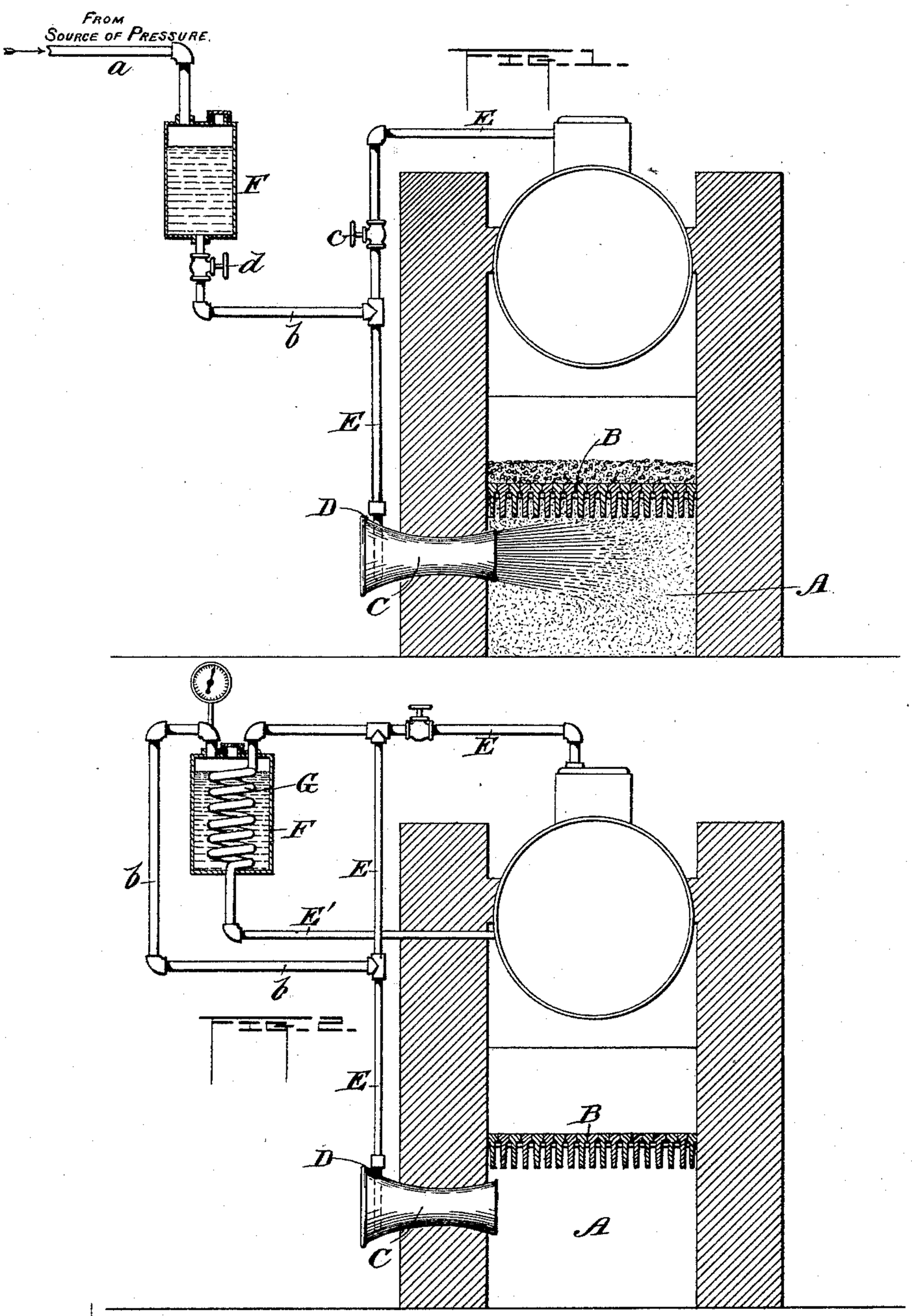
(No Model.) 2 Sheets—Sheet 1.

W. McCLAVE.

MEANS FOR BURNING SOLID CARBONACEOUS FUELS.

No. 485,820. Patented Nov. 8, 1892.



Witnesses:
Severance.
G. Hines.

Inventor:
William McClave
by his Attorneys
Mason, Fenwick & Lawrence

(No Model.) 2 Sheets—Sheet 2.

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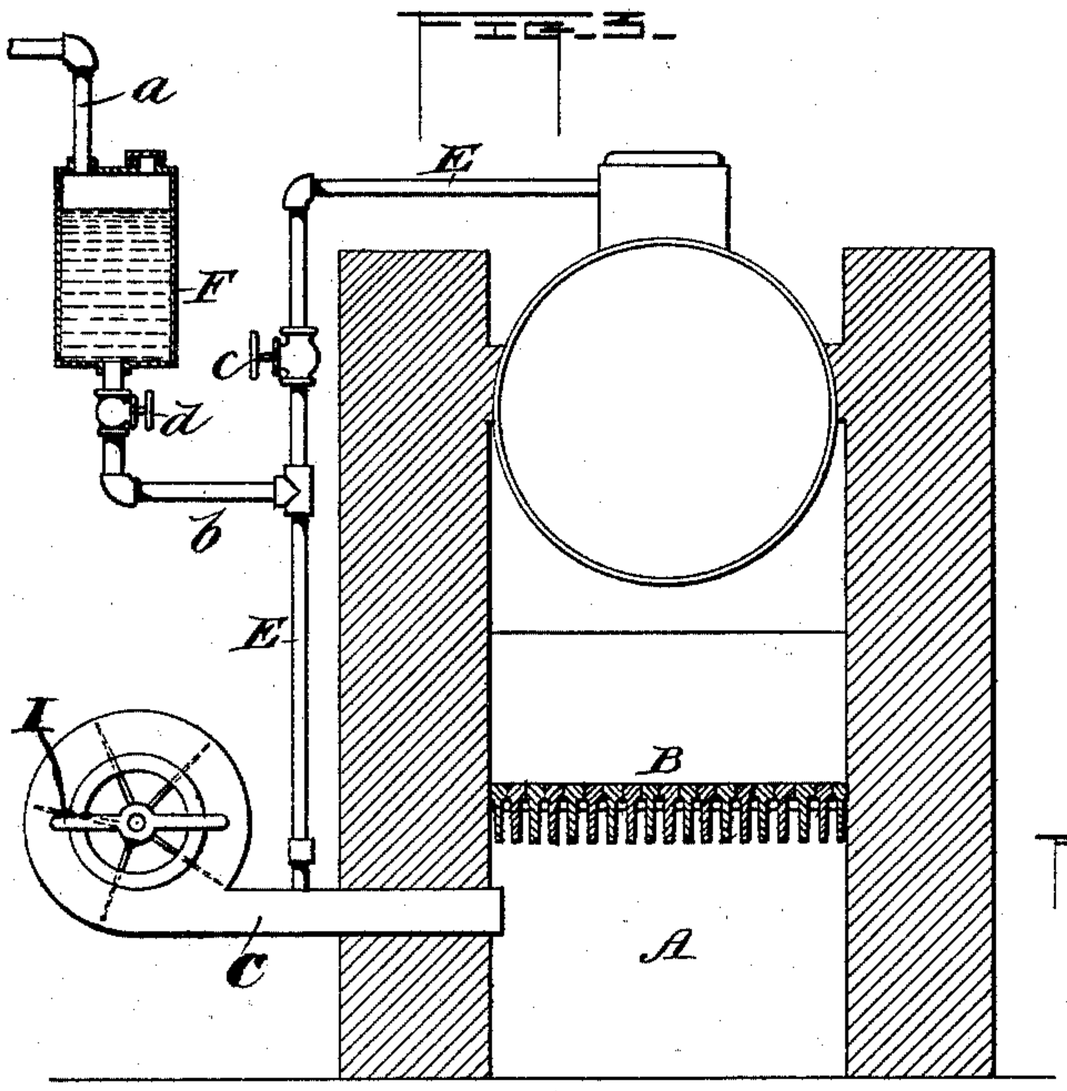


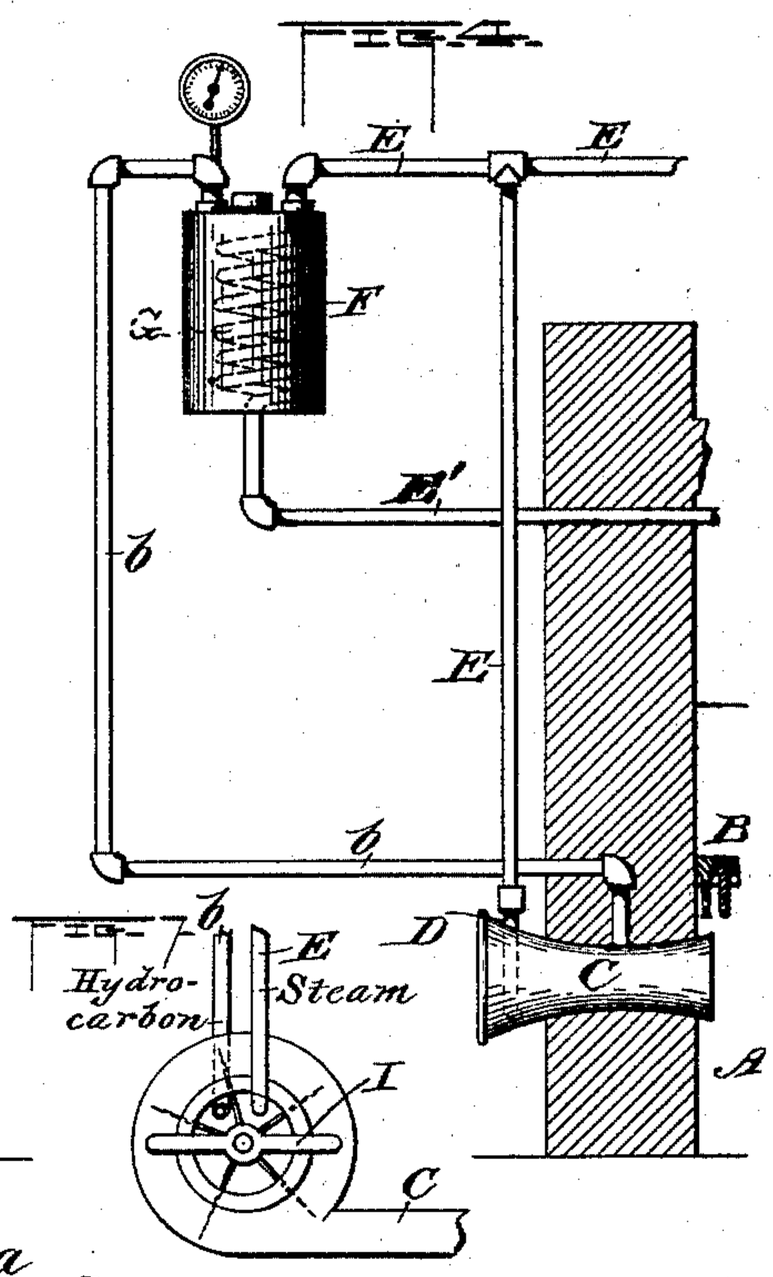


FIG. 5.

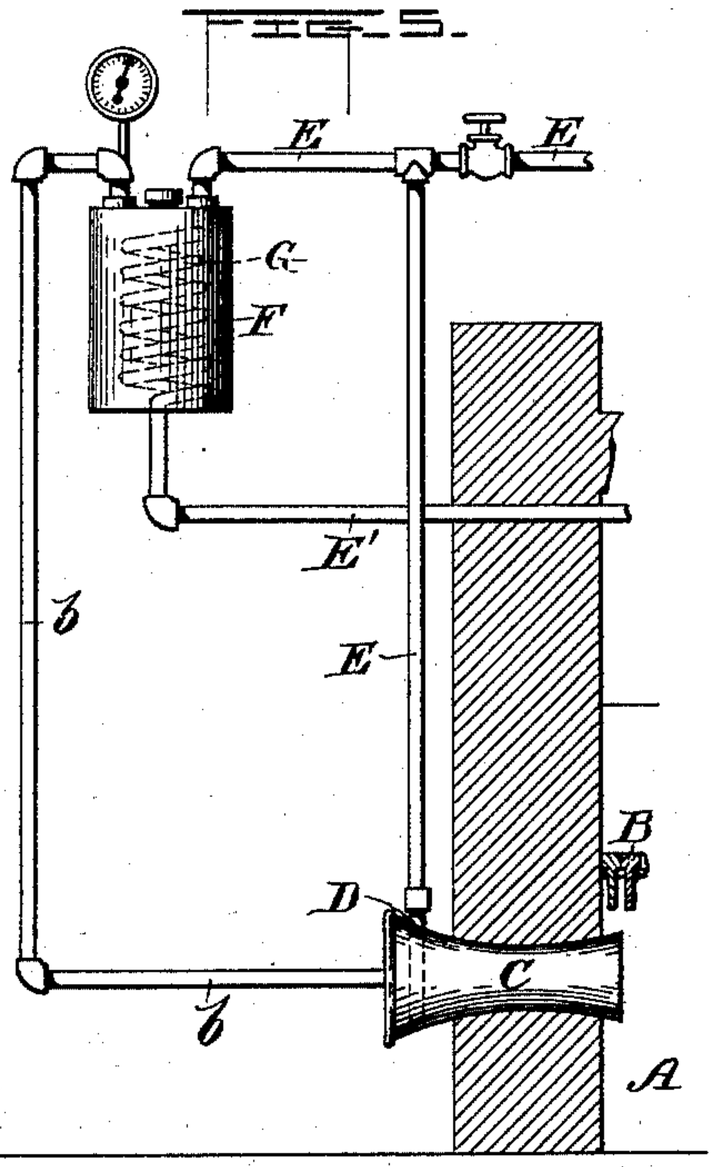
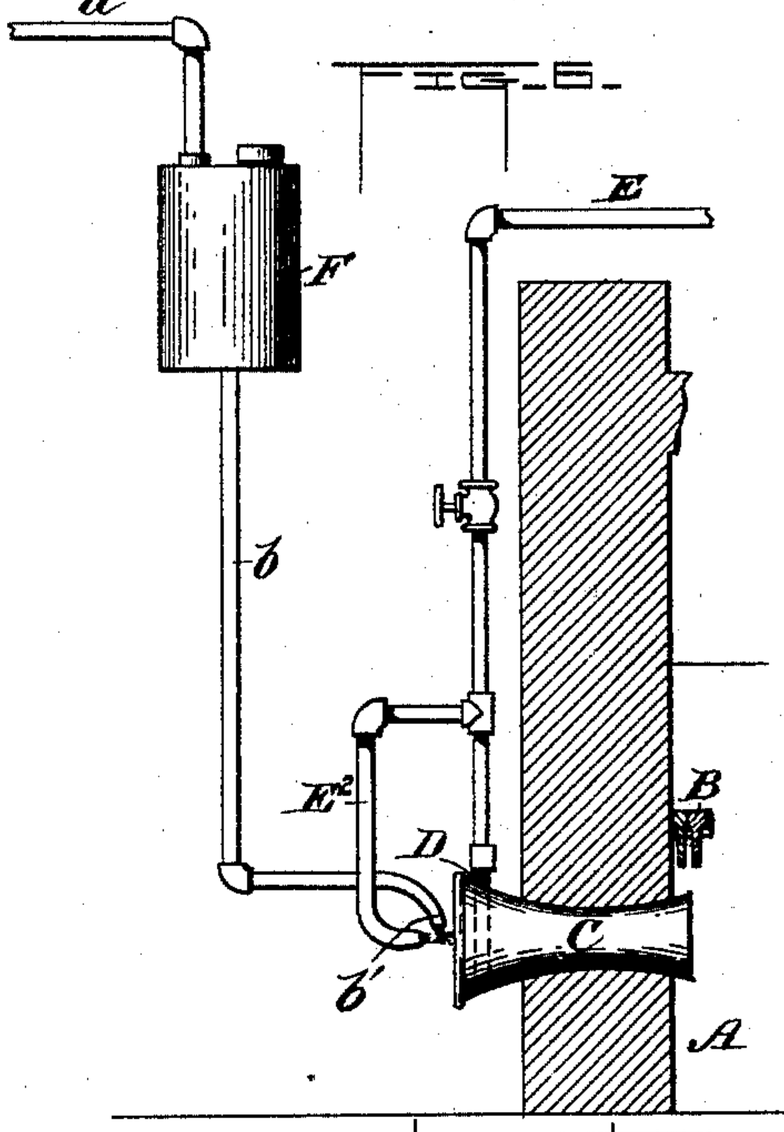


FIG. 6.



WITNESSES:—

Severance.
C. Hines.

INVENTOR:—

William McClave
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UNITED STATES PATENT OFFICE.

WILLIAM McCLAVE, OF SCRANTON, PENNSYLVANIA.

MEANS FOR BURNING SOLID CARBONACEOUS FUELS.

SPECIFICATION forming part of Letters Patent No. 485,820, dated November 8, 1892.

Application filed August 21, 1891. Serial No. 403,354. (No model.)

To all whom it may concern:

Be it known that I, WILLIAM MCCLAVE, a citizen of the United States, residing at Scranton, in the county of Lackawanna and State of Pennsylvania, have invented certain new and useful Improvements in Means for Burning Solid Carbonaceous Fuels; and I do declare the following to be a full, clear, and exact description of the invention, such as will enable others skilled in the art to which it appertains to make and use the same, reference being had to the accompanying drawings, and to the letters of reference marked thereon, which form a part of this specification.

My invention consists in an improved means for burning carbonaceous fuels, the same consisting in the apparatus for introducing under pressure beneath the bed of fuel on a grate or other open-work surface a mixed compound blast consisting of air, steam, and petroleum-oil or other hydrocarbon of similar nature with highly-inflammable properties in a thoroughly incorporated or intermixed condition, and for passing this blast up into the burning mass of fuel.

In the accompanying drawings, Figure 1 is a vertical cross-section of a furnace and of one means adopted in carrying out my invention. Fig. 2 is a similar cross-section of a furnace, illustrating another means which I adopt in carrying out my invention. Fig. 3 is a similar cross-section illustrating a fan-blast device instead of a steam-jet blower, which may be adopted in carrying out my invention. Figs. 4 and 5 illustrate in detail different means of connecting the hydrocarbon-conducting pipe with the steam-pipe and with the blower or air-duct thereof. Fig. 6 illustrates an atomizer as a means of supplying the hydrocarbon along with air and steam beneath and up into the bed of fuel. Fig. 7 shows a construction whereby steam and hydrocarbon may be introduced separately into the fan-chamber or its conduit.

A represents an inclosed ash-pit; B, a grate; C, an air-duct; D, a steam-jet blower; E, a steam-supply pipe leading from the boiler into the steam-jet blower; F, a hydrocarbon-tank having connection by means of a pipe *a* with a suitable force-pump or other proper forcing means and by a pipe *b* with the steam-supply pipe E. The steam-supply pipe and the hydrocarbon-conducting pipe are provided with suitable cocks, as *c* and *d*. The furnace has its ash-pit adapted to be closed to the atmosphere, so as to prevent combustion of the hydrocarbon before it enters between the grate-bars and reaches the fired fuel. The means adopted for supplying the compound blast of air, steam, and hydrocarbon are such that the elements of the blast are mixed before entering the chamber, this essential requisite being secured by discharging the said blast from a single tuyere into the chamber. Where the hydrocarbon is discharged through an independent nozzle, combustion is likely to ensue, thereby prematurely producing carbonic-acid gas and reducing the operation to that of ordinary combustion both at the end of the nozzle and upon the grate. If found desirable, where the ash-pit is large a plurality of tuyeres may be introduced at different points through the wall of the ash-pit, and each of these tuyeres will be a duplicate of the one represented and serve for mixing and discharging the compound blast—viz., air, steam, and hydrocarbon—in the same manner as hereinbefore described. With this arrangement, when the cocks *c* and *d* are opened and the pressure of the boiler and of the force-pump are acting the steam will flow through the steam-supply pipe E and hydrocarbon will flow into this steam-pipe and mix with the steam, and the mixed hydrocarbon and steam, both being now in a highly-vaporized condition, will pass through the jets of the blower D and mingle with air inducted by this combined blast in the air-duct C. The whole being thoroughly incorporated and intermixed will pass into the ash-pit A of the furnace and beneath and into the fire-bed or fuel upon the grate. By this means the hydrocarbon is introduced into the bed of fuel and by its quick combustion is made to serve the purpose of quickly igniting the carbon of the fuel throughout the lower stratum of the fire-bed, and thereby produce a very intense heat in said lower stratum, and consequently effect better combustion and consumption throughout the entire mass of fuel. The air portion of the blast furnishes oxygen to produce com-

bustion mainly in the lower and middle strata of the fire-bed and the steam portion of the blast serves for furnishing oxygen by disassociation in the upper stratum of the fire-bed, and thereby preventing to a large extent the formation of carbonic oxide by conversion from carbonic-acid gas produced in the lower and middle strata of the fire, and in furnishing at the same time oxygen at the proper point to burn the carbonic oxide that may and will be formed in the fire. The hydrogen of the steam thus set free becomes another element or combustible, which is also burned by coming in contact with oxygen above the fire.

In Fig. 2 means are shown whereby the hydrocarbon is vaporized in a tank F by means of steam from the boiler, passed through the supply-pipe E and a coil G in said tank, one of the terminating ends of said coil connecting with the supply-pipe E of the boiler and the other with a pipe E′, leading to the boiler, the latter pipe serving for conducting into the boiler the water of condensation from the steam. A pipe *b*, connected to the tank and with the steam-supply pipe E of the boiler, conducts the vaporized hydrocarbon into the steam-supply pipe, where it mingles with the steam and passes to the blower, and there mingles with air and passes into the ash-pit and beneath and up into the fire-bed, as hereinbefore described.

In Fig. 4 the hydrocarbon-conducting pipe *b* is shown passing through the blower duct or shell C of the blower and in Fig. 5 said pipe is shown arranged centrally in line with the steam-jet blower D. In both of these constructions the steam, hydrocarbon, and air become thoroughly incorporated and intermixed in their passage as a combined blast into the ash-pit beneath and up into the fire-bed, as hereinbefore described.

In Fig. 6 a tank F for containing fluid hydrocarbon is represented, and from this tank extends a conducting-pipe *b*, terminating in a nozzle *b′* in close proximity to the outlet end of the steam-supply pipe E, the relation of the hydrocarbon-outlet and the steam-outlet being such that they form an atomizer for the hydrocarbon by the action of the steam against the jet of hydrocarbon as it flows diagonally across the path of the steam-jet. In conjunction with this tank F and its hydrocarbon-conducting pipe *b* a branch pipe E^2, leading from the steam-supply pipe E and terminating immediately at the nozzle *b′*, is employed, as shown. The tank may have a connection by means of a pipe *a* with a force-pump or other source of pressure. With this arrangement the hydrocarbon is mingled in small atoms with the steam and air and discharged into the ash-pit and beneath and up into the fire-bed, and the result is essentially the same as when air, vaporized hydrocarbon, and steam are introduced beneath and up into the fire-bed.

In Fig. 3 a hydrocarbon-tank E, having a pipe *a* for connection with a suitable force-pump or other source of pressure and a pipe *b* for connecting with the steam-supply pipe from the boiler, are shown. In this illustration a fan I is adapted for furnishing the air portion of the blast, and the steam-supply pipe is shown connected with the conduit of the fan; but, if desirable, the steam-supply pipe and the hydrocarbon-conducting pipe may lead to and be made to discharge into the chamber of the fan-case separately, as shown in Fig. 7.

With the construction shown in Fig. 3 the hydrocarbon is forced into the steam-supply pipe and caused to mingle with the steam and pass with the same into the conduit of the fan-case and therein mingle with air and the whole as a compound blast forced into the ash-pit and beneath and up into the fire-bed. It is preferable to pass the mingled steam and hydrocarbon into the fan-case, whether mixed before or after entrance into the same, as by the revolution of the blades of the fan a thorough incorporation and intermixing of the constituents of the blast will be better effected. With the construction shown in Fig. 7 the mixing of the three constituents of the compound blast within the fan-case is aided by the revolutions of the blades of the fan; but, while this is so, the mixing will be thorough enough if the steam and hydrocarbon are introduced mixed or unmixed into the conduit of the fan-case.

While the greatest advantage will be derived from the use of my invention in burning small cheap fuels—such as "anthracite-culm," "birdseye," "buckwheat," "coke-screenings," and other small solid carbonaceous fuels containing but a small amount of volatile matter—I do not confine the use of my invention to burning such small carbonaceous fuels, as it may be of advantage in any fire where steam is a constituent.

In order to show the importance of my invention, I deem it proper to make the following additional description: It is a well-established fact that a small amount of steam in a blast used for burning fine carbonaceous fuels in boiler and other furnaces where a large body of hot gaseous flame is more desirable than an incandescent radiant heat simply is very beneficial for the purpose named, on account of the chemical and mechanical effect of the steam on the fire, the commonly-accepted theory of the chemical effect of the steam upon the fire, and one that appears to be consistent with the admitted beneficial result obtained from its use, being that it furnishes oxygen by dissociation in the upper stratum of the fire, thereby preventing to a large extent the formation of carbonic oxide in said stratum by conversion from the carbonic-acid gas made in the lower stratum of the fire, and also furnishing oxygen to burn the carbonic oxide that may and will be formed, the hydrogen or at least a large portion of it thus set free by the dissociation of the steam

being burned above the fire at a temperature below the point of dissociation by coming in contact with oxygen that has passed through the fuel of the fire-bed without forming a chemical union with the same, and also with oxygen that passes into the furnace through the crevices around the fire-doors and through the ventilators in the same. The mechanical effect of the steam is that it keeps the clinkers soft and porous, thereby permitting the blast to pass uniformly up through the entire mass of fuel, instead of being forced up around solid slabs of clinkers, and thus forming what is usually termed "forge-flames" against certain portions of the boiler or other object being heated, as is usually the case when an all-air blast or a strong natural draft is employed. It also serves to so moisten the fine ash in the lower stratum as fast as it is formed that it is prevented from being blown up into the upper or burning surface, so as to choke it by filling up the interstices between the particles of fuel; but while these advantages are secured it is a fact that when the steam is thus used it always lowers the temperature of the lower stratum of the fire, thereby causing imperfect consumption of the solid fuel of said stratum, and therefore the object of making a proper percentage of hydrocarbon a constituent element of the blast is, it will be seen, to furnish elements of quick combustion in the lower stratum of the fire, where it is required for the purpose of keeping up the temperature at that point, it serving to facilitate combustion and consumption not only in said lower stratum, but also throughout the entire bed of fuel, by raising the temperature in said lower stratum and of the whole mass, thus obviating the disadvantages of using a blast of steam and air alone.

My invention, as hereinbefore described, differs from means which simply introduce into the ash-pit in a separate state three elements of my thoroughly incorporated and mixed compound blast and then into retorts widely spaced, and each of said separated elements being allowed to find its way toward an outlet through the coke as best it may, as my invention combines means whereby all of the constituent elements of the blast are caused to become thoroughly incorporated and intermixed or made into a compound blast even before the blast is discharged into the ash-pit, and therein lies the greatest value of my invention, especially when this feature is combined with the method of introducing this improved blast at a degree less than burning-temperature into the burning layer or mass of carbonaceous fuel lying on the grate or open-work fire-bed and from a point below said fire-bed and igniting the hydrocarbon of the blast by the burning lower stratum of said bed of fuel.

To make more plain my means, I make the following general recapitulation of the aforegoing specification:

In carrying out my invention, ordinarily, the fire on the grate, grates, or the fire-bed may be first started with wood, and after the wood is fairly kindled then the carbonaceous fuel is spread on top of the wood and ignited by the burning wood beneath it, this being accomplished with the ash-pit doors open—*i. e.*, with natural draft. After the bed of coal is well ignited—*i. e.*, becomes incandescent—then the ash-pit doors are closed and the described compound blast is turned on, and it fills the ash-pit and forces its way up into the glowing solid carbonaceous fuel. If this mode of starting the fire is not preferred, incandescent carbonaceous fuel may be taken from a furnace already started and shoveled into the fire-box of the furnace that is to be started in sufficient quantity to form a bed on which to start or ignite fresh fuel spread over it. In such case the blast may be turned on immediately after the fire is started sufficiently; but in no case should the blast be turned on until there is a bed of incandescent solid carbonaceous fuel to receive it, for it should be borne in mind that when steam is a constituent of an under-grate blast such blast should never be turned on until the fire into which it is to be projected is hot enough to decompose the steam portion of same. The compound blast takes effect on the fire from the grate upward, but not below the grate, as the temperature of the ash-pit will always be too low to permit even the ignition of the hydrocarbon below the grate on account of its being incorporated with air and steam, neither of which will be raised to the temperature of ignition until it comes in contact with the incandescent carbonaceous fuel on top of the grate, and also on account of the blast constantly moving forward into the fire and being as constantly supplied by the means which is furnishing the blast. It may be said, therefore, that the compound blast takes effect on the fire from the top of the grate and onward as far as the combustion or chemical union continues, which is often for a long distance beyond the bed of fuel, for it should be kept in mind that this kind of blast furnishes not only the supporter of combustion—viz., oxygen—but it also furnishes combustibles, for the hydrocarbon constituent is combustible and the hydrogen set free from the steam is also a combustible, while the oxygen furnished by the dissociated steam is the supporter of combustion and the oxygen of the air constituent is also the supporter of combustion, and as the combined blast enters the bottom stratum of the bed of carbonaceous fuel, the hydrocarbon constituent being volatile, it at once combines with the oxygen of the air, the heat of which more quickly gasifies the carbon fuel of the fire-bed, so that the oxygen of the air will also unite with the solid fuel in the lower stratum, the combined heat of both serving to more quickly raise the steam portion of the blast to the point of dissociation, and also serving to produce a more intense heat in the middle and upper strata of the

carbon fuel, the steam being dissociated in the middle and upper strata by the intense heat of same, and by the strong affinity of incandescent carbon for oxygen it furnishes oxygen to combine with the carbon in said strata, thereby preventing to a large extent the formation of carbonic oxide by conversion from the carbonic-acid gas coming up from the lower stratum, also furnishing oxygen to burn the carbonic oxide that may and will be formed in the fire, said carbonic oxide being burned not only in the bed of fuel, but also above and beyond the bed of fuel, for it should be kept in mind that carbonic oxide is a gas and a product of the combustion going on in the bed of fuel, and as the whole gaseous product (of all kinds) is constantly moving forward toward the chimney, so this gas must, for the most part, be burned above and beyond the fire-bed as fast as it can come in contact with oxygen. Again, the hydrogen set free from the steam will also be burned (or at least a large portion of it) at a point above the fire where the temperature is lower than the temperature of dissociation by coming in contact with oxygen that has passed through the fire without combining or that may work in over the top of the fire around the fire-doors and the dampers in the same.

Thus it will be seen that with my invention there will not be any ignition of the blast and the production of a flame below the grate.

What I claim as my invention is—

The combination, with a furnace having a combustion-chamber, a grate, and an ash-pit adapted to be closed to the external atmosphere, of a tuyere extending through a wall of the ash-pit, so as to discharge below the grate, and in communication with sources of air, steam, and hydrocarbon, substantially as described.

In testimony whereof I affix my signature in presence of two witnesses.

WILLIAM McCLAVE.

Witnesses:
C. SEVERANCE,
E. T. WHITE.