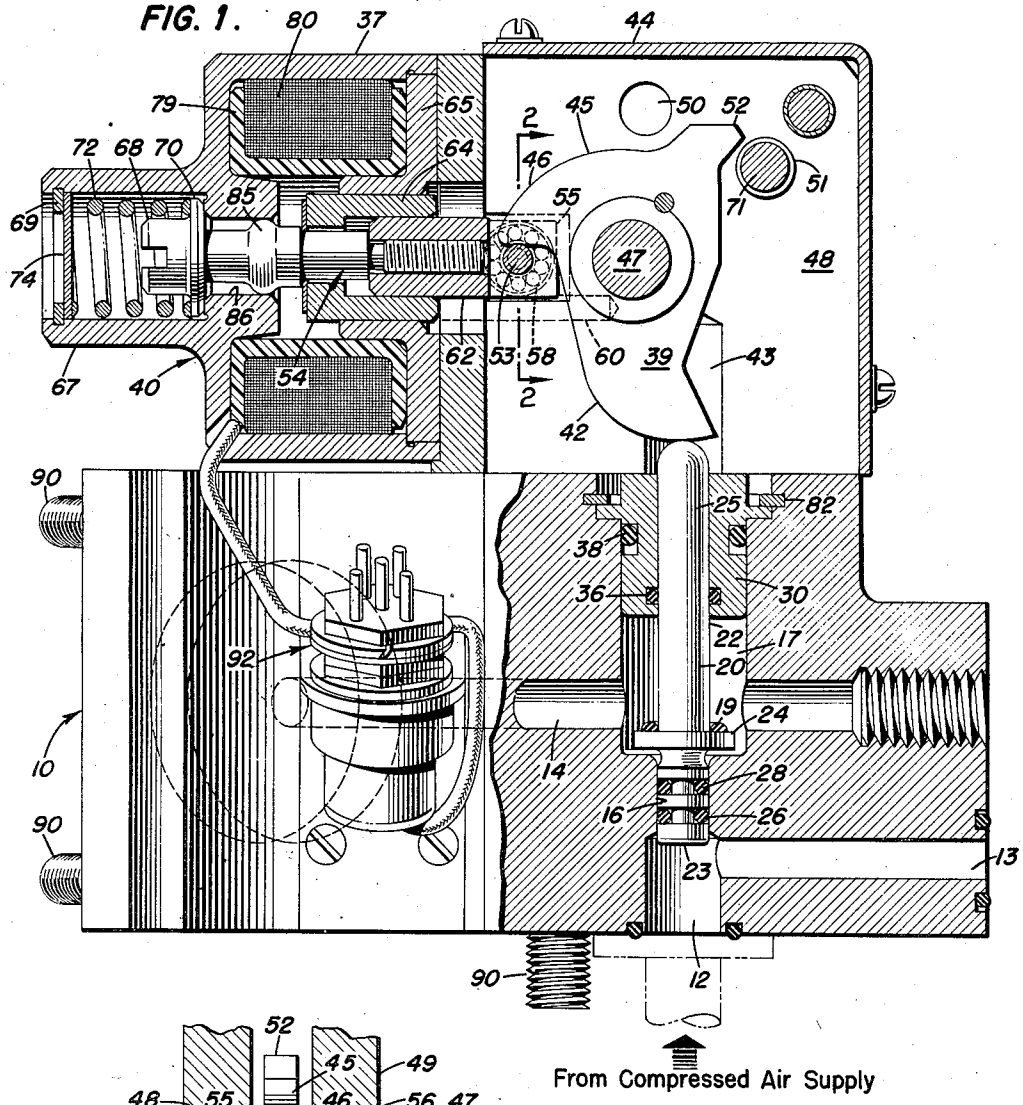
Aug. 5, 1958 S. KONGELBECK 2,846,180

AIR SHUT-OFF VALVE

Filed April 25, 1955

FIG. 1.



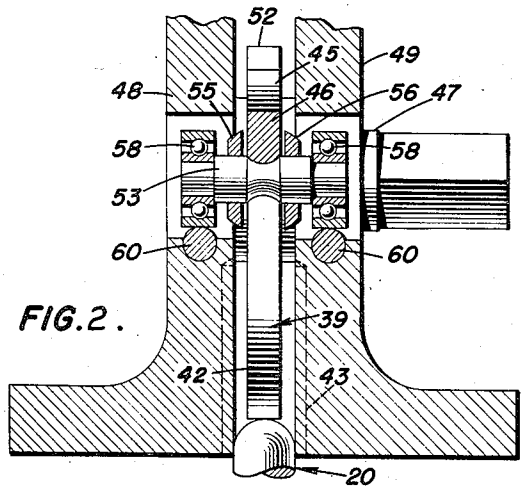


FIG. 2.

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AIR SHUT-OFF VALVE

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Application April 25, 1955, Serial No. 503,838

4 Claims. (Cl. 251—68)

The present invention relates to valve mechanisms, and more particularly to a valve for connecting a source of high-pressure air to a prime mover inside a guided missile.

In guided missiles, as well as for other applications, high pressure air is frequently utilized to provide power because it poses no shelf life problems such as are normally encountered with other types of power supplies. For example, in the case of a guided missile intended for tactical uses, air under pressure which is to be used for driving an electrical generator to furnish power for the electrical circuits of the missile and for similar purposes when the missile is fired, can be stored for relatively long periods of time in air storage bottles in the missile.

For making high pressure air available for actuating an electrical generator, a conventional "burst-diaphragm" valve has been used in the rocket type of aerial missile. This type valve is utilized to block the air passage between the air storage bottle and the air motor with its associated air pressure regulators by means of a thin metal diaphragm firmly and tightly secured in the valve body. The valve mechanism is provided with a special mechanism for puncturing the diaphragm by the means of a sharp tipped plunger, which is spring loaded and solenoid triggered for opening the air passage when required.

One of the obvious shortcomings of this type of valve is that once it has been opened, that is, the diaphragm punctured, the air bottles cannot be recharged again without replacing the punctured diaphragm with a new one. It is important to observe that the operation of recharging the air storage bottles is a tactical necessity in a case when, for instance, the missile is energized on the launcher through its internal power supply by piercing the diaphragm and that subsequently the missile is not fired, for instance, through malfunctioning of the booster squib or for any other causes. In such a case, the air passage between the air storage bottle and the power package must be closed off and the air storage bottle again charged up to the required air pressure before the missile again can be prepared for launching.

The burst-diaphragm type of valve can only be closed off again by removing the outer missile shell and dismantling the valve in order to replace the diaphragm. This is a cumbersome operation which, in some missiles, requires a recheck of the missile, and is, indeed, an undesirable condition.

One of the objects of this invention is to provide a unique valve mechanism which eliminates the shortcomings of "burst-diaphragm" valve.

Another object of the invention is to provide a quick opening air valve mechanism which can be reset manually from outside the missile.

Another object of the invention is to provide a simplified valve mechanism which is utilized for rapidly opening and closing bottles storing high pressure media.

These and other objects and many of the attendant advantages of this invention will be readily appreciated as the same becomes better understood by reference to the following detailed description when considered in connection with the accompanying drawings in which:

Fig. 1 is a sectional view through the invention with parts thereof being shown in elevation; and

Fig. 2 is a fragmentary section on an enlarged scale taken along line 2—2 of Fig. 1.

In accordance with the invention, a valve mechanism is provided for connecting air or any other substance under pressure from a storage bottle to the missile power package. This valve mechanism includes a valve block having a passageway therein, together with a valve plunger provided with rubber O-rings and which is slidably mounted in the block and arranged to be moved to close the passageway.

A contoured cam, which is located in position by a pin on a solenoid plunger, is rotatably supported adjacent the valve plunger for releasably maintaining the valve plunger in a position to close the passageway. In addition, the cam is provided with a projection thereon, together with a solenoid actuator which is mounted adjacent to the cam. The solenoid actuator includes a moveable mounted armature, with a solenoid plunger slidably received in the armature.

The pin carried on the solenoid plunger is arranged to engage the projection on the cam. A coil provides a magnetomotive force for moving the armature and the solenoid plunger to partially withdraw the pin to release the cam, as will be described more in detail subsequently, so that it can rotate about a shaft center. A spring means urges the plunger into engagement with the projection on the cam.

The force required to rotate the cam is provided by the air pressure in the bottle forcing the valve plunger end against the cam profile, which is contoured and oriented so as to create a turning torque on the cam, and which, when turning, permits the ejection of the valve plunger with its O-rings from the air passage and thereby permitting air to flow to the power package in the missile.

The improved valve mechanism provides exactly the same function as the burst-diaphragm valve, that is, by energizing the solenoid the air passage between the storage bottle and the power package has been opened.

However, the improvement provided by this new valve mechanism will become quite self-evident subsequently. In this new valve mechanism, the cam, when turned approximately 90° clockwise, will push the plunger with its O-rings back into its original seat and provide a closure for the air passage should it so be desired and the air bottle may again be recharged with high pressure air.

Means are also provided for turning the cam clockwise by extending the cam shaft outside the housing and providing this extension with a wrench-engagement which can be reached through a small hole in the outer missile shell, the closure of which can be achieved with a cap or a screwed-in plug.

Referring to Fig. 1, there is illustrated a valve block 10 which has an air inlet passageway 12 for introducing air therein from an air storage bottle (not shown), an outlet passageway 14 for the air, and a passageway 16 and a chamber 17 for interconnecting the air inlet and outlet passageways 12 and 14. A passageway 13 is provided in the valve block 10 for recharging the air storage bottle through a check valve (not shown).

The passageway 12 is connected to the storage bottle or vessel containing high pressure air, and the passageway 14 is connected to an air motor (not shown), or other

equipment which furnishes electrical and hydraulic power for the missile and for similar purposes.

A valve plunger **20** comprising a valve stem **22**, a piston **23**, and a flange **24** is slidably mounted in the valve block **10** for controlling the flow of air through the interconnecting passageway **16**. Piston **23** of the valve plunger **20** is provided with a pair of spaced O-rings **26** and **28** so that when the valve plunger **20** is in the position shown in Fig. 1, the passageway **16** is closed and no air can flow from the inlet passageway **12** to the outlet passageway **14**. An O-ring valve stem gasket **19** provides a seal between the valve stem **22** and the flange **24**.

End **25** of valve stem **22** is slidably carried in a valve bushing **30** which is held in place by a snap ring **82** located between the bushing **30** and the block **10**. An inner O-ring valve bushing **36** and an outer O-ring valve bushing **38** are carried on the valve bushing **30** for providing an airtight seal between the valve stem **22** and the valve bushing **30**, and between the valve bushing **30** and the chamber **17**, respectively.

The valve plunger **20** is held in position by a contoured cam **39** contained in a cam housing having cover **44**. A solenoid actuated mechanism **40** in a solenoid housing **37** is provided for releasing the cam **39**, thereby allowing the valve plunger **20** to be moved upwardly into a recess **43** in block **10** by the high pressure air in the passageway **12**. The surface of cam **39** includes segments **42** and **45** joined by a projection **46**. The cam **39** is rotatably mounted on a cam shaft **47** journaled in spaced plates **48** and **49** which are integral with block **10**. The plates **48** and **49** are provided with apertures **50** and **51** which cooperate with a projection **52** on cam **39** in a manner that will be explained hereinafter.

To lock the cam **39** with the valve plunger **20** in the closed position, a pin **53** is carried on a solenoid plunger **54** and arranged to engage the projection **46**. The pin **53** is mounted between bifurcations **55** and **56** on the plunger **54**. A ball bearing **58** is mounted on each end of pin **53**, in rolling contact with a supporting rail **60** as best seen in Fig. 2.

The solenoid plunger **54** includes an enlarged section **62**, which has been slotted to form bifurcations **55** and **56**, slidably carried in a cylindrical armature **64** which is, in turn, slidably mounted in the end cap **65** of solenoid housing **37**. A plastic coil spool **79** is provided in the solenoid housing **37** to maintain the magnet coil **80** in position.

The enlarged end **68** of the solenoid plunger **54** is provided with a flange **70**, and with a spring **72** being interposed between the flange **70** and a disc **74** which is retained in the reduced end **67** of housing **37** by snap ring **69**. It is to be noted that the solenoid plunger **54** is formed with an enlargement **85** which has a spherical contour so as to permit it a certain amount of freedom within the bore **86** in the magnet pole tip.

The aperture **51** in the plates **48** and **49** is adapted to receive a pin **71** which limits the rotation of cam **39** by engaging the projection **52** thereon. Pin **71** is permanently installed in aperture **51** to prevent the cam from rotating too far in a clockwise direction. A second pin (not shown), which is removable, is inserted in aperture **50** to prevent premature actuation of the valve. Also, for ascertaining whether the valve is in operating condition, the removable pin (not shown) may be withdrawn and a special tool inserted into the aperture **50**. The special tool can be a rod having a groove extending around part of its circumference that is of proper dimension to receive the edge of the cam. This grooved rod can be inserted into aperture **50** and the solenoid **40** can be actuated. If the grooved rod is properly positioned, the edge of the cam **39** will enter the groove and it will be impossible to withdraw the rod, indicating that the valve actuator is working. This test can easily be made immediately prior to firing of the missile. The valve can then be reset and the pin withdrawn. Stud bolts **90** are provided for attaching the valve mechanism in the missile. A plug assembly **92** is also provided for making electrical connections.

While the invention is regarded as residing in the general arrangement described above, it is desirable to point out especially some of the engineering features of the valve mechanism.

Apart from the standard design considerations, such as reliability and ruggedness of the valve arrangement which govern machine design in general, there are two other features of the valve arrangement such as lightness and compactness which are required prerequisites in the design of missile components and of these two features compactness is usually the most important.

In order to obtain reliability of the solenoid operated mechanism, the solenoid is, in most cases, greatly overdesigned and the solenoid becomes a rather large and bulky component. In order to reduce the physical size of the solenoid, it is greatly important to attempt to reduce the force that the solenoid is required to exert, and, secondly, to utilize the solenoid at the optimum condition of available force.

In the valve mechanism described, these two considerations have been satisfied since the force required to trigger the cam **39** has been reduced by eliminating all rubbing friction in conjunction with the load to be triggered by mounting the triggering pin **53** on two ball bearings **58**, and the electromagnetic force of the solenoid **40** has been made as large as possible by reducing the gap between the tip of the electromagnet and the actuating armature **64** to a minimum.

When the air bottle is charged up to 4,000 p. s. i., the plunger **54** attempts to rotate the cam **39** counterclockwise but is prevented from doing so because the projection **46** of the cam **39** bears down on the pin **53** with a force of approximately 75 pounds. If this triggering pin **53** could not rotate and would have to slide away from under this load, the rubbing friction would amount to approximately 25 pounds atnd the solenoid **40** would, therefore, have to be designed to pull with a force of 25 pounds plus a rather large safety margin and the solenoid **40** would become rather bulky. By suspending the triggering pin **53** as shown between two ball bearings **58**, the pin **53** will be free to roll along the cam projection **46** because it is floating in these two ball bearings **58** and the ball bearings themselves will roll on two hardened steel pins **60** which act as rails for the ball bearings **58** which otherwise might become "brinelled" into the rather soft aluminum cam housing **41**. This arrangement has reduced the necessary force to trigger the cam **39** by a large margin and a force of about one (1) or two (2) pounds will readily trigger the valve mechanism.

In an effort to obtain the maximum pull of the small solenoid magnet, the air gap between the stationary magnet tip and the actuating armature has been made as small as possible. The reason for reducing the air gap to a minimum is based on the well-known characteristic that force between two magnetized bodies is at a maximum when they are in direct contact with each other and that the force decreases very rapidly as the distance between them increases.

Referring to Figs. 1 and 2, it readily follows that the triggering pin **53** must be moved entirely out of the way of the cam projection **46** if the cam **39** is to be permitted to rotate. However, it is also apparent that if the pin **53** is withdrawn only part of the way to a position where the rounded tip of the cam projection **46** contacts the pin **53** to the right of its center, the cam **39** will exert a force on the pin **53** attempting to push it out of the way towards the left, which direction incidentally coincides with the direction of pull of the magnet. This condition has been taken advantage of as will now be explained.

The air gap, that is the active travel of the armature **64**, has been made sufficient to move the pin **53** towards

the left about one-eighth inch (⅛"). From then on the cam **39** will exert a force attempting to push the pin **53** the rest of the way. Now, by making the plunger-rod end assembly **54** slidable within the armature **64** by an amount of another ⅛", this assembly will be pushed to the left by the force exerted by the cam **39**. Were it not for this particular arrangement, the gap between the armature **64** and the magnet pole would have to be approximately one-fourth inch (¼"), which is the distance the pin **53** would have to be withdrawn in order to permit the cam **39** to rotate and over this larger air gap the solenoid would have appreciably less than one half the pull it has with a ⅛" air gap and the required solenoid coil **80** would have had to be made appreciably larger.

In operation, let it be assumed that the valve mechanism, and associated parts are mounted in a missile which has been fired from a missile launcher. At the desired time along the missile trajectory, the solenoid is actuated to move the armature **64** and the solenoid plunger **54** with the pin **53** to release the projection **46** on the cam **39**. Upon release of the cam **39**, the valve plunger **20** is allowed to move upwardly into the recess **43** so that the air from passageway **12** is allowed to flow through passageway **16** and chamber **17**, to passageway **14**, to be utilized for driving an air motor or the like, as previously described.

Obviously many modifications and variations of the present invention are possible in the light of the above teachings. It is, therefore, to be understood that within the scope of the appended claims the invention may be practiced otherwise than as specifically described.

What is claimed is:

1. A valve mechanism, comprising, structure having a passageway therein, means slidably mounted in said structure and having an open and a closed position with respect to said passageway, means rotatably supported for controlling the position of said first-mentioned means and having a projection thereon, solenoid actuator means including a movable armature with a plunger therein, means on said plunger to engage said projection and lock said rotatable means whereby said first-mentioned means is maintained in a closed position, and means to actuate said solenoid and thereby move said armature and plunger and release said rotatably supported means whereby said first-mentioned means is allowed to move to an open position.

2. A valve for connecting a high pressure medium to a prime mover, comprising a valve block having a passageway therein, a valve plunger slidably mounted in said block and having an open and a closed position with respect to said passageway, a cam rotatably supported adjacent said valve plunger to control its position, said cam having a projection thereon, a solenoid actuator mounted adjacent said cam, said solenoid actuator including a movably mounted armature, a plunger in said armature, a means carried on said plunger to engage said projection and thereby lock said cam from rotation, a means for urging said plunger into engagement with said cam, and means to actuate said solenoid to move said armature and said plunger thereby releasing said cam and allowing said valve plunger to move to its open position.

3. A valve mechanism, comprising a valve block having a passageway therein, a valve plunger having an open and a closed position with respect to said passageway, a cam rotatably supported adjacent said valve plunger to control the position of said valve plunger, a projection on said cam remote from said valve plunger and having a locking section and a contoured section, a solenoid actuator adjacent said projection, a solenoid armature within said solenoid and having a solenoid plunger slidable therein, a pin means carried on one end of said solenoid plunger to engage said projection, a means remote from said pin means to urge said solenoid plunger and pin means into engagement with the locking section of said projection, said armature being connected to carry said solenoid plunger only a distance sufficient to release said pin means from said locking section, said plunger thereafter sliding within said armature under the force of the contoured section acting against said pin means whereby the cam is allowed to rotate and the valve plunger to slide into its open position.

4. A valve arrangement for connecting a high pressure medium to a prime mover, comprising, a valve mechanism for controlling said medium under pressure and including structure having a passageway therein, means slidably mounted in said structure and having an open and a closed position with respect to said passageway, means rotatably supported on said structure for controlling the position of said first-mentioned means and having a projection thereon, solenoid actuator means mounted on said structure adjacent said rotatable means and including a movable armature with a plunger therein, means on said plunger to engage said projection and lock said rotatable means whereby said first-mentioned means is initially maintained in the closed position, and upon actuation of said solenoid means said armature and plunger are moved to release said rotatably supported means, thereby allowing said pressurized medium to pass to said prime mover to be operated by said medium.

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