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APPARATUS FOR PRODUCING IMPINGEMENT CARBON BLACK

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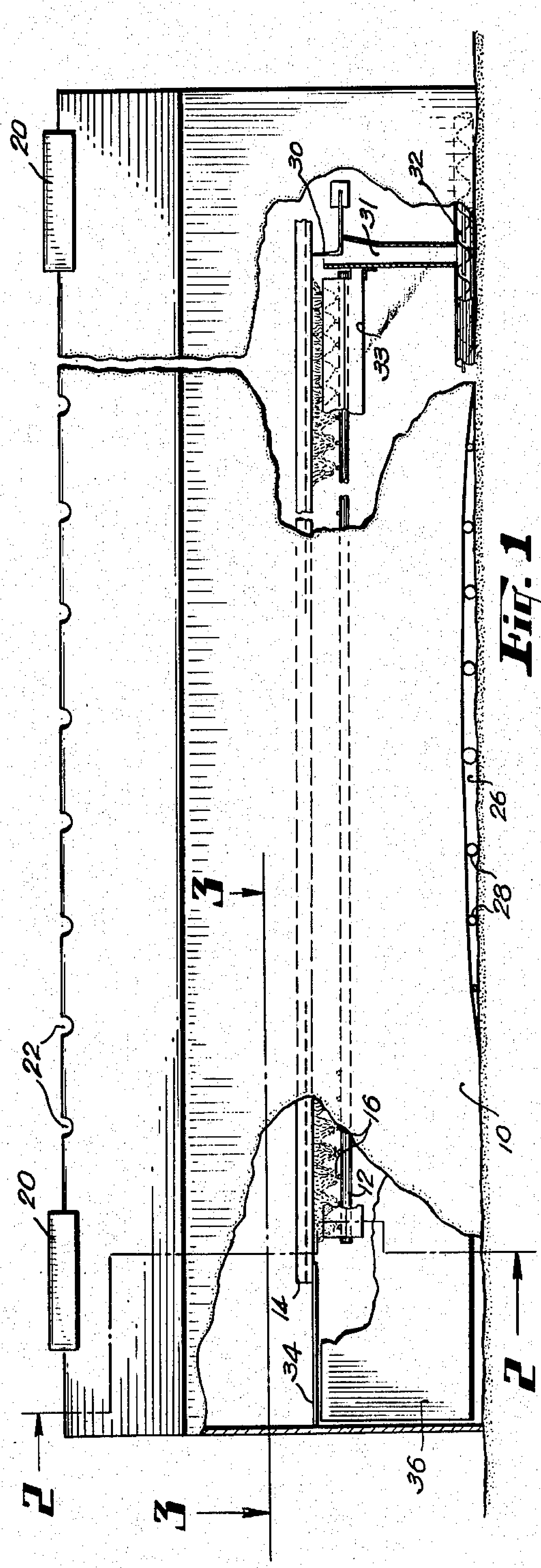

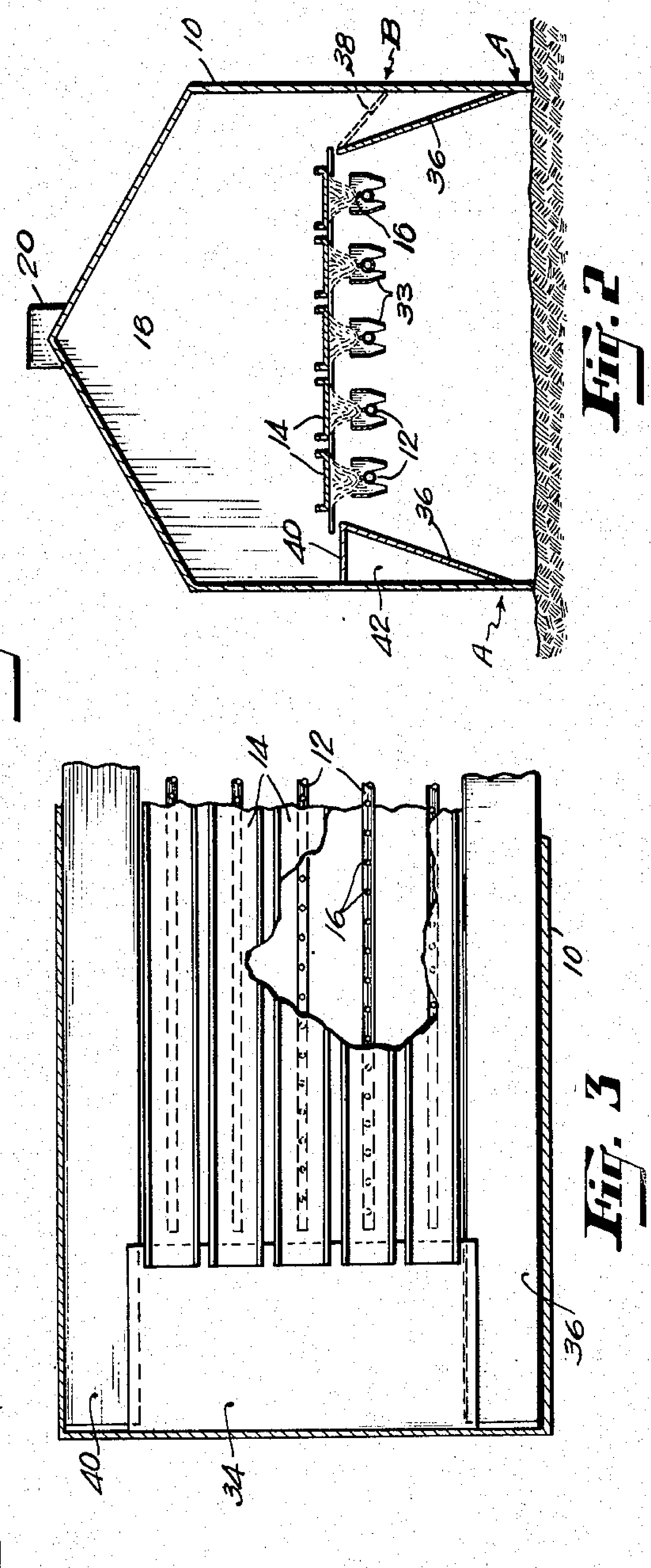

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APPARATUS FOR PRODUCING IMPINGEMENT CARBON BLACK

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This invention relates to the production of carbon black by the impingement process and more particularly to processes and apparatus by which the yield of such carbon black may be increased.

To produce carbon black by the impingement or channel process a hydrocarbon flame, containing a quantity of uncombusted hydrocarbon, is impinged upon a relatively cool metallic surface. A portion of the uncombusted hydrocarbon within the flame is dissociated by the heat of the flame to form carbon black most of which deposits on the impingement surface. While natural gas is the most commonly utilized hydrocarbon source of channel carbon black any gaseous or vaporized liquid hydrocarbon may likewise be used.

A number of critical factors are involved in the production of channel blacks, viz., the rate of hydrocarbon flow, volume of air available to support combustion, shape and size of the hydrocarbon flame and distance between hydrocarbon orifice and impingement surface (tip distance). All of these factors are variable within circumscribed limits to control the quality of the black produced. Over the productive range they have little effect upon yield (percentage of theoretical carbon content of the hydrocarbon recovered as carbon black) except insofar as higher quality (smaller particle size, greater jetness, etc.) is achieved at the expense of yield.

The productive unit of a commercial channel plant is the hot house or burner shed of which there may be and usually are more than a hundred per plant. The size of the hot house is largely a matter of choice and may range from 100 to 200 ft. in length, 8 to 14 ft. in width and 10 to 15 ft. in height. The building serves to shelter the myriad small flames and control combustion conditions by limiting the amount of air available to support combustion.

The hot building itself is often a crude structure consisting of a frame covered with metal sheets. To admit air for combustion of the gaseous raw material a series of openings may be provided in the side walls near the ground or, more commonly, wedges are inserted beneath the side walls along about the middle ⅔ portion to raise the walls from the ground. Excess air, products of combustion and smoke are exhausted through a series of openings along the top ridge of the structure.

Inside the building the hydrocarbon gas pipes with their many small lava-tipped orifices, which we refer to collectively as the burner, are raised about six feet above the ground and extend hori-

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zontally the length of the building in parallel rows. The collecting channels are suspended above the burner pipes where they slowly travel back and forth on rollers and above stationary scrapers. The channel assembly is known collectively as the burner table. The area beneath the burner table is partially occupied by pipes, ducts, scrapers, hoppers and structural supports.

In order to provide access to the equipment for maintenance and servicing a passageway must be left on either side of the building between side walls and burner. Additionally, at each end of the building a space must be available to accommodate the reciprocating movement of the channels.

It will readily be appreciated that far more air than is necessary to support combustion of the gas passes through the hot house, the greater portion rising adjacent the house walls. In fact we have found that the total volume of air flow exceeds gas flow by 50 to 100 times. With such a large volume of air flowing through the hot house, some of which must likewise pass many obstructions, it is obvious that considerable turbulence exists within the hot house and it has been found that this turbulence is distinctly harmful to the efficient and quiet burning of the carbon-producing flames. The turbulence may be further aggravated by external weather conditions. In Texas, for instance, where the bulk of the channel carbon black is produced, the wind blows almost continuously at high velocity and from every conceivable direction.

To reduce air turbulence in the vicinity of the flames various devices have been used with apparent success. In U. S. Letters Patent #2,399,969, Williams et al., are described baffles to reduce the velocity, although not the volume, of the air entering the hot house before it rises to the flames. We have found that shields placed adjacent the flames as described in U. S. Letters Patent #2,399,591, Amon, are particularly efficacious to establish a more compatible or coducive atmosphere in the flame zone and to effect an increase in carbon black yield.

While decreasing turbulence in the flame zone, by reduction in velocity of the air as it enters into the body of the hot house and using flame shields will effect increased yield of carbon black, we have found that a further and unexpected increase in yield may be achieved by substantially reducing the total amount of air passing through the hot building per unit time without reducing the amount of air available for combustion and without substantially reducing inlet air velocity.

It is thus an object of our invention to provide an improved process of making channel carbon black of superior quality at increased yields wherein the volume of air passing through the hot house is greatly reduced and more efficiently utilized than heretofore.

It is also an object of our invention to provide apparatus for guiding the air directly to the zone of utilization and excluding it from the non-functional areas of the hot house.

In general our invention consists in directing and flowing all of the air entering the hot house through the flame zone or burner table, with a minimum of turbulence, so that the total amount of air passing through the hot house may be substantially reduced. This is accomplished by means of impervious guide elements extending from the edges of the burner and immediately below the burner table to the hot house walls which prevent air from passing upwards outside the confines of the burner table and which concentrate and carry the air directly to the flame area. While the guide elements at the narrow ends of the building, where no external air is admitted, may lie horizontally, those extending the length of the building preferably have some downward slope towards the sides of the building and should preferably meet the walls not far above the air inlets to provide as large an angle as possible and promote steamline flow.

Because approximately ¾ of the open area of the conventional hot house at the burner table level is external to the table the air passing there-through is not only useless but is also positively harmful in that it carries off heat and promotes turbulence. By interposing guide elements of this invention across that area air is permitted to pass only through the burner and between the channels, such remaining open areas totaling but ¼ the horizontal area of the hot house at that level. By reducing the air passage within the hot house the volume of air passing through the house is likewise reduced with the result that the air is more efficiently used and attains a higher temperature. By the use of such air guiding elements in conjunction with flame shields we have increased yields of carbon black of any given type on an average by about 6½% and in some instances by as much as 13% over yields of black obtainable by the use of shields alone.

The various features of our invention will more readily be appreciated and understood from the following description of preferred apparatus designed for carrying out the process of our invention and shown in the accompanying drawings in which:

Fig. 1 is a view in elevation, partly in section, of a typical hot house,

Fig. 2 is a sectional view of a hot house taken along the line 2—2 of Fig. 1 and showing various arrangements of the air guiding apparatus of our invention, and

Fig. 3 is a plan view of the end portion of a hot house equipped with the apparatus of our invention taken along the line 3—3 of Fig. 1.

Referring to the drawings, the individual carbon black producing unit consists of hot house 10 within which are enclosed burner pipes 12, channels 14 and miscellaneous carbon black harvesting and conveying equipment. Burner pipes 12, of which there may be as many as twelve rows per building and which are referred to collectively as the burner, extend longitudinally nearly the full length of hot house 10 parallel to one another and elevated about six feet above the ground. Overhanging each row of burner pipes 12 for its full length is a corresponding channel 14 arranged at such a height above the burner pipe that the flames from the plurality of lava tips 16 in pipes 12 will impinge against and deposit carbon black upon the underside of channels 14. The flames from the parallel burner pipes collectively form a rectangular horizontally disposed flame zone spaced about two feet from the side walls of the hot house. Products of combustion and undeposited carbon black flow up and around the sides of the channels 14, filling the upper portion 18 of the house with smoke and eventually exhausting to the atmosphere through large stacks 20 and small vents 22.

Since the gas flowing from tips 16 initially contains no oxygen, combustion cannot occur until external oxygen is made available to the gas jets. Thus air must be admitted to the hot house 10 below the burner level by any convenient means. As here illustrated, an air inlet 26 is provided by inserting wedges 28 underneath the side walls of the buildings thereby raising the walls off the ground for approximately ⅔ the length of the central portion of the building. The size of air inlet 26 can readily be changed by varying the sizes of wedges 28.

In addition to regulating the flow of air into building 10 the escape of combustion products from the building through stacks 20 and vents 22 must likewise be regulated to maintain proper draft conditions for the most efficient production of black. The criterion of proper draft for the production of any given type of carbon black is the position of the "smoke roll" relative to the channels. The smoke roll or layer, is the mass of combustion products made visible by the entrained carbon black escaping deposition on the channels and is so called because of its slowly swirling or rolling appearance as it rises. For the production of some types of black the bottom of the smoke roll is maintained at or slightly below the bottom surface of the channels while for others it may be held at a considerable distance above the tops of the channels. The rate of air flow through the building determines the position of this smoke roll. Accordingly adjustable shutters (not shown) are provided in stack 20 and vents 22 whereby to control the outlet orifice size and hence rate of flow through the building of the various gases.

In order to make available a constantly fresh surface upon which to impinge the flames and at the same time collect the black already deposited the channels 14 are kept in slow but constant longitudinal motion, first in one direction and then in the other. The distance of channel travel in each direction for convenience usually will not exceed about eight feet. Scrapers 30 (one shown) placed at intervals along the length of the channels 14 are held against the under surfaces thereof and serve to remove the black, causing it to drop into hoppers 31 (one shown) from which it is transported to storage by a screw conveyor 32.

In operation, tips 16 tend to clog up and must be brushed clean from time to time. Also they tend to erode and must be replaced with new tips. Additionally, a change in type of black to be produced frequently requires corresponding changes in size and shape of tips. When cleaning or changing tips in a hundred or more hot houses, each one of which may have around 3000 or more tips, at a single plant it is evident that easy access to the burner in each house is requisite. Such access is provided in the typical building by leaving a passageway of about two feet between the side walls of the hot house and the outer edges of the burner.

The apparatus and operating procedures thus far described are generally standard and typical of the channel carbon black industry as a whole.

It will be evident without specific illustration thereof that the space in hot building **10** below the burner is not empty but contains numerous obstructions in the form of supports, pipes, conveyor ducts, hoppers, etc. As the air flows upwards to the burner it is made turbulent by these obstructions. To protect the flames from the adverse effects of rapidly-flowing, turbulent air streams shields **33** of design similar to those described in the Amon patent, above, are placed adjacent tips **16**. It is in conjunction with such shields that the apparatus and method of our invention are most effective.

Notwithstanding the effectiveness of such shields in protecting the individual flames from detrimental air currents we have discovered that a still more compatible atmosphere for carbon black production can be created by blocking off the passage of air upwards between burner and side walls of the hot house. The air ordinarily rising through such opening outside the confines of the burner serves no useful purpose and is in fact detrimental in that it carries off heat and promotes additional turbulence by drag from its higher velocity. By directing all of the available air to the burner in accordance with our invention we can, as we have said, reduce the volume of air passing through the hot house **10**, thereby conserving heat and diminishing air turbulence, both factors contributing to increase yield of carbon black.

The apparatus of our invention is herein illustrated as air guiding elements **34** and **36** positioned across the open area between the borders of the burner table and the hot house walls in such a manner that the air entering hot house **10** is inhibited from rising through these areas and is diverted without additional turbulence to the burner. Elements **34** cover the end bays of the hot house while elements **36** and optional additional element **40** close off the passageway running the length of the house parallel to the channels and next to the walls. For economy and convenience guide elements **34** as here shown are supported horizontally immediately below the channel level but may equally well be constructed to slope downwardly to meet the walls at any point below the horizontal level. On the other hand elements **36** must have some downward slope toward the house walls to achieve the best results.

It is obvious, of course that if element **36** meets the house wall at point A immediately above the air inlet there will be less disturbance in air flow than if the element is placed as shown by dashed lines **38** and terminates at point B. However, we have achieved increased yields with the use of guide elements placed as indicated at **38** and thus the use of elements **36** which meet the walls of building **10** at any level below the burner level is within the contemplation of our invention. It may be said in general, however, that the lower the bottom edge of element **36** the smoother the air flow and the greater the increase in yield of carbon black.

Optionally, an additional element **40** may be placed horizontally across the area between burner and house side walls. Such supplementary element serves to improve fluid flow conditions slightly and will prevent the space **42** behind element **36** from becoming filled with carbon black. The increase in yield of carbon black effected by the use of element **40** is slight.

The guide elements **34**, **36** and **40** may be constructed of any semi-rigid, heat-resistant sheet material. Preferably the material should be as light in weight as possible to permit of temporary removal for servicing the equipment. We have employed both V-crimp black iron and hard corrugated aluminum with equally good results.

While, as we have said, the open area at the burner table level is reduced fourfold by the use of guide elements **34** and **36**, we have found that to achieve proper draft in the burner shed it is necessary to reduce the building inlet and outlet areas only twofold. Illustrative are the dimensions of the various openings in a 140′ x 14′ twelve channel hot house, before and after being equipped with such guide elements, set forth in the following example:

Example I

	12 Channel Building, 140 ft. x 14 ft.	
	No Guide elements	With Guide elements
	Sq. ft.	*Sq. ft.*
Burner level opening	882	205
Air inlet	6.2	3.6
Exhaust outlets	20.3	10.2

We have found that if, for any given production conditions, the smoke roll must be held at the same level with guide elements in place as without such elements, air velocity at the burner must likewise remain unchanged. It follows, then, that for the same velocity, the volume of air passing through the burner must be reduced proportionately to the reduction in passageway area at the table level. Just why proportionate air volume reduction at the table level is accomplished by a disproportionate reduction of building inlet and outlet areas we do not attempt to explain.

Concomitant with the decrease in volume of air flow we have observed an increase in temperature within the hot house. Measured one inch above the burner pipe and midway between two tips **16** temperatures in some instances were increased by as much as 70° F. by the use of guide elements **34** and **36**.

We are inclined to the opinion that increased hot house temperature brought about by reduced air flows constitutes the principal factor governing increased yield of carbon black and that decreased turbulence is a secondary factor. While we have not been able to work out a direct relation between degree of temperature increase and amount of increased yield there is no question that increased temperatures within the hot house accompany increased yields of carbon black. Undoubtedly higher temperatures favor the dissociation of carbon black from the gas in the flame. Furthermore, as is well known, air becomes more viscous as its temperature rises and this viscosity increase promotes stability to reduce the intensity of turbulence.

In the following example are set forth the results of twelve runs of 48 hours duration each in the buildings of Example I comparing yields of substantially the same quality black obtained with and without the use of guide elements **34** and **36**. In all cases flame shields were used as standard equipment.

Example II

Run	Gas Flows/Bldg. M. C. F./24 hr. day	Production Lbs./Hour/Bldg.		Percent increased yield with Guide Elements	Temperatures, ° F.	
		Standard	with Guide Elements		Standard	with Guide Elements
M1	175	15.02	16.07	7	867	904
M2	175	14.92	15.87	6½	848	889
M3	175	15.13	16.30	7¾	865	893
M4	190	16.13	16.86	4½	898	949
M5	190	15.91	16.93	6½	893	944
M6	190	15.30	16.87	10	919	938
M7	210	16.67	17.41	4½	983	1,025
M8	210	16.09	17.50	8¼	943	1,018
M9	210	16.36	17.42	6½	962	993
M10	225	16.19	16.93	4½	1,017	1,056
M11	225	16.34	17.96	10	986	1,054
M12	225	14.81	16.75	13	943	1,000

As might be expected external conditions under which channel plants are operated are never the same from day to day. The weather is variable and the quality of the natural gas supplied is rarely uniform over any extended period. The tests from which the data in Example II, above, were compiled were conducted over a period of about 3 months during which time numerous weather changes as well as gas quality variations were encountered. The results of the tests, then, may be said to agree very well with one another and it would in fact be surprising if agreement had been much closer. Furthermore, all tests were run on hot houses in commercial operation.

It is clear that the novel apparatus and improved process of our invention have great commercial utility in that larger percentages of carbon black are recovered from the hydrocarbonaceous raw material. Furthermore this increase in yield can be obtained for a very low initial capital expenditure. Assuming 6½% additional yield from the practice of our invention and a cost of approximately $290 to equip each hot house with such apparatus we conclude that at the present market price of natural gas and carbon black the apparatus will pay for itself in about six months.

Having thus disclosed our invention and described in detail an illustrative embodiment thereof, we claim as new and desire to secure by Letters Patent:

1. In a hot house for producing carbon black having side walls with air inlets at their lower edges, a series of horizontally disposed spaced burners maintaining a zone of flames spaced from the side walls and disposed a substantial height above the air inlets, and spaced overlying burner channels forming a table; that improvement which comprises imperforate deflecting sheets fast at their lower edges to the side walls of the hot house above the air inlets, extending inwardly and upwardly in convergent relation toward said flame zone and into proximity to the longitudinal edges of the burner table thereby deflecting substantially all the air passing through the inlets inwardly from the side walls and directing it upwardly in a single convergent stream toward and through said zone.

2. In a hot house for producing carbon black having side walls with air inlets at their lower edges and end walls, outlets adjacent the top of the hot house, a series of horizontally disposed spaced burners maintaining a zone of flames spaced from the side and end walls and disposed a substantial height above the air inlets, and spaced overlying burner channels forming a table; that improvement which comprises imperforate deflecting sheets fast at their lower edges to the side walls of the hot house above the air inlets extending inwardly and upwardly in convergent relation toward said flame zone and into proximity to the longitudinal edges of the burner table; and imperforate sheets fast at their outer edges to the end walls of the hot house and extending generally horizontally at the level of said table inwardly in proximity to the ends of the burner table, said deflecting sheets deflecting substantially all of the air passing through the inlets upwardly into a single convergent stream toward and through said zone.

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