United States Patent

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[54] **ROTATIONALLY RESPONSIVE DEVICE**
6 Claims, 3 Drawing Figs.

[52] **U.S. Cl.** **102/79**
[51] **Int. Cl.** **F42c 15/26**
[50] **Field of Search** 102/79, 80

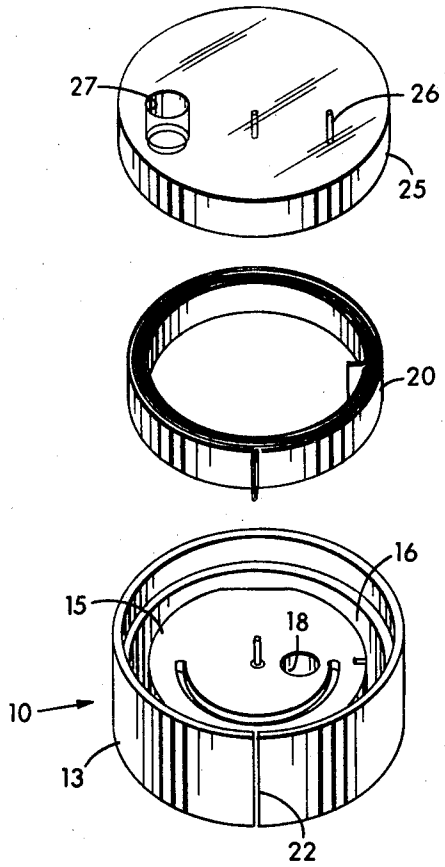
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ABSTRACT: A rotor is rotationally supported on a housing and spring urged in a first rotational sense. The spring is a multiconvolution resilient steel tape wound on the rotor and disposed between the rotor and the housing in a narrow annular space. Rotation of the housing in a second rotational sense urges the rotor to unwind the spring tape and thereby rotate a predetermined distance. A configuration for a safe and arm mechanism is disclosed.



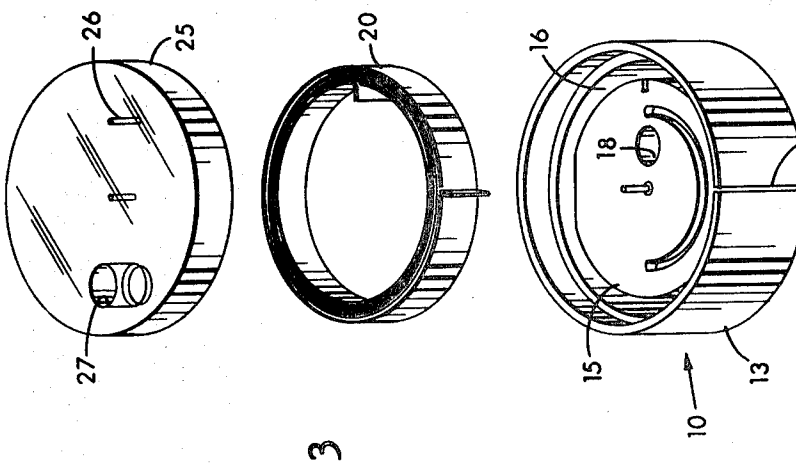


FIG. 1

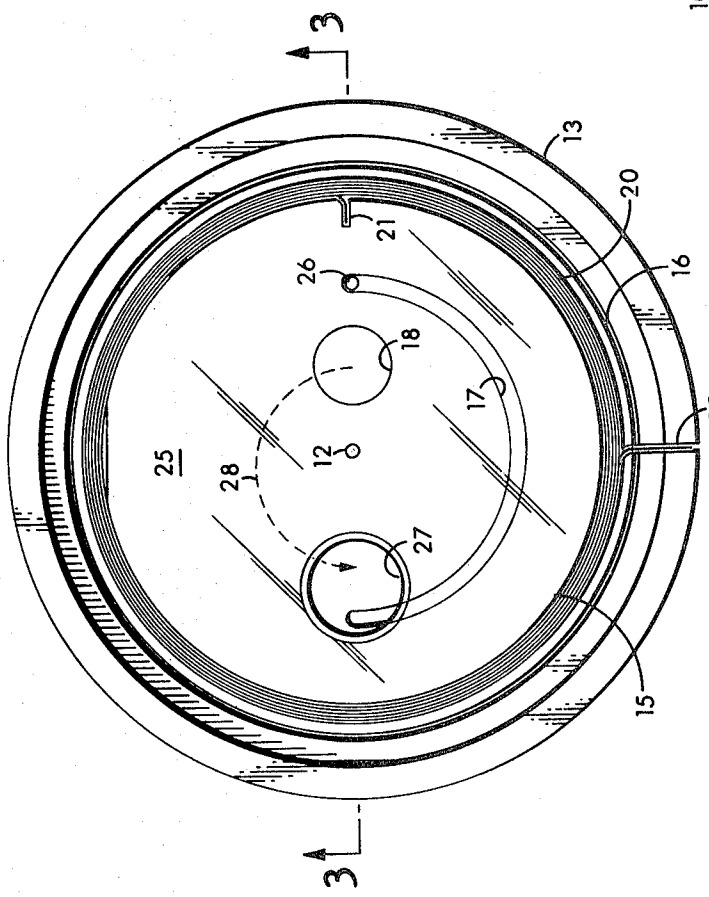


FIG. 2

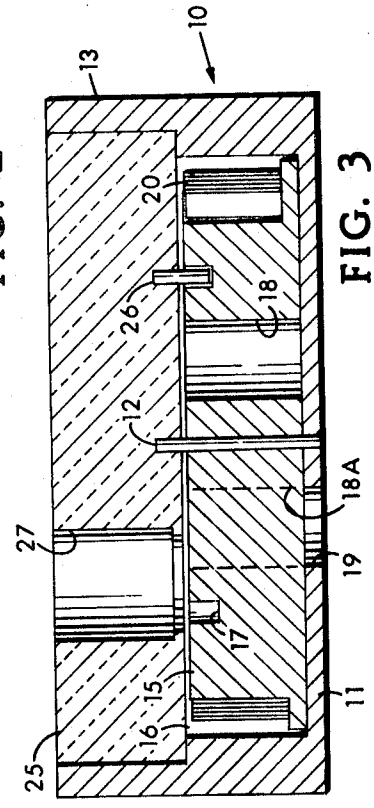


FIG. 3

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ROTATIONALLY RESPONSIVE DEVICE

BACKGROUND OF THE INVENTION

This invention relates to spin-actuated devices and more particularly to such devices utilizable for safe and arm mechanisms.

The safe handling and proper detonation of artillery shells has been a long problem with many proposed solutions. Many of these solutions require mechanisms of undue complexity which, in effect, reduces the pay load, i.e., the explosive charge that can be carried by a given projectile.

Inventors in Germany during World War II developed a safe and arm device of the rotationally responsive type that utilized a multiconvolution coil of dead soft copper tape wound around a pedestal in the center of the mechanism. As the housing supporting the pedestal rotated in a given direction, the dead soft copper tape-shaped material would unwind by a sliding action to rotate a device within the mechanism to an armed position. These devices had the usual setback pin for preventing actuation before firing from an artillery weapon.

The setback forces in some of the 20 and 40 millimeter weapons could and did on occasion deform the dead soft copper tape such that it could not properly function. The detonation of the shell was then caused by impact rather than by arming the artillery shell in a desired manner. The desired result would then be altered because of the time of detonation was altered.

Also, the frictional engagement between the pedestal and the tape often would give a nonlinear reaction of the dead soft copper tape to the rotational urging altering the time when the projectile was armed. This action would cause defects in the arming of the shell.

The annular space between the pedestal and the outer housing wall was a distance greater than the diameter of the pedestal. The dead soft copper tape rotated three times for an arming. However, because of imperfections in the tape, the tape could coil up in between the pedestal and the outer housing wall thereby preventing arming. Deformation of the soft copper tape caused by the setback forces of the artillery weapon also could cause and did cause malfunctions to occur. Another defect in this mechanism is that it could only be used once because of the hardening of the dead soft copper tape. This made it difficult to trouble shoot difficulties in a given design. For example, the center piece of a typical unit was three-eights of an inch diameter and under spin forces the dead soft copper strip would be expanded to a 1 inch diameter. During the expansion to the larger diameter, there is a rotation of the center bearing about 17 revolutions. A light steel spring was wrapped around the copper coil to prevent it from unwinding until a particular spin rate at which the centrifugal force overcame the spring tension.

There have been several designs following the above mentioned principles and all these safe and arm devices have the common characteristic of seeking to escape from the so-called safe position in which they are retained by the inner convolute of the unwinder strip. The U.S. Pat. to Guerne No. 3,076,410 shows an unwinder of the type described above.

Of course, if the rotationally responsive device could be reused they could be used as a limit switch on a governor.

SUMMARY OF THE INVENTION

It is an object of the invention to provide a rotationally responsive device having only two parts rotatably movable with respect to a housing and which motion is substantially free of friction.

It is another object of this invention to provide a rotationally responsive device of the unwinding tape type wherein the tape convolutions move radially outward with insubstantial slipping for reducing friction during actuation of the device.

It is a further object of this invention to provide a rotationally responsive device of the unwinding tape type wherein the tape cannot loop upon itself during unwinding.

A feature of the present invention is the disposition of a spring steel tape having several convolutions with one end attached to a center rotatable rotor and an outer end attached to a radially outward housing wall.

It is a further feature of this invention to have a spring steel tape of several convolutions disposed between a rotor and a housing wall wherein the distance between the rotor outer periphery and the housing wall is not much greater than the radial thickness of the tape. The radial thickness of the annular space is typically less (usually substantially less) than the radius of the center rotor.

Another feature is the rotor rotation is equal to the number of turns or convolutions of the tape multiplied by the rotor rotation of any one of the convolutions; that is, the unwinding of the tape by urging of the rotor due to rotational forces is substantially linear.

According to this invention, there is provided a housing having a base portion rotatably supporting a rotor and having annular walls closely spaced radially outward of the rotor. A multiconvolution spring steel tape is disposed between the rotor and the annular wall having one end affixed to the outer periphery of the rotor and the other end affixed to the annular wall. As the housing is rotated, the rotor urges the spring to unwind one convolution at a time, each outer convolution moving radially outward with minimum friction. The rotor has an arcuate recess preferably of 180°. A stop member on the housing extends into the recess and prevents the rotor from rotating beyond a predetermined limit.

Apertures are provided in the rotor, the base portion and the cover portion. The apertures in the cover and base portions are aligned, whereas, the rotor aperture is preferably 180° displaced from the other apertures in the devices in a safe position. Upon actuation, the rotor rotates such that the aperture therein is aligned with the cover and base portion aperture. Typically, the cover portion has a detonator disposed in there, the rotor will carry a lead charge; while a booster is disposed in the aperture of the base portion.

THE DRAWING

FIG. 1 is an exploded isometric view of an apparatus used to illustrate the teachings of the present invention.

FIG. 2 is an enlarged plan view of the FIG. 1 apparatus when the cover portion is formed of transparent material to show internal constructional features. The device is shown in the safe position or unactuated position.

FIG. 3 is a sectional view taken in the direction of the arrows along line 3–3 in FIG. 2 and shows some of the internal constructional features of the illustrated embodiment.

DETAILED DESCRIPTION OF AN ILLUSTRATIVE EMBODIMENT

Referring now more particularly to the drawing, like numbers indicate like parts and construction features shown in the various views. The rotationally responsive device includes a cup-shaped housing **10** having a base portion **11** with an upstanding central pin **12** extending along the axis of the housing. Annular walls **13** extend in concentric relationship to pin **12**. The upper end of annular walls **13** are adapted to receive cover portion **25** to complete housing **10**. A rotor **15** is rotationally disposed about pin **12** which serves as a low friction bearing.

Annular space **16** exists between the outer periphery of rotor **15** and the inner surface of annular wall **13**. The radial distance of annular space **16** should never be greater than the radius of rotor **15**. The reason for this will be explained later with respect to coiled spring tape **20**.

Rotor **15** has a arcuate recess or slot **17** extending concentric with respect to pin **12**. As shown, recess **17** encompasses an arc of 180°. Through the use of a stop pin **26** in cover portion **25**, which extends into recess **17**, the rotation of rotor **15** is limited to 180° as will become more apparent.

Since the device may be used for a safe and arm device in an artillery shell, aperture **18** is formed in rotor **15** for receiving a lead charge (not shown) which when in the armed position **18A** can be actuated by a detonator (not shown) disposed in aperture **27** in cover portion **25**. This lead charge in turn sets off or detonates a booster charge (not shown) disposed within aperture **19** of base portion **11**. Then the regular payload charge (not shown) of the projectile is then in turn detonated by the booster (not shown). The housing **10** may be affixed at the nose of an artillery shell in any known manner such that it rotates therewith to actuate the device from the safe to the armed position. The usual setback safety devices should be provided.

The rotor **15** is one of two parts that rotate with respect to housing **10**. The second rotatable part is the multiturn or multiconvolution spring steel tape **20** disposed in annular recess or space **16**. One end of spring tape **20** is secured in notch **21** of rotor **15**. A second and outer end of spring tape **20** is secured in slot **22** of annular wall **13**.

In FIG. **2** the device is shown in the safe or unactuated position. Since the cover **25** is shown as being constructed of transparent material, all of the internal parts may be seen in the plane view. In a practical embodiment, the cover portion **25** would be made of metal and one could not see the internal construction. Spring tape **20** has urged rotor **15** clockwise to engage pin or stop member **26** which determines the maximum clockwise rotation of rotor **15**. Aperture **18** for containing a lead charge (not shown) is disposed 180° away from apertures **27**, **19**. The spring tape **20** in this position is wound around the outer periphery of rotor **15**.

As the housing **10** is rotated in a counterclockwise sense, as by a projectile, the resultant centrifugal force urges rotor **15** to rotate counterclockwise toward the fully actuated or armed position. In such a movement, aperture **18** is moved from the illustrated position along dotted line **28** to the armed position (dotted lines **18A** in FIG. **3**) wherein it is aligned with apertures **19** and **27**. Recess **17** moves along pin **26** until the counterclockwisemost or armed position is reached whereupon pin **26** again stops rotor **15**.

As rotor **15** rotates counterclockwise, the centrifugal force is transmitted to spring **20**. Since the end of spring tape **20** is fixedly secured in slot **22** in annular wall **13**, it cannot move; therefore, the radially outermost convolution of tape **20** first moves radially outward from the next adjacent convolution. In the illustrated device when such outermost convolution has moved adjacent annular wall **13** the rotor rotated 18°. For example, it is desired to move the rotor 180°. Since there are 10 convolutions, each convolution moving radially outward corresponds to a rotor rotation of 18°. As the counterclockwise centrifugal force continues and increases, the next outermost convolution is next moved radially outward as the rotor continues counterclockwise rotation. It should be noted that the innermost convolutions of tape **20** do not move nor slide with respect to rotor **15** since tape **20** has an innermost end firmly attached to rotor **15**, as at notch **21**. Therefore, as rotor **15** with the portion of the spring tape **20** securely wound thereto rotates, the outermost convolution first moves radially outward to engage the annular wall **13** or the next adjacent outer convolution which had previously been moved outward. Since the outer convolutions move radially outward due to the centrifugal force, there is no sliding motion therebetween.

Annular wall **13** is radially outward stop for tape **20**. It is understood that wall **13** may take any form including wire mesh, axially extending pins, and the like so long as an effective radially outward stop is provided.

It stroboscopic investigations of this invention the housing **10** was rotated by an electric drill, one could see the outermost tape convolutions successively move radially outward without sliding motion. If the rotational velocity was decreased and sufficiently strong spring was used, the spring would cause the rotor to return to the original position. In such action the radially inwardmost convolution would first return to the rotor, then the successively outer convolutions would return to the rotor in opposite sequence to the unwinding.

It is seen that annular space **16** has a relatively short radial dimension. Therefore, the radial excursion, i.e., the radial distance the tape must travel from the unactuated position to the actuated position, is relatively short. This means the tape has very little change in shape. As a result, there are very little internal changes in the tape, i.e., molecular or crystal structure changes, thereby causing very little internal friction. This assists in keeping the response of the spring tape **20** to the rotational urging linear.

The annular space between rotor **15** and annular wall **13** is quite short. This narrow annular space serves to prevent tape **20** from curling on itself as it is unwound. Most readers will have experiences unwinding a coiled tape or wire and noticing that as it is unwound it tends to curl on itself. This curling is caused by the setting of the tape while it is wound in coil form. For reliable operations annular space **16** should be kept small enough to prevent such curling. Actually, the narrower the annular space, the more reliable the operation. This approach is limited by machining tolerances. For example, if the space between the spring **20** outermost convolution and annular wall **13** was less than 1,000th inch, there is required a greater number of convolutions to effect a 180° rotation of rotor **15**. In other words, the narrower the space **16**, the greater the number of turns or convolutions of tape **20** are required to effect a given rotor rotation. Rotor rotational movement is the product of the number of convolutions and the rotational movement permitted by the radial outward movement of each convolution. It is apparent that the smaller this radial outward movement, the smaller the rotational movement of the rotor; hence, the greater number of turns required.

The timing delay of the unwinding of the rotational responsive device is in proportion to the number of convolutions in tape **20**. For a given tape, the greater the number of convolutions, the greater the time required to move from FIG. **2** illustrated position to the actuated position indicated by dotted line **18A** in FIG. **3**.

Because of the low friction in the illustrated embodiment, all of these design parameters may be considered in a straightforward manner. That is, by and large this invention provides an easily designable rotational responsive device because of the low friction involved. In other words, it is essentially a reliable linear rotationally responsive device.

For armament applications it is usual to provide a setback pin such that the mechanism is deactuated until the weapon fires the projectile thereby providing a setback force which withdraws a setback pin for permitting actuation of the rotational responsive device. Also, as the projectile is reaching its maximum rotational velocity it may be desired to lock the rotor in the actuated position. It is well known that as the projectile goes through air the air resistance tends to slow the rotational velocity. In certain instances this rotational velocity may be sufficiently reduced to permit spring **20** to return rotor **15** to an unarmed position. Such locking devices are known and are not discussed for that reason.

The present illustrated embodiment is designed for high spin rate projectiles such as ones that have a spin rate of 12,000 r.p.m. or higher. By adjusting the spring tension to a lower value, lower r.p.m.'s may be used to actuate the device. Experience has shown that in most embodiments the higher spin rates cause the device to operate in a reliable manner.

Therefore, there has been illustrated and described a rotationally responsive device which has only two rotatable moving parts with respect to the housing being rotated. The rotor is rotatably mounted on the housing such that there is a low friction support by axial pin **12**. The unwinder spring or tape **20** is mounted on the rotor and rotates therewith and unwinds by radially moving convolution by convolution outward to provide a low friction unwinding of the spring.

I claim:

1. A rotationally responsive device, including the combination,

a housing having a base portion, an axis and an annular wall portion concentrically extending around but spaced from said axis,

platelike rotor means disposed on said housing and rotatable about said axis and having an outer periphery spaced from said wall portion to form an annular space therebetween,

coiled tape means having plural convolutions disposed in said annular space and having one end connected to said rotor means at its outer periphery and another end connected to said annular wall portion for yieldably urging said rotor means in a first rotational sense,

said tape means being responsive to rotation of said housing to urge said tape means to unwind and urge rotation of said rotor means in a rotational sense opposite to said first rotational sense, said tape means unwinding by moving convolution-by-convolution radially outward with insubstantial rubbing between adjacent convolutions during such action, and said rotor means and a radially inward portion of said tape means being the only parts having rotational motions with respect to said housing.

2. The subject matter of claim 1 wherein said tape means has a total radial thickness slightly less than the radial thickness of said annular space.

3. The subject matter of claim 1 wherein said annular space has a radial thickness not greater than a radius of said rotor means.

4. The subject matter of claim 3 wherein said tape means is made of spring steel and has at least 10 convolutions.

5. The subject matter of claim 3 wherein said housing further includes a cover portion closing an end portion of said annular wall portion opposite to said base portion,

a pin extending between said base portion and said cover portion along said axis with said rotor means rotatably supported by said pin,

an arcuate recess in said rotor means extending concentric to said pin, and

a stop member on one of said portions extending inwardly toward said rotor means into said recess for limiting the rotational movements thereof between first and second rotational position.

6. The subject matter of claim 5 wherein said recess extends for 180° for permitting a one-half revolution of said rotor,

said cover portion and said base portion each having aperture means for receiving explosive charges with said apertures being substantially axially aligned,

said rotor means having an aperture located 180° from said apertures in said portion when said housing is not rotating such that said tape means is urging said rotor means to engage such stop member with one end of said arcuate recess in said one rotational sense.