

Dec. 13, 1932.

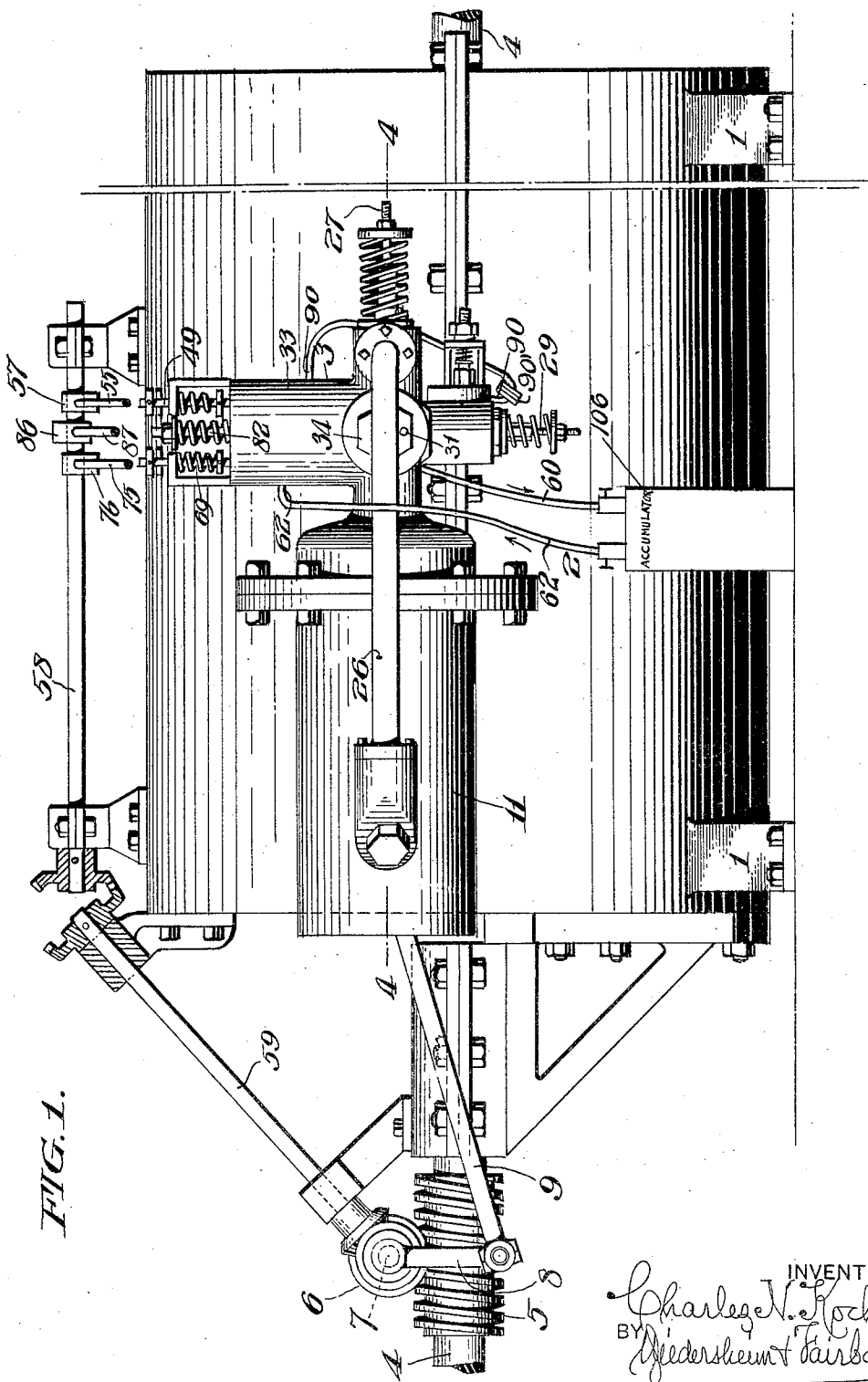
C. N. KOCH

1,890,651

CHARGE FORMING MECHANISM

Filed July 14, 1922

8 Sheets-Sheet 1



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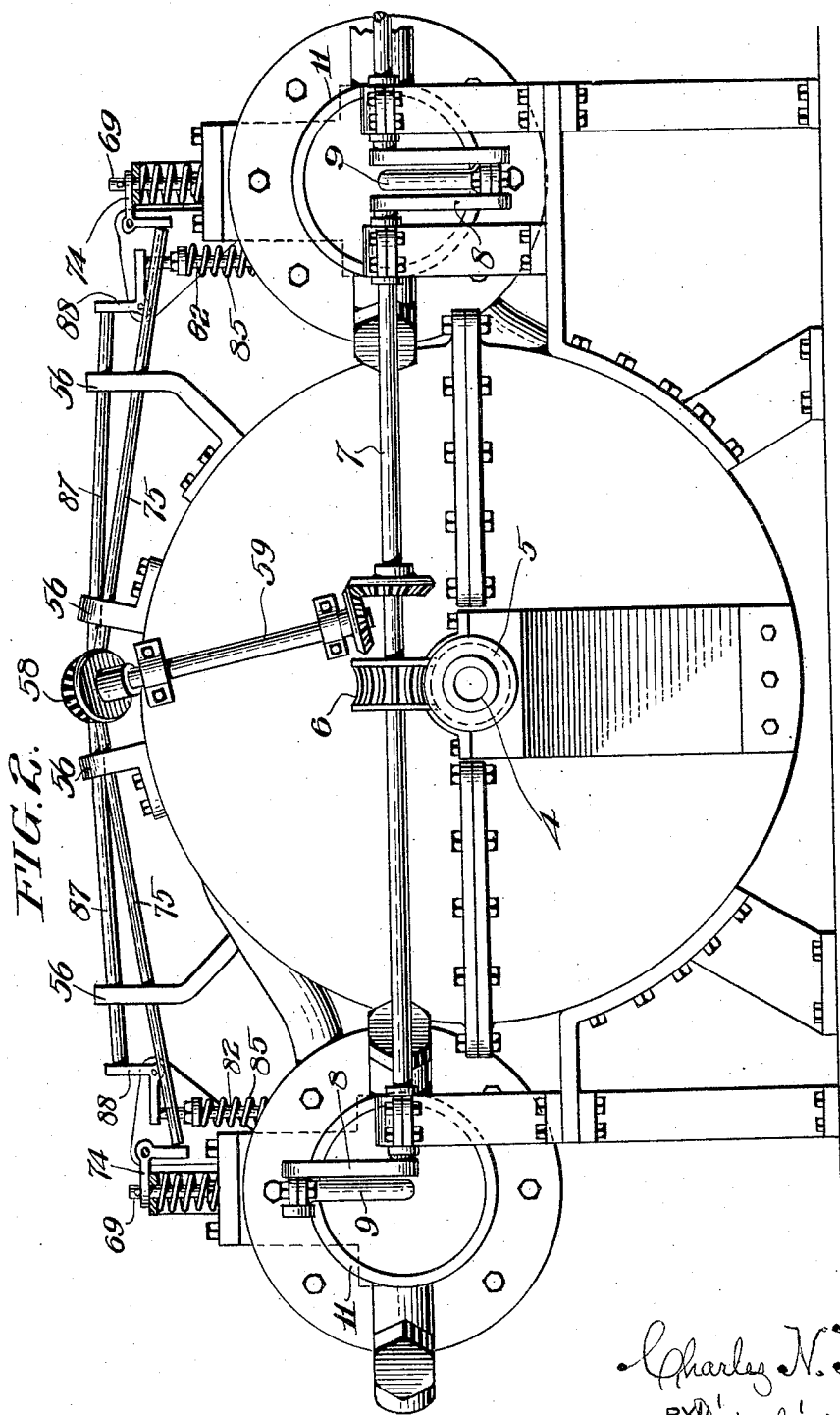
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CHARGE FORMING MECHANISM

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8 Sheets-Sheet 2



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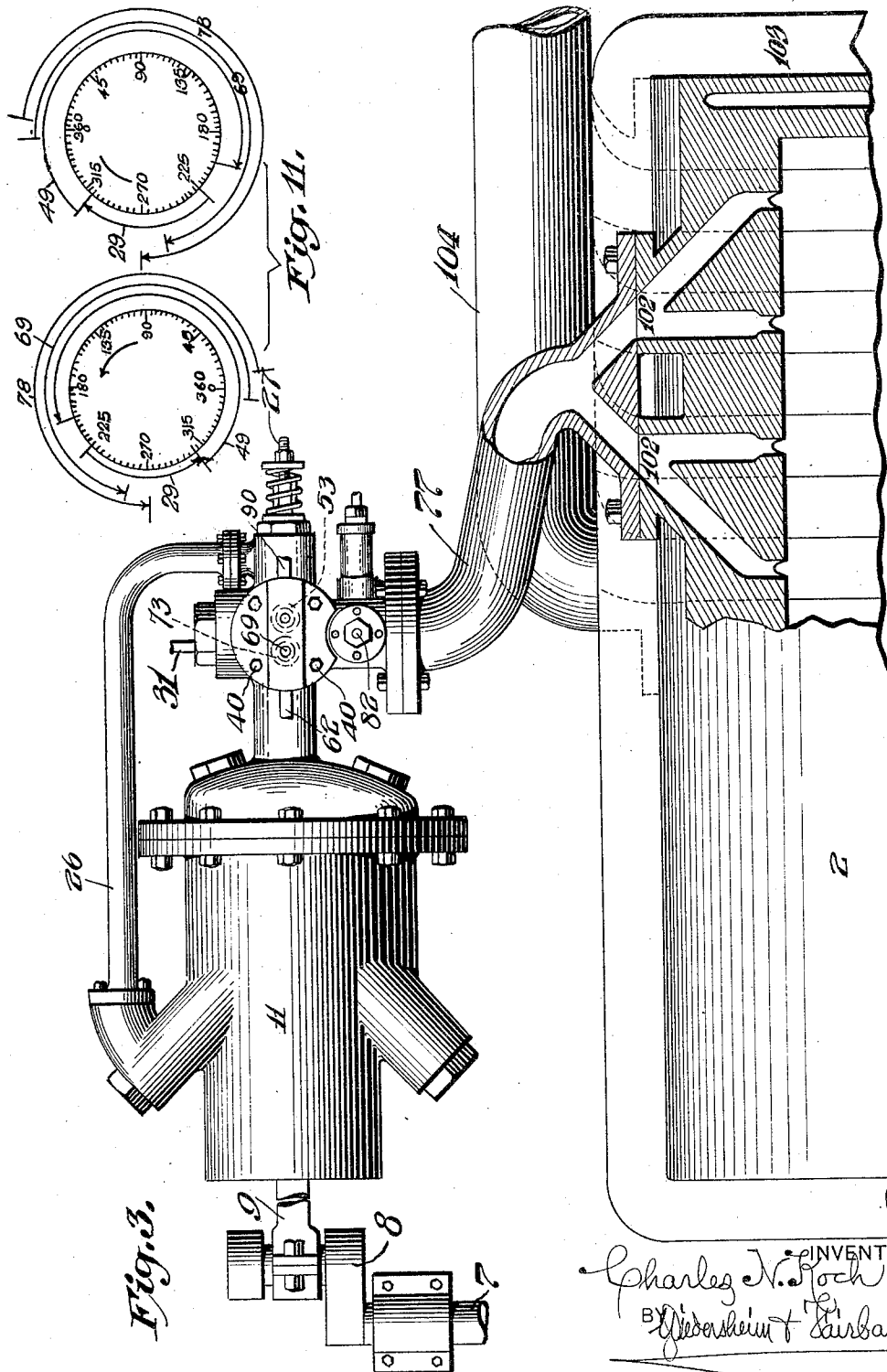
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CHARGE FORMING MECHANISM

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8 Sheets-Sheet 3



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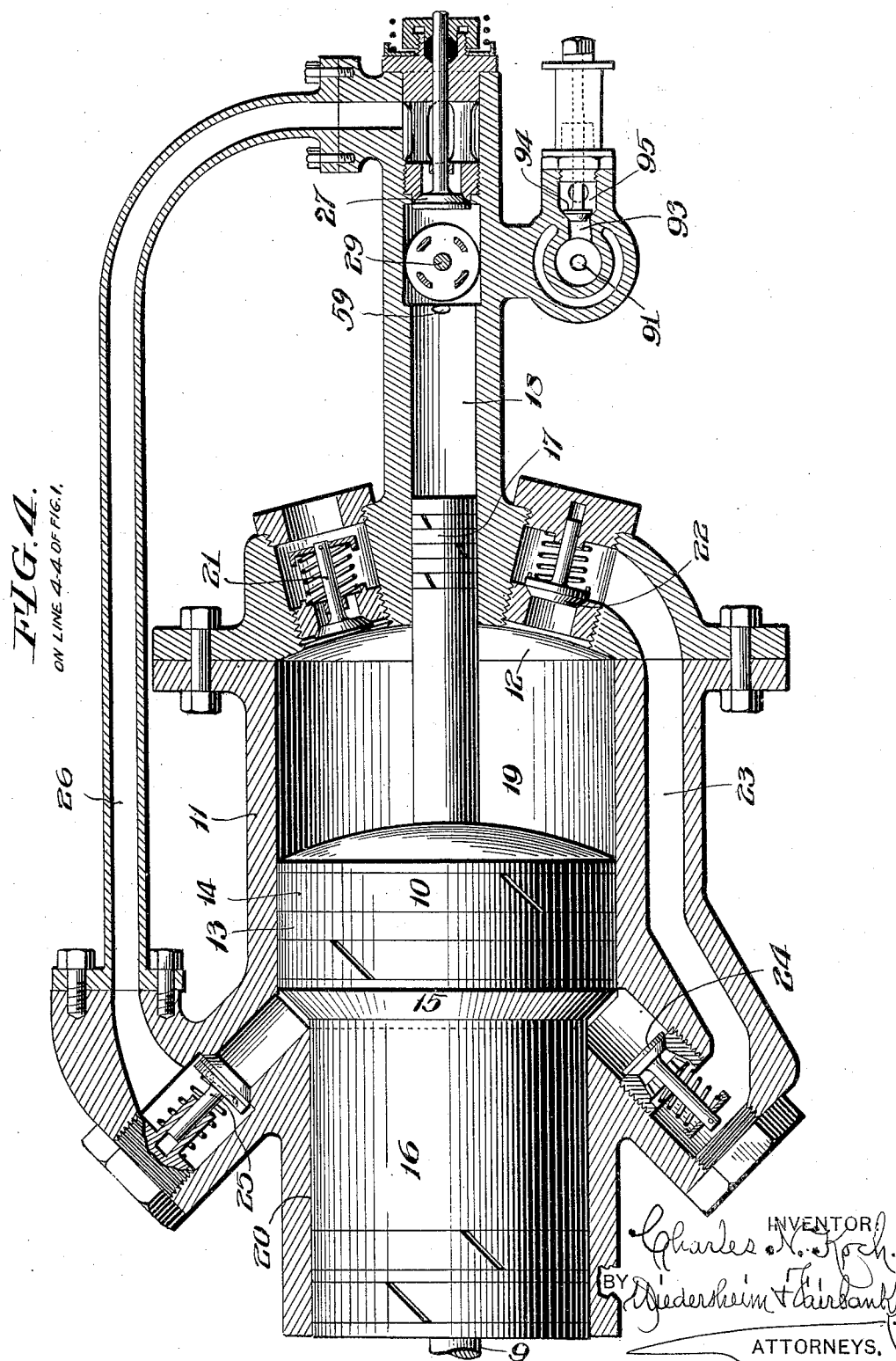
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CHARGE FORMING MECHANISM

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8 Sheets-Sheet 4



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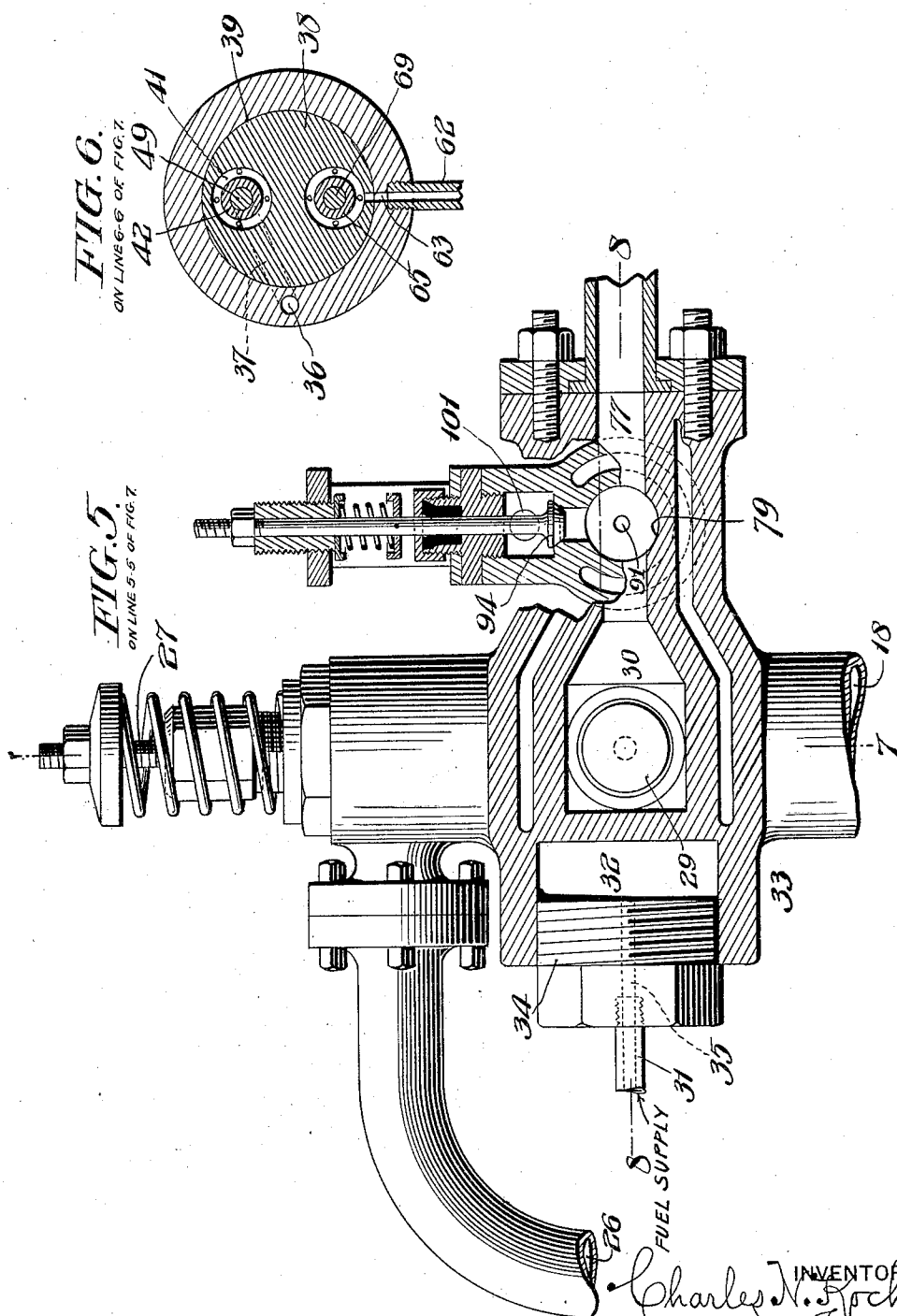
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CHARGE FORMING MECHANISM

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8 Sheets-Sheet 5



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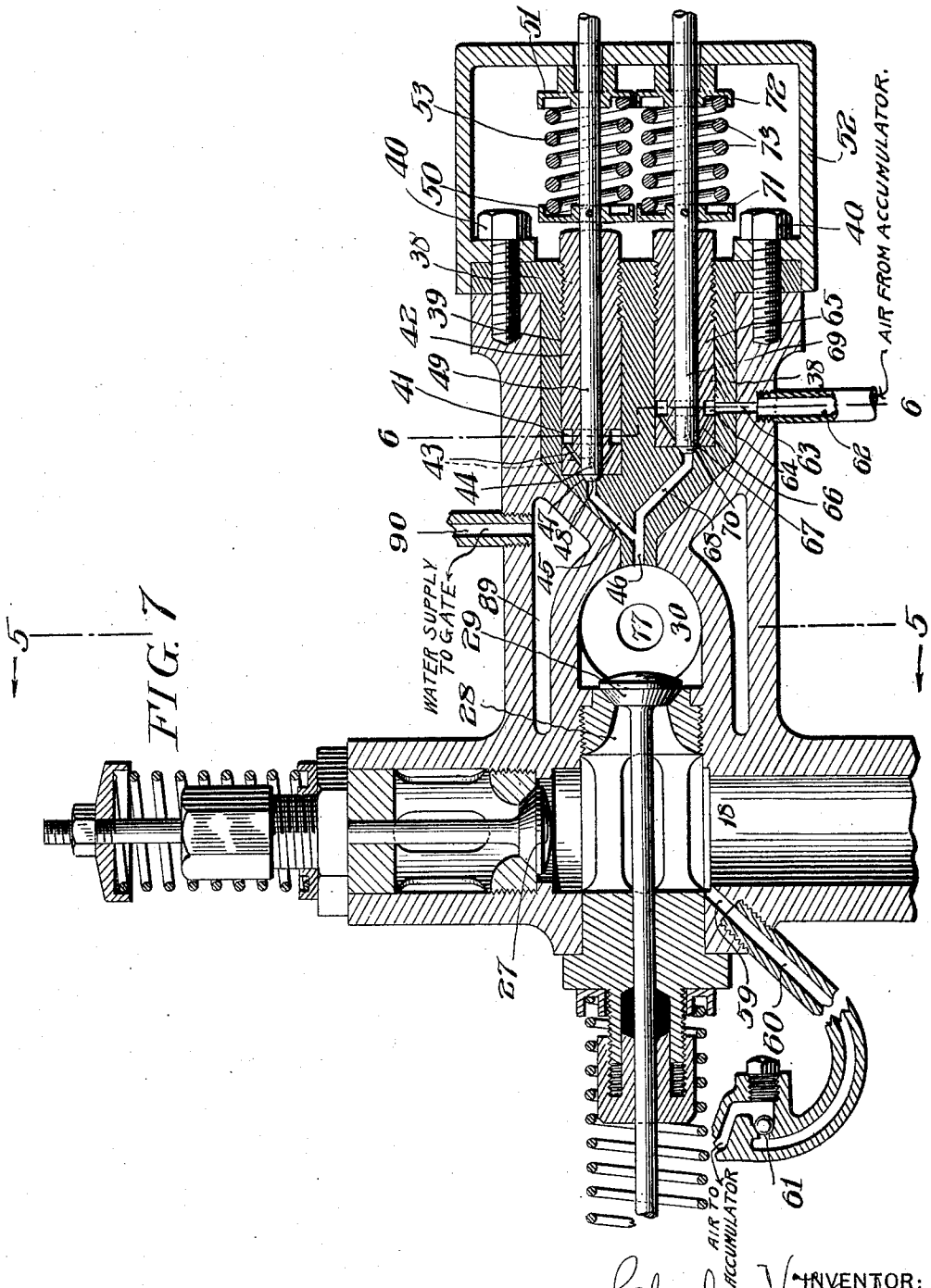
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CHARGE FORMING MECHANISM

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8 Sheets-Sheet 6



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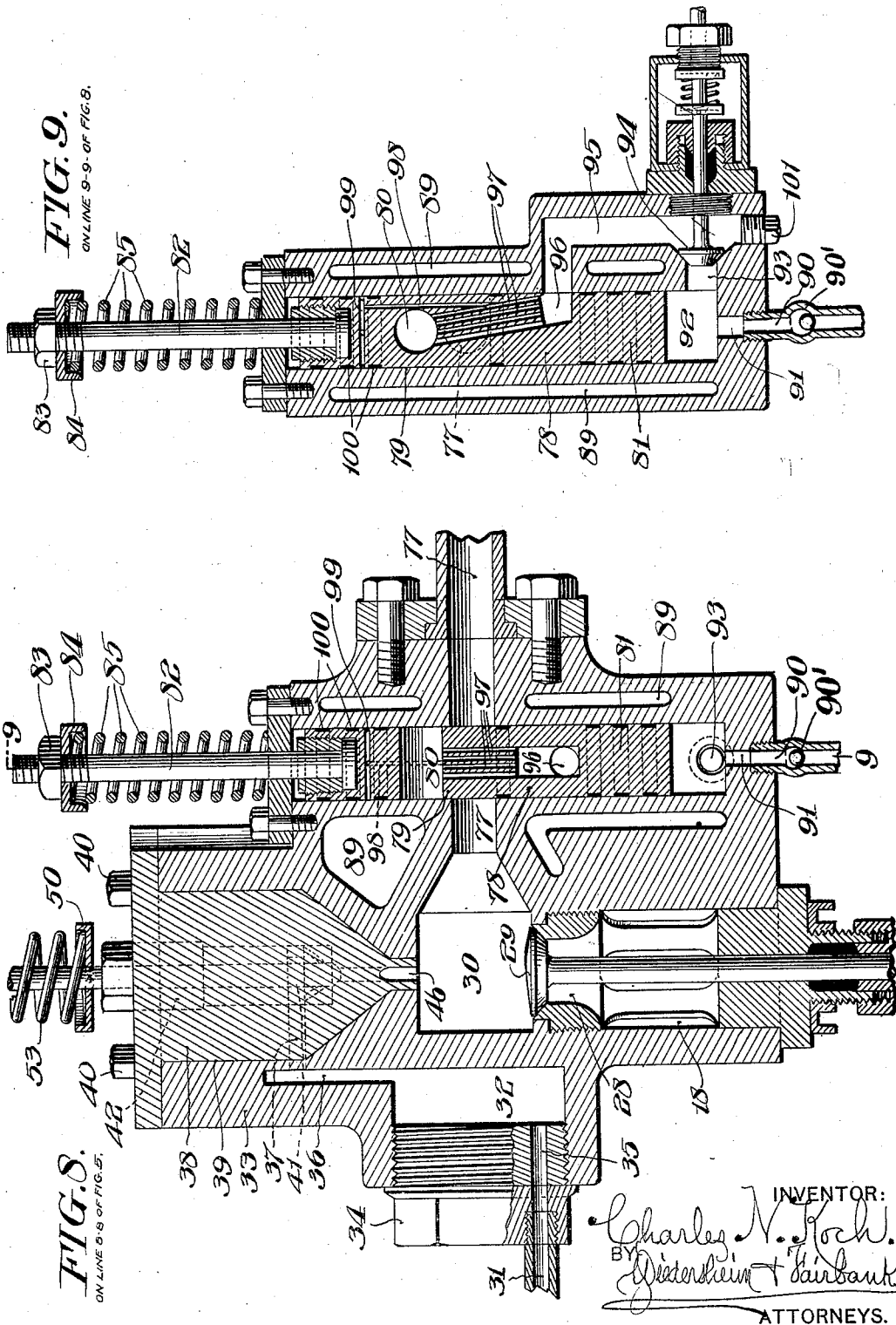
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CHARGE FORMING MECHANISM

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8 Sheets-Sheet 7



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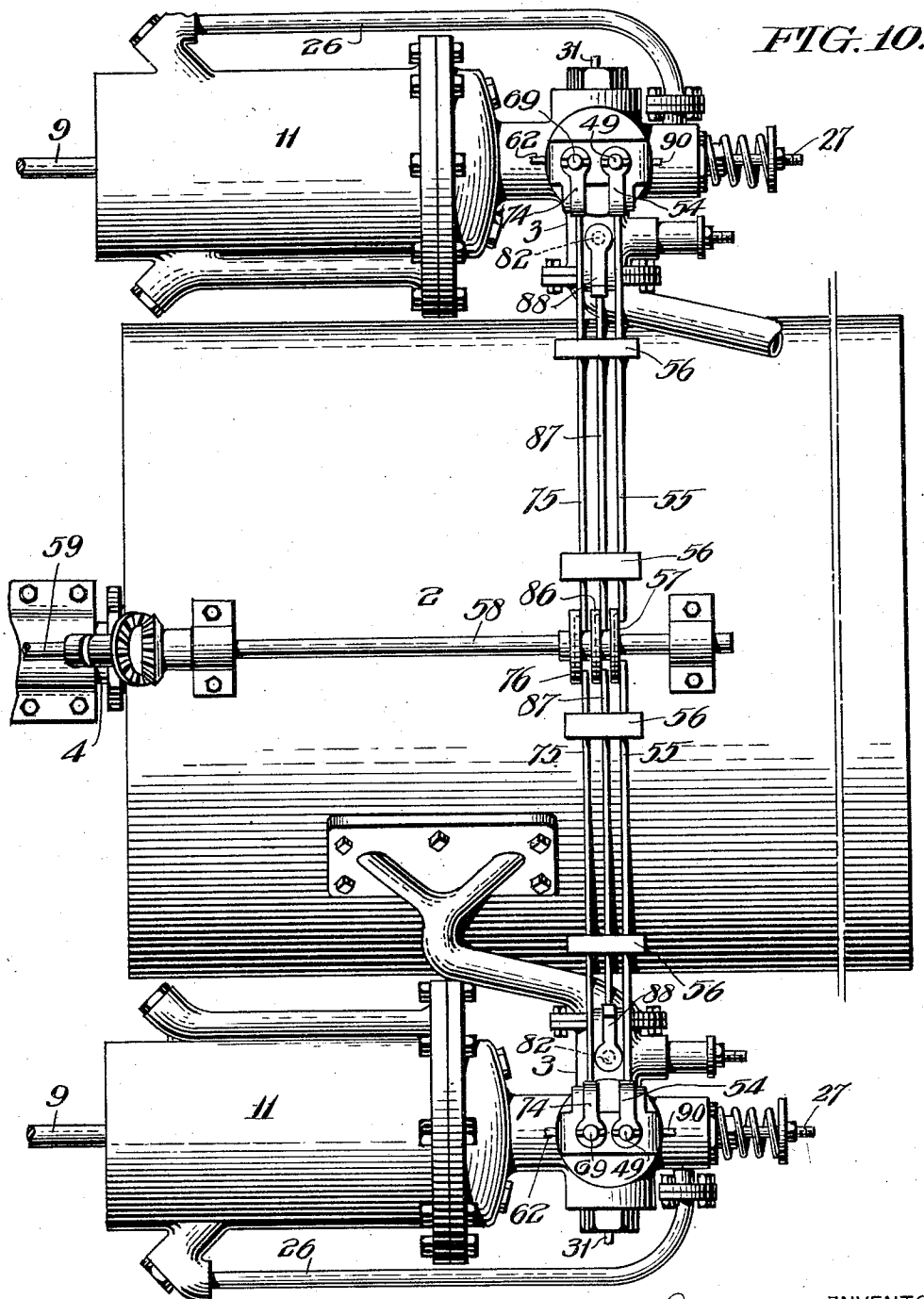
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CHARGE FORMING MECHANISM

Filed July 14, 1922

8 Sheets-Sheet 8



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UNITED STATES PATENT OFFICE

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CHARGE FORMING MECHANISM

Application filed July 14, 1922. Serial No. 574,873.

(GRANTED UNDER THE ACT OF MARCH 3, 1883, AS AMENDED APRIL 30, 1928; 370 O. G. 757)

The object of this invention is to inject a jet of highly heated oil into a confined volume of compressed and therefore highly heated air thereby forming and igniting the explosive mixture which is further supplemented by prolongation of the jet of fuel and introduction of a supplementary jet of highly compressed air to prolong combustion. Water is preferably sprayed into the path of the incandescent gases as they are being delivered to a desired point of utilization.

With the above and other objects in view which will hereinafter more clearly appear in the detailed description and the appended claims, my invention in its broad and generic scope comprehends a novel method of and novel means for forming and igniting an explosive charge with a prolonged duration of the explosion interval.

Other novel features of construction and advantage and novel steps in the carrying out of my method will hereinafter appear.

For the purpose of illustrating my invention, I have shown in the accompanying drawings a typical embodiment thereof which is at present preferred by me, since this embodiment will be found in practice to give satisfactory and reliable results. It is, however, to be understood that the various instrumentalities of which my invention consists can be variously arranged and organized and that my invention is not limited to the precise arrangement and organization of these instrumentalities as herein shown and described.

Figure 1 represents a side elevation of a charging mechanism for heavy fuel, embodying my invention, illustrated in conjunction with a turbine.

Figure 2 represents an end elevation of the construction seen in Figure 1.

Figure 3 represents a plan view of a portion of the mechanism, in conjunction with an engine, a portion of which is shown in section.

Figure 4 represents a section on line 4—4 of Figure 1.

Figure 5 represents a section on line 5—5 of Figure 7.

Figure 6 represents a section on line 6—6 of Figure 7.

Figure 7 represents a section on line 7—7 of Figure 5.

Figure 8 represents a section on line 8—8 of Figure 5.

Figure 9 represents a section on line 9—9 of Figure 8.

Figure 10 represents a top plan view showing more particularly the valve operating mechanism.

Figure 11 represents a diagrammatic view showing the periods the respective sets of valves 29, 49, 69 and 78 remain open in one type of service construction or adjustment.

Similar numerals of reference indicate corresponding parts.

Referring to the drawings:

For the purpose of illustration, I have preferred to show my present charging mechanism in conjunction with an engine but this is only one of the many uses for which it has been designed. It can be employed in conjunction with any device such as, for example, combustion engines, evaporators, accumulators, or in fact, in any case wherein it is desired to pass the products of combustion in an ignited condition to any desired mechanism to effect their operations. Provision is made for spraying or atomizing water, steam or air into the ignited fuel prior to its discharge from the charging mechanism.

1 designates a supporting framework which, as illustrated, carries a combustion turbine 2 in conjunction with which I have preferred to illustrate my novel charging device 3.

The controlling devices for the charging mechanism may be independently driven if desired, but are preferably driven and actuated by the mechanism to which the ignited fuel is delivered.

4 designates the rotor or driven shaft of the turbine which carries a worm 5 meshing with a worm gear 6 mounted on a jack-shaft 7 suitably journaled. The shaft 7 has mounted thereon crank arms 8. The crank arms 8 are connected with their respective connecting rods 9, see Figure 2, said connecting rods 9 being connected to differential counter-bal-

anced three stage pistons 10 mounted in their casings 11 within a differential piston chamber 12. Each piston 13 is provided intermediate its ends with a head 14 which is of greater diameter than the piston head 15, which latter converges forwardly from the piston head 14 and merges into the guide portion 16. At the rear of the piston head 14 is a piston head 17 of reduced diameter which travels in the chamber 18. The heads 14 and 15 travel in the chamber 19 and the guide portion 16 reciprocates within the bore 20. 21 designates the inlet valve which is a spring actuated valve of conventional construction which controls the introduction of atmospheric air into the piston chamber 19.

22 designates a spring actuated discharge valve, of conventional design, controlling communication between the chamber 19 and the passage 23, the communication of which with the chamber 19 is controlled by means connected with the valve 24. A spring actuated discharge valve 25 controls the communication between the piston chamber 19 beneath the head 15, with a discharge passage 26, the communication of which latter with the chamber 18 is controlled by means of a spring actuated valve 27.

The chamber 18 is provided with a discharge port 28, see Figure 8 which is controlled by means of a spring actuated valve 29, the spring tending to maintain the valve in seated condition together with the pressure in its associated chamber 30. The port 28 communicates with a combustion chamber 30 into which the fuel is injected under pressure.

The heavy fuel is fed from the source of fuel supply in the usual manner and passes through the fuel supply pipe 31, see more particularly Figures 3 and 8, into the supply chamber 32 which, as seen in Figure 8, is in close proximity to a wall of the combustion chamber 30, so as to provide for the heating of the heavy fuel. The chamber 32 is cored in the casing 33 opening through a side wall thereof and a relatively large closure 34 is provided in threaded engagement with the wall of the chamber, so that it can be longitudinally adjusted to vary the amount of fuel contained within the supply chamber 32 as well as to occasionally clean chamber 32. The closure 34 is provided with a passage 35 leading the fuel coming through the supply pipes 31 into the chamber 32.

The chamber 32 communicates with a passage 36, see Figures 6 and 8, which communicates with the passage 37 in a valve bushing 38 which is secured in the recess 39 and provided with flanges secured in position by means of fastening devices 40. The passage 37 communicates with an annular groove 41, see Figures 7 and 8, in the periphery of a valve case 42 which is in threaded engagement with the valve bushing 38. The dis-

charge ports 43 converge downwardly from the annular groove 41 and discharge into a port 44, which opens through the inner end of the valve seat 42 and communicates with a passage 45 which opens into a port 46 leading to the combustion chamber 30. The valve bushing 38 is provided with a seat 47 for the cone-shaped inner end 48 of the valve 49, which latter is slidably mounted in the valve case 42.

The valve 49 is in the form of a rod, the periphery of which when in seated condition closes the port 43, see Figure 7. The spindle of the valve 49 has secured to it a washer 50 between which and a washer 51, which latter bears against a yoke 52, is interposed a spring 53, the tendency of which is to retain the valve 49 in seated position.

The valve stems 49 are connected with one end of bell crank levers 54, similar to 74, see Figures 2 and 10, the opposite ends of which are adapted to be actuated by means of push rods 55 slidably mounted in guides 56, in order to effect the opening at the proper time of the valve 49.

The push rods 55 are actuated by means of a cam 57 carried by a shaft 58 which is intergeared with the shaft 59, the latter being intergeared with a shaft 7 which is driven thereby.

A portion of the air in a chamber 18 is led therefrom through the port 59, see Figures 4 and 7, to accumulator 106 of any desired type through the passage 60 having a check valve 61 therein. The compressed air is fed from the accumulator by means of a conduit 62 see Figures 10, 3, 7 and 2 which communicates by means of a passage 63 with an annular groove 64 in a valve sleeve 65 in threaded engagement with the valve bushing 38 so that it can be removed when desired. The valve sleeve 65 is provided with converging passages 66 leading from said groove 64 to the ports 67, which communicate through valve 69 with the passages 68, which open into the port 46 which leads to the chamber 30. A valve 69 is provided having its inner end of a conical contour, as at 70, and the spindle of this valve has secured to it a washer 71 between which and the washer 72, loosely mounted on the spindle, is interposed a spring 73, the washer 72 bearing against the yoke 52.

The valve 69 has its spindle connected with a bell crank lever 74, see Figures 2 and 10, which is actuated by a push rod 75, guided in the guide members 56 and actuated by a cam 76.

Each combustion chamber 30, see Figure 8, is provided with a discharge passage 77, which leads to the intake manifolds of the turbine, or any other desired mechanism to which the ignited gases are to be introduced. The passage 77 is controlled by means of a gate valve 78 slidably mounted in a chamber 79, the lower end of which forms a water

pump chamber. The valve gate 78 is provided with a port 80 through it and its inner end forms a piston head 81. The valve gate stem 82 has a threaded portion, which carries a nut 83, against which bears a washer 84, between which and the casing is interposed a spring 85, so that the tendency of the spring is to maintain the gate in its closed position.

The shaft 58, see Figure 10, carries a cam 86, which controls the push rods 87, which actuate the bell crank levers 88 one end of such bell crank levers bearing against the gate valve stem 82. 89 designates a water jacket which surrounds the combustion chamber 30 and the gate valve 78. A portion of the water which is under pressure in the jacket 89 is withdrawn therefrom through the conduit 90, Figs. 1, 7, 9, and passes into the water pumping portion 92, see Fig. 9, of the chamber 79 through the port 91. As the piston head 81 carried by the gate valve 78 moves downwardly, the water in the chamber 92 is forced through the port 93, the spring actuated valve 94 opening and permitting the water to pass through a passage 95 into a chamber 96 opening into its respective valve gate 78, the fluid then passing substantially in a spray of steam through a plurality of relatively small ports 97, extending through gate valve 78, into the port 80 therethrough and through which port 80 at this time the ignited gases in the respective combustion chamber 30 are passing. When gate-valve 78 is moved into the position shown in Figure 8, the discharge from ports 97 is confined in port 80 until the pressure therein equals that in port 96 when flow through ports 97 stops until the next registration of ports 77 and 80.

The valve gate 78 is provided in its outer surface with a groove 98 which leads from the chamber 96 to an annular groove 99, Fig. 9, in the periphery of the gate, in proximity to its sealing rings 100 to effect their proper lubrication. Provision is made for cleaning the various ports and passages as may be desired, and, in Figure 9, I have shown a removable plug 101 which enables a suitable implement to be inserted to clean, for example, the passage 95.

The passage 77, leading to the intake manifold of the mechanism which is to be driven, is shown in Figure 3 as communicating with the nozzles 102 which conduct the ignited gases into the blading of a combustion turbine 103, see Figure 3.

In Figure 11 I have illustrated diagrammatically the periods during which the respective sets of valves 29, 49, 69 and 78 remain open in one type of service construction or adjustment, the portions of circles being designated 29, 49, 69 and 78 to denote said respective valves correspondingly numbered. The right and left hand portions of Figure 11 denote the respective sets of valves 29, 49, 69 and 78 for each combustion chamber 30

on opposite sides of the turbine or power objective in the instance shown in Figures 1 and 2 of the drawings.

In Figure 11 the right and left center portions portray circles having the degrees of the circle thereon, each degree marking starting at substantially opposite points in opposite directions in order that said valves of each set may have the same, or substantially the same, degrees of movement of their respective driving cams, in which they open, remain open and are closed.

In said figure, relative to each other, valves 29 open alternately substantially at 225 degrees, dependent upon when the pressure in each chamber 30 falls below that of the compressed air (about 500 pounds per square inch) inlet by valve 29, and close at substantially 310 degrees; valves 49 open alternately at substantially 310 degrees and close at substantially 200 degrees; valves 78 open alternately substantially at 5 degrees and close at substantially 270 degrees; valves 69 open alternately substantially at 360 degrees and close at substantially 255 degrees.

This valve timing will be found efficient for charging the pre-combustion chambers 30 of heavy duty turbines where different turbine blading is charged from each chamber 30. Said valves may remain open a different extent consistent with the fuel, air and outlet 77 ratios, arising from the relative volumes and velocities of fuel and air inlet by valves 49 and 69, as well as with the volatility of the fuel employed and the degree of scavenging desired.

Valve 69 and passages 68 and 46 are relatively smaller in area than valve 29 and outlet 77-80. Consequently as soon as the combustion, promoted by open valve 69, tends to abate, the combustion pressure cannot be maintained by open valve 69, at or above the air pressure behind valve 29, and hence further scavenging air enters each chamber 30 from valve 29.

The operation of my mechanism for heavy fuels will now be apparent and is as follows:—

The turbine, being at rest and without load, may be started by compressed air or other power derived from an external source, which air pressure may be applied also to the fuel.

Assuming now that the rotor or driven shaft 4 of the turbine is revolving, the shaft 7 will be driven as is apparent, see Figure 2, thereby actuating the connecting rods 9 to effect the reciprocation of the pistons 13. As the piston 13 moves towards the left, see Figure 4, atmospheric air is drawn into the chambers 19, through the valve 21 opening, and on the return stroke of the piston the compressed air is forced to open valve 22 and into the passage 23. The valve 24 is by said pressure opened allowing the compressed

air to pass therethrough to the piston chamber 19 in advance of the piston head 15.

On the next downward movement of the piston 13, the compressed air will be forced to open valve 25 and pass into and through the passage 26 and through valve 27 into the piston chamber 18 in which the third stage of the compression takes place as the piston 17 moves outwardly or to the right. The highly compressed, therefore highly heated air, in the piston chamber 18 is forced through the port 28, Fig. 8, into one of the combustion chambers 30, the valve 29 opening under pressure. The combustion chamber 30 under discussion is now substantially filled with highly compressed air which has been heated to a high degree due to the compression to which it has been subjected, and fills the combustion chamber 30.

The next step in the cycle of the operation is the injection of the heavy fuel into the combustion chambers. The shaft 59, see Figure 2, is intergeared with the shafts 7 and 58 so that the shaft 58 is driven in proper timed relationship. The cam 57 on the shaft 58 is so constructed that during one-half of its revolution it is moving forwardly one of the push rods 55 and during the other half of its revolution it is advancing the other push rod 55, so that the fuel is alternately injected into the two combustion chambers 30. As a push rod 55 moves forwardly, it actuates the bell crank lever 54, thereby causing the valve spindle 49 to be moved upwardly opening the port 47, Fig. 7, and permitting the fuel to pass from the annular groove 41 to the passages 43 and ports 44 into the passages 45 and therefrom to the port 46 into the combustion chamber 30 in which it is immediately ignited, due to the high compression of the compressed air therein.

The fuel is fed from a source of fuel supply under pressure, higher than the pressure of air in chamber 30, through the conduit 31 and the port 35 into the supply chamber 32 in which it is subjected to the heat from the combustion chamber 30, so that when it passes through the passages 36 and 37, to annular ring 41, thence through inclined passages 43 past open valve 49 into openings 45 and 46 and therefrom into the combustion chambers 30, as heretofore explained, this fuel will also be in a highly heated condition. The gate 78 opens substantially simultaneously with, or slightly after the commencement of, the injection of mixed fuel and air into the combustion chamber 30, in the succeeding step, according to the volatility of the fuel used.

The next step in the cycle of the operation is the introduction of highly compressed and heated air into the combustion chamber 30. This additional air is led from the chamber 18 to the port 59 and passage 60, see Figure 7, to the usual and conventional type of accumulator 106, and from the accumulator through

the pipe 62 to the passage 63 into the annular groove 64, thence into the inclined openings 66 past the open valve 67 on valve stem 69, thence through openings 68 and 46 to combustion chamber 30. At this stage of the operation, the cam 76 in the shaft 58 advances a push rod 75 to actuate its bell crank lever 74 and open one of the valves 69 thereby permitting additional highly compressed and heated air to pass through the ports 66 and 70 into the passage 68, and through the port 46 into one of the combustion chambers 30. The fuel valve 49 and the air valve 69 remain in their open position during a predetermined time of the interval of the opening of the gate valve 78, during which the fuel flowing from opening 45, and the air coming through opening 68, each at an angle, commingle in opening 46, and issue therefrom into combustion chamber 30 substantially in a fine spray, in which each particle of the fuel, being heavier and under greater velocity than the air content of said spray, is propelled past and receives heat from a number of air particles of said spray, and becomes rapidly commingled with the air and the combusting contents of chamber 30 and quickly ignited and consumed.

At the time of said spray the combusting contents of chamber 30 is flowing at high velocity through open port 80 to the turbine or other point of consumption, so that any fuel injected in a solid stream into said rapid flow would not be readily volatilized and combusted, and its combustion in such case would continue past the port 80 and into the turbine or other utilizing means.

The sprayed superheated fuel and air causes a rate and volume of flame propagation substantially exceeding that of fuel in the form of a solid stream; and such combusting spray rapidly commingles with, and accelerates the velocity with which, the products of the previous fuel injection are projected against the turbine blading, as well as produces a cracking or complete volatilization of the less volatile constituents of said previous fuel injection, and creates an excessive temperature which must be kept down to an efficient working temperature by radiation losses or otherwise; but this invention also converts said excess temperature into useful work by means of the final injection of only air into chamber 30 to be further heated by said excess temperature within chamber 30 and in the turbine and intervening parts, and all walls thereof, during the interval of said last step in the rapidly recurring cycles of this invention.

In spraying the heavier and greater pressure fuel, each particle thereof is propelled past a number of air particles, absorbing heat each until the more volatile constituents of said fuel are ignited thereby, as well as by the combusting rapidly flowing contents of

chamber 30; while the less volatile constituents of said sprayed fuel are impacted against a wall of chamber 30 and the heat thereof and of the contents of said chamber encountered by said fuel after impact volatilizes and combusts the same.

In the injection of the solid stream of superheated liquid fuel into the heated air content of chamber 30, the more volatile constituents of said fuel are ignited at once by the temperature of said air, while the less volatile constituents thereof are impacted against the opposite wall of chamber 30 and thereby diffused throughout said chamber 30 and absorb heat in the course of said diffusion and become volatilized and combusted thereby, especially during the more intensive and rapid combustion of the sprayed fuel.

The valve 49 preferably closes prior to the closing of the valve 69, so that additional or auxiliary highly heated air is admitted to the combustion chamber after the closing of its fuel valve 49. The further purpose of this is to effect a scavenging action through the port 46 and the combustion chamber 30. The admission of the auxiliary air has the additional effect of combining with any fuel in excess of the amount ignited by the primary air supply, thus ensuring complete combustion of such fuel as may collect around port openings, in corners, or in other relatively inaccessible places. It will be obvious that an excess of air produces a desirable result in allowing progressive combustion entailing less maximum stress on the walls of the combustion chamber.

After the close of each valve means 69 further air is admitted to further scavenge each chamber 30 by each valve means 29 commencing when the pressure in chambers 30 falls below that of the air tending to open valve 29. This further scavenging air is discharged through open port 80 of valve 78. When valve 78 closes its port 80 said further air supply continues and builds up the pressure and temperature required for the succeeding charge. The cam 86 actuates a push rod 87 thereby actuating the bell crank lever 88 which bears against a gate valve stem 82 to move the gate valve 78 into its open position, whereupon the port 80 will register with the passage 77. As the gate valve 78 moves downwardly, see Figures 8 and 9, a portion of the water from the water jacket 89, which is introduced by means of the conduit 90 and port 91, enters the pump chamber where it is normally held by valve 94, but by said valve 78 is forced from such pump chamber through the port 93 and to open valve 94 and enter passage 95 into the recess or chamber 96 in the gate 78, which at this time registers with the port opening of the passage 95. A check valve 90' is provided in conduit 90 to prevent the water being forced back through the conduit. This water or steam, as the

case may be, is injected through the spray nozzles passages 97 into the path of the incandescent gases passing thereinto. This spraying action increases the volume of the ignited gases and decreases, below the destructive degree upon the turbine blades and other parts, their temperature. Furthermore, as will be obvious, advantage is taken of the expanding quality of the steam developed, when contact is made with the hot gases, to impart a substantially constant velocity to the outgoing gas stream. The ignited gases pass through the passages 77 to a desired point of utilization which will vary in accordance with the mechanism which it is desired to charge.

As illustrated, see Figure 3, the gases at said non-destructive temperature pass through the passages 102 to the blading of a turbine such as, for example, is generically claimed in a copending application Serial No. 660,470, filed September 1, 1923.

Where in the claims I have referred to the spraying of water into the ignited gases prior to their discharge it is to be understood that this water may have been heated sufficiently to atomize it or to form steam prior to its introduction into the ignited gases due to the heated walls around the passages to which it discharges.

The valve 49 governing the oil supply to the combustion chamber closes at a predetermined interval, followed by the closing of the air valve 69 of the combustion chamber, sufficient intervals being allowed between the closing of the fuel valve with resultant cessation of combustion and the closing of the air valve, to allow the air passing through the air valve, and such air as may enter through air valve 29 before the closing of valve 78, to thoroughly scavenge the combustion chamber.

Coincident with the seating of the air valve or nearly so, the valve designated as the gate closes, thereby stopping the supply of water through the jet above mentioned.

In accordance with my present invention, any desired relative amount of water can be fed through the ignited or incandescent gases being delivered so that the motive fluid generated may approximate wholly or in part the qualities of steam, either saturated or superheated.

Many forms of apparatus may be employed in practicing my aforesaid method of combusting fuel into a motive fluid in which heat and pressures and their reactions form a material component part.

It will now be apparent that I have devised a new and useful charge forming mechanism which embodies the features of advantage enumerated as desirable in the statement of the invention and the above description, and while I have, in the present instance, shown and described a preferred embodiment thereof which will give in practice satisfactory

and reliable results, it is to be understood that this embodiment is susceptible of modification in various particulars without departing from the spirit or scope of the invention or sacrificing any of its advantages.

The invention herein described may be manufactured and used by or for the Government of the United States for governmental purposes without the payment to me of any royalty thereon or therefor.

Having thus described my invention, what I claim as new and desire to secure by Letters Patent, is:—

1. The method of combusting fuel for the production of power, including the steps of supplying to a closed combustion volume air under pressure and temperature capable of igniting fuel; injecting fuel under a higher pressure into said air and volume and igniting the same; opening said volume to enable the production of power from the contents thereof; supplying further air and fuel in separate columns impinging near their outlet to said volume substantially after the commencement of said ignition and under a pressure higher than that existing in said volume at substantially the close of this step; and supplying further air to said volume.

2. The method of combusting fuel for the production of power, including the steps of supplying air to a closed combustion volume and of a pressure and temperature to ignite fuel; injecting for a substantial period heavy fuel in a column under a higher pressure into said closed volume and igniting the same; substantially after the commencement of said ignition opening said volume to enable the production of power from the contents thereof; substantially with the opening of said volume commencing an injection of a column of air into said fuel column to discharge a mixed fuel and air spray into said volume for a period; stopping the fuel content of said spray and continuing its air content for a period; closing said volume; commingling moisture with the products coming from said volume throughout substantially the period from said opening to said closing of said volume; and successively repeating substantially said cycle of operation.

3. The method of combusting fuel for the production of power, including the steps of supplying air and heavy fuel in a column to a closed combustion volume and igniting said fuel; continuing said fuel supply (and changing it into a fuel spray for a substantial period after the commencement of said ignition) into said volume and combusting fuel under a substantially higher pressure than that within said volume at the termination of said fuel supply, and commencing to lead the combustion products from said volume to a power means substantially after the commencement of said fuel supply.

4. In a device for forming motive fluid by

combusting fuel, the combination of, a chamber; means for supplying air and fuel to said chamber and igniting the same; means for opening and closing said chamber; means for injecting further air into said chamber and to convert said fuel supply into a spray as it enters said chamber during the period they are synchronous; means for stopping said fuel injection and later stopping said further air supply; means for opening and closing said chamber; a water-jacket for cooling said chamber; and means for supplying moisture from said water-jacket in a plurality of fine streams commingling with the products coming from said chamber throughout substantially the period from said opening to said closing of said chamber.

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