Feb. 13, 1945. W. L. McGRATH ET AL 2,369,310

MECHANICAL TIME FUSE

Filed Dec. 29, 1938 4 Sheets-Sheet 1

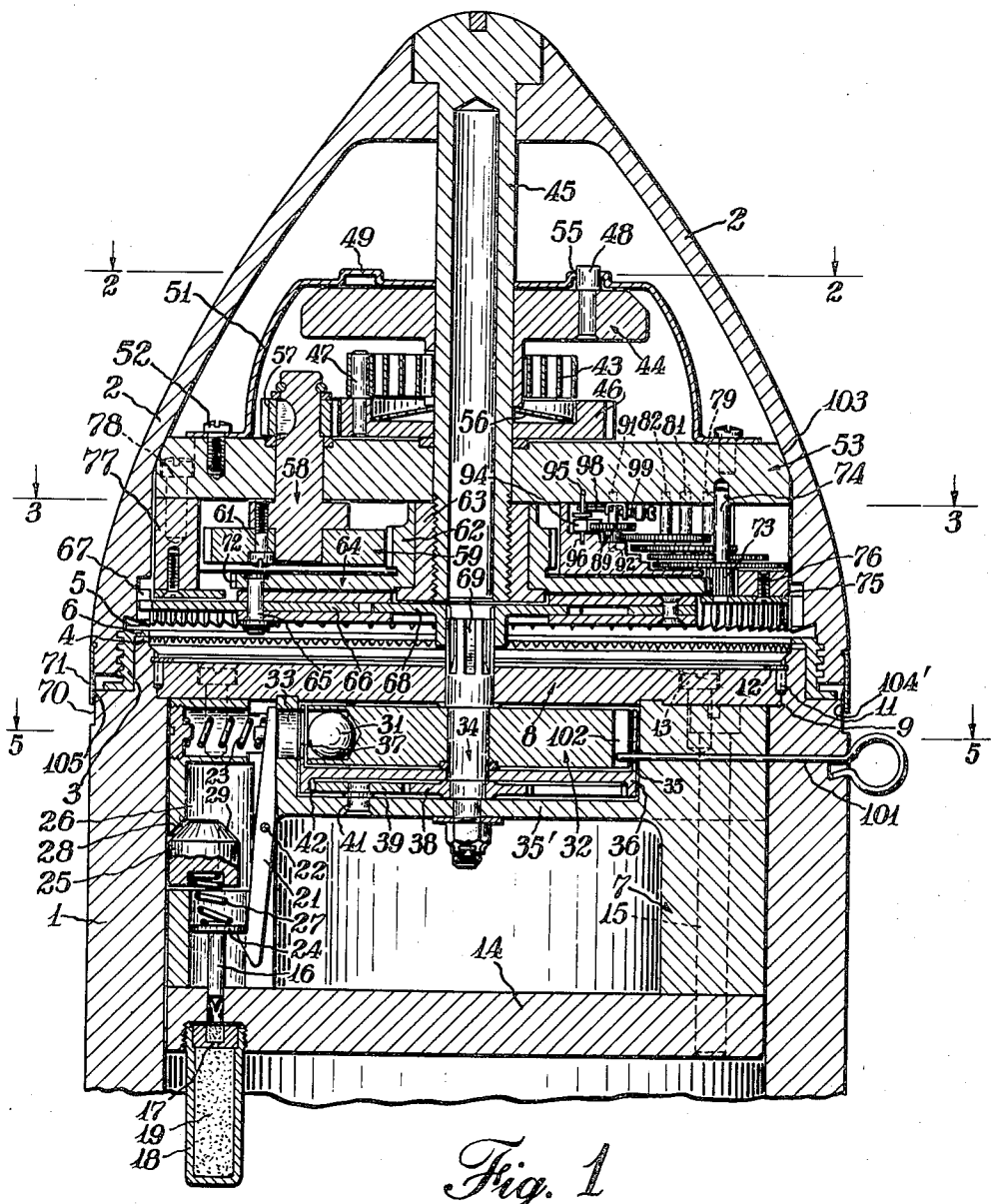


Fig. 1

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MECHANICAL TIME FUSE

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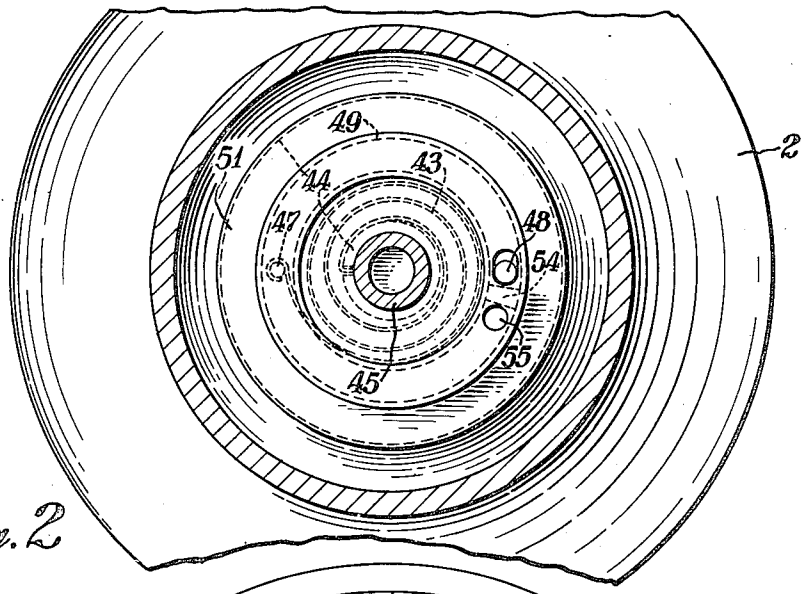


Fig. 2

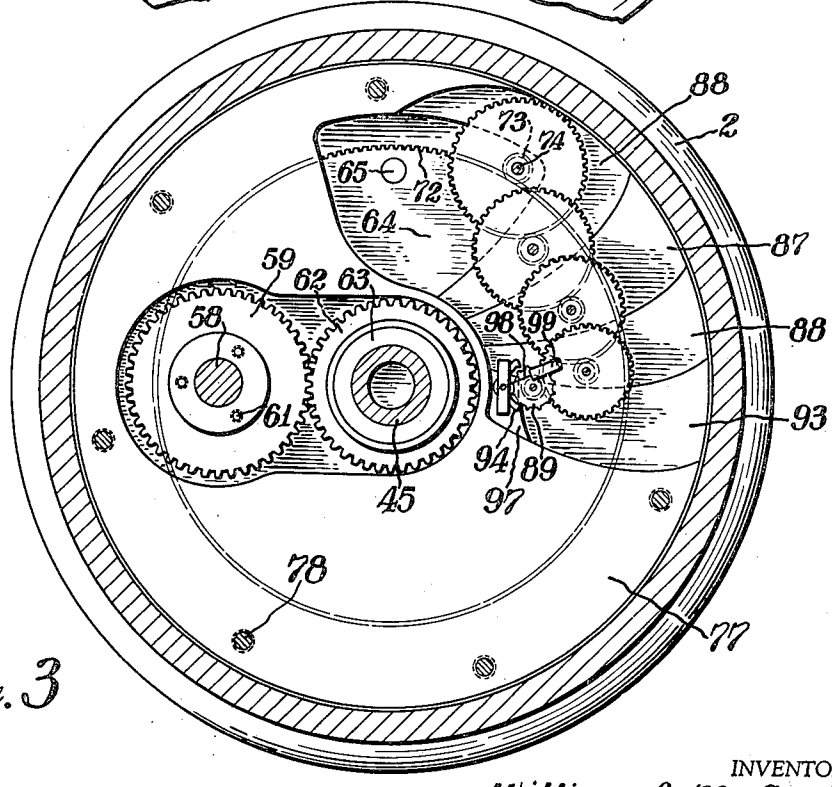


Fig. 3

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Fig. 6

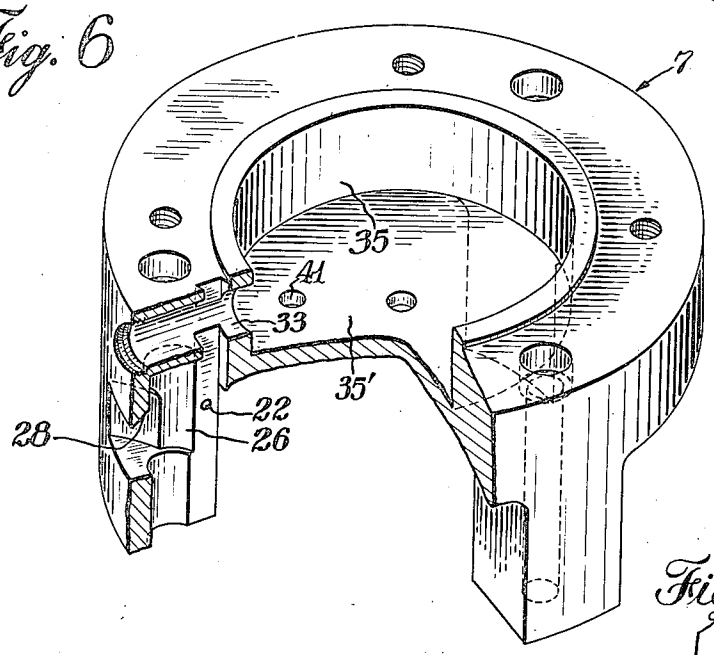


Fig. 8

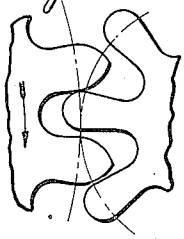


Fig. 9

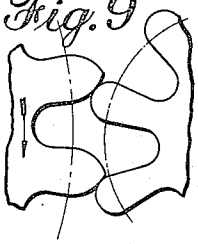


Fig. 10

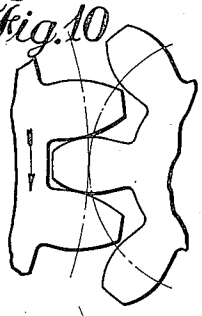
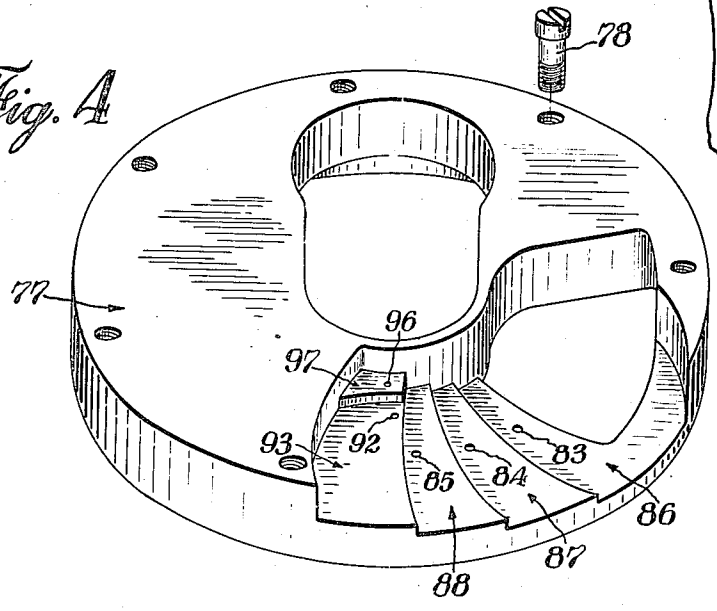


Fig. 4



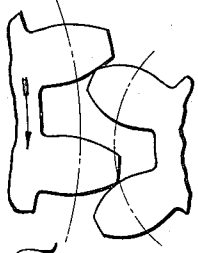


Fig. 11

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Fig. 5

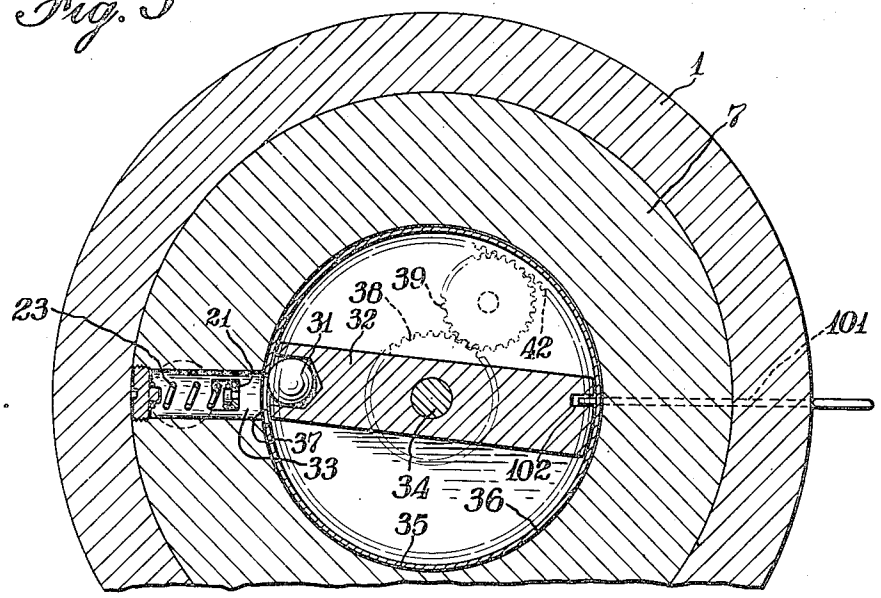
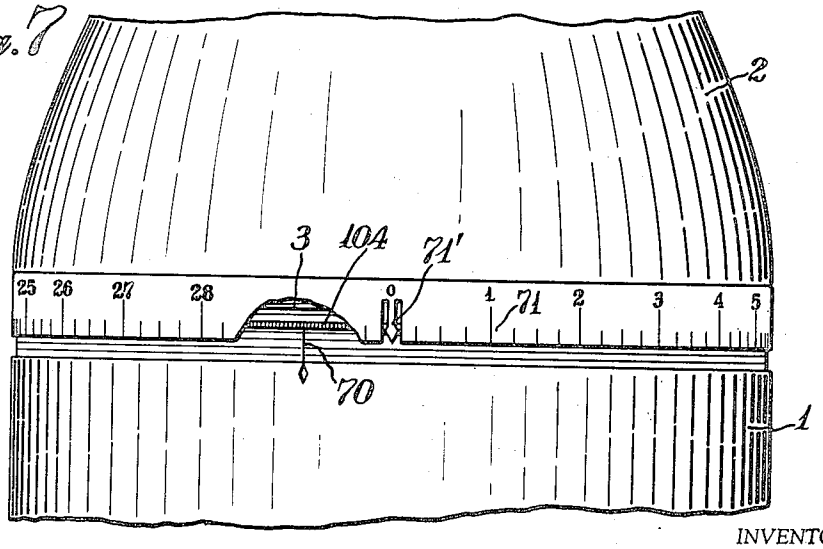


Fig. 7



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2,369,310

UNITED STATES PATENT OFFICE

2,369,310

MECHANICAL TIME FUSE

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Application December 29, 1938, Serial No. 248,224

2 Claims. (Cl. 102—84)

The present invention relates to a mechanical time fuse for explosive projectiles and more particularly to a device operated by energy derived from the acceleration of the projectile, for timing and actuating the firing mechanism of the projectile.

Mechanical fuses have heretofore been constructed using various types of inertia and/or spring-actuated driving mechanism with gearing and escapement devices to control the release of the firing pin. It has been found possible to construct such fuse mechanism having a time scope of thirty seconds or more with an accuracy tolerance of a few hundredths of a second, which will operate quite consistently under laboratory test conditions. Under conditions of actual use, however, it has been found that in spite of accurate workmanship and close fitting, discrepancies in operation occur, and it is even possible for the devices to become inoperative due to the accelerational and centrifugal forces exerted on the parts.

As nearly as can be determined, these defects in operation are caused by deformation and disturbances of the elements from which the frame and housing for the gearing and escapement mechanism is built up, and by displacement and distortion of the gearing and escapement elements in the frame.

Difficulty has also been encountered in providing a positive lock for the setting mechanism which will unfailingly maintain the setting of the fuse in all conditions of use. Moreover, the usual types of trip mechanism for the firing pin place such a frictional load on the gearing that the variations in such load impair the accuracy of control of the gearing by the escapement mechanism.

It is an object of the present invention to provide a novel mechanical time fuse which is reliable and accurate in operation while being safe to handle and easy to set for timed operation.

It is another object to provide such a device including a source of power adapted to deliver substantially uniform torque throughout the flight of the projectile, and multiplying gearing actuated thereby under the control of an escapement mechanism.

It is another object to provide such a device including a novel anti-friction type of trip for the firing pin.

It is a further object to provide such a device including a rigid frame comprising an integral supporting member for the gearing and escapement mechanism.

It is another object to provide such a device in which the gearing is designed and arranged to operate without interruption or inaccuracy regardless of variations in center distance of the gears due to accelerational or centrifugal forces.

It is another object to provide such a device in which the firing mechanism is armed only by the discharge of the projectile and remains armed only during the flight thereof.

It is another object to provide such a device in which the timing mechanism may have a wide scope of adjustment with a large scale facilitating rapid and accurate setting of the fuse.

Further objects and advantages will be apparent from the following description taken in connection with the accompanying drawings in which:

Fig. 1 is a vertical substantially mid-sectional view of the nose of a projectile in which a preferred form of the present invention has been incorporated;

Fig. 2 is a section taken substantially on the line 2—2 of Fig. 1, showing more particularly the construction of the source of power for the timing mechanism;

Fig. 3 is a section taken substantially on the line 3—3 of Fig. 1, showing the multiplying gearing and escapement mechanism;

Fig. 4 is a perspective view of the frame member which carries the reduction gearing and escapement mechanism;

Fig. 5 is a section taken substantially on the line 5—5 of Fig. 1, showing the trip mechansm for the firing pin latch;

Fig. 6 is a perspective view, partly broken away, of the frame member which forms the mounting for the firing pin with its latch and trip mechanism;

Fig. 7 is a detail in side elevation of the shell and nose cap, showing the setting scale;

Fig. 8 is a detail in side elevation on a greatly enlarged scale showing portions of a meshing gear and pinion formed according to the conventional practice in chronometric devices;

Fig. 9 is a view similar to Fig. 8 showing the positions assumed by the gear and pinion when the center distance thereof is increased by reason of the effects of centrifugal force, etc.;

Fig. 10 is a similar view of a gear and pinion formed in accordance with the teachings of the present invention; and

Fig. 11 is a view similar to Fig. 10 showing the parts in the positions assumed when the center distance thereof is increased as in Fig. 9.

In Fig. 1 of the drawings a portion of a shell of

conventional type is illustrated comprising a casing 1 and a cap 2 threaded thereon by means of a sleeve 3 of soft metal such as lead or copper bonded to the casing and having threads engaging in internal threads formed in the interior of the cap. The upper rim of the shell is preferably provided with teeth 4, and the interior of the cap 2 is provided with a corresponding annular series of teeth 5 so arranged that upon discharge of the shell from its rifle, the threads of the soft metal member 3 are stripped, and an inwardly extending flange 6 thereof is clutched between the teeth 4 and 5 of the casing and cap respectively, thus securely locking the cap to the casing and preventing relative rotation thereof.

A frame member 7 (Fig. 6) is mounted in the shell casing 1 in any suitable manner as by means of a mounting plate 8 seated in a counterbore 9 in the top of the casing, keyed against rotation by means of dowels 11 and maintained in its seat by means of a locking ring 12. The frame 7 is attached to the mounting plate 8 by suitable means such as cap screws 13, and a partition plate 14 is rigidly connected to the frame as by means of cap screws 15.

A firing pin 16 is slidably mounted in the frame 7 and partition plate 14 in position to engage and detonate a cap 17 of suitable explosive material mounted in the end of a cartridge 18 containing explosive material 19 for detonating the main charge of explosive contained in the body of the shell. The firing pin is normally maintained retracted from the percussion cap 17 by means of a latch 21 pivoted at 22 in the frame member 7 and maintained by a spring 23 in engagement with a flange 24 on the upper end of the firing pin. Means responsive to acceleration of the shell on discharge from the rifle for arming the firing pin is provided in the form of a weight member 25 slidably mounted in a recess 26 in frame member 7 and bearing on a firing pin spring 27 which engages the firing pin. The firing pin spring 27 is normally released, but on acceleration of the shell upon its discharge from a rifle, the weight 25 is set back to the position illustrated in Fig. 1 in which the firing pin spring 27 is compressed. During the flight of the projectile, the set-back weight 25 is maintained in the position shown by the engagement of an inclined shoulder 28 on the frame 7 with the tapered upper portion 29 of the weight member, this engagement being firmly maintained by centrifugal force due to the rapid rotation of the shell.

Means are provided for tripping the latch 21 to allow the spring 27 to actuate the firing pin 16 a predetermined time interval after discharge of the projectile. As here shown, this means comprises a spherical weight member 31 seated in the periphery of a rotary carrier 32 which is slowly revolved during the flight of the projectile to roll the weight member 31 into alignment with an opening 33 in a gate member 35 in the form of a cylindrical wall in the frame 7. The opening 33 is adjacent the upper end of the latch 21 whereby the weight member 31 can strike the upper end of the latch by reason of centrifugal force operating on the weight member, thus causing release of the latch.

As here illustrated, the carrier 32 is fixedly mounted on a shaft 34 journalled in the supporting plate 8 and in a partition 35' formed in the frame member 7 below the gate wall 35. In order to provide greater latitude of adjustment than could be secured merely by the rotation of the spherical weight member 31 into registry with the opening 33 in the gate member 35, a cylindrical diaphragm 36 is freely journalled on the shaft 34 within the gate member 35 and is provided with an opening 37 similar to the opening 33. A pinion 38 is fixed to the shaft 34 and meshes with a pinion 39 fixed as indicated at 41 in the partition 35' and meshing with an internal gear 42 formed in the rim of the diaphragm member 36. The sizes of the pinion 38, gear 39 and internal gear 42 are so proportioned that the diaphragm will make a suitable number of revolutions backward while the carrier 32 is making one revolution forward. Thus, if the gear ratio is 4:1, the opening 37 in the diaphragm will register with the opening 33 in the gate member at the same time that the spherical weight member 31 is brought into registry therewith once during four revolutions of the carrier. It is thus possible to set the fuse so that the carrier will have to make up to slightly less than four revolutions before the tripping mechanism will be operated.

Means for rotating the carrier 32 at a predetermined speed during the flight of the projectile is provided in the form of a power source, multiplying gearing and an escapment mechanism. The power source here illustrated is in the form of a spring 43 attached at one end to a weight member 44 freely journalled on a clamping bolt 45, and attached at its other end to a main drive gear 46 as by means of a pin 47. The weight member 44 is provided with a stud 48 arranged to traverse a channel 49 in a locking block 51 fixed as indicated at 52 to a cap mounting plate 53. The channel 49 is provided with an abutment 54 (Fig. 2) for the pin 48 and, adjacent the abutment 54, with an opening 55. The weight member is normally urged upwardly with the pin 48 bearing in the bottom of the channel 49 by suitable means such as a spring 56. In will be understood that the normal position of the weight 44 is with the pin 48 in the channel 49 against the abutment 54. When discharge of the shell occurs, however, the rotation of the shell causes the weight 44 to be rotarily displaced, the pin 48 traversing the groove 49 until it strikes the opposite side of the abutment 54, whereupon the spring 56 expands and forces the pin 48 into the opening 55 as illustrated in Fig. 1, whereby the spring 43 is wound up to store energy therein.

A pinion 57 meshing with the main drive gear 46 is fixedly mounted on a shaft 58 journalled in the mounting plate 53 and carrying on its lower end a gear 59 fixed thereto as indicated at 61. Gear 59 meshes with a pinion 62 journalled on the exterior cylindrical surface of a clamp nut 63 threaded on the bolt 45. A planet carrier disc 64 is formed on or rigidly connected with the pinion 62 and carries a plurality of studs 65 on which are journalled planet gears 66 meshing on their outer edges with an internal gear 67 formed in the interior of the cap 2, and also meshing with a sun gear 68 having a splined connection 69 with the upper end of the shaft 34 for the tripping mechanism. It will thus be seen that if the cap 2 is held stationary, rotation of the gearing by the spring 43 will cause rotation of the trip mechanism. On the other hand, if the main driving gear 46 is held stationary and the cap 2 rotated by hand, the trip mechanism may be set to any desired position.

In order to indicate the setting of the cap 2 and consequently of the trip mechanism, a micrometer scale having a suitable zero line 70 (Fig. 7) is engraved on the shell casing 1 and

arranged to cooperate with an engraved scale 71 suitably fixed on the rim of the cap 2.

In order to control the rotation of the gearing, an escapement mechanism is provided. As shown in Figs. 1 and 3, the planet carrier 64 is provided with peripheral gear teeth 72 meshing with a pinion 73 mounted on a shaft 74 bearing at one end in the mounting plate 53 and at the other end in a bearing plate 75 fixed as indicated at 76 to a gear frame member 77 (Fig. 4) rigidly connected as by means of cap screws 78 to the mounting plate 53.

A series of multiplying gearing is driven from the pinion 73, the mounting shafts of which bear at one end in the mounting plate 53 as indicated at 79, 81 and 82 and at their other ends in bearing openings 83, 84 and 85 formed in stepped surfaces 86, 87 and 88 of the gearing frame member 77. An escapement wheel 89 driven by this multiplying gearing is mounted at one end as indicated at 91 in the mounting plate 53 and at its other end in the opening 92 in the step 93 of the gearing frame. A pallet 94 is arranged to cooperate with the escapement wheel 89, being mounted at 95 in the mounting plate 53 and at 96 in the step 97 of the gearing frame. A hair spring 98 for the pallet is provided having a suitable adjusting mechanism 99 mounted on the mounting plate 53.

It will be understood that all the parts within the shell are subjected to very heavy translational and rotational forces, and in particular centrifugal forces generated by the extremely rapid rotation of the shell. It has heretofore been customary in devices of this character to employ gearing of the type usually used in chronometric work in order that the usual formulas and operations might be adapted for use in the timing mechanism for the shell. It has been found, however, as above pointed out, that the stresses engendered particularly by centrifugal forces on the components of the gearing may be of such values as to impair the accuracy of the gearing or even render it inoperative by reason of distortion of the frame and/or displacement and distortion of the gear shafts.

According to the present invention, it is proposed to substantially eliminate the possibility of distortion of the gear frame by forming the gear frame as an integral unit having steps or terraces for the accommodation of the various steps of the gearing. Moreover, it is a further feature of the invention to utilize a form of gearing in which the operation of the gearing is substantially unaffected by changes in center distances thereof within reasonable limits, and the possibility of the gearing being rendered inoperative by the causes above mentioned is substantially elminated. It has been found that the so-called involute gearing in which the tooth contour may be said to be described by a point on a line unwrapped from the base circle of the gear, possesses the desirable qualities above referred to. It is proposed, therefore, according to the present invention to incorporate involute gearing both as drive gearing for the trip mechanism and for the escapement mechanism for the purposes stated.

Figs. 8, 9, 10 and 11 illustrate the old and new types of chronometric gearing and the difference in operation brought about by the adoption of the involute type of gear tooth. Fig. 8 illustrates the ordinary form of chronometric gearing in which the tooth contours are formed by simple arcuate lines joined by straight lines. As there shown, the tooth engagement in this form of gearing occurs mainly at and near the point of tangency of the pitch circles, and if the center distance of the gear and pinion is maintained constant so that the pitch circles are actually tangent, the gearing operates quite satisfactorily. If the center distance is increased substantially, however, due to the accelerational or centrifugal forces encountered in this art, a condition may occur such as illustrated in Fig. 9 in which the tooth contacts take place substantial distances from the pitch circles which are no longer tangent, and a wedging and locking condition may be encountered.

Fig. 10 shows the type of involute gearing which is incorporated in the chronometric gearing according to the present invention and which is so arranged that a constant gear ratio is maintained between the driving gear and driven pinion irrespective of the point of engagement of the gear teeth. When the center distance of a gear and pinion of this type is increased, the operation of the gearing is not adversely affected since a wedging condition is not encountered as will be seen by an examination of Fig. 11. The only effect of the spreading of the gear and pinion centers is to introduce the possibility of backlash between the gear and pinion, but since the driving force of the gear is constant, the driven pinion is rotated at constant speed without backlash.

The zero position of the carrier 32 for the weight member 31 is defined by suitable removable means such as a pin 101 (Figs. 1 and 5) traversing the wall of the shell case and entering a notch 102 in the carrier 32. The pin and notch are preferably so related that the weight member 31 is slightly out of register with the openings 37 and 33 in the diaphragm 36 and frame 7 respectively, the distance out of registry corresponding to a short time interval such as one tenth of a second. In this way it is impossible for the trip to be inadvertently operated in any manner prior to the discharge of the shell. Moreover, the weight member 31 is thus retained in its pocket in the carrier 32 at all times prior to discharge of the shell.

In assembling the fuse mechanism, the supporting plate 8 with its associated parts including the frame 7, partition 14 and the parts mounted therein are inserted in the end of the shell case 1, being rigidly fixed therein by means of the keys 11 and locking ring 12 (Fig. 1).

The power source and gearing assembly mounted on the plate 53 are then inserted in the cap 2, the bolt 45 being inserted loosely in the nut 63 to hold the parts in the cap with freedom for rotation therein as a unit. The cap 2 is then threaded on the casing 1, the splines 69 of the shaft 34 entering the splined hub of the sun gear 68. The cap 2 is thus threaded down snugly on the casing 1 until the zero pointer 71' (Fig. 7) on the cap comes opposite the zero line 70 on the casing.

It will be understood that when the cap is being screwed onto the casing, the timing member 32 is held stationary by the pin 101, thus preventing rotation of sun gear 68. Since the drive gearing is prevented from rotation in its frame by the engagement of the pin 48 of the weight member 44 against its abutment 54 in the groove 49, the mounting plate 53 with all its associated parts rotate as a unit within the cap 2 during this operation.

When the cap has been screwed down to the zero position, the bolt 45 is tightened up so as

to wedge the mounting plate 53 in the cap 2 on the inclined surfaces 103 whereby the mounting plate 53 and all its associated parts are rigidly connected to the cap. The shell is now in condition for shipment and storage preparatory to use.

When it is desired to use the shell, the pin 101 is withdrawn and the cap 2 is unscrewed until the number on the scale 71 corresponding to the estimated range of the target comes opposite the zero line 70 on the proper ring of the micrometer scale on the shell. During the unscrewing of the cap 2, the timing member 32 and diaphragm 36 will be rotated away from their zero positions a distance depending on the setting of the cap 2, and it is the timed rotation of these parts back to their zero positions under the control of the chronometric gearing which determines the time interval between discharge and detonation of the shell. The shell is then inserted in the rifle and fired in the usual manner.

It may be desired to provide a temporary locking means for the cap with respect to the shell after being set. This is readily accomplished by forming corrugations 104 (Fig. 7) on the periphery of the shell casing into which corresponding corrugations 104' (Fig. 1) in the interior of the scale 71 may be caused to engage by a blow or pressure applied thereto.

Upon discharge of the shell from the rifle, the longitudinal acceleration of the shell causes the cap 2 to strip the threads of the soft metal sleeve 3, whereby the teeth 5 on the cap bite into the flange 6 and force it against the teeth 4 on the shell casing, thus securely locking the cap to the shell. At the same time the set-back weight 25 is moved down to the position illustrated in Fig. 1, compressing the firing pin spring 27, the centrifugal force due to the rotation of the shell causing the set-back weight to move radially outward as illustrated whereby it is held in its lower position by the inclined shoulder 28 of the frame member 7.

Simultaneously with these functionings, the weight member 44 is caused by its inertia to move down, compressing the spring 56, and at the same time the cap 2 and associated parts move rotatively with respect to the weight member 44, causing the pin 48 to traverse the channel 49 until it strikes the opposite side of the abutment 54. The spring 56 thereupon expands and forces the pin 48 into the opening 55, thus holding the weight in its rotated position with respect to the cap 2, and causing the main drive spring 43 to be held in its wound-up position. Torque from the spring 43 is thereupon transmitted through gear 46, pinion 57, shaft 58, gear 59, pinion 62 and planet carrier 64 to the planets 66, causing planetation thereof.

When the shell is discharged, the cap 2 is tightly locked to the casing 1, as above set forth, by the engagement of the teeth 4 and 5 in the flange 6 of deformable metal. The internal gear 67 in the cap 2 is thus maintained stationary. Planetation of the planets 66, therefore, causes rotation of the sun gear 68, which rotation is transmitted through shaft 34 to the carrier 32 to rotate the carrier back toward the zero position. This rotation of the sun gear 68 is controlled by the gear train driven from pinion 73 meshing with the gear 72 of the planet carrier 64, the speed of which gear train is accurately governed by the escapement wheel 89 and pallet 94. After the time interval predetermined by the setting of the cap 2 has elapsed, the carrier 32 and diaphragm 36 will rotate back to their zero positions, at which time the openings 37 and 33 line up and permit the spherical weight member 31 to strike the upper end of the latch 21 as it is projected from the carrier 32 by centrifugal force. The firing pin 16 is thus released to cause detonation of the shell in the usual manner.

If the flight of the shell should terminate for any reason prior to the detonation thereof, as for instance, by a miscalculation of the setting in the fuse or for any other reason, as soon as the shell comes to rest, the firing pin spring 27 is permitted to expand since the set-back weight 25 is no longer held in its armed position by centrifugal force, so that the shell is entirely safe to handle irrespective of the condition of the tripping mechanism.

It will be appreciated that there is here provided a mechanical fuse structure which is simple but positive in its action, in which a wide latitude of setting with fine adjustment is provided, the trip mechanism being substantially frictionless by virtue of its rolling action, and in which the timing mechanism is extremely rigid and not susceptible to inaccuracies or failure due to accelerational or centrifugal forces.

Although but one form of the invention has been shown and described in detail, it will be appreciated that variations in the precise arrangements shown are possible without departing from the spirit of the invention as defined in the claims appended hereto.

What is claimed is:

1. In a mechanical time fuse for explosive projectiles, a source of power, involute gearing driven thereby, a firing pin movably mounted in the fuse, a latch movably mounted in the fuse normally positioned to engage and hold the firing pin inoperative, releasing means therefor controlled by said gearing, and an escapement mechanism governing said gearing, said release means comprising a roll member moveable by centrifugal force to engage and trip the latch, a gate member having an aperture, means for positioning the aperture in registry with the latch, and means actuated by said gearing to roll said roll member on the gate member into registry with said aperture so that the roll may traverse the aperture and engage and trip the latch.

2. A mechanical time fuse as set forth in claim 1 including further a frame for uniting the elements of said gearing, said frame comprising a plurality of circular plate members providing bearings for the gearing, including an integral intermediate frame member having surfaces in a plurality of planes providing bearings for a plurality of gears arranged in stepped planes, and clamping means traversing the plate members for attaching the end plates to the intermediate frame member.

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