United States Patent

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[33] **France**
[31] **965,880 and 991,222**

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[54] **CHARGING EXPLOSIVE PROJECTILES, ESPECIALLY HOLLOW CHARGE PROJECTILES**
11 Claims, 8 Drawing Figs.

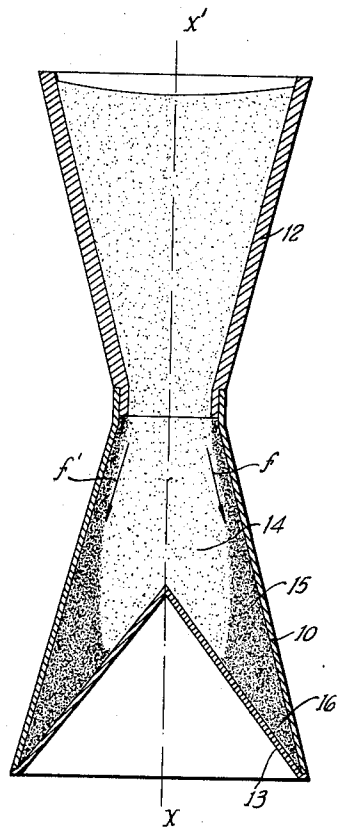
[52] **U.S. Cl.** **86/31**
[51] **Int. Cl.** **F42b 1/02**
[50] **Field of Search** 86/20, 20.3, 20.5, 31, 1, 20.2; 264/3

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Attorney—Davis, Hoxie, Faithfull & Hapgood

ABSTRACT: Explosive projectiles are charged with the aid of a mixture comprising a molten liquid explosive and a granular solid explosive more brisant and powerful than the molten liquid explosive. During charging the projectile is set in motion by a rotation about its longitudinal axis, that is to say, the projectile, being vertically positioned, the rotation about the longitudinal axis of the projectile is carried out during cooling of the projectile filled with explosive mixture. During centrifuging and cooling the projectile is furnished with a plug sealing the bottom of the projectile, said plug having an inner shape in contact with the explosive mixture of such form that the centrifuging throws out toward the periphery the particles of the heavy, brisant, powerful, nonmolten explosive.

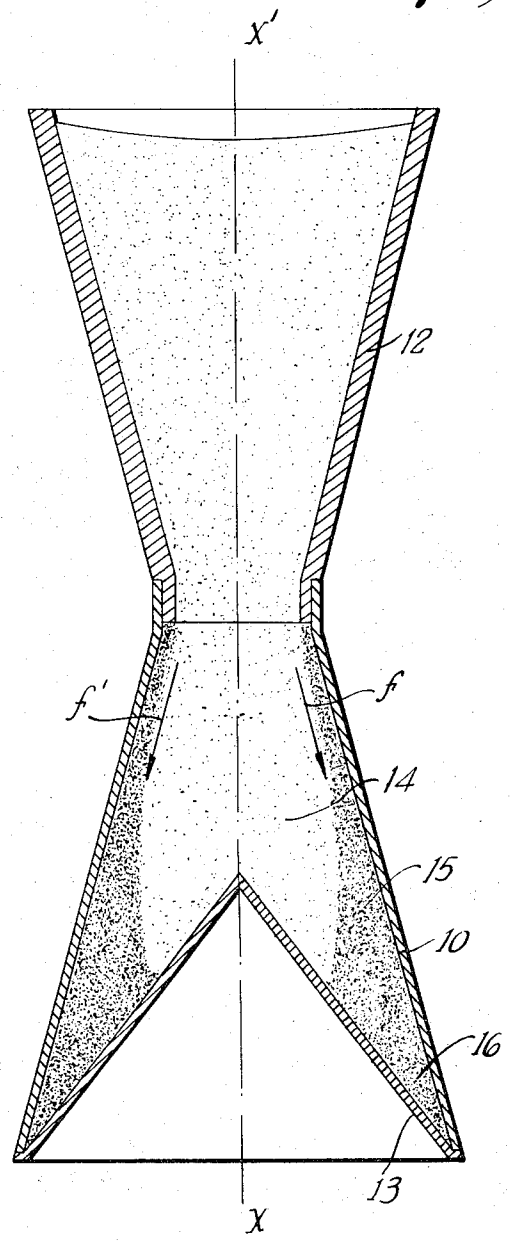


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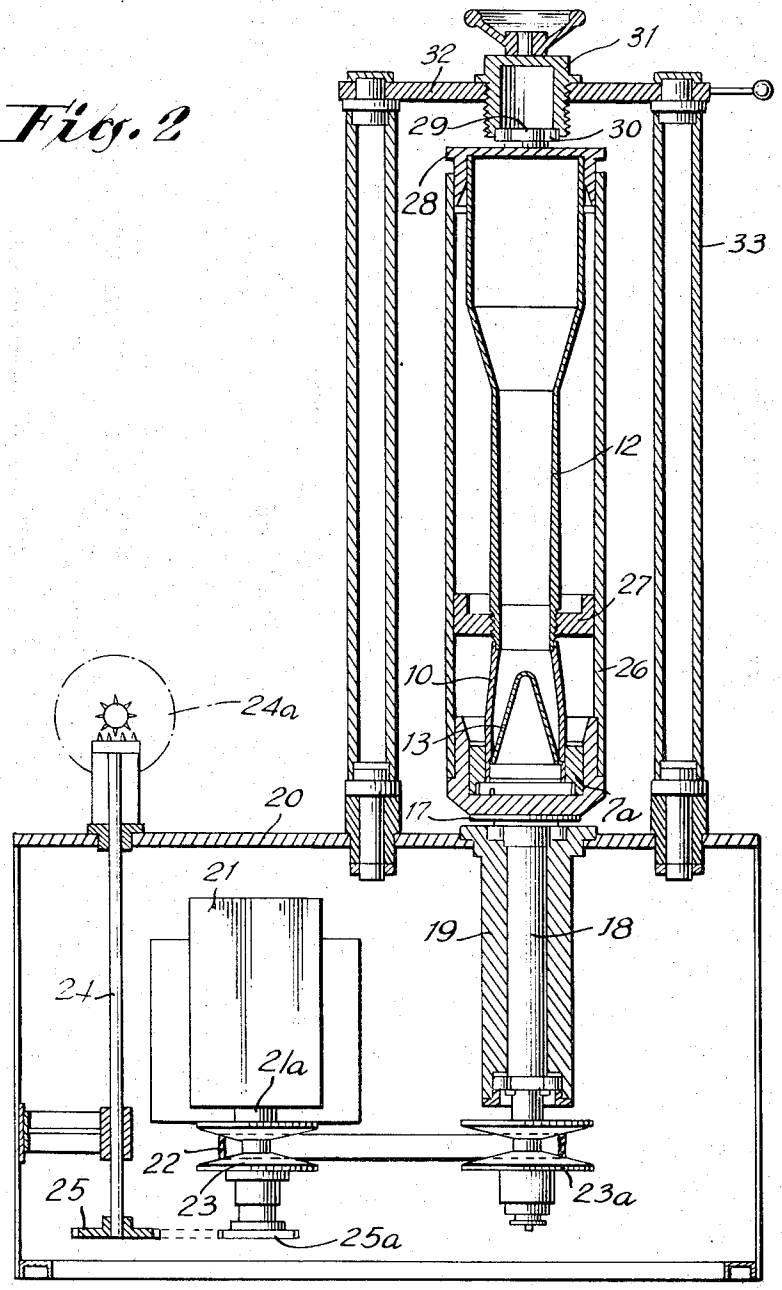
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Fig. 1



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Fig. 2



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Fig. 3

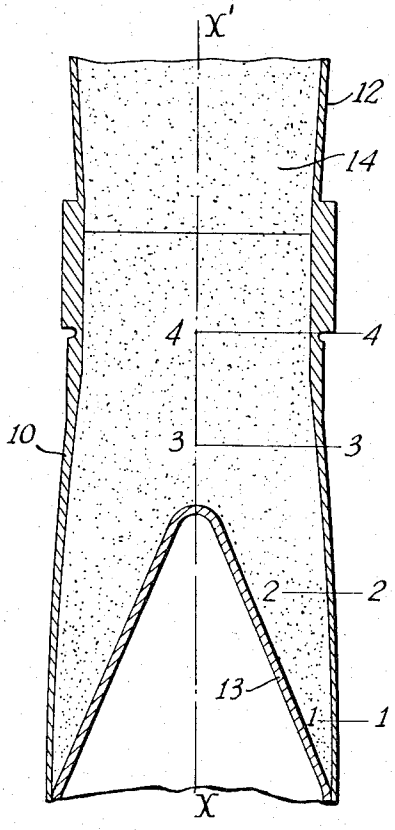
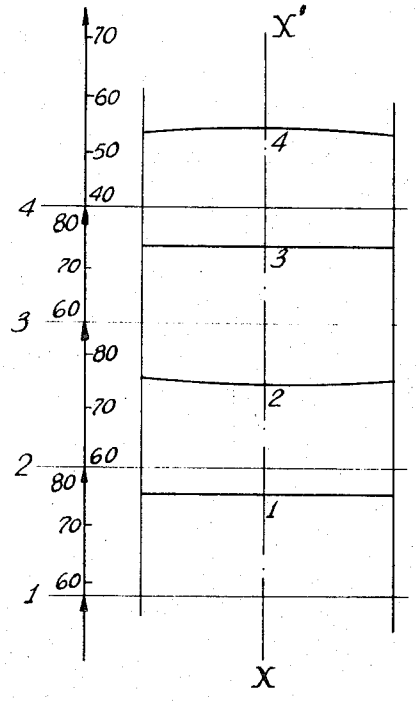


Fig. 4



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Fig. 5

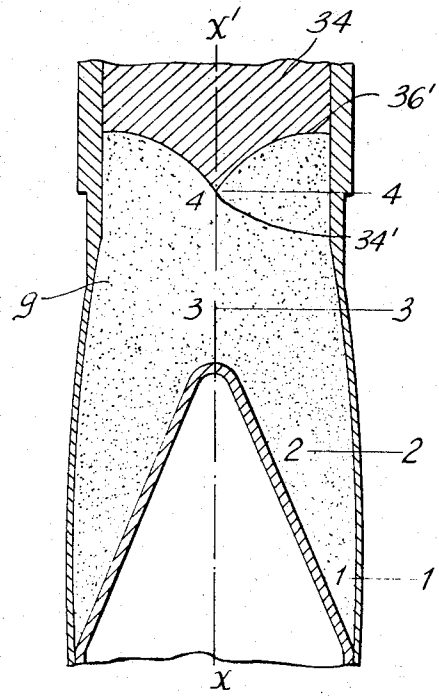


Fig. 6

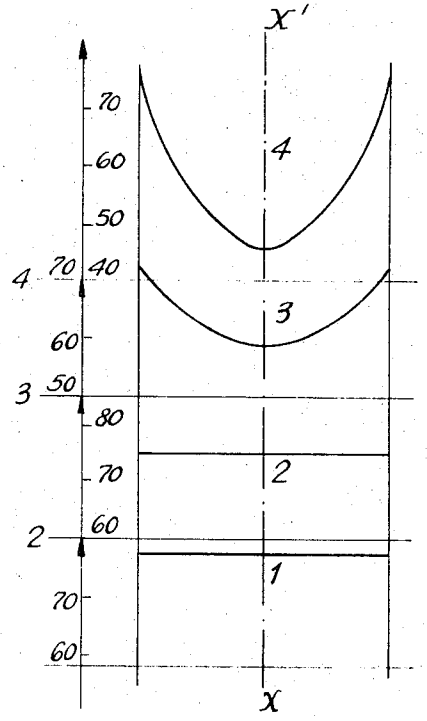


Fig. 7

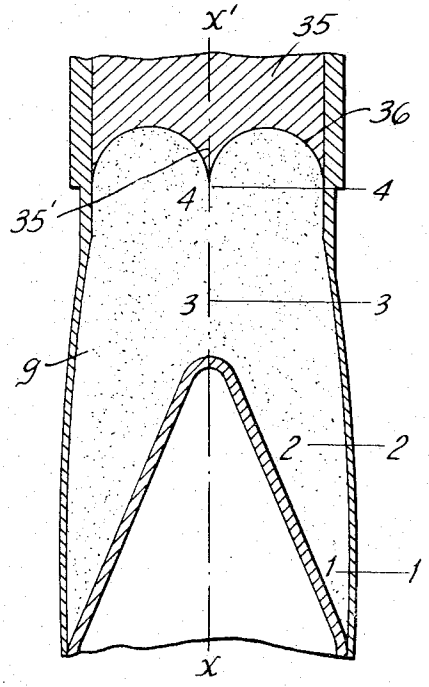
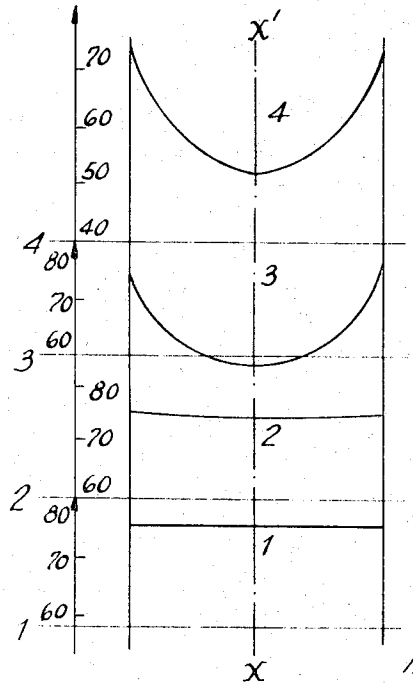


Fig. 8



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CHARGING EXPLOSIVE PROJECTILES, ESPECIALLY HOLLOW CHARGE PROJECTILES

This invention is concerned with charging projectiles with the aid of a mixture containing a molten liquid explosive (tolite or TNT for example) and a granular solid explosive, powerful and brisant ("Hexogen" (RDX) of octogen, for example).

It is well known to effect charging when the charge is still liquid by centrifuging around an axis perpendicular to the longitudinal axis of the projectile, with a suitable position before the axis of rotation or to the rear of the casing, depending on the direction in which one desires the density and the content of the heavy explosive in the interior of the principal charge to progress or increase. A position sufficiently remote from the axis of rotation with relation to the cavity receiving the explosive and the use of a sufficient mass of the explosive employed, permits, moreover, one to obtain a homogenous charge.

Nevertheless, such a process leads, by its very nature, to embodiments which are costly and complex, given the necessity of making a tightly closed container turn about an axis perpendicular to its own axis, and of reheating.

Further, this principle of charging results in the sections or planes perpendicular to the axis of charging having constant characteristics.

The present invention has for an object a process of charging which also involves rotation and centrifuging, but having for its purpose to effect nonuniform concentrations of nonmolten, heavy, powerful, brisant explosive particles, such as RDX of octogen, for example, mixed with a liquid explosive, such as TNT, for example, and in particular to effect a concentration of heavy nonmolten explosive, toward the periphery of the projectile, along the casing; and also toward the base of the casing or internal sheath of a hollow charge, when a device of that nature is concerned.

This peripheral concentration of brisant, heavy, powerful, nonmolten explosive, because of its very high speed of detonation, permits one to obtain the effects of priming through a toroidal shock wave, even if the priming is an axial priming; and permits one also to reinforce and amplify the speed of propagation of the peripheral wave, that is to say of the transformed toroidal wave, even if the priming is already of such a composition as to develop a toroidal wave.

For the realization of a process according to the invention, one submits the projectile at charging and during the pouring of the explosive mixture, to a rotation about its longitudinal axis, which results, through centrifuging, in a concentration of the heavy, brisant, powerful, nonmolten explosive toward the periphery of the charging.

The combination of the effect of gravity with the effect of centrifuging, about the longitudinal axis of the projectile, and the action of the profile of the conical internal sheath (in the case of a hollow charge), procures at the same time, according to the invention, a concentration of heavy, brisant, powerful, nonmolten explosive toward the base of the sheath. To this effect, the projectile to be charged according to the invention is placed vertically, the sheath being downward.

The various other characteristics and advantages of the invention will become obvious from the description which follows. It is emphasized, moreover, that the description is merely exemplary and is not intended to be limiting; and that many other modes of construction, shapes, proportions and dispositions may equally well be used without departing from the limits of the invention.

The example described below is concerned with a projectile having a hollow charge. It is pointed out, however, that the invention may be applied without departing from its principles to all other types of explosive projectile not provided with a hollow charge.

In the description which follows reference is made to the attached drawings in which:

FIG. 1 is a view in longitudinal section of a hollow charge projectile, charged, in accordance with the invention, with centrifuging about its longitudinal axis during pouring;

FIG. 2 is a view in elevation and in section of an apparatus suitable for carrying out a charging, in accordance with the invention;

FIG. 3 is a partial view in longitudinal sections of a projectile charged according to the invention;

FIG. 4 is a diagram, relating to FIG. 3, representing the content of granular, heavy, brisant, nonmolten explosive, in different charging zones of the projectile of FIG. 3;

FIG. 5 is a view analogous to FIG. 3, of a projectile furnished during centrifuging and chilling with a seal at the base, illustrating a preferred construction of said seal;

FIG. 6 is a diagram analogous to the diagram of FIG. 4, but relating to FIG. 5;

FIG. 7 is a view analogous to that of FIG. 5, of a projectile, furnished during centrifuging and chilling, with a seal for the base, illustrating another form of said seal;

FIG. 8 is a diagram analogous to the diagram of FIG. 4, but concerned with FIG. 7.

A projectile in accordance with the invention comprises an envelope or casing **10** on the after part of which is fixed, for charging, a funnel-support **12**, the inner sheath **13** of the hollow charge closing the cavity to be charged with explosive.

The mixed explosive **14**, liquid and hot, is flowed into the casing **10** and the funnel **12** until the device is completely filled.

The mixed liquid **14** contains as pointed out above, first, a molten explosive, such as TNT, for example, and second, a heavy, brisant, powerful nonmolten explosive having a high speed of detonation such as RDX, for example. The proportions of the two types of explosive may vary considerably but in general there will be from 40 to 60 parts by weight of the liquid explosive (e.g. TNT) per 100 parts of granular explosive.

The assembly, brought to the fusion temperature of the molten explosive is placed in a mechanical device, which functions according to the invention, to rotate the assembly about the longitudinal axis X–X′ of the projectile. For the mechanical device one may use that shown in FIG. 2.

Referring to FIG. 2 a suitable device comprises a plate **17**, carried on a shaft **18** turning in a support-bearing **19** formed integrally with a frame **20**. The shaft **18** is rotated by a motor **21**, the shaft **21***a* of which is connected to the shaft **18** of the plate **17** by a conventional power train having a belt **22** and pulleys **23**, **23***a*. Variation of the speed of rotation of the shaft **18** may be obtained by any conventional means, as by varying electrically the speed of the motor **21**. Preferably, however, the control mechanism shown in FIG. 2 is used. This permits one to vary the spacing of the flanges of the pulley fixed on the driving shaft **21***a*; the system containing a rod **24**, operated by a handwheel **24***a* which functions through the gearing **25**, **25***a* to displace the flange **23** of the pulley in question.

On the plate **17** is disposed a cylindrical casing **26** into which is introduced the body **10** with the sheath of the hollow charge **13**. The funnel-support **12** is fixed to this body. The supports **27**, **27***a* maintain the assembly in place in the casing **26**. At its upper part the casing **26** is closed by aseal **28**,introduced between the internal wall of the casing and the upper part of the funnel-support **12**. The seal **28** carries an axle or spindle **29** above which is applied, through rolls **30**, a centering piece **31**, screwed on a fixed cover **32**, carried by the posts **33** formed integrally with the frame **20**.

The rotation to which the body of the projectile is subjected is continued for the duration of the chilling of the projectile. In the case of pouring or decantation by gravity, the axis X–X′ is vertical. Reheating in the course of the operation may be provided if necessary. Naturally, by varying the parameters such as the speed of rotation, the duration of decantation and chilling, the temperature of decantation, the characteristics and proportions of the explosive mixture, the quantity of explosive employed, and the proportions and the form of the funnel-support **12**, one may determine the characteristics of the charge which one desires to obtain.

However, in general, there is enrichment and increase of the content of heavy, powerful, brisant explosive having a high speed of detonation when one moves away from the axis X–X′ of the projectile and, similarly, an increase, in the same direction, of the density. There is therefore a maximum concentration of heavy, brisant, powerful explosive having a high speed of detonation near the periphery **15** of the charge and equally toward the base **16** of the charge, surrounding the base of the internal sheath in the case of a hollow charge. The arrows *f–f′* show the amplification of the effect of the toroidal priming shock wave as a result of the increase in speed of detonation in the zone **15** having a higher density and a higher content of heavy, brisant, powerful explosive of higher speed of detonation.

One will note, moreover, the advantage, by no means negligible, which is prescribed by the great simplicity of a system of rotation about the axis of the projectile during the pouring and chilling of a projectile filled with a mixed liquid explosive and carrying a charging funnel, without it being necessary to have recourse to the heavy complex and sealed apparatus which is required with rotation about an axis perpendicular to the longitudinal axis of the projectile.

FIGS. **3** and **4** show schematically the results which one obtains by centrifuging about the axis X–X′ of the projectile **10**, the latter having been topped by the supported reservoir **12** containing the mixed liquid explosive **14**.

In FIG. **4** the ordinate represents the content in percent of heavy granular nonmolten explosive (RDX, for example). The solid lines represent the content of RDX obtained after centrifuging in the charging zones **4** to **1** of FIG. **3** on both sides of the axis X–X′ of the projectile.

The pouring and chilling having been conducted during centrifuging, one obtains according to FIG. **4**, an increasing content of RDX from the zone **4** to the zone **1** at the base of the internal sheath **13**. The centrifuging system according to the invention permits therefore, one to obtain in the zone **1** more than 75 percent RDX, a remarkable result for pouring at atmospheric pressure.

However, in the different zones the content of RDX is substantially constant from the axis X–X′ to the periphery of the projectile.

According to another feature of the invention there may also be obtained an improved charge by obtaining an enrichment of the heavy, brisant, solid, particulate explosive in the charge, at the periphery of the axial zone included between the apex of the internal sheath and the primer.

For this effect, according to the invention, the projectile is provided, during centrifuging and chilling with a base plug a such as **34** or **35** (FIGS. **5** and **7** respectively) whose profile in contact with the liquid explosive, is formed as an hydrodynamic deflector effective to throw toward the periphery of the charge (region *g*) the granular nonmolten particles of heavy, powerful, brisant explosive such as RDX or octogen, thus enriching the periphery of the charge.

According to the invention, the profile of the base sealing plug in contact with the liquid explosive has a cusp **34′** or **35′** lying on the longitudinal axis X–X′ of the projectile and a hollow section, for example like a half torus **36** (FIG. **7**) or a quarter torus **36′** (FIG. **5**) which functions to throw the particles of heavy explosive in a centrifugal direction.

FIG. **6**, analogous to FIG. **4**, shows the content of RDX in zones **1** to **4**, which may be obtained with the plug **34** in the form of a quarter torus of FIG. **5**.

FIG. **8** shows the content of RDX in zones **1** to **4** which may be obtained with the plug **35** in the shape of the half torus of FIG. **7**, analogous to FIG. **5**.

Naturally, the percentages of RDX indicated in FIGS. **6** and **8** are only illustrative and all other proportions may be obtained, without departing from the principles of the invention.

The same is true of the sealing sections of FIGS. **5** and **7**.

It is apparent, therefore, from FIGS. **6** and **8** that the use during centrifuging and chilling of a plug having a section according to the invention keeps a fundamental advantage of the invention, the sensible enrichment in heavy nonmolten explosive at the base of the internal sheath. At the same time as one goes toward the rear of the projectile (zones **3** and **4** particularly), i.e. toward the priming, the RDX content increases transversely from the axis X–X′ of the projectile, with very appreciable enrichment at the periphery. For example, in the rear zone **4** there is 75 percent RDX at the periphery compared to 45 to 50 percent at the axis, while in zone **3** there is 70—75 percent at the periphery against 68 percent at the axis.

One obtains, therefore, thanks to the base plug according to the invention, a transfer of nonmolten particles of heavy, powerful explosive from the axis toward the periphery with a corresponding impoverishment in the RDX content in the axial zone of the charge between the apex of the internal sheath and the priming.

This distribution of powerful brisant explosive resulting from these arrangements, produces again a more toroidal form of wave of detonation, initiated by the primer, in its propagation through the charge.

There follow all the advantages of efficacy and perforating power of a hollow charge, as already described in prior patents.

It is emphasized, however, that the invention is equally applicable, without departing from its principles to all explosive projectiles, as well as to projectiles having a hollow charge.

Similarly, the invention is not applicable only to charging with decantation during centrifuging. It is applicable also without departing from its principles to charging in two phases:

a. preliminary pouring with a reserve of liquid explosive.

b. centrifuging with chilling of a projectile having a plug with a section according to the invention.

I claim:

1. In a process for charging an explosive projectile having a base plug with a fluid mixture comprising a molten liquid explosive and a heavy, brisant and powerful explosive in granular, nonmolten form, the improvement which comprises rotating the projectile about its longitudinal axis during charging and deflecting the nonmolten explosive particles toward the periphery of the projectile by the action of a surface provided on said base plug.

2. The process claimed in claim **1** wherein the nonmolten explosive is decanted by gravity.

3. The process claimed in claim **1** wherein the nonmolten explosive is decanted by gravity in a separate prior operation.

4. The process claimed in claim **1** wherein the plug has an interior cusp directed toward the projectile along the axis of the projectile.

5. The process claimed in claim **1** in which the plug has a section in the form of a quarter hollow torus.

6. The process claimed in claim **1** in which the plug has a section in the form of a half hollow torus.

7. In a process for charging hollow charge explosive projectiles with a fluid mixture comprising a molten liquid explosive and a heavy, brisant and powerful explosive in granular nonmolten form, said projectile having a forward end and a primer end and including an inner sheath for the hollow charge, the improvement which comprises rotating the projectile, disposed vertically, about its longitudinal axis during charging and transferring the particles of nonmolten explosive from the axis to the periphery of the charge to cause an impoverishment in the concentration of nonmolten explosive particles in the axial part of the zone lying between the apex of the conical inner sheath and the primer end of the charge, with a corresponding enrichment at the periphery of that zone.

8. The process claimed in claim **7** wherein the projectile filled with the fluid explosive mixture is cooled and the rotation is carried out during cooling.

9. The process claimed in claim **8** wherein the molten explosive is poured with the aid of gravity into the po projectile to fill it.

10. The process l claimed in claim **7** wherein the projectile is heated during rotation.

11. The process claimed in claim **7** wherein during rotation the projectile is provided with a support-funnel filled with explosive mixture.