July 7, 1953 J. RABINOW 2,644,398

CONSTANT TORQUE CLUTCH

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Fig. 1.

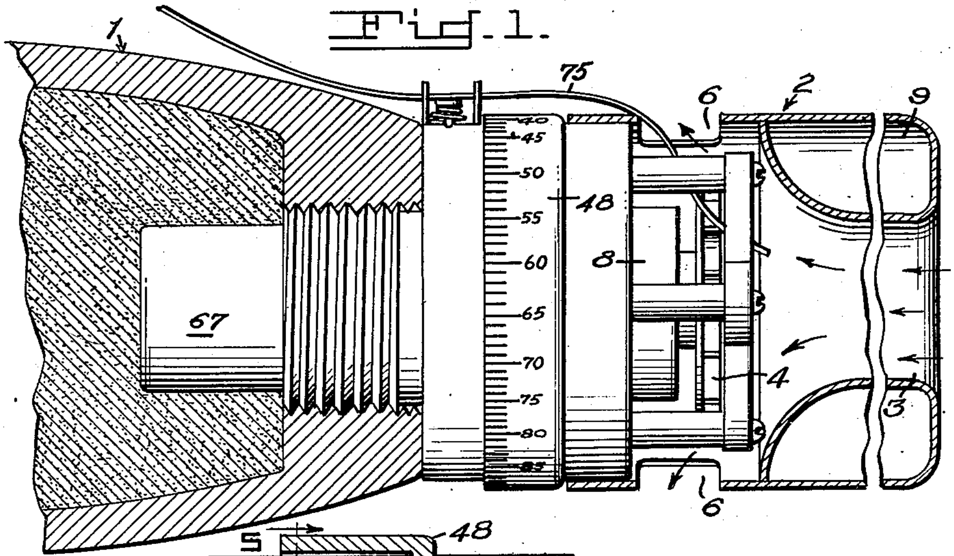
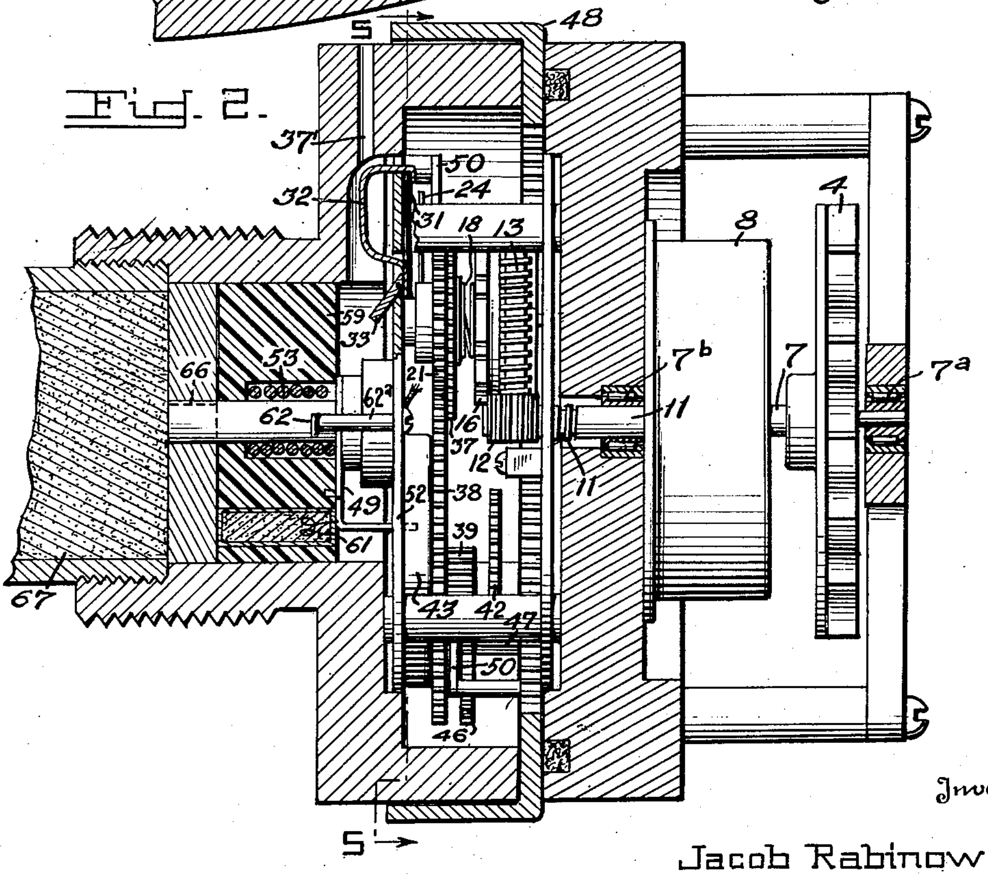


Fig. 2.



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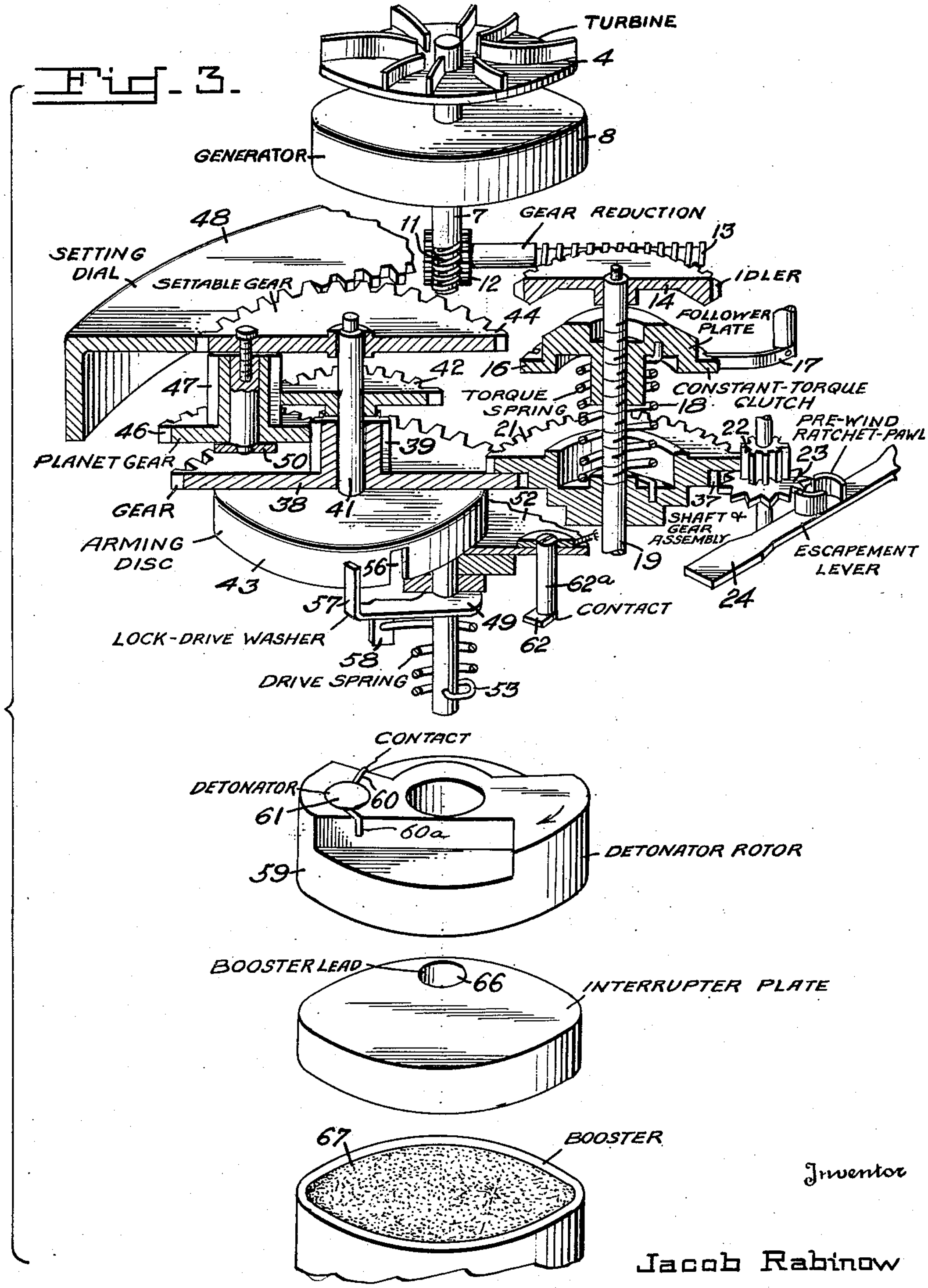

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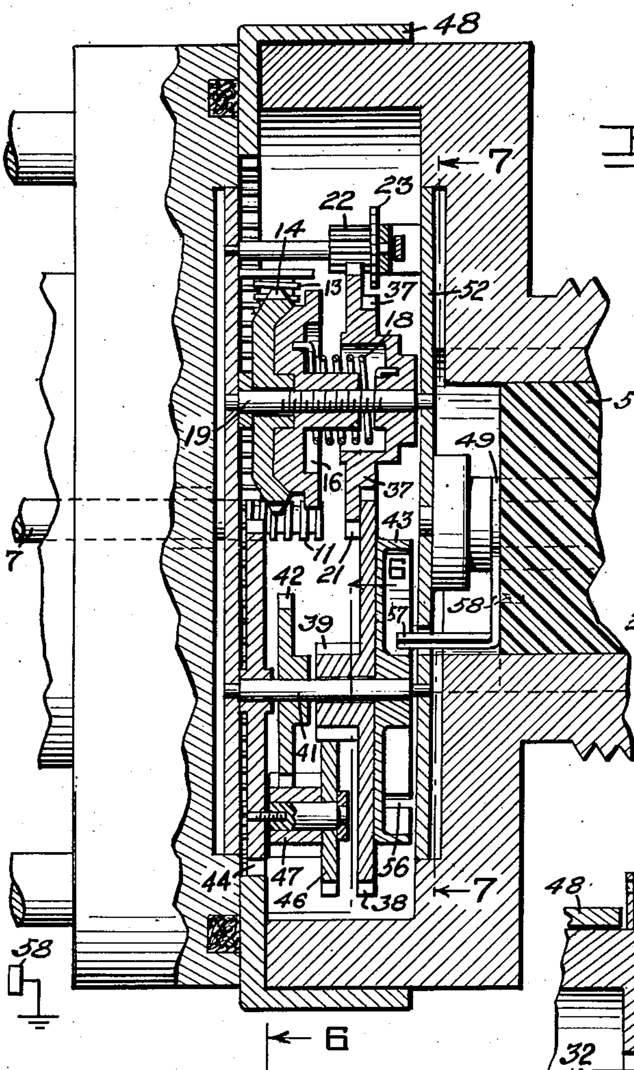

Fig. 4.

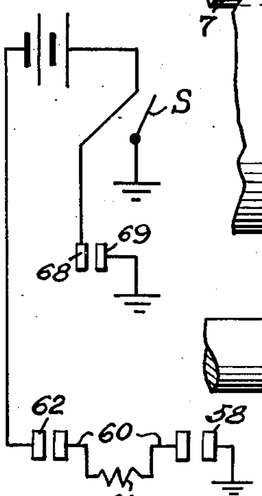

Fig. 5.

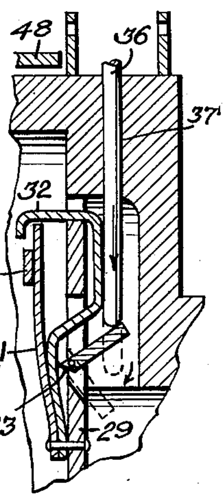

Fig. 8a.

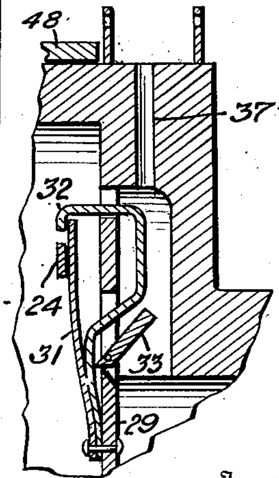

Fig. 8.

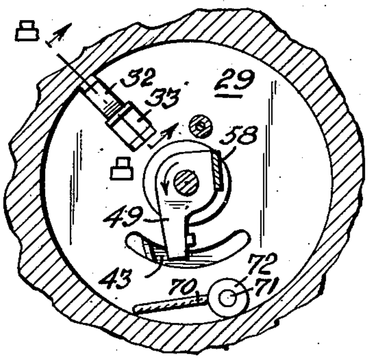

Fig. 7.

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FIG. 5.

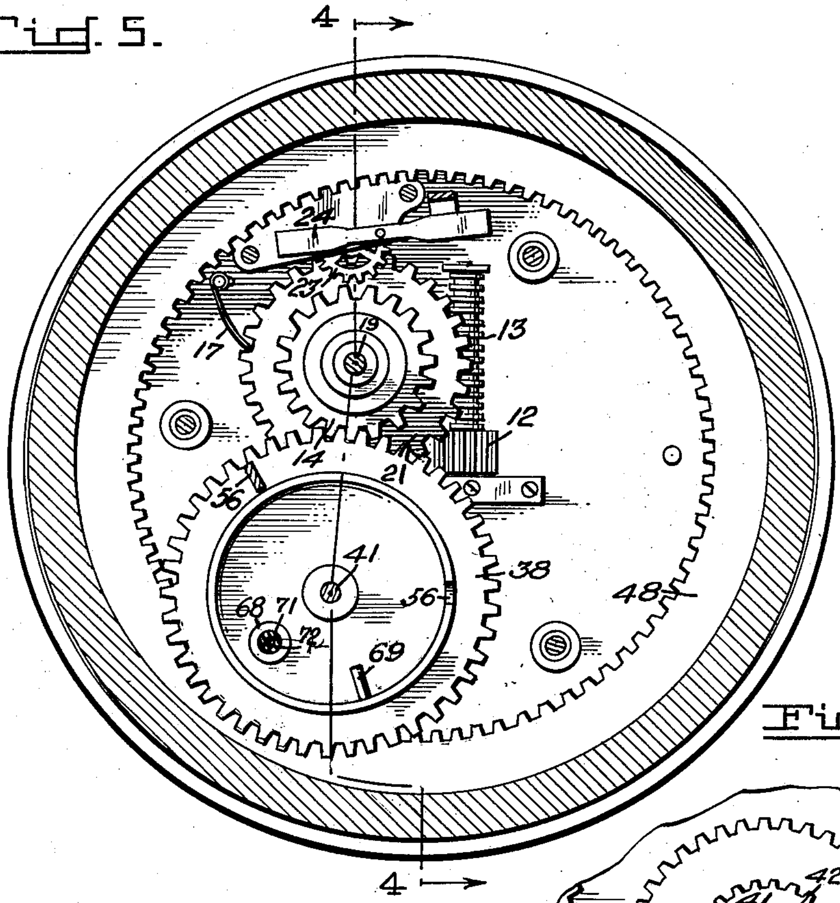


FIG. 6.

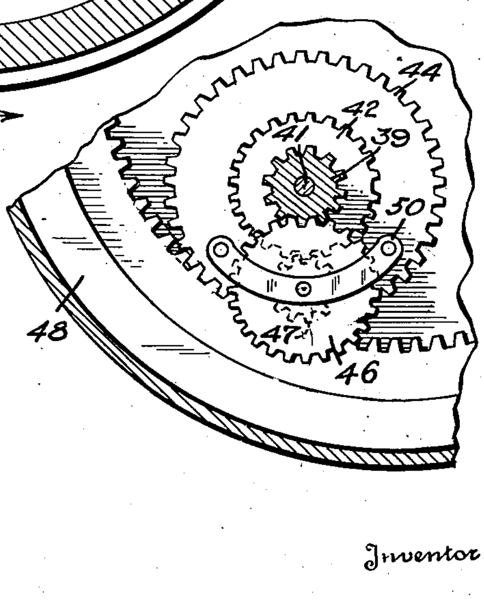
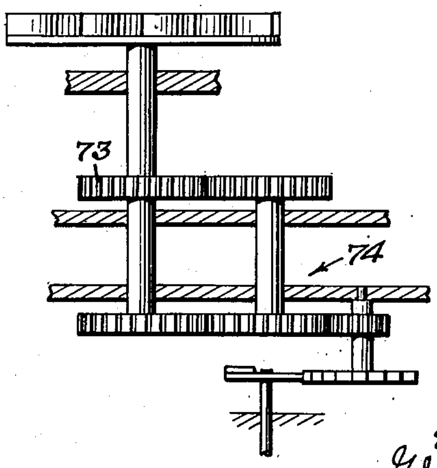


FIG. 10.



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2,644,398

CONSTANT TORQUE CLUTCH

Jacob Rabinow, Washington, D. C., assignor to the United States of America as represented by the Secretary of the Army

Application December 17, 1947, Serial No. 792,252

5 Claims. (Cl. 102—70.2)

(Granted under Title 35, U. S. Code (1952), sec. 266)

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The invention described herein may be manufactured and used by or for the Government for governmental purposes without the payment of any royalty thereon.

My invention relates to safety arming mechanisms for fuzes and particularly to an arming mechanism for electrically-actuated bomb fuzes, said arming mechanism having a time delay mechanism adapted to control the time of arming of said fuze. More specifically my invention relates to means for utilizing a variable force driving source such as a wind vane to provide a constant torque for driving an escapement mechanism to provide a definite, controllable time delay for a fuze arming mechanism.

My invention is applicable to any projectile fuze of the mechanical or electrical type for which safe operation requires that the projectile remain in the unarmed condition until a predetermined interval after it is released; the invention is particularly applicable to electrically actuated bomb fuzes in which an electric squib is fired to set off the fuze and it will be disclosed in connection with such a fuze although it will be understood that it is equally applicable to any other type of fuze employing a wind vane or turbine.

So-called "air travel" arming has long been used for projectile fuzes. In this type of device a wind vane or turbine is so associated with the arming device that after a predetermined number of turns of the wind vane due to travel of the projectile through the air, the fuze is in the armed condition. One important objection to this type of arming is that the time required to complete the arming depends on the velocity of the projectile during the arming period, and this is different for different sizes and types of projectiles such as bombs and rockets. As it is desirable to use one type of fuze for more than one type or size of projectile, it will be seen that the arming time is not necessarily a definite quantity with air-driven type of arming. The arming time with this type of device will also vary with the horizontal initial speed of the projectile. It has therefore been proposed to use a spring driven clock mechanism, and such mechanisms have been developed, but they lack the essential safety of air travel mechanism in that they may operate if defective even when the projectile is not in flight.

If the wind vane is used as a power source to drive a generator, as is the case in some types of electric fuzes, driving a clock mechanism directly from the wind vane shaft does not al-

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ways supply suitable torque to the clock mechanism, since the wind vane speed may vary widely and in this case the torque will also vary so that it is difficult to obtain a desired accuracy of timing. As the generator requires a high-speed drive, considerable gearing down is necessary to drive the clock work. Such direct operation of slow-speed clock work from a high-speed shaft through gearing results in large forces on the clock mechanism which makes it difficult to secure good operation. If the wind vane is not used for other purposes, it may be designed so that it will be slowed down by the clock work without producing excessive forces, and therefore may be used to drive the clock work directly.

It is an object of my invention to secure accuate "time" arming (as against "air travel" arming) by the use of a clock work timing mechanism driven from the high speed turbine shaft, the above mentioned and other difficulties being obviated when the wind vane is also used to drive a generator, by the use of a novel constant-torque clutch which slips whenever a predetermined torque is exceeded.

Other objects are to provide a fuze arming mechanism that can be used with existing types of fuzes; that is readily adjustable as to timing; that can be inexpensively constructed of simple and readily available parts; and that is reliable and foolproof in use and operation.

Other objects and advantages will be apparent from the following description and drawings in which:

Fig. 1 is a longitudinal view partly in cross section of a projectile embodying my invention,

Fig. 2 is an enlarged longitudinal sectional detailed view of the fuze,

Fig. 3 is an "exploded" schematic diagram of the essential elements of my invention showing the principle thereof,

Fig. 4 is a view of partial section taken on line 4—4 of Fig. 5,

Fig. 5 is a sectional detailed view taken on line 5—5 of Fig. 2,

Fig. 6 is an enlarged detailed sectional view taken on line 6—6 of Fig. 4, of the planetary setting gear showing its cooperation with the setting dial,

Fig. 7 is a detailed sectional view taken on lines 7—7 of Fig. 4 of the latch mechanism immediately after the latch has been released,

Fig. 8 is an enlarged sectional view of the preset catch taken on line 8—8 of Fig. 7 in the initial safety position,

Fig. 8a is a view similar to Fig. 8, showing the catch actuated by the safety arming pin,

Fig. 9 is a schematic diagram of one circuit which may be employed in the electric fuze; and

Fig. 10 shows a modification in which a clock mechanism is driven directly from a wind vane shaft.

Referring to the drawings, a projectile 1, carrying the usual explosive charge, is provided with fuze 2, which may be of any type, but which is shown as an electric fuze of any known type. The fuze shown is provided with an aperture 3 for admitting an air stream to wind vane or turbine 4 which is thereby caused to rotate when the projectile is in motion. The air escapes through a series of peripheral exhaust ports 6. Turbine 4 drives shaft 7 which is supported in bearings 7a, 7b, and, in turn, drives a generator indicated at 8 in Figs. 1 and 3. The generator serves to supply power to the electric circuits of the fuze which may be housed, with the construction shown, in the annular space 9, although this arrangement is not material to my invention.

Shaft 7 terminates in worm 11 which drives gear 12; this, in turn, drives idler 14 through spiral gear 13 to provide a suitable speed reduction. Idler 14 rotates freely on the shaft 19 of shaft and gear assembly 19, 21, 37 and constitutes the driving element of my constant-torque clutch in that it bears upon the follower friction plate 16, and tends to rotate the latter with it. The follower friction plate 16 is threaded on shaft 19 and is urged by torque spring 18 in such direction of rotation as tends to make it bear against idler 14, while the torque transmitted to the follower friction plate from idler 14 tends to drive the plate away from the idler whenever it causes relative motion between the idler and shaft 19 on which it is threaded; this of course occurs only when there is slippage between idler 14 and friction plate 16, which happens whenever the torque of spring 18 is exceeded. The other end of torque spring 18 is fixed with respect to and drives shaft gear assembly 19, 21, 37 which are all fastened together. If the speed of rotation of idler 14 is correct to drive its load, which consists chiefly of a clock escapement mechanism, then the idler and the shaft and gear assembly rotate as a unit. If the speed of input idler 14 rises to a rate higher than necessary, so that the input torque of the system shown tends to become too great, the friction plate 16 tends to wind torque spring 18 still further by rotating on shaft 19 away from idler 14 toward gear 21. Thus, overdrive from idler 14 causes follower 16 to be driven so that its rotation on shaft 19 causes it to be partially withdrawn from frictional engagement with idler 14 against the torque of spring 18. The resultant time action is such that the friction force is self-regulating to a point just sufficient to exceed the opposing torque of spring 18. This action occurs independently of wear, aging, or coefficient of friction between idler 14 and friction follower plate 16, since the effect of changes in such constants is merely to change by a slight amount the position of follower 16 at which it commences to disengage from idler 14. Since spring 18 is a relatively long helically wound spring, the overall change in spring tension is very slight for small angular motion of the follower 16 with respect to shaft 19. The amount of angular motion is determined by the relative speeds of idler 14 and shaft 19 and by the pitch of the threads on shaft 19 and the follower. Normally, standard fine threads are used on these members, but changing the pitch of the threads within reasonable limits does not appreciably affect the operation of the device.

If the output gear 21 or 37 is forceably restrained from rotating, slippage will occur between idler 14 and follower 16, and the torque delivered to gear 21 will be determined solely by the tension of spring 18.

Thus it is seen that the force between the idler and the output gears is automatically controlled by the tension of spring 18, and that the torque delivered at the output gear 21 is constant regardless of the speed at which idler 14 is rotated.

It will be noted that the constant torque clutch above described is needed only because of the different speed and power requirements of the generator on the one hand and the clock work and arming rotor (which are described below) on the other hand. The generator, to meet very exacting space and weight requirements, must be driven at high speed; the clock work must be driven at low speed. This necessitates a high gear reduction ratio which means that when the wind vane is going faster than the clock work requires, large torque forces are set up which are difficult to withstand without excessively heavy and rugged construction, and which also tend to drive the clock work faster than its normal speed. Both of these undesirable effects are eliminated by using the constant torque clutch. However, there are also applications in which no generator is employed and where the problem of a suitable power source for a clock mechanism can be solved by directly coupling a wind vane or turbine to the clock gearing without the use of slipping clutch, and this too is within the purview of my invention. As shown in Fig. 10 the clutch may be eliminated when there is no generator to be driven, and the shaft may directly drive gear train 74 through gear 73. In this case the wind vane, other things being equal, will be smaller and less powerful than in the previous case, and will be pitched to run at a speed only slightly higher than needed by the initial gear of the clock work, which will employ a smaller gear reduction than in the first case, so that if the wind speed past the turbine blades is greater than required, the clock work load will be able to retard the turbine speed without either damaging the clock work or undue tendency to speed variations.

Gear 21 drives escapement pinion 22 which drives "deadbeat" escapement 23, 24 which may be of the type commonly used in ordnance timers. This serves to regulate accurately the timing of the arming system which will now be described.

Small gear 37 which is fastened to gear 21 and rotates therewith drives large gear 38, to which is fastened pinion 39, the two gears rotating freely, as a unit, on final gear shaft 41. Pinion 39 drives planet gear 46 to which is fastened pinion 47, the two gears, as a unit, being mounted physically on settable gear 44 by means of bracket 50 fastened to gear 44. This settable gear 44 is meshed with the internal gear teeth of the setting dial 48 which surrounds the base portion of the fuze. During the arming cycle this dial 48 is of course stationary, resulting in a fixed position of gear 44 and the planet gear assembly 46, 47. Pinion 47 meshes with the final gear of the system 42, which is rigidly fastened to the shaft 41 which carries arming disc 43. Thus, when the setting dial 48 and the settable gear 44 are stationary the output of the clutch serves to turn the arming disc 43 through the gears as shown.

To vary the arming time of the fuze the setting dial 48 is rotated, driving the settable gear 44 which carries with it the planet gear assembly. Since at this time gears 46 and 47 are not rotating, this motion of the planet gear causes the arming disc 43 to rotate, thus changing the setting.

With the clock work in operation, when the arming disc 43 reaches the predetermined position corresponding to a preset time interval, finger 57 on lock-out washer 49 is made to snap through notch 56 by the force of drive spring 53, and due to the engagement of the ear 58 (on washer 49) with detonator rotor 59, the latter is rotated approximately 90° into the armed position wherein contact 60 on the rotor engages stationary contact 62 on insulating post 62*a* which is supported by base plate 52, to provide a circuit through the detonator 61 to arm the fuze for detonation at a subsequent time by the electric element carried in space 9. This circuit is completed through contact 60*a* which is engaged and grounded by ear 58. At the same time the detonator is also aligned with booster lead 66 whereby booster 67 can be fired by the detonator to explode the projectile charge.

In the event that the fuze fails to operate for any reason, self-destruction is provided by an insulated contact 68 (Fig. 5) which is grounded by contact 69 mounted in the arming disc in such a manner as to close the detonator circuit several seconds after the instant of arming. Contact 68 is supported from base plate 52 by means of post 71, and insulated grommet 72. One arrangement of electric circuits is schematically shown in Fig. 9, although the actual circuit connections would depend on the type of electric fuze employed, and is a matter within the skill of any competent person versed in this art. In this figure the electric fuze would normally close the circuit to effect detonation is scrematically represented at S.

Since this timing mechanism is driven by an air turbine, it is necessary to take care of the time lag which may be introduced, in the case of a bomb, by the depth of the bomb bay, which, in a large plane may be as much as 16 feet. This, together with the normal time taken by the turbine to come up to speed, might result in a timing error of more than one second. To overcome this, the coil spring 18 of the constant torque clutch is made use of to provide approximately a one second "prewind" to the clock mechanism. This is done during assembly by manually rotating the follower friction plate 16 for approximately one or two revolutions on its screw thread, and locking it in place with the prewind ratchet pawl 17. The escapement is prevented from oscillating by means of a locking pin to be later released by the arming wire, in the case of a bomb, or in any other desired fashion. This prewind of the clutch serves two purposes. It eliminates the starting error mentioned above, and it completely disconnects the turbine and generator system from the arming system. The fuze then can be tested for electrical performance without any torque being transmitted through the clutch.

The prewinding of the torque spring 18 requires the gear assembly 19, 21, 37 to be held against rotation until the projectile is released. This is accomplished by normally restraining escapement lever 24 by means of a small soft leaf spring stop 31 (Fig. 8) riveted to plate 29 and biased against lever 24 to restrain same against motion. Spring stop 31 is normally restrained from engaging lever 24 by spring catch 32, which is stronger than spring stop 31 and normally keeps stop 31 away from lever 24 as shown in Fig. 2. A pivoted latch 33 is provided which, in the initial position of the unarmed fuze, disables catch 32 as shown in Fig. 8 so that stop 31 is effective to restrain lever 24. Insertion of arming pin 36 in hole 37′ maintains spring catch 32 in the disabled state, but pivots latch 33 out of the way (as shown in Fig. 8*a*) so that it is henceforth inoperative. Withdrawal of the arming wire when the projectile (in this case a bomb) is released, permits a spring (Fig. 1) to eject arming pin 36 which activates catch 33 to restrain stop 31. This starts the clock mechanism, due to the prewind of spring 18, which threads shaft 19 down relative to follower plate 16 (which does not move) until idler 14 engages the plate 16. Actually, friction follower plate 16 travels up on shaft 19 during this action until engagement with idler 14 occurs; by this time the turbine has come up to speed, as the bomb is out of the bomb bay into free air, and plate 16 will drive the system as previously described, the direction of rotation being such that the pawl 17 has no further effect.

It may be noted that even without the use of the ratchet pawl, this arming system permits testing of the electric system without effecting the time setting since the clutch design is such that when the escapement is held in a fixed position, this idler will automatically slip when the spring torque is exceeded.

Arming wire 75 may also be extended, as shown in Fig. 1, to pass through port 6 and into path of the turbine as an additional safety feature, or a second pin similar to pin 36 may be provided for this purpose if it is desired to insure locking of the turbine against rotation, the details of an arrangement for this purpose being within the skill of those versed in the art.

It will be seen that the above described conclusion accomplishes the objects of the invention but it will be apparent that other mechanical motions and elements than the ones shown could be used to accomplish the same objects within the scope of the invention as defined by the appended claims.

I claim:

1. An arming system for an electric fuze comprising a wind vane in the nose of said fuze, a shaft driven by said wind vane, a clockwork timer driven by said shaft, a powder train interrupter including an element movable from a safe position into an armed position, a latch for retaining said element initially in the safe position, spring means biasing said element into the armed position, means controlled by said timer for releasing said latch from said retaining position after a predetermined time of operation of said timer, and a high speed generator driven by said shaft for supplying power to said electric fuze, and a friction clutch between said shaft and said clockwork timer.

2. The invention as recited in claim 1, wherein said friction clutch is a constant-torque clutch.

3. The invention as recited in claim 2, wherein said clutch comprises an idler rotatably freely mounted on a threaded shaft and driven by said

wind vane shaft, said idler having a friction bearing surface, a follower threaded on said shaft and having a friction bearing surface arranged for cooperation with said first bearing surface, a spring fixed at one end to said idler and arranged at the other end to bias means fixed to said threaded shaft for driving said clock timer and said latch.

4. The invention as recited in claim 3 and including means associated with said latch for setting the time after starting at which the latch is released.

5. The invention as recited in claim 4 and including catch means for releasably restraining said clockwork against operation, means for restraining said follower in a position threaded down on said shaft a predetermined distance away from said idler but permitting rotation of said follower in the same direction as said idler

and means for releasing said catch means when arming of the fuze is initiated.

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