Jan. 27, 1953 S. S. PODNOS ET AL 2,626,568

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Filed Aug. 24, 1949 2 SHEETS—SHEET 1

FIG. 1.

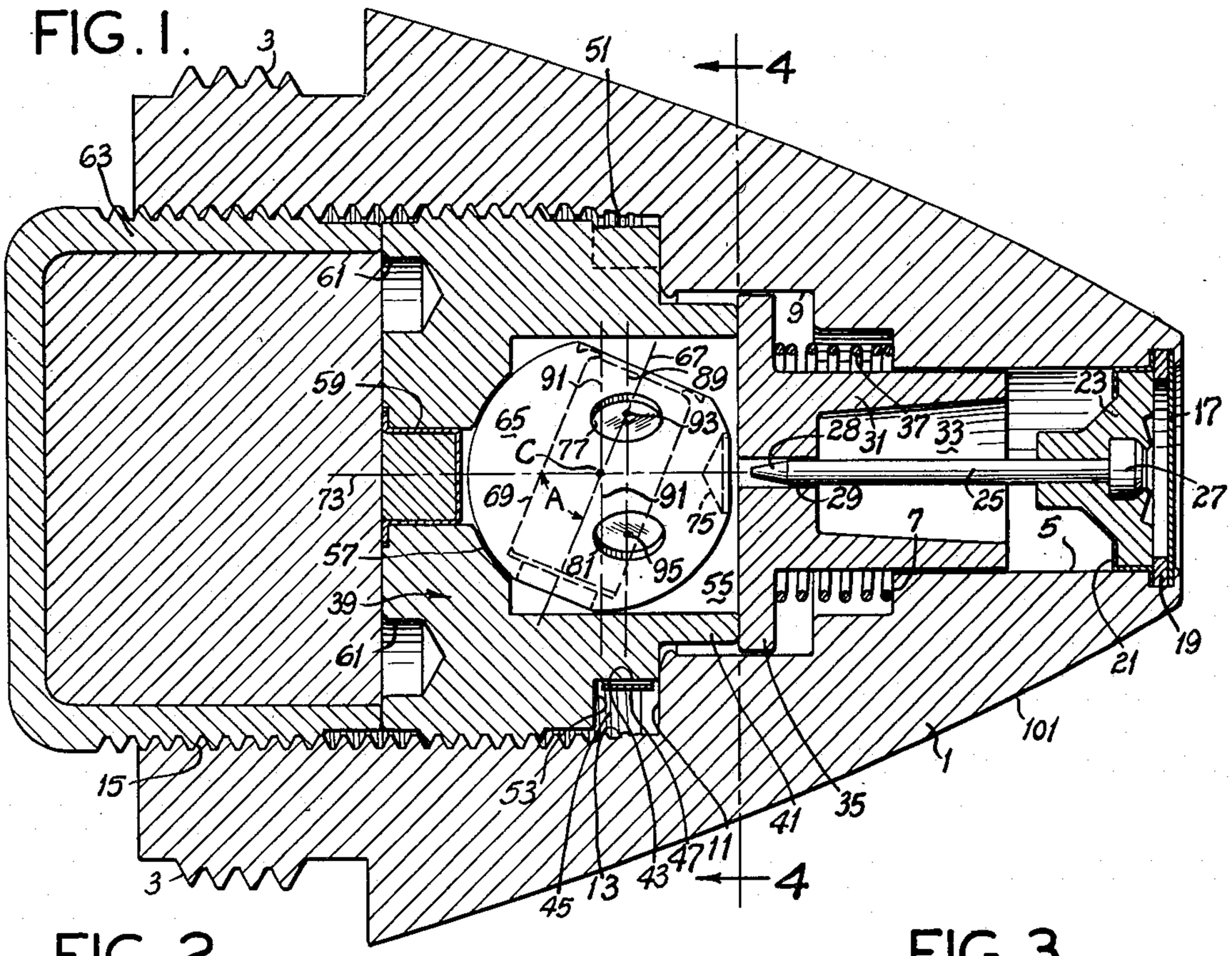


FIG. 2.

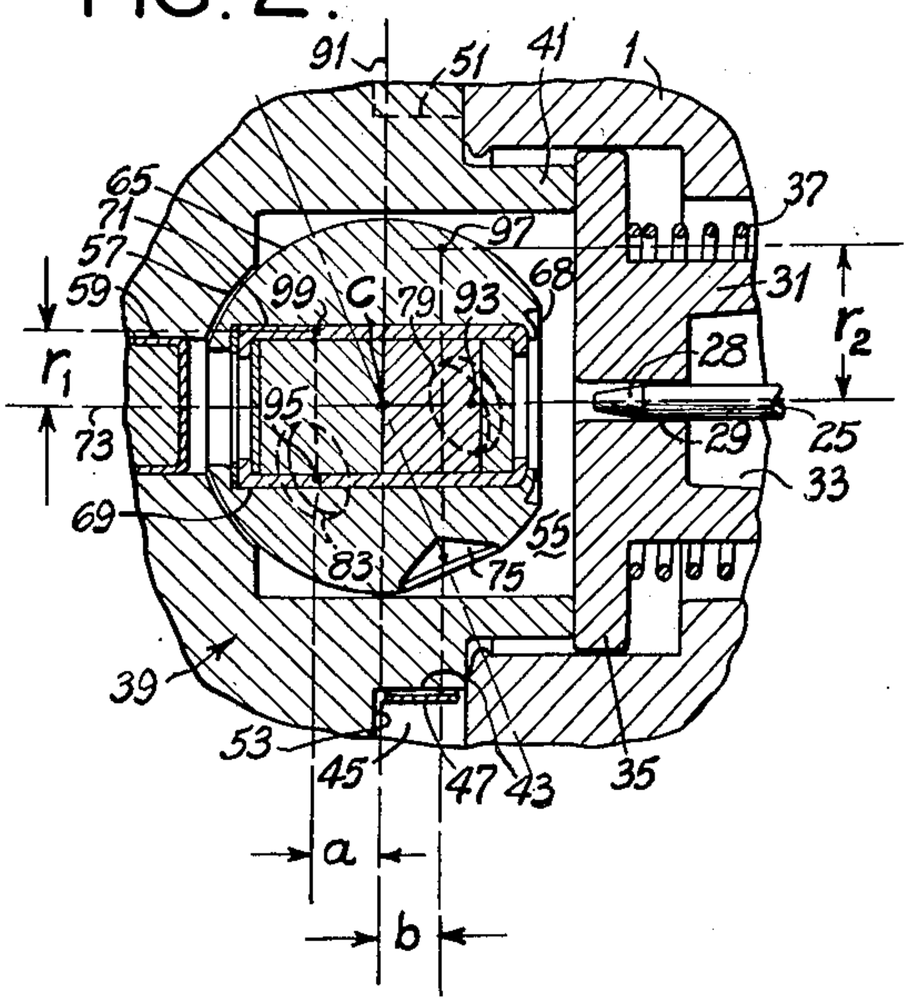


FIG. 3.

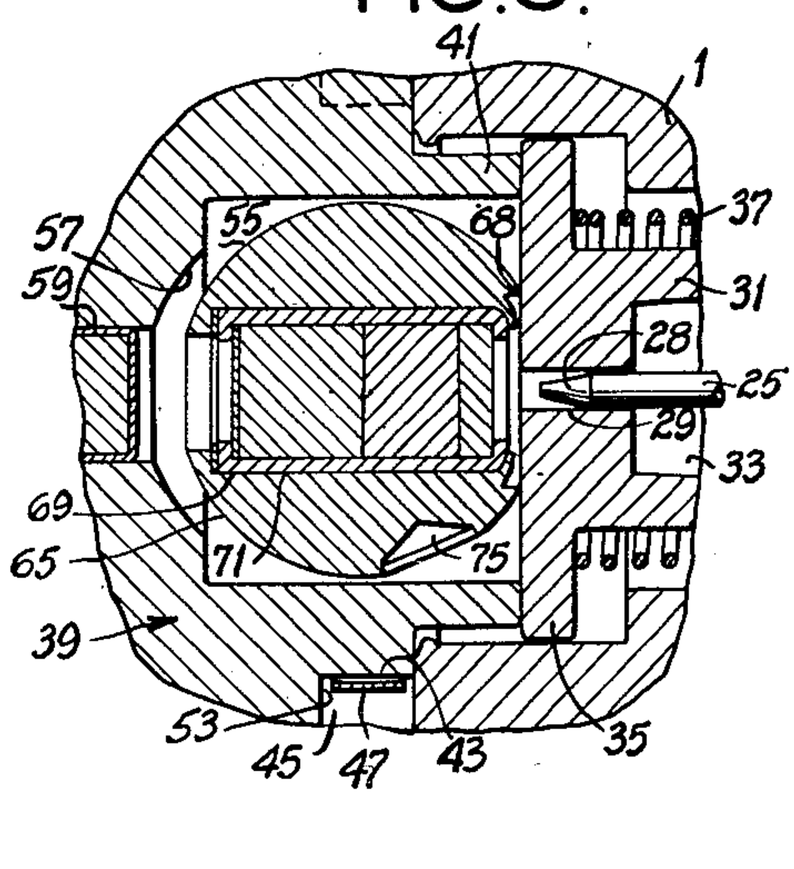


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FIG. 4.

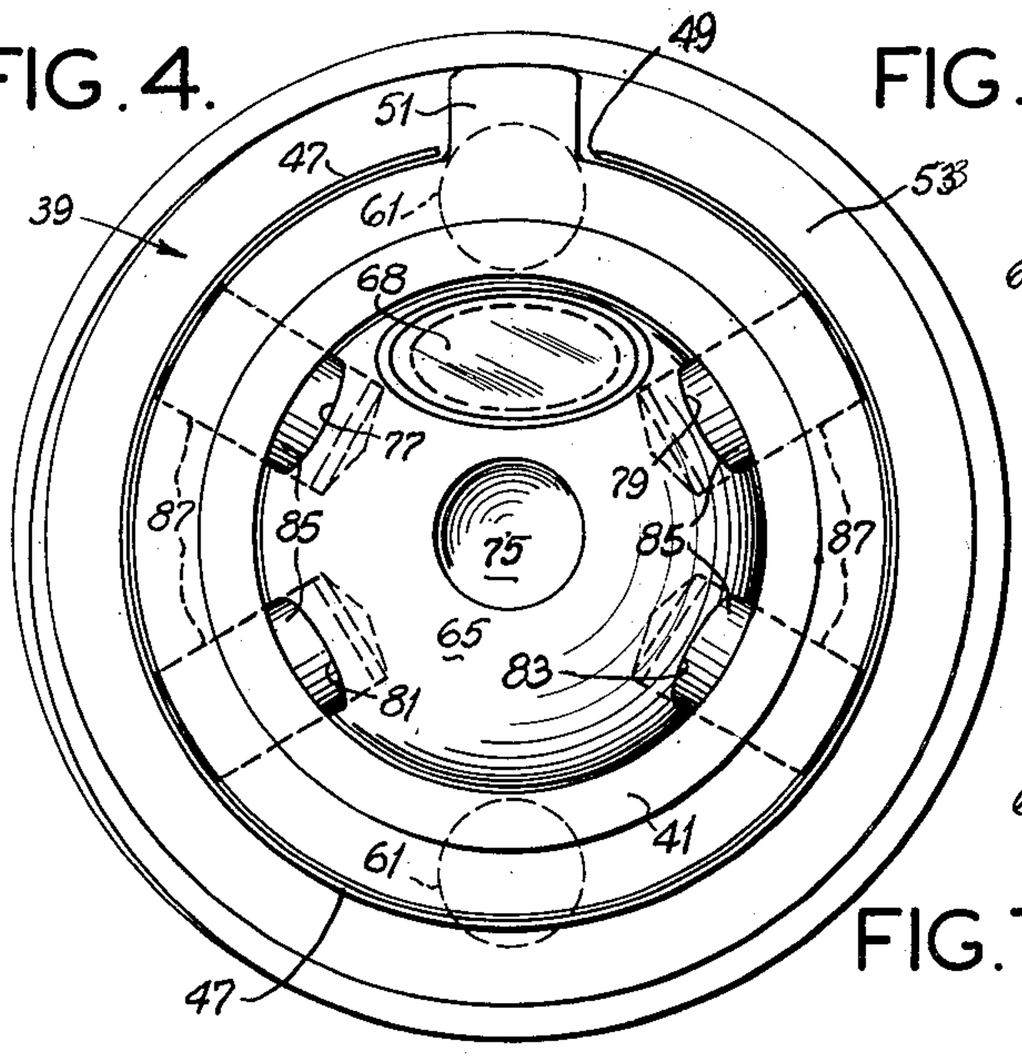



FIG. 5.

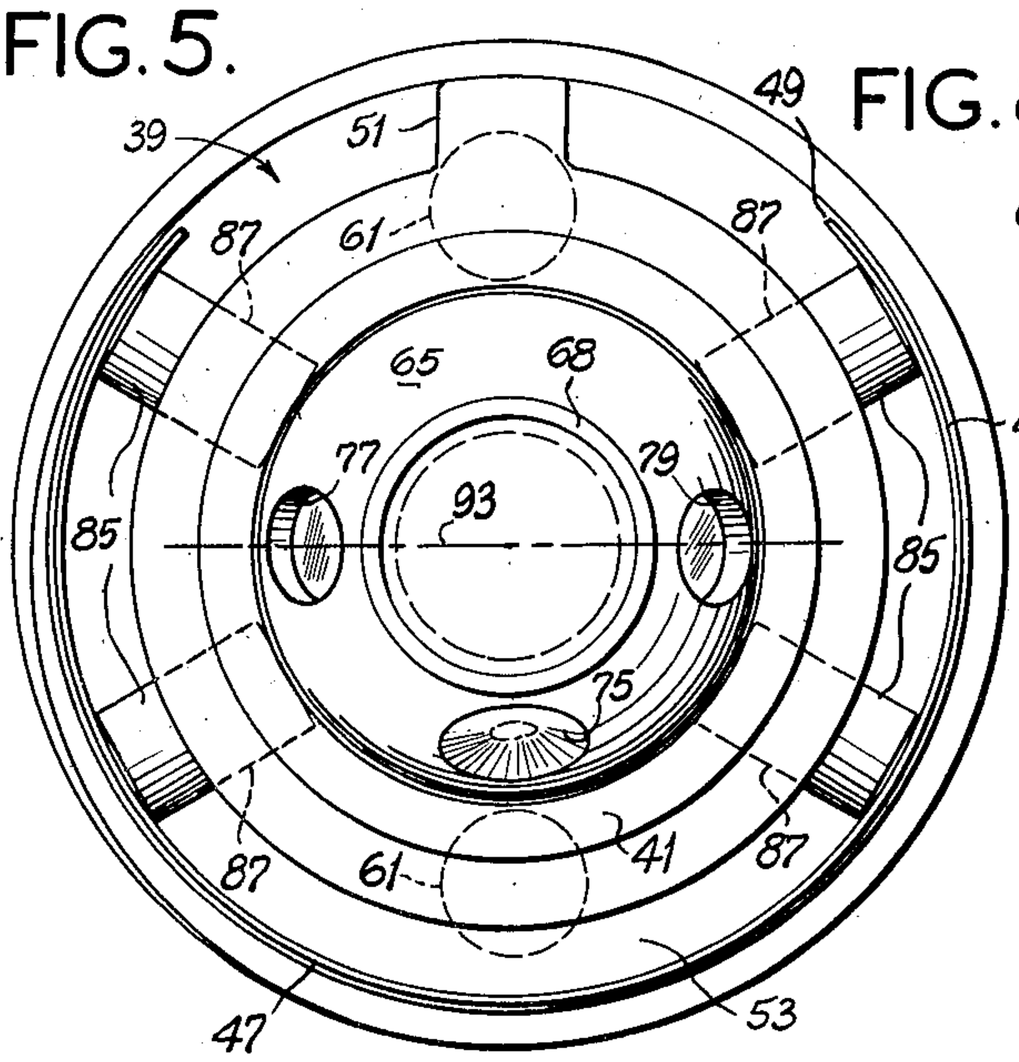



FIG. 6.

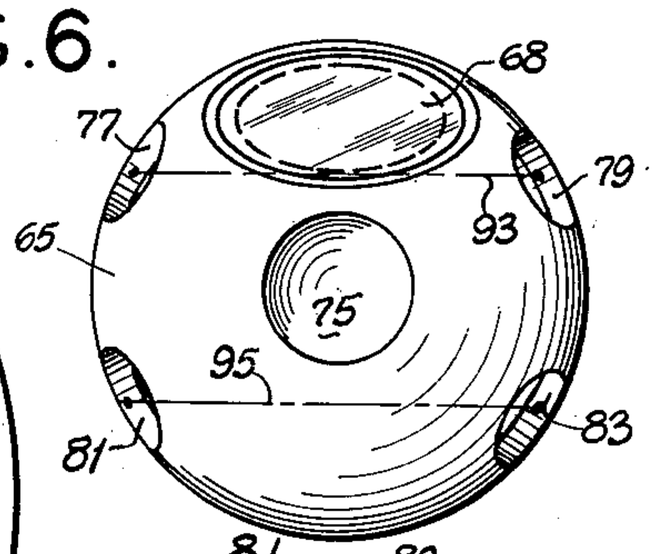



FIG. 7.

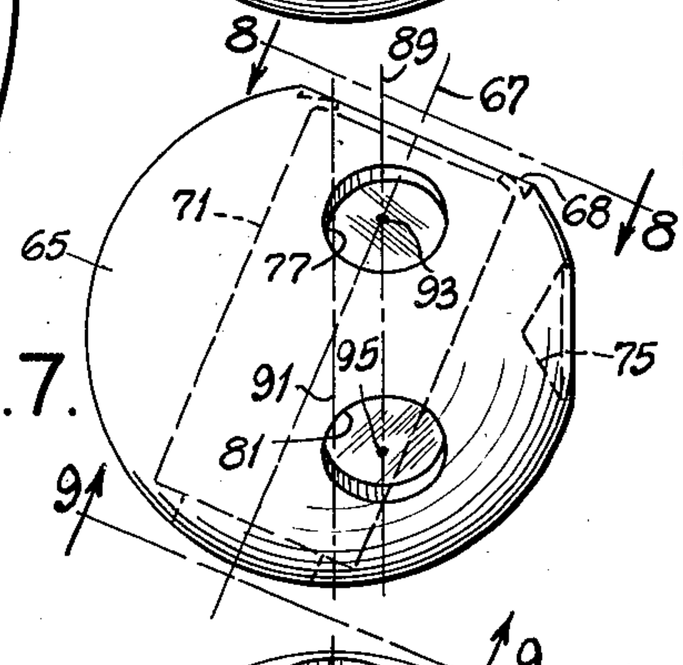



FIG. 8.

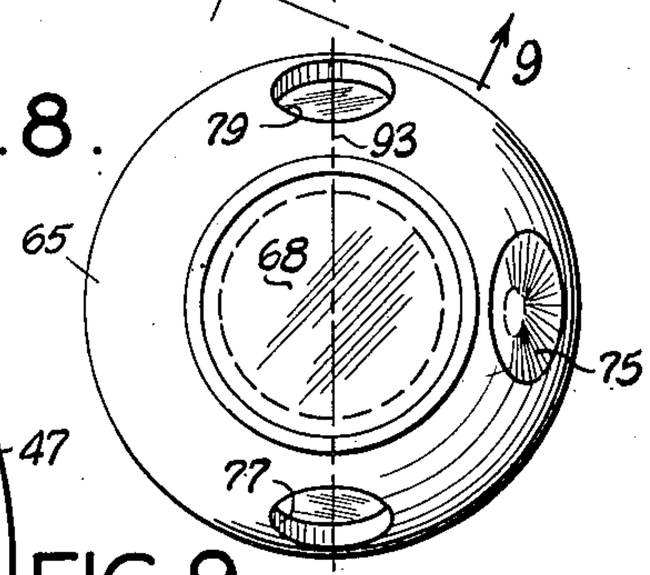
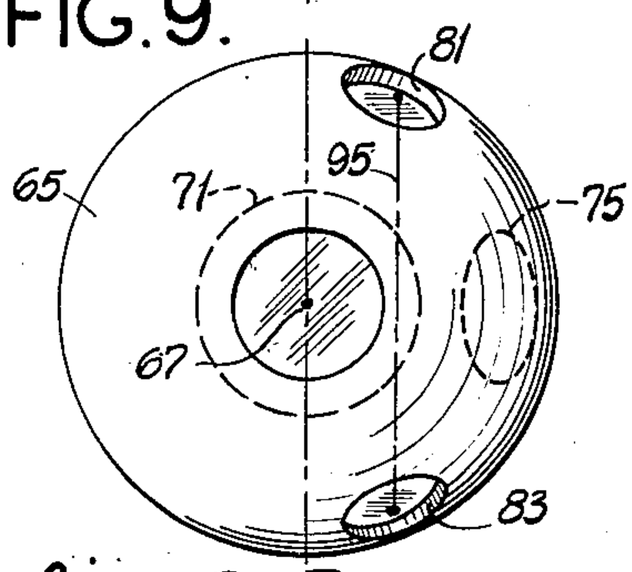



FIG. 9.

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Patented Jan 27, 1953 2,626,568

# UNITED STATES PATENT OFFICE

2,626,568

## FUSE

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Application August 24, 1949, Serial No. 112,942

3 Claims. (Cl. 102—79)

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This invention relates to fuzes for ammunition, and more particularly to safety fuzes of the so-called ball rotor type.

Briefly, the invention comprises, for a ball rotor carrying a detonator, means for locking the rotor in safety position by means of centrifugally responsive safety locking pins. In response to projectile spin, these pins recede from their locking positions to free the rotor for precession into armed position, but not before their positively applied torque has angularly accelerated the rotor sufficiently to start its precession well towards armed position. According to the present invention, none of the locking pins functions as a permanent axis for precession, thus allowing the rotor not only to precess but in response to applied frictional torque due to set-back also to assume a nutation around its arming axis so as to delay arming for a suitable period.

The nose of the containing shell is provided with a fixed firing pin assembly from which the rotor in its armed position is withheld against creep by means of a resilient restrainer until the point of the nose engages the target, whereupon the firing pin assembly is instantaneously driven back through the restrainer into the detonator carried by the rotor, thus initiating an instantaneous burst.

Should the shell after firing and before properly striking an intended target make a ricochet contact either on its ogive or behind it, the firing pin assembly remains fixed in position, whereupon the inertia of the rotor and of the restrainer is sufficient to carry the detonator in the rotor into contact with the firing pin, thus initiating a burst with some desirable time delay.

An additional feature of the invention is that an indicator recess and the detaining recesses employed in the rotor are arranged so that the armed position of the rotor is not dynamically disturbed during spin in armed flight of the containing shell. Moreover, an arrangement is employed whereby a certain amount of creep of the rotor in bringing it into contact with the restrainer results in steadying the rotor in its armed position.

Thus the objects of the invention are to produce by means of a relatively simple and low-cost structure a safety fuze which will cause instantaneous detonation upon intended point contact and a relatively delayed detonation upon ricochet contact. Other objects will be in part apparent and in part pointed out hereinafter.

The invention accordingly comprises the elements and combinations of elements, features of construction, and arrangements of parts which

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will be exemplified in the structures hereinafter described, and the scope of the application of which will be indicated in the following claims.

In the accompanying drawings, in which one of various possible embodiments of the invention is illustrated,

Fig. 1 is a longitudinal section of a fuze in the nose of a shell incorporating the invention and being shown in unarmed safety position;

Fig. 2 is a fragmentary view of parts of Fig. 1, showing the fuze in a preliminary armed position before creep;

Fig. 3 is a view similar to Fig. 2, showing a final armed position after creep;

Fig. 4 is an enlarged right-end view of a detached rotor housing assembly in safety position, viewed substantially on line 4—4 of Fig. 1;

Fig. 5 is a view corresponding to Fig. 4 but showing the detached rotor housing assembly in armed position;

Fig. 6 is an enlarged detail view of a ball rotor per se, viewed as in Fig. 4;

Fig. 7 is a left side elevation of Fig. 6;

Fig. 8 is an upper end view of Fig. 7, viewed from line 8—8; and,

Fig. 9 is a lower end view of Fig. 7, viewed from line 9—9.

Similar reference characters indicate corresponding parts throughout the several views of the drawings.

Referring now more particularly to Fig. 1, there is shown an assembly consisting of an enclosing body 1 threaded at 3 for attachment to an explosive shell. This body includes a first cylindric forward passage 5 formed with a first seat 7, a second and intermediate cylindric passage 9 formed with a second seat 11, and a third rearward passage 13 threaded at 15. Spun into the front of the passage 5 is a thin closing disc or diaphragm 17 seated on a washer 19, the latter holding in place a supporting cup 21 for the head 23 of a firing pin assembly. The diaphragm 17 collapses upon engagement with a target. Besides the head 23, the firing pin assembly includes a firing pin 25, the enlarged end 27 of which is staked into said head 23. Thus the firing pin assembly 23, 25 is rigidly held in a stationary position in the passage 5, its point 28 being directed rearward toward the passage 9. Surrounding the point of the firing pin is an opening 29 of a restrainer 31, the latter having a cup-shaped front 33 slidable in the passage 5 and a disc-shaped rear portion 35 which is slidable in the second passage 9. The restrainer is biased rearward by a spring 37 which reacts upon

seat 7. The opening 29 normally forms a sheath or guard around the pointed end 28 of the firing pin.

Threaded down to the seat 11 in the third passage 13 is a rotor housing 39. This has a step shouldered front providing an annular nose 41 with which engages the flat rear face of the disc 35 of the restrainer 31. A second step 43 provides a spring seat and space 45 in the body 1 for the reception of a split circular spring 47, the latter being better shown in Figs. 4 and 5. The split or interruption of the spring which is shown at 49 accommodates a driving lug 51 formed on the periphery of the step 43. The lug 51 and adjacent seats 11 and 53 position the spring which normally clings to the outer surface of the step 43 but which has space for radial expansion (compare Figs. 4 and 5).

Interiorly, the housing 39 consists of a forward cup 55, the bottom of which forms a spherical seat 57 forming the rim of a rearward opening which contains a booster lead cup 59. In the rearward face of the housing 39 are openings 61 for the reception of a spanner wrench which is employed for threading the housing 39 against the seat 11. Threaded into the opening 13 and against the rear of the housing 39 is a booster cup 63. It will be understood that the lead cup 59 and the booster cup 63 are loaded with explosive material in the usual manner for such parts.

Located within the cup 55 is an essentially spherical rotor 65 having an axis 67 along which is a bore 69 containing a cylindric detonator 71, the latter being loaded in the usual manner with detonating material. The radius of the sphere according to which the rotor is formed equals that of the seat 57 so that upon setback they have complementary engagement. The angled safety position of the spherical rotor is indicated in Figs. 1 and 4, wherein the axis 67 lies at an obtuse angle A with respect to the axis of spin 73 of the body 1. In order properly to set the angle A, a conical indicator recess 75 is provided. Thus when the rotor 65 is applied to the seat 57 (before assembly of the housing 39 in the body 1), the proper angular position of the axis of spin 67 is determined by placing the indicator recess central with respect to the open end of the cup 55, a suitable pointed tool for the purpose being engaged with the recess 75.

Detent means is provided for holding the rotor in its safety position, consisting of four recesses 77, 79, 81 and 83 with which cooperate cylindric detent pins 85. These are in a plane 89 normal to the diameter through recess 75 and between said recess and a great circle in plane 91, which circle is normal to the diameter through recess 75. The pins 85 pass through radial openings 87 in the step portion 43 of the housing 39. At their outer ends they are normally withheld from radial movement by the spring 47 which surrounds and springingly clings the step 43 (Fig. 4). Under centrifugal force, the pins 85 move to the positions shown in Fig. 5, wherein the spring 47 is spread open by the centrifugal forces associated with the pins 85 under spin of the shell around the axis 73. Centrifugal force of the material of the spring contributes to its expansion under rotation.

The openings 87 in the housing 39 are established in the plane 89 normal to the axis of spin 73. This plane 89 is established just ahead of a plane 91, also normal to the axis of spin 73



but passing through the geometric center or axis C of the rotor sphere when the latter rests upon the seat 57. Likewise, the detent recesses 77, 79, 81 and 83 are established in this plane 89. The detent openings 77 and 79 have their centroids established upon a line 93 which passes normally through the axis 67. Therefore, after the rotor 65 moves from the angled safety position shown in Figs. 1, 4 and 7 to the coaxial armed position shown in Figs. 2, 3 and 5, the static balance of the rotor is undisturbed, so far as the openings 77 and 79 are concerned. This is because the centroids of these openings are then equally radially spaced from the axis of spin 73. On the other hand, the centroids of the openings 81 and 83 lie upon a line 95 (parallel to the line 93) but which does not pass through the axis 67, as will be clear from Figs. 1, 7 and 9. Therefore, when the rotor 65 moves to the armed position shown in Figs. 2 and 3, the line of centroids 95 of the openings 81 and 83 is below the axis of spin 73 and behind the plane 91. Moreover, under these conditions the centroid of the indicator recess 75 is moved down to a point ahead of the plane 91. The arrangement is then such as shown in Fig. 2.

The loss of material from the rotor due to the indicator recess 75 will be effective as a positive centroid symmetrical and opposite to the centroid of the recess 75, as indicated at 97. The loss of material due to the detent recesses 81 and 83 will be effective as a positive centroid 99 symmetrical and opposite to the centroid of the recesses 81 and 83. The centroids 97 and 99 represent dynamically unbalancing concentrations of masses but their radii from the axis 73, and their distances from the plane 91, are such that their respective centrifugal forces about axis 73 operative over their moment arms from plane 91 are opposed and balance one another so that the rotor has no turning moment about the axis C. In other words, if $w$ is taken as the angular velocity (in radians) of spin of the rotor 65 in the armed position of Fig. 2; $m_1$ the mass of material removed by both recesses 81 and 83; and $m_2$ the mass of material removed by recess 75; then referring to Fig. 2,

$$m_1(w^2r_1xa) - m_2(w^2r_2xb) = 0$$

The result will be that there is no moment tending to turn the rotor from the armed position after it reaches that position. The slight dynamic unbalance caused by both centroids 97 and 99 being on one side of the axis of spin 73 cannot translate the rotor laterally since the spherical diameter of the rotor is practically equal to the inside diameter of the cup 55, with only a slight amount for clearance. Hence the rotor is constrained only to move axially, in its armed position as may be seen by comparing Figs. 2 and 3.

Assembly is accomplished as follows, assuming that the body 1 is empty. First the firing pin assembly 23, 25 is inserted with the cup 21, washer 19 and disc 17, this assembly being spun into fixed position. The spring 37 is then applied to the seat 7 and the restrainer 31 inserted.

The body 1 is then ready for the reception of the rotor housing 39. The latter, before threading into position in the body 1, is provided with the lead cup 59. Before the ball rotor 65 is inserted, the spring 47 is sprung into position surrounding the step 43, its split at the lug 51 (Fig. 4). The detent pins 85 are then inserted into the openings 87 radially from the inside of the

cup 55. The ball rotor 65, having been loaded with its detonator 71, is then inserted into the cup 55, being forced towards the spherical seat 57. During this operation the indicator recess 75 is centered by eye at the center of the cup, as shown in Fig. 4. This properly angles the axis 67, and if now the rotor be turned until the upper end of the detonator 71 is opposite the lug 51 and the rotor pushed to the seat 57, the detent pins 87 will, after an initial spring outward, drop into the openings 77, 79, 81 and 83. This holds the rotor in the position shown in Fig. 4. Then the rotor housing 39 (containing the rotor) may be threaded into the position shown in Fig. 1, against the seat 11. This biases the restrainer 31 to the position shown, the restrainer closing in the end of the cup 55 and the spring 37 being placed under compression. Finally, the booster cup 63 is screwed home, as indicated in Fig. 1.

Operation is as follows:

Prior to and upon loading the shell into a gun, it is safe, because the rotor is positively locked in the position shown in Fig. 1, from which it is impossible to move it except by rapid spin about the axis 73. Sufficient spin cannot occur except upon firing. Before firing the detonator 71 cannot be reached by, or itself reach, the firing pin 25.

Upon firing, both axial and angular accelerations occur, maximum angular velocity being attained as the body 1 leaves the barrel of the gun. Initially the spin of the shell is applied as torque to the rotor 65 around axis 73. This is because of the interlocking action of the pins 85. Finally sufficient spin is introduced around the axis 73 to move the detent pins 85 outward by centrifugal force against the reaction from the spring 47. The result is as shown in Fig. 5, wherein the pins 85 have left the openings 77, 79, 81 and 83 to release the rotor 65. As these detent pins release, some torque application may be continued by reason of set-back of the rotor against the seat 57, which continues to apply frictional torque around axis 73. The applied torque, in view of the component of spin which may be assigned around axis 67, causes the rotor to precess from the position shown in Fig. 1 to the position shown in Fig. 2, a time delay occuring in the process. This delay is sufficient that the projectile passes safely through the bore of the gun and some distance beyond.

There is no tendency for the rotor to leave its coaxial position shown in Fig. 2 after it has once reached it. This is because of the balanced moment relationships already described in connection with the recesses 77, 79, 81, 83 and 75 of rotor 65.

As the projectile passes through its trajectory, a small axial deceleration (due to external air friction) sets in. This however does not affect the inside rotor which therefore creeps forward from the position shown in Fig. 2 to the position shown in Fig. 3. In the latter armed position the forward flat or truncation 68 on the rotor established by the opening required for the detonator 71 engages the restrainer 31. This constitutes a positioning means further assuring proper alignment with axis 67 of the rotor in its armed position. The forward momentum of the rotor relative to body 1, due to creep, is not sufficient to force the restrainer 31 forward, the spring 37 being strong enough for the purpose.

If and when the projectile strikes a target head on, as intended, the disc 17 is crushed and the pin is driven back into the detonator, which fires into the lead cup 59, the latter firing into the booster 63, which in turn explodes into the main charge in the shell (the latter not shown). This action is instantaneous upon contact with the target.



Should the projectile ricochet, as for example strike upon its ogive 101 or behind the ogive, the firing pin 25 will in general be unaffected. This, however, will decelerate the body 1. The momentum of the rotor 65 and restrainer 31 will then carry these parts ahead with considerable force, overcoming the resistance of the spring 37. The restrainer will then move forward and expose the point of the firing pin 25, which will be met by the oncoming detonator 71, exploding the latter with the occurrence of the subsequent series of events already described. In the case of detonation by ricochet, there is a short delay while the rotor and restrainer move forward, which is a desirable feature, preventing explosion of the shell at the point of ricochet. This facilitates skip bombardment and is desirable for other reasons unnecessary to detail here.

In view of the above, it will be seen that the several objects of the invention are achieved and other advantageous results attained.

As many changes could be made in the above constructions without departing from the scope of the invention, it is intended that all matter contained in the above description or shown in the accompanying drawings shall be interpreted as illustrative and not in a limiting sense.

We claim:

1. A fuze comprising a hollow body having a target contact point, a normally fixed firing pin extending rearward from said point and adapted to be driven back upon point contact, an axially movable cup-shaped restrainer having a flat back in which is an opening forming a sheath around the rear end of the firing pin, a rotor housing forming a hollow cup, a spring biasing the restrainer to a position in which its flat back forms a front wall enclosing the open end of the cup and positioning the restrainer so that said opening is effective as said sheath, the rear of said cup being formed as a spherical seat, a spherical rotor in said cup and engaging said seat upon set-back and carrying an axial detonator normally positioned at an angle to the firing pin, said rotor having a truncated portion at the end of the detonator, means normally holding the rotor in an angled position of said detonator relative to the firing pin and centrifugally releasable therefrom in response to projectile spin to permit precession of the rotor for aligning the detonator with the firing pin, creep of the rotor under the latter conditions being sufficient to engage the rotor with the restrainer without moving the latter to unsheathing position but the mass of the rotor and restrainer being sufficient to overcome the bias of said spring upon ricochet to carry the restrainer into unsheathing position whereby the detonator engages the firing pin.

2. In a ball rotor type of fuze, a normally fixed firing pin, an axially movable cup shaped restrainer having a flat back in which is an opening forming a sheath around the end of said firing pin, a cup-shaped rotor housing formed with a spherical seat at the bottom of the cup, a spherical rotor in the cup and having a cylindric detonator along an axis adapted to be placed at an angle to an axis of spin of a shell body to which the fuze is applied, said rotor having a truncated

portion at the end of the said detonator to engage said restrainer flat, an outside step on the cup forming a spring seat and determining a plane ahead of the spherical center of the rotor, a spring on said seat, said rotor having two pairs of detent openings, the members of a first pair being coaxial on a line positioned in said plane and passing through the cylindric axis of the detonator, the members of the second pair being coaxial on another line in said plane but spaced ahead of said cylindric axis, detent pins slidable in openings in the cup transverse of said step and engageable with said detent openings under bias of said spring, all of said pins lying in said plane.

3. A fuze comprising a hollow body having a contact point, a normally fixed firing pin extending rearward from said point and adapted to be driven back upon point contact, an axially movable cup-shaped restrainer having a flat back and an opening therein adapted to form a sheath around the end of the firing pin, a rotor housing forming a cup behind the firing pin having an opening toward the firing pin but closed by the flat back of the restrainer, a coil spring biasing the restrainer to a position in which it forms the closing wall for the open end of said housing and wherein the restrainer sheaths the firing pin, the rear of said housing cup forming a spherical seat, a spherical rotor in said cup and engaging said seat upon set-back and carrying an axial detonator normally positioned at an angle to the firing pin, said rotor having a truncated portion at one end of the detonator for arming engagement with the flat wall of the restrainer, the rotor having an indicating recess normally adjacent the opening in the restrainer and when centered determining the proper angle of the detonator, an outside step on the cup forming a spring seat and determining a plane ahead of the spherical center of the rotor, a circular spring on said seat, said rotor having two pairs of detent openings, the members of a first pair being coaxial on a line positioned in said plane and passing through the cylindric axis of the detonator when properly angled, the members of the second pair being coaxial on another line in said plane but spaced ahead of said cylindric axis, detent pins slidable in openings in the cup transverse of said step and engageable with said detent openings under bias of said circular spring, all of said pins lying in said plane, the arrangement of the detonator recess and said second pair of detent openings being such that when the cylindric axis of the detonator coincides with the axis of spin of the shell on which the fuze is used the resulting centroids due to the removal of material in producing the recess and openings will produce off-setting torques, the axis of said first pair of openings intersecting the axis of spin.



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## REFERENCES CITED

The following references are of record in the file of this patent:

UNITED STATES PATENTS

| Number | Name | Date |
|---|---|---|
| 2,043,266 | Rogers | June 9, 1936 |
| 2,392,430 | Teitscheid | Jan. 8, 1946 |
| 2,427,671 | Graumann et al. | Sept. 23, 1947 |
| 2,427,977 | Semple | Sept. 23, 1947 |
| 2,446,019 | Nichols | July 27, 1948 |
| 2,455,603 | Nichols | Dec. 7, 1948 |