W. RABSILBER.

INTERNAL COMBUSTION ENGINE.

APPLICATION FILED JUNE 24, 1907.

899,186. Patented Sept. 22, 1908.

5 SHEETS—SHEET 1.

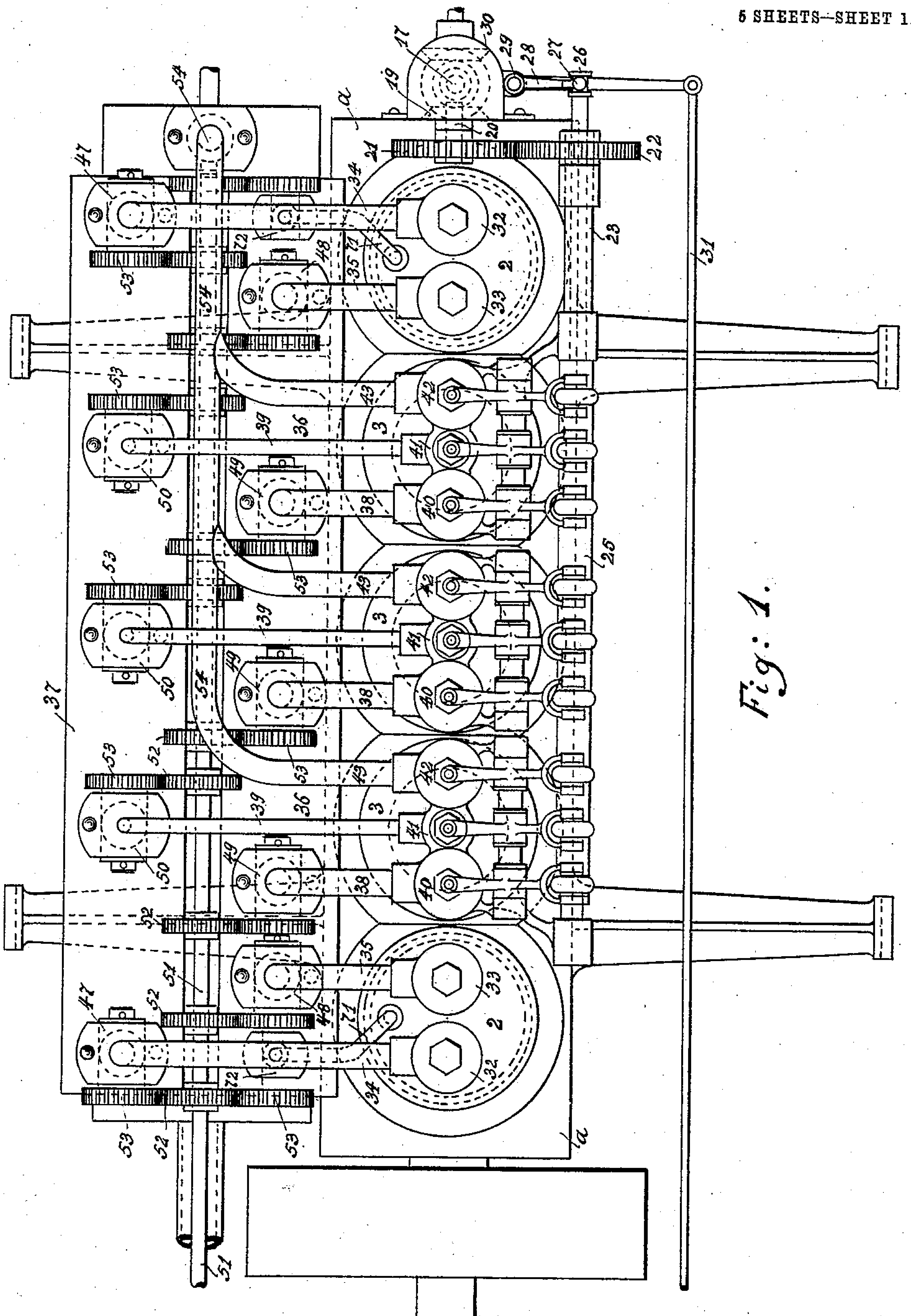

Fig: 1.

Witnesses:
J W Rache
M. Hamilton.

William Rabsilber Inventor

By Attorney
James Hamilton

W. RABSILBER.

INTERNAL COMBUSTION ENGINE.

APPLICATION FILED JUNE 24, 1907.

899,186.

Patented Sept. 22, 1908.

5 SHEETS—SHEET 2.

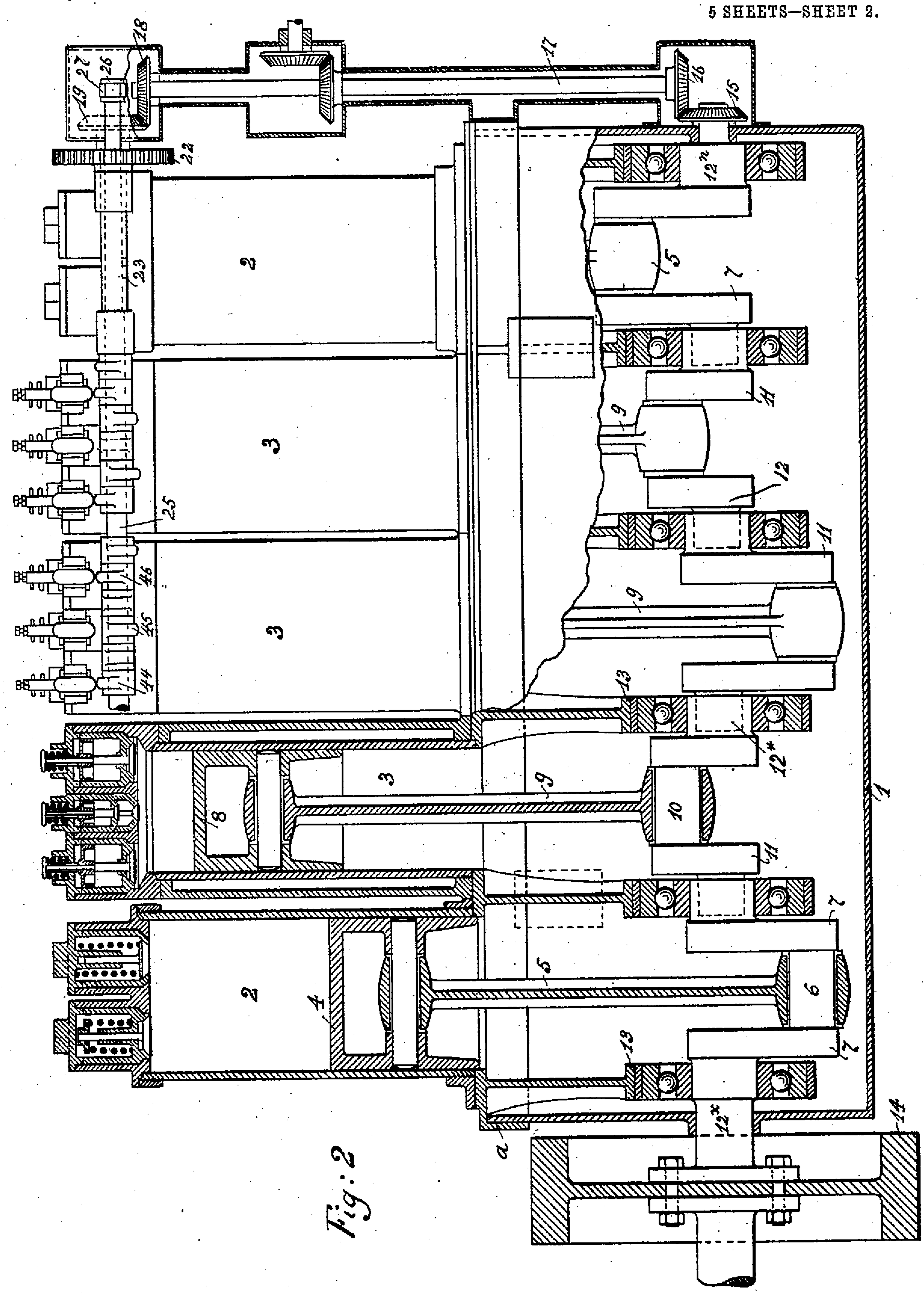

Fig: 2

Witnesses:

F W Rader

M. Hamilton.

William Rabsilber Inventor

By James Hamilton Attorney

W. RABSILBER.

INTERNAL COMBUSTION ENGINE.

APPLICATION FILED JUNE 24, 1907.

899,186.

Patented Sept. 22, 1908.

5 SHEETS—SHEET 3.

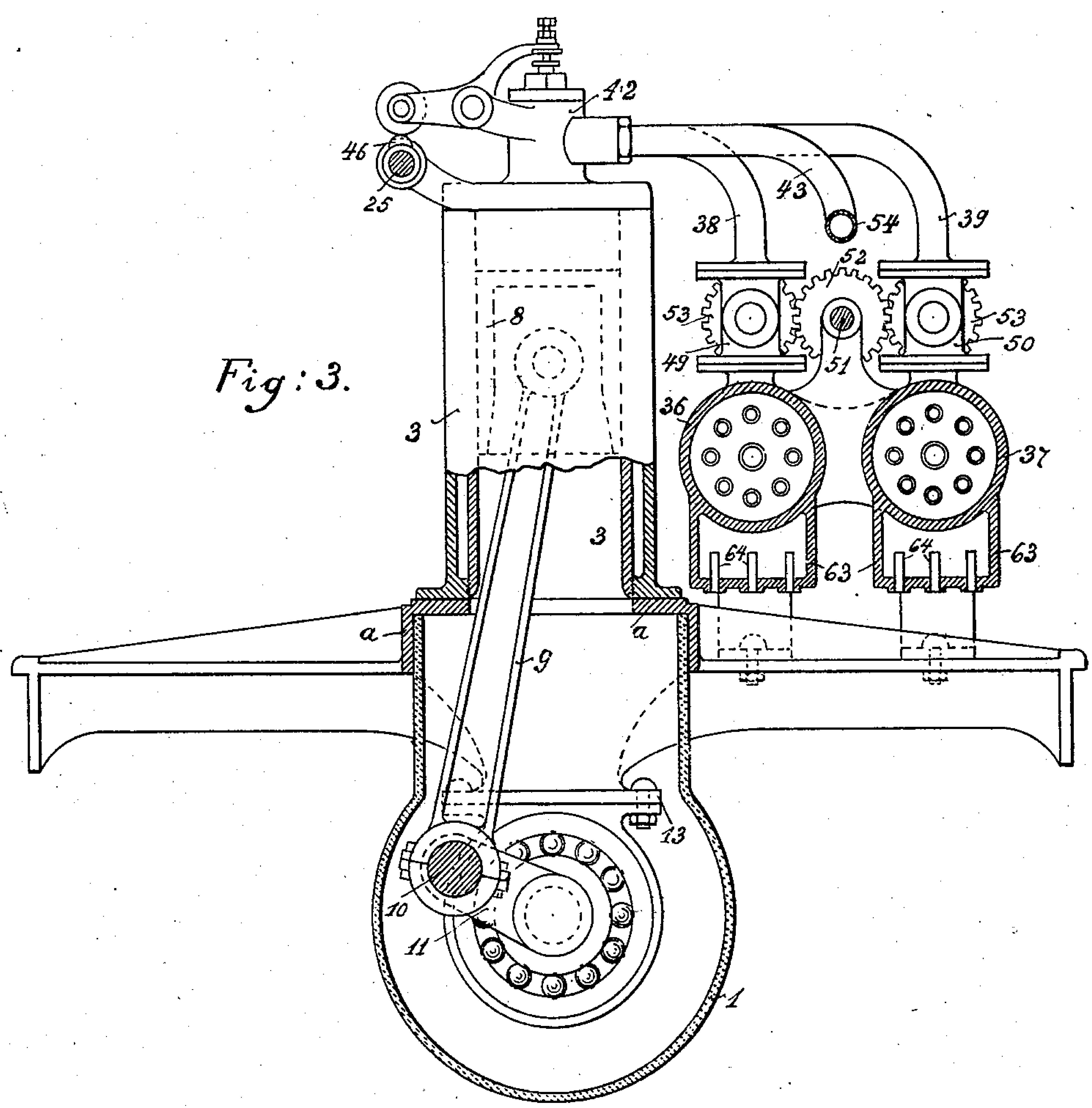

Fig: 3.

Witnesses:
J W Rader
M. Hamilton.

William Rabsilber Inventor

By James Hamilton Attorney

W. RABSILBER.

INTERNAL COMBUSTION ENGINE.

APPLICATION FILED JUNE 24, 1907.

899,186. Patented Sept. 22, 1908.

5 SHEETS—SHEET 4.

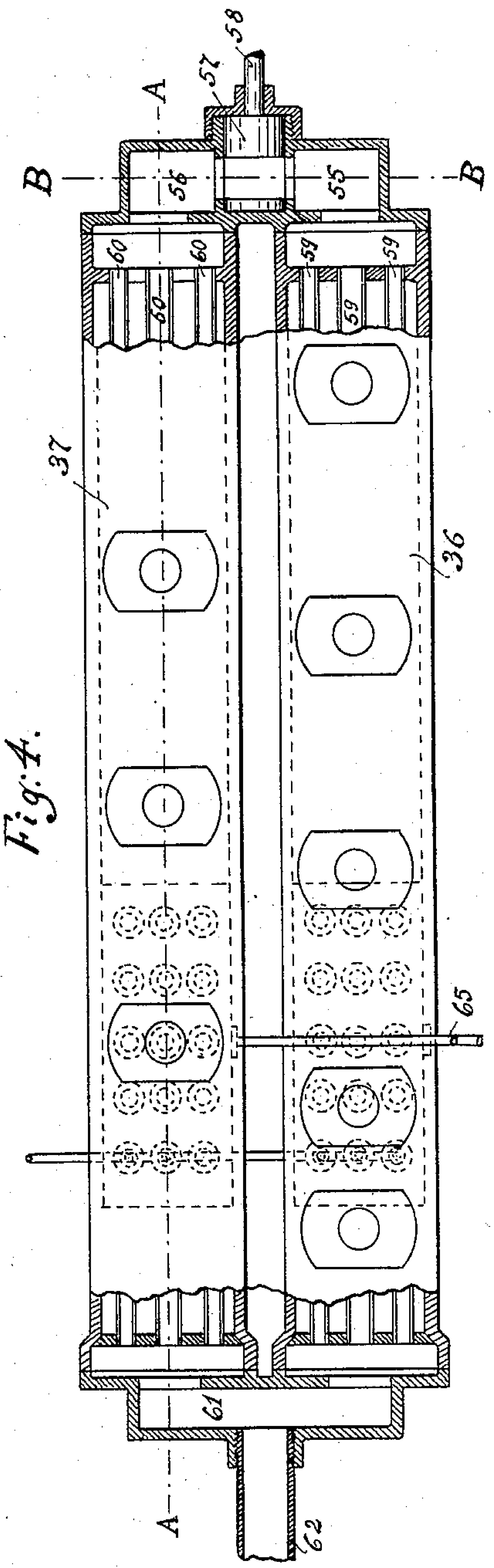

Fig: 4.

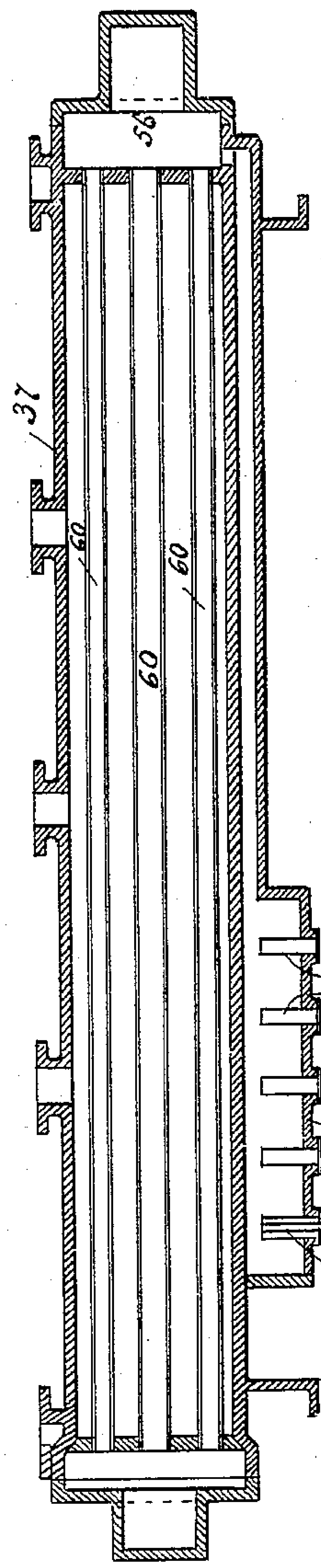

Fig: 5.

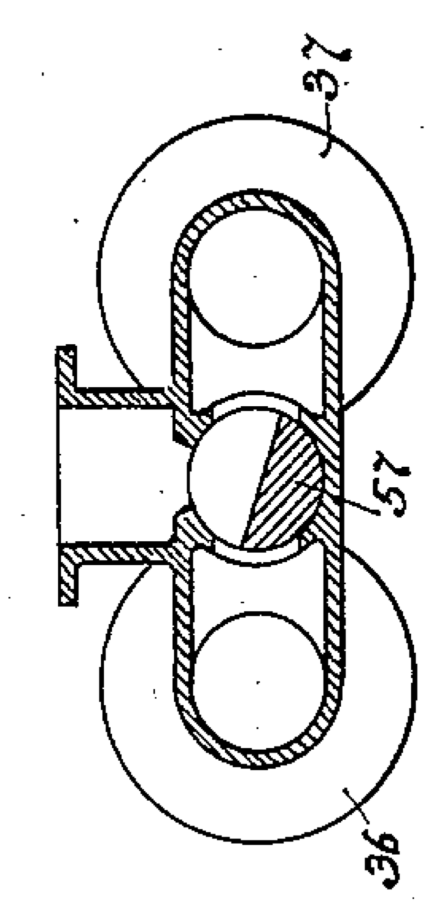

Fig: 6.

Witnesses:
J W Rader
M. Hamilton.

William Rabsilber Inventor

By James Hamilton Attorney

THE NORRIS PETERS CO., WASHINGTON, D. C.

W. RABSILBER.

INTERNAL COMBUSTION ENGINE.

APPLICATION FILED JUNE 24, 1907.

899,186. Patented Sept. 22, 1908.

5 SHEETS—SHEET 5.

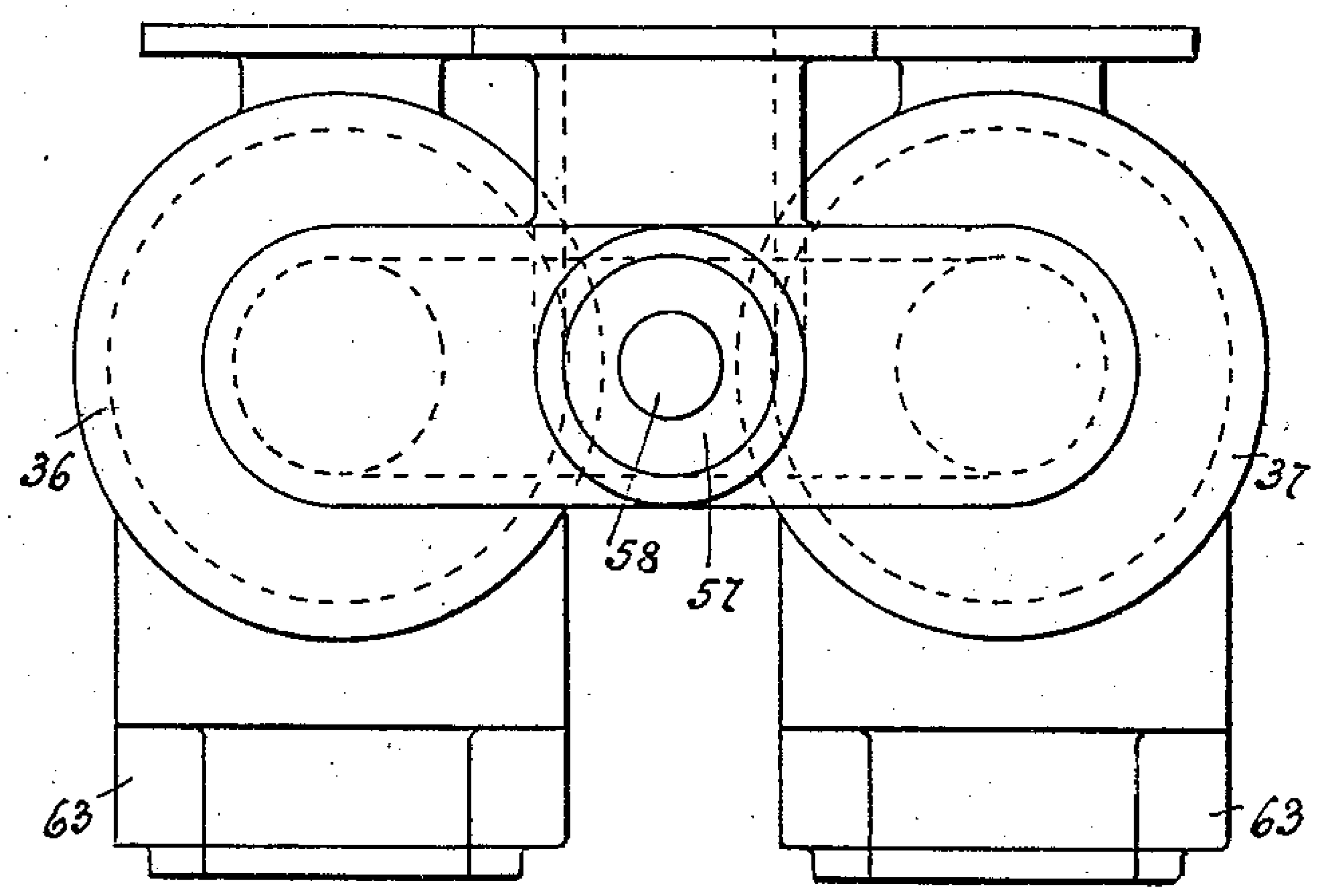

Fig: 8.

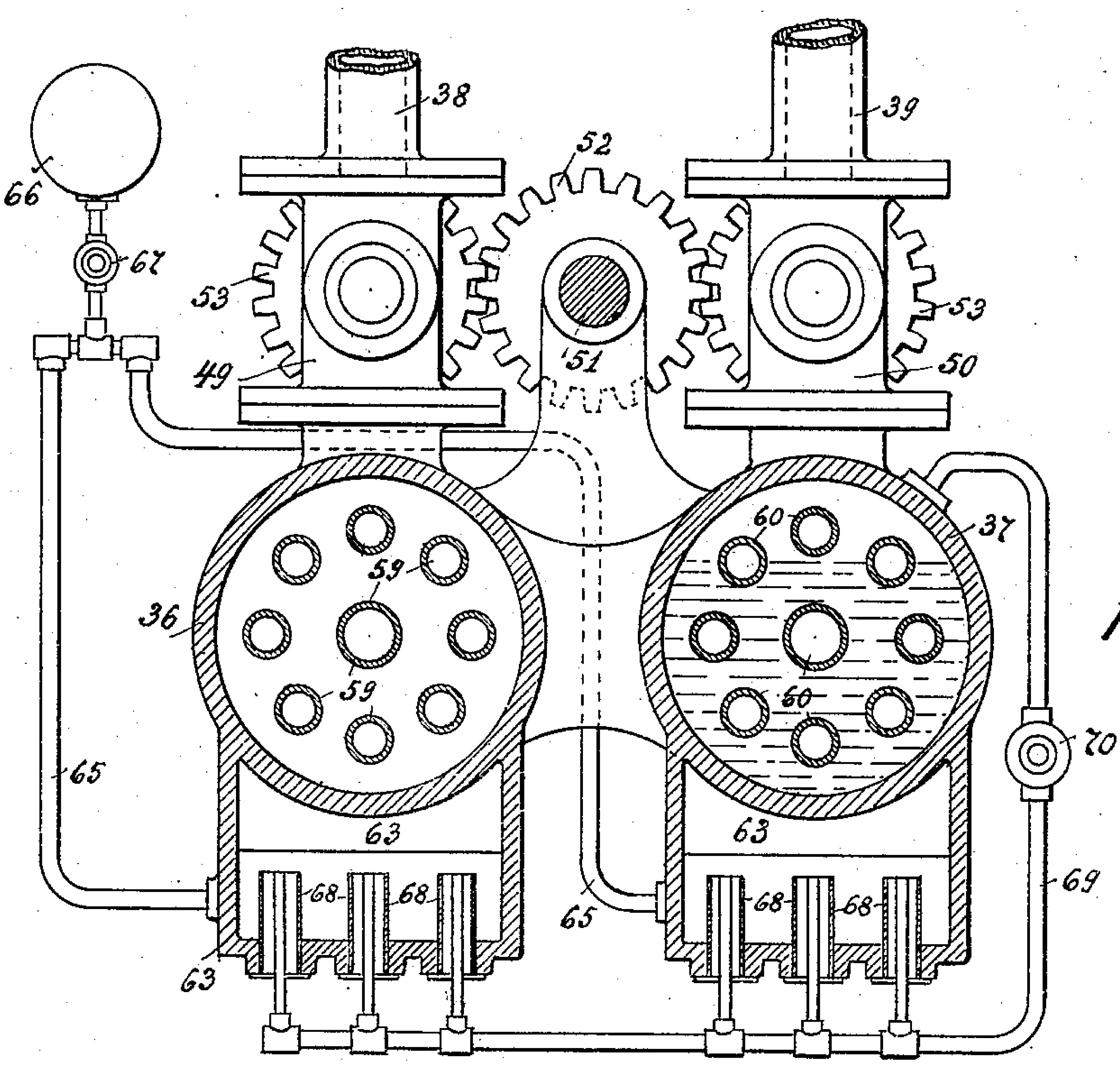

Fig: 7.

Witnesses:

J W Rader

M. Hamilton.

William Rabsilber Inventor

By James Hamilton Attorney

UNITED STATES PATENT OFFICE.

WILLIAM RABSILBER, OF NEW YORK, N. Y.

INTERNAL-COMBUSTION ENGINE.

No. 899,186. Specification of Letters Patent. Patented Sept. 22, 1908.

Application filed June 24, 1907. Serial No. 380,380.

To all whom it may concern:

Be it known that I, WILLIAM RABSILBER, a subject of the Emperor of Germany, residing at the city of New York, in the county of Kings and State of New York, have invented certain new and useful Improvements in Internal-Combustion Engines, of which the following is a specification, reference being had to the accompanying drawings.

My invention relates to improvements in internal combustion engines, and especially to those adapted for automobile and traction purposes; and one object of my invention is to provide an internal combustion engine which will differ from those heretofore known in that it will be self-starting, reversible and as flexible in speed and power as is a steam-engine. These results are attained in the following manner: Heretofore the air has been compressed in the motor-cylinders, after its mixture with the gaseous fuel; but in my new internal combustion engine hereinafter fully described, air-compressors separate from and driven by the motor-cylinders are provided for compressing the air in air-reservoirs from which the air is led under pressure to the motor-cylinders. Reservoirs are also provided for the liquid fuel in which the gas arising from the liquid is stored under a pressure greater than the pressure of the air in the air-reservoirs. The pressure of the gas in the fuel-reservoirs is produced by heating the liquid fuel in these reservoirs; and the pressure of the air in the air-reservoirs is increased by heating the air. Thus, there is always stored energy at the command of the engineer or operator, in the form of air and gaseous fuel at high pressure and temperature. The gaseous fuel and the air are admitted to the motor-cylinders by means of mechanically-operated valves; and since the compressed air is admitted first, the pressure of the gaseous fuel must be higher than the pressure of the compressed air.

The air under pressure in the air-reservoirs and the fuel likewise under pressure in the fuel-reservoirs are heated by the exhaust gases from the motor-cylinders during the operation of the engine; while at starting and during the stoppages of the engine, they will be heated by means of suitable burners. An important feature of this arrangement is that by simply changing the flow of the exhaust gases, the degree of compression and therefore the power of the engine may be varied. Any degree of compression may be attained; and since the air and the fuel are stored in separate reservoirs, there can be no danger of pre-ignition. In contradistinction from what is possible with engines heretofore known, the air and the fuel may be heated to such a high degree that combustion will take place upon their meeting in the motor-cylinder and without the use of any igniting mechanism. Thus, all the troubles of a complicated system of ignition are avoided in my new engine. Further, different volatile fuels requiring different compressions may be used without necessitating any change in the design of the engine.

By using the exhaust gases for heating the contents of the air-reservoirs and fuel-reservoirs, it will be obvious that the efficiency of the engine or the economy of fuel per horse-power per hour may be greatly increased, since the heat wasted in other engines by passing off with the exhaust is here saved and used to increase the heat of the working fluid.

An automobile equipped with my new engine can be controlled without the use of a change-speed or reversing gear, solving the problem of the gearless car, cheapening the construction and simplifying the operation.

In the drawings illustrating the principle of my invention and the best mode now known to me of applying that principle, Figure 1 is a plan and Fig. 2 a front elevation (partly in section) of my new engine; Fig. 3 is a side view of one of the motor cylinders and its connected parts, the same being partly in section on the line C—C of Fig. 1; Fig. 4 is a plan (partly in section) of the reservoirs for the compressed air and the fuel; Fig. 5 is a section on the line A—A of Fig. 4; Fig. 6 is a section on the line B—B of Fig. 4; Fig. 7 is a transverse section through the reservoirs for air and fuel on an enlarged scale and shows the supplementary heating devices; and Fig. 8 is an end view of the reservoirs for air and fuel on the same scale as that of Fig. 7.

Upon each end of the base-plate *a* is mounted an air-compressor cylinder 2 the lower end of which communicates with the crank-case 1 or is open thereto; and between the air-compressor cylinders 2 are mounted the motor-cylinders 3 the lower end of each of which is similarly open to the crank-case 1 (Fig. 2). In each air-compressor cylinder 2 is slidably fitted a piston 4 to which is pivotally secured one end of a connecting-rod 5 the other end of which is connected by the crank-pin 6 with the cranks 7. Within each motor-cylinder 3 reciprocates a piston 8 to which is pivotally secured one end of a connecting-rod 9 through the other end of which passes a crank-pin 10 the ends of which are each secured to a crank 11. The cranks 7 and 11 are each connected to a part of the drive-shaft 12 which is not continuous but which is made up of several intermediate parts 12^* journaled in the hangers 13 and of the end portions $12^{\times}$ and 12^{n} which project through the crank-case. Upon the end portion $12^{\times}$ of the drive-shaft is mounted the fly-wheel 14 and upon the other end portion 12^{n} is mounted a bevel gear 15 which meshes with a bevel gear 16 on the lower end of a shaft 17 upon the upper end of which is mounted a bevel gear 18. The latter meshes with a bevel gear 19 mounted upon one end of a stub-shaft 20 which carries fast upon it a spur gear 21 in mesh with a spur gear 22 fast upon one end of a hollow shaft 23. Keyed to the latter so as to rotate therewith and yet free to slide lengthwise therethrough is a valve-controlling cam-shaft 25 formed with a circumferential groove 26 at one end in which groove engages a lug 27 projecting from a reversing-lever 28 fulcrumed at 29 upon the casing or housing 30 in which the shaft 17 is mounted. The reversing-lever 28 is controlled by a rod 31 (Fig. 1); and by moving the latter the valve-controlling cam-shaft 25 will be moved lengthwise so as to substitute one set of cams for another under the mechanically operated valves, and thereby to reverse the direction of rotation of the drive-shaft 12, in a manner already well known.

In the head of each of the air-compressor cylinders 2 are mounted two valves, one of which is the air-inlet valve 32 and the other of which is the air-exhaust valve 33. Both the valves 32, 33 are self-closing. The valve 32 controls the flow of air from the suction-pipe 34 to the air-compressor cylinders 2 while the valve 33 controls the flow of air from the air-compressor cylinders 2 to the reservoir-pipe 35. The latter connects the cylinder 2 with the air-reservoir 36 which extends along in rear of the cylinders 2, 3 (Fig. 3). Parallel with the air reservoir 36 extends the fuel-reservoir 37 which holds the gasolene or like fuel that combines with the air on meeting it in the motor-cylinders 3 and burns therein. Each motor cylinder 3 is connected by an air-pipe 38 with the air-reservoir 36 and by a fuel-pipe 39 with the fuel-reservoir 37. Further, in the head of each motor cylinder 3 there are mounted three valves; to wit, the air-valve 40 which controls the passage of the air under compression from the air-pipe 38 to the explosion-cylinder 3; the fuel-inlet valve 41 which controls the flow of the gaseous fuel from the fuel-pipe 39 into the explosion cylinder 3; and the exhaust valve 42 which controls the flow of the products of combustion from the explosion-cylinder 3 to the exhaust-pipe 43. The valves 40, 41 and 42 are mechanically operated by means of cams 44, 45 and 46, respectively, mounted fast upon the valve-controlling cam-shaft 25 (Figs. 1, 2 and 3). There are two sets of these cams 44, 45 and 46, one set being for forward motion of the engine and the other set being for reverse movement of the engine. By moving the reversing-lever 28 the cam-shaft 25 will be moved to bring the inactive set of cams into operation and thereby to reverse the engine in a manner already well known.

In the suction-pipe 34 which communicates with the outer air and with the air-compressor cylinders 2 is mounted a throttle-valve 47 which controls the flow of the air from the outside into the suction-pipe 34; and in the reservoir-pipe 35 is mounted another throttle valve 48 which controls the flow of the air under compression from the reservoir-pipe 35 into the air-reservoir 36. Similarly, in the air-pipe 38 is mounted a throttle valve 49 which controls the flow of the compressed air from the air-reservoir 36 to the air-pipe 38; and in the fuel-pipe 39 is mounted a throttle valve 50 which regulates the flow of the gaseous fuel from the fuel-reservoir 37 to the fuel-pipe 39. Parallel with the reservoirs 36, 37 extends a shaft 51 upon which are mounted fast a number of spur-gears 52 each of which meshes with a spur-gear 53. Each of the latter is mounted upon the valve-stem of one of the throttle-valves 47, 48, 49, 50, so that by turning the shaft 51 all these throttle-valves may be actuated.

The several exhaust-pipes 43 lead from the motor-cylinders 3 into a main exhaust-pipe 54 from which the exhaust gases pass into the chambers 55, 56 past the rotary valve 57. The latter is shown in Fig. 6, from which it will be clear that by turning the valve-stem 58 the flow of the exhaust gases into one of the chambers will be increased, while their flow into the other of said chambers will be correspondingly decreased. From the chamber 55 extend pipes 59 through the air-reservoir 36, while from the chamber 56 lead similar pipes 60 through the fuel-reservoir 37. The two sets of pipes 59, 60 empty into the chamber 61 at the other end of the reservoirs and the exhaust gases pass off finally through the pipe 62. It will be understood by all skilled in this art that the hot exhaust gases, while passing through the pipes 59, 60 give up much of their heat, which is absorbed by the contents of the reservoirs 36, 37. It is important to note that the amount of fuel which will enter the motor-cylinder 3 will depend, other conditions remaining the same, upon the effective pressure acting upon the fuel; and that this effective pressure is the difference between the pressure of the air and the pressure of the fuel, the air entering the motor-cylinder ahead of the fuel, as has already been stated. Obviously this effective pressure may be increased in two ways; namely, by reducing the pressure of the air and increasing the pressure of the fuel. Hence, by turning the valve-stem 58 so that more exhaust gases will flow through the pipes 60 and less through the pipes 59, the effective pressure acting upon the fuel will be increased in both these ways, since not only is the pressure of the fuel increased but the pressure of the air is decreased. Similarly, the effective pressure may be decreased by turning the rotary valve 57 in the contrary direction and thereby reducing the pressure of the fuel and increasing the pressure of the air. From this it clearly follows that the power of the engine may be regulated by means of the valve 57. It will, however, be observed that, in order that the engine may operate, the pressure of the air must be less than the pressure of the fuel, thereby permitting the fuel to enter against the pressure of the air which is fed into the cylinder before the fuel is admitted.

Besides heating the contents of the reservoirs 36, 37 by means of the exhaust gases (which are available for this purpose during only the operation of motor-cylinders in the regular running of the engine), two other methods are employed by me, which I shall now proceed to describe: The first of these two methods is that of heating the contents at starting, after the engine has been unused for a comparatively long period of time and the contents of the reservoirs have been thoroughly cooled. Beneath each reservoir 36, 37 is a heating chamber 63 provided with air-flues 64 and connected by a pipe 65 with a fuel-tank 66. The heating chambers 63 are further in communication with the chambers 55, 56 and through the latter with the sets of pipes 59, 60. After a long stop, as over night, the operator turns the valve 67 and allows the liquid fuel to flow from the tank 66 into the heating chambers 63, where it is ignited by means of an electrical device, for example. The products resulting from the combustion of this liquid fuel rush through the chambers 55, 56 and the pipes 59, 60 and heat the contents of the reservoirs 36, 37 to such a degree that the gaseous fuel, upon meeting the compressed air in the motor-cylinder combines with it and true combustion results.

The second of the two methods just referred to consists in providing each of the heating chambers 63 with a set of burners 68 which are fed by the gaseous fuel which is led through the pipe 69 past the valve 70 from the reservoir 37. After the production of gas has been started in the reservoir 37 by burning liquid fuel from the fuel-tank 66, as just described the burners 68 will continue lighted and will compensate for the heat radiated from the reservoirs 36, 37, during the short stoppages made by the automobile during the run, and will thereby insure a sufficient supply of gaseous fuel being on hand after such stoppages.

From each air-compressor cylinder 2 there leads a pipe 71 to the outer air; and in this pipe is mounted a throttle valve 72 the valve-stem of which is turned by turning the shaft 51 in the same manner as are turned the valve-stems of the throttle valves 47, 48, 49 and 50.

In view of what has been disclosed in the foregoing description, it will suffice to give only a brief description of the operation of my new engine. The contents of the reservoirs 36, 37 having become cooled by a long period of rest, the engine is started by turning the valve 67 and then igniting the liquid fuel in the heating chambers, to which air is supplied through the air-flues 64 to maintain the combustion of the liquid fuel. The pressure of the air in the reservoir 36 and of the gaseous fuel evolved in the reservoir 37 gradually rise, until they are such that it is certain that the fuel and the air, upon coming in contact with each other in the motor cylinder, will burn spontaneously. The valve 70 may then be opened and the burners 68 may be lighted. To unbalance the pressures acting upon the main drive-shaft 12 and to give the cranks 7, 11 an initial impulse, the throttle-valve shaft 51 is turned slightly, so as to open only the throttle-valves 72 and to bring the pressure in the air-compressor cylinders 2 to that of the atmosphere. The greater pressure now acting upon the pistons in some of the motor-cylinders 3 will now give the cranks connected therewith an initial impulse. The throttle-valve shaft 51 is now turned still further in the same direction, whereby the valve 72 is closed and the throttle-valves 47, 48 and 49 are opened slightly. Upon turning the shaft 51 still further, the throttle-valve 50 is opened and gaseous fuel at a higher pressure than that of the air in the reservoir 36 flows to the motor-cylinder and there burns on contact with the air already admitted. At starting the air forced into the reservoir 36 is just sufficient to replace the air admitted to the motor-cylinders 3, thereby avoiding too great a pressure in the air-reservoir (the pressure in which must be lower than the pressure in the fuel-reservoir 37, as already explained) and reducing the work thrown upon the motor devices to correspond to the power of the engine at starting.

It will be observed that the effect of increasing the opening of the throttle-valves 49 and 50 simultaneously is cumulative; for, a greater amount of heat is produced in the motor-cylinders by the combustion of the greater amount of working fluid and a greater amount of exhaust gases is also expelled from the motor cylinders. The greater amount of exhaust gases at a higher temperature increases greatly the pressure of the contents of the reservoirs 36, 37, and from this results the cumulative effect just referred to.

I claim:

1. The combination of a reservoir for compressed air; a reservoir for fuel; an internal combustion engine connected with both said reservoirs; an air-compressor connected with said reservoir for compressed air; means controlling the supply of compressed air and fuel from said reservoirs to said engine; and means for heating the entire contents of one of said reservoirs before admission to said engine, said reservoirs being separate and free from communication with each other.

2. The combination of a reservoir for compressed air; a reservoir for fuel; an internal combustion engine connected with both said reservoirs; an air-compressor connected with said reservoir for compressed air; means controlling the supply of compressed air and fuel from said reservoirs to said engine; and means for heating the entire contents of both of said reservoirs before admission to said engine, said reservoirs being separate and free from communication with each other.

3. The combination of a reservoir for compressed air; a reservoir for fuel, said reservoirs being separate; an internal combustion engine connected with both said reservoirs; an air-compressor connected with said reservoir for compressed air; means controlling the supply of compressed air and fuel from said reservoirs to said engine; and means for leading the exhaust gases from said engine to one of said reservoirs for heating the contents of the same.

4. The combination of a reservoir for compressed air; a reservoir for fuel, said reservoirs being separate; an internal combustion engine connected with both said reservoirs; an air-compressor connected with said reservoir for compressed air; means controlling the supply of compressed air and fuel from said reservoirs to said engine; and means for leading the exhaust gases from said engine to both of said reservoirs for heating the contents of the same.

5. The combination of a reservoir for compressed air; a reservoir for fuel, said reservoirs being separate; an internal combustion engine connected with both said reservoirs; means controlling the supply of compressed air and fuel from said reservoirs to said engine; and means for heating the contents of one of said reservoirs.

6. The combination of a reservoir for compressed air; a reservoir for fuel, said reservoirs being separate; an internal combustion engine connected with both said reservoirs; means controlling the supply of compressed air and fuel from said reservoirs to said engine; and means for heating the contents of both of said reservoirs.

7. The combination of a reservoir for compressed air; a reservoir for fuel, said reservoirs being separate; an internal combustion engine connected with both said reservoirs; means controlling the supply of compressed air and fuel from said reservoirs to said engine; and means for leading the exhaust gases from said engine to one of said reservoirs for heating the contents of the same.

8. The combination of a reservoir for compressed air; a reservoir for fuel, said reservoirs being separate; an internal combustion engine connected with both said reservoirs; means controlling the supply of compressed air and fuel from said reservoirs to said engine; and means for leading the exhaust gases from said engine to both of said reservoirs for heating the contents of the same.

9. The combination of a reservoir for compressed air; a reservoir for fuel; an internal combustion engine connected with both said reservoirs; means controlling the supply of compressed air and fuel from said reservoirs to said engine; means for leading the exhaust gases from said engine to both of said reservoirs for heating the contents of the same; and means for distributing the exhaust gases between said reservoirs.

10. The combination of a reservoir for compressed air; a reservoir for fuel; an internal combustion engine connected with both said reservoirs; means controlling the supply of compressed air and fuel from said reservoirs to said engine; an air-compressor connected with said reservoir for air; a suction-pipe for said air-compressor; and a valve-controlled pipe for bringing the air in said air-compressor to atmospheric pressure independently of said suction-pipe.

11. The combination of a reservoir for compressed air; a reservoir for fuel; an internal combustion engine connected with both said reservoirs and provided with exhaust valves and with admission valves for the compressed air and fuel; an air-compressor connected with said reservoir for air and provided with admission and outlet valves; and throttle valves for controlling the admission of air to said air-compressor and the admission of compressed air from said air-compressor to said reservoir for air; throttle valves for controlling the admission of compressed air and fuel from said reservoirs to said engine; and means common to all said throttle valves for controlling the same.

12. The combination of a reservoir for compressed air; a reservoir for fuel, said reservoirs being separate and free from communication from each other; an internal combustion engine connected with each of

said reservoirs; and means independent of said engine for heating the entire contents of said reservoirs at starting.

13. The combination of a reservoir for compressed air; a reservoir for fuel, said reservoirs being separate and free from communication from each other; an internal combustion engine connected with said reservoirs; and means for heating the contents of each of said reservoirs during the stoppages of said engine.

14. The combination of a reservoir for compressed air; a reservoir for fuel, said reservoirs being separate and free from communication from each other; an internal combustion engine connected with said reservoirs; and heaters under each of said reservoirs for heating the entire contents thereof at starting before said engine is running.

15. The combination of a reservoir for compressed air; a reservoir for fuel, said reservoirs being separate and free from communication from each other; an internal combustion engine connected with said reservoirs; and burners for heating the entire contents of each of said reservoirs, said burners being operatively connected with said fuel reservoir.

16. The combination of a reservoir for the compressed air; a reservoir for the fuel, said reservoirs being separate; an internal combustion engine connected with both said reservoirs; and means for raising the temperature of one of said reservoirs while allowing the temperature of the contents of the other of said reservoirs to fall.

17. The combination of a reservoir for the compressed air; a reservoir for the fuel; an internal combustion engine connected with both said reservoirs; means for leading the exhaust gases to said reservoirs; and means for controlling the amount of heat imparted by said exhaust gases to each of said reservoirs.

18. The combination of a reservoir for the compressed air; a reservoir for the fuel; an internal combustion engine connected with both said reservoirs; means for leading the exhaust gases from said engine to the reservoir for fuel; and means controlling the flow of the exhaust gases to said fuel reservoir, said last-named means being separate from said engine.

19. The combination of a reservoir for the compressed air; a reservoir for the fuel; an internal combustion engine connected with both said reservoirs; means for leading the exhaust gases from said engine to the reservoir for air; and means controlling the flow of the exhaust gases to said air reservoir, said last-named means being separate from said engine.

20. The combination of a reservoir for compressed air; a reservoir for fuel; an internal combustion engine connected with each of said reservoirs; means for leading the exhaust gases from said engine to each of said reservoirs; and means for controlling the relative flow of the exhaust gases to said reservoirs to vary the pressure of the contents thereof, said pressures of the air and the fuel being independent of each other.

In testimony whereof I have hereunto set my hand at New York city, N. Y. this twenty-second day of June, 1907, in the presence of the two undersigned witnesses.

WILLIAM RABSILBER.

Witnesses:

J. W. RADER,

JAMES HAMILTON.