

June 1, 1965

L. C. BLANDING ETAL

3,186,241

CAGING SYSTEM FOR GYROSCOPIC DEVICES

Filed July 12, 1962

2 Sheets-Sheet 1

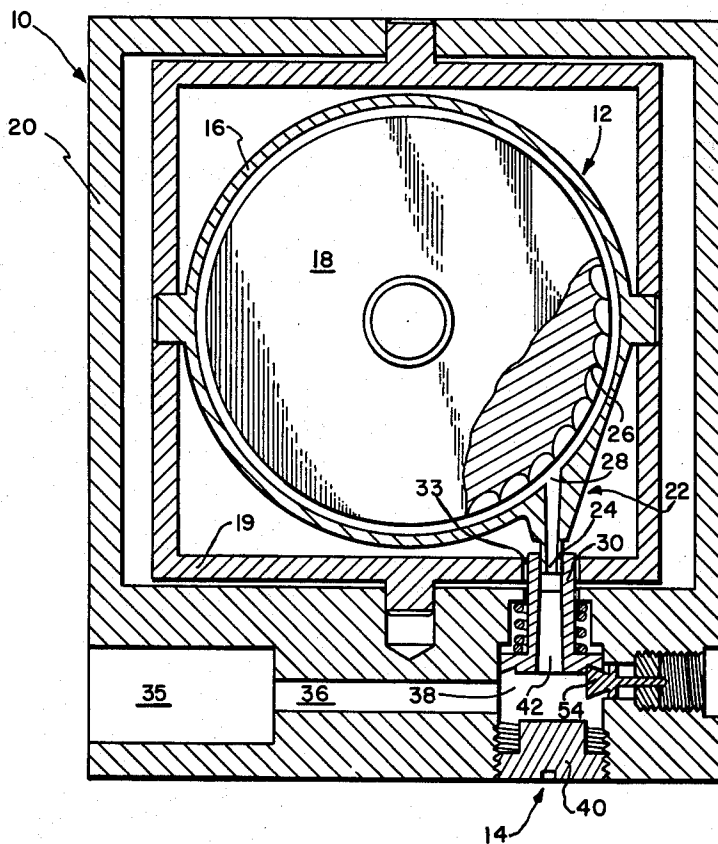


FIG. 1

INVENTORS
LEONARD C. BLANDING
BY CHRISTIAN H. WILL, JR.

Price & Heneveld
ATTORNEYS

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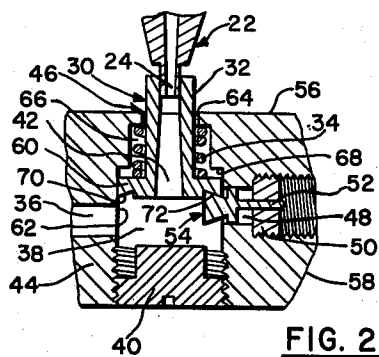
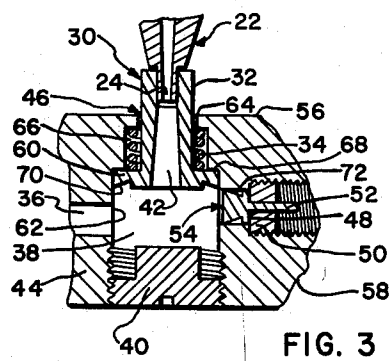
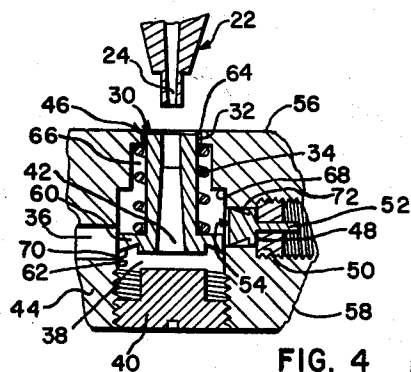
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INVENTORS
LEONARD C. BLANDING
CHRISTIAN H. WILL, JR.

BY

Price & Heneveld
ATTORNEYS

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CAGING SYSTEM FOR GYROSCOPIC DEVICES
Leonard C. Blanding and Christian H. Will, Jr., Grand Rapids, Mich., assignors to Lear Siegler, Inc.
Filed July 12, 1962, Ser. No. 209,346
4 Claims. (Cl. 74-5.12)

This invention concerns caging mechanisms for gyroscopes, and more particularly a caging mechanism especially adapted to the requirements of so-called hot-gas gyros.

In the field of short range missilery in which the duration of the mission does not exceed a few minutes, it is advantageous to use gyroscopic devices which are run up while the gyro is caged in a fixed, predeterminable position, and are then uncaged and allowed to coast for the entire duration of the mission. In missiles such as solid fuel rockets which can be instantaneously fired at any time, it is necessary to run up the gyro in an extremely short time which may be, as a matter of example, on the order of 25 milliseconds or less. In order to achieve the tremendous angular velocity of the inertia wheel necessary to insure accurate functioning of the gyro, it has been proposed to use a solid, explosive propellant which burns in about 10 milliseconds and generates combustion gases at pressures of several thousand pounds per square inch and at temperatures of several thousand degrees Fahrenheit. The high temperature of the combustion gases is necessary to prevent condensation and freezing of the caging mechanism due to the sudden expansion of the combustion gases when they impinge against the inertia wheel at these pressure levels necessary to accelerate the inertia wheel at the required rate.

It has previously been proposed to cage gyros during run-up by inserting a gas nozzle through the gimbals and then withdrawing the gas nozzle from the gimbals when run-up has been completed. The previously proposed devices of this nature, however, have been of a complexity and mode of action which makes them unsuitable for the explosive run-up for which the device of this invention is designed.

The present invention provides a device usable for the purpose described by discharging the combustion gases generated by the detonation of the explosive fuel directly into a plenum chamber in which they can act directly on the caging piston, the action of the caging piston being independent of any gas flow through the caging piston. This construction also permits the spring chamber surrounding the caging piston to be vented so as not to impede the motion of the caging piston by a vacuum effect. In accordance with another aspect of the invention, the caging piston is interlocked with its locking means by a camming action so as to prevent accidental uncaging of the gyro prior to the detonation of the fuel.

It is therefore the object of this invention to provide a caging mechanism for gyroscopes capable of running up the gyroscope and uncaging it in a matter of milliseconds.

It is a further object of this invention to provide a mechanism of the type described which utilizes a venturi construction to provide laminar flow of the gas at the inertia wheel of the gyro in spite of extremely high gas pressures and flow velocities.

It is another object of this invention to provide a caging mechanism of the type described which cannot be accidentally uncaged.

It is a still further object of this invention to provide a caging mechanism for gyroscopes suitable for operation with explosive fuels.

These and other objects of this invention will become apparent from the following specification, taken in con-

nection with the accompanying drawings, in which:
FIG. 1 is a horizontal section, partly cut away, of a typical gyroscopic unit in which the device of this invention may be used;

FIG. 2 is a cross-sectional detail view of the caging mechanism in its caged rest position;

FIG. 3 is a view similar to FIG. 2 but showing the mechanism at the moment of firing; and

FIG. 4 is a view similar to FIGS. 2 and 3 but showing the mechanism in its uncaged rest position.

Basically, the device of this invention provides a caging mechanism in which a retractable caging piston engages a portion of the gyro gimbals to cage the gyro. In accordance with one aspect of the invention, the gas path through the caging piston and the gimbal portion engaged thereby forms a venturi which assures laminar gas flow against the inertia wheel and a satisfactory rate of recovery. The gyro is run up by the detonation of an explosive fuel which discharges combustion gases against the caging piston at extremely high pressures and temperatures for a very short period of time. The leading edge of the pressure pulse generated by the explosion of the fuel unlocks the caging piston, which is normally locked in the caged position. The subsequent cessation of the pressure pulse then causes the caging piston to rapidly withdraw from engagement with the gyro gimbal when the run-up of the gyro is completed. In accordance with an aspect of the invention, the caging piston and its locking mechanism are so constructed that the locking mechanism cannot practically be released except by the pressure pulse of the detonation.

Referring now to the drawings, it will be seen that the gyroscopic device 10 shown in FIG. 1 includes a gyro generally designated as 12 which is normally held caged by a caging mechanism 14. The gyro 12 has a housing 16 which encloses the inertia wheel 18 and serves as the inner gimbal of the gyro 12. The housing 16 is in turn journaled in an outer gimbal 19 which is in turn journaled in the case 20 of the gyroscopic device 10. The housing 16 is provided with an extension 22 whose extremity forms a venturi throat 24 from which impeller gases are discharged against the pockets 26 of inertia wheel 18 through the nozzle 28 for run-up purposes. The venturi construction of the extension 22 results in a laminar gas flow along inertia wheel 18 and in a good recovery rate, which are essential in imparting sufficient momentum to the inertia wheel 18 in the extremely limited time allowed for run-up.

During storage and run-up, the extension 22 of housing 16 is held caged by the bore 42 of caging piston 30 which is locked in engagement with extension 22 by the locking pin 54 against the bias of spring 34. At the same time, the outer gimbal 19 is caged by engagement of the outer surface 32 of caging piston 30 with the opening 33 formed in gimbal 19. Combustion gases from a suitable solid fuel cartridge 35 are conveyed through a duct 36 to the plenum chamber 38 which is pressure-tightly closed by a plug 40. The gas conveyed into the plenum chamber 38 is fed into the venturi throat 24 through a preferably frustoconical bore 42 formed in the caging piston 30.

The construction of the caging mechanism is shown in more detail in FIGS. 2 through 4. The mechanism is housed in a block 44 which forms part of the case 20. The plenum chamber 38 has four openings: the duct 36 through which combustion gases are introduced into the plenum chamber 38; the recaging opening closed by the plug 40 through which the gyro can be recaged after use; the piston opening 46 through which the caging end of the caging piston protrudes; and the locking member guide opening 48 closed by a plug 50 through which the stem 52 of the locking member 54 protrudes. For practical

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purposes, the environment outside surfaces 56 and 58 of the block 44 can be considered atmosphere, although surface 56 is actually enclosed in the case 20.

It will be noted that the clearance between the shoulder 60 of the caging piston 30 and the annular wall 62 of the plenum chamber 38 is as small as possible to provide good piston action without, however, risking jamming of the piston under the dynamic stresses produced by the pressure pulse when the mechanism is fired. At the piston opening 46, air passages 64, or a sufficient clearance to achieve a like result, are provided to permit quick entrance or exit of air to and from the spring chamber 66 which is the extension of the plenum chamber 38 in which the return spring 34 is located. Likewise, the locking member 54 should fit closely into the opening 48, but sufficient clearance should be provided between the stem 52 and the plug 50 to allow the locking member 54 to be rapidly thrown to its unlocked position by the pressure pulse in the plenum chamber 38. It should be noted that in accordance with a preferred feature of the invention, a small clearance exists between the shoulder 60 of the caging piston 30 and the annular shoulder 68 of the plenum chamber 38 when the caging piston 30 is in its caged rest position, for a purpose hereinafter described.

The shoulder 60 of the caging piston 30 is preferably provided with a frustoconical surface 70 which matches a frustoconical surface 72 formed on the locking member 54. The surfaces 70 and 72 cooperate to hold the locking member 54 in the locked position under the influence of the spring 34. The spring 34 is normally quite powerful, and it is therefore practically impossible to accidentally uncage the gyro.

Operation

In order to provide good storage life and accurate operation, the device of this invention is preferably powered by a solid fuel cartridge. In preparing the missile for a mission, it is directed at its launching site and is aligned by appropriate means so that the caged gyro assumes a predetermined fixed reference position in space. In this condition, the caging mechanism is in the position of FIG. 2 and holds the gyro in the predetermined run-up position. If the missile is now to be fired, the solid fuel cartridge is detonated by appropriate means (not shown). The explosive combustion of the solid fuel cartridge creates a pulse of combustion gases at extremely high temperatures and pressures whose duration is on the order of one to two one-hundredths of a second. The combustion gases are conveyed through duct 36 into the plenum chamber 38. The resulting pressure surge in plenum chamber 38 immediately pushes the caging piston 30 upwardly into the position shown in FIG. 3. The upward movement of the shoulder 60 takes the camming surface 70 out of engagement with the camming surface 72 and frees the locking member 54 for movement. The same pressure surge acts on the locking member 54 and pushes it rightwardly in FIG. 3 to its unlocked position as shown in FIG. 3.

As combustion gases continue to enter the plenum chamber 38, the high pressure in the plenum chamber 38 maintains the caging piston 30 in its uppermost position, and gas flows through the tapered bore 42 of the caging piston 30 and the venturi throat 24 into the housing 16, where it energizes the inertia wheel 18. The gradual acceleration of the gases by the taper of the bore 42 and their subsequent expansion after passing through the venturi throat 24 results in a laminar gas flow along the inertia wheel 18 in spite of the extreme gas velocities and pressure necessary to accelerate the inertia wheel 18 to full operating speed in the extremely short duration of the gas pressure pulse.

When the combustion of the fuel cartridge has been completed, the pressure in the plenum chamber 38 quickly drops to substantially atmospheric pressure. When

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this happens, the pressure in plenum chamber 38 becomes insufficient to counteract the resilient force of spring 34, and the caging piston 30 moves rapidly downward, to the position shown in FIG. 4. Because of the fact that the locking member 54 has been pushed out of the way by the pressure pulse, the caging piston 30 can move all the way downward until halted by the plug 40, and in so doing, it frees gimbal 19 and the extension 22 of the gyro housing 16 and enables the gyro to function as a stabilizing device.

If the missile is recovered following the mission, the device can be recaged to the position of FIG. 2 by simply unscrewing the plug 40, pushing the caging piston into the position of FIG. 3, pushing the locking member 54 in, and releasing the caging piston 30 to return to the position of FIG. 2.

It will be seen that the present invention provides an effective run-up and caging mechanism particularly adapted to the needs of hot-gas gyros. Obviously, the invention can be carried out in many different ways, of which the embodiment shown is merely illustrative. I therefore do not desire to be limited by the embodiment shown and described herein, but only by the scope of the following claims.

We claim:

1. A caging mechanism for a hot-gas gyro, comprising: a gas connection fixed with respect to said gyro; a piston housing fixed with respect to the axis stabilized by said gyro; a hollow caging piston movable in said housing and engageable with said gas connection; a chamber in said housing; means for discharging gas at high pressure into said chamber; means biasing said caging piston out of engagement with said gas connection; primary lock means disabled by high pressure in said chamber holding said piston in engagement with said gas connection; secondary lock means operatively associated with said caging piston and said primary lock means preventing disabling of said primary lock means until said chamber is subjected to high pressure; said secondary lock means being disabled by movement of said caging piston in a direction toward said gas connection; said piston forming a gas passage to convey said gas from said chamber to said gas connection, and said piston being held in engagement with said gas connection by high pressure in said chamber independently of said lock means.

2. A caging mechanism for a hot-gas gyro, comprising: an explosive fuel cartridge, means for detonating said fuel; a plenum chamber; means conveying the gases produced by said detonation into said plenum chamber; a piston in said plenum chamber; locking means in said plenum chamber holding said piston in a position where it engages said gyro; said piston having a bore there-through for conveying gas from said plenum chamber to said gyro; and resilient means biasing said piston out of engagement with said gyro; means disabling said locking means by the appearance of said detonation gases in said plenum chamber, and said piston being held in engagement with said gyro by said detonation gases until the gas pressure in said plenum chamber drops to a predetermined level; said piston and said locking means being provided with matching cam surfaces arranged to positively bias said locking means into locking position by the action of said resilient means; said piston when subjected to detonation gas pressure moving out of camming engagement with said locking means to permit disabling of said locking means by said gas pressure.

3. A caging mechanism for a hot-gas gyro, comprising: a gas connection fixed with respect to said gyro; a piston housing fixed with respect to the axis stabilized by said gyro; a hollow caging piston movable in said housing and engageable with said gas connection; a chamber in said housing; means for discharging gas at high pressure into said chamber; means biasing said caging piston out of engagement with said gas connection; a locking pin ar-

ranged for movement transverse to the movement of said caging piston and being adapted for movement in a direction away from said caging piston in response to high gas pressure in said chamber; said caging piston being adapted to move in a direction toward said gas connection and away from said locking pin in response to high pressure in said chamber; said locking pin and caging piston having secondary locking means preventing movement of said pin away from said piston until after said piston is moved a distance toward said gas connection; said piston forming a gas passage to convey said gas to said gas connection, and said piston being held in engagement with said gas connection by high pressure in said chamber independently of said lock means.

ing means includes a protruding portion of said pin extending toward said piston into a recessed portion of said piston whereby the piston is required to be moved away from said pin before said pin is permitted to move away from said piston.

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15 BROUGHTON G. DURHAM, *Primary Examiner*.
DON A. WAITE, *Examiner*.

4. The device of claim 3 in which said secondary lock-