May 2, 1933. L. C. KARRICK 1,906,755

METHOD OF IMPROVING THE PROPERTIES OF SOLID FUEL BY LOW TEMPERATURE CARBONIZATION

Filed June 19, 1928 2 Sheets-Sheet 1

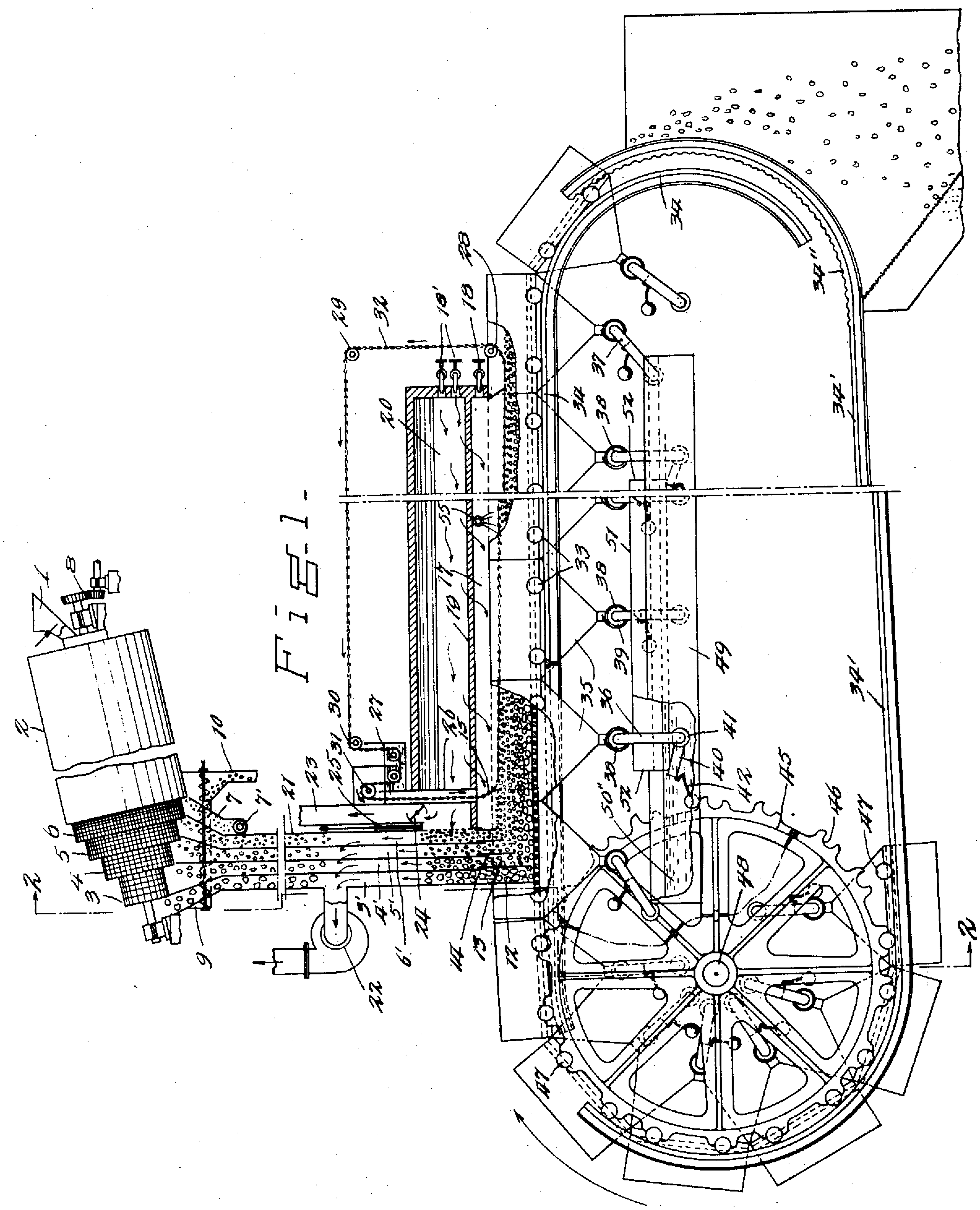

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Fig. 2.

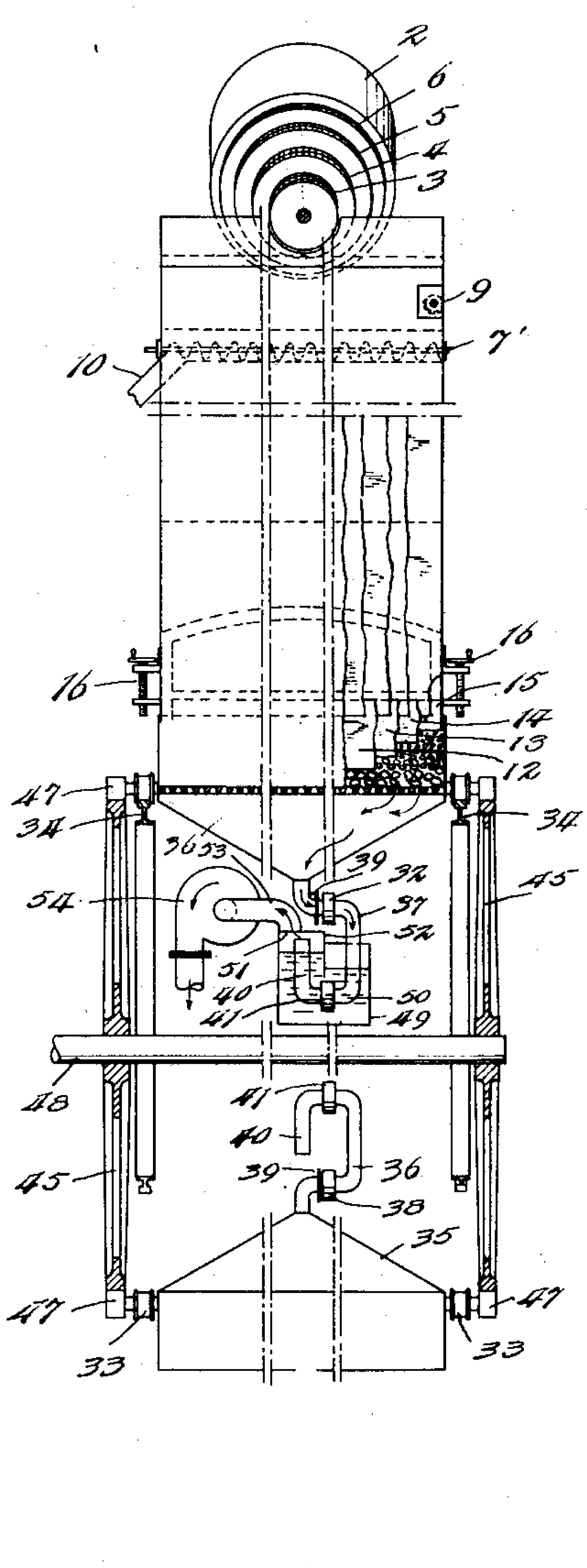


Fig. 3.

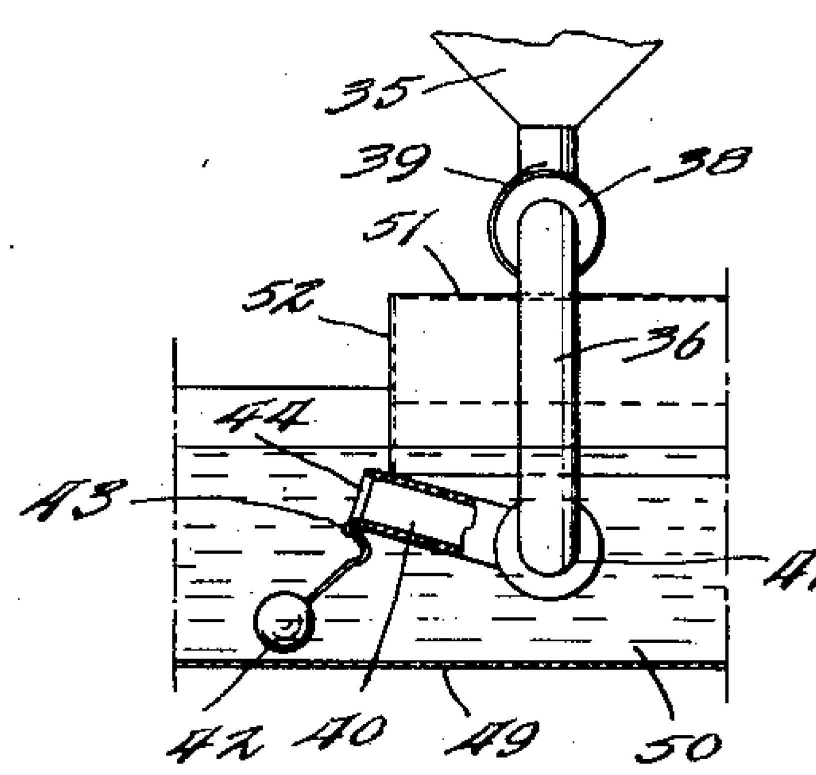
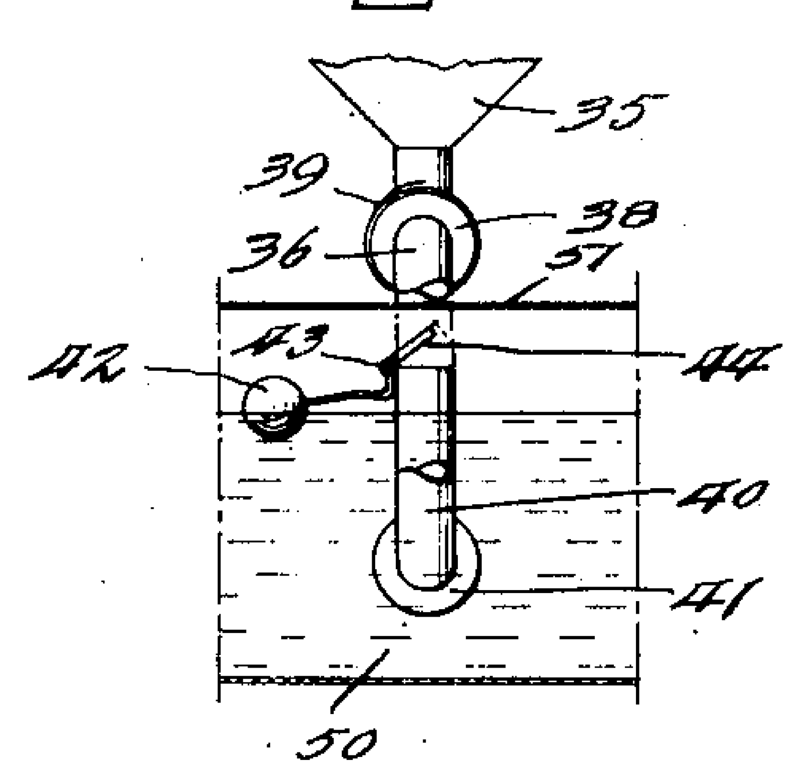


Fig. 4.



INVENTOR

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UNITED STATES PATENT OFFICE

LEWIS C. KARRICK, OF NEW YORK, N. Y.

METHOD OF IMPROVING THE PROPERTIES OF SOLID FUEL BY LOW-TEMPERATURE CARBONIZATION

Application filed June 19, 1928. Serial No. 286,698.

This invention relates to a process of treating any carbonizable material in mixed sizes, and especially crushed coal with the dust removed, so that the material will yield a reactive coke, tar-oils, and a variable rich gas. The invention is particularly suited to treating power-plant coals which have been crushed to the sizes normally used on stokers and part or all of the finest dust removed.

I have discovered a method of accomplishing the distillation of various types of coals used in power plants at low temperatures so that the resulting coke is very combustible and much more reactive, chemically, than high-temperature cokes, also the coke is formed into a maximum of large sizes either by preserving the original sizes of the coal lumps or by causing agglomeration to take place by imposing controlled, localized pressures to the coal while undergoing distillation. A large yield of primary tar-oils is formed by so operating that the oil vapors are released and removed from the zone of distillation at the lowest practicable temperatures suited to low-temperature carbonization. The fixed gases from the process may be varied in yield and quality as required in controlling the operation because of the fusing properties of the coal and to suit the market demand.

In carrying out the process the coal is first screened into a number of sizes and is then spread on the carbonizing hearth in a series of layers or strata, grading in sizes from the coarsest on the bottom to the finest on top. Each layer may be fixed as governed by the character or size of coal treated or the type of products desired, also, the total thickness of the series of strata may be fixed.

The carbonizing hearth moves continuously and the charging is continuous. The hearth may revolve or move in one direction approximately horizontally like a belt conveyor or a chain grate stoker, the latter form being described herein. The hearth is perforated throughout its top surface, the holes being tapered to assist cleaning and small enough to prevent the coal in contact from falling through.

Heating is accomplished by using heated fluids which will not react injuriously with the gases and vapors. For the gaseous media, I prefer to use hot combustion gases or superheated steam with hot water-gas. The hot fluids pass downward through the layer of coal and cause a zone of distillation to move down through the coal strata. This causes progressive devolatilization of the coke and gasification to any desired degree of the finest material forming the top layer.

When the heat is gradual, which I control by regulating the fluid temperature and by the rate of movement of the coal into hotter zones, the coke is free of graphitic carbon in its cell walls and is very reactive. I utilize this discovery to convert the finest coke into gas, the finest coke being of lowest potential value as a source of revenue. This reaction will take place at relatively low temperatures and when using hot products of combustion I form producer gas or, water gas when using superheated steam.

When using hot products of combustion as a source of heat, I prefer to dry and preheat the coal prior to charging on the carbonizing hearth so that the inert gases used to preheat the coal to its distilling temperature will be removed and will not dilute the gases generated during the distillation operation of the process. Very hot combustion gases for distillation may then impinge directly on the surface layer of fine coal without bad effect to the gases, vapors, or coke. The fine coal presents a very large surface to receive heat and, since the dimensions of the particles are small, the hot gases are quickly cooled to non-injurious temperatures and the particles completely distilled; the resulting volatiles pass downward at reduced temperature while distilling the lower strata. I find that when using gases which are so highly heated as to produce only high-temperature reaction products from layers of 1-inch coal one foot thick, will give substantially 100% of low-temperature products from layers of 1/8 in. coal of only a few inches in thickness; with finer sizes of coal the difference is even more noticeable. These examples show how my process provides a large amount of surface in the top layer of coal so as to use highly heated fluids for distilling the coal.

When using superheated steam I likewise dry and preheat the coal with hot combustion gases, thereby minimizing the amount of steam needed for the process. The steam will react rapidly with the low-temperature coke to form water gas at temperatures above 1200° F. so that I prefer to use steam in this range of temperature above 1200°F. in order that water gas will be formed while the cooling capacity of the fine coke and coal, by virtue of the heat absorbed and the water gas reaction, serves to reduce the temperature of the steam to values suited to production of good yields of low-temperature distillation products.

Some coal is very fusible and will melt and render the layer impervious to flow of gases unless special means are applied to insure permanently open coal layers. I have found that oxidation of the surface of the coal lumps will produce a shell of less fusible material which will partially maintain the original shapes of the individual lumps; I therefore provide means for preheating such coal with combustion gases containing variable amounts of carbon dioxide and air. This treatment tends to reduce the quality and fuel value of the volatiles and therefore has its objections in some instances and, therefore, I have provided for an alternative pretreatment. After preheating I subject the lumps to a sudden high temperature of either combustion gases or superheated steam and hot water gas whereby the surface of the lumps are "scorched" and a shell is formed of more rigid material. This pretreatment forms high-temperature distillation products from the outer layer and thereby the potential value of the total possible products is not appreciably reduced with respect to the total yield of low-temperature products.

I have found it desirable to use a mixture of fine coal and granular coke for the top stratum of the coal layer in order to insure continuous permeability to the gas flow and for the sake of uniform porosity of the mass. Coke may also be introduced in any suitable proportions and above or into any stratum or in direct contact with the hearth or in any other manner for better operation with badly fusing coals.

By this process I can control the fusibility of the coal lumps so as to insure against fusing of the entire mass but I also make use of the fusible nature of the coals under controlled conditions so as to cause cohesion or agglomeration of the particles so that dense lumps of coke are formed which are suited to domestic use. Coal may be successfully formed into solid homogeneous aggregates by sudden application of pressure provided the entire mass is in a substantially uniform state of fusion and devolatilization. In this process the coal undergoes progressive distillation, the top layer always being in advance of the lower layers, the bottom layer being retarded most. I, therefore, provide a means by which a continuous pressure may be applied sufficient to compress the coal into the desired final form, density and hardness while the distillation progresses. This may be accomplished by placing on the layer of coal a layer of regularly spaced pieces of iron or other heavy material of the proper weight, size and shape to give the desired density, size and shape pieces of resulting coke. I have used metal punchings, cut and cast washers, nuts, bolts, scrap iron, a mat of chain links, etc., with successful results. It is desirable to use hearth decks with a surface contour, such as a gridiron, so as to shape the pieces of coke produced by the pressure. I have used square, cylindrical and hemispherical depressions while using similar cooperating shapes above by means of which the coke is pressed into definite shapes.

The moving layer of coal may have continuous parallel strands of chain placed on its surface running longitudinally which will provide continuous pressure. This will cause the coke to be pressed into long parallel elements of greater density than the adjacent coke and the proximity of the parallel strands of chain governs the compression of the entire mass and effects thereby the permeability of the mass to flow of hot gases. Since the process depends on an intimate contact of the coal with the hot gases, particularly until the devolatilization is well under way, it is sometimes necessary to introduce coke into the mass at regular intervals and form permanent channels at proper distances apart into which the hot gases can penetrate as the natural voids of coal mass will in some instances close up due to external pressure or due to the extreme fusibility of the coal substance.

The hot fluids and distillation products are drawn down through the coal layer by suction producd by an exhauster. The hearth is preferably in rectangular sections (or the sections may be sector shaped if a circular hearth is used) and each is provided with end walls of approximately the over-all height of the coal layer. Below each hearth section is a closed vapor box and delivery piping, traps, etc. to remove the volatiles continuously and deliver them to the condenser.

The invention will be understood from the description in connection with the accompanying drawings in which Figure 1 is a side elevation partly in section and partly broken away showing an illustrative embodiment of the invention; Fig. 2 is a section along the line 2—2 of Fig. 1; Fig. 3 is a side view partly in section on an enlarged scale showing some of the details and Fig. 4 is a view similar to Fig. 3 showing some of the parts in a different position. Crushed coal is elevated to bin 1 from which it is fed into rotary screens 2 where it is separated into a number of sizes corresponding to the different concentric screens 3, 4, 5, 6, and a rejected material of substantially dust size which is caught by casing 7. The screens may be operated at varying speeds by drive gears 8.

After the coal is classified it drops from the screens into individual hoppers and chutes 3′, 4′, 5′, 6′ while the very fine material drops into conveyor box 7′ and is carried away and used up in a pulverized coal carbonizer or gasifier. If the bulk coal contains an excessive amount of certain sizes which cannot be treated so as to give the best plant results, the surplus overflows from the hopper into the conveyor 9 and is dropped into chute 10 from which it is disposed of by further crushing, or is carbonized in another unit.

The sized coal passes down through the chutes and is distributed on hearth 11 in even layers by levelers 12, 13, 14, 15 which can be raised and lowered by elevating screws 16 provided at the ends of each leveler. The hearth moves to the right as shown by arrows and the sized coal flows from the respective chutes and is stratified in successive layers with the coarsest on the bottom.

Above the composite layer of coal is a heater 17 which is shown as consisting of an oven in which superheated steam and hot water gas is introduced at 18 and is distributed over the entire coal surface and gives up its sensible heat as it contacts with the coal on moving downwardly. Above the oven is a metal roof 19 and above it oven 20 in which gas is burned from burners 18′. Much of the heat produced in 20 is conducted through metal roof 19 into oven 17 and serves to supplement the heat required in the lower oven. Both ovens are shallow so that the movement of fluids will be rapid and heat will be transmitted rapidly from the oven 20 of higher temperature into oven 17.

Hot combustion gases from oven 20 are passed through the perforated metal chute wall 21 into chute 6′ in contact with the fine coal and thence through similar perforated walls between the chutes 3′, 4′, and 5′ or is delivered to the respective chutes by conduits, while drying and preheating the coal, and thence the cooled inert gases are drawn off and wasted by exhaust fan 22. Part or all of the hot gases from oven 20 may be diverted up the stack 23 by adjusting stack damper 24 and inserting slide gate 25 between the stack 23 and chute 6′ thereby closing off the openings in wall 21. If a rich gas is not required from the process then the superheated steam and hot water gas will not be used in oven 17 but hot combustion gases will be introduced at connection 18 at such temperatures that producer gas is formed from reaction between the hot carbon dioxide and the reactive fine coke forming the top layer. A surplus of fuel gas will thereby be formed from the finest particles of coke. When combustion gases are used in oven 17 to distill the coal enough gas will be burned in oven 20 to supply heat for preheating the coal and to maintain an inward flow of heat through roof 19.

In order to provide downward pressure to the coal while undergoing distillation a link chain 32 is shown entering the lower oven via conduit 26. This chain passes through a water-seal 27. The conduit 26 is attached to the roof 19 and passes through the oven 20. Chain sheaves direct the course of the chain through the seal box 27 and down through the conduit 26 where the chain rests on the top of the coal layer and moves at the same rate as the hearth to the discharge and where the chain is lifted off the coke layer by sheave 28 and passed around sheaves 29 and 30 to the point of beginning. The master gear 31 causes the chain to move at the same rate as the hearth. It it intended that a number of parallel chains be used at intervals across the width of the hearth and therefore the equipment above described will apply to each chain. The chain could be made to traverse its course along the coal and return all within the oven and use water-cooled shafting and external bearings. In the latter form the chains may be joined at intervals so as to operate as a unit by equally spaced bars or plates so as to provide dies for shaping the coke into briquets or chunks.

The hearths are supported by rollers 33 on rails 34 and each carries a vapor box 35 and vapor swing-pipes 36 which connection is automatically "made" and broken with the suction box while the hearths are in motion.

The swing-pipes are made to swing at swivels 38 against the tension of the springs 39 which tends to hold the swing-pipes in a vertical position. Each swing-pipe 36 is provided at its lower end with a swivel 41 similar to the swivel 38 to which is attached an open-ended pipe 40 normally extending in a direction parallel to the pipe 36. A float 42 is provided with connection 43 to the open end of each extension pipe 40 and carries a flap valve 44 that can be turned to close the end of the pipe 40.

A pair of sprockets 45 are provided around the peripheries with openings 46 into which the extensions 47 on the shafts of the hearths 35 fit, so that when the sprockets 45 are driven through the shaft 48 from any convenient source, the hearths will be pushed forward along the tracks 34. The hearths return along the lower tracks 34′ by gravity so that the sprockets 45 again push them along the track 34.

A trough 49 is provided below the track 34 and is partially filled with oil 50 to form an air-tight seal. The trough 49 has one-half covered with a cover 51 shorter than the trough with end and side flanges 52 extending downwardly into the oil 50. A suction pipe 53 is connected to the space below the cover 51 and a fan or suction pump 54 withdraws the vapors or other volatile materials that may pass into the space from the vapor boxes 35 through the pipes 36 and 40.

As the hearths move in a continuous train over the trough 49 the swing-pipe 36 of each is deflected to permit it to enter the trough 49 and then the riser pipe 40 is deflected as it passes under front flange 52. The float 42 causes the valve 44 to close the end of the pipe 40 when it is below the liquid level and permits it to open when it assumes a vertical position and projects above the liquid level 50 and thereby is placed in air-tight connection with vacuum line 53 to the condenser. The trough 49 is of such length that any desired part of the volatiles of the coal may be removed and drawn into the condensing system.

The hearths may move around a course similar to a chain grate, but I prefer to use a train of unconnected hearth elements extending only slightly more than half way around the course, as shown in Fig. 1. While charged with coal undergoing distillation the hearths move up-hill slightly in order that there will always be a close contact between the abutting edges of adjacent hearth elements. The driving power is applied to the hearth ready to be charged which is the lowest, and it forces the others along the course.

At the discharge end the swing-pipes 36 having been disconnected from the suction box, the hearths move over the end of the horizontal path and race rapidly downward into an inverted position and back along the lower set of rails 34′ to a point below the charging hoppers where they are picked up and righted by the sprockets 45 and are ready for recharging. On the downward course and while inverted, the charge is thrown out. Jarring of the hearth may be necessary to remove clinging coke and this may be done by using corrugated rails 34″ on the return course. With some coals I have found that a wire gauze lining on the hearth floor insures that coke will not adhere to the hearth, or a layer of coke may be introduced next to the hearth surface.

The heating fluids supplied through valves 18 and 18′ may be introduced near the feed end so as to "scorch" the coal, or at any other point.

By gauging the amount and temperature of superheated steam or combustion gases used, the yield and heating value of the combustible gases may be varied between wide limits to suit the market requirements. When a minimum of superheated steam is used at temperatures below 1200° F. there will be no water gas formed and very little cracking of the tar-oils so that gas of approximately 1000 B. t. u. per cubic foot is formed. However, if very hot combustion gases are used much of the coke may be gasified by the producer reaction with the finest coke particles so that the fuel value of the gas produced may be as lean as producer gas, or leaner, depending on the amount of diluent combustion gases. I have found that by adding tar-oils or petroleum oils to the layers of carbonaceous materials that cracking is efficiently accomplished and thereby the gases from the process are enriched and the carbon formed by the cracking is deposited in the coke residue which forms a harder solid fuel. The oil may be introduced by perforated pipe 55 located under roof 19 of oven 17.

I claim:

1. The process of forming improved fuel products from distilling solid carbonizable material, which comprises providing a continuously moving plurality of superposed layers of particles of carbonizable material in open communication with each other differing in size from each other and passing hot gaseous material substantially air free transversely of said layers, the subjection of the carbonizable material to contact with the gaseous material being such that the gaseous material is of an increased temperature as the distillation proceeds and that the material is destructively distilled.

2. The process of forming improved fuel products from distilling solid carbonizable material, which comprises providing a continuously moving plurality of superposed layers of particles of carbonizable material in open communication with each other differing in sizes from each other and with the layer of smallest size at the top, and passing hot gaseous material substantially air free transversely of said layers, the subjection of the carbonizable material to contact with the gaseous material being such that the gaseous material is of an increased temperature as the distillation proceeds and that the material is destructively distilled.

3. The process of forming improved fuel products from distilling solid carbonizable material, which comprises providing a continuously moving plurality of superposed layers of particles of carbonizable material in open communication with each other differing in size from each other and passing hot gaseous material substantially air free downwardly through said layers, the subjection of the carbonizable material to contact with the gaseous material being such that the gaseous material is of an increased tempera-

ture as the distillation proceeds and that the material is destructively distilled.

4. The process of forming improved fuel products from distilling solid carbonizable material, which comprises providing a continuously moving plurality of superposed layers of particles of carbonizable material in open communication with each other of sizes increasing progressively downwardly, and passing hot gaseous material substantially air free transversely of said layers, the subjection of the carbonizable material to contact with the gaseous material being such that the gaseous material is of an increased temperature as the distillation proceeds and that the material is destructively distilled.

5. The process of forming improved fuel products from distilling solid carbonizable material, which comprises providing a continuously moving plurality of superposed layers of particles of carbonizable material in open communication with each other of sizes increasing progressively downwardly, and passing hot gaseous material substantially air free downwardly through said layers, the subjection of the carbonizable material to contact with the gaseous material being such that the gaseous material is of an increased temperature as the distillation proceeds and that the material is destructively distilled.

6. The process of forming improved fuel products from distilling solid carbonizable material, which comprises providing a continuously moving plurality of superposed layers of particles of carbonizable material having the character of being somewhat fusible in open communication with each other, consisting of sizes different from each other, pretreating the same with substantially air free hot gases to reduce any tendency of the solid material to fuse, and passing hot gaseous material substantially air free transversely of said layers to destructively distill the same.

7. The process of forming improved fuel products from distilling solid carbonizable material which separates crushed carbonizable material having the character of being somewhat fusible into various separate sizes, pretreating the material in the various sizes with substantially air free hot gases to reduce any tendency of the solid material to fuse, providing a continuously stratifying bed of different size of the aforesaid sized material, and passing hot gaseous material substantially air free transversely of said layers to destructively distill the same.

8. The process of forming improved fuel products from distilling solid carbonizable material, which comprises providing a continuously moving plurality of superposed layers of particles of carbonizable material in open communication with each other consisting of sizes differing from each other substantially free from dust, and passing hot gaseous material substantially air free transversely of said layers, the subjection of the carbonizable material to contact with the gaseous material being such that the gaseous material is of an increased temperature as the distillation proceeds and that the material is destructively distilled.

9. The process of forming improved fuel products from distilling solid carbonizable material, which comprises providing a continuously moving plurality of superposed layers of particles of carbonizable material in open communication with each other consisting of sizes differing from each other, and passing hot gaseous material substantially air free transversely of said layers to destructively distill the same.

10. The process of forming improved fuel products from distilling solid carbonizable material, which comprises providing a continuously moving plurality of superposed layers of particles of carbonizable material in open communication with each other consisting of different sizes with the layer of smallest size at the top, and passing hot gaseous material substantially air free transversely of said layers to destructively distill the same, said gaseous material being of such a character that the layer of smallest particles is converted into combustible gas and that the material is destructively distilled.

11. The process of forming improved fuel products from distilling solid carbonizable material, which comprises providing a continuously moving plurality of superposed layers of particles of carbonizable material in open communication with each other consisting of different sizes with the layer of smallest size at the top, and passing hot gaseous material substantially air free transversely of said layers, said gaseous material being of such a character that the material is carbonized and the contact of the solid material with the gaseous material being such that the solid material is subjected to an increased temperature as the distilling proceeds.

12. The process of forming improved fuel products from distilling solid carbonizable material, which comprises providing a continuously moving plurality of superposed layers of carbonizable material in open communication with each other consisting of different sizes with the layer of smallest size at the top, adding an oil substance to the top portion, and passing hot gaseous material substantially air free transversely of said layers and of such a character that the material is carbonized with the subjection of the solid material to the hot gaseous material being such that it is subjected to an increased temperature as the distillation proceeds.

13. The process of forming improved fuel from distilling solid carbonizable material,

which comprises providing a continuously moving plurality of superposed layers of particles of carbonizable material in open communication with each other consisting of sizes differing from each other, and passing preheated steam through said layers, the subjection of the solid carbonizable material to the steam being such that the solid material is subjected to an increased temperature for carbonizing the same and water gas is formed from the coke residue.

14. The process of forming improved fuel products from distilling solid carbonizable material, which comprises providing a continuously moving plurality of superposed layers of particles of carbonizable material in open communication with each other consisting of sizes differing from each other, and passing hot gaseous material substantially air free transversely of said layers while exerting a pressure thereon in a downward direction to destructively distill the same.

15. The process of forming improved fuel products from distilling solid carbonizable material, which comprises providing a continuously moving plurality of superimposed layers of particles of carbonizable material in open communication with each other consisting of sizes differing from each other, supporting said layers of material bodily in a manner to permit the free passage of fluid out of the lower surface thereof, passing a substantially air free hot gaseous product downwardly through said layers and destructively distilling the carbonizable material.

16. The process of forming improved fuel products from distilling solid carbonizable material, which comprises providing a continuously moving plurality of superimposed layers of particles of carbonizable material in open communication with each other consisting of sizes differing from each other, supporting said layers of material bodily in a manner to permit free passage of a fluid out of the lower surface thereof, and causing substantially air free hot reacting gaseous products in varying quantities, temperature and composition to pass downwardly through said layers to destructively distill and form additional gas from the carbonizable material.

Signed at New York city in the county of New York and State of New York this 18th day of June A. D. 1928.

LEWIS C. KARRICK.