July 27, 1948. W. F. MAYER 2,445,856

ROTARY REACTION MOTOR

Filed May 26, 1945 5 Sheets-Sheet 1

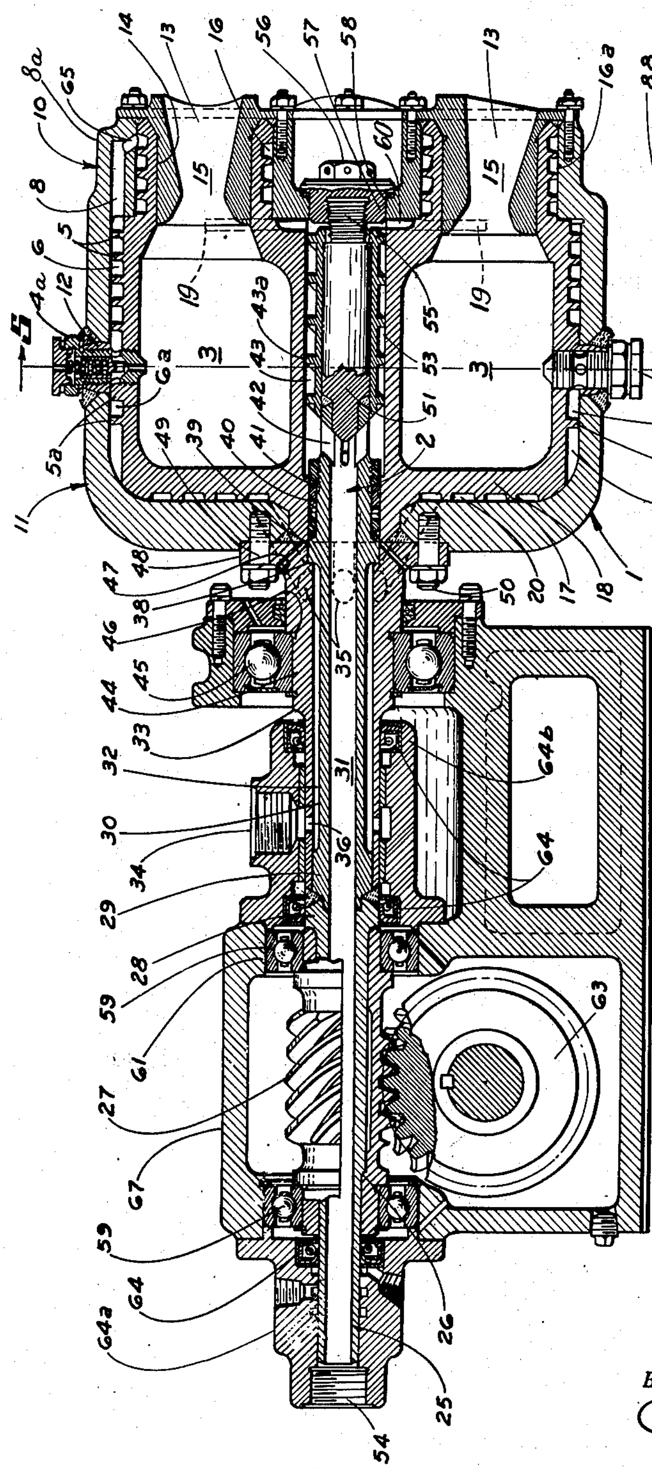

FIG-1

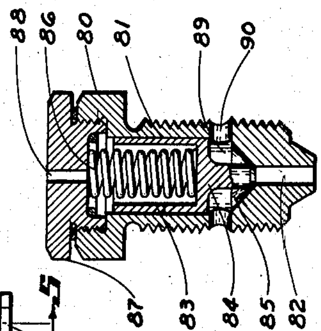

FIG-2

INVENTOR.

WALDEMAR F. MAYER

BY

Christie & Angus

ATTORNEYS

July 27, 1948.

W. F. MAYER

2,445,856

ROTARY REACTION MOTOR

Filed May 26, 1945

5 Sheets-Sheet 2

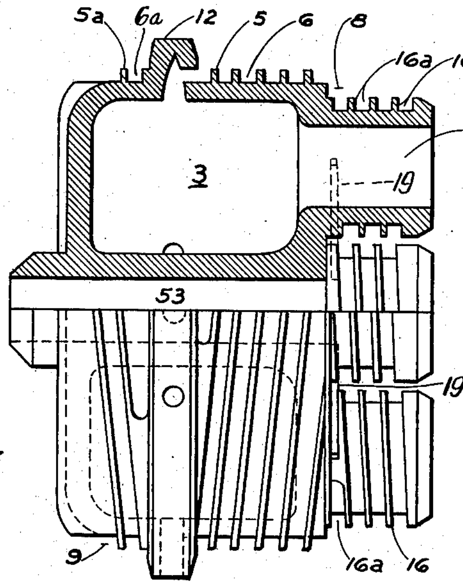

FIG-3

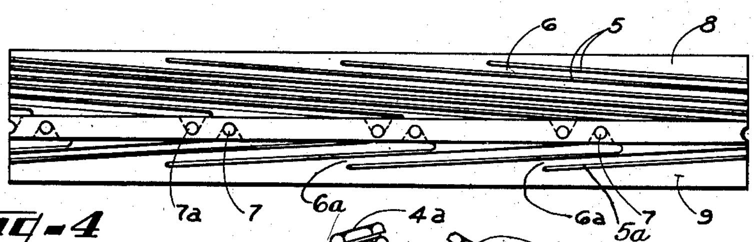

FIG-4

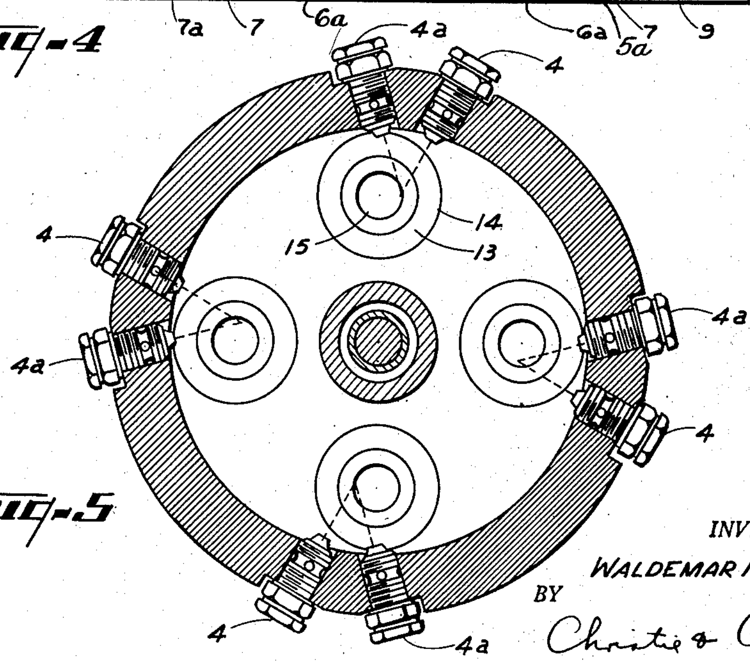

FIG-5

INVENTOR.

WALDEMAR F. MAYER

BY Christie & Angus

ATTORNEYS

July 27, 1948. W. F. MAYER 2,445,856

ROTARY REACTION MOTOR

Filed May 26, 1945 5 Sheets-Sheet 3

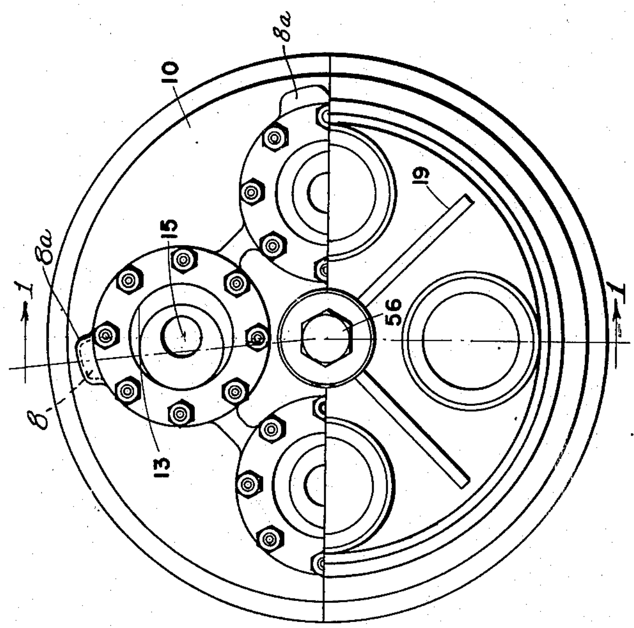

FIG-7

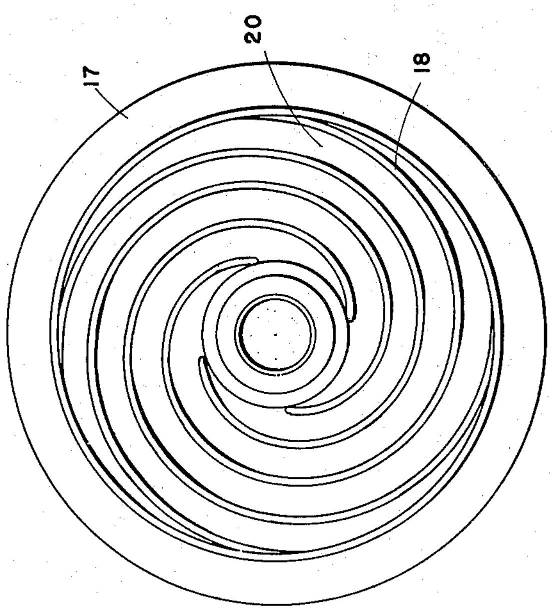

FIG-6

INVENTOR.
WALDEMAR F. MAYER
BY
Christie & Angus
ATTORNEYS

July 27, 1948. W. F. MAYER 2,445,856

ROTARY REACTION MOTOR

Filed May 26, 1945 5 Sheets-Sheet 4

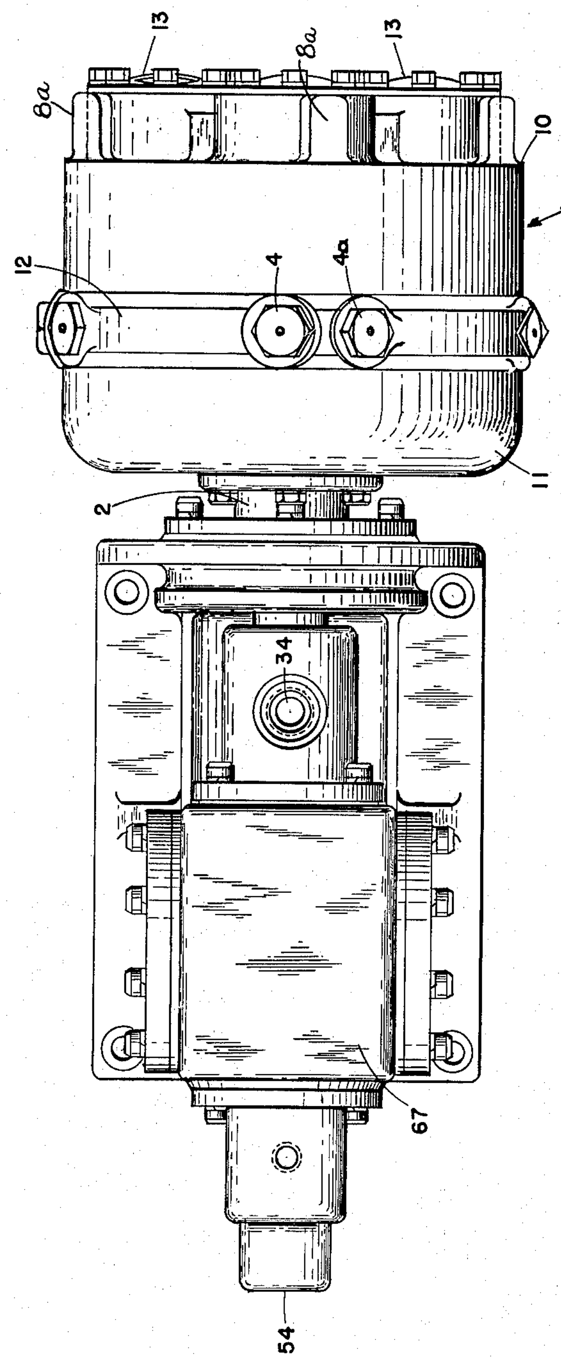

Fig-8

INVENTOR.
WALDEMAR F. MAYER
BY
Christie & Angus
ATTORNEYS

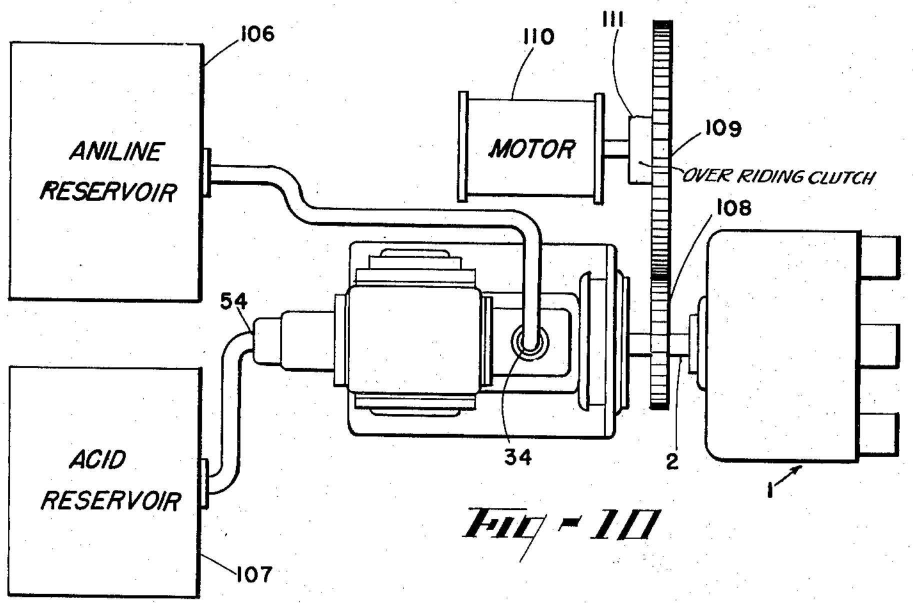

FIG-10

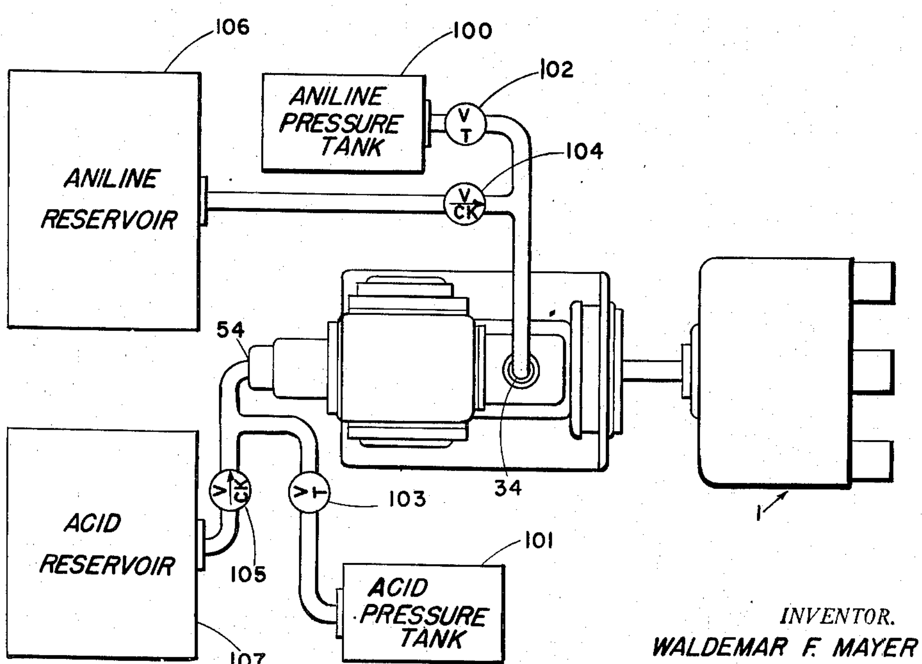

FIG-9

INVENTOR.
WALDEMAR F. MAYER
BY
Christie & Angus
ATTORNEYS

Patented July 27, 1948

2,445,856

UNITED STATES PATENT OFFICE

2,445,856

ROTARY REACTION MOTOR

Waldemar F. Mayer, Los Angeles, Calif., assignor to Aerojet Engineering Corporation, Azusa, Calif., a corporation of Delaware

Application May 26, 1945, Serial No. 595,940

4 Claims. (Cl. 60—35.6)

1

This invention relates to jet propulsion and has for its object the provision of a jet propelled motor capable of pumping its own propellant.

Jet propulsion motors are well known. They commonly comprise a combustion chamber provided with an exhaust nozzle. Propellant material is placed or injected into the combustion chamber, where the propellant is burned or decomposed creating gases which pass at high velocity through the exhaust nozzle to create the propulsion. Where the propellant is a liquid it is forced into the combustion chamber at a pressure high enough to overcome the pressure in the chamber. In order to develop the required injection pressure various expedients have been used, for example, pumps or high gas pressure tanks.

According to my invention I avoid the necessity for such auxiliary apparatus for pressurizing the propellant and I do this by constructing the jet motor to rotate when in operation. The motor is rotated by the provision of a plurality of exhaust nozzles directed at some angle from the straight rearward direction so as to produce the force for rotating the motor.

According to a feature of my invention I provide passageways communicating from the propellant supply source to the injection devices of the motor through which the propellant is injected into the combustion chamber. These passageways are arranged so that the rotation of the motor applies sufficient centrifugal force to the propellant to force it into the motor. Related features are the construction of the passageways in spiral form and their arrangement around the combustion chamber and nozzles to act as a coolant. The passageway through which the liquid flows is designed to insure adequate velocity of fluid to cool the motor at all places.

A feature of the motor construction is that there is provided a single combustion chamber to which all of the nozzles are attached. A plurality of injectors spray the propellant or propellants into the reaction chamber. It is desirable that these injectors be uniformly spaced about the firing chamber and that the streams from these injectors all enter at substantially the same cross section plane of the firing chamber. This insures a more intimate mixing of the streams and thereby produces a more uniform reaction throughout the entire reaction region avoiding unequal effects on the exhaust nozzles.

This and the above features will be better understood from the following detailed description and accompanying drawings in which:

2

Fig. 1 shows the revolving jet motor in longitudinal cross section taken on line 1—1 of Fig. 7, including a worm and worm wheel transmission which may be coupled to any desired device;

Fig. 2 is an enlarged sectional view of an injector nozzle for introducing fuel and oxidizer into the combustion chamber;

Fig. 3 is a view partly in relief, partly in cross section showing the relationship of the firing chamber to the conduit spirals which surround the firing chamber and exhaust nozzle;

Fig. 4 shows the spiral scrolls laid out in flat pattern and indicates the manner in which the fluid or fluids are conducted to their respective injectors from the spiral channels;

Fig. 5 is a cross section view taken on line 5—5 of Fig. 1 showing the position of the injectors in relation to the firing chamber;

Fig. 6 is a plan view showing the spiral located at the front of the combustion chamber which pumps the fuel into the injectors;

Fig. 7 is a cutaway front view of a motor showing the nozzles and also showing the inside construction in back of the nozzle cover including the oxidizer cross vanes which pump the other fluid into the motor;

Fig. 8 is a top plan view of an assembled apparatus;

Fig. 9 is a schematic view of the device showing the method of starting by employing pressure tanks;

Fig. 10 is a view similar to Fig. 9 and shows the method of starting the motor using an auxiliary electric motor.

The motor illustrated in Figs. 1 to 8 comprises a combustion chamber within a cylindrical assembly 1 which is fastened centrally on the end of a hollow shaft 2.

The cylindrical assembly 1 comprises an annular chamber 3 which is the combustion chamber of the motor. For the purpose of injecting propellant fluid or fluids into the combustion chamber 3 there are provided a number of injectors 4 and 4a around the periphery of chamber 3. These injectors are screwed into the periphery of chamber 3 and are designed to prevent the flow of fluid into the reaction chamber when the apparatus is at rest due to a check valve arrangement within the body of the injector. When the apparatus is revolving the check valve is opened by pressure of the liquid.

The particular motor shown is adapted to be operated by two propellant fluids, for example, aniline and red fuming nitric acid which are separately injected into the combustion chamber.

Accordingly the injectors 4 are adapted for injecting one of the propellants, for example the aniline; and there is provided an additional set of injectors 4a for injecting the acid. The arrangement according to Fig. 5 shows an oxidizer injector adjacent each fuel injector so that the fluid stream from each fuel injector impinges against the fluid stream from each oxidizer injector within the annular chamber.

Two sets of spiral fins 5 and 5a are cut into the horizontal surface of the firing chamber forming spiral channels 6 and 6a. Fuel is supplied to injectors 4 by the spiral channels 6a and oxidizer is supplied to the oxidizer injectors 4a by the spiral channels 6. The manner in which these spiral channels convey fuel and oxidizer to the respective injector is clearly shown in Fig. 4 which shows fuel channels 6a ending at orifices 7 into which the injector nozzles 4 fit; and channels 6 which lead the oxidizer to the injector orifice openings 7a into which injector nozzles 4a fit. All the oxidizer conduits 6 are formed by spiral fins 5 beginning at the rear channel 8 and the fuel conduits 6a are formed by fins 5a which start at the front annular channel 9.

The injectors 4 and 4a comprise a body 80 which is threaded on the outside to screw into the threads cut in the wall of the reaction chamber 3. The inside of the body is bored to within a short distance of the discharge end by bore 81 at which point the diameter of the bore 81 is reduced to a small size creating the injector orifice 82. A hollow cylindrical piston 83, open at the top and closed at the bottom, has a plunger rod 84 centrally attached to the bottom which seats into the opening 85 leading to the injector orifice 82. The hollow piston is lapped to snugly fit the inner bore 81 of injector body 80. The piston plunger is held against the seat opening 85 by means of a compression spring 86 which rests against the bottom of the hollow cylinder at one end and against a cap 87 which screws into the threads cut into the upper end of the bore 81. An orifice 88 is drilled in the center of the cap to permit drainage and release any pressure which may build up during the operation of the apparatus. A series of holes 90 drilled through the wall of the body 80 permit passage of the fluid from the adjoining spiral channel into the injector chamber 89. When the plunger 84 is away from the seat 85 fluid may pass into the reaction chamber through the orifice 82 in the nozzle.

Rear cover 10 and front cover 11 are secured to the annular injector mounting ring 12, which is integral with the firing chamber and extends outwardly beyond the outer edge of the spiral fins 5. These covers 10 and 11 are attached by any suitable method, preferably welding. The front and rear covers are machined inside to fit snugly over the outer edge of the fins 5 and 5a and in this manner prevent the escape of any fluid through leakage between the covers and the fins. A plurality of nozzles 13 (four in this embodiment) preferably of the De Laval type are bolted to the rear cover 10 after being inserted in sockets 14. The orifices 15 of nozzles 13 are inclined at an angle to the horizontal axis of the firing chamber as shown in Figs. 1 and 7 and in this manner provide angular thrust to the unit. The exhaust nozzle sockets 14 are preferably surrounded by spiral fins 16 which are machined into the outside edge of the socket portion of the reaction chamber 3. These fins form channels through which the fluid may flow after the rear cover 10 has been secured in position.

The fins 18 on the vertical portion of the front wall 17 of the firing chamber 3 are preferably shaped like an Archimedean spiral as shown in Fig. 6. This device has the effect of whirling the incoming fluid in much the same manner as the impeller of a centrifugal pump, when the firing chamber assembly rotates. The fluid flowing through channel 20 is discharged into the front annular horizontal conduit 9 and flows in channel 6a to the injector 4a.

The pumping action for the fluid flowing at the rearward side of the motor is achieved by a series of straight impeller blades 19 shown in Figs. 3 and 7 in the form of a cross lying between the nozzle sockets 14. The fluid flowing from the spiral channel 43 in the central portion of the assembly discharges from spiral channel 43 into a space 60. This space is formed by providing a plurality of straight impeller blades 19 on the rear outside surface of the firing chamber against which rear cover plate 10 fits flush. The liquid entering the space 60 is picked up by the blades 19 and thrown by centrifugal force into the spiral channels 16a which surround each nozzle socket, and on reaching the end of the channel 16a the fluid passes through a conduit 65 into the rear horizontal conduit 8 provided in boss 8a which in turn leads to the main spiral channels 6.

The hollow shaft assembly 2 is built up in the following manner: Starting at the front end, that is the end in front of the firing chamber 3, the shaft comprises a hollow tube 25 which enlarges slightly in outside diameter at point 26 to fit a splined worm 27, the inside bore of the shaft remaining the same. Beyond gear 27 the shaft again increases in size until at point 28 it is large enough to merge into the central composite portion of the shaft 29 to which it is welded. This composite section 29 of the shaft is hollow and is made up of two members. The inner member 30 continues the central bore 31 of the member 25. The outside diameter of the inner member 30 of the central portion of the shaft is decreased in diameter in order to form an annular space 32 when fitted into the outer member 33 of the composite section of the shaft. This annular space 32 extends between a fuel entry connection 34 and the fuel discharge conduit 35 shown by dotted lines which feeds the fuel to the spiral channel 20. Fuel is introduced into this annular section from the connection 34 through a series of holes 36 drilled through the thin wall of the outer member 33 to correspond to the annular groove 32 which connects the entry opening 34 to the holes 36.

From the rear end of the annular passageway the diameter of the inner member 30 increases to form a shoulder 38 which terminates at point 39 where the shaft meets the front cover 11 of the firing chamber 3. Beyond point 39 the shoulder again decreases to a smaller diameter 40 which permits the use of sealing rings or packing 41 between the firing chamber 3 and the surface 40 of the shaft and in this manner prevents any of the fluid oxidizer from leaking into the joint between the shaft and the firing chamber. A plurality of slots 42 are cut at the rearward end of the inner member 30 of the composite section of the shaft and permit the passage of the fluid into the central cooling spiral 43 which surrounds the shaft and leads the fluid to the spiral channels 16a surrounding the nozzles from where it passes into the horizontal channel 8 and spiral channel 6 into the injectors 4a.

The outer diameter of the outside member 33 of the shaft increases slightly in size to conform with the bore 44 of ball bearing 45. The shaft then increases again in diameter forming a shoulder 46 against which the bearing securely rests. This diameter continues to approximately the end of the outer member to point 47 at which point it increases sharply in diameter to form flange 48 large enough to accommodate holes 49 through which the stud bolts 50, which secure the firing chamber assembly 1, may pass. These bolts 50 attach the shaft to the front of the firing chamber. The inner portion 30 and outer portion 33 of the central section of the shaft are welded together forming the central composite portion 29. The rearward portion 51 of the shaft which is welded to the central composite portion 29 comprises a solid shaft to which is secured a spiral finned sleeve 43a which when introduced into the central bore 53 of the firing chamber 3 creates a leakproof spiral channel 43. This channel connects with the rear centrifugal pumping device 19. The rearward end 55 of the solid portion of the shaft is threaded to receive a cap nut 56. Nut 56 has a large cylindrical body portion 57 which slides into the central bore 58 of rear cover 10 and helps to secure the entire firing chamber assembly to the rotating shaft. The shaft of the assembled reaction motor is supported by a main bearing 45 and a pair of smaller ball bearings 59 which are located at either side of worm gear 27. All three of the bearings are in turn supported in the bearing housings 61 of the framework 67 which in this particular embodiment of my invention also serves as a gear box for housing the worm 27 and worm wheel 63. These bearings and shaft are sealed from leakage by seal rings 64. These seal rings are housed in packing glands 64a and 64b.

The manner in which the embodiment, shown in the drawings, operates is as follows: Fuel, which may be aniline, flows through the entry connection 34 from a supply tank 106 and travels through the annular space 32 formed between the inner and outer members of the central portion of the shaft. After flowing the length of this shaft the aniline is conducted by conduits 35 shown by the dotted lines in Fig. 1 and is discharged at the central end of the forward spiral channel 20 from which point it travels outward toward the horizontal conduit 9 thereby reaching the injector 4. The oxidizer which may, for example, be nitric acid enters at the connection 54 from a supply tank 107 and flows through the bore 31 of the shaft until it is distributed through and into the slots 42 of the shaft 30 and into the central spiral 43. This spiral serves to cool the central wall of the firing chamber. From this point the fluid passes into the opening between the rear wall of the firing chamber 3 and the rear cover plate 10; there being straight impeller blades 19 fastened at this opening. The liquid is thrown by the impeller blades into the spiral passageways 16a which surround each nozzle socket 14. After the oxidizer has travelled around the entire length of the spiral in the exhaust nozzle sockets it then passes through connecting passageway 65 into the end of rear horizontal passageway 8 in boss 8a and travels forwardly following the helical passageway 6 until it ends at the oxidizer injector nozzle 4a. Both the fuel and the oxidizer in this manner are injected at the same circumferential plane in the firing chamber thereby assuring that the two fluids impinge on each other regardless of the speed of the revolving motor.

Before the pumping arrangements, located at the front and rear of this firing chamber, are capable of operating efficiently it is necessary that the motor be caused to revolve sufficiently fast to create a centrifugal force high enough to overcome the firing chamber pressure. This may be accomplished by initiating the operation of the motor by introducing fuel and oxidizer from auxiliary tanks 100 and 101 under pressure as shown in Fig. 9 and delivering them through the injector nozzles at a pressure sufficient to overcome the chamber pressure. These auxiliary tanks 100 and 101 may be manually disconnected by throttle valves 102 and 103 after the apparatus has reached the desired speed, at which point the centrifugal pumps 18 and 19 of the revolving motor are capable of handling fluids. Check valves 104 and 105 prevent the fuel and oxidizer from the pressure tanks from flowing into the main storage tanks 106 and 107.

Another manner in which the apparatus may be started is shown in Fig. 10 by attaching a pinion 108 to the shaft 2 which meshes with a driving gear 109 connected to electric motor 110 through an overriding clutch 111. The motor will rotate the shaft and the jet motor with sufficient speed to generate the desired pressure on the propellants by means of the centrifugal force created by the whirling pumping devices.

The fuel and oxidizer are introduced separately through their respective nozzles and impinge against each other in the reaction motor in a transverse plane perpendicular to the axis of rotation as shown in Fig. 5. When thus mixed the fuel and oxidizer react and burn and the resulting gases generated by the reaction issue through the nozzles at high velocity to produce thrust. These nozzles are inclined from the horizontal axis of the motor and each nozzle is tilted at the same general angle and in this manner a portion of the thrust resulting from the reaction between the fuel and oxidizer is converted into rotary motion causing the entire motor assembly to revolve. The amount of force lost in revolving the motor is comparatively small to the direct rearward thrust obtained from the reaction.

While aniline and acid have been found especially well suited as the fuel and oxidizer in this embodiment of my invention, it is possible to use other combinations of fuel and oxidizer which will cause spontaneous combustion when mixed together or the apparatus may be adapted for use with a single monopropellant type of fuel such as nitromethane with slight modifications.

It can be seen by the use of this invention a suitable revolving jet motor is available to drive any type of craft in which jet propulsion is desirable.

I claim:

1. A jet propulsion motor comprising a firing chamber mounted for rotation, a plurality of exhaust nozzles for exhausting gas at high velocity from the chamber, said nozzles being directed at an angle from the axis of rotation to produce the rotating force, a plurality of injectors for introducing a fluid fuel, a second plurality of injectors for introducing a second fluid which is spontaneously reactive with said fuel, a conduit means for leading the first fluid from a source to its respective injectors, a second conduit means for leading the second fluid to its respective injectors, both said conduit means comprising spiral conduits in paths of communication from separate conduits located in the shaft to the outer periphery of the chamber and extending to the respective plurality of injectors, the spiral conduit

for conducting one of the fluids encircling an exhaust nozzle before reaching the outer periphery.

2. A jet propulsion motor according to claim 1 in which an impeller blade is positioned at the said second conduit means between the respective conduit which is located in the shaft and the spiral conduit encircling the exhaust nozzle.

3. A jet propulsion motor comprising a cylindrical firing chamber mounted on a shaft which extends axially through the chamber and forming an annular space around the shaft, said chamber having a front wall and a rear wall, exhaust nozzles from within the chamber through the rear wall, said nozzles being directed at an angle from the axis of rotation to produce a rotating force, an injector located at the periphery of the chamber, for injecting fuel into the chamber, and means for leading fluid propellant to the injector, said means comprising a passageway extending along the shaft to the nozzles, then helically around the nozzles to the periphery of the chamber and then helically around the chamber to the injector.

4. A jet propulsion motor comprising a cylindrical firing chamber mounted on a shaft which extends along the longitudinal axis of the chamber and through the chamber, said chamber being closed at the front by a front wall and being closed at the back except for a plurality of exhaust nozzles extending from within the chamber to the atmosphere, said nozzles being directed rearwardly and at an angle to the axis of the shaft in order to produce a rotating force as well as a thrust, fluid fuel injectors located at the periphery of the chamber, each injector having a pair of injector orifices, one of which is to inject one propellant fluid and the other of which is to inject the other propellant fluid, in directions so that the two propellant fluids from the two orifices meet within the chamber, means for leading a first propellant fuel to said injector, said means comprising a conduit along the shaft, a spiral passageway joined to the conduit and extending outwardly along the front wall, a helical passageway connected with the outer part of the spiral passageway and extending along the outer periphery of the chamber and communicating with one of the orifices of the injectors, and another fluid passageway extending along the shaft and passing helically around the nozzles and outward to the periphery of the chamber and helically around the chamber to the other orifice of the injectors, whereby the passage of the fluids around the chamber and the nozzles serve for cooling, and the spiral passageway serves for pumping the fluids to the injectors by centrifugal force, so that the two propellant fluids emerging from the orifices meet in the chamber for combustion.

WALDEMAR F. MAYER.

REFERENCES CITED

The following references are of record in the file of this patent:

UNITED STATES PATENTS

Number	Name	Date
1,418,444	Josephs	June 6, 1922
2,188,128	Armstrong	Jan. 23, 1940
2,395,114	Goddard	Feb. 19, 1946
2,395,403	Goddard	Feb. 26, 1946
2,407,852	Smith	Sept. 17, 1946

FOREIGN PATENTS

Number	Country	Date
459,924	Great Britain	Jan. 18, 1937
339,847	France	Apr. 28, 1904
841,015	France	Jan. 28, 1939