Jan. 14, 1969 A. N. PEALE 3,421,414

FLYWEIGHT

Filed March 15, 1966 Sheet 1 of 2

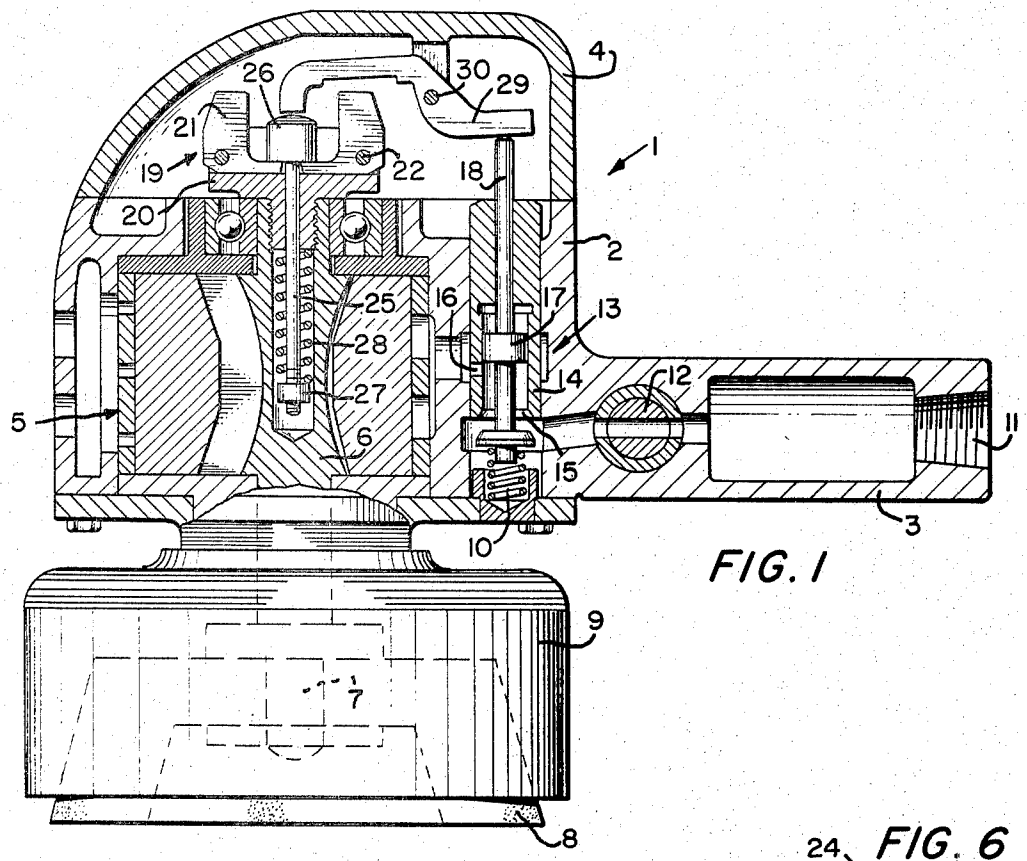


FIG. 1

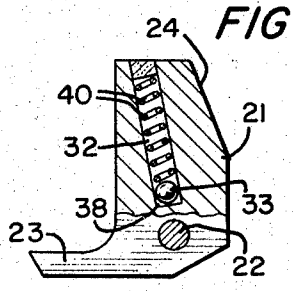


FIG. 6

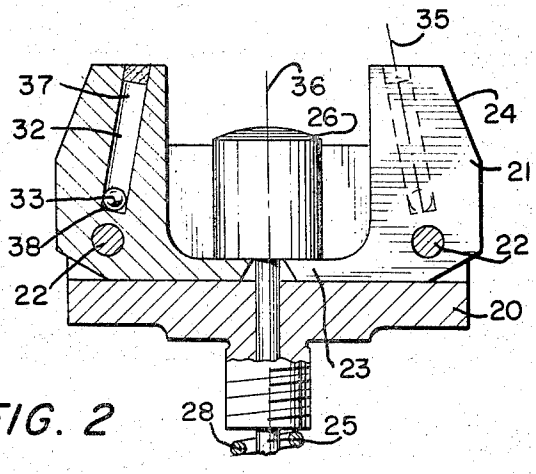


FIG. 2

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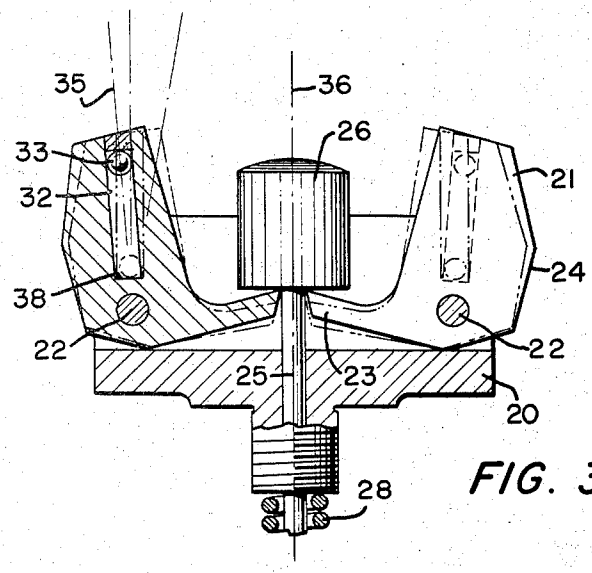


FIG. 3

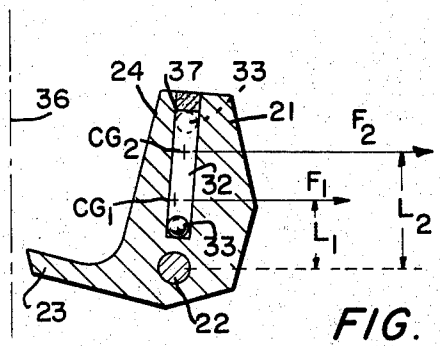


FIG. 4

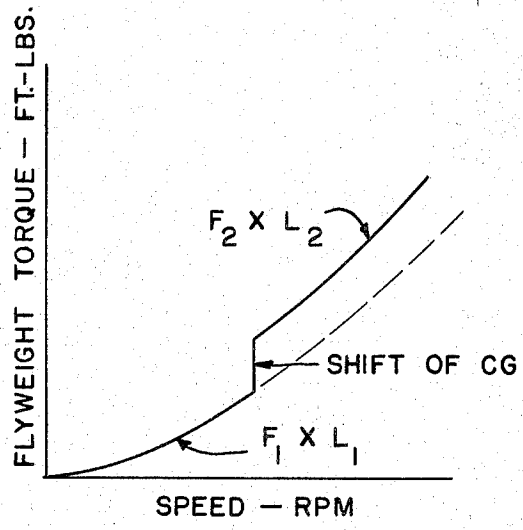


FIG. 5

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FLYWEIGHT

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Int. Cl. F01c *21/12;* F15b *13/04*

ABSTRACT OF THE DISCLOSURE

A motor speed control mechanism including a variable speed motor, a valve controlling the supply of energy to the motor, a radially movable flyweight pivoted on the rotary shaft of the motor and a linkage interconnecting the flyweight to the valve to vary the speed of the motor in response to the radial movement of the flyweight. The flyweight includes a bore arranged with one end being closer to the axis of the flyweight pivot and the other end being closer to the axis of the shaft in the retracted position of the flyweight. A weight is movably enclosed in the bore whereby the weight is urged by the centrifugal force to the one end of the bore in the retracted position of the flyweight and to the other end of the bore in the extended position of the flyweight resulting in the center of gravity of the flyweight shifting away from the flyweight pivot as the flyweight moves radially outward toward its extended position.

This invention relates to motor speed control systems using centrifugally actuated flyweights as speed sensing means.

In certain applications, it is desirable that the speed of a motor be maintained within a relatively narrow speed range. In general, conventional speed control systems using flyweights do not control speeds within a relatively narrow speed range, particularly, when the flyweights are retracted by strong springs.

The primary object of this invention is to substantially overcome or minimize the above disadvantages in conventional speed control systems of the flyweight type.

Further important objects of this invention are: to provide a flyweight speed control system which maintains motor speeds within a relatively narrow speed range; to provide a rapid acting flyweight speed control system; to provide an improved flyweight for use in speed control systems; and to provide a flyweight speed control system which abruptly shifts the forces acting on a flyweight at some point during its normal operation.

The foregoing objects are attained, in general, by the provision of a flyweight speed control system having pivoted flyweights with means for abruptly changing the centrifugal torque acting on the flyweights at some point intermediate the limits of pivoting movement of the flyweights. This is accomplished by providing each flyweight with a means which acts to shift the center of gravity of the flyweight at a predetermined speed of the shaft or motor driving the flyweight. This shift in the center of gravity is caused by the centrifugal force acting on the flyweight.

The invention is described in connection with the accompanying drawings wherein:

FIG. 1 is an elevational view with portions shown in section of an air-powered grinder tool utilizing the improved speed control system of this invention;

FIG. 2 is an enlarged fragment of FIG. 1 illustrating the flyweights and with one of the flyweights being sectioned to show its interior;

FIG. 3 is similar to FIG. 2 and shows plural positions of the flyweights during operation of the tool of FIG. 1;

FIG. 4 is a diagrammatic view illustrating the shift of the center of gravity of a flyweight;

FIG. 5 is a graph or curve illustrating the centrifugal torque forces acting on a flyweight in relation to its speed; and

FIG. 6 is an elevational view with a portion cut away illustrating a modified embodiment of flyweight.

The air powered grinder **1** shown in FIG. 1 comprises a casing **2** including a handle **3** and a head cover **4**. The casing **2** contains a conventional air-powered motor **5** having a rotor **6** driving a spindle **7**. The spindle **7** carries a grinder wheel **8** rotating within a stationary shield **9** fixed to the casing **2**.

The end of the handle **3** is provided with an inlet **11** adapted to be connected to an air supply hose (not shown). The inlet **11** leads to a conventional throttle valve **12** mounted in the forward part of the handle **3**. When manually opened, the throttle valve **12** feeds air to a speed control valve **13** which acts to throttle and vary the quantity of air delivered to the motor **5** for controlling and limiting the speed of the motor **5**.

The speed control valve **13** includes a valve sleeve **14** carried in the casing **2** and having an air inlet **15** at one end and an air outlet **16** extending through its sidewall. A valve piston **17** reciprocates in the valve sleeve **14** in a manner to vary the effective area of the air outlet **16**. The valve piston **17** includes a piston rod **18** which slidably extends through the upper end of the valve sleeve **14**, as shown in FIG. 1, for operating the valve piston **17**. The valve piston **17** is urged upwardly in the valve sleeve **14** by a spring **10**.

A flyweight-type of governor **19** is carried by the upper end of the motor rotor **6** and includes a cap plate **20** attached to the end of the motor rotor **6** and a pair of L-shaped flyweight **21** pivoted at **22** on the cap plate **20**. Looking at FIG. 1, each flyweight **21** includes a foot **23** and a leg **24** extending upwardly from the foot **23** at a right angle. The governor **19** further includes an axial plunger **25** slidably mounted in the cap plate **20** and extending into a cavity provided in the motor rotor **6**. The plunger **25** includes a head **26** at its upper end resting on the feet **23** of the flyweights **21** and a nut **27** threaded at its lower end. A spring **28** is interposed between the nut **27** and the cap plate **20** to urge the plunger head **26** downwardly against the flyweights **21** for biasing them radially inward.

As is conventional in flyweight-type speed control systems, as the motor speed increases, centrifugal force acting on the flyweights **21** serves to lift the plunger **25** upwardly, as seen in FIG. 1, against the force of the spring **28**. The vertical upward movement of the plunger **25** is transmitted to the speed control piston rod **18** by a bell crank **29** pivoted on a pivot **30** fixed in the head cover **4** and having opposite arms resting respectively on the plunger head **26** and the piston rod **18**. All of the foregoing structure is conventional, as shown in United States Patent No. 2,897,832.

The invention in this application is the concept of providing each of the flyweights **21** with a means which abruptly shifts the center of gravity of the flyweights outwardly from the pivot axis **22** of the flyweight at some point intermediate the limits of the pivot travel of the flyweights. This expedient is carried out in FIGS. 2 and 3 by providing the legs **24** of each of the flyweights **21** with an elongated bore **32** having a ball **33** which can readily roll or shift between the opposite ends of the bore **32**. The outer end of the bore **32** is closed by a plug **34** for trapping the ball **33** therein.

The axis **35** of the bore **32** is arranged so that, when the flyweights **21** are at rest in their retracted positions with the flyweight feet **23** resting on the cap plate **20**, as

shown in FIG. 2, the outer end 37 of each bore 32 remote from the flyweight pivot 22, is closer to the motor axis 36 than the inner end 38 of the bore 32. In this position of the flyweights 21, centrifugal force will maintain the ball in the inner end 38 of the bore 32, as shown in FIG. 2. As centrifugal force on the flyweights increases, the flyweights will pivot outwardly to a position where the axis 35 of the bore 32 pivots through a line parallel with the motor axis 36, as shown in FIG. 3. In the latter position of the flyweights, each bore axis 35 is arranged with the outer end 37 of the bore 32 further away from the motor axis 36 than its inner end 38, and the ball 33 is forced to the outer end 37 of the bore 32 by centrifugal force. This movement of the ball 33 shifts the center of gravity of the flyweights 21 radially outward from the flyweight pivot 22. Shifting the center of gravity of the flyweights 21 radially away from the flyweight pivot 22 increases the torque or moment forcing the flyweights 21 radially outward about their pivots 22. This shift in center of gravity occurs relatively abruptly as the ball 33 shifts from one end of the bore 32 to the other. The amount of the shift in the center of gravity depends on the weight of the ball 33 and the length of the bore 32.

The abrupt shift in the center of gravity of the flyweight 21 as it pivots radially outwardly about its pivot axis 22 is illustrated in FIGS. 4 and 5. Initially, when the ball 33 is located in the inner end 38 of the bore 32, looking at FIG. 4, the center of gravity of the flyweight 21 is located at CG_1. It will be understood that the center of gravity of the flyweight is determined by the combination of its mass plus the mass of the ball 33. At this time the centrifugal force F_1 acting on the flyweight is acting through CG_1. The moment arm of the centrifugal force F_1 acting about the pivot 22 is indicated as L_1. The torque or moment of the flyweight 21 is the product of $F_1 \times L_1$.

As explained earlier, as the motor speed increases, the flyweight 21 is forced to pivot radially outward about its pivot 22 by centrifugal force. The flyweight bore 32 eventually reaches a position relative to the motor axis 36 wherein the centrifugal force acting on the ball 33 forces it outward in the bore 32 to the outer end 37 of the bore, as shown in dotted lines in FIG. 4. When the ball 33 reaches the dotted line position shown in FIG. 4, the center of gravity of the flyweight 21 is shifted away from the flyweight pivot 22 to the position indicated as CG_2. At this time the centrifugal force F_2 acts through CG_2 and the moment arm of F_2 about the pivot 22 is L_2. Now the torque or moment of F_2 is $F_2 \times L_2$. Since CG_2 is at a greater distance from the pivot 22 than CG_1, $F_2 \times L_2$ is greater than $F_1 \times L_1$.

The result of the shift in the center of gravity of the flyweight is further shown in FIG. 5. FIG. 5 is a curve having a vertical axis indicating the torque of the flyweight 21 about its axis 22 and a horizontal axis indicating the speed of the flyweight 21 about the motor axis 36. The initial portion of the curve, rising from zero torque, indicates the change in the initial torque, $F_1 \times L_1$. This torque varies in accordance with the increase in centrifugal force as the rotary speed of the flyweight 21 increases. As is well known, the centrifugal force acting on the flyweight will increase relative to the square of the speed of the flyweight.

The abrupt vertical leg of the curve indicates the shift of the center of gravity of the flyweight 21 from CG_1 to CG_2, due to the movement of the ball 33 between the ends of the bore 32. The final leg of the curve illustrates the torque $F_2 \times L_2$ which acts about the center of gravity CG_2. The curve in FIG. 5 further includes a dotted line indicating the nature of the torque curve if the shift in center of gravity had not occurred. As is easily seen from this, the shift in center of gravity of the flyweight 21 causes a substantial change in the value of the torque acting on the flyweight 21 about its pivot 22.

It has been found that the provision of this abrupt change in torque acting on the flyweight 21 results in causing the speed control means to regulate and maintain the speed of the motor within a much narrower speed range than is possible without the abrupt change of flyweight torque. The disclosed abrupt torque change means is particularly necessary in flyweight speed control systems when relatively strong springs are used for retracting the flyweights.

A second embodiment of the invention is shown in FIG. 6. The only difference between this embodiment and the earlier embodiment is the addition of a light spring 40 to the bore 32 serving to bias the ball 33 toward the inner end 38 of the bore. The spring 40 is so light or weak that it does not substantially interfere with the movement of the ball 33 to the outer end 37 of the bore 32 during operation of the flyweight 21. The only purpose of the spring 40 is to insure that the ball 33 remains in the inner end 38 of the bore 32 at low speeds when the grinding tool 1 is placed in a position where gravity might otherwise move the ball 33 to the outer end 37 of the bore 32.

Although two embodiments of the invention are illustrated and described in detail, it will be understood that the invention is not limited simply to these embodiments but contemplates other embodiments and variations which utilize the concepts and teachings of this invention.

Having described my invention, I claim:

1. A motor speed control system comprising:
   - a rotary motor;
   - variable valve means for supplying energy to said motor and including means urging it to an open position;
   - a flyweight pivoted on a shaft driven by said motor and movable between a retracted position and an extended position;
   - means interconnecting said flyweight to said valve means for progressively closing said valve means as said flyweight moves from said retracted position to said extended position; and
   - means on said flyweight operative to abruptly shift the center of gravity of said flyweight outward from the flyweight pivot as said flyweight is moved outward by centrifugal force from its retracted position to its extended position.

2. A speed control mechanism for a rotary shaft comprising:
   - a rotary shaft;
   - drive means connected to said shaft for driving it at a controlled variable speed;
   - control means connected to said drive means for varying the driven speed of said shaft;
   - a flyweight pivoted on said rotary shaft for movement radially outward under centrifugal force from a retracted position to an extended position and connected to said control means for controlling said control means in response to the radial movement of said flyweight; and
   - means on said flyweight operative to abruptly shift the center of gravity of said flyweight outward from the flyweight pivot as said flyweight is moved outward by centrifugal force from its retracted position to its extended position.

3. A speed control mechanism for a rotary shaft comprising:
   - a rotary shaft;
   - drive means connected to said shaft for driving it at a controlled variable speed;
   - control means connected to said drive means for varying the driven speed of said shaft;
   - a flyweight pivoted on said rotary shaft for movement radially outward under centrifugal force from a retracted position to an extended position and connected to said control means for controlling said control means in response to the radial movement of said flyweight; and
   - means on said flyweight for abruptly changing the magnitude of torque caused by centrifugal force acting on the flyweight as the flyweight moves between its retracted and extended positions.

4. A speed control mechanism for a rotary shaft comprising:

a rotary shaft;

drive means connected to said shaft for driving it at a controlled variable speed;

control means connected to said drive means for varying the driven speed of said shaft;

a flyweight pivoted on said rotary shaft for movement radially outward under centrifugal force from a retracted position toward an extended position and connected to said control means for controlling said control means in response to the radial movement of said flyweight;

an elongated closed bore provided in said flyweight with one end of said bore being substantially closer to the pivot of said flyweight than the other end of said bore;

said bore also being located in said flyweight so that said other end of said bore is located closer to the axis of said shaft than the one end of said bore in the retracted position of said flyweight;

said bore being located so that in the extended position of said flyweight the one end of said bore is located closer to said shaft axis than said other end of said bore; and

an inner weight movably contained in said bore for movement between the opposite ends of said bore wherein in the retracted position of said flyweight, centrifugal force maintains said inner weight at said one end of said bore and as said flyweight moves to its extended position, the bore eventually moves to a position wherein centrifugal force moves said inner weight to the other end of said bore to shift the center of gravity of the flyweight away from the flyweight pivot, thus increasing the torque of the centrifugal force acting on said flyweight.

5. The combination of claim 4 wherein:

said flyweight is pivoted on said shaft to move in a plane parallel to the shaft axis.

6. The combination of claim 4 including:

a relatively weak spring located in said bore biasing the inner weight toward said one end of said bore.

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U.S. Cl. X.R.

91—76; 137—53; 73—538