

May 20, 1952

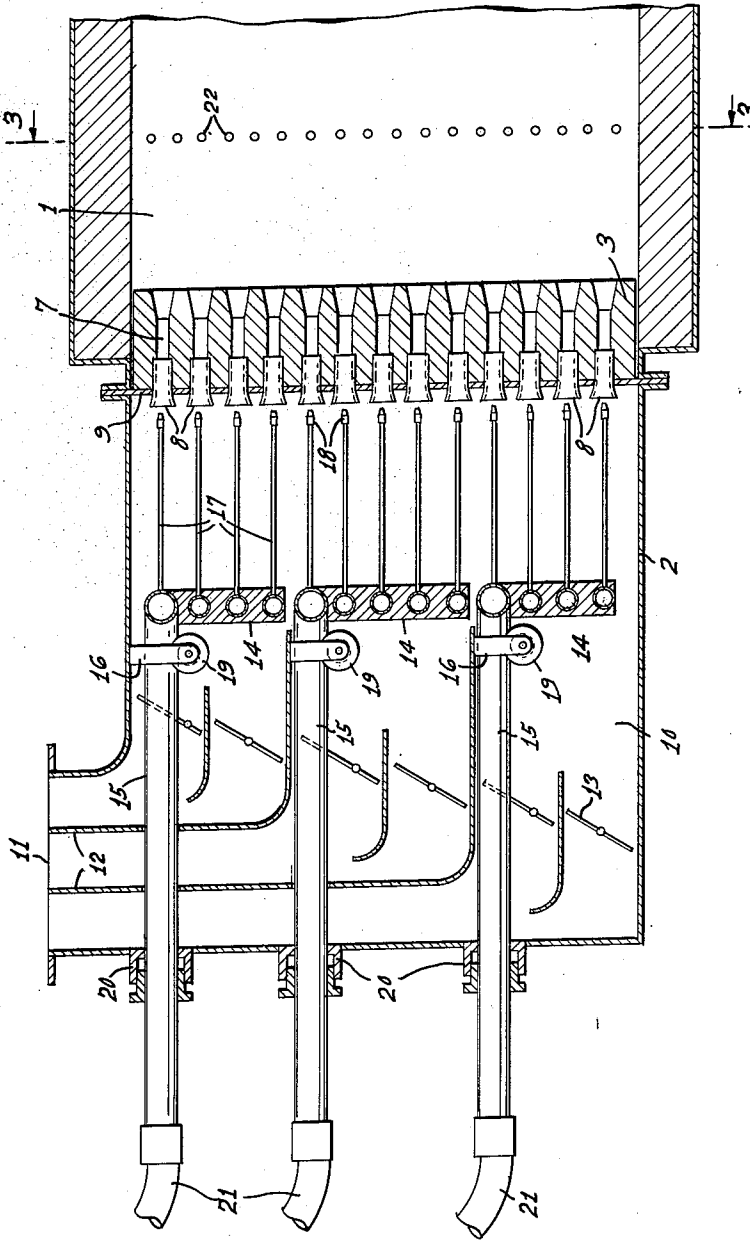
W. C. EKHOLM ET AL
MANUFACTURE OF CARBON BLACK

2,597,233

Original Filed March 23, 1948

3 Sheets-Sheet 2

FIG. 2



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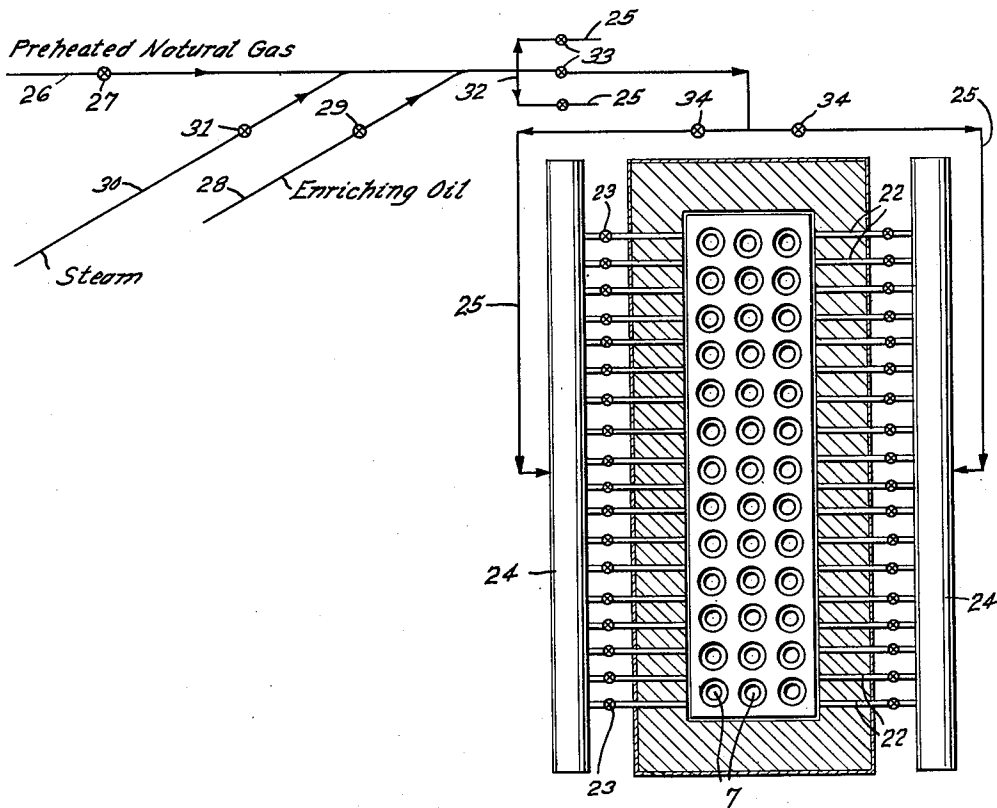
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FIG. 3



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MANUFACTURE OF CARBON BLACK

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Continuation of application Serial No. 16,586, March 23, 1948. This application August 25, 1950, Serial No. 181,424

6 Claims. (Cl. 23—259.5)

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The present invention relates to the manufacture of furnace blacks and provides improved apparatus especially adapted to the carrying out of the process described and claimed in the Wiegand and Braendle Patent No. 2,378,055 and a special adaptation of that process described in the Wiegand and Braendle Patent No. 2,440,424. In a particularly advantageous modification thereof, the apparatus of our present invention is further especially adapted to the carrying out of the process described and claimed in our co-pending application Serial No. 16,585, filed March 23, 1948, as more fully described herein. The present application is a continuation of our co-pending application Serial No. 16,586, also filed March 23, 1948, now abandoned.

In accordance with the process of the said patents, a hot, high velocity violently turbulent stream of blast flame gases is generated at one end of an elongated reaction chamber by the burning of a combustible mixture of air and a fuel gas therein and a fluid hydrocarbon, herein designated "make" or "make gas," is forcefully injected as a plurality of relatively small streams into the blast flame gases as they pass through the reaction chamber in a zone near the burner end thereof so that the make gas is substantially, instantaneously mixed with the blast flame gases and is decomposed by heat absorbed therefrom to form carbon black which is separated from the furnace gases passing from the downstream end of the chamber.

We have found that, in operations of that type, the character, and especially the yield of the resultant carbon black, are materially influenced by the configuration and dimensions of the transverse section of the stream of blast flame gases, especially at the point of injection of the make, and the manner in which the make gas is injected into and mixed with the blast flame gases. The process of our said application provides a particularly advantageous method of effecting a rapid, uniform mixing of the make gas with the blast flame gases and constitutes an improvement in the process of the said Wiegand and Braendle patents.

More particularly, we have found that the arrangement and dimensions of the furnace chamber and auxiliary equipment for injecting the make gas into the furnace chamber and for supplying the hot blast flame gases thereto, materially affect the uniformity of the mixing of the make gas with the blast flame gases. The apparatus of the present invention is so designed and constructed as to promote a more rapid uni-

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form mixing of the make gas with the blast flame gases with the resultant increase in yield of carbon black for a given quantity of hydrocarbon consumed and greater ease and nicety of control of the characteristics of the carbon black produced.

From careful observation and tests, it appears rather unexpectedly that the streams of make gas injected radially into the stream of blast flame gas passing through the reaction chamber maintain their identity for an extremely short period of time, of the order of microseconds, despite the violently turbulent flow conditions in the reaction chamber. It further appears that uniformity of mixing is promoted by maintaining a uniform temperature, velocity and composition of the blast flame gases throughout the transverse area of the stream, particularly in the zone where the make gas is injected. However, uniformly rapid mixing with resultant uniform dispersion and heating of the make gas does not appear to be obtained where the entering make gas streams do not penetrate a sufficient distance into the stream of blast flame gases before losing their identity. It appears that, in commercial sized units, there is a danger of a core of blast gas, without its quota of intermixed make, passing through the center of the furnace and resulting in undesirable reactions and quality of product, together with loss in yield. It appears that maximum yields and optimum fineness, as reflected by color, are obtained only where there is no such core of blast flame gases not penetrated by the entering streams of make gas. On the other hand, we have found that where a furnace of circular cross-section is used, yield and color may be sacrificed even though the radially entering make gas streams penetrate to the center of the circular section of the furnace chamber, due to the tendency to form a core of concentrated make gas.

Regardless of the accuracy of this explanation of our improved results, we have found that improved yields are obtained in operations of this type when carried out in a furnace chamber of substantially rectangular cross-section not exceeding about 1½ feet in width, and advantageously of greater height, provided with a blast burner of a type adapted to generate in the chamber a turbulent stream of hot blast flame gases of substantially uniform temperature, velocity and composition throughout the transverse section of the chamber and the hydrocarbon make is forcefully injected into the chamber in a direction across the width thereof as a plu-

ality of streams spaced along opposite sides of the furnace wall.

Predicated upon this discovery, our present invention in its broader aspect provides apparatus of the type described, comprising an elongated furnace chamber of substantially rectangular cross-section not exceeding $1\frac{1}{2}$ feet in width and of greater height and having a blast burner positioned in one end thereof, the burner comprising a rectangular burner block substantially coextensive with the transverse area of the chamber with a plurality of burner ports uniformly spaced over the face of the burner block. The furnace is further provided with a plurality of make gas injection tubes spaced along opposite sides of the furnace chamber and equi-distant from the burner end thereof, the tubes being unrestricted at their inner ends and being directed across the width of the chamber from opposite sides thereof, each being substantially perpendicular to the opposite wall of the chamber and being directly opposite a corresponding tube entering the chamber through the opposite wall. Minor deviations from the perpendicular are permissible. Advantageously, the make gas injection tubes are of $\frac{1}{4}$ to $\frac{3}{4}$ inch inside diameter and are uniformly spaced over the entire height of the chamber at $1\frac{1}{2}$ inches to 5 inches between centers. As previously noted, the reaction chamber should be of somewhat greater height than width. However, it should not usually exceed 5 to 6 feet in height. Reaction chambers about 4 feet high have been found particularly advantageous.

Further, though rectangular reaction chambers up to about $1\frac{1}{2}$ feet wide may be used, with advantage, in accordance with our present invention, as previously noted, optimum results have been obtained in furnaces approximately 10 to 14 inches in width. We have obtained exceptionally advantageous results with apparatus in which the furnace chamber approximates 1 foot in width and 4 feet in height, provided with make gas injection tubes of $\frac{1}{2}$ inch inside diameter spaced about $2\frac{1}{2}$ inches between centers over the entire height of the chamber and positioned about 18 inches downstream from the face of the burner block.

The invention will be further described and illustrated by reference to the accompanying drawings which represent, conventionally and somewhat diagrammatically, a presently preferred embodiment thereof comprising three reaction chambers opening at their downstream ends into a common blending chamber. It will be understood, however, that the invention is not restricted to the particular arrangement shown, but contemplates apparatus comprising a single reaction chamber as well as other known means within the scope of the appended claims for generating the blast flame gases and for injecting the make into the chamber.

Referring to the drawings, Figure 1 represents a horizontal sectional view of the apparatus;

Figure 2 is a fragmentary, vertical, longitudinal sectional view of the upstream end of a single reaction chamber, including the blast burner and make gas injection tubes; and

Figure 3 is a vertical, transverse sectional view along the lines 3, 3 of Figure 2.

As previously noted, the unit specifically illustrated comprises three reaction chambers 1, each provided at its forward end with a blast burner 2, the burner block 3 of which fits into the for-

ward end of, and is coextensive with, the transverse area of the chamber.

Each of the chambers at its downstream end opens into the common blending chamber 4 which, in turn, leads into an elongated, cylindrical chamber 5, in which the effluent from the blending chamber is cooled, as by means of water sprays 6, of which there may be a plurality spaced along the length of the chamber. The effluent from the chamber 5, which comprises a gaseous suspension of the furnace black, is passed to a collecting system, not shown in the drawing, for the recovery of the furnace black from the gases.

The chambers 1 are substantially uniform cross-sectional throughout and, in the particular apparatus illustrated, are approximately one foot wide and four feet high.

Uniformly spaced over the face of the burner block are 39 burner ports 7, $1\frac{1}{8}$ inches in diameter and flared at their inner ends to a diameter of three inches, as more clearly appears in Figure 2 of the drawings. At their upstream end, the respective burner ports are provided with metal tubes 8, slightly flared at their inlet end and securely held in the burner ports by means of metal plate 9 to which they are fastened as by welding.

The respective burner ports open at their upstream end into the wind-box 10. Air for supporting combustion is forced under super-atmospheric pressure into the upstream end of the wind-box, through air inlet 11, which is connected with a blower, or the like, not shown. Air is thus forced at high velocity through the respective burner ports. In order to secure uniform distribution of the combustion air, the wind-box is provided with a plurality of vanes 12 and adjustable dampers 13 for directing the air flow uniformly to highly and lower zones of the wind-box.

Also within the wind-box, there are three fuel gas manifolds 14 supported by the feed lines 15 and carriages 16. Extending downstream from the respective manifolds, coaxially with the burner ports is a plurality of tubes 17, each terminating at its downstream end in a jet or spud 18. Tubes 17 are advantageously of substantially greater length than the depth of the burner ports so that the respective burner ports may be moved forward to a position such that the spuds are at, or near, the downstream end of the burner ports without substantial interference by the manifolds with the flow of air into and through the burner ports.

The manifolds 14 are adapted to roll freely backward and forward over the carriages 16, equipped with flanged rollers 19, thus providing ready means for adjusting the position of the spuds with respect to the burner ports.

Each of the fuel gas manifold feed lines 15 extends to the rear through the vanes and rear wall of the wind-box through a packing gland 20 and is connected with a supply of fuel gas, under pressure, through flexible tube 21. Advantageously, the lines 15 are calibrated just without the wind-box so that the position of the spuds with respect to the burner ports may be readily determined. Where a burner such as described is used, adjustment of blast flame conditions may be readily accomplished.

In operation, the blast burner is so regulated as to inject at high velocity through the respective burner ports a uniform combustible mixture of fuel gas and air which is burned as it leaves the ports within the reaction chamber

forming a highly turbulent stream of blast flame gases which, by the time it has reached the make gas injection tubes 22, is of substantially uniform composition and is moving at a uniformly high forward velocity throughout the transverse area of the chamber.

The make gas is forcefully injected as a plurality of streams through make gas injection tubes 22 into the stream of hot blast flame gases at a zone about 18 inches downstream from the face of the burner block. The optimum distance from the make gas injection tubes to the burner block varies somewhat with different operating conditions. Distances of one to five feet have been used, with advantage. It is frequently desirable to have a plurality of sets of such tubes positioned at different distances from the burner block, for alternative use, as desired, and such arrangement is within the contemplation of our present invention.

The size and number of the make gas injection tubes are, likewise, subject to some variation. In the particular apparatus illustrated, 36 make gas injection tubes of $\frac{1}{2}$ inch I. D. are provided, 18 on either side of the chamber and uniformly spaced over the height of the chamber, $2\frac{1}{2}$ inches between centers, as more clearly appears from Figure 3 of the drawing. The outer ends of these tubes are provided with control valves 23 and are connected with make gas manifolds 24 to which the make gas is supplied under pressure through valved connections 25. The inner ends of the tubes open into the reaction chamber without constriction.

The make gas, usually natural gas, is supplied to the system, under pressure, through conduit 26 at a rate controlled by valve 27 and the gas is, with advantage, preheated by conventional means, not shown in the drawing, to a temperature of about 700° F. Where make gas enrichment is employed, the enriching oil may be injected into conduit 26 through line 28 at a rate controlled by valve 29. Where steam is to be mixed with a make gas, it may be injected into conduit 26 through line 30 at a rate controlled by valve 31. From conduit 26, the make gas, either alone or enriched, or admixed with steam, or both, is passed to manifold 32 and, from thence, through branch line 25 leading to the make gas manifolds 24, as previously described. Branched lines corresponding to line 25 lead from manifold 32 to the other reaction chambers of the unit. The amount of make gas passed to the respective manifolds of the several reaction chambers may be controlled by adjustment of the several valves 33 and valves 34 indicated in the branch lines and, by proper adjustment of these valves in conjunction with the valves 23 in the respective make gas injection tubes, the rate of injection of make gas through the several injection tubes may be controlled and regulated.

The respective chambers should be lined with an appropriately highly refractory material capable of withstanding high temperatures. Such refractory materials and methods of applying them are well known to the art and need not be described herein.

It is frequently desirable to vary the contact time within a given apparatus. For this purpose, one or more water sprays are provided within the blending chamber, as indicated at 35, and in the downstream end of the reaction chambers, as indicated at 36.

The transverse dimensions of the reaction chamber may be varied somewhat within rather

well defined limits. Its width should not exceed about $1\frac{1}{2}$ feet and is, with advantage, somewhat less. As previously noted, chamber widths of 10 to 14 inches have been found particularly advantageous, under most conditions. With chambers of greater width than $1\frac{1}{2}$ feet, the yield or characteristics of the black, usually both, are sacrificed.

Further, as previously noted, the height of the reaction chamber should generally not exceed 5 to 6 feet. It has been found that, with chambers of greater height, difficulties are encountered due to thermal head in the chamber.

The optimum length of the chamber is subject to considerable variation, depending upon intended operating conditions, primarily the velocity of the mixed gases through the chamber. The chamber should be sufficiently long to provide the necessary time factor at the elevated temperature to effect the required reaction.

It is generally advantageous that the make gas injection tubes be of circular cross-section of about $\frac{1}{2}$ inch in diameter and that the tubes be spaced about $2\frac{1}{2}$ inches between centers. However, the diameter of the tubes and the spacing of the tubes are subject to some variation, the optimum inside diameter of the tube being dependent upon the spacing between the tubes and the width of the furnace chamber. The number of and spacings between the make gas injection tubes are, with advantage, such as to give a uniform pattern of make gas streams over the entire height of the chamber.

Close spacing of the make gas injection tubes appears to promote more uniform use of the hot blast flame gases by preventing excessive bypassing of the hot flame gases between adjacent jets of make gas, and more effective mixing of the make gas and blast flame gases is promoted. At the same time, the increased number of make gas tubes makes possible the use of tubes of smaller diameter and facilitates the developing of velocities necessary to effect the desired penetration of the make gas streams into the stream of blast flame gases and provides more rapid, uniform heating as well as dispersion of the make gas.

We have found that, as the diameter of the make gas injection tubes approaches $\frac{3}{4}$ inch, it becomes increasingly difficult to effect the desired make gas pattern across the reaction chamber and the optimum rate of mixing of make gas and blast gases. We, therefore, prefer to restrict the inside diameter of the make gas tubes to a maximum between $\frac{1}{2}$ and $\frac{3}{4}$ of an inch. However, injection tubes of 1 inch, I. D. have been used with advantage. At diameters less than about $\frac{1}{4}$ inch, the make gas streams, at acceptable operating loads, appear to become too readily shattered, i. e., before adequate penetration of the blast gas stream, and a condition ensues where the make gas concentration across the width of the furnace does not reach uniformity until after the onset of cracking, which condition it is one of the objects of this invention to avoid. Likewise, with very small make tubes a coking up and plugging of the make tubes may become a serious operating problem with certain types of hydrocarbon raw material.

The invention is not restricted to the use of round make gas injection tubes. Square or somewhat flattened tubes of corresponding transverse area may be used with substantially equal advantage so long as their upstream-downstream thickness is within the range of about $\frac{1}{4}$ to $\frac{3}{4}$

inch and are so proportioned as to avoid serious coking difficulties and to effect mass velocity sufficiently great to avoid the too rapid shattering just described, with resultant non-uniformity of mixing.

Apparatus particularly adaptable to changes in the characteristics of the product, within reasonably broad limits, has been constructed having a reaction chamber width of about 12 inches and a height of about 4 feet and using make gas injection tubes $\frac{1}{2}$ inch in diameter, uniformly spaced along each side of the chamber over its entire height and about $2\frac{1}{2}$ inches between centers. However, as previously indicated, the optimum spacing of these tubes will vary somewhat with the diameters of the tubes and the mass velocities to be employed, which are, in turn, dependent upon furnace width. Frequently, as the diameter of the make gas tubes approaches the upper permissible limit, the spacing between centers may be increased to about 5 inches. Where tubes of the smallest permissible diameter are used, they may frequently be arranged as close as $1\frac{1}{2}$ inches between centers.

The transverse area of the reaction chamber is, with advantage, so correlated with the cross-sectional area of the respective make gas injection tubes and the number of make gas injection tubes employed as to provide, under intended operating conditions, a ratio of the mass velocity of the make gas streams to the mass velocity of the blast flame gases within the range of 3:1 to 10:1, the optimum ratio varying somewhat with the width of the furnace. With a furnace 12 inches in width, a correlation of the dimensions of the respective elements to provide ratios within the range of 5.5:1 to 9:1 at the intended operating conditions has been found particularly advantageous.

The minimum width of the furnace chamber of our present invention is dictated primarily by a consideration of furnace capacity and problems related to construction and maintenance. The capacity of a furnace is, of course, largely dependent upon its cross-sectional area, since the volume and rate of flow of the blast flame gases must be sufficient to effect the necessary turbulence and the ratio of make gas to blast flame gases must be kept within a rather well defined range. Further, construction and maintenance costs and difficulties are multiplied where the furnace width is less than about 10 to 12 inches. Consequently, furnace widths less than about 10 inches are usually not desirable.

As previously noted, an important aspect of the apparatus of the present invention is its ability to generate a stream of blast flame gases of uniform temperature, composition, and linear velocity over its entire transverse area. This is, with advantage, effected by the use of a blast burner of the type described having a rectangular burner block coextensive with the transverse section of the chamber and provided with a large number of blast burner ports of relatively small diameter, uniformly spaced over the entire face of the burner block. It has been found that, for this purpose, burner ports of about 1 inch to $1\frac{1}{8}$ inches in diameter and aggregating about 25% of the entire area of the burner block are particularly effective.

It will be understood, of course, that where the apparatus comprises a single reaction chamber, the reaction chamber may be connected at its downstream end directly with the cooling chamber, the blending chamber being omitted.

The apparatus of our present invention has been found to be particularly effective in operations of the type described in which the make gas is enriched by a normally liquid mineral oil fraction, as more fully described in our previously noted copending application.

We claim:

1. Apparatus of the type described comprising an elongated reaction chamber of substantial rectangular cross-section not exceeding $1\frac{1}{2}$ feet in width and of a greater height than width, a blast burner positioned at one end thereof and comprising a rectangular burner block substantially coextensive with the transverse area of the chamber and provided with a plurality of burner ports uniformly spaced over the entire face of the burner block, a plurality of make gas injection tubes vertically spaced along opposite sides of the chamber, near and equi-distant from the burner end thereof, the tubes being unobstructed at their inner ends and being directed across the width of the chamber, each being substantially perpendicular to the opposite side wall of the chamber and each being directly opposite a corresponding tube entering the chamber through the opposite side wall.

2. The apparatus of claim 1 in which the height of the reaction chamber does not exceed 5 to 6 feet.

3. The apparatus of claim 1 in which the reaction chamber width is 1 foot, the reaction chamber height is 4 feet and the make gas injection tubes are $\frac{1}{2}$ inch inside diameter, are uniformly spaced about $2\frac{1}{2}$ inches between centers over the entire height on opposite sides of the chamber and are positioned about 18 inches downstream from the face of the burner block.

4. The apparatus of claim 1 in which the aggregate sectional area of the blast burner ports approximates 25% of the transverse area of the furnace chamber.

5. The apparatus of claim 1 in which the make gas injection tubes have an inside diameter of $\frac{1}{4}$ inch to $\frac{3}{4}$ inch and are uniformly spaced over the entire height of the opposite side walls of the chamber at $1\frac{1}{2}$ inches to 5 inches between centers.

6. The apparatus of claim 5 in which the reaction chamber is 12 to 14 inches wide and about 4 feet in height.

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REFERENCES CITED

The following references are of record in the file of this patent:

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Number	Name	Date
2,378,055	Wiegand et al.	June 12, 1945
2,440,423	Wiegand et al.	Apr. 27, 1948
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