

- [54] **METHOD FOR INJECTION MOLDING OF EXPLOSIVE AND PYROTECHNIC MATERIAL**
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- [63] Continuation-in-part of Ser. No. 249,599, May 2, 1972, abandoned.
- [52] U.S. Cl. **264/3 C**; **264/3 B**; **149/35**; **149/92**; **149/93**
- [51] Int. Cl. **C06b 21/02**
- [58] Field of Search **264/3 C**, **3 B**; **149/35**, **92**, **149/93**

- [56] **References Cited**
- UNITED STATES PATENTS**
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|-----------|--------|----------------|---------|
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- [57] **ABSTRACT**
- A method and apparatus for manufacture of explosive and pyrotechnic articles in which explosive and pyrotechnic materials are injection molded into small cavities of long length. The explosives and pyrotechnics are made up of very fine powders mixed together with an elastomer or oil. In some cases a catalyst or polymerizing agent is used.
- 4 Claims, 4 Drawing Figures**

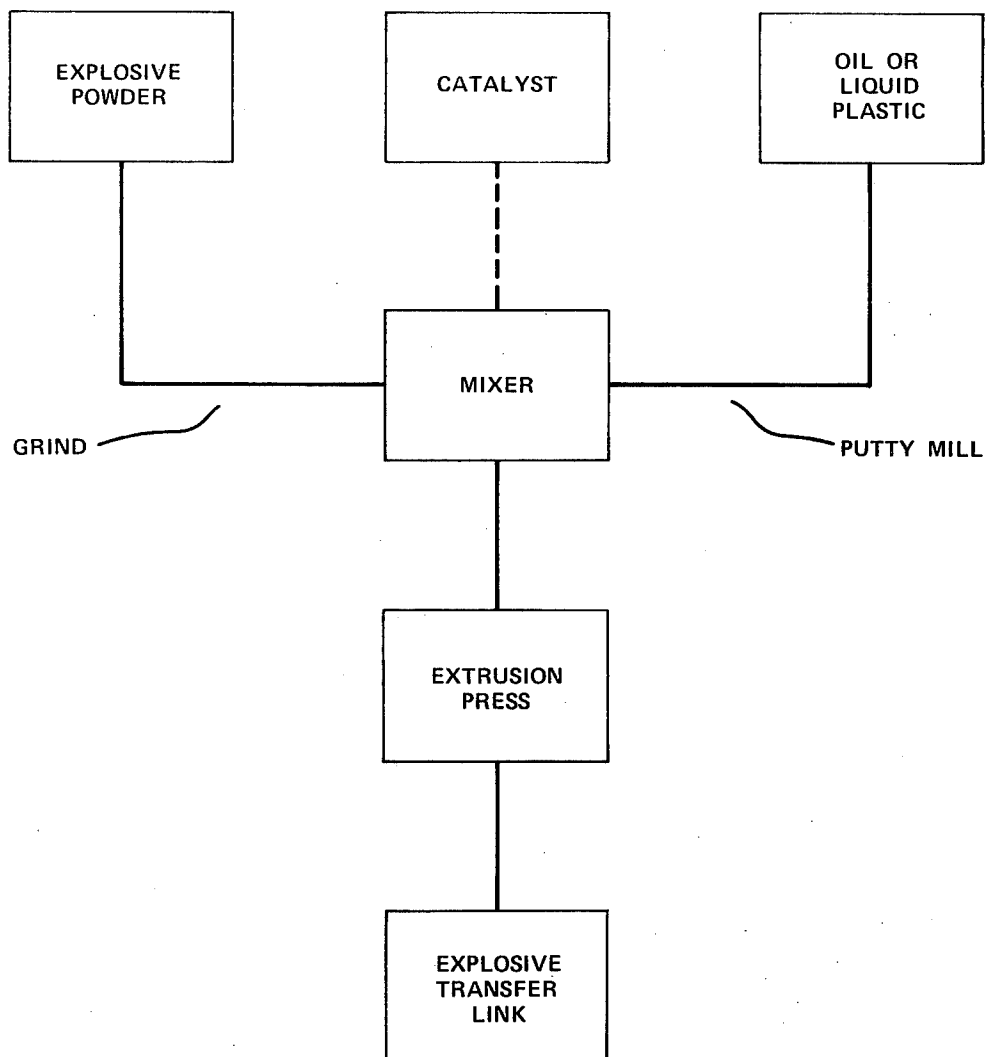


Fig. 1

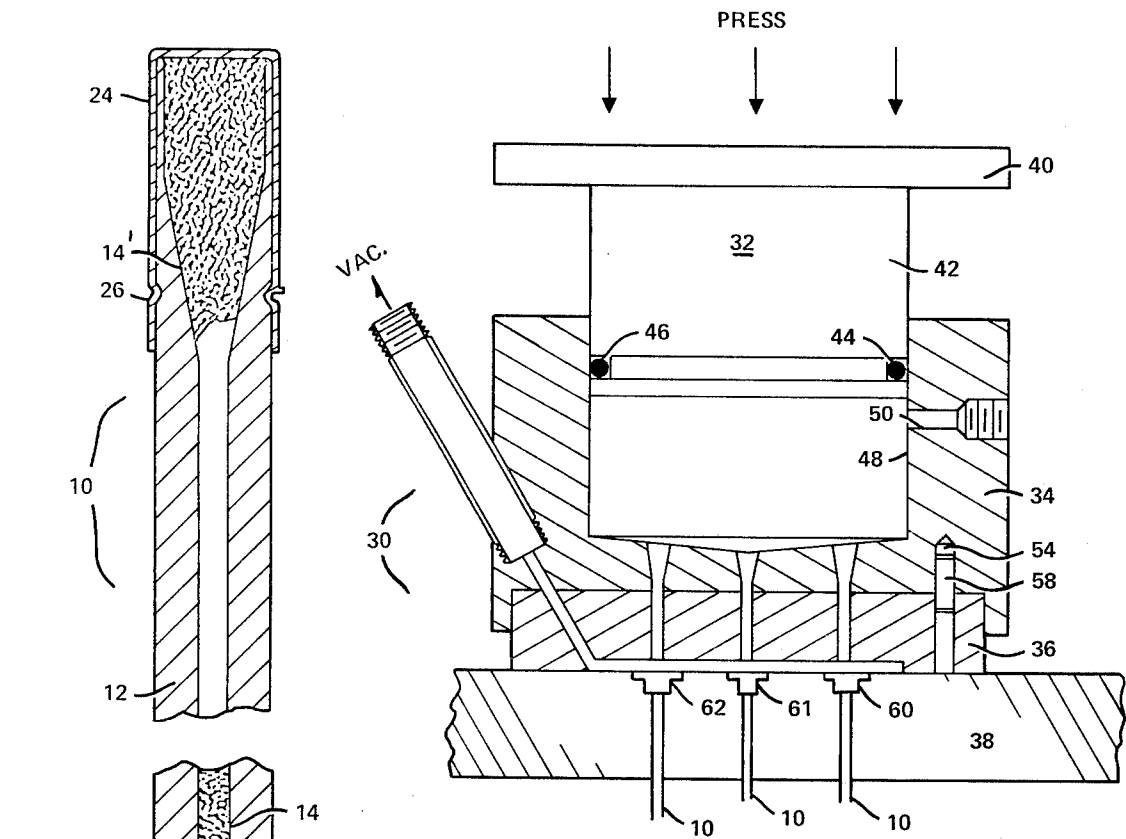


Fig. 3

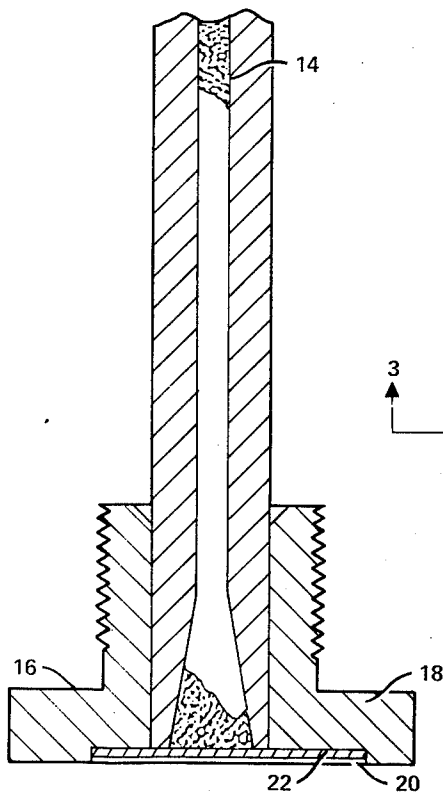


Fig. 2

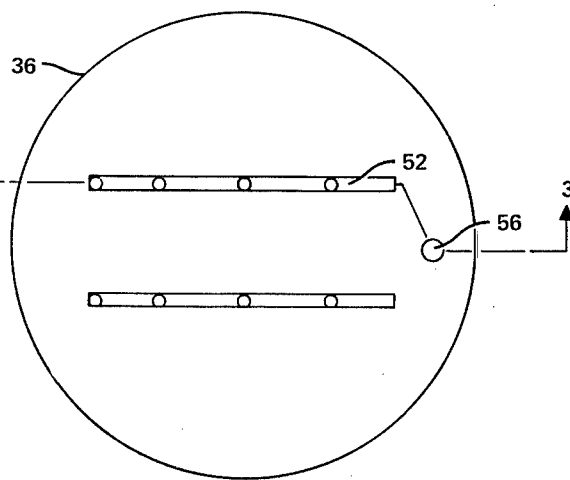


Fig. 4

METHOD FOR INJECTION MOLDING OF EXPLOSIVE AND PYROTECHNIC MATERIAL

CROSS REFERENCE TO RELATED APPLICATION

This application is a Continuation-in-Part of applicants' copending application Ser. No. 249,599, filed May 2, 1972, now abandoned.

BACKGROUND OF THE INVENTION

The invention relates to the manufacture of explosive and pyrotechnic articles wherein a small diameter column is filled with explosive or pyrotechnic material to provide for detonation or burning communication between two points. Such articles in the past have been manufactured by incrementally consolidating a powdered explosive into a tubular container or by filling a tube with the material and running the tube through successively smaller dies. Either of the abovementioned processes is either excessively time consuming or does not lend itself to automatic operation. The prior processes also suffer from a difficulty in providing a reliable interface when the internal diameter of the tube is increased.

According to this invention, injection molding techniques are used to force a homogenized mixture of very fine powder and a liquid elastomer or oil into the tube cavity. The material, when properly prepared, may be pushed, using relatively low pressure, into a small diameter cavity without losing the liquid wherein a uniform mass is formed. The material may contain a polymerizing agent or catalyst and the material "cured" in place if desired.

The method and apparatus according to this invention provides a means of manufacturing small diameter and long length detonation and pyrotechnic trains at a lower cost and with greater reliability than by other known methods. The method is particularly advantageous where irregularity of shape causes interface problems. The apparatus shown is sufficient to illustrate operability of the method but it will be understood that applicants' contemplate that the equipment may be greatly simplified and adapted to mass production techniques without departing from the invention.

BRIEF DESCRIPTION OF THE SEVERAL VIEWS OF THE DRAWINGS

FIG. 1 is a flow diagram illustrating the process of manufacture according to the invention;

FIG. 2 is a typical article of manufacture made according to the process of FIG. 1;

FIG. 3 is a cross sectional view of an assembled pressing die used in the manufacture according to FIG. 1; and

FIG. 4 is a top plan view of a portion of the assembly of FIG. 3.

DETAILED DESCRIPTION OF THE INVENTION

As shown in FIG. 1, in the process followed in manufacturing the explosive transfer links according to the invention, explosive or pyrotechnic materials in the form of very fine powders are mixed together with a liquid plastic (elastomer) or oil and, in some instances, with a catalyst placed, in an extrusion press and then extruded to form explosive transfer links. The term very fine powders may be taken here to mean solid powders in which the largest diameters of the largest

particles are in the range of from 2 to about 50 microns. The characteristics of the resultant mixed material, when properly "homogenized", includes the ability to be "pushed" using relatively low pressure into small diameter cavities without losing the liquid and yet forming a uniform mass in the cavity. In some applications the material may be cured in place. The method according to this invention involves lower cost and provides greater reliability in the manufacture of small diameter and long length pyrotechnic and explosive trains, especially where irregularity of shape causes interface problems.

The method according to this invention may be utilized by preparing special mixtures of solid explosives such as trinitrotrimethylenetriamine (also known as cyclonite and RDX), pentaerythritol tetranitrate (also known as PETN), lead azide, etc. with elastomers such as silicone rubber or oils such as poly trifluorochloroethylene (Kel F). If it is desired, solid metal fuels such as magnesium, zirconium, aluminum, boron, etc. and solid oxidizers such as barium chromate, potassium perchlorate, etc. may be mixed, along with solid explosive, with the elastomer or oil. The mixtures are special in that very fine (2 to 50 microns) solid explosive and, when used, solid fuel and solid oxidizer particles are utilized.

Very fine solid particles (2 to 50 microns) are prepared by comminuting (reducing to a fine powder by grinding, etc.) the solids (explosives such as RDX, PETN, etc.; metals such as magnesium, zirconium, boron, aluminum, etc.; and oxidizers such as barium chromate, potassium perchlorate, etc.) until all of the solid particles will pass through a 50 micron screen or the like. The time it takes to comminute the solid particles to 50 micron or less sizes may vary from a few seconds up to possibly several hours depending upon the properties of the original solids, i.e., resistance to comminution, original particle size, etc., or will not be necessary at all if the solids are originally made up of particles having largest diameters of from 2 to 50 microns.

After very fine solid particles have been provided, they are mixed with an elastomer such as silicone rubber or an oil such as polytrifluorochloroethylene with the mixture is placed on a roll mill until it becomes homogeneous. Naturally, if an elastomer is used it must be uncured and must remain substantially uncured during this mixing step. By homogeneous it is meant that the mixture resembles the uncured elastomer or oil in appearance and texture. An observer can easily tell when a mixture is homogenous by noting its appearance and texture. The time it takes a mixture to become homogeneous naturally, like comminution time, may vary considerably.

After it has been treated on a roll mill until it becomes homogeneous, a mixture, i.e., explosive and plastic; explosive and oil; explosive, metal, oxidizer and plastic; explosive, metal, oxidizer and oil; etc., has characteristics such that it can be injected, under low pressure, into small diameter cavities. Injection is discussed below.

Lead azide, mentioned above as an explosive suitable for use in this invention, is extremely sensitive and it would not be advisable to obtain very fine particles of lead azide by grinding large particles into smaller particles with a mortar and pestle. However, very fine (2 to 50 micron) particles of lead azide may be obtained by pre-

pairing colloidal lead azide. Colloidal lead azide is prepared by rapidly adding, with stirring, a solution of sodium azide to a solution of either lead acetate or lead nitrate. The colloidal lead azide which precipitates when sodium azide is rapidly added to either lead acetate or lead nitrate has particle sizes of less than 50 microns, can be separated by means of filtration from the solution and dries quickly and easily. It can be used *per se* (without grinding) in the practice of this invention.

It will also be apparent to those skilled in the art that it would not be advisable to reduce the particle size of HMX or RDX by grinding with a mortar and pestle. One way by which HMX and PDX powders can be reduced in size is by mixing either with water and rolling the mixture in a drum which is substantially filled with porcelain balls. The action of the rolling balls reduces the HMX or RDX, whichever the case may be, in size and the presence of water acts to prevent the explosive from detonating.

Very fine PETN particles can be prepared by dissolving PETN in a solvent such as acetone and then cooling the solution very rapidly by adding water or some other nonsolvent for PETN. Very rapid cooling causes crystals of PETN to come out of solution. Crystal size can be controlled by rate of quenching or cooling.

It will still further be apparent that very fine particles of metals or oxidizers are dangerous. However, as in the case of the explosives, there are well known techniques for obtaining very fine particles of such materials.

In summary, the method of this invention involves providing solid particles which have largest diameters which are in the 2 to 50 micron range, mixing the solid particles with an elastomer or oil until the mixture appears homogeneous and injecting the mixture into small, elongated tubes. The mixture may naturally comprise almost any combination of solids such as explosive alone, explosive plus fuel and oxidizer, etc. with elastomer or oil. If elastomer is used it must naturally be uncured. However, a curing agent may be added, during mixing, if it is desired to have the elastomer cure after injection. Since it requires some time, after addition of a curing agent, before an elastomer actually cures the addition of a curing agent during mixing presents no problem.

Particles having largest diameters of from 2 to 50 microns are preferred in this invention because of the size of the tubes into which the homogeneous mixtures are rejected. The tubes are extremely small in diameter and it is preferred that the largest diameters of the particles not exceed 1/10 the diameter of the tube into which the mixtures are injected.

THE ARTICLE

A typical article which is advantageously made by the disclosed method is shown at 10 in FIG. 2. The transfer link 10 and its use in explosive and pyrotechnic devices may be more fully understood by reference to co-pending application Ser. No. 68,585, filed Aug. 30, 1970.

The detonation transfer link or train 10 is formed from an elongated metal tube 12 having a uniform central cavity 14 on the order of about 0.040 inch but with material removed to provide tapered enlarged portions 14' at both ends. The initiating end of tube 12 is fastened into a threaded member 16 having a flange 18

which is recessed at 20 to receive an end cap 22. A cup-shaped end cap 24 is placed on the detonation end of the tube and crimped thereto as shown at 26.

A die and plunger arrangement for filling 6 tubes with the aid of a conventional press is shown in FIGS. 3 and 4. The die arrangement 30 consists mainly of a piston or plunger 32, a molding die 34, a vacuum plate 36 and a lower platen element 38.

Plunger 32 is formed with a flange portion 40 and a cylinder portion 42 and may be grooved as shown at 44 to receive an O-ring 46. Cylinder 42 fits very closely into chamber 48 in die 34. Die 34 has a port 50 which may be connected to a vacuum pump (not shown) for the purpose of evacuating chamber 48 as will be further discussed below.

The view of vacuum plate 36 in FIG. 3 is a section taken along line 3—3 in FIG. 4. The die 34 and vacuum plate 36 have a like number of holes (in this case 6) through which the explosive material will pass when the press is operated. The holes are arranged in two rows as shown and the vacuum plate 36 is relieved along the line of holes as shown at 52. In the embodiment shown each of the relieved portions 52 communicates with a port through the vacuum plate 36 and die 34 with a second vacuum pump (not shown). Die 34 and vacuum plate 36 are provided with respective aligning holes 54, 56 in which an aligning pin 58 is fitted to insure the proper alignment of the extrusion holes and exhaust port passages.

Bottom platen 38 is relieved, for example, at 60, 61, 62 to hold the flanged ends 18 of a plurality of detonation devices 10 to be filled.

OPERATION

In practice, the piston 42 is removed from die 34 and a quantity of material which has been previously homogenized and which is sufficient to fill the number of tubes accommodated in lower platen 38 is placed in the chamber 48. The piston 42 of plunger member 32 is placed in the chamber 48 and the chamber is evacuated as much as possible by pumping through port 50. Pressure is then applied to the top member 32 on flanged portion 40 and piston 42 is gradually forced against the material in chamber 48 as evacuation continues. As pressure resistance begins between the piston 42 and the material in chamber 48, suction is applied to the relieved portion in vacuum plate 36. As pressure builds up on plunger 32, explosive material will be forced through the holes in die 34 and vacuum plate 36 and, finally, into and filling the tubes 12 of the devices 10.

What is claimed is:

1. The method of manufacturing explosive transfer trains including the steps of:
 - a) comminuting an explosive material selected from the group consisting of RDX, PETN, and lead azide to form particles having largest diameters of 50 microns or less;
 - b) mixing said comminuted material with a fluid selected from the group consisting of an uncured silicone rubber, and an oily copolymer of trifluorochloroethylene; and
 - c) injecting the resulting mixture into elongated tubes by application of pressure.
2. The method of claim 1 wherein the fluid selected is a polymerizable silicone rubber and wherein a polymerizing agent is added before mixing.
3. The method of claim 1 including curing of said explosive after injection.
4. The method of claim 3 including the step of curing said explosive mixture after injection.

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