No. 898,134. PATENTED SEPT. 8, 1908.

H. A. POPPENHUSEN & J. HARRINGTON.

PROCESS OF BURNING COAL.

APPLICATION FILED JULY 17, 1907.

3 SHEETS—SHEET 1.

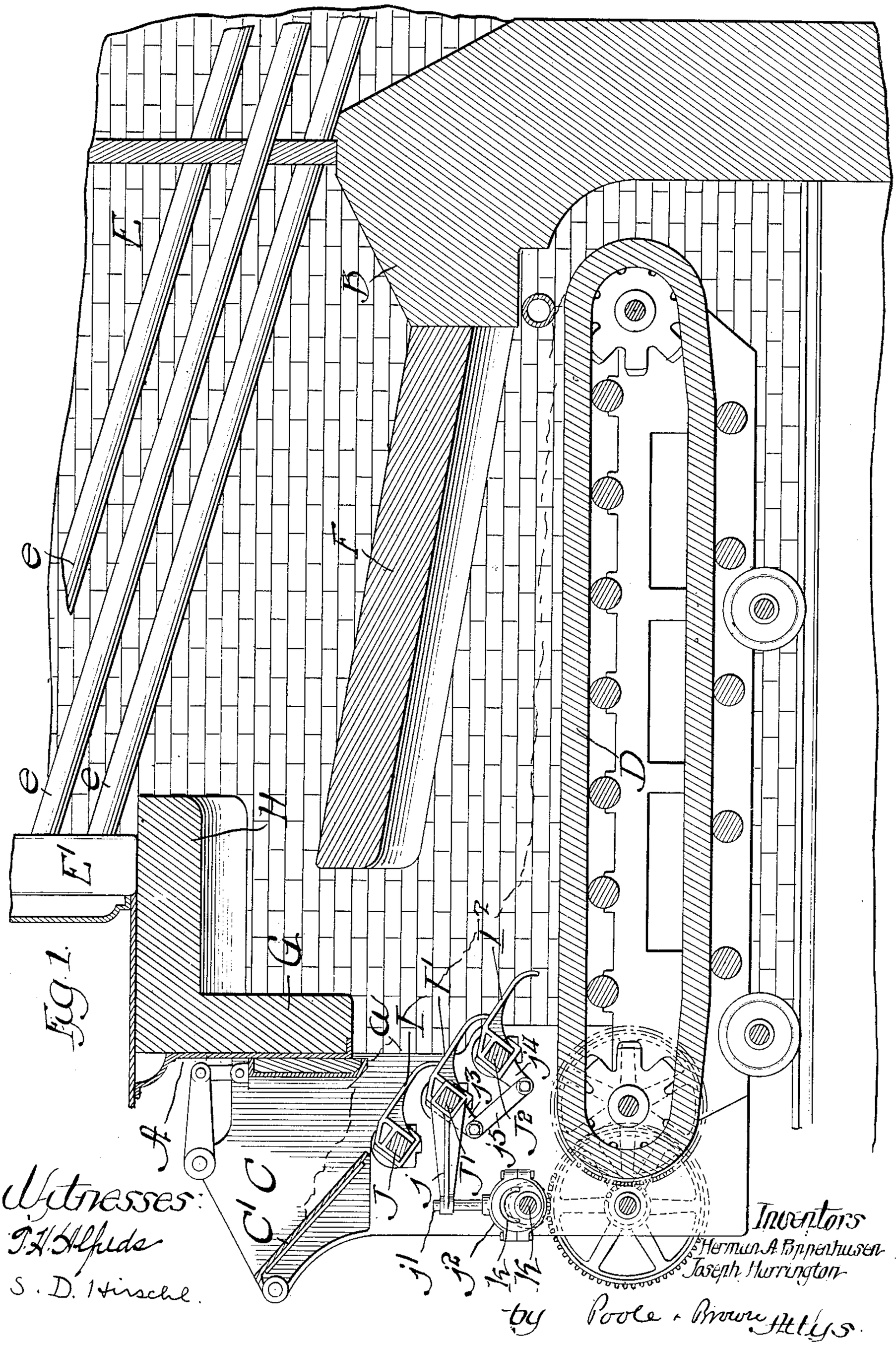

Fig. 1.

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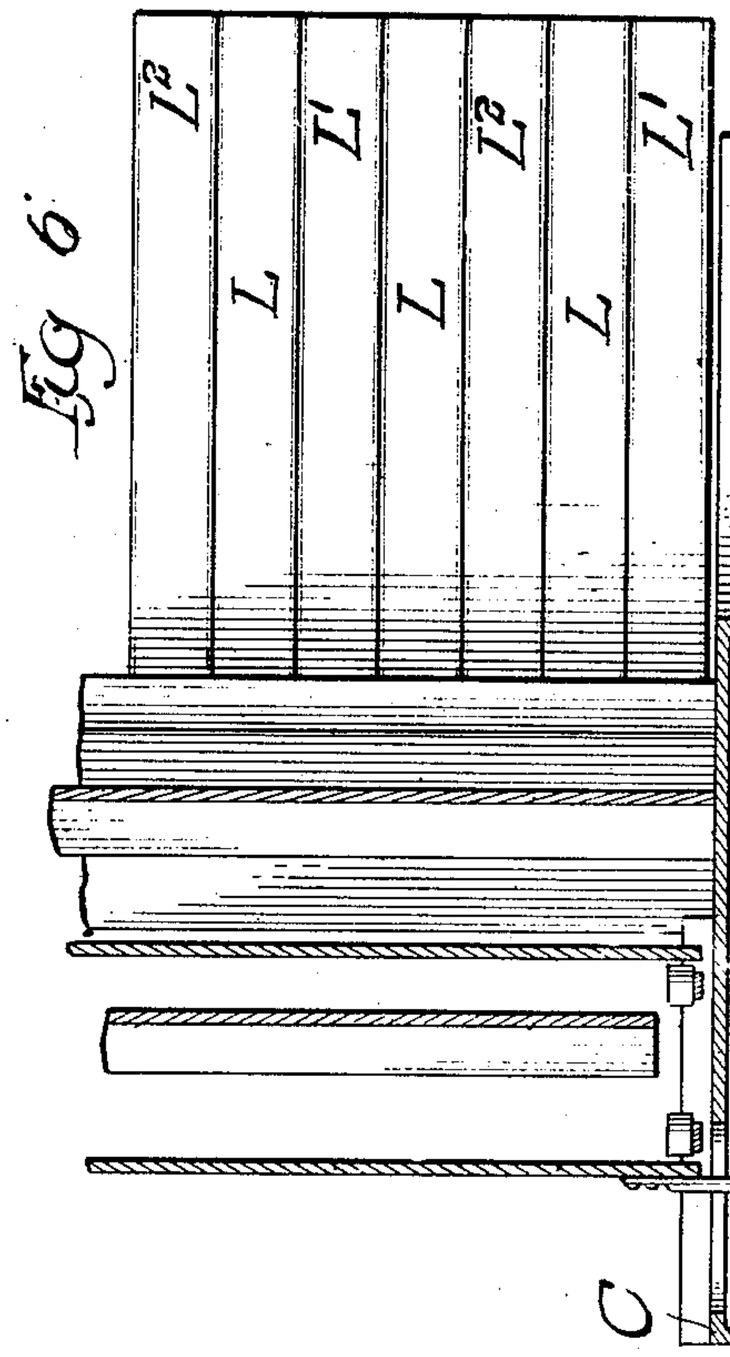

Fig 6.

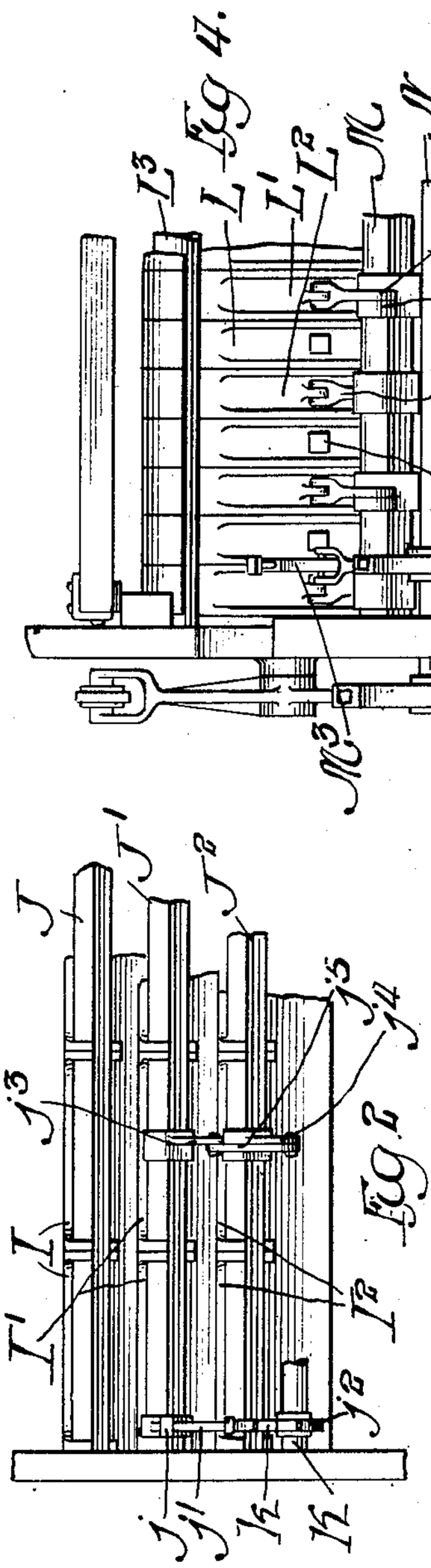

Fig 2.

Fig 4.

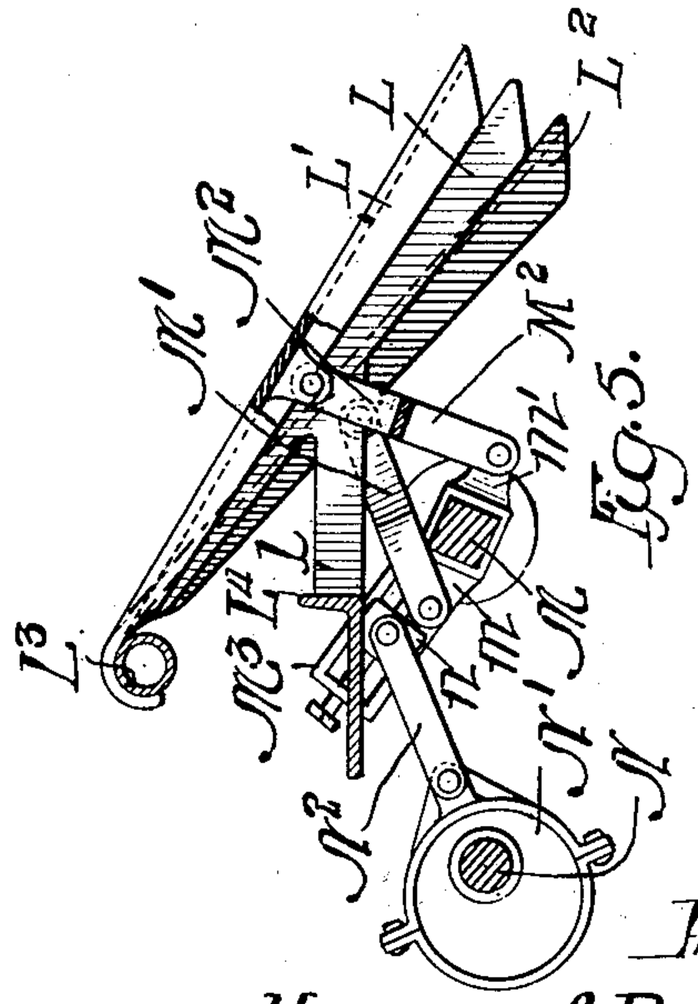

Fig. 5.

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3 SHEETS—SHEET 3.

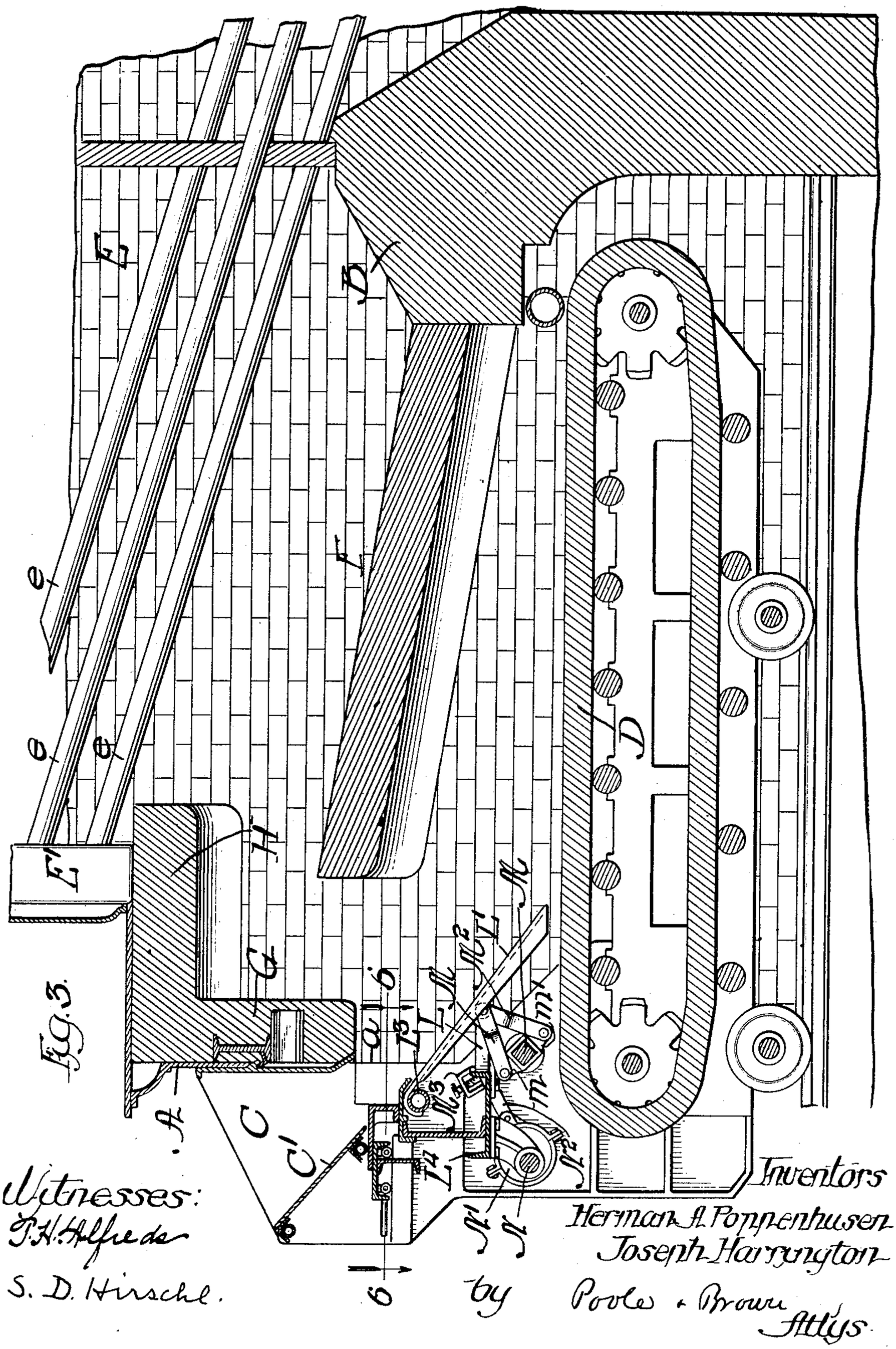

Fig. 3.

UNITED STATES PATENT OFFICE.

HERMAN A. POPPENHUSEN, OF EVANSTON, AND JOSEPH HARRINGTON, OF CHICAGO, ILLINOIS.

PROCESS OF BURNING COAL.

No. 898,134. Specification of Letters Patent. Patented Sept. 8, 1908.

Application filed July 17, 1907. Serial No. 384,286.

To all whom it may concern:

Be it known that we, HERMAN A. POPPENHUSEN and JOSEPH HARRINGTON, citizens of the United States, and residents of Evanston and Chicago, respectively, in the county of Cook and State of Illinois, have invented certain new and useful Improvements in Processes of Burning Coal; and we do hereby declare that the following is a full, clear, and exact description thereof, reference being had to the accompanying drawings, and to the letters of reference marked thereon, which form a part of this specification.

This invention relates to an improved process or method of burning fuel in boiler or like furnaces of that kind in which fuel fed to the furnace is continuously advanced or moved in a horizontally disposed layer along or through the combustion chamber of the furnace during the progress of combustion.

The process or method constituting our invention consists generally in subjecting the coal or like fuel to a coking operation, without aeration or the supply of air thereto for combustion, while such fuel is being advanced in a continuous layer, subjecting the advancing layer during the coking operation to a mechanical agitation to prevent caking or solidification of the layer during such coking operation and after the completion of the coking operation continuing the advanced movement of the layer, without any mixing of the fuel constituting the layer and in such manner as to maintain the upper part or surface portion of the layer and the lower part or bottom of the layer in the same relation that they occupied during the coking operation, and during such continuous advance of the layer after completion of the coking operation, admitting air to the layer for effecting combustion of the fuel during the remainder of its travel or advance movement. Our process or method also includes the deflecting or directing of all of the products of combustion arising from the burning of the fuel during the second or combustion period, into contact with or over the portion of the moving layer which is being subjected to the coking operation, for the purpose of effecting the coking thereof.

Our process or method may be better understood by reference to the accompanying drawings in which is illustrated, in two different forms, apparatus adapted for carrying out our said process or method.

In said drawings:—Figure 1 is a view in central vertical section of a form of furnace adapted for carrying out our invention. Fig. 2 is a detail elevation of the transverse fuel supporting plates at the forward end of the furnace, as seen from the front of the furnace. Fig. 3 is a sectional view similar to Fig. 1 showing a modified form of construction of the furnace. Fig. 4 is a detail elevation of a portion of the inclined fuel supporting bars shown in Fig. 3, as seen from the front of the furnace. Fig. 5 is a detail view showing three of the inclined fuel supporting bars of Fig. 3 and the actuating devices therefor. Fig. 6 is a detail plan section, taken on line 6—6 of Fig 3.

As shown in the accompanying drawings, A designates the front wall of the furnace, and B the bridge wall thereof.

C indicates a fuel hopper located on the front wall of the furnace in connection with the fuel inlet or feed opening *a* thereof.

D indicates an endless traveling or chain grate of that class which is moved or driven by suitable actuating devices in such manner that the upper lap of the grate moves inwardly or from the feed opening towards the bridge wall of the furnace; said upper lap being substantially horizontal.

E indicates a boiler, shown in said figures as a water tube boiler, having a front header E^1 and a plurality of water tubes *e* which extend downwardly and rearwardly from said header.

F indicates a deflecting arch or partition which extends from the bridge wall B forwardly over the grate to a point near the front wall A of the furnace, a space being left between the forward edge of said partition and the front wall, which space constitutes the outlet opening for the upward or outward passage of the products of combustion. Said bridge wall B is extended upwardly past the top surface of the grate and joins the rear margin of said deflecting arch or partition.

G is a wall, of fire brick or like refractory material, which is built against the front wall A of the furnace above the feed opening, to protect said front wall, and H is an arch which extends rearwardly from the top of the

wall G and forms a protection for the front header E^1 of the boiler; said parts being arranged to afford space for the passage of products of combustion around the forward edge of the said deflecting partition F on their way to the stack or exit flue of the furnace. As shown in Figs. 1 and 3, the said arch or partition F is inclined upwardly and forwardly from its rear end at which it is joined to the bridge wall, but it need not necessarily be so inclined. At the forward end of and above the chain grate D, in position to receive the fuel discharged from the feed hopper C, is an inclined fuel support arranged at an angle corresponding substantially with the angle which will be assumed by the upper surface of a layer of coal resting thereon under the action of gravity. Said inclined fuel support is provided with means for agitating the layer of coal resting thereon in such manner as to aid the downward movement thereof and to prevent the same from caking or becoming solidified during the coking operation, which takes place when the coal is passing over said support, without stirring the fuel or disturbing the relation between the surface portion and the under portion of the coal in the layer, which relation remains the same throughout the operation or during the entire movement of the layer through the furnace.

In the construction shown in Figs. 1 and 2, said inclined support is formed by means of three transversely extending, inclined and overlapped metal plates I I^1 I^2. Said plates are arranged with the upper edge of the uppermost plate I adjacent to the lower edge of the bottom wall C^1 of the feed hopper C, and with the lower edges of said upper plate I and the intermediate plate I^1 overlapping the adjacent plates below them. The lower margins of said plates I I^1 I^2 are shown as deflected downwardly so as to form a series of transversely extending ledges or shoulders in the supporting surface formed by the said plates. Said ledges or shoulders constitute means to aid in agitating or breaking up the layer of fuel resting on the plate becoming baked into a solid mass by the action of the coking heat to which it is subjected. The said plates I I^1 I^2 are movably supported in such manner that their lower edges may be oscillated or vibrated for the purpose of aiding in the downward movement of the layer of coal and to prevent the caking of said layer. As shown in said Figs. 1 and 2, the said plates are attached to and supported upon horizontal rock-shafts J J^1 J^2 which are mounted in bearings at their ends and afford oscillatory supports for the individual plates. Devices are provided for giving oscillatory movement to said rock-shafts which, as shown in Figs. 1 and 2, is constructed as follows: The intermediate rock-shaft J^1 is provided with forwardly extending horizontal arms j j, the outer ends of which are connected with upright rods j^1 which are attached at their lower ends to eccentric straps j^2 engaging eccentrics k k mounted on a transversely arranged horizontal rotative shaft K. By the turning of said shaft K the eccentrics k k act through the rods j^1 j^1 to give oscillatory movement to the arms j j, which oscillatory movement is transmitted to the rock-shaft J^1 and the fuel supporting plate I^1 attached to said rock-shaft. Oscillatory movement is given to the lowermost rock-shaft J^2 and the lowermost supporting plate I^2 by connections between the rock-shafts J^1 and J^2, consisting, in the instance shown, of rigid, radial arms j^3 j^4 on said rock-shafts, which arms are connected with each other by means of connecting rods or links j^5 j^5. In the construction shown in the drawing, the uppermost rock-shaft J and the supporting plate I are not directly moved or actuated but a certain amount of oscillatory movement is given thereto by means of contact of the lower edge of said plate I with the upper portion of the oscillating plate I^1 on which it rests.

From the construction described in the plates I I^1 I^2, it will be seen that the lower margins of said plates are given a vibratory or shaking movement tending to aid or facilitate the downward movement of the layer of coal resting thereon. It will also be observed that the presence of the transfer ledges or shoulders formed by the lower marginal parts of said plates in connection with the vibratory movement given to said lowermost margins of the plates will have the effect of agitating the downwardly moving layer of fuel resting on said plates in such manner as to break up the same or prevent it becoming solidified into a continuous mass by the action of the coking heat to which it is subjected and that the breaking up or disintegration of the mass takes place without disturbing the layer to such extent as to result in the turning over, mixing up or the imparting of a rolling motion to the fragments constituting the mass.

In the operation of the fuel supporting means consisting of the supporting plates I I^1 and I^2 and the horizontal traveling grate D, fuel will be fed from the feed hopper C in a layer of uniform thickness and the layer of fuel thus discharged upon the inclined supporting surface formed by said plates will rest thereon with its surface inclined substantially at the angle at which the coal will naturally rest under the action of gravity; the mass or layer on said supporting surface being sustained thereon by the contact of the lower part of said layer with the traveling grate which, in its rearward movement, carries rearwardly the coal from the lower part of said inclined layer, thereby permitting the latter to descend or slide downwardly along or over said inclined surface at a rate of speed

depending upon the rate of traveling of the chain grate. The layer of fuel passes from the inclined surface to the traveling grate without having the upper and lower portions of the layer mixed with each other. In other words, the top portion of the layer on the inclined surface continues as the top portion of the layer on the grate, while the lower part of the layer, which is subjected to a less degree to the coking heat, remains at the bottom of the layer and rests in contact with the grate as the layer passes to and is carried forward on said grate.

The gaseous products of combustion arising from the burning of the fuel upon the chain grate rise into contact with the deflecting wall or partition F and by the latter are deflected forward toward the front of the furnace and against the surface of the layer of coal resting upon the said supporting plates I I^1 I^2 and thereafter pass upwardly around the forward edge of said arch or partition. The products of combustion being highly heated operate by their contact with the layer of coal resting on said inclined supporting surface to effect a preliminary heating or coking operation by which the volatile constituents of coal are driven off, and the coal is prepared for burning off its less volatile constituents as soon as it reaches the chain grate, through which air is supplied to effect combustion. The gaseous products of combustion distilled from the coal on said inclined surface will be mixed with and ignited by the highly heated products of combustion arising from the burning fuel on the grate, and with said highly heated products of combustion will be deflected forwardly and pass upwardly around the front end of the deflecting arch or partition. In the case of bituminous or semi-bituminous coal the preliminary heating or coking operation will result in a tendency to solidify the mass or layer resting upon and traveling downwardly over the plates I I^1 I^2, while the volatile constituents are being distilled therefrom, or, in other words, tends to effect a caking of the coal by the melting and running together of some of the fusible constituents thereof. The caking of the coal or the cohesion of its particles to form a solid mass is, however, prevented through the disturbance or agitation thereof resulting from the movement downwardly over the transverse shoulders or ledges hereinbefore referred to and also by the shaking or vibratory movement given to the lower edges of said plates I I^1 I^2, so that when the layer of coal reaches and is deposited upon the chain grate it is broken into fragments and is therefore prepared for the rapid combustion thereof as soon as it reaches the chain grate; its fragmentary condition permitting the free passage therethrough of air for supporting combustion.

In the modified construction of the inclined supporting surface illustrated in Figs. 3 to 7, said surface is formed by a plurality of parallel, downwardly and rearwardly inclined, narrow plates or bars L L^1 L^2 supported at their upper ends upon a transverse horizontal pivot rod L^3, and having their lower ends terminating adjacent to and above the top surface of the chain grate D. The bars L are fixed or stationary, being supported in position by rigid arms *l* thereon which bear against a horizontal, transverse girder L^4 extending across the front of the furnace below the feed hopper. The bars L^1 and L^2, which are arranged in alternation with the fixed bars L, are adapted to swing or oscillate at their lower ends. The bars L^1 have movement upwardly from the plane of the fixed bars L, while the bars L^2 have movement downwardly from said plane. Provision is made for giving vibratory movement to the lower ends of said bars L^1 and L^2 consisting of a horizontal rock-shaft M provided with oppositely extending, rigid arms *m* m^1, one for each of the bars L^1 and L^2. Each arm *m* is connected with one of the bars L^1 by means of a connecting rod M^1 and each of the arms m^1 is connected with one of the bars L^2 by a connecting rod M^2. With this construction, when the rock-shaft M is rocked, alternate oscillatory movement is given to the two sets of bars L^1 L^2 in such manner that the bars L^1 rise above the bars L and the bars L^2 descend below said bars L, with the result of agitating the layer of fuel resting on the inclined surface formed by the several bars and thereby preventing the caking of the same, without otherwise disturbing said layer, as before described, in the case of the construction shown in Figs. 1 and 2. The rock-shaft M may be given oscillatory movement from a rotative shaft N by means of an eccentric N^1 on said shaft, and an eccentric rod N^2 which is pivotally connected with a block *n*, mounted on a rigid arm M^3 affixed to one end of the rock-shaft M; said block *n* being adjustably mounted on said arm M^3 so as to provide for adjustment of the extent of rocking movement in the rock-shaft.

In the performance of our novel process by the use of the furnace constructed as hereinbefore set forth, the layer of coal resting upon the inclined supporting surface at the forward end of the furnace is subjected to a distilling or coking operation by which the volatile constituents of the coal are driven off, and said volatile constituents, being immediately brought into contact or mixed with the highly heated products of combustion which are deflected forwardly over the layer of coal on said inclined supporting surface by the deflecting arch or partition, are entirely burned or consumed. The agitation to which said layer of coal resting upon the said inclined supporting surface is sub-

jected, continuously breaks up the said layer during the process of distillation, so that it reaches the surface of the traveling chain grate in a fragmentary condition, thereby permitting the free passage of the air therethrough to effect rapid and complete combustion thereof. After the lower layer of coal reaches the chain grate it moves rearwardly thereon without further disturbance of agitation until completely consumed.

One important advantage arising from our novel process is that of the avoidance of formation of clinkers during the progress of combustion of the layer of fuel passing through the furnace. This result arises from the fact that there is no disturbance or agitation of the layer of fuel, when upon the inclined supporting surface or upon the chain grate, such as would result in the lower part of the layer being brought to the top of such layer and subjected to the high heat within the interior of the furnace. It will be understood in this connection that the formation of clinkers usually arises from the lower parts of the layer of fuel resting on a grate being brought to the top of said layer when nearly consumed or reduced to ashes, with the result that the incombustible constituents of the ashes are fused and clinkers are produced. In the process hereinbefore described, the layer of fresh fuel is broken up while being subjected to the preliminary coking operation and before such layer of the fuel reaches the part of its path in which combustion takes place, so that during the combustion period no further disturbance or agitation of the layer is required in order to permit the free passage of air therethrough. Moreover, there is no mixing up or rolling over of the coal during the coking period, such as would tend to the production of clinkers, it being manifest that if, during such coking period, the layer be not stirred up, but only broken or fractured, the surface portion thereof, which is first coked or prepared for combustion, will remain at the top of the layer during the combustion period, while the lower part of said layer, which is less nearly prepared for combustion, will first receive the action of the air at the beginning of such combustion period. The coking action will have extended through the entire thickness of the layer by the time the said layer reaches the point in its path when combustion begins and such layer will then be thoroughly prepared for combustion without the formation of clinkers, because its lower portion, which has been least subjected to the coking operation, will be more directly acted upon by the incoming air to effect combustion thereof, while the upper part of the layer, having been more thoroughly coked, will be in readiness for burning with the relatively smaller supply of oxygen which will reach said upper part of the layer as the air passes through the same from below.

Another important advantage gained by our process is that of the increase of igniting effect arising from the better preparation of the fuel for ignition and complete combustion. This is due to the fact that the heated gaseous products of combustion from the entire layer of fuel are deflected forwardly against the fresh incoming layer of coal to effect the coking thereof, thereby giving increased coking effect according to the increase of the quantity of fuel fed into the furnace. In prior processes, carried out by the use of an igniting arch located over the forward end of a traveling chain grate, there has been no increase of coking effect upon an increase of the amount of fuel fed to the furnace, because the ignition arch is heated only by the heat radiated from the forward part of the layer of burning fuel on the grate and there is therefore no more heat transmitted from the ignition arch to the greater amount of incoming fresh fuel when the feed is rapid than to the lesser amount of incoming fresh coal when the feed is slow. Manifestly, in our process the increase in the rate of feed will result in a larger quantity of fuel being burned upon the chain grate and the heat resulting from the combustion of such larger quantity of fuel will produce an increased heating effect upon the incoming fuel substantially corresponding to the increase in the rate of feed.

We claim as our invention:—

1. The process of burning coal which consists in advancing the coal continuously into and through a furnace when spread in a layer, first applying coking heat to the top surface of the layer without aeration thereof, to effect the coking of the coal, and immediately after the completion of the coking operation admitting air to the bottom of the layer to effect combustion, agitating the part of the layer undergoing the coking operation to break up the layer and prevent caking or solidification of the coal; the agitation of the layer during the coking operation and its subsequent advance movement during combustion being effected without stirring or mixing the coal constituting the layer.

2. The process of burning coal which consists in advancing the coal continuously into and through a furnace when spread in a layer, first coking the coal without aeration and after the completion of the coking operation admitting air to the bottom of the layer to effect combustion, the coking being effected by directing the heated products of combustion arising from the portion of the layer undergoing combustion into contact with the top surface of the portion of the layer undergoing the coking operation, and agitating the part of the layer undergoing the coking operation to break up the layer and

prevent caking or solidification of the coal, the agitation of the layer during the coking operation and its subsequent advance movement during combustion being effected without stirring or mixing the coal constituting the layer.

In testimony, that we claim the foregoing as our invention we affix our signatures in the presence of two witnesses, this 2nd day of July A. D. 1907.

HERMAN A. POPPENHUSEN.
JOSEPH HARRINGTON.

Witnesses:
A. M. BUNN,
T. H. ALFREDS.