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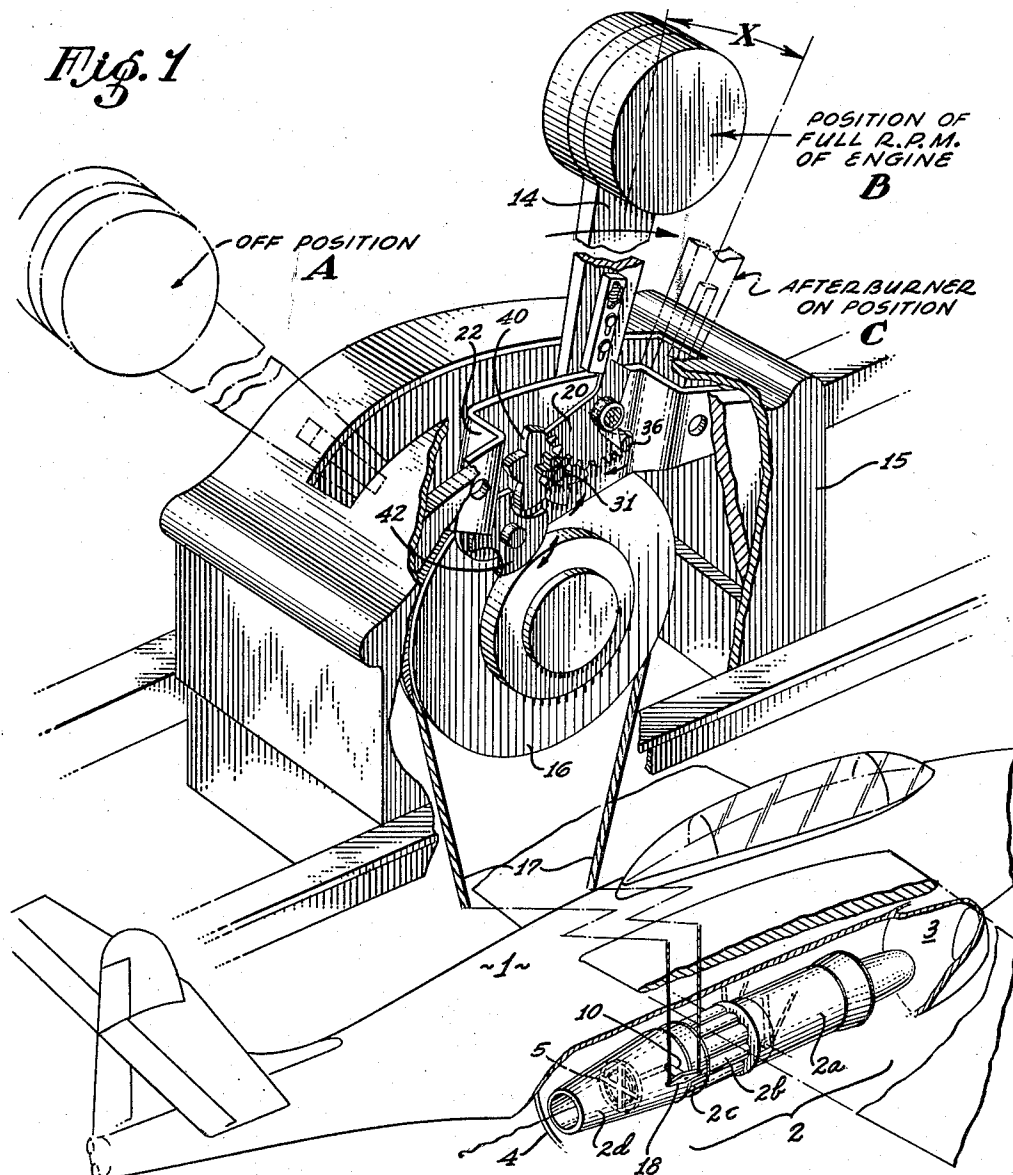
W. B. MORRIS

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JET ENGINE THROTTLE CONTROL

Filed Aug. 3, 1951

2 Sheets-Sheet 1



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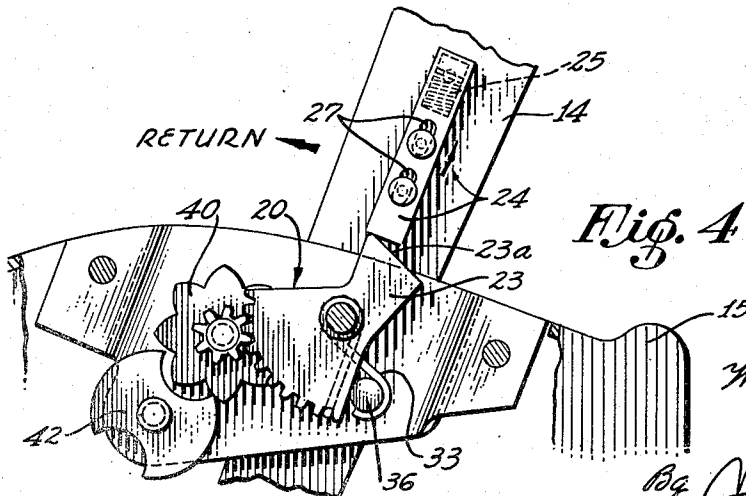
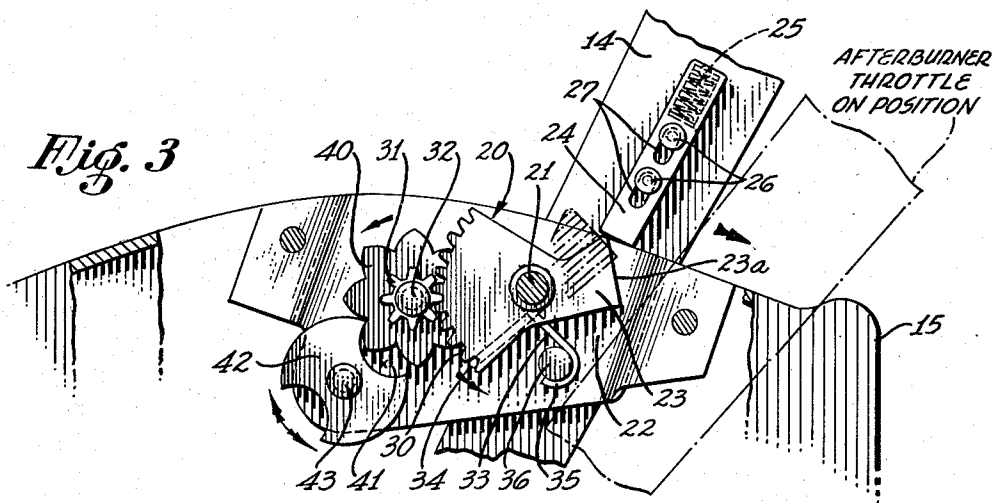
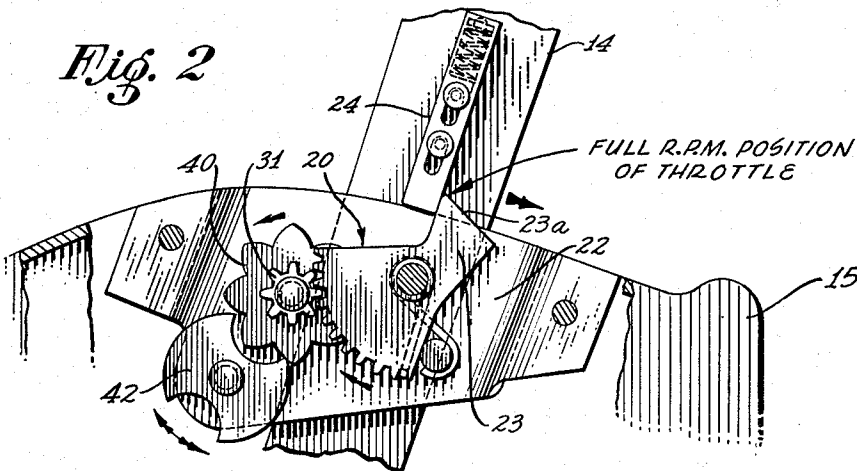
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2 Sheets-Sheet 2



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## UNITED STATES PATENT OFFICE

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## JET ENGINE THROTTLE CONTROL

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2 Claims. (Cl. 74-565)

1

My invention relates to turbo-jet engine controls for airplanes, and more particularly to the pilot's throttle controls where the turbo-jet engines are equipped with afterburners.

The term "afterburner" is used herein as meaning any means for admitting fuel to a jet engine to be burned in the jet gas after it has passed the turbine wheel of the engine. Such additional fuel is ignited by the heat of the jet gas, and adds substantial thrust to the jet. However, the fuel economy is relatively poor, and afterburning is usually resorted to only on take-offs or to provide extra power in emergencies.

In the usual jet engine installation where the engine is equipped with an afterburner, the throttle shaft of the engine controlling fuel admission thereto, has a minimum engine R. P. M. position, and a maximum R. P. M. position. It is required that fuel be admitted to the afterburner after the engine has reached a minimum of 90% R. P. M. It is usual for the throttle shaft to rotate beyond maximum R. P. M. position, to a position where fuel is also admitted to the afterburner.

A throttle arm is positioned for manual operation by the pilot of the airplane and is connected to rotate over a sector having positions corresponding to the minimum R. P. M., maximum R. P. M., and "afterburner on," positions, with a detent type of retard at the maximum R. P. M. position, so that the pilot will feel the retard but can overcome the retard to move the throttle arm freely thereafter into afterburning position. It has been found however, that such types of retards positioned at the maximum R. P. M. position are often overridden in the normal control of the jet engine R. P. M. by the pilot, and fuel accidentally admitted to the afterburner when not desired.

For example, the throttle arm can be moved by the pilot to maximum R. P. M. position before the engine actually reaches even 90% of maximum R. P. M. and if, under these circumstances, such as might occur when accelerating after a balked landing, fuel were to be admitted to the afterburner, the result might well be disastrous because the afterburner fuel would not burn properly.

It is an object of the present invention to provide, in a jet engine throttle control system in an airplane, means for preventing accidental admission of fuel to an afterburner in said engine.

It is another object of the present invention to provide, in a jet engine throttle system, a firm indication to the pilot of the airplane that

2

maximum R. P. M. position of the throttle has been reached.

It is still another object of the invention to provide means, in a jet engine throttle control, for imparting a forced time delay between maximum R. P. M. position and the position at which fuel is admitted to the afterburner. Such a time delay permits the engine to attain full R. P. M. before the fuel is admitted to the afterburner.

Other objects will become apparent as the description of the invention progresses.

Briefly the present invention in one form comprises a throttle arm operable by the pilot of an airplane to control a turbo-jet engine in the airplane between the minimum R. P. M. and the maximum R. P. M. of the engine, and movable beyond the maximum R. P. M. position to admit fuel to an afterburner in the engine. At the maximum R. P. M. position the throttle arm engages an inertia type governor, so that as the throttle arm is moved by the pilot toward the afterburning position, the force by which the throttle arm can be moved is increased over a remaining portion of the arc prior to reaching the position at which the afterburner fuel is turned on, and the pilot must, therefore, before the afterburner can be turned on, exert a steady and greatly increased force to cause the arm to pass through the sector position over which the governor is engaged. Short of structural failure, it is impossible for the pilot to rapidly push the throttle arm past maximum R. P. M. position, as the governor acts as a solid stop under these conditions until the arm speed is reduced to a speed permitted by the governor under the force applied. At any speed the inertia of the governor makes an unusually large force necessary for movement of the arm, as compared to the force required to move the throttle arm between minimum and maximum R. P. M. positions. Thus a time factor is introduced between the maximum R. P. M. position and the position where fuel is admitted to the afterburner, this time delay being sufficient for the engine to reach a safe R. P. M. before the afterburner is turned on.

My invention will be more fully understood by reference to the drawings in which:

Figure 1 is a perspective view of a pilot's throttle arm, along with a diagram showing connection to a turbo-jet engine driving an airplane.

Figures 2, 3 and 4 are side views of the governor shown in Figure 1 in various operational positions.

Referring first to Figure 1, an airplane 1 (only

partially shown) is provided with a turbo-jet engine 2, the latter being mounted in the airplane 1 to provide an air inlet duct 3, and a tailpipe shroud 4. Turbo-jet engines, as at present used in airplanes, comprise a compressor portion 2a receiving air from inlet duct 3, a plurality of combustion chambers 2b in which fuel is burned in the air coming from compressor section 2a, and a turbine section 2c in which a turbine wheel (not shown) is rotated by the heated compressed air. The hot gases, after passing through the turbine section 2c are exhausted rearwardly of the airplane as a jet through a tailpipe section 2d inside of the tailpipe shroud 4 to provide the propulsive thrust for the airplane.

As a substantial percentage of oxygen still remains in the hot gases passing through the turbine of the engine, it has become customary, particularly in military airplanes, to release fuel into the jet for burning this residual oxygen. This may be done for example, by the use of a ring type afterburner 5 disposed in the tailpipe section 2d just rearwardly of the turbine wheel. Fuel released through fuel feed holes in the afterburner ring 5 is immediately ignited by the hot jet gas and burns, thereby providing a substantial additional propulsive thrust for the airplane.

However, as the fuel economy of such an afterburner is very low, the afterburner is only used when extraordinary thrust is required such as for take-offs, on short fields or, in the case of military airplanes, for "military power" in emergencies, particularly in combat.

As the afterburner thrust is highest when the jet engine is running at full R. P. M., it is customary for a throttle shaft 10 on the jet engine 2 to be made rotatable to control the fuel supply to the combustion chambers 2b from zero to maximum, and then to be further rotatable to admit fuel to the afterburner 5.

A pilot's throttle arm 14 is positioned in the airplane to be manually moved over an arc in an arm housing 15; the arm 14 being connected to the throttle shaft 10 through a throttle arm pulley 16, throttle cables 17 and a throttle lever 18 attached to the throttle shaft 10 on the engine 2.

Ordinarily, a substantial angle of rotation of the throttle arm 14 is used to move the throttle from "off" or zero engine R. P. M. position A, to maximum engine R. P. M. position B, at which point a spring detent device is normally installed, to be felt and overridden by the pilot in case he desires to move the throttle arm 14 beyond the maximum R. P. M. position into "afterburner on" position C. This latter position is reached by moving the throttle arm 14 over a smaller angle X to the end of the control sector, at which point fuel is admitted to the afterburner.

As a spring detent such as just described offers only a momentary retard to the movement of the throttle arm, in the nature of a signal, it is readily possible for the pilot to move the arm 14 past the detent into afterburning position before realizing what he has done, and it is possible for the afterburner to be turned on before the engine has reached the 90% maximum R. P. M. required for proper afterburner operation. This is particularly apt to occur, and has occurred with damage to the engine, when full acceleration is desired from idling engine speed for example.

To insure that proper engine speed is attained before the afterburner can be turned on, the present invention utilizes a governor which prevents the arm 14 from being moved rapidly over the angle X between maximum R. P. M. position

B and afterburner on position C, and which forces the pilot to greatly increase the force necessary to move the throttle arm 14, thus providing a time delay during which time the engine speed can "catch up" to throttle arm position.

One form this governor can take is shown in all the figures. A governor lever 20 is mounted on a pin 21 supported by a housing bracket 22 to have an arm portion 23 extending upwardly in the path of a governor block 24 slidably attached to the side of the throttle arm 14. Block 24 is forced toward the axis of rotation of arm 14 by block spring 25 and the block is limited in travel by block pins 26 attached to arm 14 and operating in slots 27 in block 24. The end of arm portion 23 is provided with a camming surface 23a sloping toward position C.

Governor lever 20 extends below pin 21 in the form of a gear segment 30. In engaging at all times a pinion 31, mounted on a pinion shaft 32 extended from bracket 22, governor lever 20 is urged rearwardly by spring 33 wound around pin 21 and having one end 34 engaging a tooth in gear segment 30, the other end 35 engaging a stop pin 36 against which gear sector 30 normally rests, as best shown in Figure 2.

A star wheel 40 is attached to pinion 31 to be rotated with it, and the points of star wheel 40 are shaped to engage an escapement arc 41 in a balanced wobble weight 42 free to rotate on a weight pin 43 also supported by bracket 22.

The operation of the device at different positions is shown in Figures 2, 3 and 4.

In Figure 2, arm block 24 is shown in its lower position contacting arm portion 23 of the governor lever 20. This contact is made at full R. P. M. position B. In order for the throttle arm 14 to be moved past this position, sufficient force must be used by the pilot to rotate governor lever 20 which in turn rotates pinion 31 and attached star wheel 40. Star wheel 40 cannot rotate without wobbling wobble weight 42, which due to the inertia of repetitive direction change, prevents the pilot from moving the throttle 14 freely between maximum R. P. M. position B and the afterburner position C. The force must be continuously applied until a position is reached just prior to the afterburner on position C. At that point, contact between arm block 24 and arm 23 of governor lever 20 is lost, as shown in Figure 3, and the governor lever 20 is free to return to its original position under the urge of spring 33, leaving the throttle arm 14 free to be moved slightly farther into afterburner on position C.

When it is desired that the afterburner be turned off and the throttle arm 14 returned to maximum R. P. M. position B, free movement of the arm 14 is provided for, as arm block 24 on the return movement, hits the angular camming surface 23a on the end of the arm portion 23 of the lever 20, and rises in slots 27 to pass over the arm portion 23. Arm block 24 then returns to its original position under the urge of block spring 25. The throttle arm 14 is then back in the engine R. P. M. range of the throttle arm 14.

It is to be noted that while the throttle arm 14 can be moved at various speeds through the range where the force producing assembly is operating, that the force required to move the arm increases as the arm speed is increased, and that this force must be continuously applied over the entire range where the force producing assembly is in operation.

Under normal circumstances, when the pilot

wishes to move the arm 14 rapidly into the maximum R. P. M. position B, only a relatively light force is required. However, when contact is made between the moving arm block 24 and the arm portion 23 of the governor lever, a solid stop effect is produced for that force. Continued progress of the throttle arm 14 past the maximum R. P. M. position requires the continued application of a much higher force by the pilot, a force that must be deliberately and consciously exerted and maintained over a substantial arc of the throttle arm between maximum R. P. M. sector position and afterburner, and a time delay is important to the movement of the throttle arm.

Thus the present invention makes it practically impossible for a pilot to accidentally move his throttle control arm into afterburning position, and prevents such motion until the engine has had time to accelerate to at least 90% full R. P. M.

While in order to comply with the statute, the invention has been described in language more or less specific as to structural features, it is to be understood that the invention is not limited to the specific features shown, but that the means and construction herein disclosed comprise the preferred form of putting the invention into effect, and the invention is therefore claimed in any of its forms or modifications within the legitimate and valid scope of the appended claims.

What is claimed is:

1. A pilot's throttle assembly for controlling a jet engine propelling an airplane, when said jet engine is equipped with an afterburner which comprises a throttle shaft on said engine rotatable from minimum to maximum R. P. M. positions and beyond maximum R. P. M. position to admit fuel to said afterburner, a throttle arm shaft, a throttle arm mounted on said shaft and movable over a predetermined arc by the pilot of said airplane, means connecting said arm shaft to rotate said throttle shaft, said arm arc including a minimum R. P. M. position adjacent one end thereof, an afterburner fuel admission position adjacent the other end thereof, and a maximum

R. P. M. position intermediate said minimum R. P. M. position and said afterburner fuel admission position, said arm being free to move between said maximum and minimum R. P. M. positions at the will of the pilot, a contact block slidably mounted on said arm, a spring urging said block to a lower position, a lever having one end thereof engageable with said contact block when said block is at said lower position and at said maximum R. P. M. position to move said lever as said throttle arm is progressed over a substantial distance toward said afterburner fuel admission position, governor means connected to be actuated by movement of said lever, said block disengaging from said lever as said afterburner fuel admission position is approached, means for returning said lever to its original position after block disengagement, and a camming surface on the end of said lever originally engaged by said block, over which said block rides when said throttle arm is returned to maximum R. P. M. position.

2. Apparatus in accordance with claim 1 wherein said governor means includes a gear sector on the other end of said lever, a gear pinion engaged with said sector, a star wheel connected to said pinion, a weight pivoted adjacent said star wheel, said weight having an escapement area positioned to be engaged by said star wheel.

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