should undoubtedly be designed with removable slag pockets and blowers for the checkers.

We have in our plant three open-hearth furnaces making 50 tons per heat, using all cold stock. Two of these are producer gas fired and the other fired with pulverized coal. This last furnace was built in December, 1915. As regards the fuel consumption on these two classes of furnaces, we find that the pulverized coal furnace uses from 100 to 150 pounds of coal less than the producer gas furnace per ton of ingots produced.

As regards the life of the furnace refractories and quality of steel produced, we notice no appreciable difference between the two classes of furnaces, although the increase of production by the use of powdered coal over producer gas is very marked. The average time of heats being cut down from one and one-half to two hours. We have made 50-ton heats of 10 to 15 carbon steel in our pulverized coal furnace in little over seven hours, and have averaged over several weeks' run approximately eight hours.

I do not believe the cost of an open-hearth furnace installation, using pulverized coal on one furnace only, is any cheaper than a producer-gas furnace, but where a number of furnaces (at least three) are involved, the powdered coal installation is undoubtedly cheaper than the producer gas, due to the central coal pulverizing building, which can be built at approximately the same cost for three furnaces as for one, being much cheaper than the gas producers.

I consider pulverized coal about the best fuel on the market for open-hearth furnaces. (Applause.)

Vice-President King: A discussion of this paper by Mr. W. E. Snyder, of Pittsburgh, will be inserted in the record by the Secretary and it will appear in the Year Book.

# PULVERIZED COAL AS A FUEL FOR METALLURGICAL FURNACES

DISCUSSION BY W. E. SNYDER

Chief Mechanical Engineer, American Steel and Wire Company, Pittsburgh, Pa.

Colonel Fuller's paper gives a very good and complete description of the preparation, distribution and burning of pulverized coal. I agree with the main principles discussed therein, but I am inclined to think that the part relating to the checker work in open hearth furnaces and ash removal partakes somewhat of the nature of faith as defined by St. Paul, being "the substance of things hoped for and the evidence of things not yet seen." In a brief discussion of this paper, only the main points which it includes or suggests, can be touched upon.

Coal in pulverized form is an attractive fuel for a number of reasons. If its application in steel works eventually becomes as well standardized as it is now in cement works, the results will be of great importance to the steel industry, and in the more general problem of the conservation of fuel. For these reasons, I would bespeak a square deal for pulverized coal when it is first tried. If not applied properly, pulverized coal will be condemned, not because there is anything essentially wrong with the fuel itself, but because the principles of its use are not fully understood or followed. Installations have been made, the success of which would be little less than miraculous, as important and fundamental principles were wholly disregarded in their design.

The paper enumerates what I believe are essentials for success, which I may summarize and extend somewhat as follows:

1. Proper preparation of the coal; thorough pulverizing, using the results from a 100 mesh screen as that of the coarse limit, and insisting on at least 70 per cent. through a 300 mesh sieve—the finer the coal, the more favorable is its

condition for rapid and complete combustion. It approaches a gaseous form. Fine pulverizing means also proper crushing and complete drying.

2. Proper distribution of the pulverized coal. The essential features are, safety, reliability and convenience of operation. Some objections have been made to conveying with air, on the ground that an explosive mixture is present in the pipes, which may, under certain conditions of circumstances, be ignited. This system of conveying coal is simple and convenient, and it is probable that its increased use will so improve the details, as to eliminate any features that are not entirely safe. No serious objections can be urged against the use of elevators and spiral conveyors. The service is not severe, and the upkeep should not be expensive. This kind of equipment and the storage bins at the furnaces should be put in after careful analysis of the operating conditions, so as to provide for the convenience of the operating men who have to look after the plant. All parts must be accessible; bins arranged so that it is possible to tell when they are full, and so that the flow of coal can be readily switched from one bin to another, etc.

3. Proper provision for burning. This includes a regulable supply of coal and air which will remain approximately constant for any conditions decided upon; sufficient air, either from fan, induction, or stack draft, to burn the coal; heated air if possible, not so much to recover the heat contained in the air, as to promote rapid and complete combustion.

4. Provision for cleaning checkers and flues. The above points are comprehensively discussed in the paper, and I believe there has been enough demonstrated in practice to speak with certainty. However, with regard to construction of checkers, keeping flues clean, etc., I may be allowed to say with Mr. R. Burns that "I ha' me doots." This part of the process will require more experience before any standard practice is evolved, but there ought not to be any problem here impossible to solve. With powdered coal now used for heating steel to rolling temperature, for puddling furnaces, and for smelting in open hearth furnaces,

it ought to be possible to devise means for taking care of the ash, in the powdered form or as slag, with a minimum of interruption, and of maintenance cost. The solution of this ash problem requires time and experience.

Another essential requirement mentioned in the paper, is that of the proper velocity of gas in furnaces and flues. This is a matter that has not received much attention in this country, though the Germans have studied and written considerable about this phase of furnace design. We have been too easily satisfied, and either copy a blue print of some other furnace, or else adopt the rule used by a famous engineer in designing fly wheels—"figure it out, double it and add some." The velocity of gas and air, and its relation to combustion and heat transfer are points on which there is still much to be learned by research, but enough is known to show that these velocities are, as explained in the paper, of real importance and must receive consideration when determining dimensions of all passages for air and gas.

Another important point that is not very fully brought out in the paper, is that of capacities of the respective parts in the installation. The operating conditions ought to be analysed far enough, to proportion the capacity of the different bins and that of the conveying equipment, in such a way that the cost of labor for attendance will be kept low. Generally speaking, it will be of advantage to unload coal from cars faster than it can be dried; to dry faster than it can be pulverized, and pulverize faster than it can be burned. This insures reliability of operation, opportunity for repairing machinery, a minimum working force and a good reserve stock of coal in the bins to provide against delay in switching, etc.

Another side of this matter not fully discussed in the paper, is the business side. It is possible to pulverize a ton of coal and deliver it to the furnaces, for less money than it can be converted into gas in gas producers and delivered to the furnaces. The combustion of the coal within the chamber where the heat is required, is certainly favorable to high thermal efficiency, which means lower coal per ton of product. With lower cost of preparation and delivery of the fuel to the burners and most favorable conditions for using the fuel, the result should be a lower heating cost than with producer gas. I am aware that product per turn or per heat, cost of repairs to furnace, etc., must also be considered in such a comparison before final conclusions can be drawn. Here again, more experience is required with pulverized fuel, as there is not enough information now available on these points. When comparing with producer gas, the results thus obtained, must be compared with other plants also using producer gas before they can be used as a standard, or the comparison is misleading. I have seen plants where the saving due to using pulverized coal, as compared to results with producer gas at the same plants, is very large, but this was due to the fact that the producer gas results were poor; part of the saving could have been affected by improving producer gas results, without the use of pulverized fuel.

Considering the whole subject as covered by the paper, I believe the problems connected with the preparation and burning of the coal in powdered form in metallurgical furnaces, are more completely solved than those relating to furnace and flue design for this fuel; to the application of heat in the furnace; to the best method of handling the resulting ash, etc. Such papers as Colonel Fuller's, with the resulting discussion, are of material benefit in the working out of all problems having to do with this most efficient method of using coal.

VICE-PRESIDENT: The next discussion of this paper will be by J. P. Kittredge, of the National Malleable Castings Company, Sharon, Pennsylvania. In the absence of Mr. Kittredge, the discussion will be read by the Secretary.

# PULVERIZED COAL AS A FUEL FOR METALLURGICAL FURNACES

## Discussion by Joseph P. Kittredge

Manager, The National Malleable Castings Company, Sharon, Pa.

The subject of Mr. Fuller's paper covers such a broad scope in dealing with metallurgical furnaces that the writer, in offering his discussion, will confine his statements to open-hearth furnace installations, as the application of pulverized coal to that type of metallurgical furnace seems to offer the most difficult problems and, in turn, the most interesting study to the engineer and furnaceman.

The following observations are taken from the experience of a plant which started the application of pulverized coal to a basic open-hearth furnace, about four years ago.

The first experimental heats were made successfully. The all-important information, as to whether or not the siliceous ash would deposit on the basic slag, was determined by taking frequent tests of the slag during the progress of the heat and comparing them with tests taken in a similar way from the slag of a furnace using oil as a fuel. It was found the ash had little, if any, influence, indicating that it was not being deposited on the slag in any great quantities.

With this point settled and the conclusion reached that high temperature and rapid time could be obtained, the permanent equipment was installed for four thirty-ton furnaces and has been in uninterrupted service ever since. The equipment was further extended to serve three smaller open-hearth furnaces in another part of the plant. The entire open-hearth capacity of the plant is now being operated with pulverized coal as a fuel and approximately six thousand heats have been made to date.

This is cited to illustrate that at the plant referred to the use of pulverized fuel for open-hearth furnaces has passed the experimental stage and has started on the next cycle, which is the slow but gradual development of any new practice.

## Time of Making Heats.

The time required to make heats is largely dependent upon furnace design, but there has been no difficulty in making heats with pulverized coal in the same time that they could be made with fuel oil in practically the same open-hearth furnace.

## Oxidation.

Mr. Fuller has emphasized the matter of decreased oxidation, due to the pulverized coal fuel. I regret we have not been able as yet to determine definitely and to our complete satisfaction that such is the case, because of the many variables which enter into melting cold charges, *i. e.*, the nature and analysis of the scrap used, the time the heat is in the furnace, and the condition of the slag. Taken all in all, we can safely say that the oxidation is not greater than with fuel oil or producer-gas practice.

## Ash.

The large quantity of ash with which we must contend offers by far the greatest problem to solve. Let us reason that with a comparatively small furnace, burning one ton of coal per hour, four to ten per cent. of such coal is non-combustible. To attempt to pocket or catch all this ash in the checkers would mean an unreasonably short life of the checker chambers before clogging. This readily leads us to conclude that a means of passing as large a percentage of the ash as possible through the checkers, and thence out of the stack, is the most logical course to follow. To reach this result it is also reasonable to assume that the effluent gases containing the ash should travel at a comparatively high velocity and with as few changes of direction as possible. Where the change of direction is unavoidable such places should be accessible, so that the deposited ash may be artificially agitated, causing it to be picked up by the draft and carried to the stack. It is quite important that no passageway for the effluent gases through the checkers be allowed to become clogged, as that immediately tends to increase the deposit at such a point.

### Slag.

The slag collected in the pockets of the pulverized coal furnace is considerably greater than that of the oil or producer-gas type, and it is important that arrangements be made to facilitate its removal by means of slag cars or otherwise. It should be the aim of the engineer, in designing the equipment, to make the reversing operation, slag removals, and all duties required of the furnacemen and helpers, as free from arduous labor as possible, as the enthusiastic co-operation of the furnacemen is, of course, essential to success.

In conclusion, we have found the results obtained from the use of pulverized coal furnaces have been very gratifying, in regard to economies obtained, and expect to see wide development in the application of this fuel to metallurgical furnaces.

Vice-President King: I find that Mr. James of the Lackawana Steel Company, who was to read the next paper, has been unavoidably detained, but Mr. McCleary will read his paper also.

# PULVERIZED COAL AS A FUEL FOR METALLURGICAL FURNACES


## Discussion by William A. James

Chief Engineer, Lackawanna Steel Company, Buffalo, New York.


Our experience in connection with powdered fuel has been almost entirely along the line of firing rotary lime and calcining kilns.

Several years ago, however, some attempts were made by us to burn powdered coal under a horizontal water-tube boiler. The coal tried out was rather low in volatile and high in sulphur, and in addition to these objections the pulverizing was not well done and the coal not thoroughly dried. However, we were able to burn this coal under the boiler, though we did not continue the experiments far enough to call it a commercial success.

With reference to our Calcining Equipment, which was furnished by the Fuller Engineering Company, I wish to say that we have three 125-foot kilns, 8 feet in diameter throughout.

The coal used is our regular coking mixture, which is dried by a rotary dryer, pulverized by a Fuller-Lehigh Mill, then conveyed to the bins from which it is fed by screw conveyors to the blast pipes, thence to the kiln burners in the regular way.

We are using about 1,400 gross tons of coal per month, and estimate the cost of pulverizing and conveying to burners to be about fifty cents per ton.

In the selection and preparation of powdered coal, there are a few points that should be noted:

First.—For most practices the coal should not be less than 30 per cent. in volatile and must be low in sulphur.

Second.—It should be thoroughly dried in order to pulverize well and prevent the lowering of temperature in the combustion chamber, which it is estimated will be reduced about 70 degrees F. for each per cent. of moisture in the coal.

Third.—The degree of pulverizing is very important in order to effect the most intimate mixture of coal and air. Ninety-five per cent. should pass through a 100-mesh test screen, and 80 to 85 per cent. through a 200-mesh screen.

In connection with the delivery of coal to the furnace this should be under control at all times to produce the desired results.

Bin capacity should be sufficient to take care of shut-downs during the ordinary repairs to machinery, but care should be taken not to store large quantities of pulverized coal because of the danger of heating and causing spontaneous combustion. This condition is more apt to occur if the coal is not thoroughly dried.

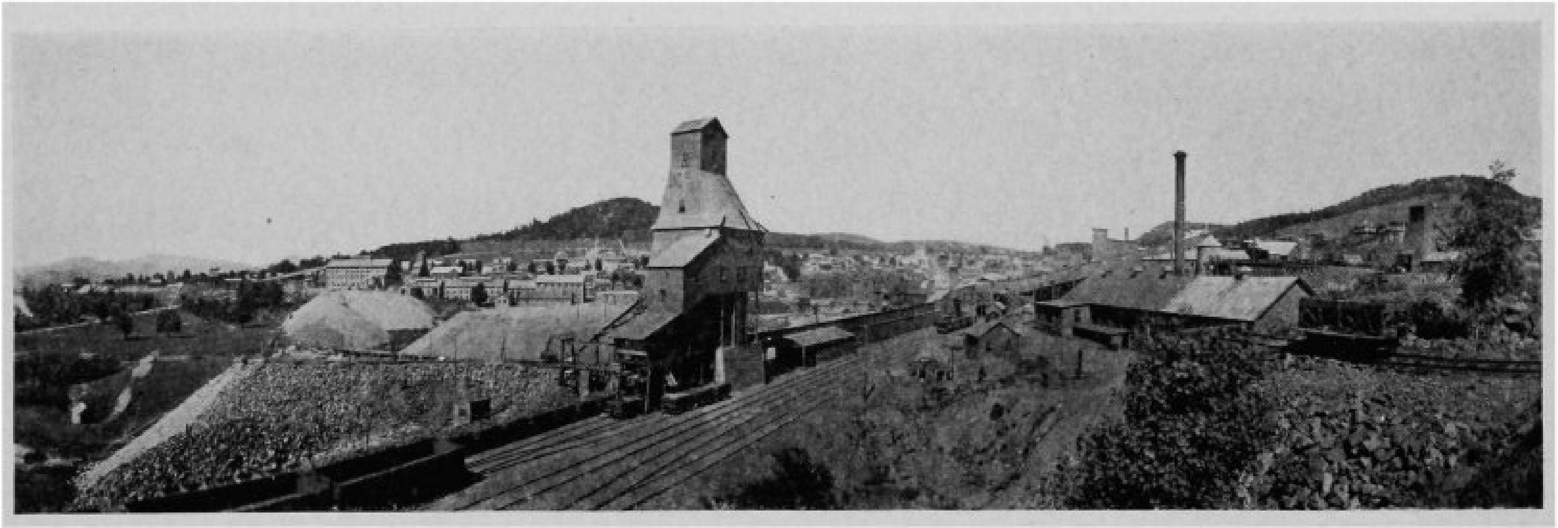
One feature that is now being given consideration is the design of furnaces and combustion chambers to take care of the conditions required for the burning of powdered coal. Due to the rapid combustion and great heat produced, large volumes of gas must be provided for, and especially is this the case since velocities must be kept down to the minimum. The best results can be obtained with high temperatures, as these are required to properly burn the small carbon particles remaining after the rapid driving off of the volatile content.

Some of the advantages that have been enumerated by the burning of powdered coal are: Heating is continuous and uniform, and combustion is complete. The heat can be directed where most needed, and the furnaces are practically smokeless.

In addition to these very desirable features of operation is the fact that considerable saving in fuel has been shown over both the direct firing of coal on grates and the gas-producer practice.

As the methods of preparing and burning pulverized fuel are becoming more familiar, it is being applied more generally.

VICE-PRESIDENT KING: The next paper is "The Iron Ores of the Adirondack Region," by Mr. Frank S. Witherbee, President, Witherbee, Sherman & Co., New York. I understand Mr. Witherbee is not here but Mr. L. W. Francis, Secretary of the Company, will read the paper.



PANORAMIC VIEW OF MINEVILLE, N. Y., WEST END

Showing type of steel shaft house, with Mill No. 3 and shops at left, and the village of Witherbee in the middle background

# THE IRON ORES OF THE ADIRONDACK REGION

Frank S. Witherbee

President, Witherbee, Sherman & Company, Port Henry, N. Y.

Major Philip Skene, of Skenesborough, now known as Whitehall, N. Y., is probably the first man who mined iron ore in the Adirondack Iron Ore District.

He received, before the Revolutionary War, a grant of about six hundred acres from the English Crown, located just north of Port Henry, on Lake Champlain, known as the Skene Ore-Bed Tract. He built a small Catalan forge at Skenesborough, and a fairly well authenticated tradition exists that ore was mined from this tract and shipped to Skenesborough, where anchors, chains, spikes and other needed appurtenances were made to fit out Benedict Arnold's fleet.

No other development in this district is known to have taken place until about 1800, when the Cheever Mine, located in the Skene Tract, and the Arnold Hill Mine in Clinton County, began to be worked in a primitive way to supply a few Catalan forges in the vicinity. But it was not until the completion of the Champlain Canal, which connected Lake Champlain with the Hudson River at Troy, that the real development of the district commenced. With this outlet established, many new Catalan forges were built, and the first charcoal blast furnace was completed at Port Henry about 1822. This furnace was supposed to be the best thus far built. It produced about twenty-five tons of pig iron weekly. Perhaps nothing in the metallurgy of iron and steel is more impressive than a comparison of the output of a modern blast furnace with the one to which I refer. Ten additional blast furnaces were afterward built in the district, chiefly in the vicinity of Port Henry, while rolling mills, nail factories, etc., were established chiefly in the Ausable Valley district.

Iron ore was shipped to outside furnaces, and it is an interesting historical fact that Lake Champlain ores were introduced into the Pittsburgh district before Lake Superior ores were delivered there. Pittsburgh also became the largest market for the charcoal billets and blooms made in the district. From 1860 to 1870, the iron industry of the district was at its height, but soon after this period the new Bessemer and Open Hearth processes of producing steel commenced to displace the crude and wasteful method of the Catalan forge, and the little charcoal blast furnaces gave way to the larger stacks which used first anthracite coal and finally coke. The small and lean deposits of ore could not compete with the newly discovered and cheaper mined Gogebic and Mesaba ores of Lake Superior, but the larger deposits and more cheaply mined ores have survived this competition, and there is more ore mined in the district to-day than ever before.

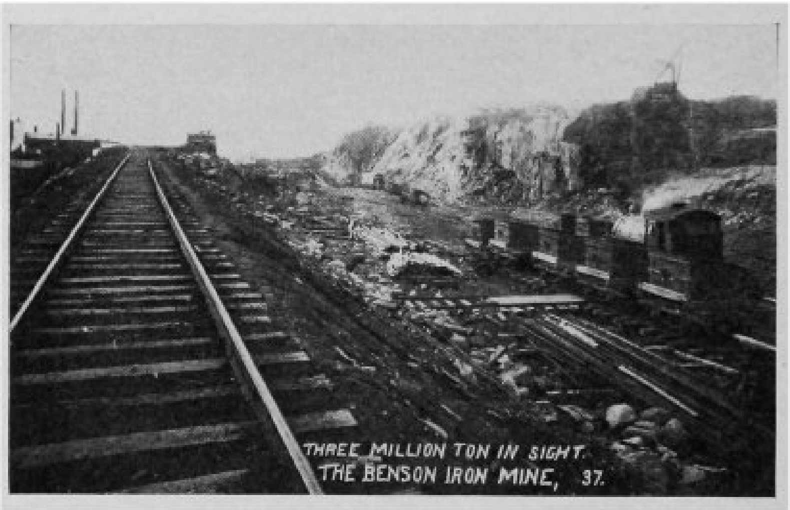
To the credit of the Adirondack district, it can be said that it has always been progressive, as is shown by the fact that the use of electric lights underground and the substitution of dynamite for black powder were first introduced there; and probably nowhere in the country to-day has electrical power for mining been more generally used than in the completely equipped plants of the Port Henry district. The ores are undoubtedly the richest and of the highest grade shipped from any district, being guaranteed from 60 per cent. iron in the crude to 65 per cent. in the concentrates, and in one special grade a guarantee is given of 71 per cent. Throughout this paper the iron content given refers to the ore dried at 212 Fahrenheit. As a rule, magnetites carry less than half of one per cent. of moisture. The phosphorus content of the different ores runs from .005 per cent. to 1.50 per cent., although probably 60 per cent. of the known deposits are well within the Bessemer limit.

It is an interesting fact that in the Barton Hill Mine of Witherbee, Sherman & Company, there was at one time an enrichment of a vein from which over 60,000 tons of crude ore were mined, with only three analyses running below 70 per cent. in iron. This is probably the richest shipment ever made from any deposit in this country.

In the Adirondack region to-day two blast furnace plants are operating, one at Standish, where an exceedingly low phosphorus special Bessemer iron is made from Chateaugay ores, and another at Port Henry, where all grades of iron are produced, including special Bessemer, forge, foundry and basic. The special Bessemer irons frequently carry phosphorus as low as .02 per cent., and are regularly sold on a guaranty of not to exceed .03 per cent. phosphorus and sulphur. Local magnetic ores are used exclusively in both furnaces, and the fuel records from the rich all-magnetic ore mixture compare most favorably with the best practice of the central west. The Adirondack region is not the ideal one, however, for the manufacture of iron, owing to the very high freights on fuel and the distance from active pig iron markets.

For the geological data and estimates of ore reserves contained in this paper I am largely indebted to Mr. Frank L. Nason, Geologist and Mining Engineer, whose former association with the Geological Surveys of the States of New York and New Jersey, together with frequent and extended examinations of the region, have afforded him ample opportunity for observation and study, and he is undoubtedly the highest authority on the magnetic iron ore deposits of the east.

The Adirondack iron ore field covers the entire Adirondack Mountain system. It lies in the northeastern part of New York in the angle formed by the St. Lawrence River on the north and by Lake Champlain on the east. Its entire area is about 10,000 square miles. Roughly outlined as a square, the distance from north to south is one hundred miles, from Malone to Old Forge, and from east to west about the same distance, from Port Henry to west of Benson Mines. Large areas of this square are covered with barren paleozoic rocks. The core of the mountain is almost wholly gabbro and norite. The productive area on the Lake Champlain side can be approximately divided into two districts, the Clinton County with a northwest diagonal from the Cook Mine to Lyon Mountain, a distance of about 30 miles, with a breadth of about 10 miles from Black Brook to the Beattie Mines. This area thus covers about 300 square miles. The Clinton County belt is divided from the Essex County belt by a broad, irregular tongue of gabbro, which reaches east from the central gabbro core of the Adirondacks to Lake Champlain along the Boquet River. The north and south axis of the Essex County belt extends from north of Port Henry to south of Crown Point—about 20 miles. The east and west axis, from Port Henry to west of Mineville is not less than 10 miles. The parallelogram covers thus about 200 square miles.




The gneisses and white limestones extend from Hammondville as far south as Whitehall and then west to near Old Forge. With the exception of a few mines from which a few thousand tons of shipping ore have been taken, this field so far as is now known is barren.

On the west slope of the Adirondacks is the great Benson Mine. This lies in the white limestone series. With the exception of the Clifton ore body which lies in the same formation, no other deposits are known. The white limestone series, however, run far north and south. The country is wild and broken and is wholly lacking in transportation facilities. It is probable, therefore, that this belt, which covers a territory of 600 to 1,000 square miles, contains other deposits of iron. But it is unlikely that other deposits comparable in surface exposure exist, otherwise they would have been reported.

Thirty-six years ago, when Magnetite ore was about 35 per cent. of the total iron ore production of the United States, the Cheever Iron Ore Company at Port Henry, Witherbee, Sherman & Company and the Port Henry Iron Ore Company at Mineville, Palmer Hill and Lyon Mountain in Clinton County, produced about 66 per cent. of the Magnetite. The remaining 34 per cent. came mainly from Pennsylvania, New Jersey and southeast New York. To-day the production of magnetic iron ore comes mainly from the Adirondack region. Two mining districts, Mineville, including the Cheever at Port Henry, and Lyon Mountain produce at the rate of 1,250,000 to 1,500,000 tons of shipping ore yearly. The crude ore carries about 60 per cent. iron and the concentrates 63 to 68 per cent. With comparatively little additional development, this production could be largely increased.

The total iron ore production of the United States in 1916 will approximate 80,000,000 tons, with an average of about 50 per cent. Fe. It is well within the range of possibility that the Adirondack field can produce over 6 per cent. of this tonnage, and, because of the richness of its ores, about 8 per cent. of the total iron. Moreover, with iron ore reserves conservatively estimated at 1,100,000,000 tons, concentrating on an average of 2 into 1 of higher than 63 per cent. Fe., the Adirondack field promises, on present showing as above, when developed, to produce 5,000,000 tons of concentrates annually for over one hundred years.

The above may seem to be a daring statement to one only somewhat familiar with iron ore production in the east. It may cause a complete surprise to many whose interests have been mainly centered in the Lake, Minnesota or Birmingham fields.

The accompanying sketch Map No. 1 shows the location of the principal mine areas of the Adirondack field. The thirty-seven locations are openings from which a few hundred to many thousand tons of shipping ore have been mined leaving untouched millions of tons of fairly high-grade milling ore.

Hogback Mountain, Prospect No. 3, Clinton County. Top of hill looking east, outcrop exposed 25 feet by 150 feet.

There are three species of iron ores in the Adirondack field. Straight magnetite, $Fe_3,O_4$; titaniferous magnetite, a mechanical mixture of ilmenite and magnetite, in which titanium varies from 1 per cent. to 3 per cent. up to straight ilmenite; and martite, $Fe_2,O_3$.

## The Straight Magnetites

As a rule, these are almost absolutely pure, except the mechanical mixture of rock and rock minerals which dilute the ores as mined. Special concentrates are now being prepared by Witherbee, Sherman & Company, running upwards of 70 per cent. Fe. It is thus practically demonstrated that the straight magnetites of the Adirondack field lack not more than 0.3 per cent. of being chemically pure iron oxides. Almost without exception they are amenable to magnetic concentration, the gangue minerals—quartz, feldspar, biotite and hornblende, as well as the magnetite itself—existing as distinct, separate grains. There seems to be no lamellar intergrowth of magnetite and other minerals. In the main the ores are friable and fairly coarse grained. Even phosphorus exists as distinct grains of apatite, a phosphate of time. The quartz is highly crystalline and thus brittle, instead of tough, as in the case of collodial silica.

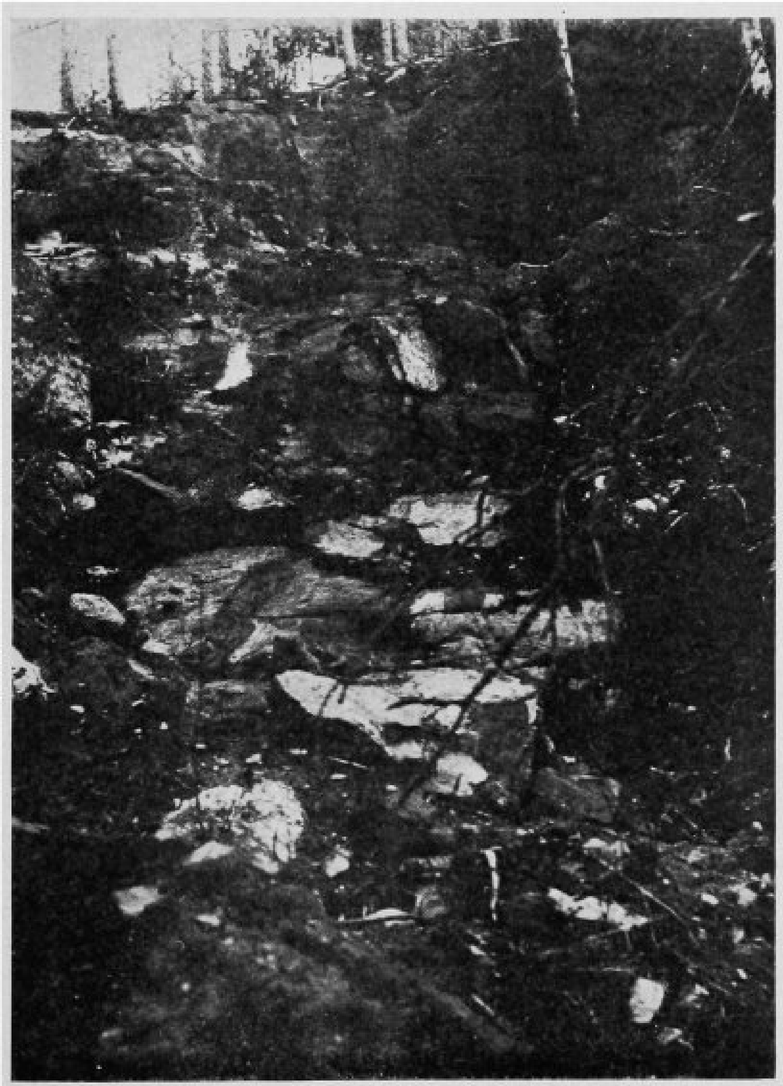
Ross Pit, Prospect No. 20, Clinton County. Outcrop uncovered 40 feet by 120 feet

The most extensive workings of straight magnetites in the Adirondacks are at Mineville, near Port Henry on Lake Champlain, where Witherbee, Sherman & Company have very extensive and modern mining plants and the largest magnetic concentrating operation in the world. The Port Henry Iron Ore Company also operates the "21 Mine" at Mineville. The other active producers of straight magnetites are the Chateaugay Ore & Iron Company at Lyon Mountain, the Cheever Iron Ore Company at Port Henry, and the Benson Iron Mining Company at Benson Mines. At all of these mines magnetic concentration is employed.

The separation or concentration of magnetic iron ore is a comparatively simple process. It consists in breaking apart the grains of iron, quartz, apatite, etc., by means of crushers and rolls; after screening and sizing, the crushed material is treated by machines equipped with electro-magnets, which pick up or deflect the magnetic particles making so-called heads and tails. The heads are the concentrates and the tails the waste product. This so-called waste product, however, frequently has considerable value. For example, the tailings of the Old Bed 21 ores at Mineville carry so large a quantity of phosphorus that they are used extensively as fertilizers, and the tailings from all grades of ore make a most excellent concrete.

The run of mine ore in the Joker-Bonanza and Old Bed 21 Mines at Mineville carries about 58 per cent. to 60 per cent. Fe. and 1 per cent. to 1.5 per cent. P. in the form of apatite or phosphate of lime. That the phosphorus is in a mineral form and mechanically mixed, not chemically combined with the iron, is proved by the fact that with fairly coarse crushing and magnetic separation the phosphorus is reduced from 50 per cent. to 75 per cent. of the original, and with no corresponding loss in iron. In other deposits, in both Clinton and Essex counties, which carry .003, .004 and .005 per cent. phosphorus in 30 per cent. to 45 per cent. Fe. ores, concentration reduces the phosphorus in every instance to less than .003 per cent. Sulphur is usually very low and occurs in the form of Fe. 17, S. 18, $FeS_2$, and in the form of chalcopyrite S. 35, Cu. 34.5, Fe. 30.5 per cent.

To sum up, the straight magnetites of the Adirondack field are nearly chemically pure. The run of mine, as mined now, varies from 30 to 50 per cent. for milling purposes to 55 to 60 per cent. for shipment without concentration. Regarding pig iron as the ultimate concentration product—with the Adirondack ores mechanical concentration can account for 72 per cent., the remaining 28 per cent. is and must be chemical. Regardless of comparative cost, 70 to 72 per cent. Fe. is the limit of mechanical concentration. The relative cost of the mechanical and chemical (blast furnace) will alone set the limit of mechanical concentration, except in the case of titaniferous ores. At present it seems to be established that the commercial limit of concentration is 60 to 65 per cent., except when a specially high-grade concentrate is desired and paid for at a much higher rate.



Hogback Mountain, Third Prospect, Looking East

## Titaniferous Magnetites

The complete analyses of these ores vary in iron content from normal with 36.8 per cent. Fe. and 31.6 per cent. Ti. to 55 per cent. to 68 per cent. Fe. and 1 per cent. to 5 per cent. Ti. As distinguished from the straight magnetites, they invariably contain vanadium up to 0.65 per cent. as, or about 0.36 per cent. metallic vanadium $V_2O_5$. In addition, they carry variable amounts of nickel, chromium, manganese, phosphorus and lime. They occur almost exclusively in the coarsely crystalline eruptive rock known as gabbro. They sometimes occur in an allied rock known as norite. In the Adirondack field there are many occurrences of titaniferous ores, but usually in small bunches or pockets. The one remarkable exception is the Sanford Lake deposit. Trenches, test pits and diamond drill holes have furnished data for safe tonnage estimates. The lowest estimate for this deposit is 70,000,000 to 100,000,000 tons. Even with the work done, neither the lateral extent nor the depth of the deposit has been determined.

The ores have been proved to be amenable to beneficiation by magnetic separators. The ores vary from fine to very coarse grained, yet some of the fine-grained ores separate magnetically as easily as the coarse grained. Some of these ores, however, are entirely unamenable to magnetic separation. This is due to interlamellar growth, alternating layers of ilmenite and magnetite. So intricate is this growth, occasionally even fine griding fails to break apart the ilmenite and the magnetite. Several experiments, however, showed that coarsely crystallized titaniferous ores crushed to 40 mesh, treated with a hand magnet yielded heads that carried 64 per cent. Fe., 3 per cent. Ti., and 1 per cent. metallic vanadium. The vanadium of the crude ore went entirely with the magnetite. Typical analyses follow:

| | Sanford Crude | Sanford Concentrates |
|---|---|---|
| Iron ....... | 50.52 per cent. | 58.39 per cent. |
| Titanium... | 11.71 per cent. | 6.19 per cent. |
| Phosphorus . | .009 per cent. | |

The great proved tonnage of the Sanford Lake deposit compels it to be acknowledged as an addition to the ore reserves of the Adirondacks, even though they are not commercial to-day. It seems quite probable that, when transportation facilities are provided which will put these ores on the market, exploration will disclose other deposits in other localities, especially since the mining of the Sanford Deposit will probably show structural features not now known. The Adirondack gabbro field, therefore, though covering 1,500 to 2,000 square miles or more, is not counted on to contribute further to the estimated reserves. It may be well to state here that the gabbros are eruptives and that they are younger than the gneisses and the white limestones (or Grenville) series of rock, both of which seem to surround almost completely the central core of gabbro. The gabbros occur as dykes and bosses, cutting the foliation planes of the gneisses, divide straight magnetic iron ore beds—sometimes lying in immediate contact with them—in other places pushing between two ore beds in a great intrusive sheet five hundred feet thick. (See Fig. 2, page 343.)

## Martite

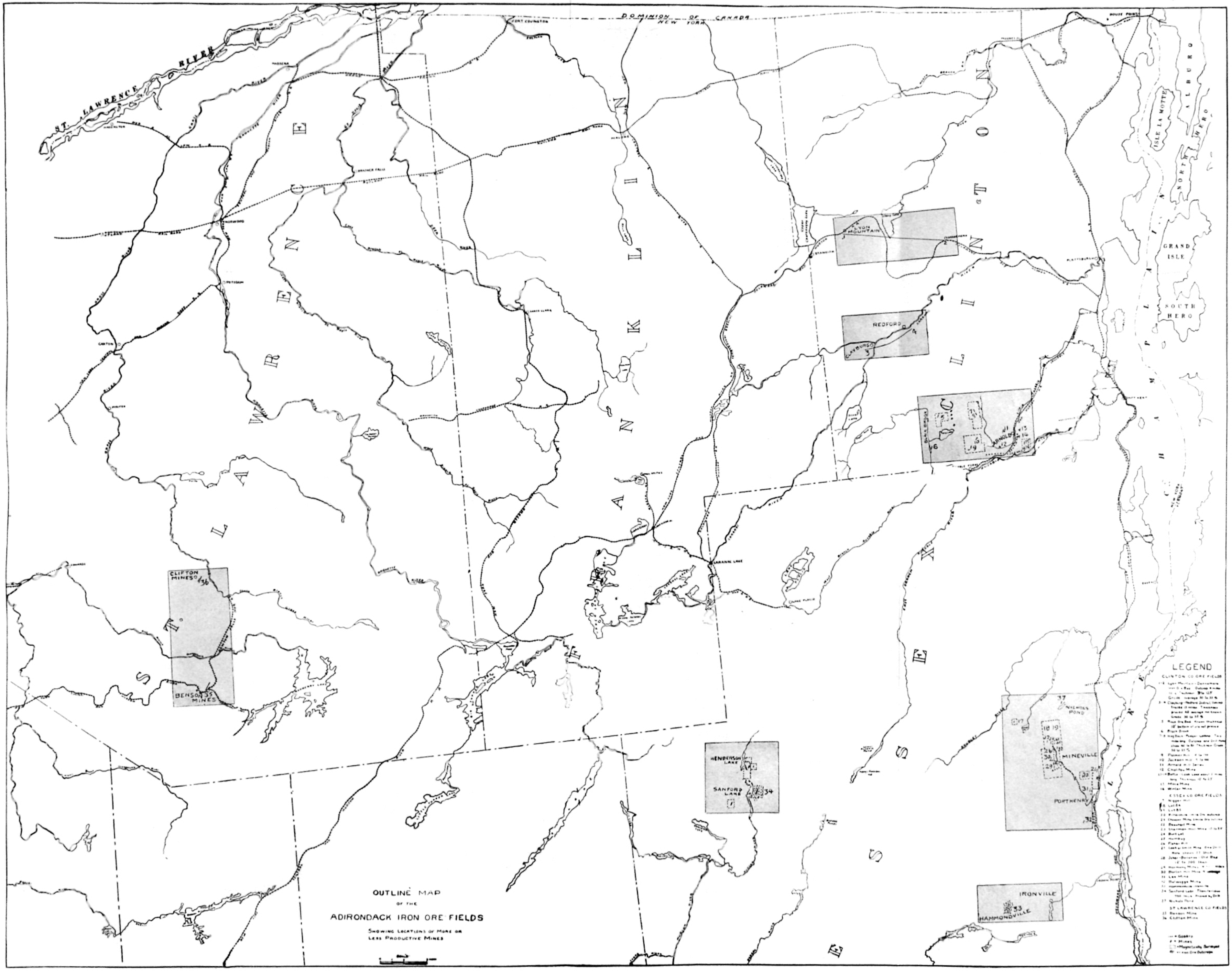
As the third class of iron ore, martite, is of a very limited occurrence and is found exclusively associated with the straight magnetites, it may be as well to mention it here. Martite, as is well known, is an ore with the crystallization of magnetite and the hematite formula. It is supposed to be a secondary mineral derived from the oxidation of $Fe_3O_4$ to $Fe_2O_3$. In the mines around Mineville it is found in a limited crushed fault zone in the Joker-Bonanza and the underlying Old Bed. So far as is known, it is not found in the main body of any one of the deposits in Essex County. In Clinton County it is nearly 33 per cent. of the iron content of one large ore body. When the ore body in which martite is found is of shipping grade as mined, it is rather beneficial than detrimental. In a milling ore, however, the case is quite different, since martite is non-magnetic. When, therefore, martite is a considerable per cent. of the total iron in milling ores, other concentration processes must be used in connection with the magnetic, otherwise heavy losses in the tailings will be unavoidable. The known occurrences of martite are, however, very rare.

## How to Distinguish the Typical Ores

The rocks which contain the straight magnetites need never be mistaken for the gabbros and norites which carry the titaniferous ores. There is, however, absolutely no need for the practical man to undertake to make the distinction. If iron ore is found, the presence or absence of titanium in amounts exceeding 2 per cent. will settle the question of the class of rock which contains it. If the ore is titaniferous, it is a pocket and the expense of development is usually thrown away. If it is non-titaniferous, if the outcrop is promising, the risk of development is a legitimate one. Of course, the above is a "rule of thumb," perfectly safe for the tyro, but is subject to exception.

For the technical man, however, there is need of ability to make distinctions. These are the main field distinctions. Without exception the iron-bearing gneisses are foliated and bedded; the gabbros, never, unless sheared. The immediate iron-bearing gneiss, known as "Mt. Hope," "Gray," or locally as "21," is gray in color, uniform in texture; its component minerals are quartz, feldspar, biotite, hornblende and grains and crystals of magnetite. The presence of magnetite is distinctive. They weather uniformly. The Benson ore deposit is a straight magnetite. Though occurring in the white limestone series the wall rocks are gneisses. These differ from the "gray gneiss," but the foliation is identical and the Benson ore beds conform to this foliation.

The gabbros are composed almost exclusively of feldspar and hornblende or pyroxene. On account of the excessive amount of iron, their color is dark green—nearly black, weathered—and the rock assumes a "warty" appearance. In the gray gneisses, the stratum occupied by iron ore is often a loose, friable, biotite gneiss or a dense black rock composed mainly of hornblende and feldspar. The above



DOMINION OF CANADA
NEW YORK
ST. LAWRENCE RIVER
ST. LAWRENCE
FRANKLIN
CLINTON
ESSEX
LAKE CHAMPLAIN
ISLE LA MOTTE
NORTH HERO
GRAND ISLE
SOUTH HERO
LYON MOUNTAIN
REDFORD
CLAYBURG
ARNOLD
CLIFTON MINES
BENSON MINES
HENDERSON LAKE
SANFORD LAKE
NICHOLS POND
MINEVILLE
PORT HENRY
IRONVILLE
HAMMONDVILLE
LEGEND
CLINTON CO ORE FIELDS
ESSEX CO ORE FIELDS
ST LAWRENCE CO FIELDS
35 Benson Mine
36 Clifton Mine
OUTLINE MAP
OF THE
ADIRONDACK IRON ORE FIELDS
SHOWING LOCATIONS OF MORE OR
LESS PRODUCTIVE MINES

are roughly outlined characteristics, subject to modifications, but in the main sufficient for practical purposes.

The occurrence of titaniferous iron ores has been described. Their occurrence is in striking contrast to the occurrence of the straight magnetites in the iron-bearing gneisses. By means of the foliation in these gneisses, the dip, strike and pitch of these rocks can be readily determined by an experienced man. When it is stated as an invariable fact that the straight magnetites conform exactly to the foliation of the gneiss, the matter of locating the direction of any given ore body is a comparatively simple problem. The solution depends wholly upon the accuracy with which the foliation is observed.

With the direction of any given ore body established, the actual and prospective volume of ore depends wholly on the linear extent. The ability to forecast the linear extent within fairly safe limits is gained mainly by experience.

## Volume of Adirondack Ores

In view of the fact that the iron ore reserves of the Adirondack district have been estimated at 1,100,000,000 tons, it may be well to cite a few facts on which this estimate is based. On Map 1, 37 separate localities of ore deposits are given. If these represented only 37 mines or bodies, the average tonnage for each would have to be 30,000,000 tons. This average has been equaled by one mine, the Joker-Bonanza and "21" at Mineville. In addition, there is another ore body underlying this which has a proved area of over 5,000 feet N.W.S.E. and a width of over 2,000 feet, with the extreme eastern and southern limits yet to be fixed. Still another proved area at Mineville has a continuous outcrop 4,500 feet, and two drill holes respectively 3,000 feet and 4,000 feet on a line at right angles to the strike. The breast of an old slope 2,500 feet long at nearly right angles to the strike is reported to have been in ore when it was abandoned, before the days of magnetic separation, and the drill holes farthermost from the outcrop show a total of 27 feet of solid ore. It is thus probable that the western limit has not been reached. The southern and northern limits have not been determined.

In Clinton County, N. Y., an almost continuous outcrop of 9,000 feet is to be seen.

Along the Saranac River, magnetic attraction shows heavily for 13 miles east and west. The attraction is proved in places by test pits. One old mine shows over 40 feet thick.

At Lyon Mountain the outcrop of ore can be traced four miles. The thickness varies from 3 feet to 125 feet. The deposit is reported to have been tested ahead of the outcrop a distance of 3,300 feet, with the ore undiminished in thickness and grade.

North of Ausable Forks an ore outcrop shows 85 feet thick. A drill hole one-half mile south shows ore 75 feet thick. Two and one-half miles west, lean ore outcrops over a distance of 3,500 feet north and south. An old opening 3,500 feet still west shows 10 feet at least of 45 per cent ore.

Taking this 3.5 miles as a south base line, 10 miles northwest is the Saranac River outcrop and 20 miles northwest is the Lyon Mountain line.

Note that this belt is continuous for over 20 miles; that faulting has exposed an east and west cross section at 0 miles, at 10 miles and at 20 miles, for distances of 3.5 miles, 13 miles and 4 miles, and the logical conclusion would seem to be a continuous ore sheet 20 miles long by an average width of 6.8 miles.

Taking an average width of this belt at 10 miles and its N.W. axis at 20, the belt contains 200 square miles. It may be 300. With an average thickness of 20 feet there are 56,000,000 tons of ore in a square mile. Ten per cent. of the above area will thus account for the total estimated reserve of 1,100,000,000 tons. Adding the Mineville district of 200 square miles, where the ore showing is equal to that in Clinton County, if not better, also the proved tonnage of 70,000,000 to 100,000,000 tons of titaniferous iron ore, and the Benson, estimated at 300,000,000 tons, we have a total of over 2,500,000,000 tons, making the original estimate appear conservative.

Another possible factor here demands consideration. It has been proved by drill holes that the whole of the Mineville iron-bearing gneiss is underlaid by the white limestone formation. The maximum known thickness of the Mineville iron-bearing gneiss is 2,500 feet. (See Fig. 2.) These gneisses in 1,900 feet thickness have three certainly, and possibly four, superimposed beds of iron ore. These are the Barton Hill, the Harmony and the Joker-Bonanza and, 100 feet below, the Old Bed. About 600 feet below the Old Bed the white limestone series has been proved by four drill

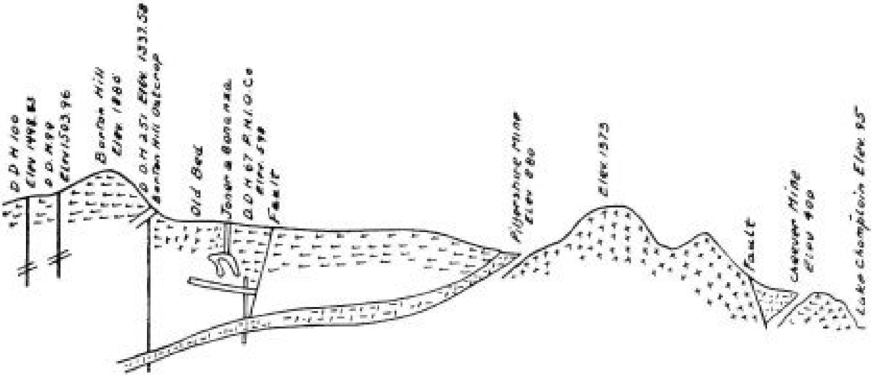



FIG. 2.—Showing formations

holes covering an area 5,000 feet north and south and about 6,000 feet east and west. A drill hole from the 1,300-foot contour in Barton Hill cut over 100 feet of the white limestone series at a depth of 1,900 feet—600 feet below sea level. These white limestones outcrop about 3.5 miles southeast of Barton Hill. At Nichols Pond large, lean iron ore beds outcrop below the white limestone series. The Pilfershire ore bed has an outcrop one mile long, with the white limestone series on the hanging wall; two miles southeast of the Pilfershire is the Lee mine, also with a white limestone hanging wall. On Lake Champlain lies the Cheever mine, also with white limestone on hanging wall.

On the west side of the Adirondack field is the Benson mine. Northeast of the Benson is the Clifton. These two mines are in or below the white limestone. With four great mines lying in or below the white limestone series, it seems well within reason to expect that sometime in the future, to the known horizon of ore-bearing gneisses will be added another horizon in the white limestone series which underlies the Mineville district.

This is, however, prospective and has not been considered in the writer's tonnage estimates. In estimating probable tonnage, nothing has been considered as an ore with a tenor of less than 30 per cent. iron. It may be questioned whether 20 feet thickness is not too high. The Old Bed at Mineville so far averages 12 feet of 59 per cent. iron. Distributing this through 20 feet instead of 12 feet, the iron content would be 35 per cent.

In the vicinity of Antwerp, New York, many thousands of tons of red hematite have been mined and shipped in the past. The district is non-productive at present. There are many outcrops, but few have become developed. No account has been made of this class of ore.

Whatever may be thought of the estimated tonnage, this is a fact: The class of iron ores in the Adirondack field is the only one where, by purely mechanical operations, the ore can be brought to 70 per cent. or 72 per cent. of purity, with pure iron 100 per cent. This fact alone is one worth considering; that in the best blast furnace practice from 75 per cent. to 85 per cent. of the consumed fuel is used for maintaining the reduction temperature alone, leaving 15 per cent. to 25 per cent. fuel for reduction. It is within the range of possibilities that with an oxide of iron, free from all impurities, some direct process may be discovered which will eliminate the blast furnace and convert these practically pure concentrates directly into a semi-finished steel product. If, however, no further economic use can be made of the purity of these ores, this is worth consideration. In a 70 per cent. concentrate there is only 30 per cent. of the inert units on which freight must be paid, as against 50 per cent. on a 50 per cent. ore, or 45 per cent. on a 55 per cent. ore.

Even with present mill practice at Mineville and Lyon Mountain, no trouble is experienced in bringing concentrates to a 62 per cent. to 68 per cent. grade.

The question may be asked how we are able to assert at the present time that the Adirondack region is capable of producing such an enormous tonnage of iron ore in comparison with what was thought to be its maximum tonnage a few years ago. The improvements in modern mining methods and machinery, together with modern crushing and preparing machinery and magnetic separation, have made it possible to utilize ores that are low in iron but mined at a moderate cost, which a few years ago had no market value whatever.

## The Markets for These Ores

Brief reference may be made in conclusion to the markets past, present and prospective, for the ores under discussion. As has been said, prior to the discovery and development of the Lake Superior iron ore ranges, the ores from the Adirondack and Lake Champlain district were largely used in Pittsburgh and vicinity, but were gradually driven back into their more legitimate district east of the Alleghenies, where for several generations they have formed the basis of the mixture in blast furnaces. The selected lump ore from the Port Henry mines has also been used for very many years as a fix in puddling; and later, with the development of the basic open hearth furnace, this ore has come into almost universal use east of the Alleghenies as an oxidizing agent.

The recent rapid development of the east furnishes a market much in excess of the capacity of the developed mines of the Adirondack section at the present time, and plants are obliged therefore to secure the balance of their ore mixtures from foreign countries or from the Lake Superior fields.

The Dominion of Canada offers a market by no means negligible for the ores mined near Lake Champlain, and steel plants in the Dominion have for many years been large buyers. In passing, it may be of interest to note the fact that in 1895 about 40,000 tons of high phosphorus Port Henry ore were exported to Germany and England, making, it is believed, the only over-seas shipment of United States ores on record.

The cost of hard ore mining, with the cost and waste of concentration, is, of course, higher than that of the steam shovel operations of the west; but mining costs compare favorably with those in underground mines in the Lake Superior region.

The freight rates from the Adirondack region to points of consumption in the east compare most favorably with the rates paid on Lake Superior ores to similar points. Using Port Henry, the largest shipping point in the region, as a basis, an analysis of freight cost shows the following:

The all-rail rates to the principal consuming points are grouped into districts and range from $1.30 to $2.00 per gross ton, while a uniform rate of $1.45 per gross ton prevails to the east from Lake Erie ports. For the purposes of comparison the following table giving the freight costs per unit metallic iron will be interesting. I have used 63 per cent. Fe. for Adirondack ores and 51.50 per cent. for Lake Superior ores, and have assumed $1.05 as a total freight rate from Lake Superior mines to lower lake ports.

| | From Port Henry | From Lake Superior Mines |
|---|---|---|
| | Per Unit | Per Unit |
| To Lehigh Valley | $.0254 | $.0485 |
| To Schuylkill Valley | .0262-0270 | .0485 |
| To Central Pennsylvania | .0292 | .0485 |
| To Pittsburgh | .0317 | .0372 |
| To Mahoning-Shenango Valleys | .0317 | .0320 |
| To Buffalo | .0206 | .0203 |

From the Adirondack mines (including Mineville) to the trunk line railroads or to Lake Champlain, there should be added to the foregoing figures from one-third to one-half cent per unit, to cover cost of terminals or mine railroads.

In the spring of 1917 the enlargement of the Champlain Canal will be completed. This is a part of the Barge Canal system of the State of New York and will provide a waterway between Lake Champlain and the Hudson River with a channel 12 feet deep and a minimum bottom width of 75 feet. To overcome comparatively slight elevations, there are 11 locks of the following dimensions: usable length 311 feet, width 45 feet, 12 feet over mitre sills.

Less than 20 miles of this waterway is through a land-cut. The balance of the total distance of 61½ miles, from Whitehall at the southern end of Lake Champlain to Waterford, is by means of the canalized Hudson River. This waterway will offer a means of transportation from Lake Champlain to New York Harbor, thence by rail to furnace plants, which will result in lowering the above rates very materially and will still further increase the differential in favor of the Adirondack ores.

From the above freight analysis it will be observed that the Adirondack district commands a most favorable location with regard to a market for its ores, particularly for eastern plants. With furnaces located on the Hudson River, New York Harbor or elsewhere on the Atlantic Seaboard, the freight on an ore supply would be remarkably low. From mines tributary to Lake Champlain it is safe to say, from trial shipments actually made on the partially completed canal, that the total freight from mine to alongside New York Harbor will be approximately one cent per unit metallic iron.

While many millions of tons of concentrated ores have been shipped from Lake Champlain mines, and many more millions of tons of high grade crude shipping ore have been moved from this district, it is frequently said that the "surface has hardly been scratched." And many competent authorities believe that the future will look toward this region more and more as one of its greatest sources of raw material for the rapidly increasing needs of its iron manufacturers. (Applause.)

Vice-President King: We will now hear a discussion of this paper by Mr. Frank E. Bachman, Port Henry, New York. Mr. Bachman will no doubt be remembered as having read a valuable paper at our Birmingham meeting. We are glad to see him again. Mr. Bachman. (Applause.)

# IRON ORES OF THE ADIRONDACK REGION

Discussion by Frank E. Bachman, Retired,

Formerly General Manager, MacIntyre Iron Company, Port Henry, N. Y.

Mr. Witherbee has so thoroughly covered the geology and available supply of iron ore in the Adirondack region that but little remains to be said.

During my connection in 1914 with the smelting test of titaniferous ores for the MacIntyre Iron Company, a report of which work appeared in the Institute's Year Book for that year, and on which I hope in the near future to report further investigations, I became familiar with their ore reserves. In addition to the Sanford Hill deposit containing 70,000,000 to 100,000,000 tons, there are the Iron Mountain deposit, which recent drilling shows to contain as much or more ore than Sanford Hill, and the Calamity and Mill Pond deposits, estimated to contain 40,000,000 tons. Mining on Sanford Hill and Iron Mountain will be by open cut, these deposits ranging from 500 to 1,200 feet wide and having almost no overburden.

## Adirondack Ores Easily Concentrated

The physical characteristics of all these ores is such that they can be easily concentrated. The ore used in the furnace test was mined at the base of Sanford Hill. It was concentrated in four different mills, none of which was designed to meet its special requirements. These tests proved that by crushing to pass a one-quarter-inch mesh, the concentrates produced contain 55.00 to 56.50 per cent. iron, 7.00 to 8.25 per cent. titanium, and from a trace to .004 per cent. phosphorus. As shown by Mr. Witherbee, crushing to 40-mesh increases the iron in the concentrates to 64 per cent. and reduces the titanium to 3 per cent. or less. The Iron Mountain, Calamity and Mill Pond ores are richer in iron and lower in titanium than those from Sanford Hill;

their crystal is larger and the interlaminar growths of ilmenite are less. It is therefore to be expected that one-fourth-inch concentrates made from them will be higher in iron and lower in titanium than are the Sanford concentrates of same size.

The furnace test of titaniferous concentrates having demonstrated that iron is produced from them with lower fuel consumption than from non-titaniferous magnetites of the same iron contents, and that their mixture with non-titaniferous magnetites tends to decrease furnace irregularities, and having indicated that, owing to the greater rapidity of their reduction, they make a better mixture with lake ores than straight magnetites, the value of this ore reserve is apparent.

## Costs of Production and Delivery

The average composition of the Sanford Hill deposit is such, and their overburden so light, that not more than two tons of material will be mined per ton of concentrates produced. In a quarry operation this will not cost to exceed 30 cents per ton. With water-power on the property, which can be developed cheaply, the concentrating cost should be less than 20 cents per ton of crude. Assuming a rail freight at 1 cent per ton per mile on the 60 miles of road necessary to bring these ores to the Champlain Canal and a 35-cent per ton canal freight to tidewater at New York harbor, we have a cost of but $1.95 per ton for a 57 per cent. ore alongside New York, or less than 3½ cents per unit. If the ore is crushed to 40-mesh and the iron contents increased to 64 per cent., necessitating clinkering or sintering before use, the cost will be increased 1¼ cents per unit, but will still be well below the lowest cost of ores delivered at Eastern furnaces.

## Value of By-Products

The tailings from each ton of concentrate contain an average of 850 pounds of recoverable ilmenite, which it is expected will soon be used for the production of a material for which there is a wide sale. I am advised that the plant to produce this material is now being erected. If the product proves as valuable as the tests indicate, the ilmenite from the tailings is likely to be of greater value than the ore.

For ten years I was directly connected with the exclusive use of magnetic ores in the blast furnace. During this period I used all of the ores then produced on the eastern slopes of the Adirondacks. I found the only difficulties connected with their use were those due to their size and where the crude ore mined was of variable composition to the variable composition of the concentrates produced.

## Overcoming Furnace Difficulties

The flue-dirt loss in using magnetic concentrates is greater than when using fine lake ores. On this account a furnace using them cannot be driven to a product equal to that which the same furnace will make when using fine lake ores. Increased flue-dirt production is due to the non-plastic nature of magnetic concentrates. Owing to the weight of the concentrates and their granular structure, their distribution in the furnace requires a great deal of attention. Unless very large charges are used and the bell opened suddenly, the ores trickle through the coke charge along the furnace walls, leaving an open center. The distribution question was solved at the Northern Iron Company's Standish furnace, which uses the exceptionally fine Chateauguay concentrates, by clinkering three-eighths of the mixture. This practice was further improved by enlarging the furnace hearth and steepening the bosh. Since these changes were made, the yearly average fuel consumption while making low phosphorous iron has been less than 2,200 pounds of coke per ton of iron.

At their Port Henry furnace, where no coarse ore or clinker is available, the shotty nature of the concentrates makes their distribution more difficult. The distribution question has never been entirely solved. The fuel consumption of this furnace has never been under pound for pound for long periods, but has ranged for year periods at from 2,240 to 2,340 pounds per ton of iron produced, the product being basic, foundry and malleable. (Applause.)

VICE-PRESIDENT KING: We are to hear another discussion of this paper by J. L. W. Birkinbine, of Philadelphia, who I believe is not present, and it will be read by the Secretary.

# THE IRON ORES OF THE ADIRONDACK REGION

DISCUSSION BY JOHN L. W. BIRKINBINE

Consulting Mining and Hydraulic Engineer, Philadelphia, Pa.

It gives me great pleasure to participate in the discussion of Mr. Witherbee's paper, not only because of our long friendship and an intimate acquaintance with the mines and concentrating mills at Port Henry and vicinity (being connected for a time with one of the Adirondack mines mentioned in his paper), but also because this paper treats of two of my professional hobbies, the "beneficiation of iron ores" and the "use of other than Lake Superior ores for eastern furnaces." Both of these hobbies are inherited. The late Mr. R. H. Lee had tacked up a remark of my father's which he claimed should be the motto of all blast-furnace managers: "The blast furnace is a very economical metallurgical apparatus, but is a most expensive place in which to prepare your raw materials." In regard to the second hobby, my life has been spent around the iron-ore mines and blast furnaces, operating and abandoned, in eastern Pennsylvania, and I have always felt a strong desire to see these mines and furnaces independent of the cause of their decline—the Lake Superior Iron Ore Region.

Although the American iron industry originally started by using limonite ores, commercially speaking this greatest of American industries developed its impetus by using Pennsylvania magnetites, but the mining methods did not keep step with the progress of metallurgical science. The exceptions to this are the mines in the vicinity of Port Henry, the Cornwall Ore Banks in Pennsylvania, and to a greater or less extent some of the mines in New Jersey. The other mines continued to operate with an output of from five to fifty tons per day, and the product varied greatly in character. The result was that when the Lake Superior ores were put on the eastern market, the furnace managers knew the character of ore which they would receive for months in advance by using the Lake ores, while in smelting local ores every carload of ore received had to be thoroughly mixed and then analyzed. And they never knew whether sufficient ore would be shipped from a number of small producers to meet the furnace demands. This, together with the high cost of mining, caused the abandonment of many properties which are undoubtedly of considerable intrinsic value. The iron and steel plants of the Pittsburgh District are interlopers when they ship their product to the eastern market, but the eastern furnaces have been helpless to resent it. The excess freight charges on coke from the ovens and ore from the lower lake ports to the eastern furnaces more than counterbalance the freight from the Pittsburgh District eastward, and the eastern furnaces realized that they had to secure some other source of iron-ore supply than the Lake Superior region. This is shown by the big steel companies. The Lackawanna Steel has its interest in the Cornwall Ore Banks and in mines in New York State. The Pennsylvania Steel Company has holdings in the Cornwall Ore Banks and in properties in Cuba. The Bethlehem Steel, with its large reserves of very rich ore in Chili, also has property in Cuba. Other steel companies have or are looking for iron-ore supplies, but the information may not be public property at this time. Unless the eastern blast furnaces can be supplied with ore from New York, New Jersey or Pennsylvania, they must secure it from abroad, and the possible sources of this are as follows:

Those of Central and South America, which are not considered favorably on account of transportation charges.

Those bordering the Mediterranean Sea, such as Algeria, Greece, etc., but these deposits are of limited size. Spain has considerable reserves of ore left, but some of these are showing signs of exhaustion, owing to European demands upon them.

Newfoundland has very large reserves, but it is doubtful if they can supply the demands of Canada and the eastern United States.

The large deposits of magnetite in the Scandinavian Peninsula are similar in many ways to the deposits described by Mr. Witherbee, but as will be seen by the following table only a small percentage of the iron ore produced in Sweden reaches the United States, the balance being consumed by its home and other European demands:

PRODUCTION OF IRON IN SWEDEN, GIVEN IN METRIC TONS.

| | Iron Ore. | Pig Iron. |
|---|---|---|
| 1910 | 5,552,678 | 603,939 |
| 1911 | 6,153,778 | 634,392 |
| 1912 | 6,700,565 | 699,816 |
| 1913 | 7,479,393 | 730,257 |
| 1914 | 6,588,300 | 639,718 |
| 1915 | 6,886,684 | 760,701 |

IRON ORE IMPORTED INTO THE UNITED STATES FROM SWEDEN.

| | Long Tons. | Value. |
|---|---|---|
| 1911 | 219,238 | $1,215,588 |
| 1912 | 333,863 | 1,781,579 |
| 1913 | 356,074 | 1,901,988 |
| 1914 | 280,887 | 1,481,747 |

From the value of the ore imported into the United States its high character is at once apparent.

On account of the similarity of the ores of the Scandinavian Peninsula to those of the Adirondack region, being magnetites varying greatly in percentages of iron, phosphorus, titanium, etc., a few paragraphs regarding them may be of interest.

Sweden for centuries has been noted for the manufacture of charcoal pig iron of high grade, smelting magnetite ores in numerous furnaces which, owing to the difficulty of securing the fuel used, are widely separated.

There was a slow, steady growth in the production of both iron ore and pig iron, the ores mined (mainly from deposits located in central and southern Sweden), until about the year 1891, being almost exclusively used in home production. Immense deposits of magnetite ore, which were discovered in Swedish Lapland above the Arctic Circle, have long been known, but owing to their geographical position and lack of transportation facilities, have not up to this time been exploited.

There are immense reserves of iron ore in Sweden, it being estimated that in Swedish Lapland these total 1,158,000,000 tons; while central and southern Sweden are expected to supply 122,300,000 tons of lump and concentrated ore; imperfectly known deposits probably 40,000,000 tons, and titaniferous ore deposits 15,000,000 tons.

Norway possesses a number of deposits of low grade, some of which have been exploited by the installation of concentrating plants operated by water power, which have been developed at very low cost. The deposits of this class of ore are, however, not nearly as large as those occurring in Sweden, the concentrating ores, which carry from 30 per cent. to 36 per cent. of iron, being estimated at about 350,000,000 tons. There are also a few high-grade titaniferous ore bodies. In addition there are other ores of comparatively low grade which may in the future become available.

The more important deposits of Sweden are found in the mountains rising more or less above the surrounding ground, and sometimes the deposits are very pure iron ore. Such is the case with Luossavaara, Kiirunavaara and Svappavaara. The first railway line constructed ran from these deposits to the post of Lulea, but the objection to this was due to the fact that during the winter months the harbor was ice-locked and therefore a second railroad was constructed to the port of Narvik in Norway. These iron-ore deposits passed through many changes of ownership and at the present time are all reported to be owned by three companies, the Luossavaara-Kiirunavaara Aktiebolag, the Aktiebolaget Freja, and the Tuolluvaara Grufaktiebolag. The first-named company is controlled by the Trafikaktiebolaget Granesberg Oxelosund, which owns half of the share capital, the other half belonging to the government. The State also owns the other deposits at Svappavaara, Leveanieni, Mertainen, Ekstromsberg, and several other small ore fields.

The Swedish Government also has the right to acquire, if it so desires, the other half of the shares of the ore field company.

The fact that the Swedish Government owns one-half of the largest iron-producing companies and controls numerous undeveloped deposits would indicate that the reserves of ore which it possesses will be used to what it considers its best advantage, and may at any time be restricted.

The ore from Gellivare and small quantities from Kiirunavaara and Tuolluvaara are exploited via Lulea, while the greater portion of the ore from the two latter deposits is sent to Narvik. A small amount of this Lapland ore is used in Swedish iron works, but from one-half to three-fourths of the exports are sent to Germany, probably one-sixth to England, and one-twelfth to Belgium and France. The United States received only a comparatively small tonnage until the year 1909.

The percentage of iron in the ores which are mined is usually high, running from 60 per cent. to 69 per cent., and even higher. The phosphorus as a rule is also high, running from 0.06 per cent. to 3.15 per cent., or more, and on this account the ore has found a ready sale in Germany, where it is used in the production of basic pig iron. Some of the ores are very low in phosphorus.

Magnetic concentration of ore has been used since its inception in Sweden, and is still an important factor. In 1915 2,279,850 tons of crude ore were concentrated, yielding 1,020,500 tons of concentrates, of which 57,967 tons carried 70 per cent. or more of iron, and 922,044 tons from 60 per cent. to 70 per cent. of iron.

Mr. Witherbee and his associates have shown what can be done in a commercial way in the magnetic concentration of iron ores, and the iron industry, especially in the East, owes a debt of gratitude to the operators of the mines in the Adirondack region.

Another debt of gratitude is due to Mr. A. J. Rossi, who, through his contributions to various technical societies and his experiments, has preached the doctrine of the usefulness of titaniferous iron ores, and to Mr. F. E. Bachman, who has demonstrated commercially that the large reserves of titaniferous iron ores can be used economically in blast furnaces.

There is no doubt but that there are enormous reserves of magnetites in New York, New Jersey and Pennsylvania which can be concentrated to yield a product equal to that produced from the existing mines in the Adirondack region, and the product will cost the furnaces considerably less per unit of iron than the ores from the Lake Superior region or Europe. And although another Cornwall Ore Bank or Lever's Hole may not be awaiting every iron company which puts a diamond drill into the ground, nevertheless a thorough investigation of not only the abandoned magnetite mines, but also search for new deposits, will offer a very inviting field, not only as a mining venture but as a source of supply to the eastern furnaces which will permit them to compete with those in the Pittsburgh District.

These magnetites vary greatly in the percentages of iron, phosphorus, sulphur, copper, lime, titanium, silica, etc., and the eastern furnaces which desire a nearby and cheap ore supply will do well to investigate deposits not only of magnetite but also of limonite, which are close at hand.

VICE-PRESIDENT KING: It is the custom of the Institute to invite brief informal discussions of papers, under the five-minute rule, and I desire to invite any one now who has anything to say on any of these papers that were read this afternoon. The opportunity for such discussion is now offered. We shall be pleased to hear from any one.

No one volunteered.

The next and last paper on the program for this afternoon is "Progress in Hot Blast Stove Design," by Arthur J. Boynton, Superintendent, Blast Furnaces, The National Tube Company, Lorain, Ohio.

# PROGRESS IN HOT-BLAST STOVE DESIGN

ARTHUR J. BOYNTON

Superintendent of Blast Furnaces, The National Tube Company, Lorain, Ohio

Furnace operators are to-day confronted with a problem in connection with the use of hot blast very similar to that which engaged the attention of the iron masters of England and Scotland in the years when the blast was heated in stoves fired by solid fuel. The fuel so used had to be added to that charged into the furnace, and remained a debit against the advantage gained by the use of hot blast. Even under these conditions the early records tell of a net saving of one thousand pounds of coal per ton of iron, and from that day to this not only the economy but the practical necessity of hot blast, excepting for charcoal practice, has not been seriously questioned.

After the advent of the closed top, which permitted the use of furnace gas in the stoves, and up to the recent period of electrification of steel works and mills, the hot-blast saving, in terms of fuel charged into the furnace, was all saving. The gas supply was normally abundant for all the furnace plant uses, the temperature of blast which could then be used was generally not high, and the subject of stove design attracted comparatively little attention.

During the past five years changes, chiefly in furnace lines and furnace fuel, have made the use of increased blast temperatures extremely advantageous from the standpoint of coke practice, while the demand for gas for power purposes has again required that extreme economy be practiced in the use of fuel in the stoves. There has been no general argument as to the advisability of limiting hot-blast temperatures for the sake of making the gas available for power purposes, but rather a disposition to make use of the highest temperatures with which it is possible for the furnace to work, and to increase the size of the stove equipment primarily for this purpose, but also with a careful regard for economy in the use of gas. Under the existing conditions it has been possible in many cases, not only to increase the blast temperatures three or four hundred degrees with no additional gas consumption, but actually to produce these higher temperatures with less gas than that formerly required for the moderate temperatures then in use.

It is the purpose of this paper to give an account of the generally accepted principles of recent stove construction, and to describe and compare some recently built stove installations.

The modern stove is a development of the last five years. The standard equipment of 1910 was a set of four stoves, built with 9-inch checker openings and 3-inch walls, or larger openings and thicker walls where radial checkers were used, containing an average heating surface of about 175,000 square feet for furnaces 21 feet 6 inches in the bosh and larger, with a range of from 150,000 to 200,000 square feet.

A considerable part of this surface was ordinarily ineffective on account of plugged checkers and cinder burnt onto the bricks. The combustion of the gas was haphazard, chiefly because a burner which gave some possibility of control gave also a flame temperature which filled combustion chamber and the tops of the checkers with cinder. The gas was therefore purposely burned with a long flame and its temperature kept down.

Under these conditions few stoves developed over a thousand degrees of blast temperature, and those which exceeded this temperature did so at the expense of stack gases in some cases hotter than the blast. The efficiency of such stoves was considerably below fifty per cent.

In addition to low blast temperatures and the wasteful use of fuel in the stoves, the conditions referred to were most unsatisfactory from the standpoint of regular furnace practice. With a furnace which could profitably use all the heat which such a set of stoves could transmit to the blast, the operator was continually perfecting an equilibrium between burden and blast temperature as stoves came off for cleaning and went into service again, while the lack of surplus heat to correct irregularities showed in off iron and occasionally decreased tonnage. Not the least difficulty was the necessity of working men inside the stoves under conditions which were exhausting and unhealthful.

The development which is rapidly changing these conditions was made possible by the introduction of washed gas. Without this improvement the only change which could be made was an increase in the size, that is, in the outside dimensions of the stoves, or in the number of stoves per furnace. All argument as to the desirability of such development has been cut off by the evidently much more advantageous arrangement possible with clean gas, which, in the case of existing plants, reduced stove improvement to a relining proposition.

### Primary Requirement.

The primary requirement of hot-blast stoves is rapidity of heat transfer between the gas or air and the brick, since upon this rate of heat exchange depends the size of the stove installation.

During the cooling phase of operation the stove must heat a given quantity of air per unit of time to a definite temperature. When this is no longer possible the cooling phase should end. The rapidity with which the heat can be disengaged from the brick is therefore the measure of the amount of effective brickwork necessary for a certain duration of the cooling phase, or, in other words, with any given construction, a measure of the size of the stove. The necessary number of stoves depends upon the relation between the time required to heat and that required to cool, or upon the practicable rate of heating.

Since the transfer of heat takes place by conduction, and since the conductivity of heat through fire brick is very slow, it is of first importance to place the average mass of the fire brick as close to a heating surface as possible. This means, practically, that the checker walls should be as thin as structural strength will permit. With any given thickness of checker wall, a decrease in the diameter of the checker opening gives additional brick within a given space, and also an increase in the heating surface.

The relations with regard to heating surface, volume of brick and percentages of free area, for square checkers of various sizes are shown in the table on pages 362 and 363.

From this table it appears that the greatest possible heating surface and volume of brick are obtained with the thinnest possible wall, and a diameter of checker opening equal to the thickness of the brick. It is also apparent that with a checker diameter of three inches and a half and a thickness of wall of two inches, there is an increase in the volume of brick within a given space of 35.8 per cent., and an increase of heating surface of 85.1 per cent., as compared with the standard nine-inch openings and three-inch walls. These dimensions have been applied to stoves in successful use to-day, and represent the advantage gained up to the present time by the use of washed gas.

The accepted practice is that the checker openings should be as small and the walls as thin as possible. For two-pass stoves, the choice is now practically confined to 2-inch or 2½-inch brick, and to diameters of openings from 3½-inch to 5½-inch, each designer going as far as his conservatism will permit. With these small checkers, the relatively great effect on the area of the openings of a slight movement of the brick, due to expansion and contraction, is the determining factor in deciding the limits of the construction.

The common practice is to state the size of a stove in terms of its heating surface. Within the present limits of construction the question of sufficient volume of brick for a given surface is not a practical one, hence the heating surface is a rough measure of the possible rate of heat exchange and therefore a proper measure of the size of the stove.

The rate of heat transfer is also dependent upon the motion of the gas or air stream within itself. A stationary body of gas within a checker, once the gas next the brick is cooled to the temperature of the brick, can only impart further heat to the brick by conduction through its own mass. This will evidently give a much slower rate of transfer than

EXHIBIT OF SQUARE FEET OF HEATING SURFACE PER CUBIC FOOT SPACE, CUBIC FEET OF BRICK WORK PER CUBIC FOOT SPACE, AND SQUARE FEET OF HEATING SURFACE PER CUBIC FOOT BRICK, FOR DIFFERENT THICKNESSES OF WALLS AND DIAMETERS OF OPENINGS IN SQUARE CHECKER WORK.

| | Thickness of Walls | Diameters of Square Checker Openings | | | | | |
|---|---|---|---|---|---|---|---|
| | | 1" | 1½" | 2" | 2½" | 3" | 3½" |
| Square feet surface per cubic foot space | 1" | 12.000 | 11.520 | 10.667 | 9.796 | 9.000 | 8.296 |
| Cubic feet brick per cubic foot space | | .750 | .640 | .556 | .490 | .438 | .395 |
| Square feet surface per cubic foot brick | | 16.000 | 18.000 | 19.185 | 19.992 | 20.548 | 21.003 |
| Percentage of free area | | 25.00 | 36.00 | 44.44 | 51.02 | 56.25 | 60.49 |
| Square feet surface per cubic foot space | 1½" | 7.680 | 8.000 | 7.431 | 7.507 | 7.142 | 6.717 |
| Cubic feet brick per cubic foot space | | .840 | .750 | .638 | .610 | .556 | .510 |
| Square feet surface per cubic foot brick | | 9.143 | 10.667 | 11.647 | 12.306 | 12.845 | 13.171 |
| Percentage of free area | | 16.00 | 25.00 | 32.65 | 39.06 | 44.44 | 49.00 |
| Square feet surface per cubic foot space | 2" | 5.333 | 5.877 | 6.000 | 5.926 | 5.760 | 5.553 |
| Cubic feet brick per cubic foot space | | .888 | .816 | .750 | .691 | .640 | .595 |
| Square feet surface per cubic foot brick | | 6.006 | 7.202 | 8.000 | 8.576 | 9.000 | 9.333 |
| Percentage of free area | | 11.11 | 18.36 | 25.00 | 30.86 | 36.00 | 40.490 |
| Square feet surface per cubic foot space | 2½" | 3.918 | 4.500 | 4.741 | 4.800 | 4.760 | 4.667 |
| Cubic feet brick per cubic foot space | | .918 | .859 | .803 | .750 | .702 | .660 |
| Square feet surface per cubic foot brick | | 4.268 | 5.239 | 5.904 | 6.400 | 6.781 | 7.071 |
| Percentage of free area | | 8.16 | 14.06 | 19.75 | 25.00 | 29.75 | 34.03 |
| Square feet surface per cubic foot space | 3" | 3.000 | 3.555 | 3.840 | 3.967 | 4.000 | 3.976 |
| Cubic feet brick per cubic foot space | | .937 | .889 | .840 | .777 | .750 | .710 |
| Square feet surface per cubic foot brick | | 3.202 | 4.000 | 4.571 | 5.106 | 5.333 | 5.600 |
| Percentage of free area | | 6.25 | 11.11 | 16.00 | 30.66 | 25.00 | 28.99 |

Exhibit of Square Feet of Heating Surface per Cubic Foot Space, Cubic Feet of Brick Work per Cubic Foot Space, and Square Feet of Heating Surface per Cubic Foot Brick, for Different Thicknesses of Walls and Diameters of Openings in Square Checker Work—*Continued.*

| | Thickness of Walls | Diameters of Square Checker Openings | | | | |
|---|---|---|---|---|---|---|
| | | 4" | 4½" | 5" | 5½" | 6" |
| Square feet surface per cubic foot space | 1" | 7.680 | 7.141 | 6.667 | 6.248 | 5.878 |
| Cubic feet brick per cubic foot space | | .360 | .331 | .306 | .284 | .265 |
| Square feet surface per cubic foot brick | | 21.333 | 21.574 | 21.788 | 22.000 | 22.181 |
| Percentage of free area | | 64.00 | 66.94 | 69.44 | 71.60 | 73.47 |
| Square feet surface per cubic foot space | 1½" | 6.347 | 6.000 | 5.680 | 5.388 | 5.120 |
| Cubic feet brick per cubic foot space | | .471 | .438 | .408 | .383 | .360 |
| Square feet surface per cubic foot brick | | 13.476 | 13.699 | 13.922 | 14.068 | 14.222 |
| Percentage of free area | | 52.89 | 56.25 | 59.17 | 61.73 | 64.00 |
| Square feet surface per cubic foot space | 2" | 5.333 | 5.112 | 4.898 | 4.693 | 4.500 |
| Cubic feet brick per cubic foot space | | .556 | .521 | .490 | .462 | .438 |
| Square feet surface per cubic foot brick | | 9.592 | 9.812 | 10.000 | 10.158 | 10.274 |
| Percentage of free area | | 44.44 | 47.93 | 51.02 | 53.78 | 56.25 |
| Square feet surface per cubic foot space | 2½" | 4.544 | 4.408 | 4.267 | 4.125 | 3.986 |
| Cubic feet brick per cubic foot space | | .621 | .587 | .556 | .527 | .502 |
| Square feet surface per cubic foot brick | | 7.317 | 7.509 | 7.674 | 7.827 | 7.940 |
| Percentage of free area | | 39.87 | 41.33 | 44.44 | 47.26 | 49.83 |
| Square feet surface per cubic foot space | 3" | 3.918 | 3.840 | 3.750 | 3.654 | 3.556 |
| Cubic feet brick per cubic foot space | | .674 | .640 | .609 | .581 | .556 |
| Square feet surface per cubic foot brick | | 5.813 | 6.000 | 6.158 | 6.289 | 6.396 |
| Percentage of free area | | 32.65 | 36.00 | 39.06 | 41.87 | 44.44 |

will be the case if a continuous current of hot gas comes in contact with the brick work. Any rate of flow brings the gas next to the brick continuously in contact with cooler surfaces, but the flow may be so slow or the checker opening so large that the gas passes through the checker somewhat as though it were a solid body with relatively little motion of the gas particles among themselves. This brings about in some degree the slow rate of heat transfer just described. The ideal condition would be that every particle of gas in the checker should come in contact with the brick at each level of the checker, or, in other words, that all the gas should come in contact with all the brick. This condition is manifestly impossible, but the closest possible approximation to it will lead to the best heat transfer, and the determination of the practicable limit is an important matter upon which so far very little action has been taken.

This principle lay at the bottom of the so-called Pfoser-Strack-Strumm system of burning gas, which consisted in practically doubling the consumption of gas in the stoves, and reducing their number, with no increase in stack temperature. Experiments upon our already hard-driven American stoves of the old type showed the possibility of increasing the rate of heat transfer, but at a very marked loss in efficiency. It seems probable, however, that a proper size of pass and ratio of length to size will permit a considerable increase in the heat exchange of the stove with but little loss of efficiency.

The progress of recent stove construction has been attended by some changes which have tended to increase the movement of the gas or air upon itself, although these changes have been generally incidental to an increase in heating surface rather than the result of deliberate design. The increase in surface has increased friction, and the lessening in area of the checker pass, due to making the checker diameter more nearly equal to the thickness of the brick, has increased the velocity through the checkers, and added still further to the friction. The reduction in the size of the checkers, which reduces the inner motion necessary to bring the gas in contact with the brick may very probably be a still further aid to heat transfer. The generally accepted laws of fluid friction state that friction is proportional to the surface, and increases with the velocity, but at a more rapid rate than the increase in velocity. It would seem, therefore, that all the recent changes in the direction of smaller checkers have promoted heat transfer in some degree aside from the increase in heating surface attendant upon their use. There is as yet, however, no tendency to complicate stove construction with the definite object of promoting inner motion of the gas or air.

## Checker Construction.

Some of the details of checker construction have necessarily been considered in the above general discussion. The square checkers referred to are practically always used for two-pass side-combustion stoves. The usual method of bonding these checkers is shown in Figure 1. The radial

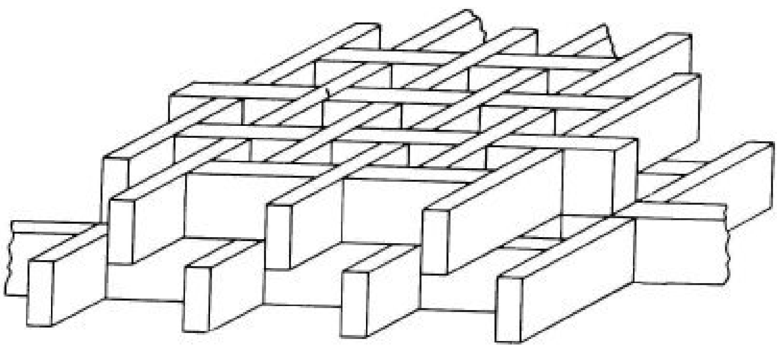


Fig. 1.—Standard Method of Bonding Square Checkers.

checker has been applied to some recent stove construction but is less economical of space than the square checker on account of the impossibility of maintaining the minimum practical opening.

The corrugated checker has been applied to some recent construction. This arrangement corrugates the brick running in one direction in an otherwise square or rectangular construction, the proportions of which may be varied. As applied to a recently built installation, this construction is shown in Figure 2. Built to these dimensions, the relations of surface, free area and brick in unit volume are shown below.

| | *Straight Wall* | *Corrugated Wall* |
|---|---|---|
| Sq. ft. surface per cu. ft. space..... | 3.5 | 3.906 |
| Cu. ft. brick per cu. ft. space.......... | .531 | .594 |
| Sq. ft. surface per cu. ft. brick.......... | 6.59 | 6.58 |
| Percentage of free area..... .......... | 46.88 | 40.63 |

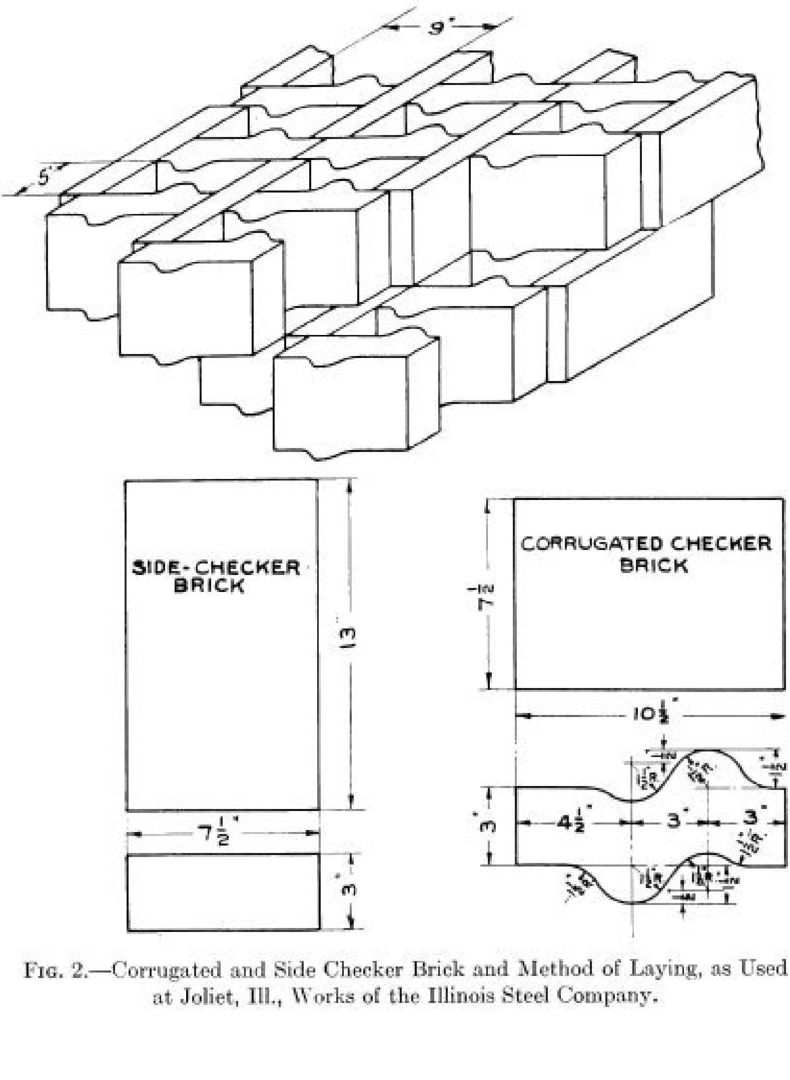



Fig. 2.—Corrugated and Side Checker Brick and Method of Laying, as Used at Joliet, Ill., Works of the Illinois Steel Company.

The increase in heating surface due to the corrugations as compared with rectangular construction of the same dimensions is 11.6 per cent. The square feet of heating surface per unit of space corresponds closely to that obtained with 3-inch walls and 4-inch openings, or with 2½-inch walls and 6-inch openings.

These three forms of checkers, square, radial and corrugated, are the ones usually employed, with the square checkers in use in the great majority of cases, and apparently gaining in favor.

A checker which has been proposed by Mr. Julian Kennedy but not as yet installed is shown in Figure 3.

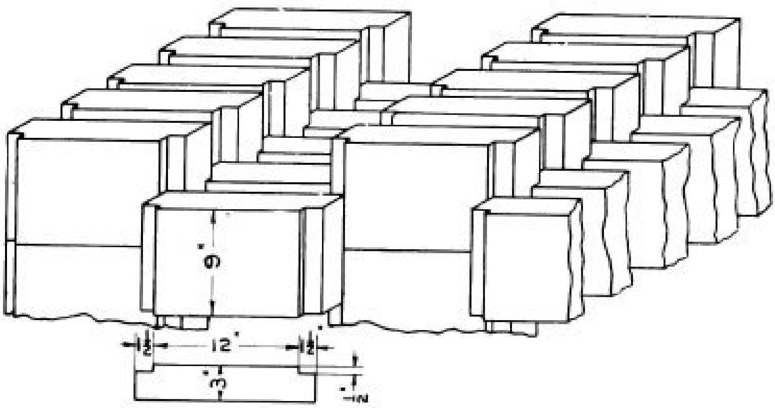



FIG. 3.—Checker Brick and Method of Laying Proposed by Julian Kennedy.

The relations for surface, area and volume are as follows:

| | |
|---|---|
| Sq. ft. heating surface per cu. ft. of space | 4.977 |
| Cu. ft. brick per cu. ft. space | .644 |
| Sq. ft. heating surface per cu. ft. brick | 7.728 |
| Percentage of free area | .356 |

The square feet of heating surface per unit of space with this construction corresponds closely to that obtained with 2-inch walls and 4½-inch openings.

An expedient for increasing the heating surface in stoves having 3-inch by 9-inch square checkers has recently been successfully tried at the Lorain works of the National Tube Co. This consisted in placing inside the existing checker openings pointed tile extending diagonally. These tile were lowered from the top, the first one resting at the ends on the bearing tile at the bottom, so that when the job was completed three-cornered checker openings resulted, the increase in heating surface being about 40 per cent. It is probable, however, that few of the older installations are in condition to permit the successful use of this device.

## Distribution of Air and Gas in the Checkers.

The remarkable series of stove tests made by Mr. A. E. Maccoun and described in his paper on "Blast Furnace Advancement" read before this Institute in May, 1915, indicate a distribution of gas and of air in the checkers of a two-pass stove which is far from correct. The inequalities which he found were apparently due chiefly to a lack of symmetry in the top and bottom of the stove. While these tests attracted much interest and showed the fallacy of considering the distribution correct on account of an apparently even temperature at the top of the stove, they have not led to any marked change in the design of two-pass stoves, on account of the mechanical difficulties involved. They show, however, the possibility of very great improvement by a construction which will equalize the flow of air and gas throughout a stove.

Frictional resistance in the checkers themselves is probably the most effective aid to this distribution. In addition to this force, according to the generally accepted idea, the buoyancy of the gas and air in the checker exercises an equalizing effect where the gas is heated in a downward and the air in an upward pass. Under conditions of natural draft in a two-pass stove, we have the weight of a column of air the height of the stack plus the weight of the gas in the checkers opposing the weight of the gas in the combustion chamber plus the weight of the gas in the stack. Consequently the total force tending to drive gas through a cold checker is greater than that operating through a hot one, with a resultant tendency to equalize the temperature of all the checkers. Conversely, in the cooling phase of stove operation, the weight of air in the checkers resists the force of the blast. The hotter the air in any given checker, the less this resistance and the greater the quantity of air which will be forced through it, the tendency being again to equal the temperature in the various checkers. Where the checkers are heated by an upward current and cooled by a downward flow, the hot checker tends to become hotter and the cold one colder.

The calculated difference in weight of gas due to an assumed average difference in temperature of 50 degrees F. corresponds to a difference in pressure of less than two one hundredths of an inch of water for a stove 100 feet high, while the total drop in pressure through the checkers of a two-pass stove is an inch of water or more. The importance of buoyancy as determining distribution in the small upward passes of three-and-four pass stoves, as built, is probably very small, but its action forms one of the arguments in favor of the two-pass stove.

A few years ago several two-pass stoves were built in which the checkers in the centre of the pass were made smaller than those on the outside, the intention being to increase the friction in what was assumed to be the hottest part of the stove, and so to equalize distribution. This feature has not appeared in more recently built two-pass stoves, the positive advantage of building the checkers to minimum dimensions outweighing the possible improvement in distribution. Recent practice is to make all checker openings and walls to uniform dimensions throughout a given pass, in square construction and in radial construction to come as near to this as practicable.

Equalization of frictional resistance presents its only problems of construction in the bottom and to some extent at the top of the stove. In two-pass-side combustion stoves it is not practicable to make air and chimney openings and supporting piers symmetrical with the checker space so as to give equal friction to the gas from all the checkers. In three-pass stoves and in some recently built two-pass centre-combustion stoves this construction is, generally speaking, symmetrical, but the symmetry is marred by the one or more hot blast and gas passages into the centre of the stove.

In the side-combustion two-pass stove the former tendency to build arches through the bottom of the stove, connecting to the checkers through ports whose varying dimensions were intended to equalize friction, has been generally abandoned in favor of pier construction, in which no attempt is made to control the distribution, but which, by large areas and small surfaces, reduces the friction as low as possible. In this type of stove the chimney valves are usually two in number and set at an equal angle to the centre line of the stove and as far apart as convenience will permit. The blast inlet is usually on the centre line of the stove, midway between the chimney openings.

Centre combustion two-pass stoves when provided with one chimney opening issuing from the side of the stove, as formerly built, have apparently shown a poor distribution of air and gas, indicating a considerable effect of difference in frictional resistance. An attempt has been made to remedy this by two diametrically opposite chimney valves connecting through two flues, one on either side of the line of stoves, into a stack located on their centre line. This construction was symmetrical outside the stove, and a considerable improvement over the single valve from the standpoint of gas distribution, though it had no effect on the distribution of air.

Recent construction provides a generally symmetrical outlet for gas and inlet for air, by a central chamber at the bottom of the stove, with outside connections either through the side of the stove, as built by the Illinois Steel Co., or through the stove bottom, as built by the Carnegie Co. at the Duquesne Works.

The determination of the influence of the gas currents in the dome of the stove as influencing distribution is a difficult matter under high temperature conditions of actual service. Experiments have been made by Mr. A. N. Diehl in connection with the stove previously referred to which, with an induced flow of cold air, showed a maximum flow through the outer ring of radial checkers, the minimum flow being just outside the ring of checkers next the central combustion chamber, with an increase in flow through this inner ring. An inclined baffle wall placed outside the checkers next the outer wall of the stove largely corrected this inequality under the same conditions of observation. The apparent conclusion from these experiments is that the gas current issuing from the combustion chamber continues upward and is deflected outward and downward by the dome. The same conclusion may be derived from Mr. Maccoun's experiments.

An exactly contrary view has been taken by other designers, whose object has been to prevent an unduly large flow of gas down the checkers next the combustion chamber. For this purpose the combustion chamber walls have been raised both in centre-combustion and side-combustion stoves. The wall is usually of a uniform height, but is sometimes varied. The newer two-pass stoves of the South Works of the Illinois Steel Co. have a fan-shaped top to the Combustion chamber wall, reaching a height of 2 feet 6 inches at the middle of the wall. These changes to the height of walls have been made as a result of observation of apparent differences in temperature at the top of the stove. Bearing in mind that gas and air are discontinuous bodies, and that all movement of one as well as of the other is the result of pressure, it is difficult to account for a marked tendency for gas to be forced down the checkers next the combustion chamber in undue proportion.

## The Size and Shape of the Combustion Chamber.

This chamber, with its dividing wall, formerly occupied nearly one-half the available space inside the side combustion two-pass stove. The reason for this is not apparent, since three-pass stoves built at the same time were successfully operated with a combustion chamber having less than half the area.

The area of the combustion chamber has been reduced in later stoves, and would doubtless have been reduced to its lowest terms, that is, a cylindrical opening located on one side of the stove, if it had not been for a natural conservatism on the part of the designers, as to what the effect would be on the distribution of the gas into the checkers. The side combustion chamber therefore retains much of its former shape and size. As a result of this condition propositions to put checkers in the upper part of the combustion chamber have been frequent. This change has been attended with notable improvement in the case of some existing stove installations. As applied to new construction or complete relining it is readily apparent that no method of putting checkers in the combustion chamber can equal, from the standpoint of available heating surface, the reduction of the combustion chamber to an equivalent area and the resultant ability to utilize this space for checkers, which will extend the entire height of the stove instead of only a part of this height. Distribution of gas is, therefore, the only apparent reason for an enlarged combustion chamber containing checker work. The free area of the combustion chamber has been reduced to 26.6 square feet in a set of four two-pass side-combustion chamber stoves at the South Works of the Illinois Steel Co. This area has been proven to be ample through many years' experience on three-pass stoves.

A very interesting use of space otherwise wasted in the combustion chambers is shown in the construction of the new stoves at Gary Works. Here a saw tooth construction on the inner side of the upper part of the combustion chamber wall is employed to increase the heating surface. This involves no corresponding reduction in the area of the checker since it makes use of the space above the skin wall in the lower part of the combustion chamber.

Structural strength of the combustion chamber walls is, of course, at a maximum when the chamber is circular. Any displacement of the combustion chamber walls causes a serious displacement in the checkers. Recent construction therefore tends to approach a circle even in side-combustion walls.

## Natural or Forced Draft.

The increased friction due to smaller checkers, and in some cases to the practice of reducing the area of the combustion chamber by installing checker work, has led to the adoption of forced draft for air or gas and recently in one installation for both. There is as yet no general tendency in this direction, but there are certain difficulties connected with getting the desired combustion with natural draft which are easily solved by forced draft. Washed gas requires for its successful combustion an intimate mixture of gas and air. This is most usually now done by nozzle burners which require high velocity of air or gas, and, in order to facilitate mixture, the smallest possible proportion in the burner. The result is that where the gas goes into the burner at the slight pressure of the main and the air at atmospheric pressure, the products of combustion will show a pressure considerably below that of the atmosphere in the bottom of the combustion chamber, resulting in apparent necessity for a higher chimney. A marked drop in pressure through the chimney valve produces the same effect, but this is easily remedied by larger valves. An important requisite in a natural draft burner is, therefore, sufficient area for air, and also a sufficiently large opening from the burner into the stove.

For the usual types of stoves the general practice is still to use natural draft. With larger and more economical stoves the increased friction and lower stack temperatures are requiring higher stacks, which are, however, well within the limits of possible construction. For such stoves, therefore, the chief argument for forced draft is one of better combustion. The design of burners in ordinary use has changed but little since Mr. Diehl's full discussion of the subject before this Institute a year ago. The idea of blowing both air and gas into the stove has, however, been reduced to practice since that time at the Joliet Works of the Illinois Steel Co. Here an air fan and a gas fan operating on the same shaft and driven by one motor drive air and gas into the burner of the large four-pass stove described hereafter. The extremely large heating surface, 128,000 sq. ft., and number of passes of this stove made forced combustion a necessity. A consequence of its use, however, has been an extremely accurate proportioning of gas and air, which can be effected continuously without trusting the judgment of the operator. This arrangement also permits accurate regulation of the amount of gas consumed, according to the necessities of the furnace, and a maximum consumption in comparison with ordinary requirements far greater than that obtainable by natural draft. A second installation for use in two-pass stoves is now nearing completion at Canton, Ohio.

## Fire Brick.

Stove linings are now practically always made of steam pressed and hard burned brick with a tendency to specify first quality brick throughout the stove. These brick withstand the highest temperatures of stove practice without difficulty. There seems to be no good reason, however, why a second quality brick cannot be used in the lower part of the stove. Such brick are stronger, generally truer to shape and are rather more easily heated than the first quality brick. The chief practical difference however, is probably the matter of first cost. Experience with these brick has entirely overcome the idea that regenerator brick should be of coarse grind in order more readily to absorb heat. Small checkers require extreme regularity of size and shape which could hardly be furnished by the old methods of manufacture. The matter of expansion under heat is of the utmost importance, but most of the standard brands of brick now in use give little trouble in this respect.

## Insulation.

New stoves are now practically always built with an insulating material between the regular fire brick and the shell. This is partially due to the commercial introduction of insulating materials not formerly in common use, but chiefly to a realization that the losses through radiation were generally in excess of 10 per cent. of the total quantity of heat furnished to the stoves. The former general practice was to use an average thickness of 2-inch of granulated blast furnace slag between the walls and the shell. This was done chiefly to provide for expansion of the brick, but it also acted as in insulator of considerable value.

The materials now commonly employed are asbestos and kieselguhr in various forms. The asbestos is used either in slabs or as asbestos cement. The kieselguhr is used either powdered, in brick made by cutting and drying the kieselguhr rock, or in brick made from powdered kieselguhr. The powdered kieselguhr has in some cases taken the place of the granulated slag, in others this space has been filled either by asbestos slabs, by asbestos cement, or by a mixture of asbestos cement and powdered kieselguhr. Kieselguhr brick when used may be placed inside the expansion space, or built next the shell, and kieselguhr powder used in an expansion space between the kieselguhr brick and the fire brick.

Comparative tests have shown that the insulating value of kieselguhr is somewhat higher than that of asbestos for a given thickness. Some designers have preferred the use of asbestos slabs for insulation on the ground that a better mechanical job is obtained by this means. These slabs are made to fit the shell and are provided with an inner cellular space which allows for expansion of the stove lining. This form of insulation is undoubtedly permanent.

An often stated objection to powdered insulation of any kind is its tendency to compact itself inside the stove shell, leaving spaces in the upper part of the stove uninsulated. This objection may be practically overcome for two-pass stoves by building only every second skew back tile of the stove dome against the shell. It has been found that where this is done, shrinkage of insulating material can be made up by additions from the top of the stove. While the kieselguhr brick has a low compressive strength, its light weight makes the strength ample to support a column the height of any ordinary stove. The cost of kieselguhr insulation as applied is less than that of the asbestos. The general use of all of these materials is too recent for any conclusion to be drawn as to the untimate choice of material.

No reliable data are yet at hand as to the actual reduction in heat loss through the application of insulation to stove construction. There is, however, no doubt as to the value of insulation when forming part of walls of standard thickness. Very naturally there seems to be no tendency to reduce the thickness of walls on account of the less heat conduction through the insulation.

## VARIETY IN THE DESIGN OF STOVES.

Recent developments have brought only one actual construction of what may fairly be called a new type of stove, the new four-pass stove at Joliet. This stove is shown in Figures 4, 5 and 6. Figure 4 shows general vertical and horizontal cross-sections through the stove. Figure 5 shows details of construction in the fourth pass, illustrating particularly the method of starting the small checkers of this pass, and

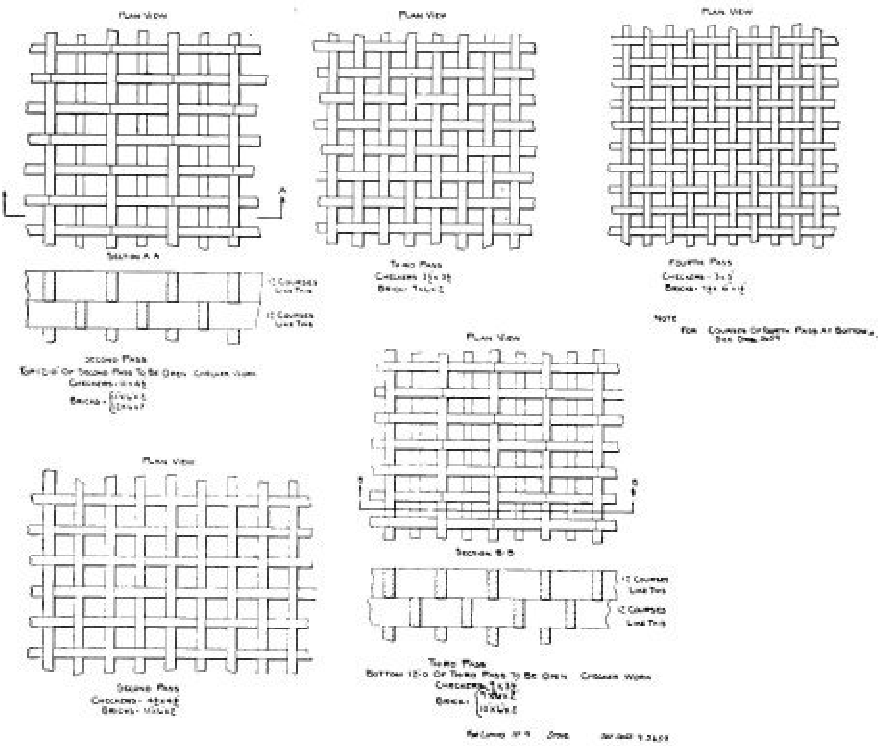


FIG. 6.—Showing Details of Checker Work in Three Checker Passes.

Figure 6 shows details of checker work in the three checker passes together with the peculiar method of laying checkers at the top of the second and bottom of the third pass, which is employed for the sake of distribution of gas. Figure 7

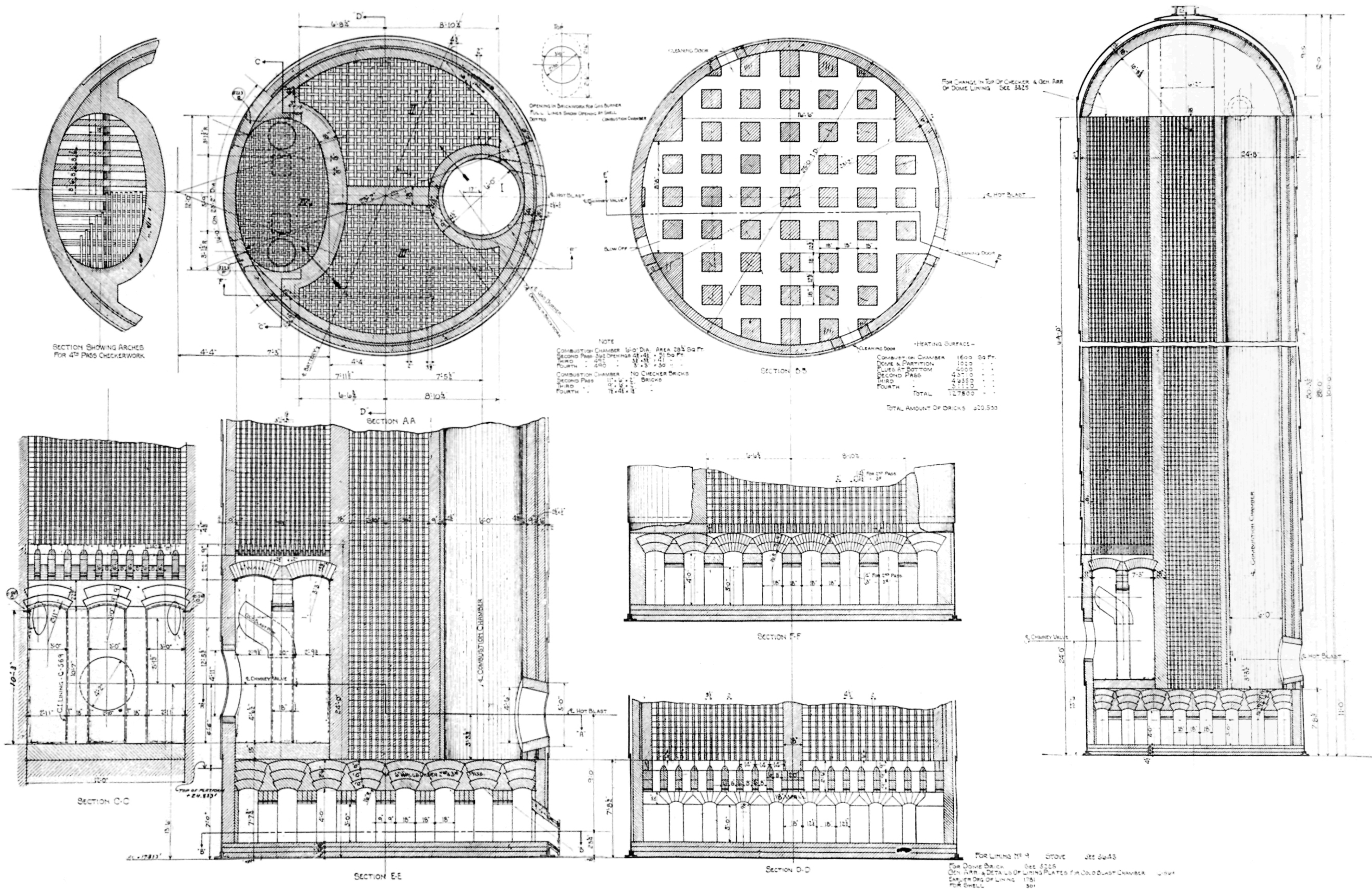
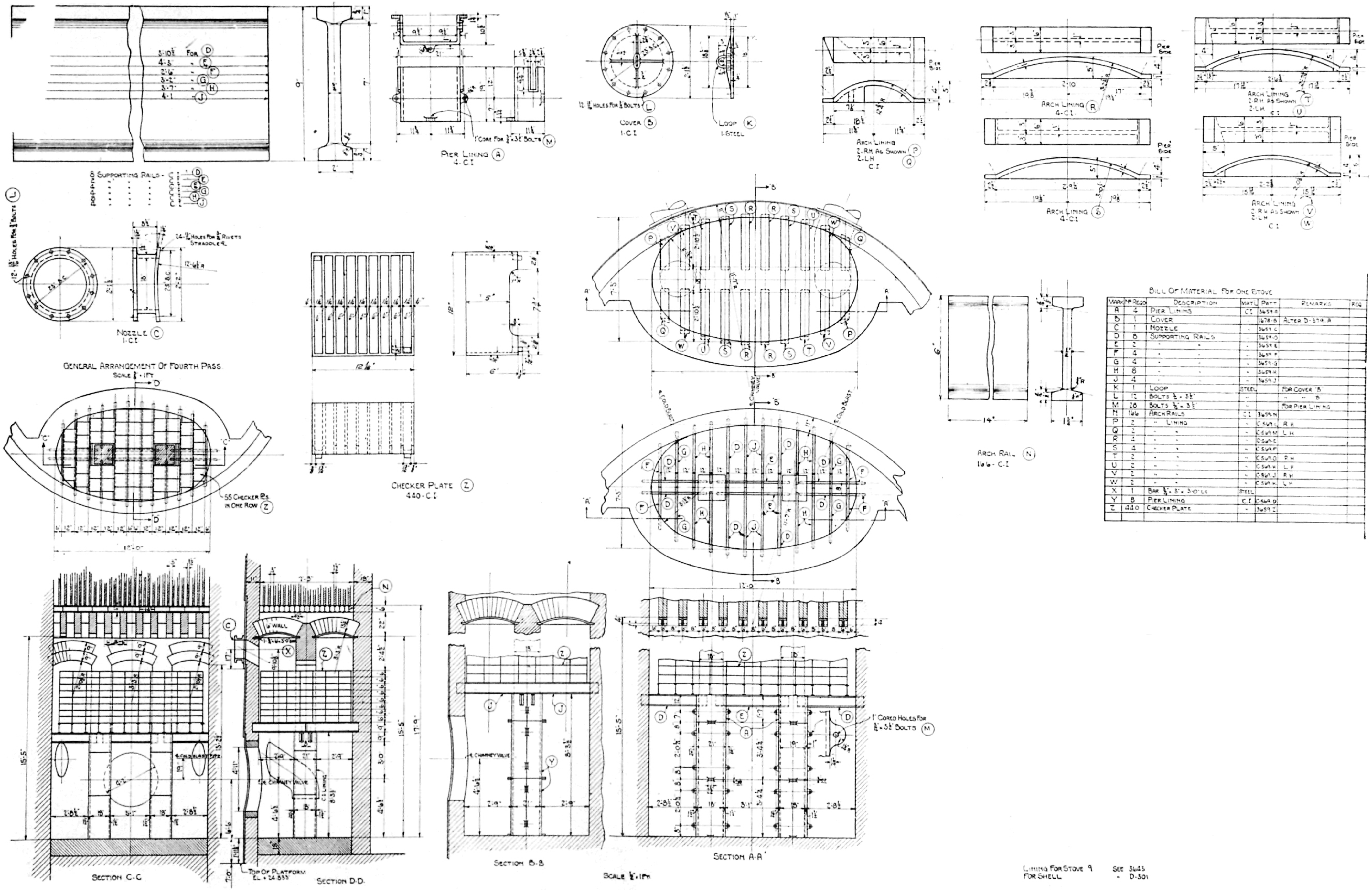



FIG. 4.—SHOWING GENERAL VERTICAL AND HORIZONTAL CROSS-SECTIONS THROUGH THE STOVE.




**Bill Of Material For One Stove**

| Mark | No. Reqd | Description | Mat'l | Patt | Remarks | Reg |
|---|---|---|---|---|---|---|
| A | 4 | Pier Lining | C.I. | 3659-A | | |
| B | 1 | Cover | " | 1678-B | Alter D-379-A | |
| C | 1 | Nozzle | " | 3659-C | | |
| D | 8 | Supporting Rails | " | 3659-D | | |
| E | 2 | " " | " | 3659-E | | |
| F | 4 | " " | " | 3659-F | | |
| G | 4 | " " | " | 3659-G | | |
| H | 8 | " " | " | 3659-H | | |
| J | 4 | " " | " | 3659-J | | |
| K | 1 | Loop | Steel | | For Cover "B" | |
| L | 12 | Bolts 1/2" × 3 1/2" | " | | " " "B" | |
| M | 28 | Bolts 3/4" × 3 1/2" | " | | For Pier Lining | |
| N | 166 | Arch Rails | C.I. | 3659-N | | |
| P | 2 | " Lining | " | C569-L | R.H. | |
| Q | 2 | " " | " | C569-M | L.H. | |
| R | 4 | " " | " | C569-E | | |
| S | 4 | " " | " | C569-F | | |
| T | 2 | " " | " | C569-G | R.H. | |
| U | 2 | " " | " | C569-H | L.H. | |
| V | 2 | " " | " | C569-J | R.H. | |
| W | 2 | " " | " | C569-K | L.H. | |
| X | 1 | Bar 3/4" × 3" × 3'-0" Lg. | Steel | | | |
| Y | 8 | Pier Lining | C.I. | C569-D | | |
| Z | 440 | Checker Plate | " | 3659-Z | | |

FIG. 5.—SHOWING DETAILS OF CONSTRUCTION IN THE FOURTH PASS.

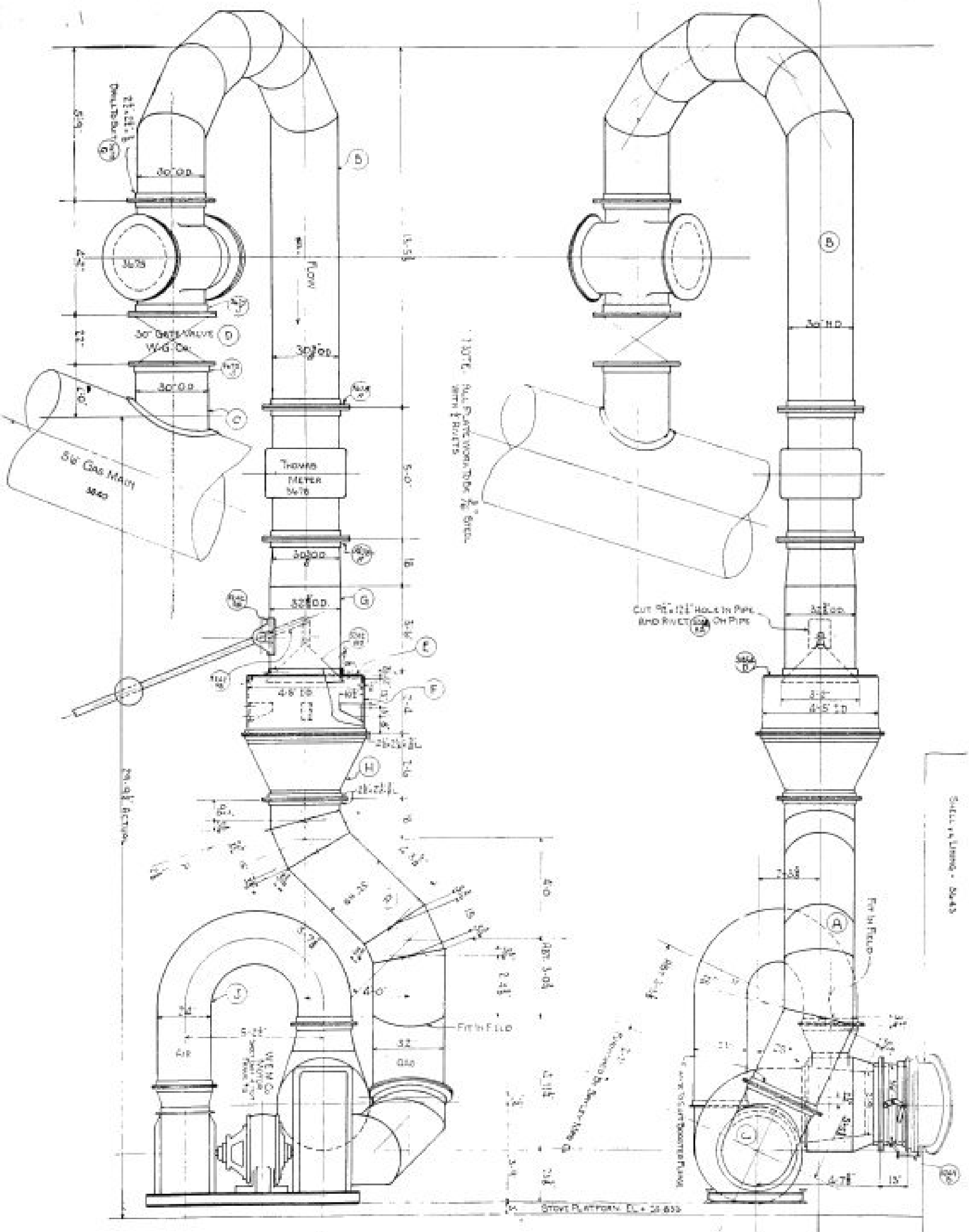


FIG. 7.—Showing General Arrangement of Pressure Burner.

shows the general arrangement of the pressure burner employed. Three stoves per furnace are provided.

Recent two-pass side-combustion stoves built with square checkers are typified by installation at the Edgar Thomson Works of the Carnegie Steel Company, at the Joliet Works of the Illinois Steel Company, at the Canton Furnace of the United Furnace Company, and at the Harbor Works of the Inland Steel Company. The oldest of these installations is that at the Edgar Thomson Works shown in Figure 8. This is a conservatively built type of stove, four stoves per furnace being provided, and the mechanical excellence and permanence have been proven by experience with this and other similar installations built about the same time. Similar stoves with 5½-inch openings and 2½-inch walls have recently been built at the same works.

Very complete tests made on the stoves shown give a thermal efficiency of 71.58 per cent., with an average blast temperature of 1119 degrees F. and 44,748 cu. ft. of air per minute.

Two-pass side-combustion stoves, as built at the Joliet Works, are shown in Figure 9. On a relatively small furnace blowing about 30,000 cu. ft. of air per minute three stoves have furnished blast temperatures up to 1200 degrees F., with stack temperatures less than 600 degrees.

A method of re-lining old stoves with small checkers, as practiced at the South Works of the Illinois Steel Company, is shown in Figures 10 and 11. These stoves are of recent construction and not fully in operation. Three of them, per furnace, are expected to furnish blast temperatures up to 1300 degrees F., with good efficiency.

New stoves, as built by the United Furnace Company, are shown in Figure 12, and as built by the Inland Steel Company in Figures 13 and 14. Three stoves per furnace are provided by both companies. These are recent installations not yet in operation.

The use of corrugated checkers in a two-pass side-combustion stove is shown in Figure 15, which illustrates the construction employed on one stove at the Joliet Works. The economy of use of these checkers is referred to above.

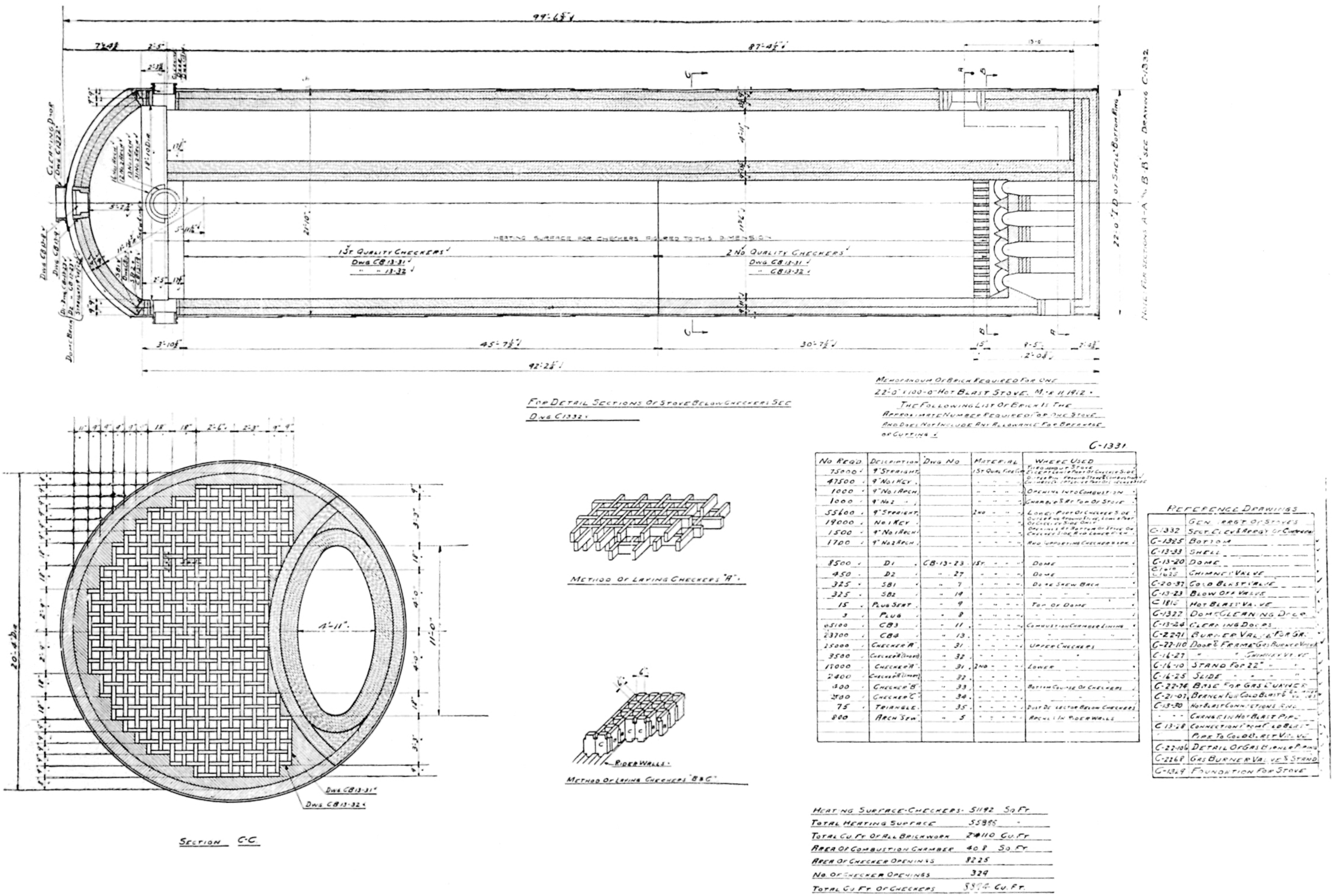



FIG. 8—SHOWING TYPE OF TWO-PASS SIDE-COMBUSTION STOVES WITH SQUARE CHECKERS, USED AT EDGAR THOMSON WORKS OF THE CARNEGIE STEEL COMPANY.

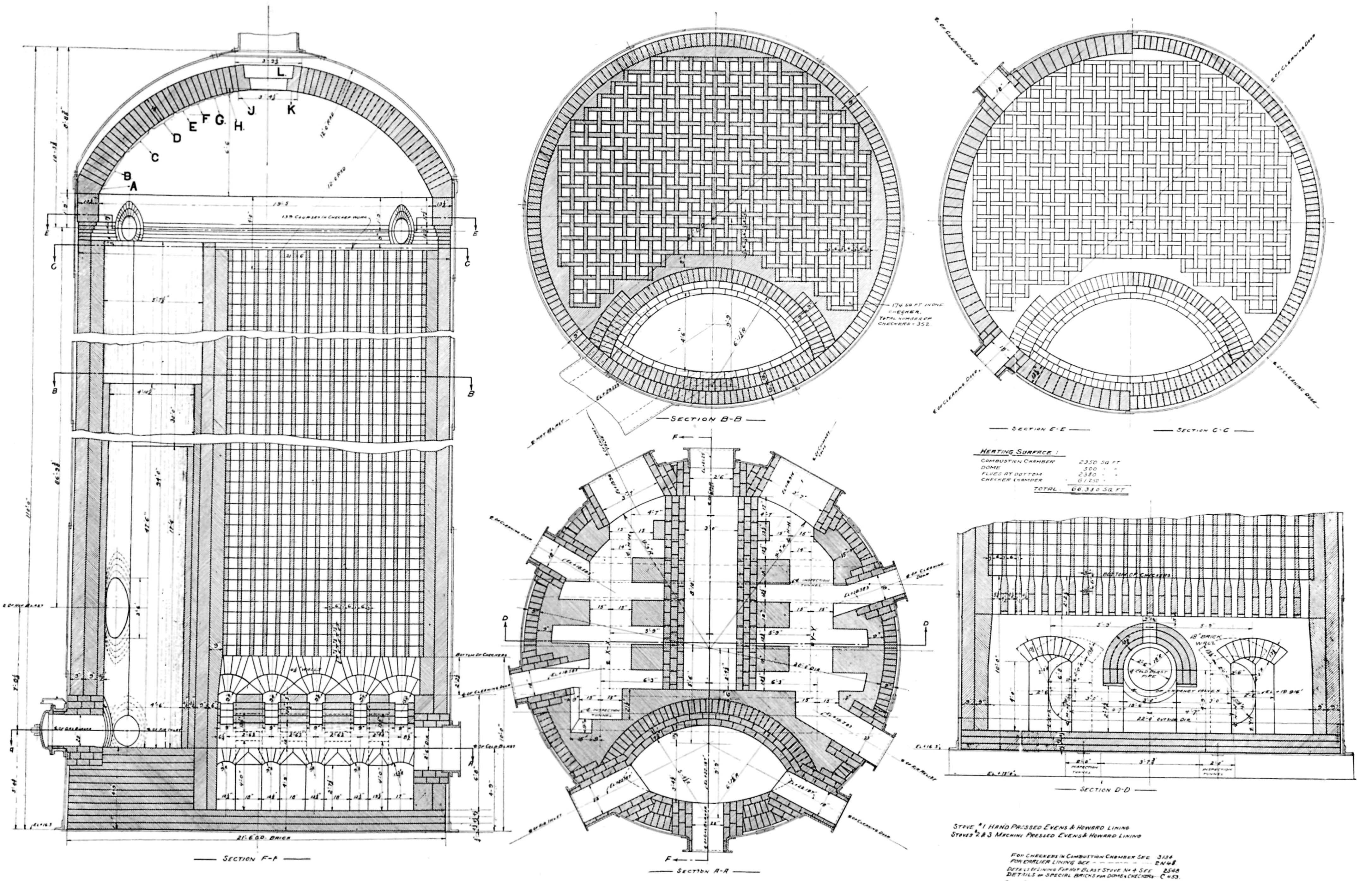



FIG. 9.—SHOWING TWO-PASS SIDE-COMBUSTION STOVES USED AT THE JOLIET WORKS OF THE ILLINOIS STEEL COMPANY.

Two-pass center-combustion stoves have recently been built by the Carnegie Steel Company at Duquesne, by the Illinois Steel Company at Joliet, and by the Gary Works of the Indiana Steel Company. The Duquesne stove is shown in Figures 16, 17 and 18.

This construction represents the re-lining of an existing stove. Test of the performance of this stove on a basis of four stoves per furnace shows a thermal efficiency of 70.3 per cent. when heating 48,555 cu. ft. of air per minute to a temperature of 1420 degrees F.

The Joliet stove, which also exemplifies the use of corrugated checkers, is shown in Figure 19. Practice results with these stoves have been fairly comparative with the side-combustion stoves at the same plant.

Three-pass stoves are exemplified by recent construction of Corrigan, McKinney & Company at their River Furnaces, Cleveland, Ohio, and by re-built three-pass stoves at the South Works of the Illinois Steel Company.

The Corrigan-McKinney Company stove, shown in Figures 20 and 21, represents standard three-pass stove construction modified by reduction in the size of the checkers. These stoves are built four per furnace.

The re-built three-pass stoves at the South Works show the application of square checkers in the second-pass to a three-pass stove. These stoves are shown in Figures 22 and 23. Four of these stoves are provided per furnace.

Very high blast temperatures have been obtained from both these designs of three-pass stoves, but data as to thermal efficiency is lacking.

Excepting the first, all of these designs of stoves are interesting chiefly in their details.

The new stoves at Joliet, however, represent an increase to a size of stove not heretofore operated, together with some novel features of design. The present stoves are rebuilt inside a shell 25 feet 0 inches by 100 feet in height, are four-pass stoves having a six-foot diameter circular side-combustion chamber, a fourth pass opposite the combustion chamber, with the second pass occupying one side of the stove and the third pass the other. Advantage has been

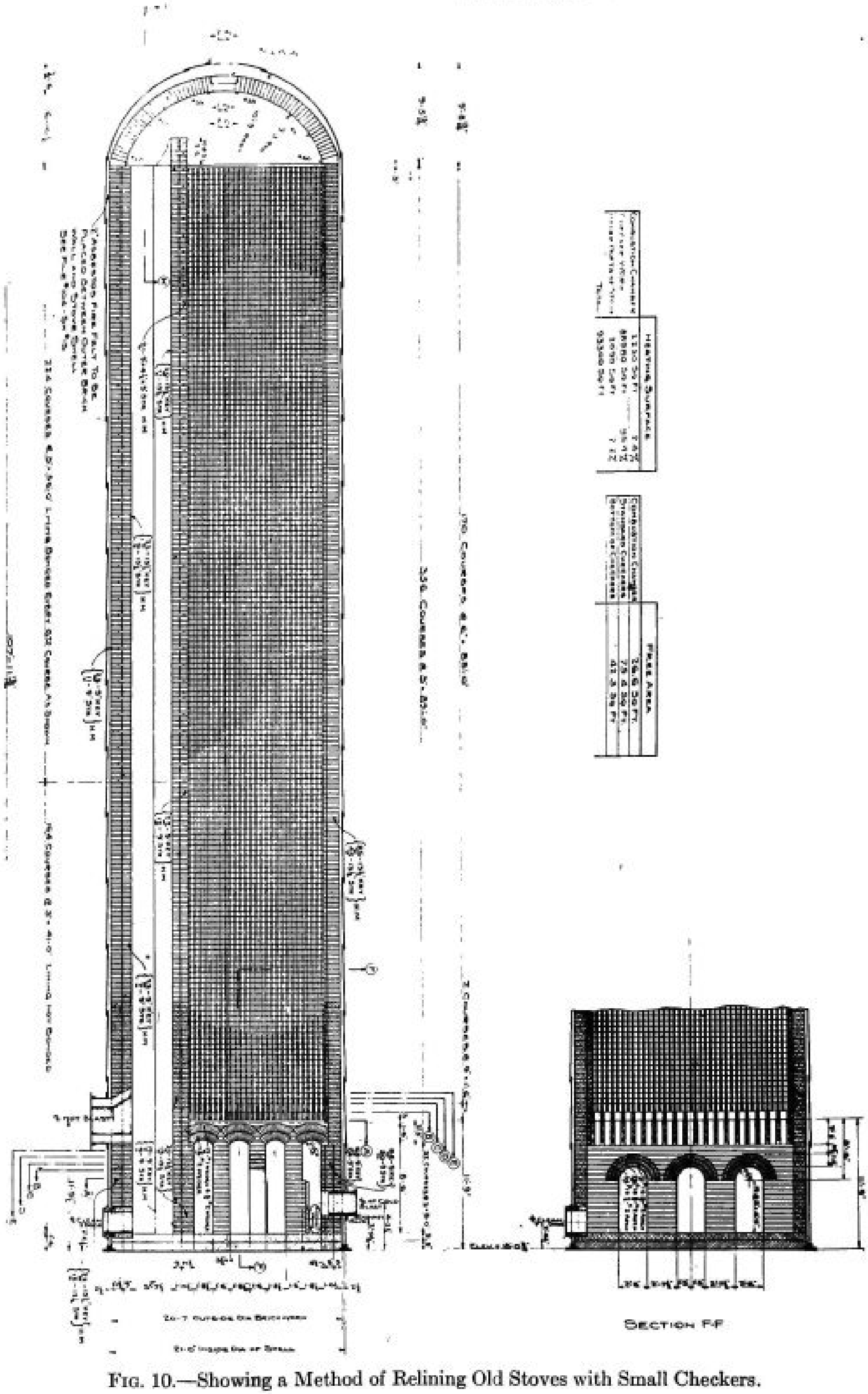



FIG. 10.—Showing a Method of Relining Old Stoves with Small Checkers.

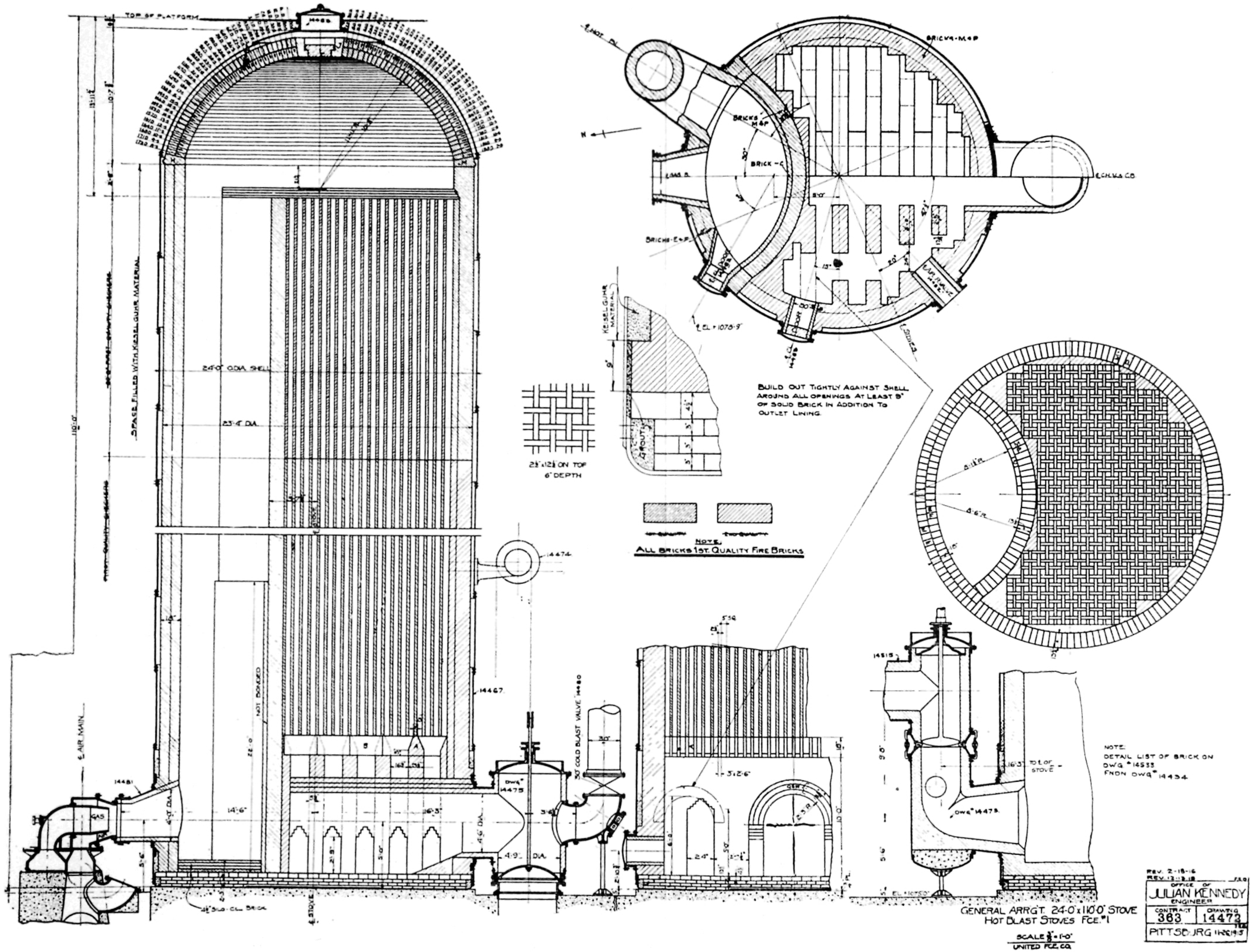



FIG. 12.—TYPE OF NEW STOVES BUILT BY THE UNITED FURNACE COMPANY AFTER DESIGNS BY JULIAN KENNEDY.

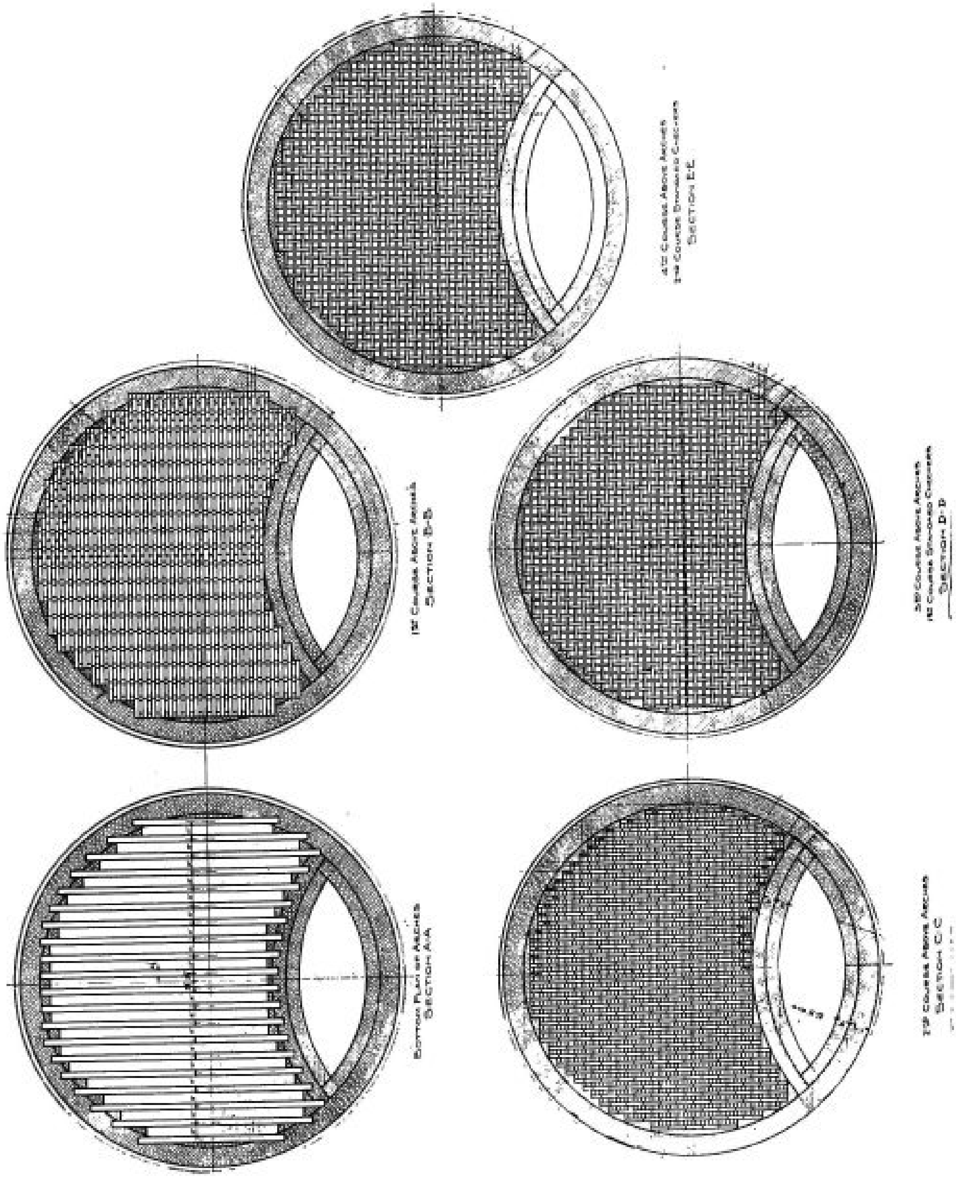


Fig. 11.—Showing Checkers Referred to in Fig. 10.

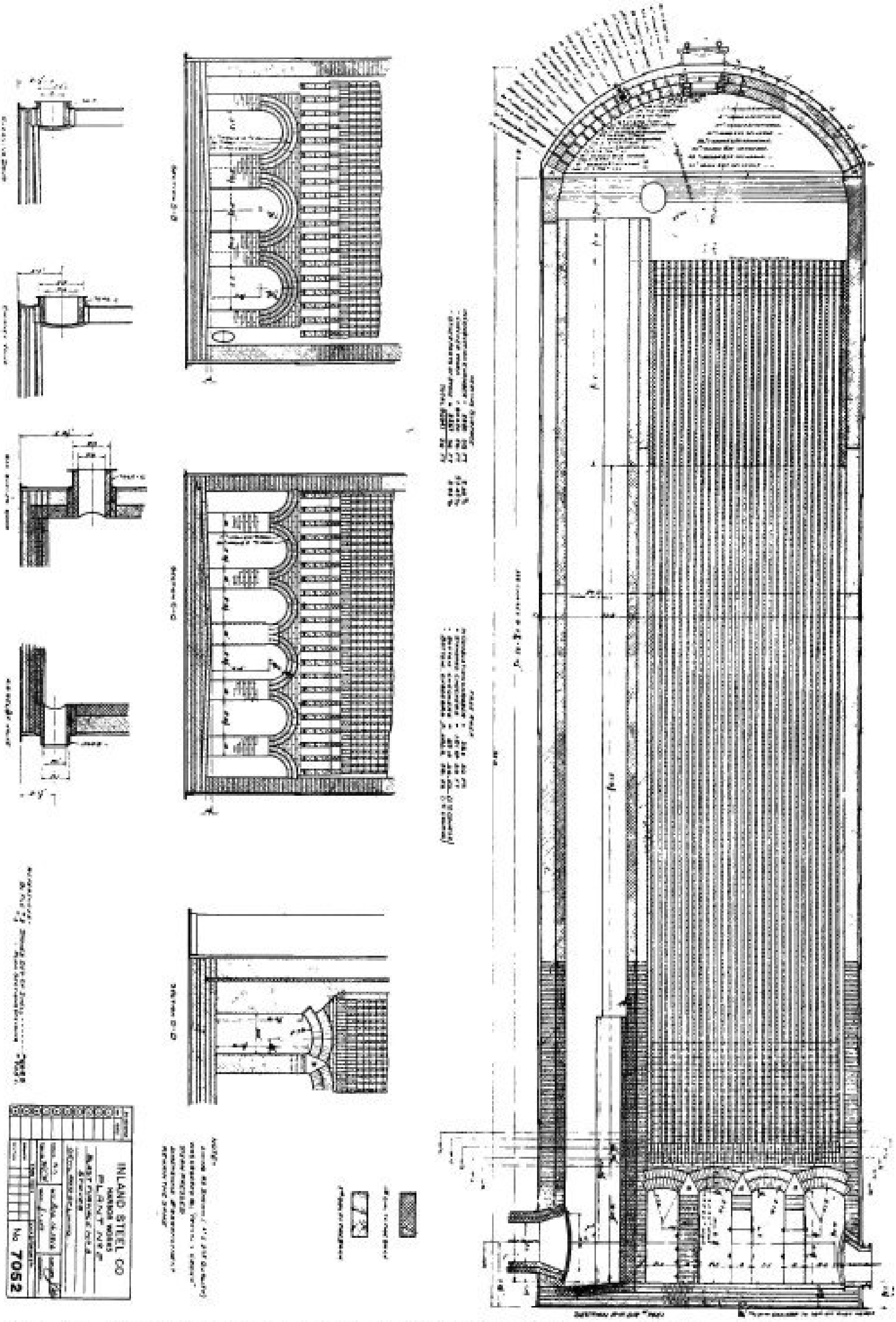


FIG. 13.—Stoves Recently Installed by the Inland Steel Company at Indiana Harbor, Indiana.

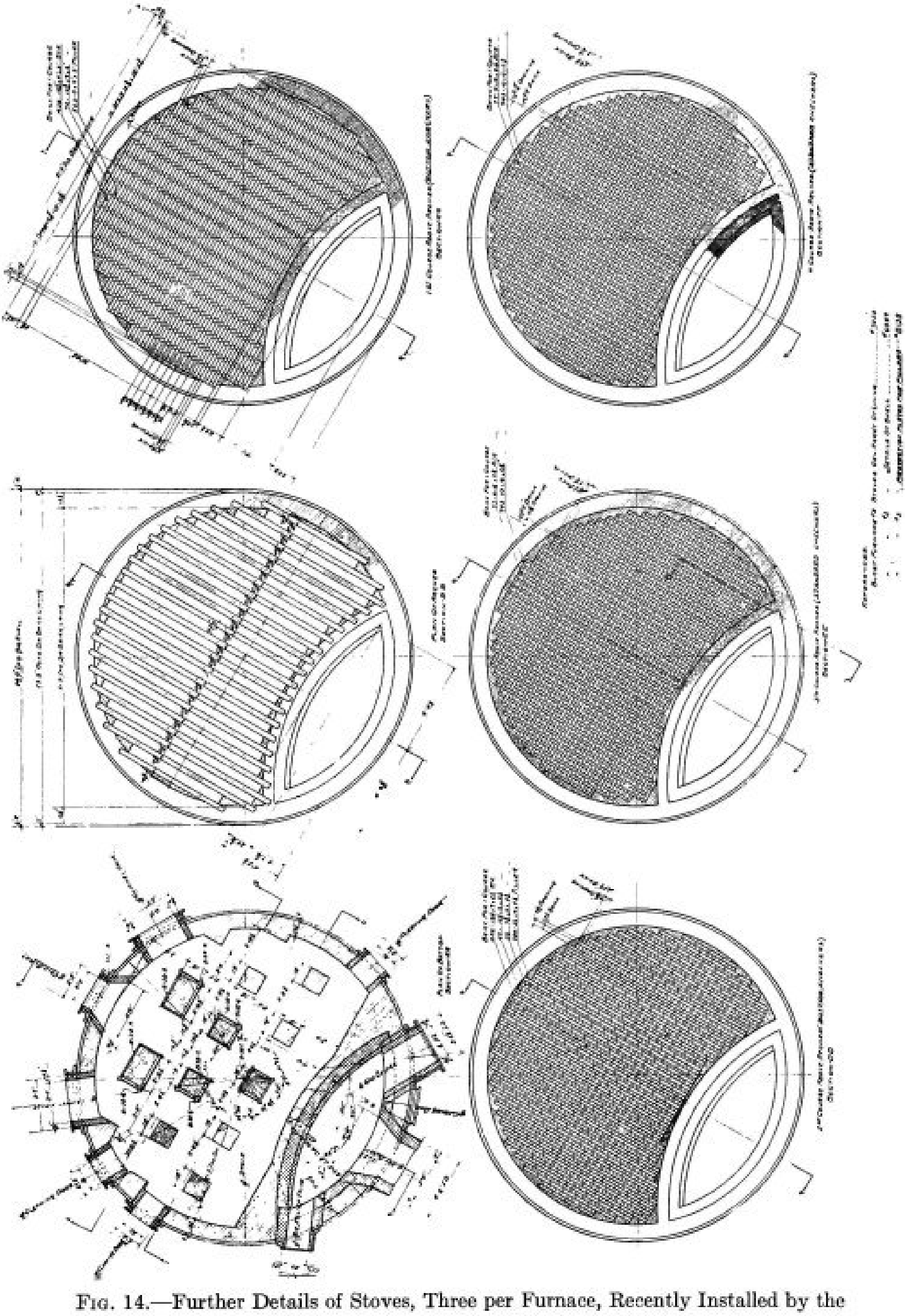


FIG. 14.—Further Details of Stoves, Three per Furnace, Recently Installed by the Inland Steel Company.

taken of the lessened temperature by reducing the size of the checkers in each successive pass after the second, the idea being not only that the volume and velocity of the gases is decreased, but that the service of the brick will be less severe. The second pass is built of 2-inch brick with 4½-inch square openings, the third pass of 2-inch brick with 3½-inch square openings, and the fourth pass of 1½-inch brick with 3-inch openings. The second pass contains 362 checkers, the third 492, and the fourth 490, the areas in the passes being, first, 28¼ sq. ft., second, 51 sq. ft., third, 41 sq. ft. and fourth, 30 sq. ft. The total heating surface is 128,500 sq. ft.

One of these stoves is capable of heating 40,000 cu. ft. of air per minute to 1300 degrees F. for two hours, with a heating period of equal length, two stoves being sufficient to heat blast at this rate. The chimney temperature for this performance is less than 300 degrees F. and the apparent thermal efficiency of the stove neglecting radiation is 92 per cent.

## Number and Size of Stoves.

The above discussion deals with the general principles in accordance with which recent stoves have been built. The specific questions that confront the designer are with regard to the total heating surface advisable in a set of stoves and its most advantageous arrangement with regard to number and length of passes per stove and number of stoves.

The demonstration by this installation at Joliet of the practicability of reducing the stack temperature almost to that of the entering blast in a set of stoves whose cost is not greatly in excess of that of stoves showing a much less efficiency, with a use of power in the fan motors corresponding roughly to only ten per cent. of the heat saving due to the lowered stack temperature, together with the ability of these stoves to furnish any required blast temperature, furnishes a new standard of stove performance which is bound to exercise a great influence on future design.

The necessity for fuel conservation which is manifesting itself in large investments for gas engines, for waste heat

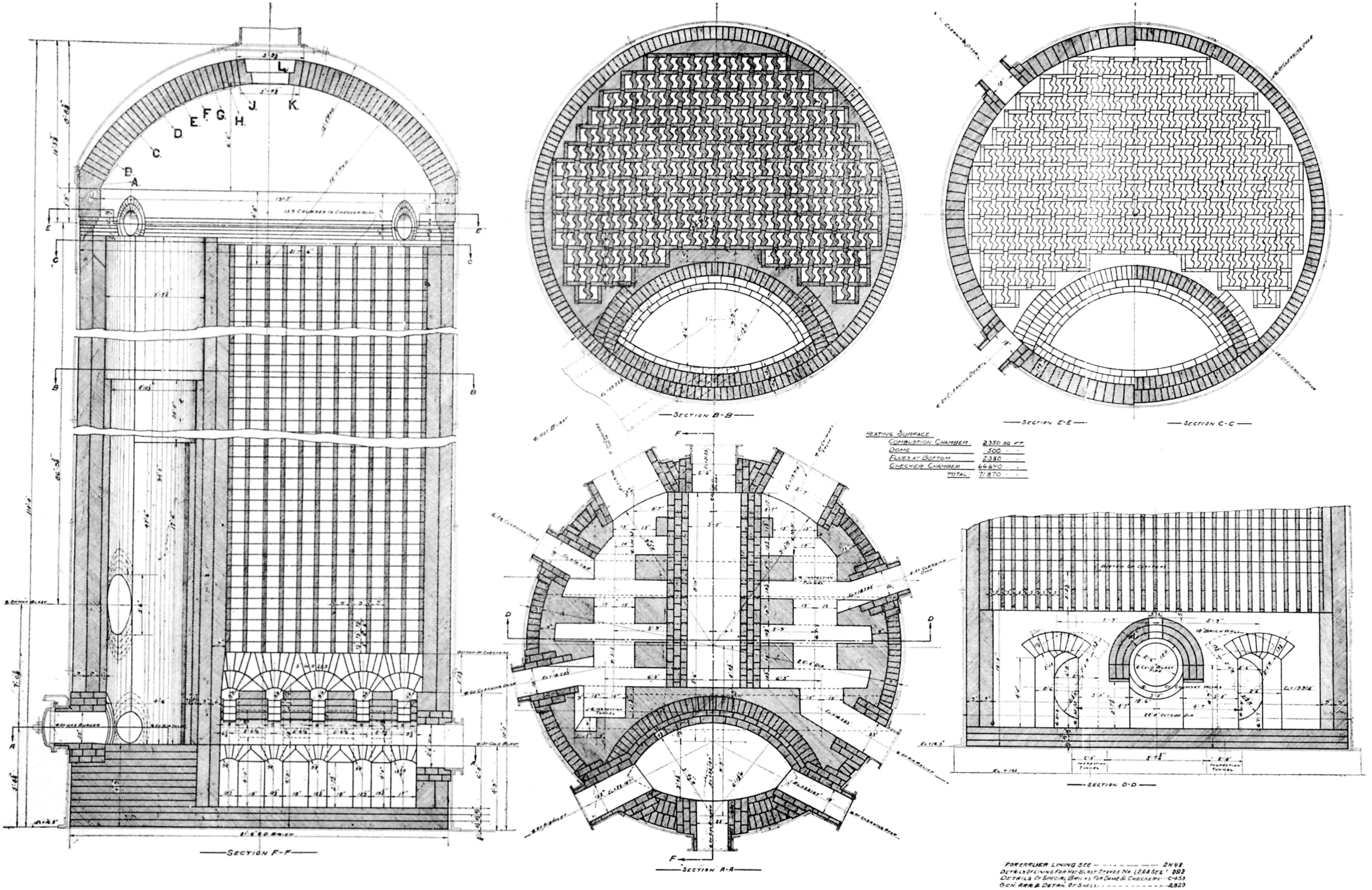
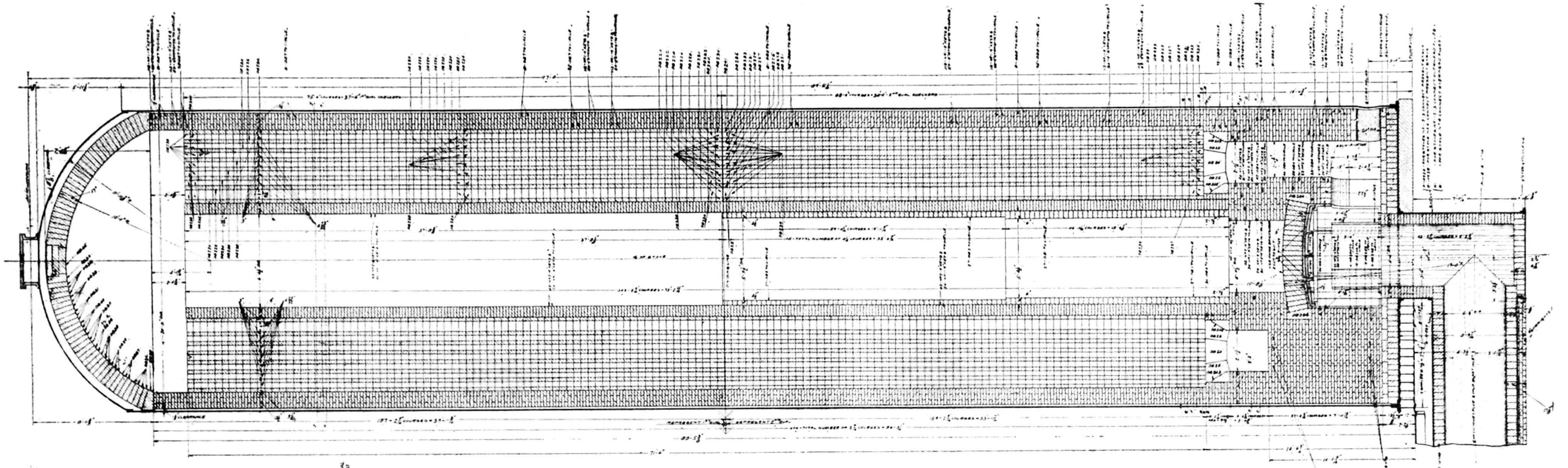



FIG. 15.—SHOWING ECONOMICAL CORRUGATED CHECKERS IN A TWO-PASS SIDE-COMBUSTION STOVE AT THE JOLIET WORKS OF THE ILLINOIS STEEL COMPANY.



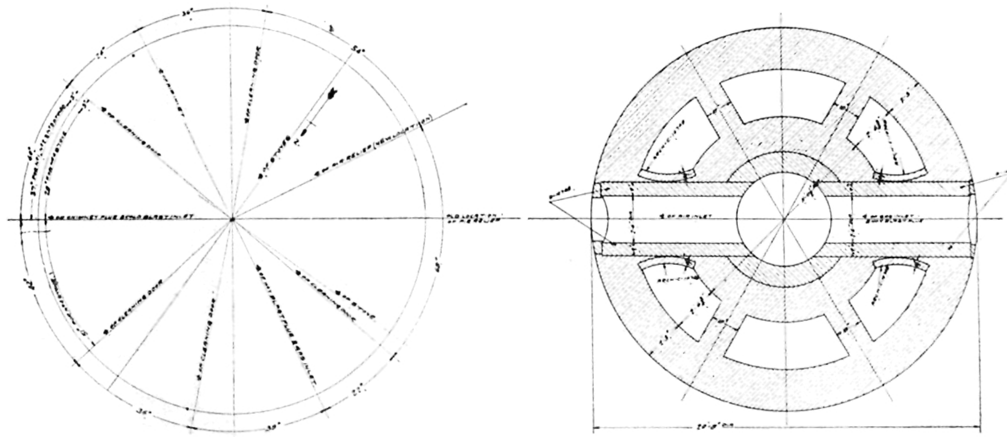
SECTION-BCDE

| ESTIMATED ACTUAL NUMBER REQUIRED FOR ONE STOVE | MARK OR DESCRIPTION | QUALITY | WHERE USED | REMARKS |
|---|---|---|---|---|
| 1,862 | DB1 | FIRST | IN COMBUSTION CHAMBER | |
| 1,833 | DB3 | FIRST | IN COMBUSTION CHAMBER | |
| 1,188 | DB4 | SECOND | IN WALL BELOW & NEAR COMBUSTION CHAMBER | |
| 16,893 | DB7 | FIRST | IN OUTSIDE WALL | |
| 8,992 | DB8 | SECOND | IN OUTSIDE WALL | |
| 48 | DB24 | SECOND | TO SUPPORT CHECKERS | |
| 72 | DB25 | SECOND | TO SUPPORT CHECKERS | |
| 48 | DB27 | SECOND | IN CLEANING DOOR | |
| 81 | DB28 | FIRST | IN DOME | |
| 240 | DB29 | FIRST | IN DOME | |
| 120 | DB30 | FIRST | IN DOME | |
| 300 | DB31 | FIRST | IN DOME | |
| [illegible] | DB32 | FIRST | IN DOME | |
| 180 | DB33 | FIRST | IN DOME | |
| 24 | DB34 | FIRST | IN DOME | |
| 5 | DB35 | FIRST | IN DOME | |
| 384 | DB36 | FIRST | IN DOME | |
| 270 | DB37 | FIRST | IN DOME | |
| 288 | DB38 | FIRST | IN DOME | |
| 170 | DB39 | FIRST | IN DOME | |
| [illegible] | DB40 | FIRST | IN DOME | |
| 1,725 | DB210 | FIRST | IN CHECKERS | |
| 1,564 | DB211 | SECOND | IN CHECKERS | |
| 3,450 | DB212 | FIRST | IN CHECKERS | |
| 3,128 | DB213 | SECOND | IN CHECKERS | |
| 3,450 | DB214 | FIRST | IN CHECKERS | |
| 3,128 | DB215 | SECOND | IN CHECKERS | |
| 3,450 | DB216 | FIRST | IN CHECKERS | |
| 3,128 | DB217 | SECOND | IN CHECKERS | |
| 3,450 | DB218 | FIRST | IN CHECKERS | |
| 3,128 | DB229 | SECOND | IN CHECKERS | |
| 3,450 | DB230 | FIRST | IN CHECKERS | |
| 3,128 | DB231 | SECOND | IN CHECKERS | |
| 3,450 | DB232 | FIRST | IN CHECKERS | |
| 3,128 | DB233 | SECOND | IN CHECKERS | |
| 5,175 | DB234 | FIRST | IN CHECKERS | |
| 4,692 | DB235 | SECOND | IN CHECKERS | |
| 1,725 | DB236 | FIRST | IN CHECKERS | |
| 1,564 | DB237 | SECOND | IN CHECKERS | |
| 10,350 | DB238 | FIRST | IN CHECKERS | |
| 9,384 | DB239 | SECOND | IN CHECKERS | |
| 1,725 | DB240 | FIRST | IN CHECKERS | |
| 1,564 | DB241 | SECOND | IN CHECKERS | |
| 48 | DB242 | SECOND | BETWEEN GIRDER TILES | |
| 72 | DB243 | SECOND | BETWEEN GIRDER TILES | |
| 81 | DB244 | SECOND | IN BOTTOM OF COMBUSTION CHAMBER | |
| 36 | DB245 | SECOND | IN WALL BELOW COMBUSTION CHAMBER | |
| 27 | DB246 | SECOND | IN WALL BELOW COMBUSTION CHAMBER | |

| ESTIMATED ACTUAL NUMBER REQUIRED FOR ONE STOVE | MARK OR DESCRIPTION | QUALITY | WHERE USED | REMARKS |
|---|---|---|---|---|
| 81 | DB247 | SECOND | IN WALL BELOW COMBUSTION CHAMBER | |
| 72 | DB248 | SECOND | IN WALL BELOW COMBUSTION CHAMBER | |
| 72 | DB249 | SECOND | IN WALL BELOW COMBUSTION CHAMBER | |
| 36 | DB250 | SECOND | IN WALL BELOW COMBUSTION CHAMBER | |
| 72 | DB251 | SECOND | IN WALL BELOW COMBUSTION CHAMBER | |
| 69 | DB252 | SECOND | IN WALL BELOW COMBUSTION CHAMBER | |
| 540 | DB44 | FIRST | IN BOTTOM OF COMBUSTION CHAMBER | |
| 8,121 | NT1-9" KEY [illegible] | FIRST | IN COMBUSTION CHAMBER | |
| 19,797 | NT2-9" KEY [illegible] | FIRST | IN COMBUSTION CHAMBER | |
| 648 | NT1-6" KEY [illegible] | FIRST | IN WALL BELOW COMBUSTION CHAMBER | |
| 430 | NT2-9" KEY [illegible] | FIRST | IN WALL BELOW COMBUSTION CHAMBER | |
| 26,131 | NT1-9" KEY [illegible] | FIRST | OUTSIDE WALL | |
| 440 | NT2-13½" KEY [illegible] | FIRST | IN WALL BELOW COMBUSTION CHAMBER | |
| 279 | NT3-9" KEY [illegible] | FIRST | IN WALL BELOW COMBUSTION CHAMBER | |
| 10,462 | 9" STRAIGHTS [illegible] | FIRST | IN OUTSIDE WALL | |
| 960 | NT1-ARCH [illegible] | FIRST | IN AIR & GAS FLUE | |
| 1,296 | NT1-ARCH [illegible] | FIRST | IN AIR & GAS FLUE | |
| 33,423 | NT1-9" KEY [illegible] | SECOND | IN OUTSIDE WALL | |
| 2,289 | NT1-9" KEY [illegible] | SECOND | IN WALL BELOW COMBUSTION CHAMB. | |
| 16,483 | 9" STRAIGHTS [illegible] | SECOND | IN OUTSIDE WALL | |
| 1,632 | NT1-9" KEY [illegible] | SECOND | IN WALL BELOW COMBUST. CHAMBER | |
| 3,724 | 9" STRAIGHTS [illegible] | SECOND | IN RADIAL SUPPORTING WALLS | |
| 1,972 | 9" STRAIGHTS [illegible] | SECOND | IN RADIAL SUPPORTING WALLS | |
| 5,990 | 9" STRAIGHTS [illegible] | SECOND | IN BOTTOM OF STOVE | |
| 1,400 | NT2-9" KEY [illegible] | SECOND | IN CHIMNEY FLUE | |
| 890 | NT3-9" KEY [illegible] | SECOND | IN CHIMNEY FLUE | |
| 492 | 9" STRAIGHTS [illegible] | SECOND | IN CHIMNEY FLUE | |
| 540 | NT2-ARCH [illegible] | SECOND | IN CLEANING DOORS | |
| 180 | NT1-WEDGE [illegible] | SECOND | IN ARCH BELOW COMBUSTION CHAMB. | |
| 720 | NT2-WEDGE [illegible] | SECOND | IN ARCH BELOW COMBUSTION CHAMB. | |
| 84 | 9" STRAIGHTS [illegible] | SECOND | IN ARCH TO SUPPORT GAS & AIR FLUE | |
| 48 | NT1-ARCH [illegible] | SECOND | IN ARCH TO SUPPORT GAS & AIR FLUE | |
| [illegible] 960 | 9" STRAIGHTS [illegible] | RIVER BRICK | IN WALL SUPPORTING CHIMNEY FLUE | NOT REQ'D FOR RELINING AFTER FIRST INSTALLATION |
| [illegible] 4,500 | 9" STRAIGHTS [illegible] | RIVER BRICK | IN BEAM SUPPORTING WALLS | NOT REQ'D FOR RELINING AFTER FIRST INSTALLATION |
| 3,680 | NT1-WEDGE [illegible] | SECOND | IN CHIMNEY FLUE | |
| 220 | NT2-WEDGE [illegible] | SECOND | IN CHIMNEY FLUE | |

1220
1225

DB 253
DB-254



GEN ARR'G'T OF STOVES NO. 1-2-3 & 4 FOR BLAST PIPE NO. 4 - AS SHOWN.
GEN ARR'G'T OF STOVES NO. 1-2-3 & 4 FOR BLAST PIPE NO. 3 - OPP. HAND.

SECTION THROUGH GAS & AIR INLET

CUBIC FEET OF BRICKWORK IN ONE STOVE

| | |
|---|---|
| IN COMBUSTION CHAMBER WALL | 1,651.3 |
| IN CHECKERS | 5,817.2 |
| IN GIRDER TILES & BRICKS BETWEEN | [illegible] |
| IN DOME | 451.4 |
| IN OUTSIDE WALL | 4,574.1 |
| IN WALL BETWEEN GIRDER TILES & COMB. CHAMBER | 17.0 |
| IN WALL BELOW COMBUSTION CHAMBER | 497.7 |
| IN RADIAL WALLS | 242.9 |
| IN DOME BELOW COMBUSTION CHAMBER | 45.0 |
| IN GAS & HOT BLAST FLUES | 137.8 |
| IN BOTTOM | 360.8 |
| TOTAL = | 13,068.1 CU. FT. |

HEATING SURFACE FOR ONE STOVE IN SQUARE FEET

| | |
|---|---|
| IN COMBUSTION CHAMBER | 1,516.4 |
| IN CHECKERS | 52,963.4 |
| IN GIRDER TILES & BRICKS BETWEEN | 712.7 |
| IN DOME | 378.5 |
| IN OUTSIDE WALL | 573.9 |
| IN WALL BELOW COMBUSTION CHAMBER | 265.9 |
| IN RADIAL WALLS | 242.4 |
| IN BOTTOM | 139.6 |
| TOTAL = | 56,750.2 SQ. FT. |

FIG. 16.—SHOWING TWO-PASS CENTER-COMBUSTION STOVES RECENTLY BUILT BY THE CARNEGIE STEEL COMPANY AT DUQUESNE WORKS.

boilers operated by the waste gases both from gas engines and from open-hearth furnaces, and for the fullest use of the gas from coke ovens, is equally urgent in compelling not only the use of high blast temperatures, but the greatest possible

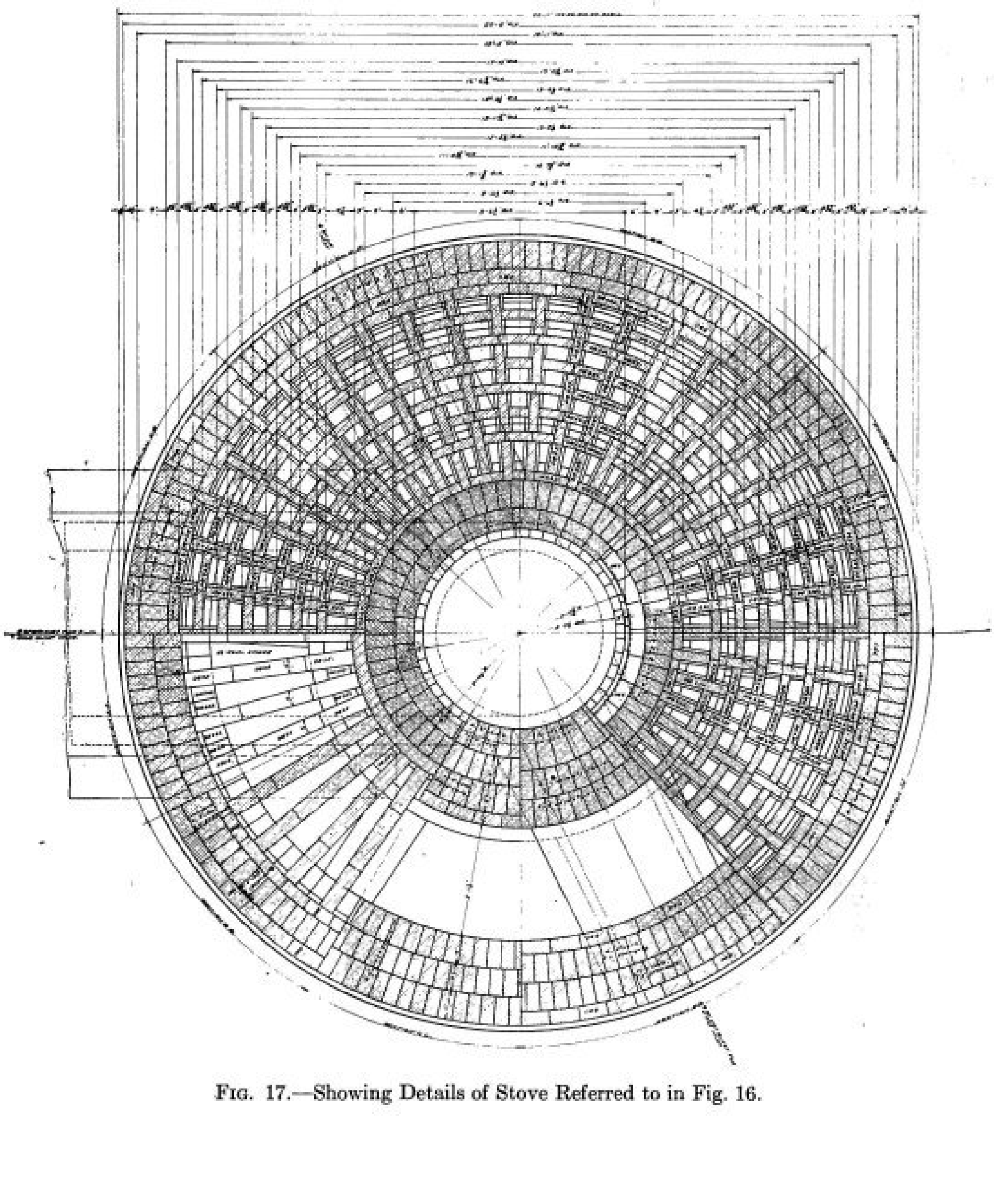


Fig. 17.—Showing Details of Stove Referred to in Fig. 16.

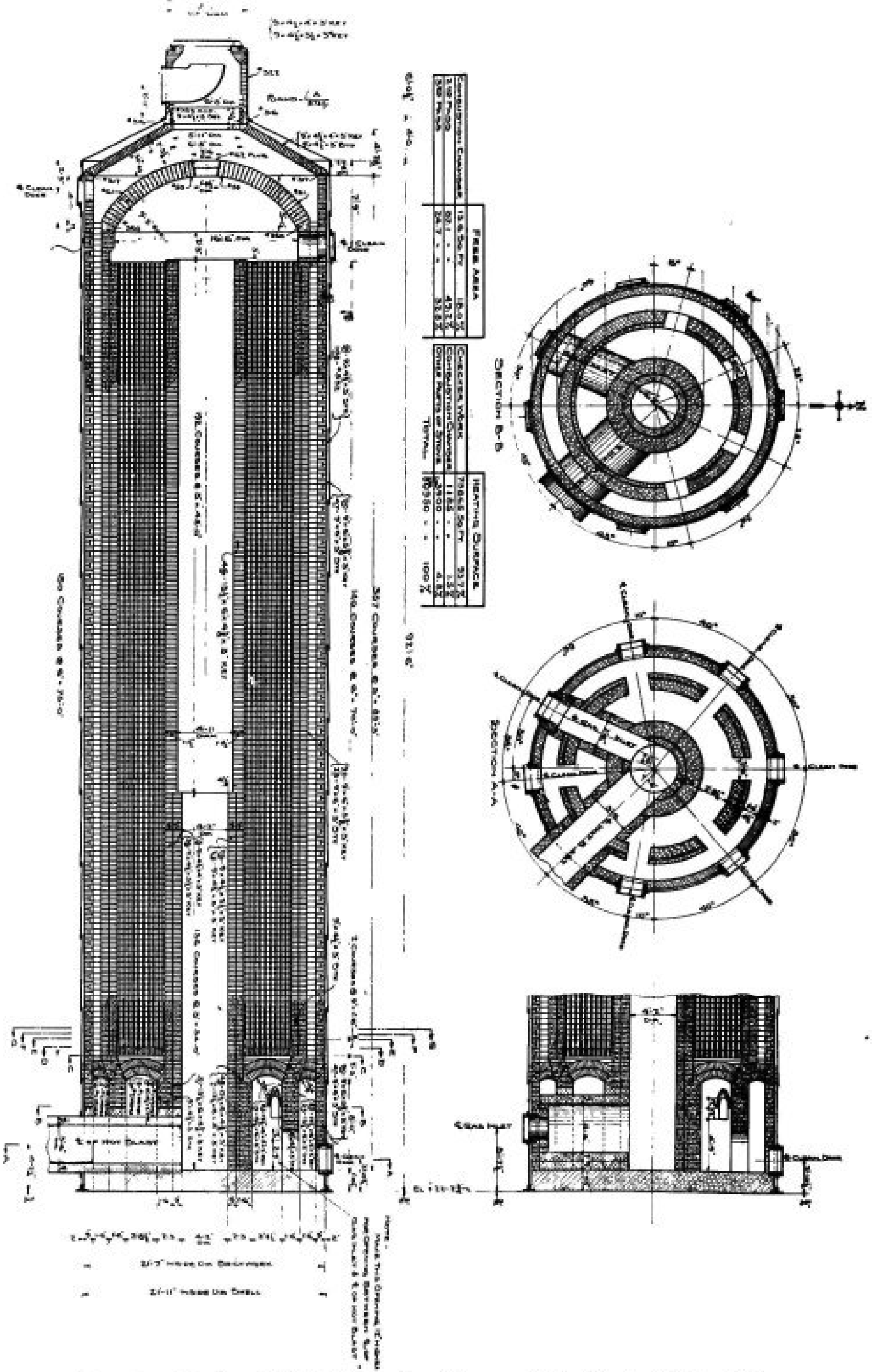


FIG. 22.—Showing Rebuilt Three-Pass Stoves at the South Works of the Illinois Steel Company. Checkers Shown in Fig. 23.

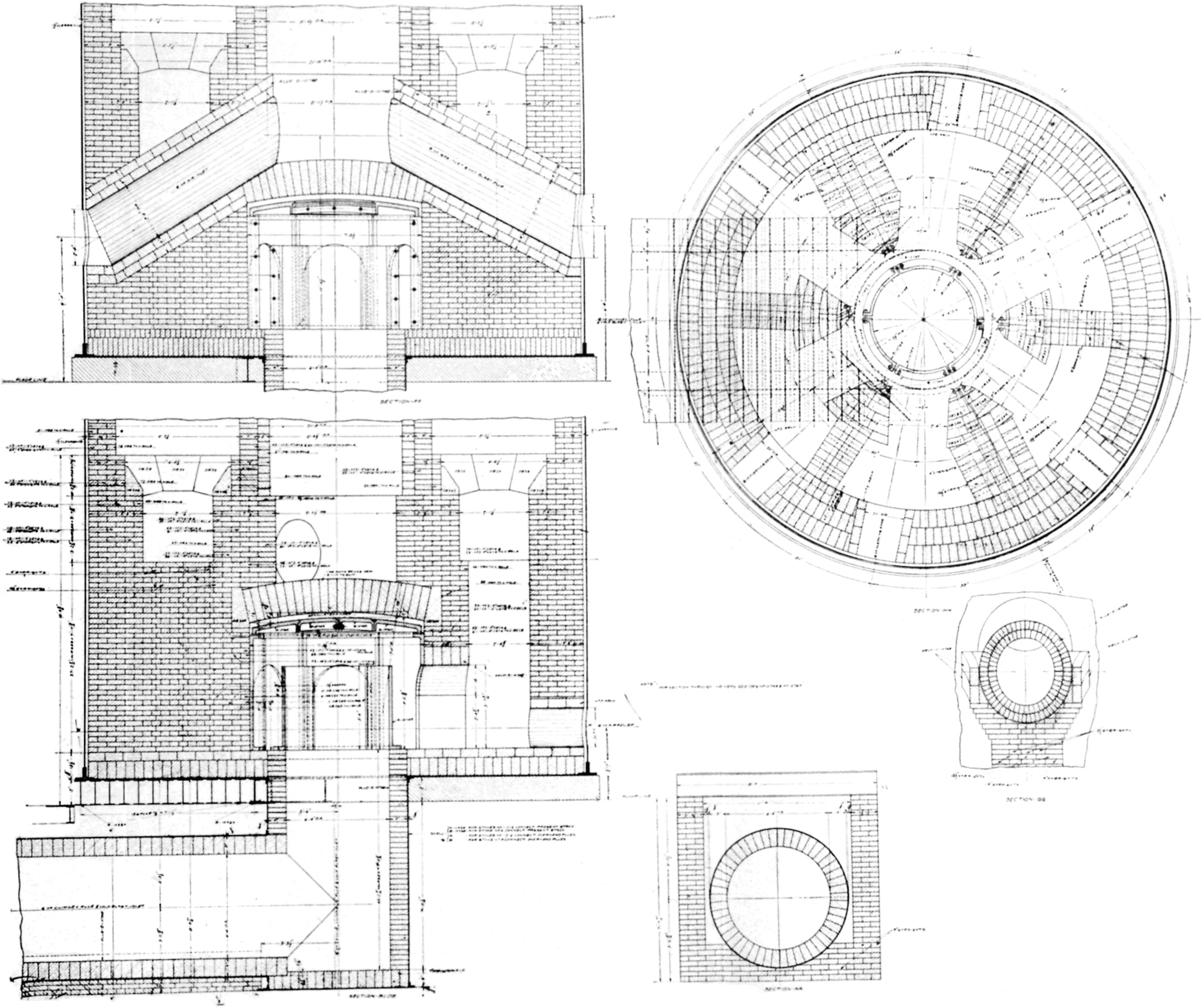


FIG. 18.—SHOWING FURTHER DETAILS OF STOVE REFERRED TO IN FIG. 16.

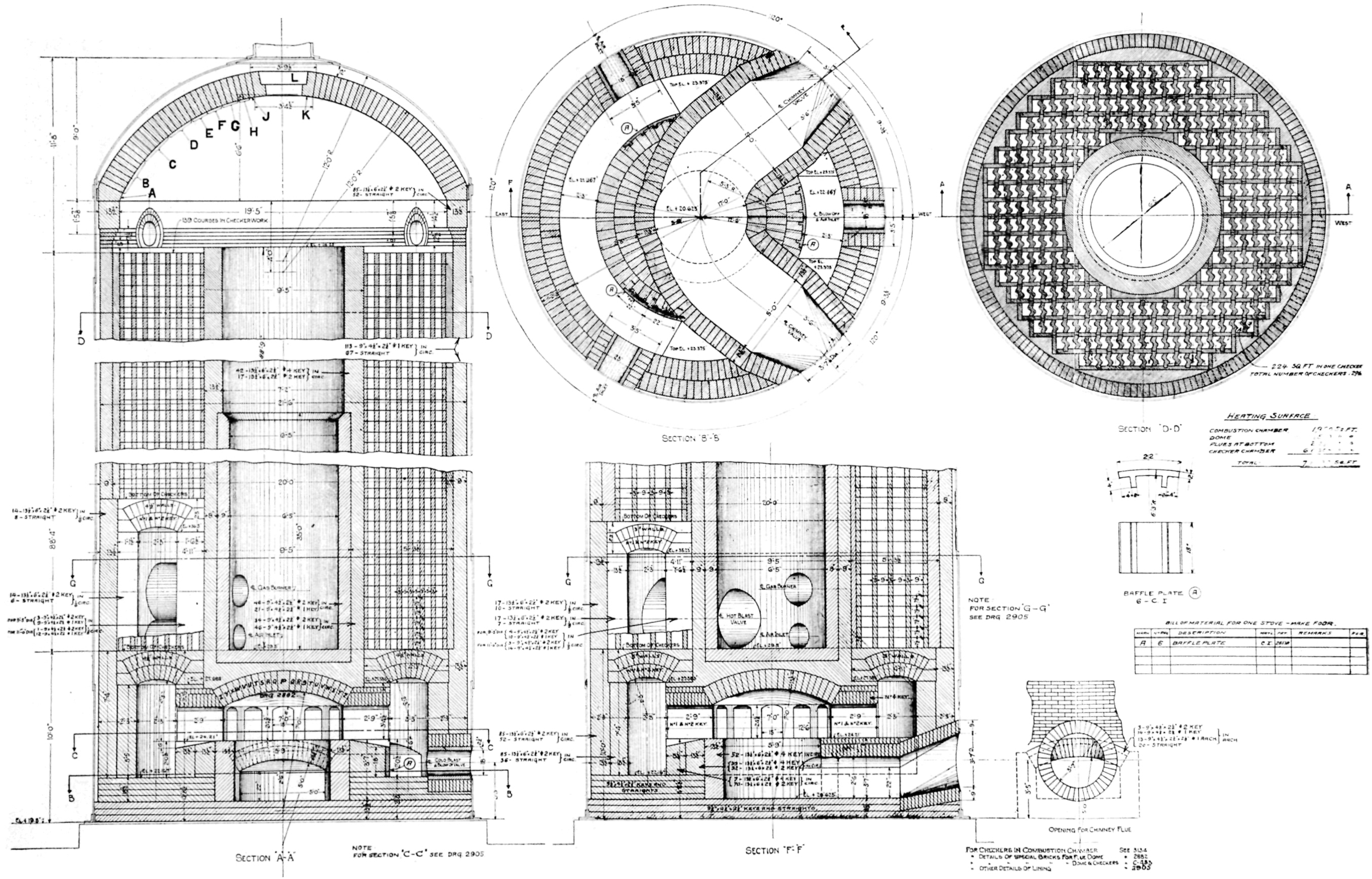



FIG. 19.—SHOWING STOVE WITH CORRUGATED CHECKERS USED AT JOLIET WORKS OF THE ILLINOIS STEEL COMPANY.

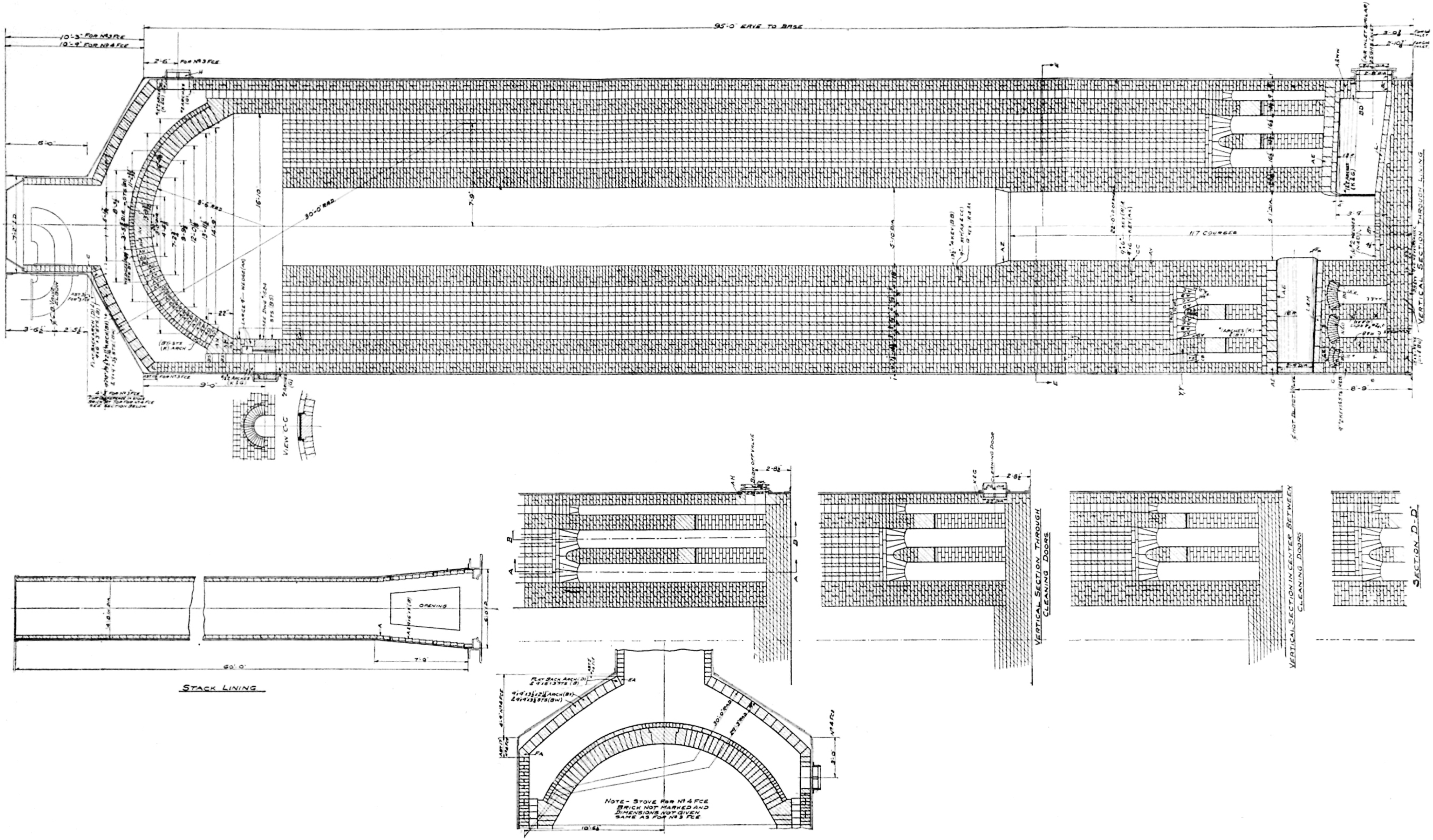



FIG. 20.—THREE-PASS STOVES RECENTLY CONSTRUCTED BY CORRIGAN, McKINNEY & COMPANY, CLEVELAND.

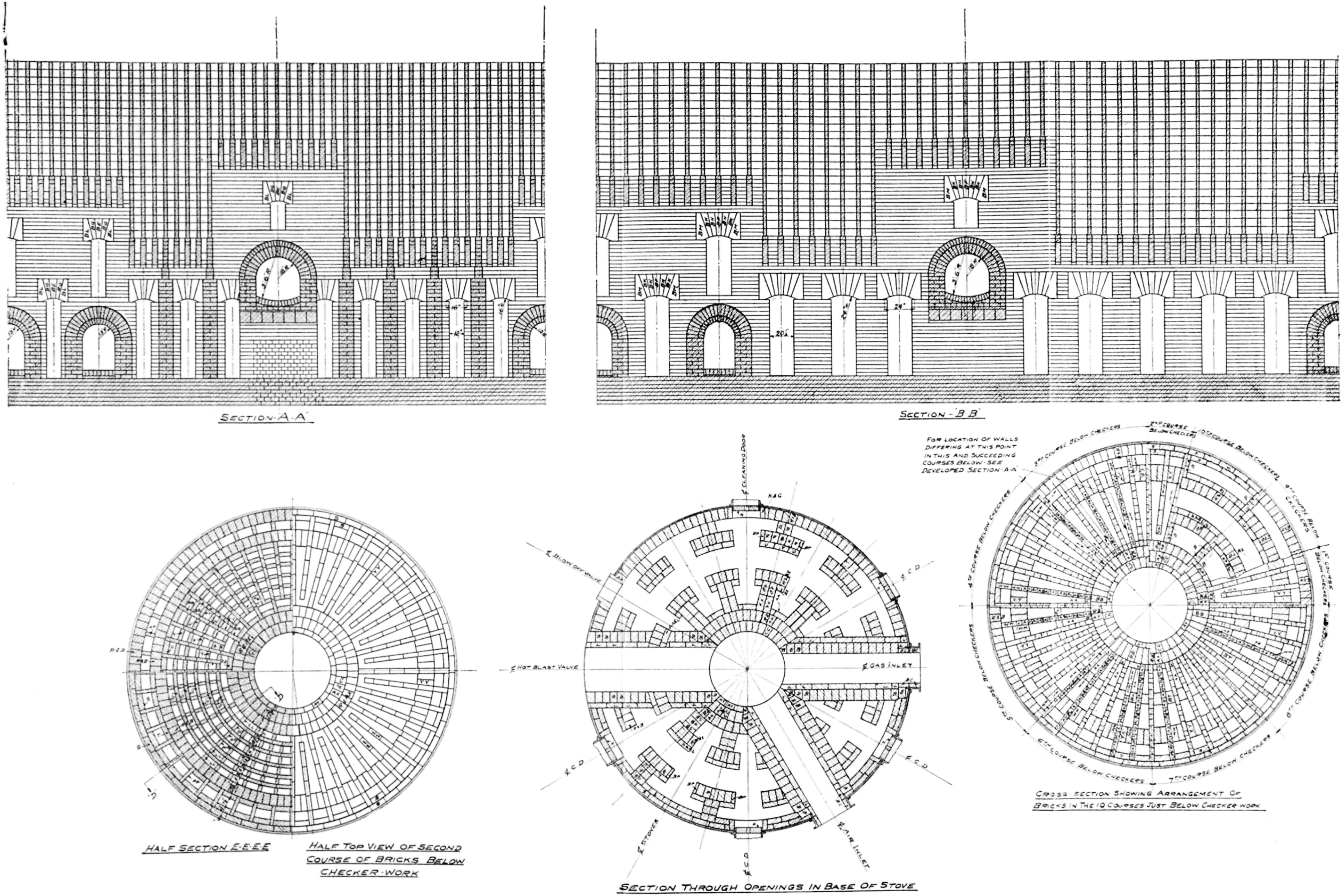



FIG. 21.—DETAILS OF STOVES SHOWN IN FIG. 20.

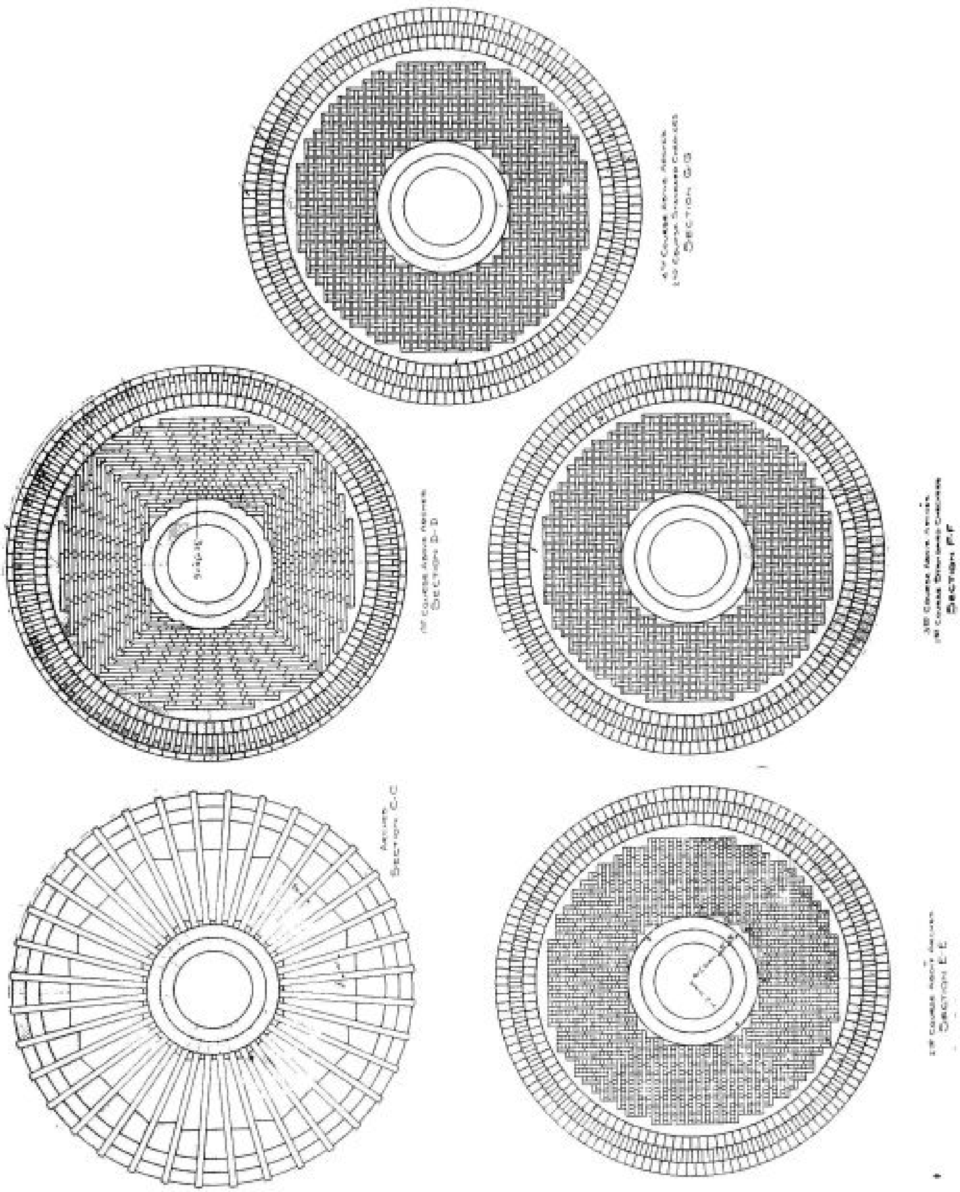


FIG. 23.—Showing Application of Square Checkers in Second Pass to a Three Pass Stove Referred to in Fig. 22.

economy in their generation. The heat actually transmitted to the blast of a modern furnace is about the same as that transmitted to the water in a boiler plant generating 1,500 boiler horse power. The same reasoning which has required higher efficiency of the boiler, and which has in some cases condemned the steam plant for lack of efficiency, will require the highest practicable efficiency from the hot blast stove.

All available data point to the conclusion that a given heating surface is best arranged both for heat and for economy when grouped in the fewest practicable units of large size. The chief argument for four stoves is the lessened interruption to operation if a stove goes out of service. On the other hand with only two stoves the furnace shuts down if one stove goes out of service, and a two-stove equipment will not come for many years, if it comes at all. The three-stove layout, however, is elastic enough to prevent severe crippling of the furnace operation when one stove comes off, particularly if it is practicable to force the remaining stove, and in all respects, excepting elasticity in operation, it is better than an outfit consisting of four stoves. There is, accordingly, a present tendency to build three stoves per furnace.

With regard to the size of the units, the information at hand seems to indicate that a heating surface of 100,000 sq. ft. per stove for three stoves is sufficient for all purposes, although this is necessarily a tentative figure. Such a surface can be contained within a stove of reasonable proportions with any checker sizes now in use, and of ordinary dimensions if the smaller sizes are employed.

There is no present conclusive reason for advocating one type of stove over another. Two-pass stoves will continue in favor on account of their mechanical simplicity, unless the advantage of length of pass and increased velocity of air and gas in the stove as exemplified in the Joliet installation prove a conclusive reason for changing to a greater number of passes. There are at present no data on which to base a prediction in this regard.

The same uncertainty exists as to the relative advantage of increased height or increased diameter in a two-pass stove. From the standpoint of first cost based on economical use of materials and of space inside the shell, the advantage is in favor of larger diameter. It is improbable that height will be reduced, but any considerable increase in height will require the same reasons that would apply in favor of a four-pass stove.

Recent development may therefore be said to have taken form to date in increase in the capacity of units and a reduction in their number, together with the application of scientific methods to their operation.

Blast-furnace men are united in looking upon this development as a most promising one for the improvement of their metallurgical practice.

VICE-PRESIDENT KING: A discussion of this paper was prepared by R. J. Wysor, of the Bethlehem Steel Company, South Bethlehem, Pennsylvania, and will be read by the Secretary.

# PROGRESS IN HOT BLAST STOVE DESIGN

DISCUSSION BY RUFUS J. WYSOR

Superintendent, Blast Furnaces, Bethlehem Steel Company,
South Bethlehem, Pa.

Until very recently, as indicated in Mr. Boynton's paper, improvement in hot blast stove design lagged behind progress in construction of the furnace itself.

Especially in modern blast furnace plants directly connected with steel works, there is a dual problem confronting the hot blast stove. On the one hand, improved furnace lines and better conditioned stock have permitted the use of higher blast heats, while on the other, the demand for gas for engines and boilers has become increasingly insistent. In brief, the present desired function of the stove is to produce more heat with less gas consumption. To meet this demand, the active co-operation of the combustion engineer and the mechanical engineer is required, the solution requiring both expert theoretical and practical knowledge.

The first half of the problem was solved at Bethlehem years ago by the construction of a battery of five standard three-pass stoves, using washed gas. The hard eastern and foreign magnetite ores, which have always constituted the bulk of our ore mixtures, permit the use of the highest blast heats, which practically can be attained. Our "straight line" hot blast temperature, in normal practice, will average well up to 1,400 degrees F.

The question of insulation of stoves and hot blast system, almost unheard of until about two years ago, is now receiving the attention it deserves. Preventing the loss of 5 to 10 per cent. of the heat developed, or what is more to the point, conserving the peaks of the temperature curves, is a strike for efficiency of no small moment. About four years ago we began experimenting at Bethlehem with various materials for hot blast main and stove insulation. At the first opportunity a section of a hot blast main was insulated

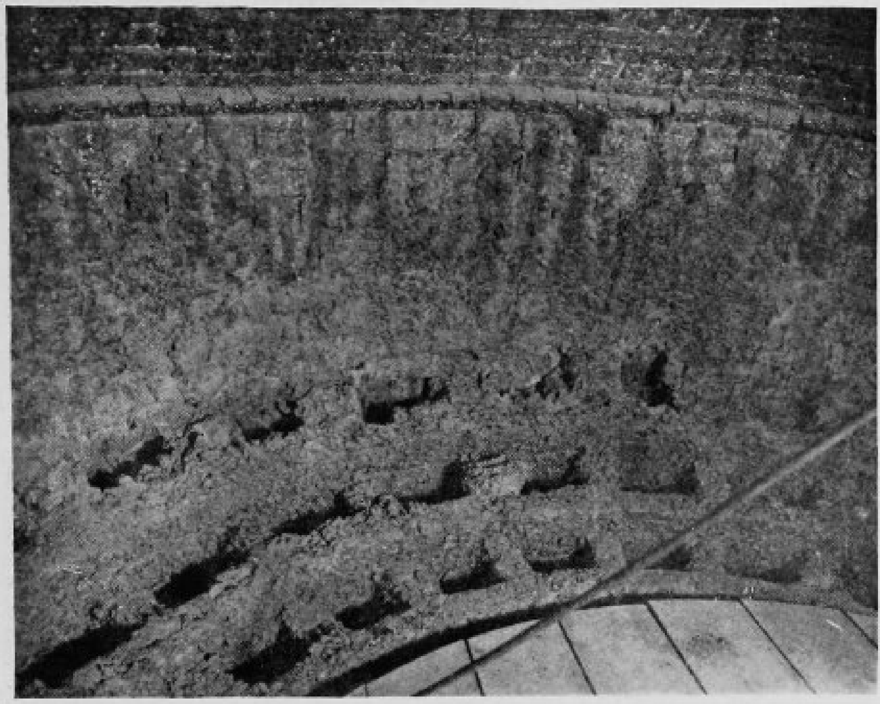


FIG. 1.—Showing effect of alkaline dust in imperfectly washed gas on second pass checkers of a 3-pass stove

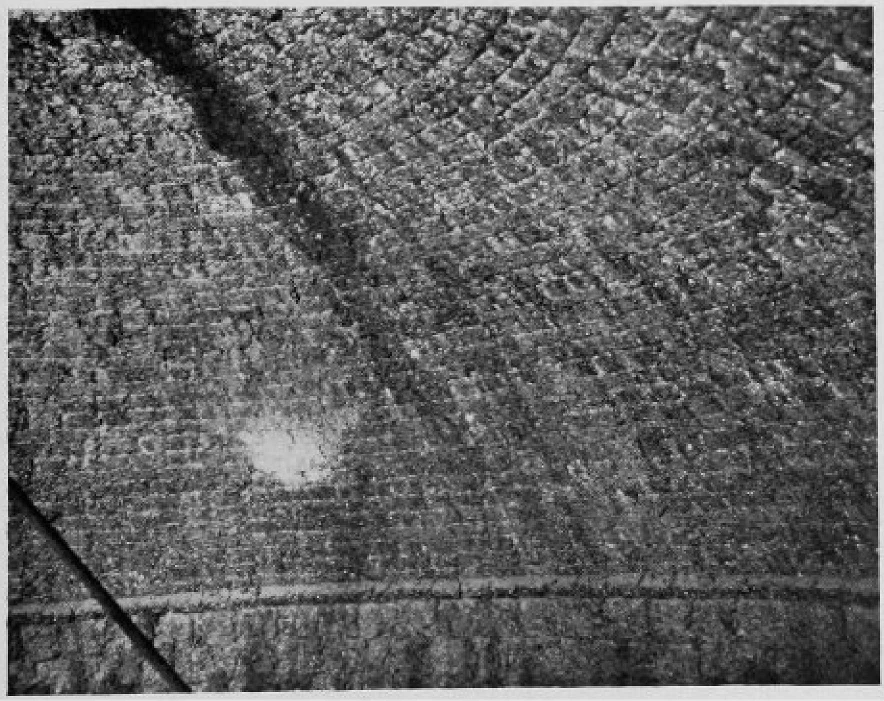


FIG. 2.—Dome above checkers shown in Fig. 1, illustrating fluxing action of alkaline dust on brick, and especially on fire clay joints

internally with a special brick, this being one of the earliest, if not the first experiment of the kind in this country. At a new furnace, now being built, the four stoves, stove necks, hot blast main and bustle pipe are being insulated throughout—the stoves in part with packed diatomáceous earth alone, and in part with insulating brick with insulating earth in the packing space, for direct comparison—the remainder of the hot blast system with manufactured kieselguhr brick.

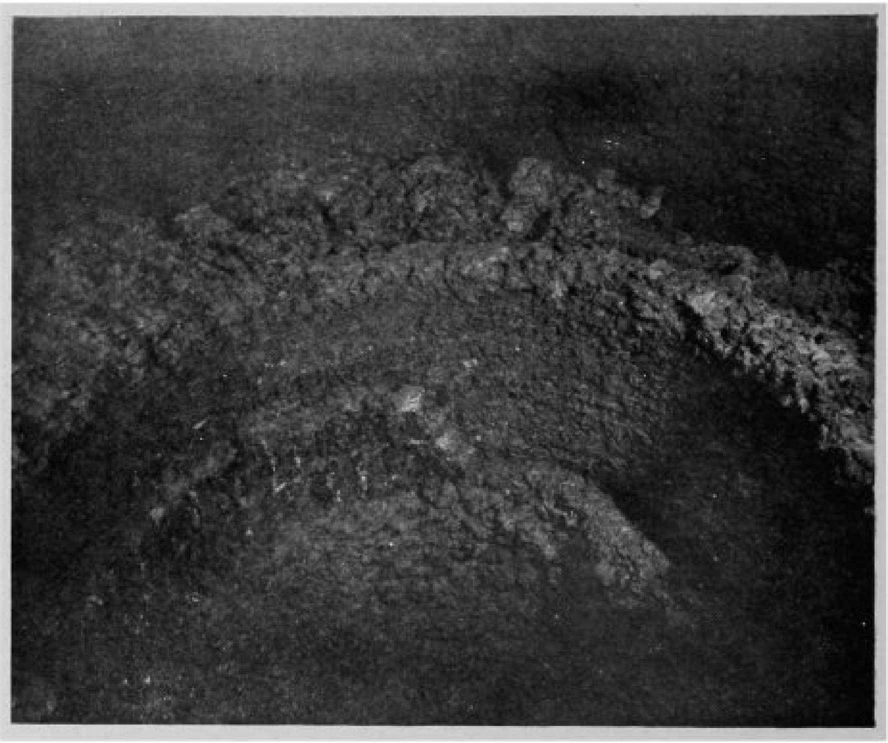


FIG. 3.—Showing a similar but worse condition in checkers than illustrated in Fig. 1

We are building four of these new stoves, of the same three-pass type, with small radial checkers, the minimum checker openings being approximately 4½ inches. The heating surface of these stoves will be about 81,000 square feet, an increase of over 50 per cent. over the old stoves of the same external dimensions. One reason for not attempting

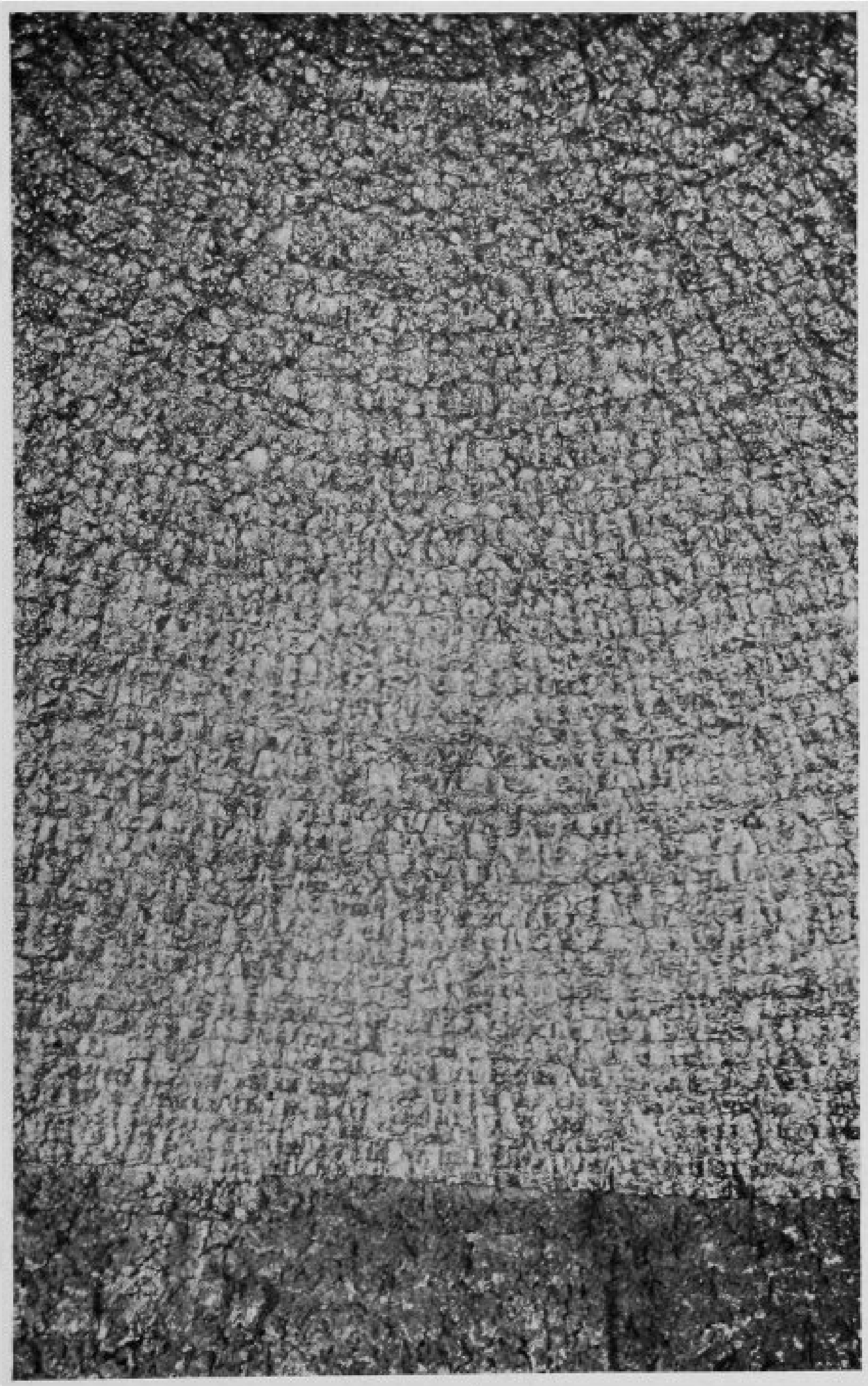


Fig. 4.—Dome above checkers illustrated in Fig. 3

still smaller checker openings is the fear of possible clogging of the openings, or destruction of the small brick by flue dust, in spite of good primary washers. In our practice an unusual quantity of fine fume, low in iron oxide but rich in alkali content, is produced, which is imperfectly removed by ordinary wet washers. No comparative amount of such fume is produced anywhere in the West, except in the manufacture of ferro-manganese of spiegel. The alkalies in this dust will flux the surface or honeycomb the entire brick causing its disintegration. The fire-clay joints are especially susceptible to attack. The combustion chamber, lower surface of the dome and upper checkers naturally bear the brunt of the action. The accompanying typical photographs show the effect on the dome and top of the second-pass checkers. To prevent this evil as far as possible in the new small-checkered stoves, we are installing an improved type of washer, and are using several high temperature, alkaline-resisting cements, instead of fire clay, in the hotter parts of the stove.

Considerable attention is also being paid to the prevention of air leakage in old and new stoves. The vulnerable points in a stove and connections for escape of air blast are many and likely to be forgotten. Too much attention cannot be given to the bottom construction, as leakage there is of an insidious nature and may not be discovered for a long time. The blast may escape through a cracked or burnt bottom plate, if not water cooled, or around the outer edge of the angles rivetted to the bottom plate and lower ring of the shell if weak, or if the caulking has been improperly done. Stove rivetting should be a fine art, as leakage can often be detected around the rivet heads and good caulking of lapped edges is necessary. Clean out doors require occasional attention. Blast leakage through cold blast, hot blast and chimney valves at times may be of unbelievable magnitude. Improvements in the construction of these valves, especially the chimney valve for the three-pass stove, which will insure perfect heating at all times, will be a boon to the blast-furnace fraternity.

Mr. Boynton states that there is as yet no general tendency toward the use of forced draft for air or gas. It is my present opinion that for our conditions at least, it is equally satisfactory, and much less expensive, to have an expert continually to look after stove efficiencies, and who will supervise the stove tenders, than it is to employ more or less self-regulating, induced pressure burners; we are now practicing this belief.

Vice-President King: There is to be no further informal discussion of this paper to-day, but Mr. Edward B. Cook of Cleveland agrees to furnish a paper later. He has been very busy and unable to furnish it in time, but it will be prepared soon and will be published in the Year Book. This, I believe, completes our program for this afternoon. We will meet this evening at 7 o'clock at the banquet hall of the Missouri Athletic Association. Till then we are in recess.

# PROGRESS IN HOT-BLAST STOVE DESIGN

DISCUSSION BY EDWARD B. COOK

Ore and Blast Furnace Department, Pickand, Mather & Co., Cleveland, Ohio

Mr. Boynton gives an excellent account of the principles governing recent stove construction. He has covered the subject thoroughly, and so in accordance with my opinions that I find little in his paper to discuss.

The merchant furnaces have not, as a rule, had an outlet for their excess gas, and consequently have not been so much interested in economy of stove operations as the steel works furnaces. Their need for high uniform heat is greater than that of the steel works furnaces, on account of the high silicon iron and various grades required; therefore the merchant plants are taking advantage of the clean gas available through the installation of gas washers and are improving their stove equipment. The fact that high heat, and not gas economy, is the controlling factor, makes no difference in the construction of the stove, as the stove designed to give high heat is economical in its use of gas, and little additional expenditure is required to obtain the best gas economy.

We agree with Mr. Boynton that thin checker walls are best. The stove checker construction is strong, and it also seems clear that the 2-inch, or at least 2½-inch, steam pressed brick is probably as strong as the 3-inch "sawdust" brick used some years ago. The use of small checkers, 3½ inches to 5 inches square, with consequently higher velocity of gases through the stove, not only improves the distribution on account of the increased resistance, but also increases the efficiency of the heat transfer. The relation of heat transfer to velocity is clearly demonstrated in refrigerating engineering.

## TWO-PASS OR THREE-PASS STOVES?

At one time, on account of troubles with the two-pass side combustion stove because of dirty gas and theories of distribution, furnace operators turned to the three-pass stove. After experience, the three-pass stove was found to be no better under the same conditions and gave more trouble, not only in cleaning but also mechanically, chiefly on account of leaking of the chimney valve located at the top of the stove.

The tendency now is to return to the two-pass side combustion chamber stove, because this stove is cheaper to build, easier to operate and maintain, and, notwithstanding theoretical objections as to distribution, practice shows that it gives excellent heats.

Some time ago we were concerned about the distribution in two-pass center combustion chamber stoves with one chimney valve. As an experiment we added another chimney valve to one of the stoves. When the stoves became dirty at the top of the checkers, the stove with two chimney valves gave much better results than the stoves with one chimney valve, because it had double the number of checkers available. When, however, a system was adopted of blowing the stoves regularly once a week from the cleaning doors on the upper platform and keeping all the checkers open on the stoves, the stove with the two chimney valves gave little better results in actual practice than the stove with one chimney valve. This experience does not contradict the evidence to the effect that the distribution in this type of stove is not good, but it does show conclusively that the trouble is much aggravated by dirty gas.

In building two-pass side combustion stoves, we favor the large central arch for supporting the checkers, not only on account of the strength of construction and the simplicity of one chimney valve instead of two or more, but also because of an opportunity to control the distribution of gas. Four of these stoves have been operating since 1902 and are giving excellent results. The cast-iron dampers installed to control distribution warped, giving trouble, and were removed. As the stoves are satisfactory, no attempt has been made to regulate the distribution; but rather than use fan walls or arches at the top of the combustion chamber for controlling distribution, I would prefer to experiment with the size of the openings into this central arch at the bottom of the stove.

### Size of Combustion Chamber.

The size of the combustion chamber should, of course, be governed by the quantity of gas to be burned, and its shape by the quality of brick used. For instance, a combustion chamber with a flat arch, which failed when built of Central Pennsylvania brick, lasted indefinitely with a New Jersey clay brick.

We agree with Mr. Boynton that stove fire brick should be dense, finely ground brick; and, although we have been using all first quality, I can see no objection to using second or third quality in the bottom of the stove, provided tests show that they will stand a crushing strain and temperature greater than will be required. On stoves operating on dirty gas it is advisable to use first quality brick throughout, as at times the temperatures are as high at the chimney as in the combustion chamber.

Some superintendents believe that, in order to obtain proper combustion with low stack temperatures and also to obtain proper distribution of gases in the stove, both the air and the gas should be blown into the stove. Others feel that with large openings in the stove and high enough draft stack to pull sufficient air and gas into the stove, equally high heats and satisfactory results can be obtained, provided attention is given to the burning of the gas and the stove tender is continually checked by analyzing the flue gases. This is a matter of opinion at the present time, and we endeavor to so design the stoves that either method may be used.

### Stove Fittings.

There has been a great improvement in stove fittings. Castings riveted to the stove shell are of annealed cast steel and are protected inside by fire brick. All castings exposed to heat or seats that may leak are bolted to the steel castings so that they can be changed quickly. A cold-blast valve is made with the rack and gear open to inspection, and capable of being changed without stopping the furnace. Welded steel hot-blast valves are in general use, and at a few plants seats made of the same material. These improvements, together with the improvements in chimney valves and gas burners, have made the modern stove much more reliable, and have stopped practically all leakage of air.

The insulation of stoves and hot-blast mains is due to theoretical considerations. Two years ago we insulated two stoves with Armstrong cork brick, and recently three stoves with Sil-O-Cel. In the relining of two stoves at present the shaped asbestos insulation is being installed. It will be some time before any definite information can be obtained as to the comparative value of the insulations. We believe, however, that all of them will prove of value, and that the insulation of heated surfaces about blast furnaces will receive more attention in the future than it has in the past.

The new conditions brought about by the availability of clean gas, and the improvement in stove fittings, make it safe and practical to design a stove installation that approaches the theoretically correct and economical. Where previously four stoves were installed, and five preferred, we have in our latest construction erected three economic stoves. It is probable that in the future five stoves will be considered sufficient for a two-blast furnace plant.

## EVENING SESSION

The Evening Session of the Institute was held in the great dining-hall of the club house of the Missouri Athletic Association. The Athletic Association had always declined to allow banquets of other organizations to be held in its beautiful dining-room. But the Association is composed of the leading business men of St. Louis, and at the urgent request of the Local Committee on Arrangements, the Association opened its dining-hall to the Institute banquet as a special expression of appreciation of the fact that St. Louis had been the first city west of the Mississippi River to be selected by the Institute as a place for holding one of its meetings. The Institute appreciates the courtesy of the Association in making this exception.

Director Joseph G. Butler, Jr., of Youngstown, had gone to France as a member of the American Business Men's Committee and found himself unable to get back in time to attend this meeting of the Institute. It is a matter of pride with Colonel Butler never to have missed an Institute meeting before. He was off the Banks of Newfoundland on his way home at the time the meeting was held, and sent a marconigram as follows:

S. S. *Philadelphia*, Oct. 26, 1916,
via Radio, Cape Race, N. F.

Gary, American Steel Institute, St. Louis, Missouri.
Absence regretted. Kind thoughts for all members. BUTLER.

Director John A. Topping found himself unable to attend the meeting, but sent the following telegram:

New York, 11:20 A.M., Oct. 26, 1916.

JAMES T. MCCLEARY, Secretary,
American Iron and Steel Institute,
Planters Hotel, St. Louis, Mo.

Please present, after the banquet, the following message: I congratulate the membership for their most successful meeting. My compliments and thanks to the St. Louis Committee for their invaluable program assistance. To our president, to whom we owe so much, all honor is due, and I heartily concur in the eulogies extended by the various speakers, and wish Judge Gary continued health and happiness. To our St. Louis friends I wish continued prosperity. My unavoidable absence I sincerely regret.

JOHN A. TOPPING.

Director Frank S. Witherbee was also unable to attend the meeting, but sent the following telegram:

New York, Oct. 26, 1916.

JAMES T. MCCLEARY, Secretary,
American Iron and Steel Institute Meeting,
St. Louis, Missouri.

Regret extremely on account of illness my inability to attend meeting. Please extend to Judge Gary personally a warm welcome home. I am sure his visit will do much to cement the close and friendly relation which should exist between this country and the Orient.

FRANK S. WITHERBEE.

The distinguishing feature of the evening session was the presentation to Judge Gary, President of the Institute, of a testimonial of the high regard in which he is held by the members. This testimonial is described and illustrated later on. The Committee on Testimonial consisted of Messrs. Frank S. Witherbee, Chairman; James A. Burden, Joseph G. Butler, Jr., E. A. S. Clarke, James A. Farrell, Willis L. King, John C. Maben, Charles M. Schwab and John A. Topping. The fund for the purchase of the testimonial was made up by small subscriptions of uniform size from all the members of the Institute, so that it is a general expression of affectionate admiration, not simply the tribute of a few of the Judge's immediate friends, who would have been glad, if selfishly inclined, to subscribe the entire amount. (The subscriptions were more numerous than the Committee had expected. After paying for the testimonial as presented at St. Louis, there was a substantial surplus. With this, two additional pieces, the roller blotter and the seal, were bought. These were presented to Judge Gary at the meeting of the Directors held on February 21, 1917, the presentation speech being made by Mr. Butler.)

After the banquet, the Toastmaster, Judge Gary, called the meeting to order and said: Gentlemen, this is a large room, well filled, and it will be necessary to maintain perfect order and quiet in order to enable all who are present, and particularly the ladies who are in the gallery, to hear what is said. We will proceed with all the diligence possible. I have been handed a list of "impromptu" speakers. I hope the speakers will remember that their time is limited to five minutes. Therefore, if you hear the gavel please remember it is not my fault. It is my pleasure to introduce Mr. George W. Simmons, Vice-President, Simmons Hardware Company, St. Louis.

Mr. Simmons: I deem it an honor indeed to be called upon to respond for St. Louis at a gathering such as this, than which we have never had here a more representative one.

If I were to attempt to explain to you in detail the many things in which St. Louis excels, I would tread upon the ground so successfully covered in your meeting this morning by the President of our Business Men's League, Mr. Howard. Furthermore, I would find myself somewhat at a loss, timid indeed, because I rather hesitate in speaking before a gathering such as this after an experience I had a couple of months ago. I was invited to talk before a club. After I had made my address, on which I was rather congratulating myself, the Secretary came to me and asked if I would let her have my address so that she might send me the usual honorarium. I assured her I was not on the Chautauqua Circuit and would make no charge. That seemed to please her very well and she said, "That will be very nice, we will put the honorarium into our special fund." That aroused my curiosity and I asked her what the special fund was for. She said, "We put all that kind of money into a special fund, so that next time we may get better speakers." (Laughter.)

St. Louis is behind some of her sister cities in the production of iron and steel and some manufactures of those precious metals—I say precious metals advisedly, because formerly we used to store our rolls of wire anywhere and we carried our galvanized iron in an open shed; but whenever we get any galvanized now we put it into the safety deposit vault under a special lock. (Laughter.) Then there were no such things as the Steel Trust or the Independents—giant independents which to-day have marked such a new era in the business of our country. It was the foresight and skill and industry and ability of you gentlemen that placed the United States of America in an entirely new relation toward the countries of the world, and it was this success which has made your industry so important a part of our national life.

Your Chairman has indicated that he is going to drop his gavel in just a moment or two and, therefore, I want to just leave a word, which I know you will not misunderstand. Those of you whose lives and activities are in the East will do well to remember that the sun does not set on the west bank of the Hudson River, or even on that of the Mississippi. To the west of us lies an immense empire, magnificent in the present, containing unlimited promise for the future, an empire with hundreds of thousands of acres still waiting the plow and millions of acres more from which each year is produced new wealth to the world. The ever increasing signs of efficiency with which those acres are tilled remove any possible doubt that we are just scratching the surface of the possibilities of that immense empire. It is entirely reasonable to believe, therefore, that from this vast country will come not only an immense future demand for the articles which you gentlemen manufacture, but also a very powerful influence on the social and economic problems which confront us. And, therefore, gentlemen we again pay to you our grateful acknowledgment that you have for this meeting selected as your meeting place the one large city so situated in this country as to have the commerce which arises out of those states of the South, with their cotton and lumber; those states of the North and West with their grain and live stock. When Mexico becomes tranquil and through St. Louis the trade of Mexico shall have been resumed, you will realize that the Almighty has located this city as the ideal distributing center for all that immense territory, the metropolis of the Mississippi Valley, St. Louis, which welcomes you heartily as her guests to-night. (Applause.)

Judge Gary: I notice Mr. W. A. Rogers, President, Rogers-Brown Iron Company, Buffalo, New York.

Mr. Rogers: Each of the Institute meetings has an atmosphere peculiar to itself. I do not know that I have correctly sensed the atmosphere of this one, but to me the spirit of the occasion to-night is the romance of wonderful growth of both objects so much in evidence at this meeting—the City of St. Louis and the American Iron and Steel Institute. The city has always had for me a romantic interest. Forty years ago it lured me as a young pig iron traveling salesman, traveling from Cincinnati. I proposed to my employer, who had not seen fit to launch my energies in this direction, that if he would allow me to come here and see some of the great names of that period, such as Shickle, Harrison and Howard, and Mr. Filley of the stove works, (applause) I would myself pay the expenses of the trip. I did not bring away many orders but I brought away recollection of mosquitoes in numbers and varieties equaled only by those of Birmingham, when the first closed furnaces were being built there. I am credibly informed that not one of those mosquitoes is now in existence and that St. Louis has become the summer resort par excellence of the Middle West. (Applause.) Certainly there is nothing in the experience of this visit to controvert those statements. St. Louis seems to have fulfilled its early promise. It is a thriving city. It has become a great metropolis, its commerce radiating in every direction across the continent, its financial institutions a power in the land, and its manufacturing interests touching the entire civilized world. All its leading citizens, if I may judge by the representatives seated on either side of me and those that we have met to-day, are veritable princes in every sense of the word. Through the energy and intelligent force which they are exerting they are carrying the city to a high plane. As to the ladies, cast your eyes, gentlemen, to the galleries. What you see is more forceful than words. (Applause.)

The development of the Iron and Steel Institute has been wonderfully interesting. I was present at its approaching birth, and when its father, a man of vision, outlined the mission of this new child, I thought it was a society entering a field already occupied and I doubted its vigorous growth. The evidences of to-day's session and of this evening are a tribute to a master builder, and I will be greatly mistaken if it will not prove to be one of the most satisfactory triumphs of the full life of our worthy Chairman. (Applause.)

The Institute has been the medium of inaugurating a new system of business ethics. It has been the medium of bringing competitors in the same line of business together and displaying to each other their excellent qualities. It is credited to Ben Johnson that he remarked: "That man going yonder I hate; I don't know him; if I knew him I would probably love him."

Co-operation, instead of destructive competition, has become the code of morals in the iron and steel circles. And that established, the door is now open to the next advance step. What direction that will take, I do not know. Possibly for just the present moment it might be well to turn the energies of this organization in the direction of counteracting some of the tendencies of the present time. There is a great danger latent in the prosperity which has been thrown upon this country. There is a great danger in sudden wealth being thrown into hands unaccustomed to its use. Extravagance, display, breaking of established conventions, lead to industrial as well as social unrest. And we all appreciate that materialism unchecked is destructive of everything that is fine in life. However, whatever direction the Institute's activities may take, none sitting in the midst of this gathering of young, vigorous, virile and efficient life, of men who have taken their present position through brain capacity and the power that accomplishes things, will fail to appreciate that there is a latent power here, or doubt that the future holds marvelous development and the application of our particular industry to the purposes of civilization. I congratulate, and almost envy, those present who have the opportunity of witnessing the accomplishment of the next twenty-five years. (Applause.)

JUDGE GARY: We shall have the pleasure of listening to Mr. E. F. Kearney, President, Wabash Railway, St. Louis.

MR. KEARNEY: On occasions of this kind it is the rule for me to tell stories, but tonight I am not going to do it. Neither am I going to talk of the railroad business, or steel business, or business of any kind—big or little. I want to leave in the minds of this vast audience, composed, as it is, of men of such vital importance to the industrial and civic life of our country, a great truth, and to call their attention to a great weakness of the American character.

The truth I want to bring to your minds is the dignity of honest toil. The defect of the American character to which I refer is the great desire of all of us to get rich quickly without the necessity of honest toil or faithful service. This defect is in evidence, not only on the part of those who work with their hands, but also with those who work with their heads. We are all striving to get rich quickly. We are not working because we love work.

There is a feeling on the part of the young man leaving school that toil is in some way or some manner degrading. If this spirit is not corrected it will work serious injury to our institutions in the years to come. Toil is a wonderful thing. It is more than the salt of life. We get so much more out of toil than we put into it. To my notion there can be no real happiness in this world unless one has experienced the joy of honest toil or has known the satisfaction of faithful service. (Applause.)

I will give you a new definition of toil. The definition of toil to which I refer will not be found in the many definitions of this word in any dictionary. I found it in the beautiful thought and language of Henry Van Dyke in his poem entitled "The Toiling of Felix." I give it to you briefly. Take it home with you, and while sorrow may enter your lives, as it enters the lives of all of us at times, if you young men will keep this definition close to your hearts you will be reasonably happy as long as you live.

In the language of the poet:

Toil is the sacrament of labour, bread and wine divinely blessed;
Friendship's food and sweet refreshment, strength and courage,
 joy and rest.

These are the things we get from honest toil or faithful service.

What wonderful examples we have had in the history of the world of the dignity of toil. Let me recite a few additional lines from this beautiful poem. You will readily recognize the divine character of the One who is supposed to repeat these words:

Well I know thy toil and trouble; often weary, fainting, worn,
I have lived the life of labour, heavy burdens I have borne.
Never in a prince's palace have I slept on golden bed,
Never in a hermit's cavern have I eaten unearned bread.
Born within a lowly stable, where the cattle round me stood,
Trained a carpenter in Nazareth, I have toiled, and found it good;
They who tread the path of labour follow where my feet have trod,
They who work without complaining do the holy will of God.
Every task, however simple, sets the soul that does it free;
Every deed of love and mercy done to man is done to me.

Oh, my friends, this doctrine, in addition to being a sacrament of labor, is also its gospel. Still using the language of the poet:

This is the gospel of labour, ring it, ye bells of the kirk!
The Lord of Love came down from above, to live with the men who work.
This is the rose that He planted, here in the thorn-curst soil:
Heaven is blessed with perfect rest, but the blessing of earth is toil. (Applause.)

I would not have you feel that I am pessimistic with reference to the future of our country. If I have spoken in a pessimistic vein please forget it, because pessimism does not in any way represent my inward hopes or aspirations for its future—"My country, 'tis of thee, land of the noble, free." Oh, I trust it will always be the land of the free and the home of the brave; the home of a happy and a united people; of brave men and beautiful women—beautiful at least in character and in graciousness; men and women fitted to be fathers and mothers of a great race; men and women whose hearts beat with the transports of patriotism, and who know what liberty means; and last, but not least, Oh, not the least, my friends, of men and of women who know and who realize that the great joys, the great blessings, of life, come only through honest toil or faithful service.

Oh, I have such a great, such an abiding, faith in the destiny of this dear land of ours! I believe it is only in its springtime, only in the early morning of its life, and that God will guard it through the strength and greatness of its noonday, and lead it toward the evening of its life with a glory and a splendor which is beyond our present comprehension. Oh, let it be, in spite of all its faults; in spite of those who would stir up strife and class hatred; regardless of what political party may be temporarily guiding its destinies under the providence of God, let this dear land of ours be as it has been in the past, a beacon of hope and a refuge for the oppressed of other lands, a blessing and an inspiration to all mankind for ages and ages to come. (Great applause.)

JUDGE GARY: It is my pleasure to present Mr. John C. Schmidt, President, Standard Chain Company, Pittsburg.

MR. SCHMIDT: It takes a brave man to follow these brilliant speeches by standing up here and reading from papers on which have been written the words that he desires to say. Impromptu remarks may be made at one's club, but in such an audience one must give more consideration to his utterances, or in the cold gray light of day they might resemble those of an honest farmer, who, in selling a blind horse, said, "He is all right except that he doesn't look good." (Laughter.) So I will read my remarks.

We are now in the midst of a great presidential campaign and the air is filled with what Dr. Holmes would call "mutual undervaluations"; and it seems to me that this "mutual undervaluation" is what is blocking our progress. We, as a nation, have never been charged with undue modesty. We proclaim our greatness only too willingly, and possibly without first fully informing ourselves as to the strength and ability of other nations. We want to blaze our own trails. We make laws which we think are for the good of all, because they are meant to prevent wrong-doing. In other words, we are searching for error and trying to correct a possible evil rather than consider what we can best do to build up. We all know that it is much easier to sit on the side of the table and criticise; but those who see visions and then crystallize them into actions producing great industries are those who must sit at the head of the table.

Oh, if those who make our laws would only realize how much too far this undervaluation has gone! The fact that a corporation has the power to do evil does not differentiate it from the genus homo. This should not be a crime. The daily press is pointing with pride to our stupendous exports, and some people even are taking credit for more than their share in producing them. We must not forget that we of almost all the world are the present financial beneficiaries of this great and terrible war. We who are now experiencing unparalleled prosperity must recall that all things come to an end; and while the sun is in the zenith, we should remember we have no Joshua to make the sun stand still, and that as the shadows begin to point to the east, we should give thought to what will happen when the war ends. I hold no brief to speak for any one. My thoughts are only those of an ordinary business man based on his reading, travel and observation.

The newspapers almost forget the price of paper when they gloat over the mass of gold possessed by this country. The pit seems to grow all the time larger and larger. This gold reminds me of an historic sword which adorned the walls of an office of a friend of mine. One day a client noticed it and asked for its history. "That," he said, "is the sword that Balaam used to slay the ass!" "You're wrong, Ed," said the visitor, "Balaam had no sword; he only wished for one." "Then," said he, "this is the sword he wished for!" Now, don't let us suppose that our commercial rivals will content themselves with simply wishing for this gold. They are now laying their plans to get it through the game of international trade. Money is always liquid, but it is most liquid when it is leaving us, and it is against such time that we should prepare. In preparation the first thing to do is to stop thinking in parishes and think in nations. (Applause.) We must forget state lines; we must take thought of what is best for the nation and not any section. (Applause.)

And how are we to continue this prosperity unless commerce is encouraged, sustained and protected? I tell you, gentlemen, if this nation is ever to take its rightful place in the nations of the world, we must have the ungrudging and heartfelt cooperation of the government, the banks and big business, and withhold criticism of business solely because it is big. Those who against fierce competition have built up our great industries must be a part, and a welcomed part, in cooperating with the government in plans to meet the changed conditions that the ending of the war will bring. (Applause.) There must be no sneers at Dollar Diplomacy. No matter who is elected in November next, the incoming President should bring to his aid as Secretary of Commerce one of the giants of industrial life. This government should now call together the unquestioned leaders in every one of the great lines of business and counsel with them. They should be asked to suggest constructive laws on broad lines to foster our commerce. The President has appointed a committee of engineers to aid the Secretary of War in formulating plans and means of defense. Is not our commerce worthy of similar aid? Who could be of greater service to the nation than those giants we all could name, and many others of similar ability in other lines?

The French have a proverb—"Adversity brings strength and prosperity weakness." Let us, while there is yet time, prepare for the future and cooperate for commerce. (Applause.)

JUDGE GARY: George P. Early, of Pittsburgh, will now address you.

MR. EARLY: It is not my intention to indulge in any profound reflections to-night. No words of wisdom will fail from my lips. I could easily deliver a scholarly address to you—if I had the ability, but the wisdom it would contain would be so little compared with what you have heard to-day and what will be given you by the other speakers this evening, as to make it hardly worth while.

Sometimes I think there is already too much wisdom in the world—excepting in Congress—and that our genius for acquiring knowledge is often a potential factor in producing unhappiness and discontent, for in my life of some seventy-nine years, (laughter) I have met a great many men who knew it all who were not only unhappy themselves but often made me unhappy, and frequently very tired.

Over in Ohio, in the village where I was brought up, it was the custom to measure a man's intellectuality by his specific gravity rather than by his specific levity. A man who had a sense of humor was generally supposed to have no other kind of sense. A man who could effectively tell a story or who thoroughly enjoyed one, was thought to be utterly unfitted to handle any of the serious problems of life.

Indeed, one of the biographers of Tom Corwin, an eminent statesman of his day, said that Corwin might have been President of the United States if it had not been for his bubbling sense of humor. Speaking of Corwin, I am reminded of a dinner that he attended in London at which were present a number of distinguished literary men. On Mr. Corwin's right sat the eminent English poet, William Wordsworth. In the course of a conversation they became engaged in a discussion as to the comparative importance of the heart and liver. "Mr. Wordsworth," said Corwin, "you poets, in my judgment, are all wrong in ascribing so much importance to the heart. You make it the repository of all sentiment, affections, aspirations, hopes and fears. You speak of a man as being kind-hearted, and of another man as being tender-hearted, and of a big-hearted individual, and of a woman with a tender and loving heart, and you speak of your beloved one as your sweetheart. Now, as a matter of fact," said Corwin, "the heart hasn't as much to do with all these things as the liver. A man may have a weak heart, or a broken heart, or valvular trouble of the heart, or he may have mural-carditis, or endo-carditis, or any other kind of carditis, yet he can get along pretty well if he has a good, sound liver." "Well, I suppose you are right," said Wordsworth, "from the anatomical and physiological point of view, but if we accepted your philosophy it would impair the dignity of so much of our beautiful English poetry." "How so?" inquired Corwin. "Well," said

Wordsworth, "take, for instance, the charming poem by Byron:

'Maid of Athens, ere we part,
Give, oh give me back my heart'."

"Well," said Corwin, "I could paraphrase that and have it truer to scientific sense and with almost as smooth a rythm." "How would you do it?" asked Wordsworth. "I would say," said Corwin:

'Maid of Athens, ere we sever,
Give, oh give me back my liver'." (Laughter.)

"Of course," said Corwin, "it would sound strange to describe a gentleman as being tender-livered, or to speak of a big-livered individual or of another as kind livered, or of your sweetheart as your sweet-liver, but such descriptions would sound euphoniously after the ear became accustomed to it."

I don't know of any lubricant that so effectually minimizes the frictions of life as a sense of humor, which begins with the development of intelligence. (Applause.)

It is most fortunate for mankind that there are so many sources of humor. We often get humor from an affliction such as stuttering. There was Charles Lamb, the English essayist, who stuttered terrifically—and he often employed this affliction as a vehicle for his humor.

Lamb was employed for many years in the office of the East India Company. He got into the habit of coming to the office late in the morning; when he was reprimanded by the manager, when he replied: That it was tr-tr-true that he had be-be-been com-com-coming late, yet he tr-tr-tried to ma-ma-make up for it by leav-leav-leaving early in the af-af-after-afternoon.

Then we get humor from deafness, and that reminds me of a couple of Ohio boys who were born about the same time on adjoining farms. They grew up in babyhood together. They started to school about the same time. They were in the same class. In their young manhood they courted the girls together. A few years later one of them went to California, where he lived for some forty years, and while living there became very deaf. One day the spirit of the wanderlust came over him, and he decided to take a trip back to Ohio. He wanted to see the old schoolhouse, and the swimming hole down in the creek, and he wanted to tramp over the fields where he hunted rabbits when a boy. He wanted to see the old tanyard where the boys used to play circus, and he was particularly anxious to see his old chum who, in the meantime, had become very religious. And so he went back to Ohio and to the home of his old chum, and when he arrived there the family had just sat down to supper, to which the visitor was invited. There was simply a hand-shake. The religious host, bowing his head, said to his friend, "Jake, will you ask the blessing," to which the visitor replied, "What, ye say, Sam? Got so damned deaf last few years, can't hear hardly nothin'."

And then we get much keen and incisive humor from the Jew. For instance, the other day I was over at the station of the New York Central, at Rochester, New York, when a Jew stepped up to the ticket window and said: "Vot time can I get a train to Syracuse?" The agent replied, "seven o'clock;" and the Jew said, "Make it six-tirty and I'll take it."

And that reminds me of a little Jewish boy who was to take part in a dramatic performance at school. At a certain time Ikey was to come on the stage and say: "Oh mighty King, we salute thee." When Ikey came out on the stage he was suffering from stage fright, and his voice was tremulous. Beginning he said:

"Oh mighty King"—. He forgot the balance, and the teacher whispered "Go on, Ikey." He started again:

"Oh mighty King"—and still forgetting the balance, said, "Oh mighty King, how's business?" And speaking of Jewish stories I am reminded of a sick Jew. There was a Jew who had been seriously sick for some three years. He was wasted away to a mere skeleton. His eyes were sunken, his cheeks hollow, his gait feeble, and his voice so faint he could scarcely speak above a whisper. It is a charming characteristic of the Jew to extend sympathy and kindness to their people in times of trouble and distress. So one evening three of his friends called on him to cheer him up. The doctor had been to see him that day and had given him a very pessimistic account of himself, and he was blue as indigo. In due time the chairman of the jollying committee, looking at the invalid, said: "By golly, Sol, you're lookin' awful good to me to-night." "Vell, I don't know, my doctor vas here to-day and he tells me I better arrange all my affairs and prepare to meet my Maker." "Oh, shame on you talkin' like dat," said the chairman. "Vy I know hundreds of people vot got de disease vot you got, and to-day dey are hale and hearty. Yes, since I tink of it, vun is a brize-fighter, and he has never been licked already yet. Sol, you musn't tink so much about yourself. Tink of somedin else. Vy Sol, how old was your fader when he passed away?" "Fader," said Sol, "was a fine ole yentleman. For years he did the leadin' cloding business in dis county. Let me see, when fader died he was ninety-two." "Vell, look at dat," said the chairman. "By golly, ven I come from stock like dat I would bid defiance to any disease. How old was your mudder, Sol, ven you lost her," inquired the jollier. "Mudder vas eighty-eight," said Sol. "Vell look at dat—a fader at ninety-two, and a mudder at eighty-eight, vy dat's an average of ninety net, no commissions. Ven I come from stock like dat I would tink I live as long as Metuselah, and you talk about meeting your Maker. Sol, how old vas you already," inquired the chairman. "Vell," said Sol, "if I lived by de twenty-second of next October I vill be sixty-two." "Vell look at dat," said the jollier, "you are just in de prime of life. You are good for twenty-dree years yet. Vait until you get to be eighty-five and den you can talk about meetin' your Maker; he vill vant you den, but He don't vant you now." "Vell," said Sol, "tell me vy my Maker should take me at eighty-five ven he can get me at sixty-two." (Hearty laughter.)

And then we get humor from the negro, but he is usually unconscious of it. To illustrate: There was a negro down in Alabama who was brought into court to be sentenced to be hanged. The Judge, in a solemn voice, said to him: "Sam Jones, you have been regularly indicted, tried by a jury of your peers, and you have been found guilty of murder in the first degree, which is the most awful crime the human mind can conceive of, or the hand execute, and which comprises the premeditated and malicious taking of human life. It is therefore the sentence of this court that on the twenty-third of next August, between sunrise and sunset, you be taken from the County jail where you will be imprisoned in the meantime, and that you be executed upon a scaffold erected in the jail-yard for the purpose, by being hanged by the neck until you are dead, dead, dead, and may the Lord have mercy on your guilty soul. Sam Jones, have you anything to say why this sentence should not be imposed upon you? (No answer.) I say, Sam Jones, have you anything to say why you should not be thus sentenced," to which he replied: "Jedge, I reckon I hasn't much to say ceptin dis is going to be a great lesson to me." (Laughter.)

And then we sometimes get humor from the minister. For instance, there was a minister in Los Angeles who was very fond of playing golf. One Saturday afternoon he made a great run until he got to the last hole, where he got all balled up and made a mess of it. It worried and annoyed him, and so the following morning when announcing the text from the pulpit he said: "What profiteth a man if he gain the whole world and lose his last hole." (Laughter.)

Before closing I would like to say a few words in regard to cultivating and maintaining a cheerful spirit in business.

Montaigne, the great French essayist, said that: "The most manifest sign of wisdom is a continual cheerfulness."

There is nothing that militates so much against cheerfulness as anger and impatience.

A hot temper is a bad thing for a man to have who ought to have a cool head. Anger is childish, senseless and often brutal, even in the commercial relation. It is the most impotent of passions. Anger rarely accomplishes anything useful. It hurts not only the one against whom it is directed but also the one who is possessed of it. A man always suffers more from anger than from that thing which caused it. Much remorse may be avoided by the suppression of anger, for even a moment's anger may cause many days of regret. Anger may be avoided by maintaining a low temperature. It is always wise to keep a cool head. A man who can do that achieves a great victory, for it is a brilliant triumph to conquer one's self.

We cannot always have ideal conditions nor perfect relations. Something is sure to happen that ought not to happen. Proprieties will be violated. Mistakes will be made in spite of the best endeavor, and some will happen because of carelessness or negligence. These incidents should have attention. Discipline demands that they should not be overlooked. But a man should not be reprimanded in public, nor in anger, nor with sarcasm, nor with the heartlessness and brutality that spring from contemptuous conceit or from the insolence of office. A reprimand should be administered in private and in a kind, firm and dignified manner, so that it will excite penitence rather than resentment. Loyalty of service will come from a penitent heart rather than from a temper made ugly by harsh treatment.

Anger begets impatience and impatience is lost motion. Impatience wastes energy. It causes peevishness. It inflames the temper. It begets brutality. It is in itself a discourtesy. Impatience is a disintegrating force. It causes strains. It weakens character. It dynamites peace of mind. Patience is one of the most powerful virtues in character. There can be no strong character without it, for patience is power. It is economic. It obtains results. It conserves energy. It governs the temper. It gives strength. It inspires justice. It begets a calm spirit. It teaches politeness. It cultivates the spirit of humanity.

Men should exercise patience in their relation with each other. I don't know of any mental manifestation on the part of a superior officer that so wounds the self-respect of a subordinate as the display of impatience when he comes to talk to his superior about matters that are proper subjects of discussion. Every man is entitled to a respectful hearing when he has proper matters to talk over with his superior, and the man who does not accord a patient and courteous hearing does not fully realize his own interest.

My closing thought is that we should all endeavor to make our business life happy by being kind, just, considerate and courteous in our relations with one another.

It gives me great pleasure to say that I belong to an organization, like this, in which such sentiments and relations prevail. (Applause.)

JUDGE GARY: Our program would be quite incomplete without Mr. James H. Hoyt, of Cleveland.

MR. HOYT: When we speak only five minutes, the last speaker reminds me of a Dutchman, who, when asked what the horse's speed was, said: "He can travel a mile in three minutes—or a very few minutes of it." Now, gentlemen, in looking around this great gathering of business men, so far as I can see there are only two practicing lawyers here. The one is Richard Grant of Cleveland, Ohio, and the other is myself. I do not include Judge Gary in that category because he has more profitable practice, is more servicably employed. But, notwithstanding this great disparity of service, it would be impolite for me to discuss the question of quality, for the Judge and I believe in the saying, "A little leaven leaveneth the whole lump."

In the very short time allotted to me before you wave your gavel for me as you did for the last speaker, I thought it would not be out of place for me to say a few words on the relation between business and the law. At the outset I will say, gentlemen, that for centuries people generally, including you business men especially, have been in the habit of saying very unkind things about lawyers and the legal profession. For over four centuries our literature is filled with unkind sarcasms at us. You remember what Shakespeare says in the "Merchant of Venice," "What plea in law was tainted and carped, but being seasoned with a gracious voice obscures the shawl or veil." Old John Macklind in 1690—he was a Scotchman and had lost a case and was somewhat angry—said, "The law is a hocus pocus; she smiles at you while she picks your pocket." And he considered the uncertainty of her as more profitable and just to the profession than the justice of it. And Tennyson also spoke of lawyers as "the essence of love, that Godless epitomy of precedent and slanders and special incidents." To come down to our own time; I was reading only a month or two ago in the New York *Sun*—I used to read the New York *Times* but for reasons which shall be nameless, which seemed to me patriotic, I am now reading the New York *Sun*—I was reading in the New York *Sun* an account of three lawyers who were in bathing in New Jersey and were driven out of the water by a man-eating shark. The reporter went on to say that that was the most flagrant case of professional discourtesy on record. (Laughter.)

Now, in the moment or two allotted to me, and I think I have a minute and a half left, I would like, if I can, to correct the erroneous impression that you have about lawyers. I am willing to admit that lawyers are quite usually a little contentious. I am certain that clergymen are generally, I want to put that mildly, that clergymen are generally so. I know that teachers, especially if they get into politics, are. And, as Lincoln said about Gideon Wells, they have never decided until after they made up their minds. Scientists are apt to be a little superior and dogmatic, physicians apt to be mysterious, and business men grasping, just as naturally and as unavoidably as a walking delegate is bound to be troublesome and the coal miner grimy. So that, in treating of business and the law to-night, I shall not treat with mere strategy, I will talk rather of the men who start the one than to follow the other.

In the first place, gentlemen, I want to say, and I say it in all candor and in all sincerity, we always are very much more appreciative of the good qualities of others than you business men are. In order to prove that statement I have only to ask why do business men always say and act as though lawyers encumber the ground? Nobody ever heard the lawyer say or even hint that for a moment we would get along without you business men. When your horizon, your financial horizon, is reasonably clear and the sun of prosperity is shining, you are apt to consider that we are noxious weeds which an ungrateful Providence has been unkind enough to allow to exist. But, gentlemen, let the thunder of commercial disaster rumble, let your credit be slipping by, let you find yourself enmeshed in a net that you have guilelessly woven—where do you turn? Not to Providence, but to us lawyers. (Laughter.) And do we decline or refuse to aid you? When such an appeal is made to us, all know that, with that generosity that always characterizes us, we extend our aid—for a consideration—and with that liberality that always distinguishes us, when we are dealing with the assets of another, we fly to your aid, gentlemen, and relieve you. And the nobility of our conduct is all the more marked and magnified when, with that consciousness of the time that when we have blown the clouds away and extricated you from your self-imposed trouble and left you in the undisturbed and undisputed possession and enjoyment of such remnants of your assets as the high cost of living and the great demands of our family will permit us or enable us to permit you to enjoy. (Laughter.) Then when we settle our accounts with you we will be met by the grumbling announcement that you could probably have gotten along very well without us.

You remember that when Noah went by in the ark the man told that servant of the Lord he did not believe the shower would be very violent or protracted, and history has told us that this man—of course he was not a lawyer—later discovered his mistake. All right, gentlemen, we admit that you are necessary to us, but we insist that we are necessary to you; and what God has joined together—let no business man, even though he be in the steel business, put asunder. (Laughter.)

Gentlemen, we not only help you when you are living but we busy ourselves about your matters long after you are dead, to see that your accumulations are much more widely and equitably distributed than you have any expectations of. (Laughter.)

It is due to us that your money flows in unexpected channels. It is because of us that you are the source from which unexpected benefactions flow. It must be very consoling to you in your last hours to know that people whom you have never known or heard of will be very grateful to you for having lived and perspired and toiled and saved. Whatever consolation may be yours from that cause, you owe it to us.

I have one thing further to say in favor of lawyers. It must be an extremely pleasant thing for you, in a legal investigation, to have your lying artistically done by somebody else. What a pleasant feeling when you are called to announce that "under the advice of eminent counsel," you refuse to answer. But what a strain it is on the lawyer's conscience and on his occupation to convince every court and jury or the public that you have acted throughout from the most disinterested and highest motives, and if you have erred it is through simplicity and benevolence. If you were only half as good as your counsel have often triumphantly proven you to be, we lawyers would be obliged to seek other occupations. (Applause.)

We have all debated, while in school, that much mooted question, "Which is the most necessary to mankind, commerce or agriculture?" The question is not debatable, gentlemen, because mankind cannot get along without either, and that is true of business and the law. The one is distinctly the ship, laden with the rich commerce, and the other is the chart, pointing out all the reefs and quicksands. The producer and the manufacturer fill her hold, the consumer is the consignee, the banker is the engineer. The merchant sails her, but the good lawyer is the pilot, who by reason of his knowledge of all the intricacies of the channel and its dangers steers the good ship safely into port. Each is entitled to credit for the success of the enterprise; each should be entitled to his due share of the reward. If you want absolute proof of that statement, I have only to point to the career of a lawyer, the Chairman of the United States Steel Corporation, who since the organization of that company has rendered such inestimable service, not only to his own corporation but to the business world at large. (Applause.) These services need no comment from me. And now, in closing—and I think I have one second left—in closing let me give you a definition of the law by Richard Hooker who lived, you remember, in the sixteenth century; that is as true to-day as it was when he wrote it in about the year 1583. "Of Law," says this great philosopher—"of Law, there must be no less acknowledged than that her seat is the bosom of God, her voice the harmony of the world. All things whether in heaven or earth must do her honor—the very least as being the subjects of her care, and the greatest as not being exempted from her power." (Applause.)

JUDGE GARY: Gentlemen, this completes the list furnished me but I have been directed by the Managing Committee to introduce that prince of good fellows, Mr. Schwab. (Applause.)

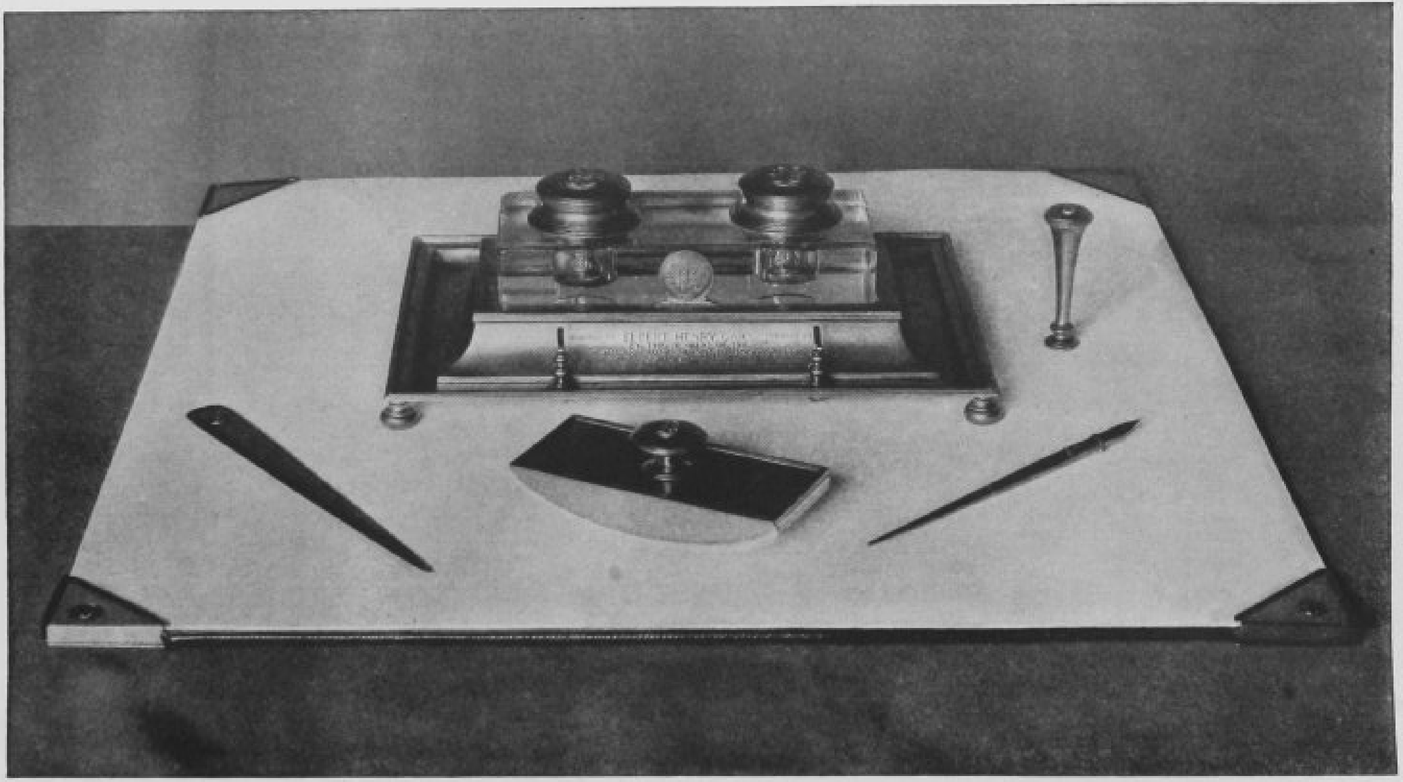
MR. SCHWAB: After the eloquent and humorous speeches of the preceding speakers it is a great relief to me to be assigned a duty and a subject that do not permit of levity.

It has been said that I am a lucky man. I am certainly a lucky man to-night in having been selected by my confreres as the person to express their sentiments and wishes to our President. This organization was formed about eight years ago by Judge Gary. It is useless for me to say how successful it has been. Everybody here knows, apprepreciates, acknowledges and admires the successful manner in which he has carried it through. It is needless to say that we all believe that no other man in our association or business could have carried it through as Judge Gary has done. (Applause.) With all his success in the organization and conduct of this association he has made one greater success than even that, and that is that he has successfully won the hearts and the confidence and the admiration of every member of this association. (Applause.)

Judge Gary, when I speak to you to-night, as it was my privilege to speak so happily five years ago, and express my personal sentiments, I know that I but express the sentiment of every man in the room and in the Institute. No one could admire more that spirit of fairness, that spirit of co-operation and that spirit of good fellowship which you have taught us all in this business. But words are only momentary as expressing the feelings of this large Association. Sometimes objects that are constant and frequently before you are pleasant reminders of the associations and friendships that you have won through so many years of loyal service. Your associates in the Institute, knowing that you do not desire extravagant expenditures of money as evidence of their appreciation of your services and worth, have each and every one contributed to a token which it is my pleasure to present to you this evening in their behalf as a slight testimonial of their love for you and their appreciation of what you have done in their interest. (Placing an open box before Judge Gary.) Accept it, Judge Gary, with my heartfelt thanks, and the heartfelt thanks of every member of this Institute, with the acknowledgment that I so freely make and make in the presence of all and with their approval, that you are the man of men in our association. May you long lead us on as you have so successfully led us, and may the love we all have for you grow with each succeeding year. (Applause.)

JUDGE GARY: Mr. Schwab, Ladies and Gentlemen: I would be less than candid if I failed to acknowledge that I knew there was to be a token of esteem tendered to me this evening. I cannot admit that I expected such a symbol of friendship as Mr. Schwab, representing others and himself, has presented. It is fortunate for me that I did know that personalities would enter into this evening's exercises, for I would not dare to trust myself to speak extemporaneously in acknowledgment. I have in my heart much to say to Mr. Schwab personally and to all of you gentlemen, but I could not satisfactorily express myself; I could not sufficiently compose myself to say clearly what I feel, and knowing that would be the case, I have reduced to writing all that I shall attempt to utter on this occasion.

I am perhaps justified in considering this reception, in a measure, personal to myself, and I thank you over and over again. I am under obligations to you which can never



THE TESTIMONIAL PRESENTED TO JUDGE GARY BY THE MEMBERS OF THE AMERICAN IRON AND STEEL INSTITUTE, AT ST. LOUIS, OCTOBER 27, 1916, AND AT NEW YORK, FEBRUARY 21, 1917.

## DESCRIPTION OF TESTIMONIAL PRESENTED TO JUDGE GARY

Prepared by the designers and makers, Tiffany & Company, New York

The desk set presented at St. Louis to the Honorable Elbert H. Gary by the American Iron and Steel Institute consists of an inkstand, a penholder, a paper knife and four triangular corners for a desk pad. Later a rocker blotter and a seal were added. All are of 18-karat gold.

The principal piece, a large double inkstand, measures $12\frac{15}{16}$ inches long, $9\frac{7}{16}$ inches wide and $4\frac{1}{4}$ inches high. The gold contained therein weighs 1203.50 pennyweights. It is made in the form of a large tray or plateau, with a raised reed border at the edge and supported at the corners by four short, turned feet. The center is elevated $1\frac{1}{8}$ inches, making a platform which also has a reed border. In the platform is a depression, in which rests a large block of greenish glass, on a silk pad. The corners of this glass are slightly rounded. In it are the two wells, each with its removable receptacle for ink and with moulded tops and covers of gold. The covers repeat the reed border. Two monograms, chased, and cut from pieces of gold, are applied to the centers of the covers, and a line is carved in each cover surrounding the monogram. The monogram on the left cover is comprised by the initials "E H G" and the monogram on the right cover is formed by the date "1916," the two monograms conforming in design and producing similar decorative effects. At the front of the glass block, and rising from the upper edge of the platform, is a chased seal of the American Iron and Steel Institute. Below it, on the front of the platform, is the presentation inscription, chased in relief, and reading as follows:

PRESENTED TO ELBERT HENRY GARY, PRESIDENT
BY THE MEMBERS OF THE
AMERICAN IRON AND STEEL INSTITUTE
AS AN EXPRESSION OF THEIR HIGH REGARD
ST. LOUIS, MISSOURI, OCTOBER 27, 1916

The inkstand is made for use on a double desk and has turned posts supporting pen rests at both the front and back.

The penholder is plain, with a reed border at the end and a monogram "E H G" made and applied in the same manner as those on the inkstand. The penholder weighs 16.40 pennyweights and contains a gold pen.

The paper knife is $9\frac{7}{16}$ inches long and has the reed border around the edge. On one side of the handle is the monogram "E H G" and on the other, the monogram "1916," made and applied in the same manner as those on the inkstand. The paper knife weighs 70.40 pennyweights.

The desk pad has four gold, triangular corners, measuring $2\frac{3}{8}$ x $2\frac{3}{8}$ x $3\frac{1}{4}$ inches, each with a reed border and made with a joint so that it is removable. The two front corners have monograms—made and applied in the same manner as those on the inkstand—"E H G" on the left front corner and "1916" on the right front corner. The four corners weigh 118.50 pennyweights. The desk pad has a red morocco back, measuring 24 x 24 inches.

The rocker blotter is $5\frac{11}{16}$ inches long and $2\frac{5}{8}$ inches wide. It has a reed border around the top and a turned knob-shaped handle, which also has a reed border. The monogram "E H G" is applied to the handle in the same manner as on the inkstand. The sides, top and handle, of 18-karat gold, weigh 149.60 pennyweights.

The handle of the seal is $3\frac{1}{8}$ inches long, and at its widest part is about $1\frac{1}{16}$ inches in diameter. It is of a baluster shape, with turned mouldings at the bottom and a reed border at the top. The monogram "E H G" is applied on the end in the same manner as on the inkstand. The seal, weighing 40 pennyweights, is cut with the full arms of Judge Gary, which are:

Argent, a chevron between three escallop shells sable, charged with three crosses pattée or.

Crest, out of a ducal coronet or, a peacock's head proper.

(The details of the seal, in exact size, are shown in the marginal cut herewith.)

The set is placed in a fitted case of French walnut, lined with dark brown chamois.

be discharged. Indeed, it would be presumptuous and ungrateful if I were to hint at such a possibility. I am proud beyond the measure of words to have, without exception so far as I know, the continuing friendship and confidence of the men representing the iron and steel industry in the United States and Canada. This constitutes a treasure of priceless value which is deposited in the deepest recesses of my heart, there to remain forever and ever. I would reciprocate fully if I could; but, alas, I cannot. I can and do return my highest respect and sincerest affection. And I express the hope that I may never give you any cause to lessen your esteem for me.

But, gentlemen, I realize your sentiment extends beyond and above personalities. I happen to be prominently connected with the endeavor to apply the principle of co-operation, in the highest sense, to our practical, everyday business life. As beautifully expressed by Mr. Schwab at the memorable meeting of October 15, 1909:

"The broad principles brought into this business were new. . . . Their effect was marvelous, their success unquestioned. It was a renaissance, a newness of things in this business that was necessary and invigorating."

Shall we ever forget the words of Mr. Morgan on that occasion: "I feel as though we were all just together."

The language of Mr. King at the same time was impressive:

"That busy men should lay aside their responsibilities and travel long distances to show their friendship and affection for a man in a purely social way, for a man who, in the nature of things, must be their most active and powerful competitor, is indeed remarkable, and I think without precedent."

In the autumn of 1907 the clouds of uncertainty loomed big and black on the business horizon. We were all more or less despondent, and this feeling was not confined to our industry. The experiences of the past had been a forceful teacher. Leading men in financial and commercial circles implored those connected with the "Barometer of Trade" to use their influence and efforts toward diverting and dissipating the impending financial typhoon.

What we did, what followed, every one knows. It is history. We did what we could, and the iron and steel men have been given and are entitled to much credit.

Wide publicity was given to our proceedings. There were in attendance at our meetings, by invitation, representatives of all the trade newspapers, many of our regular purchasing customers, outsiders, more or less interested in the movement, including, at times, representatives from governmental departments. We also gave to the general press accurate accounts of our efforts, and the same were likewise promptly reported to various departments at Washington. Consequently we received considerable praise and very little and not any important adverse criticism for what we were accomplishing. We did not wish nor intend to do anything that any responsible authority had censured. If at any meeting or meetings of individuals in other cities there was conversation which could be interpreted to be evidence of an improper design on the part of those participating, our answer is that, either the statements in question did not correctly represent the intentions of those who made them, or they did not, in any sense, indicate the views or the desires of those who were responsible for the general movement. I take this opportunity to emphasize the fact that no one directly connected with the "Gary Dinners," so-called, ever did or ever would do or say or approve anything concerning our business that is opposed to the spirit of the law or to the general public sentiment. If any one in our line of business has ever said or done anything which could properly be construed as a contradiction or modification of what I have said, then all of us deplore and disapprove.

Now, what is this principle pf co-operation? It is an honest, earnest effort to secure and maintain among business rivals a fair, healthy, vigorous competition and at the same time to oppose and to prevent an unfair, oppressive, cut-throat and destructive competition. It is calculated to establish on the one hand and to avoid on the other hand the very things so clearly and emphatically directed in the discussions of the Supreme Court of the United States. Summed up, it is described in the old expression: "Live and Let Live."

In 1907 and the months following, our conservative, open, neighborly attitude no doubt acted as a stabilizer and aided in the prevention of sudden and extreme fluctuations that would have disorganized and demoralized business to the prejudice of large numbers of both employees and employers; and purchasers, with large stocks on hand, as well. We have an abundance of testimony to this effect from our customers. It also created and fixed in our minds the sentiment that rivals in trade may at all times be considerate and solicitous concerning each other. That there is something substantial in the idea of mutual confidence and regard, even in competitive business circles, we see abundance of proof on this occasion.

On the 16th day of last August I stood before the tomb of Confucius, that ethical teacher and moral philosopher of two thousand five hundred years ago, and I remembered his written words: "What you do not like when done to yourself do not do to others," which is a statement in negative form of the Golden Rule; and my mind instantly traveled over the space of nearly ten thousand miles to the homes and offices of a highly intelligent and loyal band of business friends who are represented here this evening, and to the principle and practice which animates your conduct. Better a thousand times over for the Chinese nation if the Chinese people, without exception, had adopted and always practiced the precepts of Confucius. Better for us, in every respect, if, in our business intercourse, we and those connected with our enterprises had invariably followed this rule of conduct; better for the world at large, as now strikingly illustrated in Europe, if all the nations had maintained an attitude in harmony with the Golden Rule. I am not indulging in cant nor discussing questions of eternal salvation, although I believe the Golden Rule is the foundation of practical religion. Nor is it intended to exceed the bounds of feasible application to our every-day business. We know by experience, if we but look into the depths of our hearts and then proclaim the whole truth, we are obliged to say that when we refrain from doing anything affecting our business neighbors which we would like them to leave undone or unsaid about our business affairs, we are really advancing our own cause.

There is a principle involved in the subject of co-operation, private, public, national and international, which has become necessary to the highest success. The general sentiment throughout the world is opposed to the old notion that might makes right; that the stronger power is justified in crushing the weaker out of existence; that an individual or a collection of individuals, so long as the rules of law are observed, may ignore the rights of others. It is because of this fact that modern laws have been enacted to protect the weak. The old, hard business lines, which were altogether selfish and arbitrary, are giving way to the later methods which are considerate and fair. We have seen this in our business and we shall see more and more of it in the highest departments of business activity. The iron and steel fraternity have been leaders in the endeavor to make use of the idea of co-operation in their every-day business life. They have established a principle that will be permanent. As stated by our late and much beloved friend, Mr. Drummond: "In Canada and abroad men hold . . . that the new basic principle has come to stay." We have acquired a reputation for square dealing, for integrity of purpose, for generosity in practice and for friendly regard concerning the interests of others that is enviable and deserved. No one these days reproaches any of us with double dealing, with cruel disregard of the claims of others, or with destructive tendencies in regard to the business of another. The same could not truthfully be said of some of our predecessors. Conditions have changed; and you have helped to change them.

As a matter of course, we all realize the necessity of being practical. The ethics of business do not require us to neglect our customers or ourselves. We must get our fair share of the trade; but we are not required to misrepresent, to deceive our competitors, to go outside of our proper and natural spheres of operations, to suddenly and unreasonably change our prices in special places and on particular occasions, or to resort to any of the old tricks of the trade which were intended to harass, demoralize and bankrupt our rivals. We can be successful and at the same time fair, frank and gentlemanly towards our competitor.

Just at this particular time the demand for our products exceeds the supply and it is not difficult to apply the principles referred to; but it is altogether probable we shall see a change to some extent, temporarily at least, after the war is ended. If so, there will be opportunity to fully consider our duty towards each other as business friends. We should do everything possible and proper to protect our business, our customers and our employees; to prevent demoralization. I sincerely hope to see all of you prosperous all the time.

In times gone by, when disaster seemed possible, if not probable, we have been of real benefit to the business world and therefore to each other. Then it was that we discovered our neighbors were bigger and broader than we had supposed; in fact, that we ourselves were bigger and broader than we had believed. We have no excuse for doubt now. We know that each will do all that he properly may to steady and stabilize business.

It is probable the Federal Trade Commission may be of much benefit to business men, depending upon the disposition of its members. So far as we have had opportunity to observe, this Commission is favorable to business success. I would like to have its authority enlarged so as to permit it to advise in advance if inquiry should be made as to a contemplated action; but even under present conditions the Commission should be of real service. I do not believe in governmental paternalism or management; but I do approve of governmental supervision and I favor patriotic, intelligent, generous co-operation between private individuals, and between public officials and private interests.

Let us hope and expect that not one of us will ever deviate from the true course of the co-operative movement, for it has cemented between us a feeling of cordial, sincere regard for each other; and it has been and will continue to be of substantial benefit to others whose welfare is affected by our decisions. (Applause.)

Mr. Schwab: Gentlemen, with usual masculine self-assertion, we have attributed all the Judge's success to himself. We have forgotten that most of us, the Judge included, has a power behind the throne that directs us. Mrs. Gary has graced this banquet with her presence; I propose her health. Gentlemen, arise and drink the health of Mrs. Gary. (Here the banqueters rose and drank to Mrs. Gary in the gallery, who smiled and bowed.)

I was much amused at my friend Hoyt when he described that horse of his that could trot in three minutes, or within a few minutes of that time, because when I listened to his speech I thought of a horse I entered in a race once. An hour after the race I got a telegram that he had just arrived at the post. (Laughter.) But however lengthy Mr. Hoyt may be, he is always interesting. (Applause.) There was another thing that I felt curious about when I listened to this distinguished railroad man, Mr. Kearney, addressing a lot of honest steel workers. I didn't see the necessity of increasing real toilers in the work of making steel.

Leaving off this levity, I have asked the Judge to let me preside for a few minutes. He didn't know why, but I desire to give a few of our members a chance to say what they think of him.

The Judge's fame is not simply national; it is international. The Judge is known and honored not only in the United States, but also in every other important country in the world. We have not representatives here from every country in the world, but we have a representative here from a country that cuts a very large figure in the geography of the world, and I ask Mr. Robert Hobson, President of the Steel Company of Canada, Hamilton, Ontario, to say something about Judge Gary upon this occasion. (Applause.)

Mr. Hobson: Mr. Chairman, Judge Gary, Ladies and Gentlemen: As a Canadian I am proud of the reception which you have given me. It has not been my privilege, as it has been the privilege of many of you here, to know the Judge for a great many years. Therefore, I cannot review the different successful steps he has made in life; besides, I don't believe in looking backwards.

Ever since it was decided to hold the meeting at St. Louis I have been looking forward to coming south, because there is always a very warm spot in the heart of every Canadian for the Southerners. I have had every hospitality shown me. Very shortly after I arrived, about an hour and a half after, I was met by a lady from a photographer's establishment who invited me to have my pictures taken. She said it would be only a plain photograph and I told her I would not be satisfied with that, because I demanded everything that was coming to me. Your business men here I have found possessed of the characteristics of the true Southern gentleman and I have not been disappointed on my visit to St. Louis. (Applause.)

But what I most looked forward to, Judge Gary, was to join in doing honor to you this evening. Your name is a household word in Canada as well as it is in the United States. You have written your name indelibly upon the history of the steel business of the world. During the five years that I have been associated with you on the Institute's Board of Directors I have learned to have great admiration for you. I have found you to be a most dignified Presiding Officer and I admire in you your strong desire to put and keep the steel business on a high plane of business ethics. Judge Gary, on behalf of the Canadian members of this Association, I wish you many years of prosperity. (Applause.)

Mr. Schwab: A man is known by the opinions of the world at large, but is best understood by those who are closely associated with him and work side by side with him day in and day out. I am afraid to make any humorous remarks about the gentleman I am about to introduce, because I have too much business with him. But everybody that knows Jim Farrell knows what an honest straightforward man he is, and I would like to have Mr. James A. Farrell, President of the United States Steel Corporation, say a few words about Judge Gary from the intimate side of the life he lives with him.

MR. FARRELL: Mr. Chairman, ladies and gentlemen: It is indeed gratifying to those who are associated with Judge Gary to hear the merited words of eulogy which have accompanied this testimonial of the members of the American Iron and Steel Institute; and, in adding my felicitations to those which have already found expression here this evening, it affords me sincere pleasure to have the privilege of testifying on behalf of my associates and the great body of employees of the United States Steel Corporation to the high esteem and affectionate regard which we entertain for the President of the Institute and our honored Chairman, Judge Gary. (Applause.)

Those of the American Iron and Steel Institute who have learned to esteem Judge Gary for his work in their mutual interests can appreciate in some measure the great pleasure and beneficent experience of his associates in the steel corporation, gained by personal contact, and your recognition of the necessarily leading position in the iron and steel industry of the United States and throughout the world does not in any way detract from the achievements of other great men in the industry in the country and abroad which have been considered leaders in their time and who have occupied a distinguished position in the promotion and welfare of the industry and those who are engaged in it. Since the United States Steel Corporation was formed, each year has cemented more closely our personal relations and our deep feeling of respect and admiration for Judge Gary's clear perception, magnanimous ideals and generous aspirations for the welfare of our large family of officials and employees and of the American iron and steel industry as a whole. Judge Gary's intense interest in welfare work is too well known to need comment, and his constant solicitude for their interest has become so well known that his policies and ideas are carried out throughout all of our companies in perfect accord.

We are living in a great and wonderful age. The world is passing through the most terrible contest of all history. Our country is happily free of the great strife which has touched almost every country of the globe. The industrial and commercial problems which are arising from these conditions require, in their proper solution, the combined wisdom and experience of our most capable leaders. We are prepared to face these problems with confidence under leadership which has already accomplished so much, and in that spirit of cooperation and mutual respect which has been forced and counseled by Judge Gary with such distinct success. It is difficult upon such an occasion as this to express all that is in our hearts and minds toward Judge Gary, and more especially difficult when that man is so closely associated with us in our daily business life. The very closeness of our associations with him, and our admiration for his attainments and methods, must necessarily allow much that we think of his wisdom and ability to remain unsaid. It is, therefore, gentlemen, with a deep feeling of appreciation that we of the United States Steel Corporation, on behalf of our officials and employees, join with you. We are numbered among your members in participating in the offering of this token to Judge Gary of the esteem that is felt for him by the iron and steel industry; and, if it be true that the development of the steel industry has been one of the most vital exponents of civilization, it can be considered equally true that Judge Gary is the chief exponent of that progress in its manifestations of recent years. And posterity for decades to come will look upon his achievements with the same feeling of respect, admiration and appreciation that we bear him to-night. (Applause.)

Mr. Schwab: We will now hear from a man who is in no way connected with Judge Gary in a business way, a gentleman who is both a purchaser and a producer of steel. I would like to call on Mr. Cameron C. Smith, President of the Union Steel Castings Company of Pittsburg.

MR. SMITH: Mr. Chairman, Ladies and Gentlemen: I am very much pleased to second anything which will honor or give pleasure to Judge Gary.

I have been introduced as a user of United States Steel Corporation products. I am also a steel manufacturer, but in no sense a competitor of Judge Gary or the United States Steel Corporation. My company manufactures steel castings, a product of which the Steel Corporation is probably the largest purchaser in this country.

A number of years ago our business was in a most deplorable condition both morally and financially, and a number of us banded together to try and improve our conditions. After floundering around for some time without any appreciable results, a committee of our organization, through Mr. John A. Penton secured a conference with Judge Gary, whose reputation for organization had reached us. The Judge immediately consented to give us an evening. He met us at the Waldorf-Astoria Hotel. He dined with us, he addressed us, he visited and buddied with us, and showed us the way. This he did for a body of men in whom he had nothing more than a humanitarian interest, and of the product of whose shops he was a purchaser. We built on this foundation and we have a Steel Founders' Society of which every member is just a little more than proud. With us it is almost a religion. (Applause.)

A year or so ago, while I was on the witness stand in the U. S. Steel dissolution suit, I stated that Judge Gary's advice and business ethics had been a great factor in shaping the policy of our Steel Founders' Society, and that our Society had so changed our methods of conducting business and the relations between competitors that whereas we formerly distrusted each other, secretly rejoiced in our competitors' misfortunes, and deliberately planned to give them false impressions of our own business conditions; we now are the best of friends and when one of us gets into trouble his competitors are willing and anxious to help him out.

I was severely cross-examined by the prosecuting attorney regarding what he termed this regeneration, and in his summing-up before the Court was compared to a leopard, and only pretending to change my spots.

I do not know if he measured me by his own standard, but I do know, gentlemen, that I was in the steel-casting business before Judge Gary's influence was felt and that the distrust did exist then; and I say to you now, as I stated to a meeting of Pittsburgh manufacturers a short time ago, that to-day if I had to select a personal executor for my estate I would want it to be one of my competitors. (Applause.) I say further that the transition is so great and the conditions of business so much cleaner and more pleasant that, should it be necessary to go back to the old order of things, I would immediately retire from the arena.

I owe a lot of the pleasures now derived from business to the new conditions which were conceived, fathered and fostered by Judge Gary, and I am very glad to add my voice to others in honoring our benefactor; and I say to you without reservation that, in my judgment, Elbert H. Gary, by his influence and example, has done more to cleanse and purify business conditions and put them on an upright and honorable basis than has all the restraining legislation passed by all the congresses in our history. (Applause.)

It is very pleasant and fitting to honor a worthy man by tokens of esteem, and by words of laudation, as we do tonight, but it is only thin air compared with a good deed done.

Judge Gary, the uplift you have given the iron and steel industry in this country is a monument to you higher than Mt. Washington or Pike's Peak, and my earnest desire is that you may see it grow and grow until cut-throat competition shall have entirely disappeared and the eternal (no, not eternal, but infernal) gulf between capital and labor shall have been bridged, and employer and employee shall meet as man to man, and shall work together in peace and harmony. (Applause.)

Gentlemen, is it too much to hope that some time employers and employees will meet together with perfect confidence in each other as we do now?

All honor to Judge Gary. (Applause.)

MR. SCHWAB: Gentlemen, we come to the last speaker that I am going to ask to say something about Judge Gary; a personal friend of mine for many years, a man I always dislike to tease or say anything about because he is such a good-natured fellow, Willis King. (Applause.) He ought to tell a story here this evening that he told this morning after Judge Gary's splendid address. The story was a good one and it seemed so proper when Willis told it to me that I thought it would be well for me, in view of the fact that he won't repeat it, to tell the story myself.

You know the Judge was telling us of the dire effects that would come, and we agree with him, when, this war having ended, the nations of the world shall be competing for the commerce of the world. There is going to be a terrible struggle commercially, and things were going to require careful watching. Willis said, "That reminds me of the story of the fellow who went out hunting. He came across a big bear. He saw he was in a tight place and he prayed, 'Lord, good Lord, help me to conquer this bear; if you don't help me, don't help the bear, and you will see the damnedest scrap you ever saw.'" (Laughter and applause.)

Willis King is one of the old standbys, one of the men that has been at Judge Gary's right hand in everything connected with this organization. We have reserved him for the last—Mr. Willis L. King, beloved by all the people here, Vice-President of this organization and a warm personal friend of mine, let us hear your voice for your friend, Judge Gary. (Applause.)

MR. KING: Mr. Chairman, Judge Gary, Ladies and Gentlemen: It is my good fortune to have known Judge Gary for some twenty years, and for most of the time, rather intimately. I hesitate to speak fully of my personal feeling toward him, for he is modest as he is great; but I may at least say that I have known him under all conditions, adverse and favorable, and have always found him the "Man of the Hour," self-reliant, courageous, reasonable, just, and a stickler for observance of the law. (Applause.) But after all, a man may best be judged by his works, and I feel free to speak of what he has done for the steel industry.

As you all know, he was called from the profession of law to take a position of the greatest responsibility with the largest producer of steel in the world. He brought with him a judicial mind, a knowledge of men and affairs, and a belief in commercial morality. He found some customs and practices in the steel industry, not illegal in themselves, but, as he thought, harmful and against good business ethics. He found that a competitor was quite generally regarded as a common enemy; that there was a lack of confidence in each other, and a belief that permanent success could best be attained by the longest purse and most aggressive methods, regardless of good policy or morals.

To quote his own words, he believed that actual friendship may continually be applied to competitive business; that, in the long run, unreasonable, destructive competition is prejudicial to the best interest of all concerned, including the manufacturer, his workmen, his customers, and the general public. He believed in competition but not hostility; in rivalry but not antagonism; in progress and success for all, but not the punishment or destruction of any. (Applause.)

He did not advocate combinations or agreements in restraint of trade, or action of any kind which is opposed to the law, or to the public welfare. He believed that the public interest is opposed to any arrangement which will secure the pecuniary success of any individual not able to reach it in competition with others. He advocated fairness and friendship in business, cordial intercourse, confidence in each other, frankness in disclosure when information is properly requested.

Holding such beliefs, he did not hesitate to advocate them, and gave freely of his time and energy to bring about such a change in the methods as would make the steel industry a model of fairness and commercial integrity.

This new and untried theory was not accepted readily, because confidence is a matter of slow growth, and the custom of generations could not easily be put aside; but he refused to accept discouragement, and gradually it began to take hold. Confidence became established, theory became fact, and you have adopted an epitome of his new business principles in the mottoes of this Institute, "Co-operation" and "Right Makes Might." (Applause.)

He has brought about a broader and better conception of duty and opportunity in the business world of steel, and a higher standard has been set up by him, which it is to be hoped will never be lowered.

Shakespeare tells us "Conscience doth make cowards of us all;" but I would rather think of Conscience as one's best friend, who in the still, small voice, tells us truly whether we have done well or ill, and we may be sure that Judge Gary desires no other reward than this.

We offer this testimonial, inadequate in itself, in the spirit of the old Latin Proverb: "Those gifts are ever the most acceptable which the giver has made precious," and beg you to accept it, my dear Judge, as an earnest of the appreciation, affection, and hearty good wishes of the members of the Institute. (Applause.)

MR. SCHWAB: Now, Judge Gary, I might say to you that I could have called on any man in this room and you would have had the same specimens of loyalty and devotion as have been expressed by the four gentlemen who have just spoken. We know that you want no more. You seem nervous and ill at ease at all the commendation that has been showered on you. No more will be said and I resign the gavel, Judge Gary, back to your hands, the hands that have so ably conducted us for so many years. (Applause.)

MR. GARY: I am bound to give expression to the one thought that is uppermost in my heart. And that is the feeling of gratitude for the kind words spoken and the sympathetic disposition shown for me this evening. And it overwhelms me. Of course, it is difficult for any one to hear so much praise without feeling more or less embarrassed, and yet I am bold enough to admit that I am proud, proud beyond the expression of words, proud because I have secured the confidence and the affection of so many most distinguished men. I do not know why I should have been so honored. I do not know why I have obtained and possess such generous, kind, loyal friendship; but it is evident that I have it, and I claim it, I treasure it, and I shall hold it. The words that have been uttered to-night by my loyal friends, which will be written up and printed and kept in a book to be retained forever and ever by my friends and relatives who are to come after me, is a monument great as could be established; not because I deserve these words, but because they express a feeling of sincere trust and confidence such as I have described. And after the time when all the trials and tribulations of life and all the hopes of heaven shall have come together, and I shall have been forgotten by my friends, there will remain for those who come after me and who may have been particularly interested in me this testimony of the fact that I had, while I lived, a friendship and affection so great.

And now, as we separate, may I turn your attention to matters less personal. I would refer to the fact that in Japan during the summer Mrs. Gary and I were most impressed with evidences of the great loyalty of the Japanese people for their government. I had never known of such an intense feeling so uniformly entertained by the people of a nation. At first it was hard to realize that every living person of understanding in that whole nation had for the uppermost thought and desire the good of the nation. And I would direct the attention of every one present to-night to one thing in this room that calls our attention to patriotic duty—the duty resting on every one of us during all the vicissitudes of life, during all the conditions and contingencies that may arise—the emblem floating around the balcony of this room which inspires us with the feeling that on all occasions we must entertain an undivided respect and affection for the flag of our country, which protects us and calls us to duty and compels us to realize our obligations; which takes us away from ourselves as individuals and summons us together as a nation of people created of individuals who live and must continue to live for the purpose of protecting the lives and the property and the interests of each individual of this country, and must set an example for the peoples of all other countries to follow. (Applause.)

And now I declare this meeting of the Institute adjourned *sine die*.

Stirred by Judge Gary's patriotic words, the audience on rising spontaneously united in singing "America."

# PARTICIPANTS—MAY MEETING

Abbott, F. E.
Abbott, W. H.
Adams, Charles E.
Affleck, B. F.
Ahles, R. L.
Alder, T. P.
Alderdice, Geo. F.
*Alford, W. J.
Alley, James C.
*Allen, John H.
*Allen, J. N.
*Alwyn, A. W.
Amaden, Edwin A.
*Anderson, Nils
Anderson, W. M.
Andresen, Herbert A.
Andrews, Jas. M.
Atwater, C. G.
Armstrong, Eliot
*Armstrong, V. C.
Atcherson, R. W. H.
Austin, H. L.

Baackes, F.
Baldridge, W. H.
Bailey, William M.
Baily, T. F.
*Baillett, B. J.
Baird, D. B.
Baird, F. C.
Baldwin, Louis S.
Baldwin, H. G.
Baldwin, R. L.
Balsinger, W. R.
Barba, W. P.
*Barber, E. J.
Barbour, H. H.
Barren, H. A.
Barrett, J. C.
Bateman, J. G.
*Baxter, H. V.
Beale, Harry S.
Beatty, R. J.
Beaumont, George H.
*Becker, Joseph
Belknap, Robert E.
Bell, John E.
*Belsterling, C. S.
Bennett, C. F.
Bennett, C. W.
Bennett, William H.
Bent, Quincy
Bergquist, J. G.
Biggert, C. F.
Bihler, L. C.
*Bird, J. P.
Birkinbine, John L. W.
*Bissell, J. B.
Black, Herbert F.
*Blagden, Dexter
*Blagdon, Thomas, Jr.
*Blaine, M. C.
*Blair, George D.
Blauvelt, William H.
*Blowers, William B.
Booth, Carl H.
Booth, Charles M.
Bope, H. P.
Borie, A. E.
*Botchford, C. W.
Bourne, Henry K.
Boutwell, Roland H.
Bowler, R. P.
Bowman, F. M.
Boynton, A. J.
Bradley, John C.
Brainard, J. W.
Braine, D. L.
Braine, L. F.
*Brandler, C. F.
Brassert, H. A.
Breeden, William
Brock, John Penn
Brooker, Charles F.
Brooks, Clyde
Brooks, J. J., Jr.
Brown, Alexander C.
Brown, Charles M.
Brown, Fayette
*Brown, H. A.
Browne, de Courcy
Brunke, Frederick C.
Buck, C. A.
Buck, D. M.
Budd, R. B.
Buffington, E. J.
Burden, James A.
Burdick, W. P.
Burr, F. A.
Bush, A. R.
Bush, D. Fairfax
Butler, J. G., Jr.
Butler, Gilbert

*Calfee, R. M.
*Cameron, George T.
Camp, J. M.
Campbell, J. A.
Campbell, J. J.
Campbell, L. J.
*Campbell, N. A.
*Campbell, R. G.
Carhart, P. E.
Carnahan, R. B., Jr.
*Carpenter, C. E.
*Carpenter, W. T. C.
*Carrier, S. C.
Carse, John B.
Carter, Eugene B.
Caterson, Ed.
*Cedarlund, K. H.
Chandler, John C.
*Chapin, A. H.
*Childs, Wm. H.
Christ, E. W.
*Church, S. R.
*Claney, C. D.
*Clarey, N.
Clark, Eugene B.
Clark, John B.
Clark, R. W.
Clarke, E. A. S.
*Claypool, George L.
Clingerman, W. H.
Clopper, H. G.

Close, C. L.
Cluff, Charles C.
Clyde, W. G.
Coakley, J. A.
Coble, D. H.
Cochran, C. A.
Coffin, William C.
*Collister, E. H.
Collord, G. L.
*Comstedt, F. A.
Connell, Frederick
*Connelly, W. C.
Cook, Howard D.
Cook, Howard H.
Cooper, S. G.
Corbett, W. T.
Corey, A. A., Jr.
Cornelius, Henry R.
Corning, C. R.
Coulby, H.
*Coulier, C. H.
*Coulier, E. J.
*Court, J. M.
*Cover, Loring
*Cowley, C. O. C.
*Craig, S. N.
*Craig, W. W.
Crawford, E. R.
Crawford, George G.
Crispin, M. Jackson
Crocker, George A., Jr.
Cromwell, J. C.
Cuntz, William C.

Dalton, H. G.
Damerel, George
Darlington, Thomas
Davey, W. H.
Davies, G. C.
Davis, Arthur L.
Davis, Charles C.
Davis, S. A.
Davis, W. O.
*Day, David B.
Day, R. D.
Dean, William T.
*Debevoise, Paul
Deericks, Joseph G.
*Delafield, Edward C.
Deming, Fred C.
Dennis, M. S.
Dette, William
Deutsch, Samuel
Devens, H. F.
*Devens, Richard
*de Verdiere, Chas. Colin
Diehl, A. N.
Dillon, A. H.
Dinkey, C. E.
*Dinkey, W. C.
Dix, John W.
Dodd, Alfred W.
Donner, Robert N.
Donner, W. H.
Downs, G. F.
Dows, Davis
*Drake, Fred R.
Driscoll, Daniel J.
*Dudley, H. A.
*Duffield, A. T.
Duncan, John
*Duncan, T. S.
*Duncan, W. M.
Du Puy, Herbert
Dyer, P. S.

*Earle, Thomas
Early, George P.
*Eddy, George S.
Edmonds, Richard H.
Edwards, V. E.
*Edwards, W. M.
*Ehlers, Edward
*Ellis, John M.
*Eustis, F. A.
*Eustis, Harold
Evans, Mason

Farrell, J. A.
*Farrell, J. J.
Farrell, W. H.
Fedder, W. P.
Felton, E. C.
*Ferree, C. B.
Filbert, W. J.
*Filley, M. L.
Findley, A. I.
*Fisher, P. L.
Fitzpatrick, F. F.
*Fleming, James
*Flenniken, Robert W.
Fletcher, John F.
*Flint, Charles R.
Floersheim, Berthold
*Forbes, B. C.
Forbes, William A.
*Forwood, W. W.
Fowler, A. A.
Francis, Lewis W.
Fraser, J. S.
Frazer, Fred
Freeman, S. S.
*French, S. S.
Freyn, H. J.
*Friend, C. W.
Froment, E. McK.
*Froment, Frank F.
*Fry, R. M.
Fuller, Willard

Gage, F. E.
Gardner, K. C.
Gardner, Wm. C.
Gary, Elbert H.
Gathmann, Emil
Gayley, James
Gensheimer, P.
*Gepp, H. W.
Gessler, Theo. A.
*Gillies, J. J.
*Gillispie, H. W.
Glass, Alex
*Glass, John
Glenn, Thomas K.
Goddard, J. N.
*Goode, H A.
Gordon, Frank H.
Gould, Frank
Grace, E. G.
*Grady, Charles B.
Grange, A. B.
Gray, J. H.
*Gray, Wm. G.
Green, William McK.
Gresham, W. B.
*Griffin, J. C.
Gruss, Wm. J.

Hackett, S. E.
Hagar, Guy A.

Hale, Samuel
Hall, R. S.
Hamilton, Alexander K.
Hamilton, E. J.
*Hamilton, F. D.
Hamilton, John W.
Hamilton, J. W. H.
Harrison, Edwin W.
Harrison, H. T.
*Harter, I.
Hatfield, J. A.
*Hausherr, Louis, Jr.
*Hawley, William P.
*Hayman, E. J.
*Hays, W. C.
*Hazen, W. E.
Heedy, Henry W.
Hendricksen, J. J.
Henshaw, John O.
*Heppenheimer, W. C.
Herndon, E. L.
*Herzog, G. K.
Hewitt, George W.
*Higinbotham, W. J.
*Hilands, J. P.
Hildrup, William T., Jr.
*Hill, P. S.
Hillman, Ernest
*Hilton, A. A.
Hirschland, F. H.
Hobson, Robert
*Hodgman, Walter E.
*Hoerle, F. D.
Holloway, W. W.
Holmes, C. O.
Holmes, George C.
Hook, Charles R.
*Hoot, J. C.
Horner, W. S.
*Horton, L. M.
Hovey, O. E.
Howard, Clarence H.
Howe, Henry M.
*Howell, A. C.
Howell, H. P.
Howland, H. P.
Hoyt, Elton, 2d
Hoyt, James H.
Hubbard, P. H.
*Huffer, H. C., Jr.
Hughes, Edward E.
*Hughes, E. P.
Hughes, John
Hughes, H. L.
Hughes, I. Lamont
*Hulick, W. H.
Humbert, Ernest
Hunt, Robert W.
Hunter, John A.
*Huntington, W. C.
Huntley, F. P.
Hurd, Charles S.
*Hurley, E. N.
Huston, C. L.
*Hutchinson, A. A.
Hutchinson, B. E.
Hutchinson, O. N.
Hyatt, W. E.

*Imbrie, James
Inglis, Jas.
Irons, Robert H.
Isham, Phillips
Ives, E. L.

James, Henry L.
*Jayne, Chester A.
*Jayne, D. W.
Jennings, Robert E.
Johnson, J. E., Jr.
*Johnson, J. Ford, Jr.
Johnston, C. T.
*Johnston, M. E.
Jones, E. F.
Jones, H. L.
Jones, Harry R.
Jones, John E.
*Judd, H. E.

*Kahil, A. A.
Kaufholz, C. F.
Keefe, J. S.
Kennedy, Hugh
Kennedy, Julian
Kennedy, J. J.
Ker, Severn P.
Kerr, D. G.
Kimball, G. C.
King, Willis L.
*Kinsel, T. F.
*Klein, L. C.
Klugh, B. G.
*Knapp, William J.
Kneeland, Edward
Knowles, Alexander S.
Knowles, Morris
Knox, L. L.
Kreps, J. E.
*Kunhardt, W. B.

Ladd, George T.
Lamont, R. P.
Landgrebe, Karl L.
Langenbach, Ed.
Larkin, J. K.
Larssen, C. G. Emil
*Lathrop, A. P.
Lea, Robert C.
*Lee, Louis R.
Leech, M. W.
Leet, George K.
Lehman, A. C.
Lemoine, L. R.
*Lenhart, C. E.
*Lesley, Robert W.
*Lewis, Isaac N.
Lewis, J. E.
Lippincott, James
*Littlejohn, R. M.
Lloyd, J. F.
*Lober, John B.
*Loewenstein, Jacob
Logan, John W.
Lovejoy, Frederick B.
*Low, William
Lozier, C. E.
*Ludlum, A. C.
Lukens, W. W.
Lustenberger, L. C.

MacDonald, D. C.
MacDonald, R. A.
*MacIntire, C. V.
McAlarney, J. H.
McAteer, H. W.
McCauley, J. E.
McCleary, J. T.
*McClintic, H. H.

*McDonald, James H.
McDonald, Thomas
McDonald, William
McElhany, C. B.
McGonagle, W. A.
McIlravy, W. N.
McIlvain, E. M.
McKee, Arthur G.
McKelvy, E. A.
McLauchlan, J. C.
McLeod, John
*McMann, James R.
*McNally, A.
*McNaughton, James
*McVey, G. K.
*Mace, R. E.
Mack, A. F.
*Macon, W. W.
Manning, William E.
Marchant, C. R.
*Markowitz, A. Lincoln
Marshall, C. D.
Marshall, C. S.
Marshall, S. M.
Mather, Amasa Stone
Mather, Samuel
Mather, S. L.
Mathews, John A.
*Matlack, Howard C.
Mehlhorn, W. M.
Meissner, C. A.
Mercur, Robert J.
Mesta, George
Meyers, F.
*Millar, W. G. A.
Miller, C. D. S.
Miller, C. L.
*Miller, L. H.
*Mills, E. D.
*Mitchell, G. H.
*Moeller, R. C.
Mogan, C. J.
*Monroe, James R. M.
*Moore, H. R.
*Moore, R. P.
*Morgan, Junius S.
Morgan, W. H.
Morris, A. F.
*Morris, G. B.
Morris, L. B.
Morris, William J.
Morse, A. C.
Moss, John B.
Muchnic, Charles M.
Mudge, E. W.
*Mundo, C. J.
*Murphy, W. C.
Myers, F.
*Myers, William J., Jr.

Nash, Albert L.
Nash, H. P.
Neale, John C.
*Newcomb, C. H.
*Newhall, Morton S.
Nichols, John A.
Nicoll, Benjamin
*Nields, Benj.
Niemann, C. F.
*Nutting, L. B.

*O'Brien, D. F.
*Orbanowski, K. A.
*Overholt, A. C.

Palmer, William P.
Palmer, W. R.
Pargny, E. W.
Parker, J. A.
*Parker, J. H.
*Parsons, Henry
*Peaslee, E. H.
Peck, A. H.
Peck, H. H.
Peckitt, Leonard
Peirce, E. H.
*Penfield, R. C.
Penton, John A.
Perin, C. P.
Perkins, George W.
Perkins, H. F.
*Perley, Alden
Perley, Ward B.
Perry, J. E.
*Perry, R. P.
Pessano, Antonio C.
Peters, E. V.
Peters, Richard, Jr.
*Pettee, R. O.
Pew, John O.
*Phillips, R. H.
Pickands, Henry S.
Pilling, W. S.
*Porter, Horace
*Pratt, A. G.
Pratt, R. H.
Prendergast, G. A.
Preston, Veryl

Quarrie, B. D.
*Queal, H. P.

Rachals, Walter
Rainey, Roy A.
Ramsburg, C. J.
*Ramsey, W. H.
Rand, Charles F.
Rathbone, R. L.
Raymond, Henry A.
Rees, J. A.
Reeves, David
Reis, John
Replogle, J. Leonard
Reynders, J. V. W.
*Rhodes, Geo. P.
*Rianhard, T. M.
Rice, R. H.
Richards, F. B.
*Riddle, L. E.
Ridgway, W. H.
*Roberts, J. A.
Roberts, W. F.
Robinson, C. R.
Robinson, C. S.
*Robinson, D. P.
*Robinson, Edward S.
Robinson, T. W.
Rogers, Weaver H.
Rogers, William A.
Rowe, Wallace H.
Ruddiman, John
Rugg, D. M.
Ruiloba, J. A.
Runyon, Walter C.
Runyon, Walter C., Jr.
*Rushmore, D. B.
Russel, John R.
Russel, W. S.

Russell, N. F. S.
Rust, E. Marshall
Rust, H. B.
Rust, S. M.
Rust, W. F.
*Ryan, Alan A.
Ryding, H. C.
Rys, C. F. W.

St. Clair, G. A.
Samuel, Frank
*Sandberg, O. F. A.
*Satterthwaite, George
Sauveur, Albert
*Sawhill, E. P.
Scammell, Charles H.
Scammell, M. J.
Schiller, William B.
Schleiter, W. F.
Schmidt, John C.
Schnatz, G. Theo.
*Schneider, A. A.
Schwab, Charles M.
Scott, George C.
*Sells, W. H.
*Sheets, E. A.
*Shera, George W.
Sheridan, R. B.
Shiras, MacGilvray
Short, George W.
Sias, John M.
Siebert, W. P.
Simonds, A. T.
Sinn, F. P.
Slick, E. E.
*Slick, F. A.
Slick, F. F.
Sloane, Burrows
*Smith, George T.
Smith, James W.
*Smith, J. C.
Snyder, H. S.
Snyder, William P., Jr.
*Solomon, Max
Souder, Harrison
Sparhawk, Edward M.
Speller, F. N.
*Spilsbury, E. G.
Stackhouse, Powell
Stanton, W. A.
*Stapleton, L. D.
*Stark, C. J.
Stearns, Edward B.
Stebbins, H. S.
*Steer, E. J.
Stephenson, J. I.
Stevens, Charles G.
*Stevens, C. N.
Stevens, H. L.
Stevenson, A. A.
Stewart, Hamilton
Stewart, Scott
Stillman, J. S.
*Stineman, Harvey C.
Stoddard, H. G.
Stone, C. A.
Stratton, W. H.
Sullivan, G. M.
Sullivan, W. J.
Swartz, Alfred H.
Sweetser, Ralph H.
Sykes, Wilfred

Tallcott, Daniel W.
*Tallcott, Daniel W., Jr.
Taylor, J. M.
Taylor, Knox
Taylor, T. H.
Taylor, Wade A.
Thomas, A. J.
Thomas, E. P.
Thomas, George, 3d
Thomas, Leon E.
Thomas, T. E.
Thomas, W. A.
Thompson, A. W.
*Thompson, Lynn W.
*Thornton, Carl
Thorp, George G.
*Throckmorton J. B.
Timmins, George
Tinsley, J. F.
Todd, William B.
*Tonnele, Theo.
Topping, Jno. A.
Towne, Thomas
Townsend, H. E.
Townsend, J. F.
Trabold, Frank W.
Tracy, D. E.
*Ulm, A. H.
*Ulrich, Chas.
*Underhill, Henry L.
Unger, John S.

Valentine, S. G.
Van Schaick, A. P.
Verity, George M.
Vogt, A. W.
Vogt, Charles A.
Vom Bauer, C. H.
Vreeland, George W.

Wadsworth, J. E.
Waldeck, Jay
Walker, J. C.
*Walker, T. B.
Walker, W. R.
Wallingford, B. A., Jr.
Ward, James H.
*Warren, O. B.
Warren, William H.
Waterhouse, G. B.
*Watson, William A.
Watson, W. E.
Wayland-Smith, R.
Weaver, H. B.
Webb, Albert R.
Webster, William R.
Weir, David M.
Weir, E. T.
Weiss, Jay G.
Weld, C. M.
Wellman, S. T.
*Wells, J. Hollis
Westfall, Harry D.
Whitaker, N. P.
*White, F. H.
*Whitney, R. H.
Whittemore, E. L.
Wiley, Brent
*Willard, L. L.
Williams, Harrison
Williams, H. D.
*Williams, L. D.
*Williams, Louis W.
*Williams, R. B.
Wilputte, Louis
*Wilson, Horace N.

Wilson, H. M.
*Wingert, H. P.
Wisener, G. E.
Witherbee, F. S.
Wolfe, W. L.
*Wolvin, A. B.
*Wonham, F. S.
Wood, Alan D.
Wood, Charles L.
Wood, F. W.
Wood, Howard, Jr.
Wood, Richard G.
Wood, R. G., Jr.
Wood, Walter
Woods, John E.
Woods, Leonard G.
Woolsey, A. E.
*Woolsey, George M.
Wright, W. H.
Wright, W. L.

*Yates, Harry
Young, A G.
Young, A. H.
*Young, E. M.

Zehnder, C. H.
Zehnder, E. M.

* Guests

# PARTICIPANTS—OCTOBER MEETING

Abell, Oliver J.
Affleck, B. F.
Akin, Thomas R.
Alderdice, George F.
*Allderdice, N.
Allderdice, Taylor
Allen, J. N.
*Allen, W. L.
Anderson, Brooke
*Anderson, F. E.
Anderson, Nils
Andresen, Herbert A.
Andrews, J. I.
*Arpe, W. W.

Baackes, F.
Bachman, F. E.
Backert, A. O.
*Bailey, T. C.
Baily, T. F.
Baker, George
Baker, H. L.
*Baldwin, George B.
Baldwin, H. G.
Baldwin, L. S.
Baldwin, R. L.
*Balkwell, Geo. W.
Baltzell, Will H.
Banks, A. F.
Bannister, J. C.
*Barks, F. S.
Barrett, D. A.
*Barrows, O. B.
*Bascom, J. D.
*Batchelor, E. D.
*Bausch, F. E.
*Baxter, Ernest
Beaumont, George H.
*Beck, J. J.
*Becker, Joseph
*Beckwith, H. C.
Beegle, F. N.
Belknap, Robert E.
*Bell, J. V.
*Bellville, H. C.
Bennett, C. W.
Bentley, F. T.
*Bergandahl, V. W.
Bever, J. J.
Biggert, Cassius F.
*Bigler, F. S.
*Birney, E. H.
*Bishop, H. P.
*Bixby, W. K.
*Blake, O. P.
Block, E. J.
*Block, Harry L.
Block, L. E.
*Boekenkroeger, H. W.
Booth, C. H.
*Boughton, A. C.
Bourne, H. K.
*Boyer, Frank N.
Boynton, Arthur J.
Brassert, H. A.
*Broderick, J. J.
Brooke, Robert E.
*Brookings, R. S.
Brooks, Clyde
Brooks, J. J., Jr.
*Brown, C. M.
*Brown, P. W.
Browne, de Courcy
Brunner, John
Bryan, C. W.
Buck, D. M.
Buek, C. E.
Buffington, E. J.
*Buick, J. M.
*Bull, R. A.
Burdick, J. W.
Burdick, W. P.
*Burg, Wm.
*Burlingame, Ira L.
*Burmeister, A. B.
*Burns, George M.
Burns, Timothy
Burt, David A.
*Busch, A. A.
*Bush, A. R.
*Bush, B. F.
Butler, Gilbert

*Cabell, Carrington
Caldwell, C. D.
*Calkins, William
Camp, J. M.
Carhart, P. E.
Carnahan, R. B., Jr.
*Carter, L. Ray
Cartwright, John H.
*Champ, J. H.
Champion, David J.
Charls, George H.
*Christopher, B. E.
Clark, E. B.
Clarke, E. A. S.
*Clifford, Alfred
*Clifford, O. M.
Clopper, H. G.
Cluff, Charles C.
Clyde, W. G.
Coffin, William C.
*Cohn, I. H.
Collier, W. E.
Cook, Howard H.
Cordes, Frank
Cornelius, Henry R.
*Cotter, P. W.
*Cotter, S. E.
*Cotter, Wm.
*Cottrill, George
Coulby, H.
Crabtree, Fred
Cromlish, A. L.
Crook, Alfred
Croxton, D. T.
Croxton, S. W.
*Cuthbert, C. Morgan

Daft, Andrew C.
Danforth, A. E.
Danforth, G. L.
Davis, Charles C.
*Davis, G. L.

Davis, J. C.
Davis, S. A.
Davis, W. O.
Dean, William J.
Dean, William T.
De Forest, A. T.
Dennis, M. S.
*Destaeble, R.
Deuel, H. A.
Deutsch, Samuel
Dewey, Bradley
*Dieckmann, Fred W.
Diehl, Ambrose N.
Dodd, Alfred W.
*Dooley, T. A.
Dorman, A. D.
*Dorman, P. O.
*Dorney, J. J.
*Doyle, N. A.
Driscoll, D. J.
Duncan, John
Duncan, W. M.
Dunham, Lewis E.

*Eagle, S. S.
Early, George P.
Edgar, S. C.
Edgar, S. C., Jr.
Edwards, Jas. H.
*Einstein, A. C.
*Eks, Eddie
*Elliott, Henry
*Elliott, W. H.
Endicott, George
Eppelsheimer, D.
Eschenbrenner, D. F.
Evans, David
*Evans, George B.
Eynon, David L.
Eynon, David L.

Fairbairn, C. T.
Farrell, James A.
Field, William A.
Findley, A. I.
*Fining, F. N.
*Fisher, E. E.
*Fisher, J. B.
Fletcher, John F.
Floersheim, Berthold
Forbes, William A.
*Forrest, J. D.
*Francis, David R.
*Francis, J. D. P.
Francis, Lewis W.
*Francis, Talton
*Franklyn, C. V.
Freyn, H. J.
*Frier, T. J.
Fuller, F. M.

Gamble, J. N.
*Garneau, J. W.
*Garrett, J. M.
Gary, Elbert H.
*Gaspar, Charles
George, Jerome R.
*Giessenbier, Henry, Jr.
*Gifford, L. R.
Glass, John
Gleason, W. P.
Goddard, H. W.
Goltra, Edward F.
Gould, Frank
Grant, Richard F.
*Granville, Jos. D.
Gray, J. H.
Green, John L.
Green, Wm. McK.
*Greene, E. E.
*Greensfelder, J. B.
Griffiths, E. S.
Griswold, H. C.
Gruss, William J.

Hall, Francis J.
*Hall, John R.
Hamilton, Alex. K.
Hamilton, F. D.
*Hanley, R. S.
*Hanlon, George H.
Hanlon, W. W.
*Harding, G. F.
Harrison, Nat. C.
Harrison, W. H.
*Hartry, Frank
Hatton, Richard D.
*Hayman, E. J.
*Hedgcock, W. E.
Heggie, Charles
*Henning, W. C.
*Hensel, E. R.
*Herbert, J. M.
Hickok, Charles N.
*Hidden, Edward
Higgins, H. E.
Higgins, W. B.
*Hilands, J. P.
*Hitz, Geo. W.
Hobson, Robert
Holbrook, Percy
Holding, James C. C.
*Hoelke, Herman M.
*Holliday, John H.
*Holman, C. L.
Holmes, George C.
*Holmes, Horace B.
*Holmes, L. C.
Hook, Charles R.
*Hoot, J. C.
*Hornbrook, John
Horner, W. S.
*How, C. A.
Howard, Clarence H.
*Howard, Geo. E.
*Howard, Thornton C.
*Howell, H. C.
Hoyt, Elton, 2nd
Hoyt, James H.
Hubbard, Paul H.
*Hubbell, H. P.
*Hughes, H. H.
Hughes, I. Lamont
Hughes, William H.
Hunter, John A.
*Hurst, Chas. M.
Hutchinson, A. H.
Hutchinson, B. E.
*Hutchinson, C. E.
*Hutchinson, J. K.
Hutchinson, O. N.

Irons, Robert H.
Irvin, William A.
*Irwin, C. E.

*Jackes, F. R.
James, Henry L.
Jarecki, Alexander

Jenks, George S.
Jewell, Thomas M.
Jewell, William E.
*Johnson, Boone V. H.
Johnson, Frank H.
Johnson, J. E., Jr.
Johnston, Archibald
*Jones, Breckenridge
*Jones, C. Norman
Jones, E. F.
Jones, G. H.
Jones, Harry C.
Jones, H. C.
*Jones, I. O.
Jones, J. E.
*Jones, Wilbur

Kauffman, W. L.
*Kay, Harry F.
*Kearney, E. F.
Keefe, J. S.
*Keller, J. H.
*Kelley, J. M.
*Kelly, Joseph
Kemp, J. E.
Kennedy, Hugh
Kennedy, J. J.
*Kilner, R. H.
Kimball, G. C.
*King, C. H.
King, Willis L.
*Kinsey, E. R.
*Kleinschmidt, G.
*Kling, F. E.
*Knapp, H. P.
*Knapp, Lewis
Knowles, A. S.
*Knowles, W. V.
Knox, Luther L.
*Koken, W. T.
*Kranz, H. J.

Lacey, Harry
*Lackland, Henry K.
Lambert, John
Lanahan, Frank J.
Larimer, James I.
*Lathrop, M. A.
*Laudinghaus, H., Jr.
Leet, George K.
*Leonard, E. D.
Leonard, S. C.
LeVan, G. B.
Lewis, John F.
*Lewis, Joseph W.
Lewis, W. H.
*Lidstone, H. G.
*Lilley, E. B.
Lippincott, James
*Little, E. C.
*Littlefield, F. H.
Llewellyn, J. T.
Llewellyn, S. J.
*Lloyd, John
*Lovelace, Thos. H.
Lowell, G. C.
Lustenberger, L. C.

*MacArthur, D.
MacDonald, R. A.
*Maffitt, Thomas S.
*Mann, Henry S.
Marchant, C. R.
Marks, Anson
*Marks, David A.
*Marsh, W. R.
Marshall, D. J.
Mather, Amasa Stone
Mather, S. L.
*Mathews, W. N.
Mathias, D. R.
Mathias, D. S.
Mathias, T. H.
*McCabe, D. P.
McCauley, J. E.
McCleary, E. T.
McCleary, James T.
*McCleary, Leslie T.
McConnell, John
McDonald, L. N.
McDonald, Thomas
*McDonnell, Edward J.
*McGeary, Lewis
McGowan, C. L.
McKee, A. G.
McKee, W. S.
McKelvy, E. A.
*McKown, J. H.
McLeod, John
*McLeod, W. E.
McMahon, R. E.
McMath, F. C.
Meacham, D. B.
*Mears, J. C.
*Meier, D. I.
*Meier, H. M.
Meissner, C. A.
*Meyer, F. L., Jr.
Miller, C. L.
*Miller, E. J.
*Miller, Henry
*Miller, H. L.
Mills, Edwin S.
Mills, James R.
*Mills, J. W.
Miner, E. G.
Moffett, C. A.
Mohr, B. F.
Mohr, J. A.
*Moody, A. A.
Moore, H. G.
*Moore, Philip N.
*Morey, A. T.
*Morey, Franklin
*Morey, F. L.
Morgan, P. B.
*Morgan, W. E.
*Mueller, A. M.
*Mungenast, Andrew

Neale, John C.
Neckerman, Wm. M.
*Niedringhaus, A. W.
*Niedringhaus, G. H.
Niedringhaus, G. W.
*Niedringhaus, H. F.
*Niedringhaus, Lee
*Niedringhaus, M. W.
*Niedringhaus, Thos. K.
*Niekamp, George
Niekamp, William L.
Niemann, C. F.
Nullmeyer, F. H.
Nulsen, F. E.
*Nulsen, John

*Olson, O. A.
*O'Neil, J. F.
*O'Neil, L. O.
*O'Neil, W. D.

Pargny, E. W.
*Park, W. L.
Parks, F. E.
Patterson, P. C.
Pattison, Melvin
Peckitt, Leonard
Penton, John A.
Perkins, Herbert F.
*Pero, J. P.
Peters, Richard, Jr.
*Pflager, H. M.
Pierce, Talbot E.
Pilling, W. S.
Pope, H. F.
*Price, John M.
*Priest, Henry
*Pryor, E. B.
*Pulitzer, Jos., Jr.

Quarrie, B. D.

Ramsburg, C. J.
Rand, Charles F.
*Randolph, Tom
Rathbone, R. L.
Raymond, H. A.
Rees, J. A.
Reese, P. P.
*Rettig, D. S.
Reynders, J. V. W.
*Rice, N. M.
Richards, F. B.
Riddle, Lawrence E.
*Roach, A. R.
*Robbins, Walter
*Robertson, Alexander
Robinson, C. S.
Robinson, T. W.
*Rodier, J. H. D.
*Roesch, J. A.
Rogers, Weaver H.
Rogers, William A.
Rose, George E.
*Rossman, W. F.
Rownd, H. L.
Ruddiman, John
Rugg, Dan M.
Ruiloba, J. A.
Runyon, W. C.
Russel, John R.
Rust, H. B.
Rust, W. F.
Ryerson, Donald M.
Ryerson, J. T.
Rys, C. F. W.

*Saunders, W. F.
*Schaff, C. E.
Schiller, William B.
*Schmick, W. L.
Schmidt, John C.
*Schott, C. G.
Schuler, J. H.
*Schumm, Wm. A.
Schwab, Charles M.
*Scott, C. E.
Scott, G. C.
Scott, G. E.
Scott, W. D.
*Scott, W. W., Jr.
Selmi, L.
*Shapleigh, A. L.
*Sharp, J. B.
Sheldon, Samuel B.
Short, Geo. W.
Shover, B. R.
Sias, J. M.
Siebert, W. P.
*Simmons, George W.
*Simmons, W. J.
Simonds, A. T.
*Simpson, W. S.
Smart, Geo.
*Smith, A. B.
Smith, Cameron C.
*Smith, Claude H.
Smith, H. Sanborn
*Smith, James E.
*Smith, J. C.
Smith, Samuel L.
Snyder, George T.
Snyder, W. E.
*Sommers, Carl
*Sommers, W. H.
*Sosenheimer, H. L.
Sparhawk, Edward M.
*Spilsbury, H. G.
*Stanford, G. I.
Stanton, W. A.
Steinbreder, H. J.
Stephenson, James I.
*Stephenson, W. S.
*Stern, H. L.
Stetson, Francis L.
Stevens, Charles G.
Stewart, Hamilton
Stillman, Charles A.
Stone, E. E.
*Sullivan, F. D.
Swart, W. G.
Swartz, Alfred H.
*Sweeny, M. J.
Sykes, Fred. W.
Sykes, W.

*Taussig, J. E.
*Taylor, Charles I.
Taylor, Knox
Taylor, T. H.
Taylor, Wade A.
Thomas, E. P.
Thomas, Elmer W.
Thomas, George, 3rd
Thomas, Leon E.
Thomas, W. A.
Thompson, A. W.
Thompson, G. M.
*Thompson, H. L.
*Thompson, J. W.
Thorp, George G.
Timmins, George
Tod, Fred
Topping, W. B.
Touceda, Enrique
Towne, Thos.
Trainer, W. B.
*Tritte, J. S.

Unger, J. S.

Verity, Geo. M.
Vogt, A. W.

Walker, W. R.
*Wallace, T. P.
Wallingford, B. A., Jr.
Ward, D. L.
*Ward, M. R.

Warren, W. H.
*Warren, W. M.
Waterhouse, George B.
Waterman, Fred W.
Watson, W. E.
Weatherwax, H. B.
Weir, David M.
*Weisbrod, J. H. M.
Weiss, Jay G.
Wellman, S. T.
Wendell, Carl A.
Weston, W. B.
Wheeler, Seymour
White, G. A.
*Whitehead, C. N.
Whyte, George S.
*Wicks, J. C.
Wiley, Brent
*Wilkinson, M. L.
*Williams, B. P.
Williams, H. D.
*Willis, O. J.
*Wilson, Horace N.
Wilson, Willard
Winslow, F. B.
Wisener, G. E.
*Wolff, H. W.
*Wood, B. T.
*Woods, P. H.
*Woodward, Walter B.
*Worcester, Edward, Jr.
Wright, S. D.
Wright, W. H.

Young, A. G.
Young, A. H.
*Young, Lafayette

Zehnder, Charles H.
Zehnder, E. M.
Ziesing, August

* Guests