Aug. 14, 1962 V. I. MILANI ET AL 3,049,043

METHOD OF CASTING AN EXPLOSIVE CHARGE

Filed May 21, 1958 2 Sheets-Sheet 1

FIG.1.

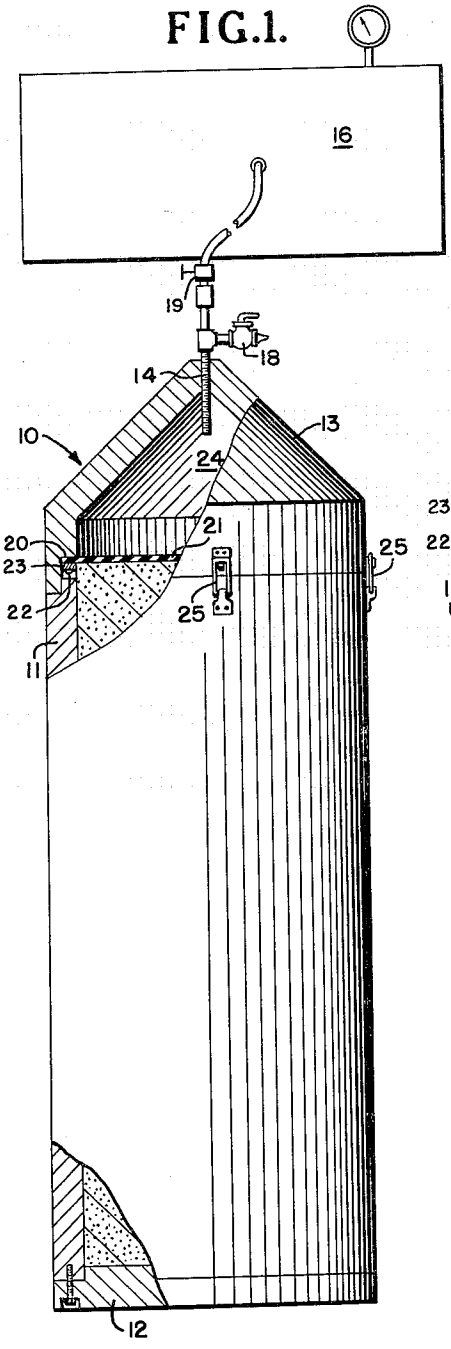


FIG.2.

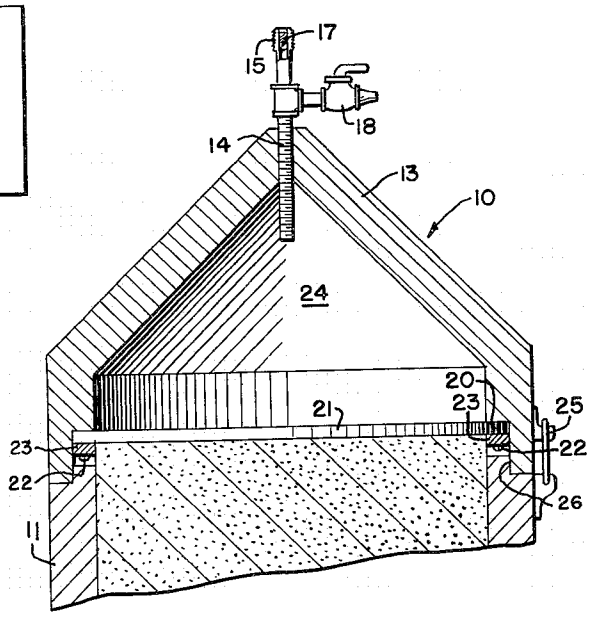
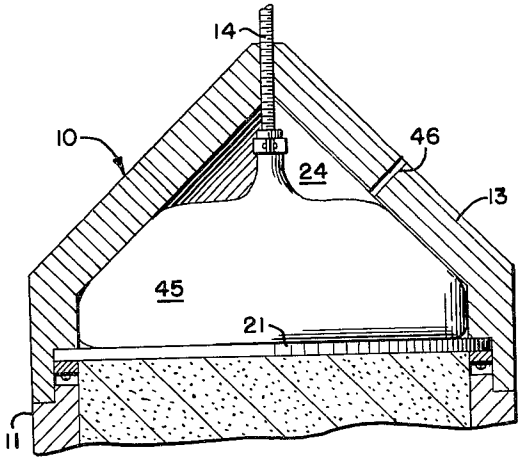


FIG.7.



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Aug. 14, 1962 V. I. MILANI ET AL 3,049,043

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Filed May 21, 1958 2 Sheets-Sheet 2

FIG.3.

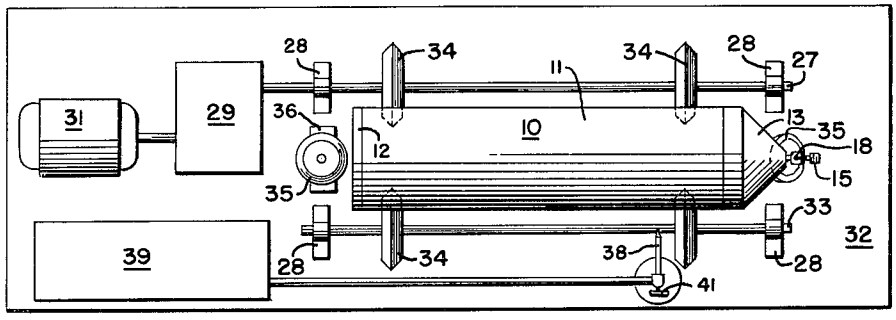


FIG.5.

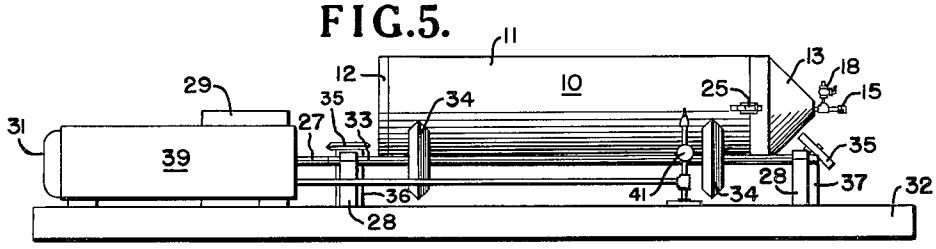


FIG.6.

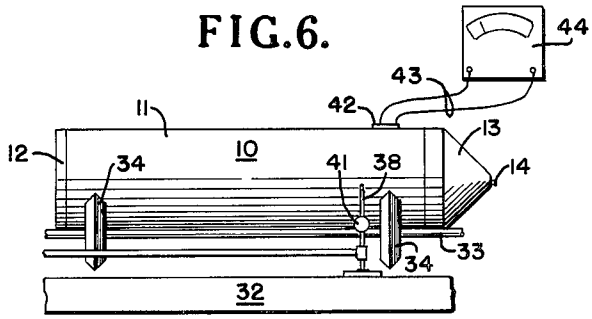
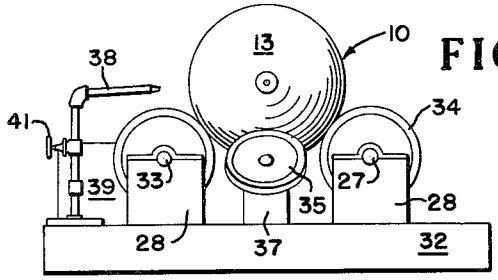


FIG.4.



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METHOD OF CASTING AN EXPLOSIVE CHARGE

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6 Claims. (Cl. 86—1)
(Granted under Title 35, U.S. Code (1952), sec. 266)

The invention described herein may be manufactured and used by or for the Government of the United States of America for governmental purposes without the payment of any royalties thereon or therefor.

This invention relates to a method of casting an explosive charge and more particularly to an explosive charge of the type employing TNT which contains solids such as RDX, aluminum and the like whereby the heavy constituents of the charge are uniformly distributed throughout the volume thereof when the charge has been cast.

As is well known, when a fluid explosive containing solids such as RDX, aluminum and the like, is poured into a mold during the casting operation thereof, the solid material settles to the bottom of the mold in such manner that the cast charge is not homogeneous throughout the volume thereof but contains a preponderance of the solid material at the bottom portion of the charge. In order to effect a uniform distribution of the solid material, it has been the usual practice to prevent the heavier constituents of the mixture from settling to the bottom by pouring the hot fluid explosive into a preheated mold of cylindrical configuration and having an axial length equal approximately to the length of the finished explosive casting. This mold is set upright upon a plane horizontal surface and fitted with a second cylindrical mold of roughly the same length as the first named mold in axial alignment therewith prior to filling the two molds with the liquid explosive therein. An arrangement is thus provided in which the second mold provides a static head for the charge within the first mold thereby to fill the cavities therein which may develop on cooling the charge. The cooling time of the charge varies with the thickness of the casting and may be of the order of a few minutes to several hours. During the cooling period the charge is probed by an operator to eliminate air bubbles that may be formed therein. This probing operation combined with the prolonged standing time of the mold required for solidification of the explosive charge causes the heavier constituents to settle to the bottom thereby creating a heterogeneous distribution of the constituents in the ultimate cast product. This prior method of casting a liquid explosive possesses an additional disadvantage that the small weight of the explosive head in the second mold or riser was insufficient to cause the charge to pack well within the first mold and furthermore the services of an operator were required for the probing operation.

In accordance with the present invention a method of casting liquid explosives has been devised which possesses all of the advantages of the foregoing method and none of the disadvantages thereof. This result is achieved by placing the liquid explosive containing the heavier solid particles into a closed and sealed cylindrical mold, applying pressure to one end of the charge within the mold, rotating the mold about a horizontal axis while the charge is solidifying therein, applying heat exteriorly to the mold at an end portion thereof adjacent the end of the charge to which the pressure is being applied, measuring the temperature of the charge at the exterior of the mold, removing the pressure therefrom when the temperature of the mold at the point of measurement has decreased to a predetermined value, removing the heat from the end

of the mold, extracting the explosive casting from the mold, and thereafter cutting a predetermined length of the casting from the portion thereof opposite to the end at which said pressure was applied.

Whereas various devices and instrumentalities may be employed for carrying out the steps recited in the method herein disclosed, applicants have also disclosed a preferred apparatus by means of which the process may be carried out in a most expeditious manner, the details of which will become more clearly apparent as the description proceeds.

One of the objects of the present invention is to provide a new and improved process for casting a cylindrical mold of liquid explosive having a quantity of heavier solid material included therein in suspension whereby the solid material is distributed uniformly throughout the explosive casting.

Another object is the process of molding an explosive liquid containing heavier particles of solid material in such manner that the solid particles are prevented from settling while the liquid is in the mold and pressure is applied thereto from a pressure source, one end of the mold being heated continuously above the melting temperature of the explosive fluid while the mold is being continuously rotated, and discontinuing the heat applied to the mold when the temperature thereof has decreased to a predetermined value.

Still another object is the provision of a new and improved cylindrical mold for a liquid explosive having a quantity of heavy solid material in suspension therein comprising means for applying pressure to one end of the liquid explosive while the mold is rotating continuously about the axis of the cylinder in a horizontal position while the explosive is congealing within the mold.

A further object is the provision of a new and improved device for casting a cylindrical explosive from a liquid explosive mixture having a quantity of heavy solid particles therein comprising means for maintaining a predetermined degree of pressure within the mold while the mold is being rotated about a horizontal axis coincident with the axis of the cylinder until the explosive mix has solidified sufficiently to prevent settling of the solid particles.

Still other objects, advantages and improvements will be apparent from the following description taken in connection with the accompanying drawings of which:

FIG. 1 is a sectional view in elevation of the mold of the present invention according to a preferred embodiment thereof;

FIG. 2 is an enlarged sectional view of the upper end portion of the mold of FIG. 1;

FIG. 3 is a plan view of the device for rotating the mold of FIG. 1;

FIG. 4 is an end view of the mold supporting and rotating mechanism with a mold mounted thereon;

FIG. 5 is a view in elevation of the mold on the rotating and supporting means thereof;

FIG. 6 is a schematic view of the heat measuring device suitable for use with the present invention; and

FIG. 7 is a view in section of an alternative means for applying pressure to the liquid explosive during the hardening thereof.

Referring now to the drawings for a more complete understanding of the invention on which like numerals of reference are employed to designate like or similar parts throughout the several views and more particularly to FIG. 1 thereof there is shown thereon a mold indicated generally by the numeral 10 suitable for use with the present invention and comprising a cylindrical casing 11 closed at the lower end thereof by a bottom plate 12 secured thereto in any suitable manner as by the screws illustrated. The casing 11 is provided with a cover 13

of any configuration suitable for the purpose such for example as the conical configuration illustrated and provided with a duct 14 threaded as at 15 for connection to a source of pressure 16. Within the threaded portion is a check valve 17 of any type suitable for the purpose such, for example, as the type known in the art as a Schrader valve employed with automobile tires. The duct 14 is provided with a valve 18 to release the pressure from the mold when it is desired to remove the cast explosive therefrom. A valve 19 is included between the duct 14 and the source of pressure 16.

The cover 13 is provided with an annular surface 20 to which is secured a flexible diaphragm 21 as by the screws 22 and annular clamping member 23 in sealed relation therewith. An arrangement is thus provided in which a pressure chamber 24 is formed within the cover 13 in such manner that the diaphragm 21 is flexed outwardly therefrom when pressure is applied to the interior of the chamber. The cover 13 is secured to the casing 11 in any suitable manner as by the latches or clamping members 25 illustrated, each of the latches having a pair of complementary latch members secured to the cover and the casing respectively. The cover is maintained in alignment with the casing when latched thereto as by the registered portion formed thereon and generally indicated at 26.

Referring now to FIG. 3 of the drawings there is shown thereon the apparatus for rotating the mold continuously while the liquid explosive therein is slowly congealing to a solid state, the apparatus comprising a shaft 27 journaled at 28 for rotation in a horizontal plane. One end of the shaft is connected by a gear reduction box 29 to a motor 31 in such manner that the shaft revolves at a slow speed relative to the speed of the motor. The journals 28, motor and gear box are all secured to and carried by a base 32. There is also carried by the base another pair of journals 28 for rotatably supporting a shaft 33 parallel to the shaft 27 for rotation by a mold 10, the connection between the shaft 33 and the mold including a pair of pulleys 34 fixed to shaft 27 and a second pair of pulleys 34 carried by shaft 33. The shafts are arranged at a distance such that the pulleys 34 support the mold 10 for rotation as clearly shown on FIGS. 3 and 4. Substantial endwise movement of the mold 10 is prevented by a pair of pulleys or rollers 35 carried by the bearing members 36 and 37 respectively as most clearly shown on FIG. 5 in such manner that one of the rollers is adapted to prevent endwise motion of the mold 10 by engagement with the bottom plate 12 thereof and the other pulley 35 by engagement with the outer conical surface of cover 13 substantially as shown. The gear box 29 has a gear ratio such that the mold 10 revolves at a relatively slow rate of rotation such, for example, as 11 revolutions per minute. The mold may be of various sizes both longitudinally and diametrically, a mold having an inner diameter of substantially 6¼ inches and an overlong length of approximately 15 inches from the inner surface of the bottom plate to the diaphragm having been found to be satisfactory when revolved at this rate of rotation.

There is also provided a nozzle 38 mounted on the base 32 and supplied by a source of steam 39, the nozzle being so arranged as to direct a jet of steam against the revolving mold 10 at a predetermined distance along the longitudinal portion thereof and preferably near the end portion of the cylindrical casing 11 near the conical cover. A valve 41 may be employed to control the rate of flow of the steam through the nozzle and interrupt the flow of steam therethrough when the explosive mix has cooled sufficiently to be removed from the mold.

The temperature of the explosive mix may be ascertained by employing the arrangement shown on FIG. 6 comprising a surface pyrometer 42 connected by the wires 43 to a meter 44 substantially as shown. The meter is of any type suitable for the purpose and preferably calibrated to indicate the temperature at the surface pyrometer. The pyrometer is applied to the casing 11 of the mold substantially as shown, the mold being brought to rest for this purpose by interrupting the circuit to motor 31.

On FIG. 7 is shown an alternative arrangement for applying pressure to the fluid explosive mix within the mold 10. In the embodiment disclosed on FIG. 7 the duct 14 is sealed to an expansible member 45 such as the bladder or balloon illustrated and which is composed of rubber or any of the synthetic varieties thereof suitable for the purpose. The bladder 45 is extended by pressure applied internally thereto into close fitting pressure engagement with the interior of cover 13 and the diaphragm 21 causing the diaphragm 21 to be forced outwardly against the end of the slurry. There is also preferably provided a plurality of vents 46 within the cover 13 to allow the escape of air that may be trapped between the cover and the bladder. When this arrangement is employed, the diaphragm 21, if desired, may be omitted and the bladder upon dilation thereof, in this case, would act as a stopper for the end of casing 11 and apply pressure to the end of the slurry by direct contact therewith.

The operation of the device in accordance with the method of the present invention will now be described. The casing 11 and cover 13 therefor are preheated to a temperature slightly above the melting temperature of the explosive mix. The mix containing a quantity of RDX, particles of aluminum and the like is heated to a fluid state and poured into the preheated mold. When the mold has been filled with the mix, the cover 13 is placed thereon and secured thereto by the latch members 25, any excess mix being forced out of the mold by the diaphragm 21 as the latch members are tightened. The valve 18 is closed and valve 19 is opened thereby causing pressure from air pressure source 16 to be applied to the interior of chamber 24, a pressure of 10 to 25 pounds per square inch having been found to be suitable for the purpose. Valve 19 is now closed and the connection between the pressure source and the duct 14 is disengaged, the pressure remaining in chamber 24, however, by reason of the check valve 17 operating to prevent a reverse flow of the pressure fluid through the duct 14.

The mold 10 is now placed on the pulleys 34 and the motor 31 is set into operation thereby causing the mold 10 and the explosive slurry therein to be rotated slowly while the slurry is being congealed. Valve 41 is now opened thereby causing a jet of steam from nozzle 38 to impinge upon the outer periphery of the mold while the mold is rotating, the temperature of the steam being sufficient to prevent congealing of that portion of the slurry adjacent to the diaphragm 21 prior to the solidifying of the remainder of the slurry sufficiently to fix the solid particles therein. As the slurry congeals, the volume thereof is somewhat reduced thereby causing a cavity to be formed in the end portion thereof in engagement with the flexible diaphragm 21. Diaphragm 21, however, maintains contact with the end portion of the slurry and continues to apply pressure thereto by reason of the pressure trapped within chamber 24 thereby preventing the formation of air pockets within the molded explosive. At the expiration of a period of time deemed suitable for the explosive mix to have become hardened sufficiently for the solid particles to be rendered immobile therein, the mold is brought to rest and the temperature thereof is ascertained by applying a surface pyrometer such as the surface pyrometer 42 illustrated at the outer surface of the mold near the end portion thereof to which the cap 13 is secured. The temperature of the mold at the point of contact with the surface pyrometer is made manifest by the meter 44. When the temperature of the mold as indicated by the meter 44 is equal to or less than the temperature at which the mix melts, the mold is removed from the pulleys 34

and set upright on a plane surface, valve 18 is opened to relieve the pressure within the cover 13, the latch members 25 are loosened and the cover is removed.

The cast explosive is now removed from the mold and the end portion thereof to which the pressure was applied by diaphragm 21 is severed from the remaining portion of the cast explosive in such manner as to leave a finished cast explosive product of predetermined length and of slightly less diameter than the inside diameter of the mold.

When the mold is employed with a liquid or fluid explosive of the type known as TNT containing solid particles such as RDX, aluminum and the like having a characteristic such that the mix melts at approximately 80° C., it has been found satisfactory to preheat the mold and cover therefor to a temperature of 10–15° C. above the melting point of the explosive to be cast and to employ a jet of steam during the cooling of the mix at a temperature of 90–95° C. to retard the solidification of the slurry at the end portion thereof at which the pressure is applied until the solid particles therein have become fixed within the mix by congealing action of the explosive mixture during cooling thereof.

Whereas the method disclosed and claimed herein has been described with reference to a specific apparatus for effectuating the method, it is not so limited as various other well known devices and instrumentalities may be employed for this purpose as will be understood by those skilled in the art to which the invention pertains, after understanding the invention, and various changes and modifications may be made in the apparatus herein disclosed without departing from the spirit and scope of the invention and it is intended in the appended claims, to cover all such changes and modifications.

What is claimed as new and desired to be secured by Letters Patent of the United States is:

1. The method of molding a heated explosive slurry having a quantity of relatively heavy finely divided solid particles in suspension therein which comprises the steps of preheating an open ended cylindrical mold to a temperature in excess of the melting temperature of the slurry, filling the mold with said heated slurry by a single operation and sealing the slurry therein by a flexible diaphragm secured to the open end portion of said mold, slowly rotating said mold about a horizontal axis until the slurry has congealed sufficiently to prevent settling of said particles therein, and applying pressure from an outside source to said flexible diaphragm continuously until the slurry has congealed.

2. The method of claim 1 including the step of applying heat from an outside source of heat externally to a portion only of said mold adjacent said diaphragm during rotation thereof sufficient to prevent congealing of the slurry within the mold at the point of application of said heat until the remainder of the slurry has congealed.

3. The method of molding an explosive mix having a quantity of relatively heavy finely divided particles of solid matter in suspension therein comprising the steps of preheating said mix sufficiently to form a slurry, preheating a cylindrical mold to a temperature just above the melting point of said mix, filling the preheated mold with said slurry, sealing said mold with a flexible diaphragm, applying pneumatic pressure to said diaphragm for transmission to one end portion of the slurry within the mold, rotating said mold and slurry at a slow rate of rotation about a horizontal axis, applying heat to a portion only of said mold adjacent the end portion of said slurry to which said pressure is applied during rotation of the mold sufficient to prevent congealing of the slurry at said end portion thereof, bringing the mold to rest for a period of time just sufficient to measure the temperature thereof, and measuring the temperature of the mold at a point adjacent to the point of application of the heat thereto while the mold is at rest.

4. A method according to claim 3 including the step of removing the pressure from the diaphragm when the slurry has congealed sufficiently to fix said solid particles immovably therein.

5. The method according to claim 4 which includes the step of removing the molded explosive mix from the mold.

6. The method of molding an explosive mix having a quantity of relatively heavy fine particles in suspension therein which comprises heating the mix sufficiently to form a slurry, filling a mold with said heated slurry, sealing the mold with a flexible diaphragm, applying pressure to said diaphragm for transmission to the slurry within the mold continuously until the slurry has hardened, rotating the mold slowly about a horizontal axis while the slurry is hardening for a period of time sufficient for the mix to be molded, arresting the rotation of said mold for a period of time only sufficient to measure the temperature of the slurry during the cooling thereof, applying a temperature measuring device to the mold while the mold is at rest, measuring said temperature, retarding the rate of cooling of that portion only of the slurry against which said pressure is applied by application of heat thereto while the mold is rotating about said axis, and removing the molded mix from the mold when the measured temperature thereof has decreased to a predetermined value.

References Cited in the file of this patent

UNITED STATES PATENTS

1,011,511	Sokolowski et al.	Dec. 12, 1911
1,231,388	Lake	June 26, 1917
2,282,623	Paris	Oct. 22, 1918
2,063,572	Woodbury et al.	Dec. 8, 1936
2,195,429	Shaler	Apr. 2, 1940
2,426,619	Knight	Sept. 2, 1947
2,435,610	Schneider	Feb. 10, 1948
2,540,610	Davis et al.	Feb. 6, 1951
2,751,810	Clark et al.	June 26, 1956
2,851,918	MacLeod	Sept. 16, 1958
2,874,964	Edwards	Feb. 24, 1959