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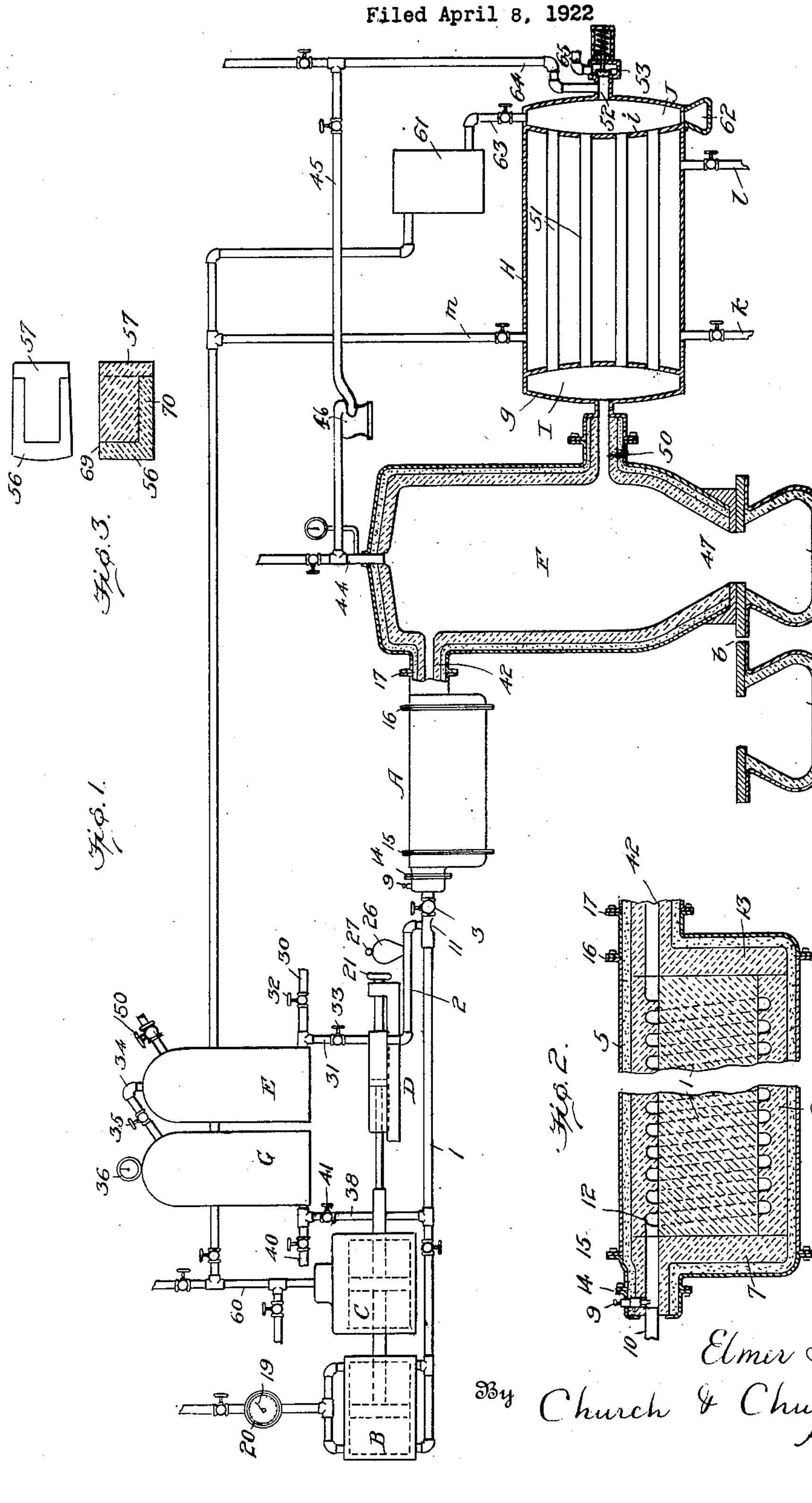

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## METHOD FOR COMBUSTION UNDER PRESSURE.

Application filed April 8, 1922. Serial No. 550,738.

This invention relates to improvements in combustion particularly to the attainment of a higher initial temperature and a lower exhaust temperature for the extraction of more heat-units from the gaseous products of combustion than have hitherto been attained.

The result is attained by centrifugally burning under pressures higher than atmospheric and by keeping the burning gases under the same pressure until they have given up their heat to the objects to be heated.

The principal object of the present invention is to attain a high initial temperature and to save as nearly as possible all of the heat that now escapes up the chimney and to reduce the temperature of the completely burned air and fuel before admitting them to the boiler by a method which does not reduce efficiency.

The apparatus for combustion under pressure and which requires less air, is carried into practice as shown in the drawings, in which:

Figure 1 is a diagrammatic view of the apparatus;

Fig. 2 is a vertical section through the combustion chamber; which is the same as described in my other said application for patent of this date.

Fig. 3 represents detail plan and vertical sectional views of a refractory unit or brick.

In Fig. 1 the apparatus, from left to right, up to the kiln or temperature-reducing chamber F is the same as in Patent No. 1,560,076, dated November 3, 1925, that is, C is a steam motor or engine; B is a double-acting air compressor; D is a fuel pump; E is a fuel-carboy; G is a tank for supplying air at a given pressure to the fuel carboy for forcing out the fuel; and A is the combustion chamber. Into the fuel carboy, and at the bottom, enters pipe 30 with valve at 32 for filling the carboy, during which time the air pressure from G as well as carboy E is removed by means of an ordinary valve 50; and pipe 31 with valve 33 supplies the fuel or oil to pump D. Pipe 34 with valve 35 admits air from air tank G, which has a gauge 36 at its top. This air tank G gets its air from pipe 1 through pipe 38 with valve 41 and through pipe 40 the air can be let out of tank G. Compressor B has a valve and pointer and scale at 19, 20. Pipe 2 with an air cushion 26 and gauge 27 leads the fuel to a contracted point 11 where it meets the compressed air coming through pipe 1 and when valve 3 is open the fuel is sprayed into the combustion chamber A, which is the same as the one described in the above mentioned Patent No. 1,560,076, and will be still more fully described hereinafter. Into the front end of this combustion chamber, the fuel and air are sprayed and ignited by an electric spark-plug and while the burning is going on the inner surface of that refractory tube is rendered incandescent and the particles of unburned fuel are centrifugally thrown, repeatedly, against this surface and constantly re-ignited until all of them are completely burned and all the oxygen used up, for the proportions of air and fuel for this method of burning are accurately measured by B, C and D so as to supply exactly enough oxygen to burn the fuel. This operation is fully shown and described in the above mentioned patent. The temperature being much too high to be admitted to the boiler tubes the burned gases are first sent through the refractory conduit 42 into the ash settling and temperature-reducing chamber or kiln F, provided with pipe 44 for injecting steam from any suitable source or cooled down products of combustion from the boiler and means for taking out ashes at 47 by ash receptacles 48 and 49. The cooled down gases pass out of the kiln through refractory conduit 50 and enter distributing space I of the boiler H and pass through the fire tubes 51 to space J and out through pop-valve 53. Behind the pop-valve rises pipe 64 to carry the cooled down products of combustion through fan (for not much power is required) 46 to the injection pipe 44. Through pipe *m* steam may come to run C. Through pipe 63 and ash settler 61 we may get cooled down products of combustion for running motor C. The ash receptacle 62 will not often need emptying, and ash settler 61 is used only when a motor is run by the cooled down products of combustion.

Fig. 2 is a vertical section through the combustion chamber. For burning under pressure higher than atmospheric, say at one-fourth the natural volume, the diameter of the tubular spiral groove need be only about one-fourth the cross sectional area, as when burning under atmospheric pressure, or, what amounts to the same thing, four times as much fuel and air will flow through it in a given time—it will do four times as much burning and four times as much work, and the refractory must withstand a higher temperature than when the burning is done at atmospheric pressures. When burning at atmospheric pressure I can use the best ordinary refractories by not allowing the temperature to rise quite as high as any given refractory will withstand. The sprayed fuel and air enters pipe 10 and is ignited by spark-plug 9 and it expands to seven or eight times its volume and rushes at a high velocity through the refractory spiral tube 12 and emerges at the rear end of the furnace at 42. The core 1 is a refractory solid cylinder and it may be made in short sections; over this core is slipped the refractory sleeve or hollow cylinder 2, which may be made in two longitudinal half-cylinders so as to more easily be placed over the core. On the inner side of this sleeve are cast the U-shaped grooves which constitute the spiral combustion chamber—the top of the U resting upon the core. At the front end of the core and sleeve combination is an end-piece 7 and another 13 at the rear end of the furnace. Over the entire combination of sleeve and the two end-pieces and between them and steel cylinder 5 is a layer of compacted carbon cemented with a small percentage (2% to 3%) of finely powdered and sedimentary zirkite. The steel cylinder comprises sections removably joined at 14, 15, 16 and 17, and at the rear end of the steel cylinder is kept a few inches away from the hot gases issuing from 42.

The refractory needs to be capable of withstanding a higher temperature than the ordinary best procurable refractory that will answer the purpose when burning under atmospheric pressure, and until I can have the facilities for making the kind of refractory I want I will use such infusible oxides as aluminum oxide and that contain no silica, because the least traces of potassa and soda (potassium oxid or sodium oxid) that are contained in practically all fuels, will act as a flux on silicate refractories and cause them to melt at a much lower temperature than they otherwise would, hence I specify for use in this centrifugal combustion chamber for burning under pressure higher than atmospheric one very good non-silicate refractory which will answer the purposes fairly well until I shall have facilities for making a better one, provided the highest producible temperatures are not allowed to be created in the furnace.

Fig. 3 shows a non-silicate refractory of the kind mentioned, in which 57 is a T-shaped mass of about 98% alumina (aluminum oxid) mixed, wet, with about 2% of very fine sedimentary zirkite and dried and heated almost red hot more thoroughly to dry it and this porous and friable mass is held by an outer hollow brick 56 made of lavite or any usual refractory—said brick being open from the top 69 and closed at the bottom 70 and the top of the T covering the whole inward end of the brick so as to expose to the flames about two inches of the porous mass. The brick is made narrow at the inner end when it is used to line the kiln or to make the sleeve, and to make the core it is wider at the outer end.

Through pipe 44 steam from a suitable source may be injected into kiln 45 for lowering the temperature below the danger point to the boiler tubes, or, through pipe 45, the gaseous products of combustion, taken from just behind the pop-valve 53, may be injected by means of the fan at 46. It will require but little power to move these gases because they will have approximately the same pressure as is in kiln F. When coal is burned, the ashes will fall through the hopper-like bottom 47 into the ash receptacle 48 which is lined with refractory material and when the ash can is full it is shoved aside, its top plate fitting tightly against the plate opposite, and this shoving is done by means of a strong screw (not shown in this drawing) with a ring handle. As it is moving aside the receptacle 49 takes the position previously occupied by receptacle 48. The top plates of these receptacles are disjoined at *b* and both are held in the same frame, not shown, so that while the plate of 49 covers ash exit 47 the other receptacle 48 can be removed from the frame and inverted and emptied and receptacle 49 will be in position to receive the ashes without the pressure in kiln having been let out.

The cooled gases pass through the refractory conduit 50 and enter the distributing space I at the front end of the steam boiler H, the front end *g* of the boiler being convex outwardly, and the end opposite space I being concave outwardly and covered with a layer non-conductive to heat. The boiler has the usual inlet for water at *k* and outlet at *l*, and an outlet for steam at the top of the boiler, and the boiler is left not quite full of water so as to leave a space for steam and for some super-heating.

From space I the flue gases pass through the boiler tubes 51—51 to distributing space J where the rear end of the boiler *i* is convex inwardly and covered with refractory material and the opposite end *j* convex outwardly. From space J the flue gases pass through a single opening 52 and then through the regulated pop-valve 53 and pass out through the exhaust pipe 65 into the atmosphere. The motor C may get its steam from an extraneous source, or from pipe 63 of boiler; or it may be run by an electric motor; or it may get the cooled down products of combustion from pipe 45 as hereinafter explained and which may be the subject of a separate patent.

The refractory in the kiln F need not withstand as high a temperature as the refractory in the combustion chamber A. The inside surface of the groove may be impregnated with a very thin (300th inch) layer of cerium oxide.

In kiln F the refractory layer may be made of any good non-silicate fire-brick made with tops and bottoms flat and parallel to each other and with the outward ends concentric with the inner periphery of the steel cylinder of the kiln and the edges parallel with the radii of kiln but preferably as described in Fig. 7.

In order to utilize for motive power some of the gaseous products of space J before they are allowed to exhaust and expand they are taken through pipe 63 and the finest ash settled in 61 and led to pipe 60. This ash that settles in space J is taken out occasionally through ash receptacle 62 similar to 48 and 49. The pop-valve may be set so as to exhaust at any temperature and then used to run the motor or injected into the kiln for reducing the temperature below the danger point, for thereby there will be no loss of the latent heat of the steam in these total products of combustion.

By burning the fuel under pressure a high initial temperature results, producing a more complete combustion of the fuel than would be secured at atmospheric pressure, and a lower exhaust temperature results because the gases, being cooled to the usual exhaust temperature when they expand into the atmosphere, are thereby reduced in temperature. The extraction of heat from the gaseous products of combustion does not begin until after all the fuel has been burned at a given pressure and the gases are then kept under that pressure until they have given up as much of their heat as they will to the boiler or other apparatus in which they are used. This is accomplished by compressing the mixed air and fuel to one half or one fourth their volume at atmospheric pressure, thereby burning more fuel with a given volume of air so that a higher initial temperature is produced and a lower exhaust temperature obtained because the products of combustion, in giving up their heat units, (down to the usual difference in temperature between the gases and what they are heating) will have only a half or a fourth the usual number of heat units left in them so that in escaping the expansion lowers their temperature still further, thereby giving an exhaust temperature lower than usual.

The air will first have taken up more of the heat units from the fuel because of the more complete combustion by a smaller volume of air and the gases produced will have delivered more of their heat units to the boiler tubes than if they had not been under pressure. If the heat units from a given quantity of fuel (burned by the same weight of air compressed to half its volume, for instance, that contains twice as much oxygen as the same volume when not compressed) are diffused through the same volume of furnace gas, either the initial temperature in the furnace is doubled, making it too hot for the boiler tubes, or, that unduly high temperature may be used by having it give up its heat units to twice as large a volume of gases and thereby have it produce twice as much flue gas at the desired boiler temperature. In this way, there is secured the production of twice as much steam from the given amount of fuel as if the fuel had been burned at atmospheric pressure. The hot gases from the combustion chamber may be lowered in temperature in the reducing kiln by performing useful work or by injecting water as a spray. If water is sprayed in the kiln the resulting steam may be used for some purpose, but preferably the cooled down products of combustion after having been passed to and used in the boiler, and while still under their initial pressure, may be admitted into the cooling chamber. In other words, after the products of combustion have had their temperature reduced in the boiler they may be returned through pipe 45 to the kiln and used for cooling down the fresh incoming, highly heated products of combustion.

What I claim is:

1. The method of securing increased efficiency in extracting heat from the burned fuel and air which consists in mixing finely divided fuel with air under a pressure higher than atmospheric, igniting the mixture, directing the burning fuel against an incandescent surface of a plurality of spirally arranged convolutions so as to repeatedly reignite the unburned portions of the fuel, and keeping the burned gases under the same pressure until all available heat units have been extracted therefrom before allowing them to exhaust from the system.

2. The method of securing increased efficiency in extracting heat from burned fuel and air which consists in mixing finely divided fuel with air under a pressure higher than atmospheric, igniting the mixture, passing the burning fuel through a continuously curved path bounded by incandescent walls, directing the burning fuel against said incandescent surface by centrifugal action continuously so that the unburned portions of the fuel may be continuously and repeatedly re-ignited and keeping the mixture of the burned gases under the same

pressure until all available heat units have been extracted therefrom before allowing them to exhaust and expand.

3. The method of securing increased efficiency in extracting heat from the burned fuel and air which consists in mixing finely divided fuel with air under a pressure higher than atmospheric, igniting the mixture, directing the burning fuel against an incandescent surface of a plurality of spirally arranged convolutions by centrifugal action continuously to repeatedly re-ignite the unburned portions of fuel and oxygen and keeping the burned gases under the same pressure until all available heat units have been extracted therefrom before allowing them to exhaust and expand.

4. The method of securing increased efficiency in extracting heat from the burned fuel and air which consists in mixing finely divided fuel with air under pressures higher than atmospheric, igniting the mixture, passing the burning fuel through a helical passageway bounded by incandescent walls so that the unburned and cooler and consequently heavier portions of the fuel will be thrown outwardly by centrifugal force against the incandescent walls and repeatedly re-igniting said unburned portions and keeping the burned gases under the same pressure until all available heat units have been extracted therefrom before allowing them to exhaust and expand.

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