

Aug. 20, 1968

R. T. ZIEMBA ET AL

3,397,640

FUZE WITH IMPROVED TIME DELAY AND SELF-DESTRUCT MECHANISM

Filed Oct. 28, 1966

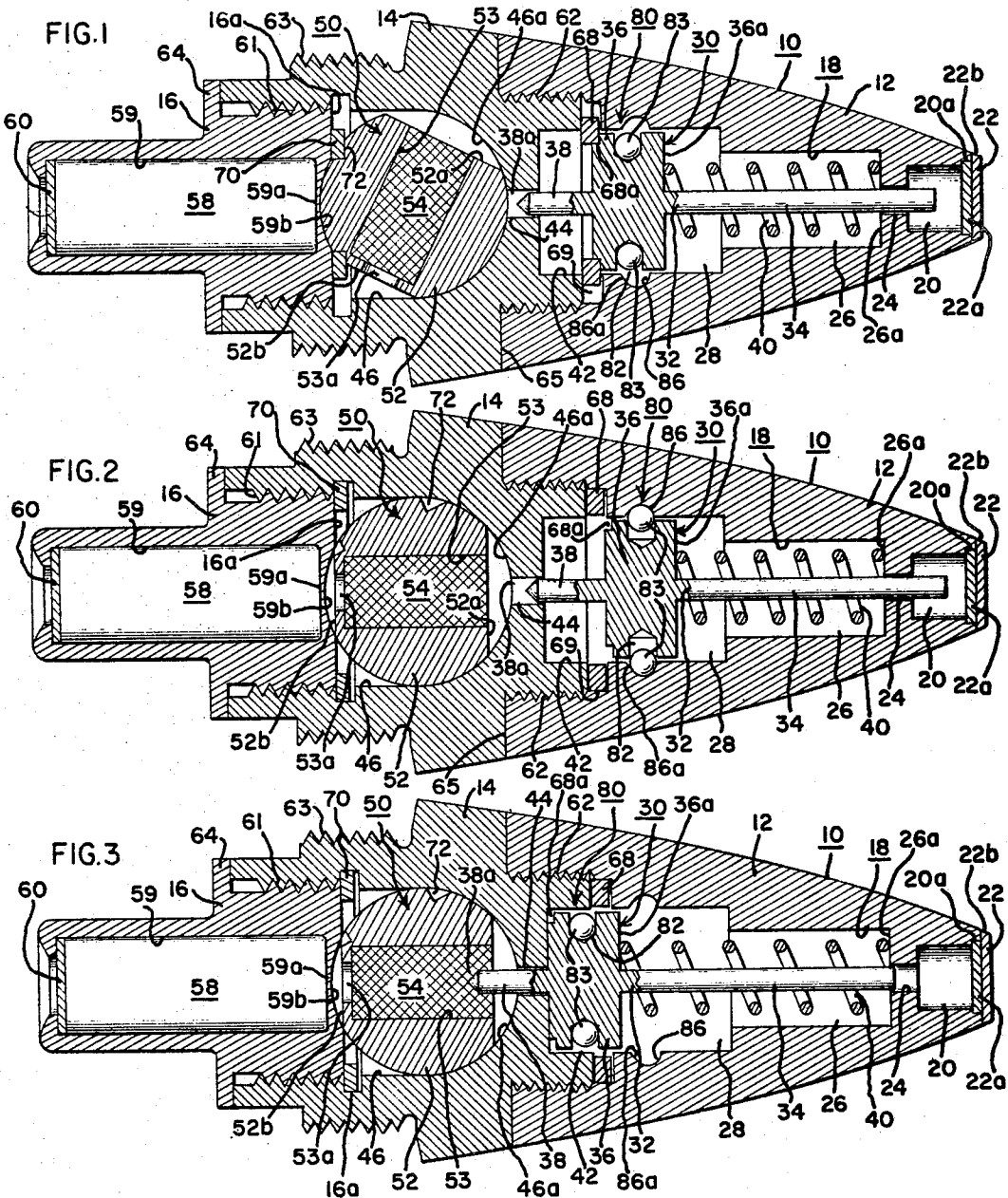


FIG. 4

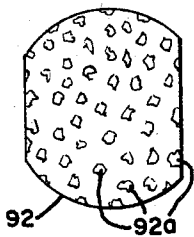
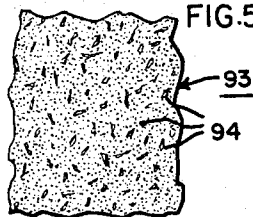


FIG. 5



INVENTORS:
RICHARD T. ZIEMBA,
JOHN W. WOLF,

BY

Harry C. Burgess
THEIR ATTORNEY.

1

3,397,640

FUZE WITH IMPROVED TIME DELAY AND SELF-DESTRUCT MECHANISM

Richard T. Ziemba and John W. Wolf, South Burlington, Vt., assignors to General Electric Company, a corporation of New York

Filed Oct. 28, 1966, Ser. No. 590,432

2 Claims. (Cl. 102-71)

ABSTRACT OF THE DISCLOSURE

The time-delayed fuze has a centrifugally operated ball and race safing mechanism controlling a spring-loaded firing pin, a ball-rotor type detonator, a pair of centrifugally actuated detent split-rings engaging the ball rotor and a collar on the firing pin, respectively, and a self-destruct mechanism including a ball and groove arrangement between the collar and the fuze housing. As the ball rotor is unlocked during spin the alignment of the ball rotor detonator is controlled by a viscous medium in the ball rotor cavity interacting with irregularities on the ball rotor surface.

This invention relates generally to a time-delayed fuze for ammunition of relatively small calibre and, more specifically, to improvements in the mechanism for effecting a delay between the time of firing of the projectile and the time at which it becomes fully armed and capable of detonation, including means causing self-destruction after a pre-determined period in trajectory.

For certain close-in infantry support tactics, it is desirable that artillery be provided with high-explosive ammunition designed to detonate within a defined, relatively short span of time in trajectory. That is, the terrain or tactical situation is often such that the shells pass within a few feet of friendly troops or are likely to encounter objects, such as trees, leaves or branches near the gun emplacement, no their way to the impact area. In addition, in jungle and hilly terrain it is not unusual to have positions controlled by friendly troops on the other side of the target area from the battery or gun position. It is desirable therefore, to provide means to disarm, or otherwise make ineffective, projectiles in the initial-trajectory period, as well as destroy shells which go past the target or otherwise go astray.

Means are known which are designed either to accomplish self-destruction of fuzes, by causing detonation of the main bursting (H.E.) charge either on impact or after a certain period of time, or delay the arming time. However, such devices as utilize mechanical escapements (e.g., leaf springs, clock-work mechanisms), unwinding foil, or fusible links, while useful, have left something to be desired in the areas of design reliability and arming time-delay control. In addition such devices are often complex and costly.

Accordingly, it is a general object of the present invention to provide an improved time-delay arming and self-destruct projectile fuze mechanism for use in relatively small calibre projectiles.

A more specific object of the invention is to provide an improved mechanism for controlling the length of the delay after which time an artillery projectile is fully armed, in combination with a self-destruct mechanism, wherein safety and reliability of the fuze and projectile is enhanced in relatively small calibre, low cost projectiles.

Briefly, in a disclosed embodiment of the invention, we provide, in combination with a fuze having a body portion including a cavity therein, a ball-rotor in the cavity, the ball-rotor having a detonating charge in, a geometrically centered bore therethrough, a firing pin,

2

and resilient detent means operable to allow the ball-rotor to assume a position such that the fuze is fully armed for explosive impact on target or self-destruction of the projectile, an improved arming-delay mechanism comprising a viscous dampening medium provided between the ball-rotor and the body cavity walls. In accordance with a further feature of the invention, the effective viscosity of the dampening medium is controllable by several means including variations in viscosity, filler materials and irregularities in the ball rotor surface, whereby the time-delay is variable for more accurate and reliable control of both the arming and the self-destruct functions.

While the specification concludes with claims particularly pointing out and distinctly claiming the subject matter of our invention, it is believed the invention will be better understood from the following detailed description of its structure and operation, taken in connection with the accompanying drawings in which:

FIG. 1 is a sectional view taken along a centerline and illustrating, generally, the internal mechanism of a relatively small-calibre fuze incorporating the improved arming-delay means of our invention and showing the fuze mechanism in the unarmed, or unfired, position;

FIG. 2 is a view illustrating the fuze of FIG. 1 in the armed position;

FIG. 3 illustrates the fuze of FIG. 1 at the instant of self-destruction or impact detonation;

FIG. 4 is a fragmentary, plan view of the surface of a ball-rotor used in another embodiment of our invention; and

FIG. 5 is a pictorialized representation of a dampening fluid utilized in still another form of our invention.

Turning now to the drawings, the invention is shown illustrated in a fuze for a projectile of approximately 20 mm. size, although it will be understood that it could have utility in arms of greater calibre. FIG. 1 shows a fuze having a body or housing indicated generally at 10. In the disclosed configuration the fuze body includes a tapered nose portion 12, a center or base portion 14, and a booster portion 16. The nose portion 12 has a central bore therethrough indicated generally at 18. The bore includes a cavity 20 at the tip of the fuze, the cavity providing a relatively thin-walled frangible nose portion. A closure cap or disc 22 having a cylindrical portion 22a fits in a recess 20a in the nose, the disc being beveled at 22b to form a blunt tip for the projectile. Central bore 18 also has a reduced neck portion 24, a spring retainer portion 26, and an enlarged, self-destruct mechanism retainer partial cavity portion 28. As seen in FIG. 1, the fuze includes means for exploding the projectile including a firing pin and retainer spring assembly, indicated generally at 30. In the embodiment shown, the assembly 30 includes a firing pin indicated at 32 having an elongated forwardly projecting contact arm portion 34 received in the tapered body bore portion 24, for sliding engagement relative thereto. The firing pin 32 also includes an enlarged, cylindrical body or collar portion, indicated at 36, the collar or body portion being located intermediate contact arm portion 34 and a striker arm portion 38 of pin 32, the latter extending rearwardly of the fuze body. Resilient means in the form of a spring 40 arranged coaxially about striker arm 34 is also provided for positioning of pin 32, as hereinafter described in detail. The spring is received in bore 18, being captured between the forward face, at 36a of the centrally located firing pin body portion 36 and the forward wall at 26a, of bore portion 26. This arrangement accomplishes spring-loading of firing pin 32. While shown as being integral with the firing pin 32, the central body portion 36 could also comprise a collar slidable on and fastened

to the arms of 34 and 38, respectively, (i.e., firing pin 32) in the location shown.

The detonator means of our improved fuze design will now be described. As shown, the central body or base portion 14 of the fuze includes a series of interconnected coaxially-arranged bores, indicated at 42, 44 and 46, respectively, proceeding from front to rear of the fuze. It will be seen that bore 44, intermediate bores 42 and 46 is the same size as bore 24, being adapted to receive the striker arm portion 38 of firing pin 32. Bore 42, on the other hand, is enlarged to the same size as bore 28 in the tapered body portion 12, being adapted to align itself coaxially therewith to form a single central cavity in the fuze within which firing pin body or collar portion 36 may move axially back and forth against the force of spring 40. Similarly, bore 46 of body portion 14 is arranged to retain a ball-rotor detonating mechanism, indicated generally at 50.

The ball-rotor detonating mechanism will now be described in detail. Indicated at 52 is rotor body which is bored out at 53 along an axis of symmetry, i.e., the bore center passes through the geometric center of the rotor body. The bore 53 contains a detonating charge, indicated at 54, which, as described hereinafter, will be set-off when contacted—with sufficient force—by striker arm portion 38 of firing pin 32. A flash passage 53a, coaxial with bore 53, is provided at the end of bore 53 opposite the point of impact of the striker arm. The ball rotor is adapted to rotate within the fuze body, being retained in a hemispherical portion 46a at the forward end of bore 46 in body portion 14. In other words, as the projectile—and the fuze—spin, ball-rotor 52 rotates in cavity 46a to align itself for detonation.

Means to facilitate setting-off the projectile high-explosive (H.E.) charge is further provided in the form of a booster charge 58 contained in a central bore 59 in body portion 16. When the fuze is assembled and "armed," flash passage 53a is in line with a thin, fragile wall portion, indicated at 59a, of the booster body 16, which wall portion also provides a cup-shaped depression 59b on the side facing ball-rotor 52 to complete the spherical cavity in combination with cavity portion 46a. The thin wall portion at 59a is breached when the detonator charge 54 explodes, thus setting off the booster. Closure means 60, at the other end of the booster body portion, maintains the charges in the body 16.

To complete assembly of the parts of our improved fuze described hereinabove, the tapered body, middle and booster portions, indicated at 12, 14 and 16 respectively, are preferably threadably engaged at 61 and 62. An additional, externally-threaded portion at 63 may be provided to engage suitable threads on the projectile body (not shown). A flange at 64 and a shoulder at 65 are provided to securely seat and maintain the booster-to-middle portion and the middle portion-to-tapered portion threaded connections, respectively.

In accordance with one feature of our invention, means are provided to maintain the fuze in a "safe" or unarmed position during transit and storage. A retainer ring 68 which is generally C-shaped in plan view, snaps into a notch 68a on the collar 36, as seen in FIG. 1. The C-shaped ring 68 supports the firing pin assembly 30 during storage and against "set-back" forces created when the projectile is accelerating within the gun bore. As seen in FIG. 1, when the fuze is on "safe" the ball-rotor is positioned in the spherical seat formed by hemispherical portion 46a and a cup shaped depression 59b, in assembly, with the axis of rotation of the ball-rotor being displaced from the fuze axis. In addition, we provide a centrifugally actuated detent mechanism comprising another semi-annular, i.e., horizontally-split detent spring 70. Spring 70, in its normally compressed position is retained in a notch or groove 72 in the surface of ball-rotor 52. Notch 72 will be displaced angularly along the ball surface from a first or nominally forward-facing flat 52a on the ball-rotor.

Ball flat 52a and a second flat 52b approximately diametrically opposite thereto, are machined on the ball-rotor body to facilitate boring the detonator charge cavity to the required dimensions. As shown in FIG. 1, therefore, when the fuze alone—or assembled with a projectile—is in storage or in transit, annular spring means 70 is at its normal diameter and engages notch 72, with a flat side of the spring bearing against forward face 16a of the booster body portion. This, together with spring means 68, provide a dual locking safety device for the detonator means.

Another feature of the invention, in combination, is the self-destruct mechanism, indicated generally at 80. In the disclosed embodiment this takes the form of a circumferential groove 82 machined in the periphery of the collar or central body portion 36 of the firing pin assembly 30. Slidably retained in groove 82 are a plurality of locking balls, two of which are indicated at 83—83. Balls 83 are adapted to move radially outwardly of groove 82 in response to centrifugal forces acting on the fuze. When fully under control of the spin forces the balls 83 move partially out of groove 82, being received in a groove 86, circumferentially extending around the walls of the cavity formed by the mating bores 42 and 28, as showing in FIG. 2. When the spin-rate decays below a pre-determined rate, the balls slide off ramp 86a, in groove 86, since they can no longer support the spring forces, and the firing pin 38 is driven into the detonator, as seen in FIG. 3.

The operation of the improved fuze mechanisms described above will now be described in detail, with particular reference to the combination time-delay arming improvement of the present invention. Assume that the projectile and fuze are ready for firing and have been chambered in the gun. The fuze mechanism will be in the "safe" position shown in FIG. 1, i.e., the retainer or detent spring 70 and spring means 68 are engaged in notch 72 and 68a in the ball rotor and collar respectively, with spring 40 in partial extension and centrifugally-operated balls 83 freely moving in the collar groove or race 82. As the gun is fired and while the projectile is still in the barrel, i.e., during initial "set-back," no significant change in relative position of the fuze mechanism occurs, i.e., the fuze is still on "safe." At a pre-determined period after clearing the muzzle of the gun barrel, however, the spin rate (caused by the barrel rifling) rises sufficiently to cause the balls 83—83 to move outwardly of the race 82 and onto the initial ramp portion 86a of body groove 86, causing retraction of the firing pin tip in passage 44. At approximately the same time, retainer or detent spring 70 will have expanded to release the ball rotor for axial alignment of the detonator charge bore 53 with the fuze body bores 42, 44 and 46. Further, as balls 83—83 move out retainer spring 68 likewise moves out of notch 86a into a groove or notch 69 in body portion 12. Both spring means 68 and 70 permanently deform under the effect of centrifugal force. Thus, as seen in FIG. 3, spring 68 does not impede the self-destruct operation.

An important feature of our invention thus concerns means for accurately controlling the timing of this alignment, i.e., the movement of the ball-rotor 52 wherein, due to the density of the charge 54 being relatively less than the rotor body, the rotor precesses into position such that its maximum moment is aligned with the projectile spin axis. This position is shown in FIG. 2. We have discovered that with our improved delay-timing arrangement a much higher reliability factor is present when controlling the alignment time of what, conventionally is a freely turning ball and socket device. In addition, use of this technique enables manufacture of rotors using lower density materials, e.g., aluminum or plastics, to increase both the arming delay time and, at the same time, decrease the cost of the ball-rotor itself. To this end we provide in the cavity or void between the rotor body and the fuze body walls a viscous or fluid mass

which acts to reduce the angular rate or velocity at which the ball-rotor moves into its armed or aligned position.

For purposes of analysis, consider the ball rotor and cavity as a concentric-spherical viscometer. Accordingly, using Newton's equation for frictional forces

$$F = \mu A \frac{V}{h}$$

where

V/h =velocity gradient in the film covering the ball and cavity surfaces

A =area of the opposing ball and cavity surfaces

μ =the fluid viscosity

the movement resulting from the frictional forces on these surfaces can be regulated—by viscosity regulation (assuming a constant surface area and spin rate)—to provide a viscous dampening action. This will enable a controllable and definitive increase in the arming delay time.

For example, in one application using a fluid whose value of absolute viscosity was approximately 100,000 centistokes, the arming delay time was regulated between 25 and 30 milliseconds, which, in this instance, corresponded to about 90 feet from the gun muzzle. In comparison, a non-viscous dampened conventional ball-rotor type fuze was armed about 10 feet (4 milliseconds) from the gun. It was also learned that the heat of firing and, in particular, the outside environment experienced in various geographic locations requires that the attention be paid to the fact that the viscosity of suitable dampening fluids varies with temperature. Careful selection of proper fluid or viscous medium is of great importance. Accordingly, one material discovered to have versatility and utility in the application of our invention was silica-containing fluids. An example is synthetic silicon grease which, when properly selected, can show a viscosity variation of 3:1 or less, over a 200° F. (e.g., -40° F. to 160° F.) temperature range. In comparison, the conventional petroleum based (e.g., hydraulic) fluids typically show a viscosity variation in this temperature range of up to 100:1. Further, silicon greases are chemically inert and resistant to breakdown over extreme temperature ranges, i.e., -100° F. to 450° F. In addition, such compounds are non-toxic, oxidation and radiation resistant, and water repellant—all advantageous in the manufacture, use and handling of ammunition.

Another variation of our improved viscous dampened, arming-delay mechanism includes providing a ball-rotor 92, as shown in FIG. 4, with an irregular surface comprising a series of depressions or ridges 92a. The result of the surface irregularity is to cause turbulence in the viscous dampening fluid boundary layer (film), thereby increasing the dampening action without adversely affecting temperature characteristics and, consequently, improving control of the alignment or arming time factor.

Another device to improve the dampening characteristics is shown in FIG. 5. Indicated therein is an enlarged diagram depicting a pictorialized view of a viscous fluid compound indicated generally at 93 containing an inert filler material 92. The filler 94 may consist of a non-metallic powder, e.g., Teflon, or minute metallic particles, either of which serve to increase the effective viscosity of the media. Thus, by employing a silicon fluid base material whose viscosity is relatively stable with temperature we have provided an improved or "filled" dampening fluid of the proper viscosity having good temperature characteristics.

What we claim and desire to secure by Letters Patent of the United States is:

1. In combination, an artillery fuze comprising:

a forward tapered body portion, an intermediate body portion and a rearward body portion, said body portions having centrally located, axially-extending bores therein and being interconnected to form a fuze housing of generally circular section;

an elongated pin having an impact head and received in a bore of said forward body portion, the other end of said pin having a striker point received in a passage in said intermediate body portion;

a collar member on said pin intermediate the ends thereof, said collar member being received in a first cavity in said housing formed by interconnecting bores of said forward and intermediate body portions;

a first resilient member in said first cavity cooperating with said collar for reciprocable movement of said pin along the axis of said fuze housing, said pin being positioned, alternatively, for safing and arming of said fuze;

a substantially spherical rotor located in a second, generally spherical cavity in said housing, said rotor having a diametrical bore therethrough about which axis said rotor precesses for rotation, said bore containing a detonator explosive charge for said fuze;

a second resilient member engaging a notch in said rotor below a pre-determined rotating speed of said fuze, said second member expanding permanently out of engagement with said rotor and into a groove at the rear of said second cavity above said pre-determined speed;

a third resilient member normally partially engaged in a second notch in the walls of said first cavity, said third resilient member bearing against a rearward face of said collar member to restrain said firing pin assembly forwardly below said pre-determined rotating speed, said third member expanding permanently into said second notch and out of engagement with said collar above said pre-determined speed;

a fuze arming and self-destruct mechanism in said fuze comprising a first circumferential groove in the wall of said first cavity, a second circumferential groove in said collar member axially alignable with said first groove, and centrifugally-responsive means normally received in said second groove, said centrifugally-responsive means moving partially out of said second groove and into said first groove, whenever said fuze attains said pre-determined spin rate, securing said collar axially of said fuze to prevent engagement of said striker point with said rotor detonator change until impact or reduction of said spin rate below said pre-determined level, at which time said centrifugally responsive means moves out of said first groove and back into said second groove to permit said first resilient member to drive said striker point into said detonator charge for self-destruction of said fuze; and

means to control the rate of alignment of the spin axis of said rotor with the spin axis of said fuze housing for arming of said fuze, said control means comprising a viscous dampening medium contained in said spherical cavity intermediate the walls thereof and the surface of said rotor.

2. In combination, an artillery fuze comprising:

a forward tapered body portion, an intermediate body portion and a rearward body portion, said body portions having centrally located, axially-extending bores therein and being interconnected to form a fuze housing of generally circular section;

an elongated pin having an impact head end received in a bore of said forward body portion, the other end of said pin having a striker point received in a passage in said intermediate body portion;

a collar member on said pin intermediate the ends thereof, said collar member being received in a first cavity in said housing formed by interconnecting bores of said forward and intermediate body portions;

a first resilient member in said first cavity cooperating with said collar for reciprocable movement of said pin along the axis of said fuze housing, said pin

7

- being positioned, alternatively, for safing and arming of said fuze;
- a substantially spherical rotor located in a second, generally spherical cavity in said housing, said rotor having a diametrical bore therethrough about which axis said rotor precesses for rotation, said bore containing a detonator explosive charge for said fuze;
- a second resilient member engaging a notch in said rotor below a pre-determined rotating speed of said fuze, said second member expanding permanently out of engagement with said rotor and into a groove at the rear of said second cavity above said pre-determined speed;
- a fuze arming and self-destruct mechanism in said fuze comprising a first circumferential groove in the wall of said first cavity, a second circumferential groove in said collar member axially alignable with said first groove, and centrifugally-responsive means normally received in said second groove, said centrifugally-responsive means moving partially out of said second groove and into said first groove, whenever said fuze attains said predetermined spin rate, securing said collar axially of said fuze to prevent engagement of said striker point with said rotor detonator charge until impact or reduction of said spin rate below said pre-determined level, at which time said centrifugally-responsive means moves out of said first groove and back into said second groove to permit said first resilient member to drive said striker

8

point into said detonator charge for self-destruction of said fuze; and

means to control the rate of alignment of the spin axis of said rotor with the spin axis of said fuze housing for arming of said fuze, said control means comprising a viscous grease-like fluid dampening medium contained in said spherical cavity intermediate the walls thereof and the surface of said rotor, wherein the surface of said rotor is irregular causing turbulence in the boundary layer of said fluid, whereby dampening is increased for further control of said alignment rate.

References Cited

UNITED STATES PATENTS

896,135	8/1908	Meigs et al.	102—82
2,280,429	4/1942	Glick	188—101 X
2,896,540	7/1959	Voland	102—82 X
2,921,527	1/1960	Guerne	102—79
3,118,379	1/1964	Jasse	102—79
3,211,099	10/1965	Popovitch	102—79
3,320,891	5/1967	Holmes	102—79 X

FOREIGN PATENTS

1,185,093	1/1965	Germany.
-----------	--------	----------

BENJAMIN A. BORCHELT, *Primary Examiner.*

G. H. GLANZMAN, *Assistant Examiner.*