

Dec. 13, 1932.

W. K. LEWIS

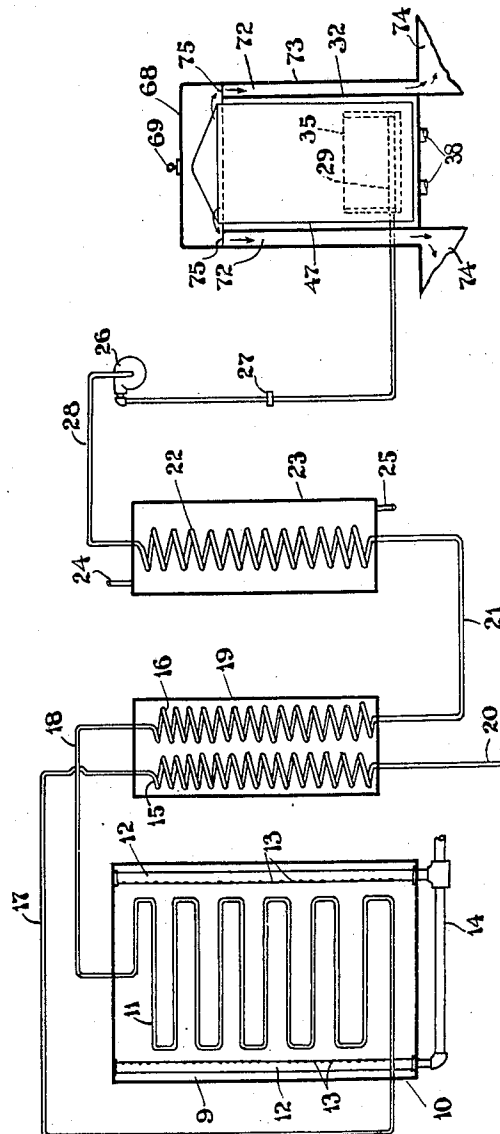
1,891,202

METHOD OF AND APPARATUS FOR PREPARING GAS BLACK

Filed Dec. 15, 1928

2 Sheets-Sheet 1

Fig. 1



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Fig. 4

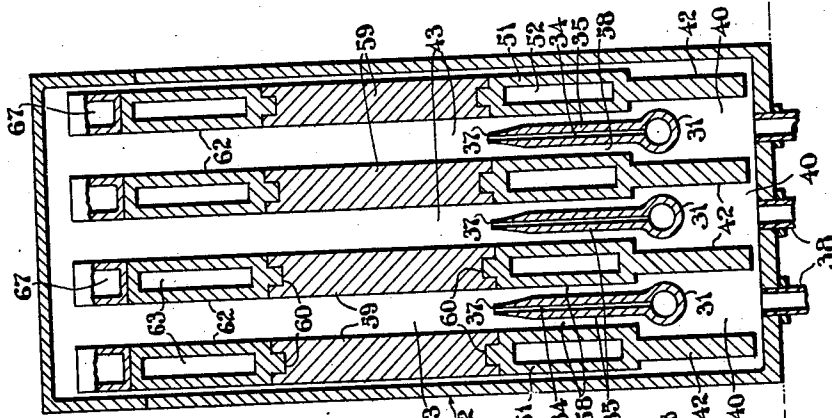


Fig. 3

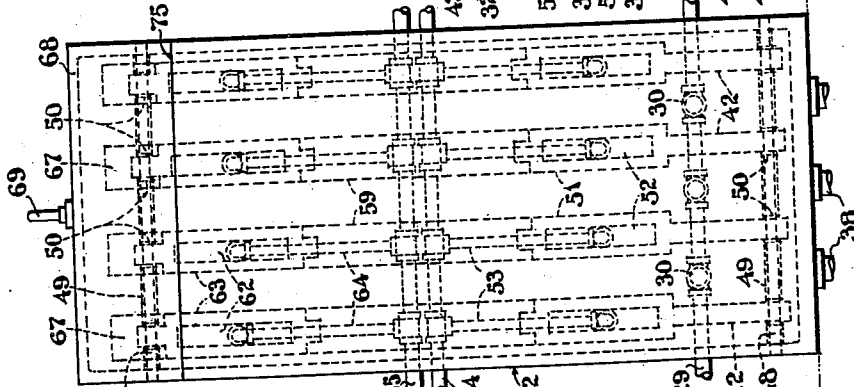
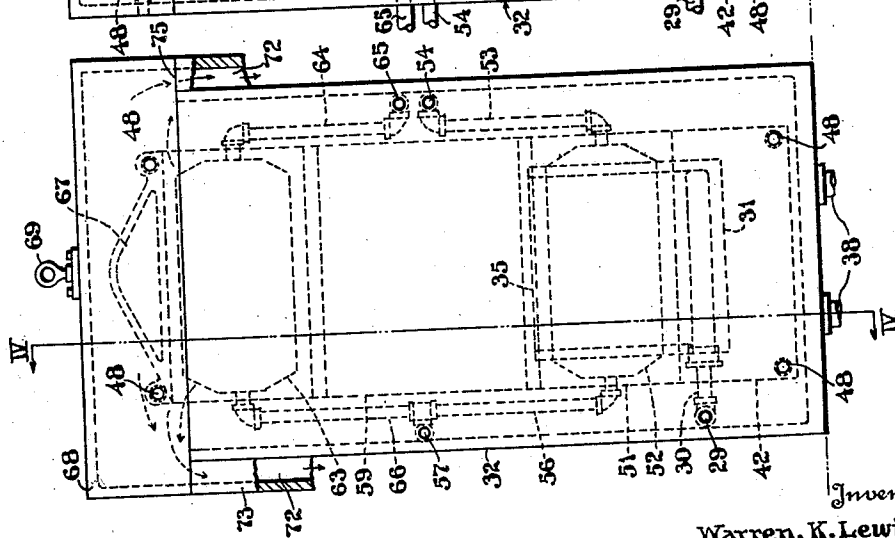


Fig. 2



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METHOD OF AND APPARATUS FOR PREPARING GAS BLACK

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This invention relates to improvements in methods of and apparatus for manufacturing carbon black, and it has particular relation to novel means for preparing such black from gaseous hydrocarbon bodies.

One object of the invention is to provide a method of and apparatus for manufacturing carbon black from hydrocarbon gases, whereby an exceptionally high yield of product is obtained.

Another object of the invention is to provide a method and apparatus whose functions are not appreciably disturbed by changes in atmospheric conditions.

One common method of manufacturing carbon black consists in projecting a jet of gas into a chamber containing an insufficient quantity of air to induce complete combustion and permitting it to impinge while burning against a cold body. Under these conditions, carbon is deposited upon the cold body from which it may be removed in any convenient manner. This method is excessively wasteful, because violent agitation is set up in the gas and air and they are more or less thoroughly intermixed. Only an extremely small percentage of carbon is actually set free and deposited upon the cold body. The remainder either is entirely consumed or passes through the combustion zone as unchanged hydrocarbons. It may also contain large agglomerations of particles of such large size as to reduce its value as a pigment, for which it is usually employed. The process is further objectionable because the conditions under which optimum results are obtained are extremely critical and are very materially affected by slight changes in atmospheric conditions and also by movement of the cold body employed to collect the carbon black. It is generally understood that by employing the type of burners heretofore known, no practical method has ever been employed for collecting carbon black in bag filters, because the continuous accumulation of carbon black in such filters causes a continuously increasing and excessive resistance to the flow of the gas therethrough. This method would be inefficient and unsatisfactory.

This invention contemplates the provision of a burner in which gas and air are projected in relatively thin films or sheets in parallel relation with respect to each other, free from turbulence, and at a velocity below that critical velocity in which eddies begin to form in the moving gases; that is, the gas and air are conducted into contact with each other in stream-line relation. Combustion is induced in a relatively thin layer of gas immediately adjacent the stream of air superposed thereon. Since the entire stream of gas is relatively thin, heat from the region of combustion penetrates uniformly throughout the gas and results in decomposition of a high percent of the hydrocarbon gases into their component elements, hydrogen and carbon. Not only is the yield thus obtained exceptionally high, but the product is extremely uniform in character and is of a better quality than that obtained by the ordinary methods of production.

Although any type of gas containing hydrocarbon may be employed, it is preferable to prepare the gases for combustion in the burner by first subjecting hydrocarbons, such as saturated propane or butane, to a treatment called "cracking", that is, the gases are heated in a furnace and are taken therefrom in the form of unsaturated compounds, such as butylene, propylene, ethylene and the like. The latter gases are then conveyed directly through a cooling apparatus and into the burner for combustion therein. The burner is adapted to burn either saturated or unsaturated gases, although more satisfactory results can be obtained by burning the latter.

In a burner adapted for practicing the process according to this invention, the confining bodies are disposed in parallel relation with respect to the line of the flame, rather than being disposed in transverse relation with respect thereto. Under these conditions, the flames are almost completely shielded by the confining bodies, and atmospheric disturbances have little or no effect upon the process.

For a better understanding of the invention, reference may now be had to the accom-

panying drawings, forming a part of the specification, of which:

Figure 1 is a diagrammatical cross-sectional view of an apparatus for treating gases according to the invention;

Figure 2 is a side elevational view of a burner employed in practicing the invention, parts thereof being omitted for the sake of clearness;

Figure 3 is a front elevational view of the apparatus disclosed in Figure 2; and

Figure 4 is a cross-sectional view taken substantially on the line IV—IV of Figure 2.

Referring to the diagrammatical illustration of Figure 1, a furnace or heater 9 is provided for "cracking" the gas employed in the production of the carbon black, thereby to reduce the degree of saturation of the hydrocarbons in the gas. It is preferable to reduce the degree of saturation until at least 25 per cent of the higher saturated hydrocarbons in the gas have been converted to olefins. The furnace comprises an outer casing or shell 10, within which is disposed a coil of gas conducting tubing 11. The latter may be heated by any convenient means; for example, a system of burners consisting of one or more tubes 12 may be disposed within the casing 10 in such relation as to permit flames from burner openings 13 formed therein to play upon the coils. Gas is supplied to the tubes 12 by means of a conduit 14 connected to any convenient source of supply (not shown).

The inlet and outlet ends of the coil 11 are respectively connected to heat exchange coils 15 and 16 by means of conduits 17 and 18. In Figure 1, these coils are shown only diagrammatically within a casing 19 to indicate a well known conventional heat exchanger. The inlet end of the coil 15 is connected to a conduit 20, which is, in turn, connected to any convenient source of supply of hydrocarbon gas (not shown) and the outlet end of the coil 16 is connected by means of a conduit 21 to a cooling coil 22, disposed within a cooling chamber 23. The upper and lower ends of the latter are preferably provided with inlet and outlet conduits 24 and 25, respectively, whereby a flow of cooling fluid is maintained within the chamber. A vacuum pump 26 and a gaseometer or other pressure equalizer 27 are provided in a conduit 28 for the purpose of insuring cracking under at least a partial vacuum.

The coil 22 is connected by means of the conduit 28 to a branched distributor conduit 29, which is connected by means of short conduits 30 to a series of burner tubes 31 disposed within a burner chamber 32. Each burner tube is formed with a relatively long, narrow slot 34, defined by projecting flanges or plates 35, which constitute burners and extend longitudinally substantially the entire length of the burner tube 31. These slots

are disposed vertically and the upper edge portions of the flanges are preferably formed with gradually tapering tip portions 37. In order to supply air for maintaining combustion of the gas from the burner tubes, a plurality of tubes 38, for supplying air under predetermined pressure, are connected to the chamber 32 and open directly into spaces 40 below the burners between vertically disposed partitions 42 that extend a substantial distance above the burner tips to provide a series of combustion chambers.

These partitions define chimneys 43 for accommodating the passage of gas and air from the tubes 31 and 38. It will be observed that the partitions, in turn, are supported within the chamber by means of rods 48, preferably four in number, extending transversely of the chamber. The rods are provided with spacing sleeves 49 which insure uniformity of distance between the partitions 42. In order to provide proper adjustment between the several partitions 42, a plurality of shims 50 are removably disposed upon the rods 48 and function in conjunction with the spacing sleeves 49.

In order to maintain the air, as it comes into contact with the jet of gas from the burner tip 37, in a relatively cool condition, and thus increase the burner efficiency, portions 51 of the partitions 42 adjacent the burner flanges 35 are composed of a material, such as iron or copper, having a relatively high coefficient of heat conductivity. Cavities 52 provided within these portions extend adjacent, and in parallel relation to, the burners 35. These cavities are connected by means of flexible tubes 53 to a distributor conduit 54 which is, in turn, connected to a convenient source of cooling fluid, such as air or water. A conduit 56 connected to the portions 51 conveys the cooling fluid from the cavities 52 into a discharging conduit 57. From this construction it will be observed that the adjacent outer surfaces of the partitions 47 and the burners 35 provide relatively long unobstructed passageways or channels 58 having smooth parallel walls.

Those portions 59 of the partitions 47 disposed adjacent the zones of the combustion, i. e., above the burners 35, are preferably composed of a refractory composition, such as fire brick or carborundum. After combustion of the hydrocarbon gases has proceeded sufficiently far, it is desirable that the gas be immediately cooled, in order to prevent further combustion and also to prevent agglomeration of the fine carbon particles which are floating in the partially consumed gases. This is effected by providing end portions 62, composed of iron or other heat conductor upon the upper ends of the partitions 47. Tongue and groove connections 60 are provided between the central portions 59 and the end portions 51 and 62, respectively, for

the purpose of maintaining all of the parts of the partitions 42 in proper alinement. Each of the upper portions 62, like the lower portions 51, is provided with a chamber 63 for cooling fluid, that is connected by means of flexible pipes 64 to a distributor conduit 65. After passing through the cooling chambers 63, the fluid is expelled through flexible pipes 66 connected to the chambers and to the discharging conduit 57. Also, the partitions are extended upwardly above the portions 62 to provide dead spaces 67. A cover 68 is disposed upon the upper portion of the chamber 32 and is adapted to fit in gas tight relation thereon. A water seal may be provided for this purpose. This cover can be removed by connecting and operating a suitable lifting device through a ring 69 secured upon the upper portion thereof, thereby providing for periodic cleaning of the chamber.

In order to provide an exit for the gases passing upwardly between the partitions 42, passageways 72 leading from the partitions extend downwardly through suitable housings 73 along the outer sides of the chamber 32 and lead to suitable collecting receptacles, such as bag filters 74 (Figure 1) adjacent the lower portions of the chamber 32. The cover 68 fits in gas-tight relation over the housing 73 and chamber 32, as indicated at 75, in such manner as to provide adequate passageways from the interior of the chamber 32 between several partitions to the interior of the housings 73.

The operation of the apparatus is as follows: A hydrocarbon gas or natural gas, e. g. methane, ethane, propane, or butane, and the like, or mixtures thereof, is admitted to the heat exchange coil 15 through the conduit 20, where it is subjected to a preliminary period or heating, after which it is discharged through the conduit 17 into the coils 11 within the chamber 10. In this chamber relatively high temperatures are created by combustion of gas from the burner tubes 12. These temperatures result in partial decomposition of the hydrocarbon gases, thus producing unsaturated gases such as propylene, ethylene, etc., which are more satisfactory for the production of carbon black than the saturated gases contained in the ordinary natural product.

The heated gas from the coils 11 is discharged through the conduit 18 into the coils 16, where it is partially cooled by absorption of heat by the incoming gas passing through the coil 15. Gas from the cooling coil 16 is delivered to the coil 22, where it is further cooled as far as practicable. The cooled, unsaturated gas is discharged into the distributor tube 29, whence it is conducted to the various burner tubes 31, and it is discharged from the tips 37 formed upon the latter into the combustion space 43 between the partitions 42. Partial combustion of the gases issuing

from the tips 37 is induced by a limited supply of air issuing from the spaces 58.

It will be observed that the sides of the burners 35 are in substantially parallel relation with respect to each other, and also with respect to the surfaces of the portions 51 from which they are spaced in relatively close relation. The several streams of gas and air flowing between these plates are thus induced to move in substantially parallel or stream lines. If the rate of flow is below that critical velocity at which there is developed an unduly strong tendency to form eddies or vortices, there is but little tendency of the gases to mix with each other. Therefore, combustion can take place only in certain relatively thin and uniform zones immediately between the layers of gas and layers of air which are moving in superposed relation. The maximum velocities at which the gas and air may move vary somewhat for different gases. These velocities may be computed or obtained by experimentation.

The channels 58 for the air, and the channels 34 for the gas are sufficiently narrow and long to provide a considerable resistance therethrough, whereas all other channels for the gas and air; that is, the conduits 31, 38, spaces 40, 43, etc., are so large that the resistance to flow through the latter is negligible in comparison with the flow through the former. Moreover, the channels 58 and 34 are identical for all burners operating in parallel in a given assembly. A common main is employed for supplying gas through all of the burners, as well as a common main for supplying air thereto.

Because of the fact that all of the openings to the gas and air spaces below the channels 58 and 34 are relatively large, the pressure drop is negligible, and this insures equal gas pressure and air pressure at the base of each burner in the assembly. Also, the combustion spaces 43 of all of the burners lead into common discharge conduits 72 and thence to a common set of bag filters. Since these conduits are spacious, and the bag filters are in parallel, the pressure of gas and air entering each combustion space 43 is uniform. Therefore, all of the burners operate identically.

In order to secure proper operation of the apparatus it is only necessary to have fixed values of the pressure drops between the air space and the gas space at the base of the burners and at the top of the combustion space. Although progressively increasing pressure occurs in the bag filters as they become clogged with carbon black, entirely successful operation is insured by maintaining the excess gas pressure and the excess air pressure in the base of the burner, above that in the collecting filters, constant.

The ratio of air to gas, of course, will be varied according to the nature of the gas em-

ployed. The ratio of air to gas that provides the more satisfactory results depends upon the dimensions of the particular burner being employed, as well as upon the specific gas under treatment and the rate at which the gas is burned. However, in general practice, the minimum amount of air that should be used is that which is slightly less than the amount required to burn all hydrogen to water, but never an amount sufficient to cause complete combustion.

The relative velocities of gas to air at the points of entrance to the burning zone may be varied considerably. Where the ratio of air to gas is low, it is sometimes preferable to have this velocity ratio greater than unity but where it is high, e. g., in burning higher hydrocarbons, it is preferable to introduce the gas at a velocity somewhat lower than that of the air, even down to 40 or 50 percent. In employing any particular type of gas, these preferred ratios are easily determined experimentally. For example, in a burner having a chimney width of one inch and a height of twenty-seven inches, functioning in conjunction with a gas-burning slot of one-eighth inch width and six inch height, burning ethylene at the rate of 0.42 cubic feet per foot of length of burner per minute, the optimum air to gas ratio is approximately 12.5. Under these conditions, it is preferable that the velocity of the gas entering the burning zone is so regulated that it is approximately 64 percent of that of the air. Then the yield is between eight and nine pounds of high grade carbon black per thousand cubic feet of ethylene (C_2H_4).

Since any change in the cross section of the path of the gases tends to develop turbulence, the channels 58 should extend uniformly a sufficient distance to suppress all tendency toward turbulence and also to suppress whatever turbulence that develops adjacent the lower entrance to the channels. The cross-sectional spaces between the partitions 42 remain the same through the combustion zone above the burner tips 37 until the gas passes the dead spaces 67. As a general proposition, the cooling of the wall portions 59 of the partitions reduces the efficiency of the apparatus. However, slight cooling of these walls may be desirable if they are composed of warpable material such as steel.

If the zone above the burner tips is properly cooled, there is but little tendency of the carbon black to agglomerate or to collect upon the walls 59 or the cooling portions 62. The partially burnt gas rising between the portions 62 is drawn through the passageways 72 and is discharged into the receptacle 74 where the carbon black is deposited and the gas is discharged.

The product thus obtained is a black in an exceedingly fine state of sub-division, approximately free from all oily matter. Fur-

thermore, since the inner chamber walls and the partitions 47 effectively screen the flames and the burners, atmospheric conditions do not appreciably affect the operation of the burners.

Although I have illustrated only one form which the invention may assume and have described in detail only a single application thereof, it will be apparent to those skilled in the art that the invention is not so limited but that various modifications may be made therein without departing from the spirit of the invention or from the scope of the appended claims. It is intended that the patent shall cover, by suitable expression in the appended claims, whatever features of patentable novelty reside in the invention.

What I claim is:

1. A method of producing carbon black which comprises directing sheets of gas between a plurality of parallel walls from a common source of supply at a velocity sufficiently low to maintain stream-line flow of the gas, directing a sheet of air in stream-line relation along each side of each sheet of gas partially burning the gas while maintaining the stream-line flow of the gas and air, supplying a cooling medium adjacent the gas before and after it passes through the burning zone and subsequently collecting the products of combustion.

2. A method of producing carbon black which comprises directing sheets of gas and air between vertical walls in uniform thin sheets in parallel stream-line flow, bringing the gas and air together after the stream-line flow of each has been established, circulating a cooling fluid about the gas and air while maintaining the flow free from disturbance by the cooling fluid, partially burning the gas as the air flows in films on each side thereof, circulating a cooling fluid about the partially burned gas and air and collecting the products of combustion.

3. An apparatus for producing carbon black comprising a plurality of uniformly spaced plates, gas conduits extending between the plates and having elongated burner slots formed therein in such manner as to cause gas emitted therefrom to be ejected in streams substantially parallel to the plates, and means for forcing currents of air about the burner slots in parallel relation with respect to the flow of gas, the spacing between the plates being so regulated that the rates of flow of the gas and the air is such that turbulence between them is reduced substantially to a minimum.

4. An apparatus for manufacturing carbon black comprising a plurality of uniformly spaced plates, burner conduits for gas extending between the plates and having elongated burner slots formed therein projecting in parallel relation with respect to the plates, the burners and adjacent plates being so

spaced as to provide air passages therebetween, means for forcing currents of air between the plates and burners, the spacing between the various plates and the burners being such that the air is conducted between the plates in substantially stream-line flow with a minimum of turbulence between the flow of gas emitted from the burner slots and the air, and means for cooling the plates adjacent the zone of combustion.

In witness whereof, I have hereunto signed my name.

Signed at Cambridge, in the county of Middlesex, and State of Massachusetts, this first day of December, 1928.

WARREN K. LEWIS.