May 10, 1960 K. K. NEUHOEFER 2,935,845

AUTOMATIC INJECTION SYSTEM FOR SELF-IGNITING PROPELLANTS

Filed May 19, 1958 2 Sheets-Sheet 1

Fig. 1.

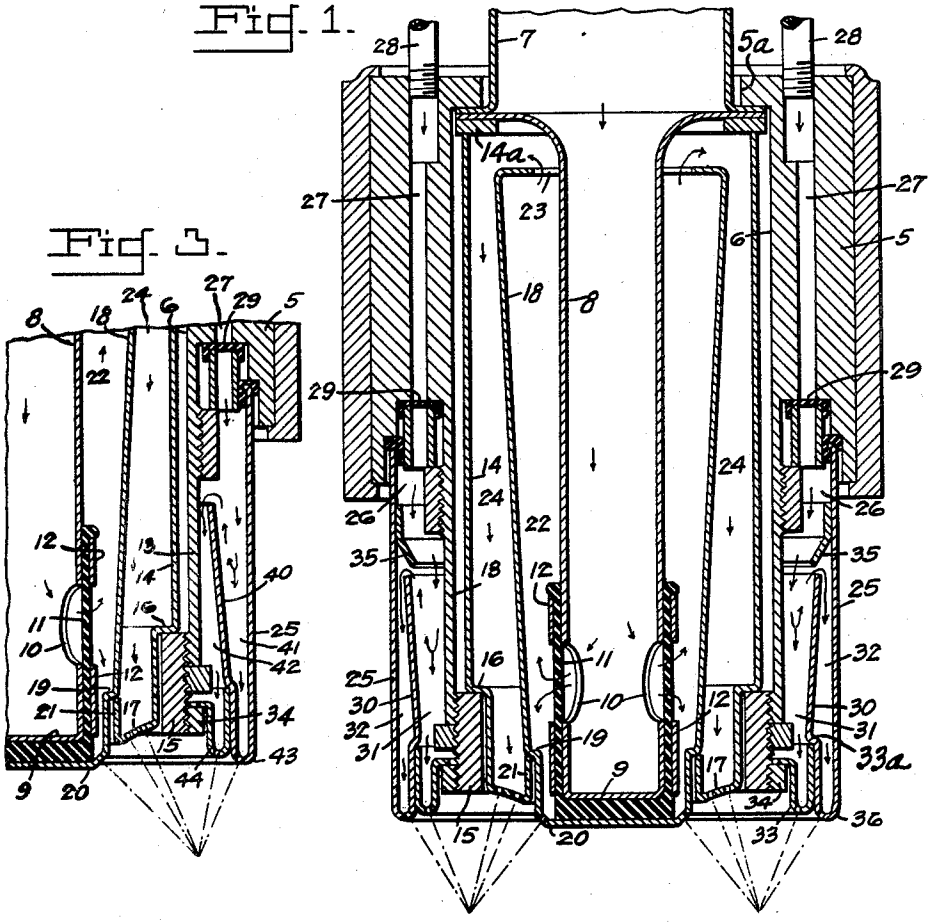


Fig. 3.

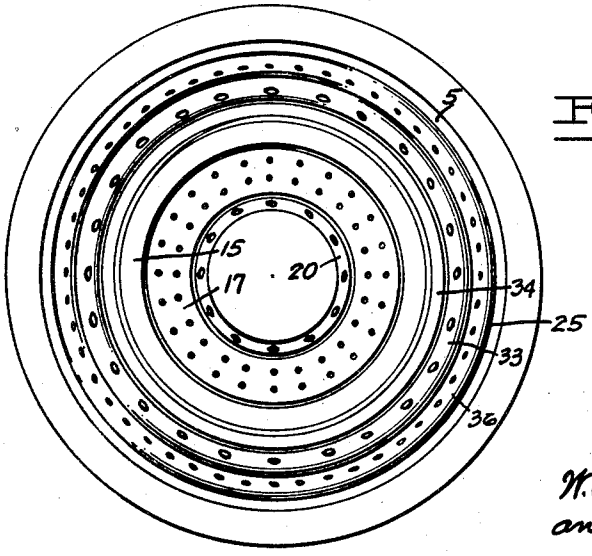


Fig. 2.

INVENTOR.
Kurt K. Neuhoefer

BY
W. E. Thibodeau, A. M. Dew
and D. P. Smith
ATTORNEYS

May 10, 1960 K. K. NEUHOEFER 2,935,845

AUTOMATIC INJECTION SYSTEM FOR SELF-IGNITING PROPELLANTS

Filed May 19, 1958 2 Sheets-Sheet 2

Fig. 4.

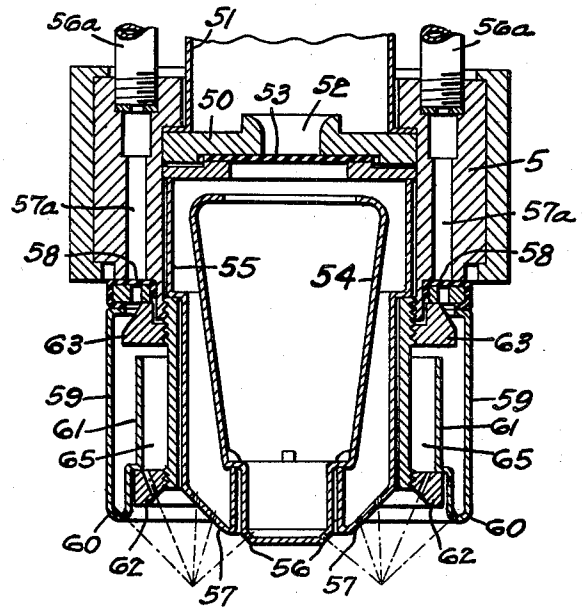
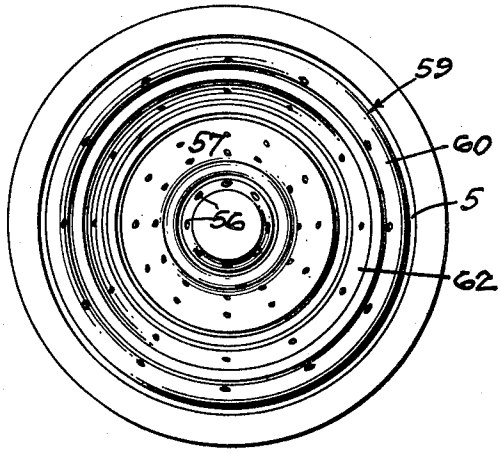


Fig. 5.



INVENTOR.
Kurt K. Neuhoefer
BY
W. E. Thibodeau, A. W. Dew
and D. P. Smith
ATTORNEYS

United States Patent Office 2,935,845 Patented May 10, 1960

2,935,845

AUTOMATIC INJECTION SYSTEM FOR SELF-IGNITING PROPELLANTS

Kurt K. Neuhoefer, Monroe, N.Y., assignor to the United States of America as represented by the Secretary of the Army

Application May 19, 1958, Serial No. 736,412

8 Claims. (Cl. 60—39.46)

(Granted under Title 35, U.S. Code (1952), sec. 266)

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

This invention is a fuel injector for rocket combustion chambers or the like.

An object of the invention is to provide a two stage injection ignition system for rocket motors of the type wherein self igniting propellant fluids under pressure are fed to their respective nozzle outlets first at a low pressure for ignition, and after a predetermined time, at a high normal pressure to produce maximum combustion without danger of an explosion.

Another object of the invention is to provide an injector device which is automatic in operation.

Still another object of the invention is to provide an injector having frangible closures in its supply ducts to prevent flow of fluid reactants until a predetermined pressure is applied to such reactants.

A still further object of the invention is to provide a device which is simple in construction and easy to manufacture and assemble.

Other objects and advantages will be apparent from the following detailed description and the accompanying drawings in which:

Figure 1 is a longitudinal sectional view of one form of the present invention.

Figure 2 is an end view of the structure illustrated in Figure 1, showing the arrangement of the multiple jet nozzles;

Figure 3 is a fragmentary sectional view of a slightly modified form of the invention shown in Figure 1.

Figure 4 is a view similar to Figure 1, showing a further modification of the invention;

Figure 5 is an end view of the structure of Figure 4, showing the arrangement of the nozzles.

In the use of hypergolic reactants, or those which react spontaneously, as a propellant in any form of rocket motor, it has been found advisable to have their several tanks pressurized to a proper degree to effect vaporization at the respective nozzles.

It also has been found necessary to provide means for limiting the initial flow of such fluids, to limit the rate of rise of gas pressure and thus avoid an explosion.

Referring now to Figures 1 and 2 wherein a concentric labyrinth is shown and wherein the reference character 5 indicates the main body portion of the injector, a central bore 6 receives at one end thereof a fluid conduit 7 leading from a reactant tank and axially disposed in the bore; and in fluid tight communication with such conduit is a first fluid inlet duct 8 which is closed at its inner end 9. Openings 10 are formed in the duct near the closed end for a purpose that will presently be explained. A frangible cup shaped cover 11 is secured to the duct by encircling bands 12. Duct wall 14 is held in abutting relationship against ring seal 14*a* by collar 15 screw threaded into sleeve 13 and bearing against

shoulder 16. In a manner obvious from inspection of Figure 1 this construction enables the clamping of the outwardly flanged ends of conduit 7 and duct 8 onto a seat formed by the inwardly flanged end 5*a* of the body portion 5.

The duct wall 14 is reduced near its bottom end to form a circular second stage multiple outlet 17 and is bent back upon itself to form a flange 21. A baffle wall 18 of frustro-conical shape is axially disposed within the duct wall in radially spaced relation therewith and surrounds the duct 8. The rearward end of this baffle wall is reduced slightly in diameter to form a shoulder 19 engageable by flange 21 and terminates in a circular first stage multiple outlet nozzle 20. Thus three concentric ducts or volumes 8, 22 and 24 are formed.

A nut 34 is threaded upon collar 15 and engages a turned out flange upon circular first stage nozzle ring 33. The upper edge of the nozzle ring wall bears against shoulder 33*a* in baffle wall 30, which is formed by bending outer wall 25 back upon itself substantially as shown. Thus two concentric ducts 31 and 32 are formed. At the lowermost portion of the baffle wall are ports constructed to provide second stage nozzle 36. Conduits 28 from a storage tank (not shown) serve to lead one of the reactants into passages 27 which are closed by frangible discs 29. A baffle 35 is welded or otherwise firmly affixed to outer wall 25 to direct the reactant flow into duct 31.

The operation of the injector is as follows:

The inlet passages 8 and 27 may be filled with their respective reactants and held against leakage by their several frangible closures until such time as suitable pressures are applied to their tanks to break the closure.

When pressure is applied the fluids will rupture the frangible closures and flow into ducts 22 and 31. As is shown by the arrows indicating the conditions of flow in Figure 1, the fluids will divide. In the case of duct 22 part of the reactant will be forced out of the first stage nozzle 20 and the remainder will raise the level at a predetermined rate in the duct. In duct 31 part of the fuel will be forced out of first stage nozzle 33 and the remainder will raise the level in the duct at a predetermined rate. A thermodynamic study of the ignition of hypergolic propellants has shown that the initial combustion in the combustion chamber should occur under under conditions of lower than normal pressure and that after a predetermined time interval, to permit temperature rise in the chamber, vaporization of the hypergolic fluid at normal pressure into the combustion chamber will yield optimum starting performance. This is accomplished in my injector by the impinging of the liquids thrown from the relatively large orifices in the first stage nozzles 33 and 20 at a relatively low pressure because of the continuing flow of the liquids into the ducts to raise the level thereof. After a predetermined time ducts 22 and 31 will spill over into the second stage outlet ducts 24 and 32 respectively. When the second stage outlet ducts are full, the flow (velocity head) is reduced and the pressure head rises in accordance with the well known Bernoulli theorem of fluid dynamics; whereupon the reactants are vaporized from the small holes formed in nozzles 36 and 17 and main combustion with all four nozzles ejecting at normal pressure begins. Thus the injector carries out the ideal starting cycle without the use of any moving parts whatsoever.

A varient of my novel injector is disclosed in Figure 3 wherein like parts are designed by like reference characters. It will be seen that the arrangement of parts is similar to the structure of Figure 1 in that a total of five concentric ducts are formed namely 8, 22, 24, 42 and 41, but the arrangement of the duct inlet baffles is such

that ducts 22 and 41 lead to the first stage nozzles 20 and 43 and ducts 24 and 42 lead to the second stage nozzles 17 and 44 respectively. This is accomplished by rearranging the outer labyrinth and having frusted conical wall member 40 converge toward the top of the nozzle substantially as shown.

The operation of this species is similar to the organization of Figure 1. Ducts 8 and 27 remain filled with the fluid reactants until the imposition of required pressure whereupon the frangible closures are shattered and the reactants rush into ducts 41 and 22 there to divide with a portion being thrown from first stage nozzles 43 and 20 and the remainder serving to raise the level in the ducts. When the ducts are full after a predetermined time from the start of the cycle they spill over into ducts 42 and 24, and when these in turn are full the fluid flow slows and normal pressure appears to force the reactants from the second stage nozzles 44 and 17 in a fine mist or spray. It will be noted that this modification provides that the second stage jet is completely surrounded by the first stage jet and all four jets cooperate to produce combustion at normal pressure.

A further species of my invention is revealed in Figure 4 wherein the body member 5 has formed therein a central cavity having an end wall plate member 50 held in fluid tight relationship with the flanged end of fluid duct 51. An opening 52 is made in the end wall which is normally closed by frangible disc member 53. A labyrinth is provided in the central cavity formed of open frustro conical member 54 mounted concentric within a flask member 55. Annular first stage nozzle 56 is constructed in the bottom of member 54 and annular second stage nozzle 57 is formed in flask member 55 substantially as shown. A second labyrinth is provided around the central cavity leading from conduits 56*a* through ports 57*a* through frangible closures 58 to ring member 59 which has formed in the bottom thereof first stage nozzle 60. The inner wall 61 of ring member 59 serves as a baffle between nozzle 60 and second stage nozzle ring 62. A deflector 63 is provided immediately below frangible closure 58 for a purpose that will now be explained.

In operation this species is similar to the two varients described above. The reactants are moved under pressure from their several tanks and rest above frangible closures 53 and 58 until the application of a pressure to rupture the closures. Upon such rupture the reactant from duct 51 flows into member 54 and a part thereof is thrown from first stage nozzle 56 and the remainder serves to raise the liquid level at a predetermined rate. When member 54 is full it spills over into the volume formed between members 54 and 55 and upon filling such volume the pressure rises to normal and the reactant is forced in a fine spray from second stage nozzle 57.

The reactant from ports 57*a* is guided by deflector 63 into ring member 59 wherein a portion thereof is thrown from first stage nozzle 60 to meet the stream from first stage nozzle 56 to initiate combustion and the remainder raises the liquid level in the ring member. After a predetermined time the reactant spills over baffle 61 and fills the internal volume 65 whereupon the pressure rises to normal and the reactant is forced from second stage nozzle 62 to meet the stream from second stage nozzle 57 whereby main combustion occurs.

While I have disclosed several forms of the invention presently preferred by me, various changes and modifications will occur to those skilled in the art after a study of the present disclosure. Hence the disclosure is to be taken in an illustrative rather than a limiting sense; and it is my desire and intention to reserve all modifications falling within the scope of the subjoined claims.

Having now fully disclosed the invention, what I claim and desire to secure by Letters Patent is:

1. An injector constructed to inject hypergolic fluids into a rocket combustion chamber comprising first outlet nozzles for passing said fluids at lower than normal input pressure during combustion starting, ducts for feeding the said fluids to their respective first outlet nozzles, second outlet nozzles for passing said fluids at normal input pressure after a predetermined time from starting and serially interconnected chamber means leading from the said ducts to the said respective second outlet nozzles.

2. An injector constructed to inject hypergolic fluids into a combustion chamber comprising first outlet nozzles for passsing said fluids at lower than normal input pressure during combustion starting, ducts for feeding the said fluids to their respective first outlet nozzles, second outlet nozzles for passing said fluids at normal input pressure after a predetermined time from starting, and serially interconnected chamber means leading from the said ducts to the said respective second outlet passages forming a volume for receiving the said fluids during the said predetermined time.

3. An injector constructed to inject hypergolic fluids into a rocket combustion chamber comprising first outlet nozzles for passing said fluids at lower than normal input pressure during combustion starting, ducts for feeding the said fluids to their respective first outlet nozzles, second outlet nozzles for passing said fluids at normal input pressure after a predetermined time from starting, and serially interconnected chamber means leading from the said ducts to the said respective second outlet passages forming volumes for receiving the flow of fluids during the said predetermined time.

4. An injector constructed to inject hypergolic fluids into a rocket combustion chamber comprising first outlet nozzles for injecting said fluid into said chamber at lower than normal input pressure during combustion starting, concentric ducts for feeding the said fluids to their respective first outlet nozzles, second outlet nozzles for passing said fluids at normal pressure after a predetermined time from starting, and concentric serially interconnected chamber means leading from the said ducts to the said respective second outlet nozzles forming volumes for receiving the flow of fluids during the said predetermined time.

5. An injector constructed to inject hypergolic flpids into a rocket combustion chamber comprising first outlet nozzles for injecting said fluids into said chamber at lower than normal input pressure during combustion starting, ducts for feeding the said fluids to their respective first outlet nozzles, frangible closures in said ducts to seal the same and adapted to break under the said normal input pressure, second outlet nozzles for passing said fluids at normal pressure after a predetermined time from starting, and serially interconnected chamber means leading from the said ducts to the said respective outlet nozzles forming volumes for receiving the flow of fluids during the said predetermined time.

6. An injector constructed to inject two hypergolic reactants into a rocket combustion chamber comprising a body member, a cylinder disposed in said member, a conduit for carrying one reactant in fluid tight communication with the top end of said cylinder, ports formed in the wall of said cylinder near the bottom end thereof, a frangible element normally closing said ports, a frusto conical member fixed around and spaced from said cylinder and defining a first volume therebetween, ports formed in the bottom of said frusto conical member constructed to provide a first stage outlet nozzle for the said one reactant, a baffle fixed around and spaced from said frusto conical member and defining a second volume therebetween, ports formed in the bottom of said baffle constructed to provide a second stage outlet nozzle for the said one reactant, a wall member fixed to said body member and having a portion thereof turned back upon itself to form a third volume, ports formed

in the bottom of said wall member constructed to provide a second stage outlet nozzle for the other reactant, a ring member fixed upon said body member and cooperating with the said turned back portion to form a fourth volume, ports formed in said ring member to provide a first stage outlet nozzle for the said other reactant, passages to carry the said other reactant formed in said body member and leading to said fourth volume, frangible members normally closing said passages, and conduit members in fluid tight communication with said passages.

7. An injector constructed to inject two hypergolic reactants into a rocket combustion chamber comprising a body member, a cylinder disposed on the longitudinal axis of said member, a conduit to carry one reactant in fluid tight communication with the top end of said cylinder, ports formed in the wall of said cylinder near the bottom end thereof, a frangible element normally closing said ports, a frusto conical member fixed around and spaced from said cylinder and defining a first volume therebetween, ports formed in the bottom of said frusto conical member constructed to provide a first stage outlet nozzle for the said one reactant, a baffle fixed around and spaced from said frusto conical member and defining a second volume therebetween, ports formed in the bottom of said baffle constructed to provide a second stage nozzle for the said one reactant, a wall member fixed to said body member and having a portion thereof turned back upon itself to form a third volume, ports formed in the bottom of said wall member constructed to provide a first stage nozzle outlet for the other reactant a ring member fixed upon said body member and cooperating with the said turned back portion to form a fourth volume, ports formed in said ring member to provide a second stage outlet nozzle for the said other reactant, passages to carry the said body member and leading to said third volume, frangible members normally closing said passages, and conduit members in fluid tight communication with said passages.

8. An injector constructed to inject two hypergolic reactants into a rocket combustion chamber comprising a body member, a longitudinal passage formed within said body member, a plate disposed transverse to the said longitudinal passage, an opening formed in said plate, a frangible element normally closing said opening, a conduit for one reactant communicating in fluid tight relationship with said plate, a frustro conical member aligned with said opening and extending beyond the said body, ports formed in the bottom of said frustro conical member constructed to provide a first stage outlet nozzle for the said one reactant, a baffle fixed around and spaced from said frustro conical member and defining a volume therebetween, ports formed in the bottom of said baffle constructed to provide a second stage outlet nozzle for the said one reactant, a wall member fixed to said body member and having a portion thereof turned back upon itself to form a second volume, ports formed in the bottom of said wall member constructed to provide a first stage nozzle outlet for the other reactant, a ring fixed to said body member and cooperating with the said turned back portion to form a third volume, ports formed in said ring constructed to provide a second stage outlet nozzle for the said other reactant, a baffle secured to said body to direct the flow of the said other reactant into the said second volume, passage formed in said body member and leading toward said baffle, frangible members normally closing said passage and conduit members in fluid tight communication with said passages.

References Cited in the file of this patent

UNITED STATES PATENTS

2,829,491 Teague ---------- Apr. 8, 1958