Aug. 8, 1961 B. K. DAUBENSPECK 2,995,090

GALLERY BULLET

Filed July 2, 1954 2 Sheets-Sheet 1

1. COAT IRON POWDER

   (a) DISSOLVE PLASTIC IN SOLVENT

   (b) MIX PLASTIC SOLUTION WITH METAL POWDER TO GET FULLY LIQUID MIX

   (c) WITH HEAT, CONTINUE MIXING UNTIL SOLVENT EVAPORATES AND POWDER IS REFORMED

2. COLD MOLD

   TABLETTING MACHINE or EQUIVALENT

   30 to 45 TONS PER SQUARE INCH

3. BAKE

   RAISE FROM ROOM TEMP. TO 200° F. AT APPROX. 9° F. PER MINUTE.
   RAISE FROM 200° F. TO 300° F. AT 3° F. PER MUNUTE ± 0.5° F. PER MINUTE.
   MAY BE HELD AT 300° F. UP TO ONE HOUR.
   COOL TO ROOM TEMP.

4. TUMBLE

Fig.1

BENJAMIN K. DAUBENSPECK
INVENTOR

BY [signature]
John H. Lewis Jr.
ATTORNEYS

Aug. 8, 1961 B. K. DAUBENSPECK 2,995,090

GALLERY BULLET

Filed July 2, 1954 2 Sheets-Sheet 2

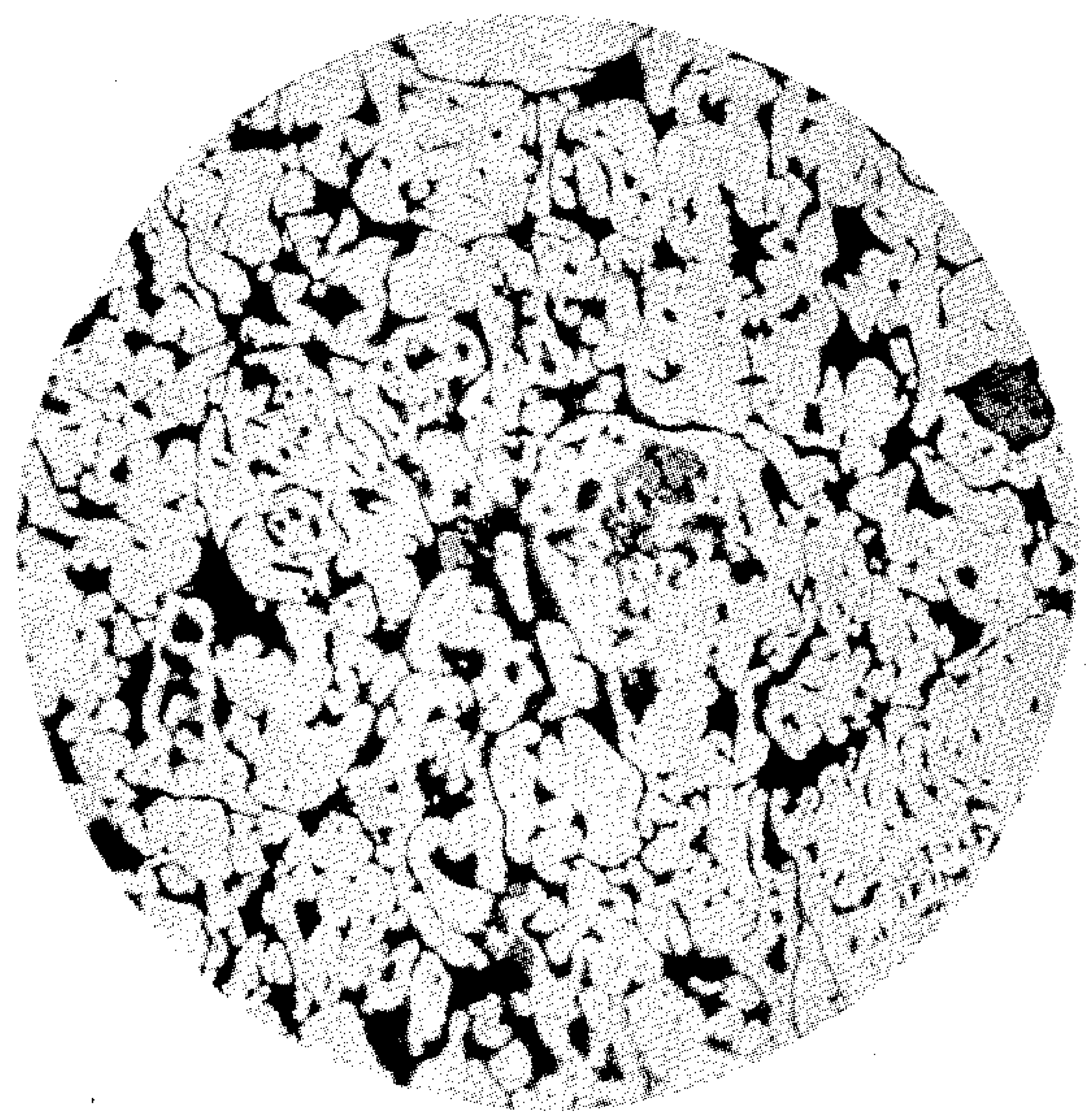

Fig. 2

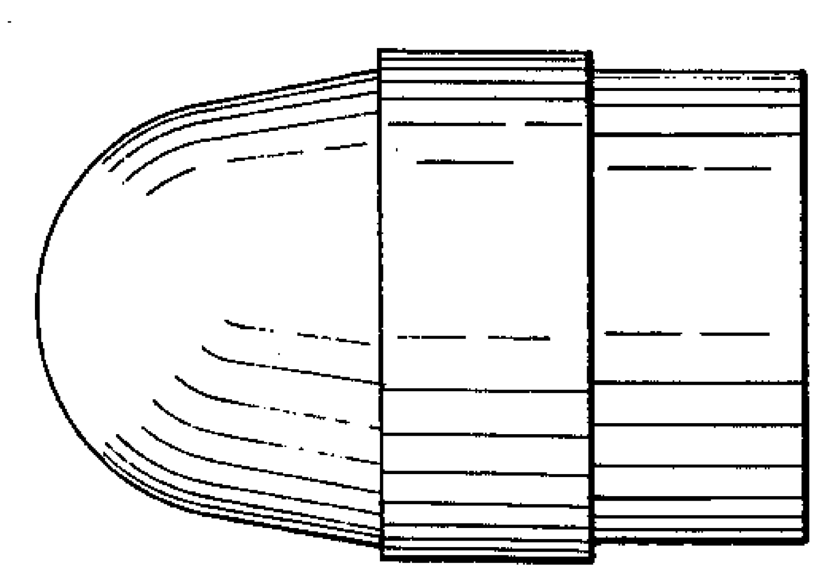

Fig. 3

BENJAMIN K. DAUBENSPECK
INVENTOR.

BY [signature]
John H. Lewis Jr.
ATTORNEYS

United States Patent Office

2,995,090
Patented Aug. 8, 1961

1

2,995,090

GALLERY BULLET

Benjamin K. Daubenspeck, Stratford, Conn., assignor to Remington Arms Company, Inc., Bridgeport, Conn., a corporation of Delaware

Filed July 2, 1954, Ser. No. 441,047
11 Claims. (Cl. 102—91)

This invention relates to a new bullet for use in shooting galleries and the like, and to the process of fabricating such a bullet.

This application is a continuation-in-part of the prior copending application, Serial No. 119,030, filed October 1, 1949, and now abandoned.

The lead gallery bullets of the prior art are best exemplified by Patent No. 2,168,381 to Woodford; No. 2,315,853 to Hodgson; No. 2,105,528 to Foisy; and No. 2,076,868 to Smith. All of these bullets are characterized by the use of powders or fragments of lead consolidated into a bullet having sufficient strength for use and intended to be disrupted into small fragments on impact with a resistant target or gallery backstop. Although such bullets are a great improvement over solid lead bullets, they break up erratically and occasionally lead fragments large enough to cause injuries to eyes and other delicate organs are returned to the shooter's position. Most large galleries are faced with personal injury claims at sufficient frequency to keep their public liability insurance rates inconveniently high. In addition, all of these bullets, upon disintegration, release quantities of lead dust into the atmosphere and require exhaust systems of more than usual effectiveness to prevent exposing the gallery operator and his employees to a lead poisoning hazard. This same hazard exists in the manufacturer's plant where loading operations with lead bullets of the type shown in the cited patents usually increase the lead dust content of the air to or above safe limits.

Accordingly, the primary object of this invention is to reduce the hazards involved in the use and manufacture of gallery rifle ammunition. In arriving at this primary object, attention may be directed at two important incidental objectives which are the elimination of back spatter to the shooting position and the elimination of lead with its poisoning tendencies. Other objects are the improvement of the accuracy characteristics of the loaded ammunition and greater economy in manufacture.

It is contemplated that these objects can be best accomplished by fabricating the bullet from a powdered metal other than lead, iron having been found most satisfactory, molded into a homogeneous body with the aid of a thermoplastic binder. It appears to be desirable to use an iron powder composed principally of particles of rough irregular shape as distinguished from smooth surfaced particles of fairly regular shape. Swedish iron powder of 100 mesh nominal size has been found to be highly satisfactory. The usable thermoplastics appear to be those which are quite ductile, having elongation greater than 150% measured at room temperature. For processing reasons, the choice of a thermoplastic material is desirably limited to those which are readily soluble in an economical solvent of fairly low boiling point, and which maintain their high elongation values at temperatures encountered in processing and in service.

The most convenient and economical processing can be briefly described as comprising the steps of thoroughly coating the individual particles of the iron powder with the binder; cold molding the coated powder; and baking the cold molded bullet.

The exact nature of the invention as well as other objects and advantages thereof will be more apparent after consideration of the following specification referring to the drawings, in which:

2

FIG. 1 is a flow sheet, outlining the various steps in processing the bullet.

FIG. 2 is a micro-photograph at an enlargement of 300 diameters, showing a section of a finished bullet.

FIG. 3 is a side elevational view of a bullet of the type produced by the process.

PROCESS

1. *Coating*

In practising the preferred process, it is essential that each particle of the metal powder filler be completely surface coated with the thermoplastic binder. This is best accomplished by dissolving the thermoplastic binder in a suitable volatile solvent and applying it to the powder. In a specific example of our preferred process, polyethylene powder in proportion of 3.5% of the combined weight of the polyethylene and the iron powder is admixed with tri-chlorethylene, or with benzene, sometimes commercially known as benzol. This solution will be facilitated by the use of a steam jacketed kettle and a mechanical mixer of the type of the widely used Hobart Mixer such as shown in Patent No. 1,747,443, and others. Sufficient solvent and sufficient heat should be used to get a highly fluid solution. The indicated amount of 100 mesh Swedish sponge iron may then be added and the mixing continued. The transfer of heat to the iron powder usually results in jelling the solution and more heat should be applied until the mixture again becomes completely fluid. Mixing is continued until the heat has caused the solvent to evaporate and the iron powder apparently has returned to its original finely divided powdered condition. Careful examination reveals that each particle has been coated with the plastic binder, although not apparently different in particle size or apparent density from the original iron powder. In the mass, the coated powder is free-flowing at all ordinary temperatures. In the interest of economy, equipment should be provided to condense and recover the solvent evaporated from the mix.

As has been indicated, the minimum amount of the solvent is dictated by the necessity for securing complete fluidity and a complete coating of the particles. The higher limit is that set by economical considerations both in solvent consumption and evaporating time. Other suitable solvents for polyethylene are toluene or naphtha. For other thermoplastic binders the choice of the solvent will be dictated by the known characteristic of the binder and the requirement of securing a completely fluid solution from which the solvent may be readily evaporated. Suitable solvents are shown for other thermoplastic binders in a table appearing hereinafter.

The content of the thermoplastic binder should be kept low for two reasons. One of these reasons is the fact that the plastic has a lower specific gravity than the metal powder. For ballistic reasons, the specific gravity of the finished bullet should be kept as high as possible, which demands a maximum metal content. The plastic content should also be kept as low as possible, consistent with adequate bonding, because higher plastic contents and particularly any free plastic tend to cause swelling and distortion of the bullets in subsequent heat treatment. Below about 2½ weight percent of Type 6 nylon or polyethylene binder, the resulting bullet lacks strength. Much above 4 weight percent, it tends to swell in baking, about 4½ of Type 6 nylon or polyethylene being about a maximum, and 3½ appears to be optimum.

Actually, volume percentage is a better criterion of optimum proportions for such bullets, as it is the volume of free plastic between the grains of metallic powder which tends to cause trouble at either limit. With polyethylene or Type 6 nylon, the weight percent limits of 2½% and 4½% correspond respectively to volume percent limits of 17% and 27½%. With other thermoplastic binders, the same volume percent limits apply and corresponding weight percent limits can be calculated from the specific gravity of the particular thermoplastic binder. In all the specific examples tabulated hereinafter, the proportions were established at 3½% by weight which in every case falls within the limits of 17 to 27½% by volume.

In a specific example of production operation, a steam jacketed 50 gallon kettle with counter-rotating agitators and a reflux condenser is utilized as the mixing means. With the jacket of this kettle heated by steam at 25 to 30 pounds pressure, the kettle is charged with 16 gallons of tri-chlorethylene, the agitators started, and 16 pounds of polyethylene added. The kettle is then closed and mixing continued to dissolve the polyethylene, the condensed vapors of tri-chlorethylene being returned to the kettle by the reflux condenser. After 15 minutes of mixing, the kettle manhole is opened and 440 pounds of powdered iron is charged. The manhole cover is closed again and after about 10 to 15 minutes, tri-chlorethylene will start to distill off. Mixing is continued, with return of condensed solvent for 30 minutes to insure that all particles of the iron powder are uniformly coated.

The condensed solvent is thereafter diverted to a solvent receiver and as flow of distilled solvent through a sight glass slows appreciably, a vacuum is applied to accelerate distillation. When the recovery of solvent is nearly complete, as shown by an appropriate gage glass on the solvent receiver, the steam is turned off in the kettle jacket and the degree of vacuum is increased to complete drawing off solvent vapors.

Mixing is continued until the jacket temperature drops to 185° F., the kettle opened, and contents discharged as a fluent coated powder through the kettle draw-off valve.

For convenience, the coated powder is screened through a 40 mesh vibratory screen to remove any lumps which may have formed and the oversize particles returned to the kettle for rework with subsequent batches. The coated powder is stored in dry moisture resistant containers but care should be taken not to hold coated powder in storage for more than 120 hours.

2. *Molding*

The coated molding powder may now be molded under high pressure in suitably shaped dies to the desired size and contour. Suitable pressures in the preferred range are 30 to 45 tons per square inch and the resulting compact is a rigid body having considerable mechanical strength. With lesser pressures, the density is lower, which is undesirable for ballistic reasons, and the mechanical strength may be somewhat lower. An upper limit to molding pressure is set by tool life. For example, at 60 tons per square inch, tool life is decreased to a materially greater extent than bullet quality is improved.

The most satisfactory equipment for molding has been found to be a rotary tabletting machine of the type much used in the pharmaceutical field. A suitable machine of this type provides a rotary table provided at spaced intervals with suitably shaped die pockets, each of which is provided with a heel forming and ejecting punch operated from beneath the table and a nose forming punch operated from above the dial. An illustrative machine has 15 die cavities in the table and when operated at 23 r.p.m., will produce 345 compacts per minute. Machines of greater capacity and similar construction are readily available in commerce, highly suitable machines being manufactured by the F. J. Stokes Machine Company of Philadelphia, Pennsylvania, and shown, for example, in Patent No. 2,043,085, and others. Production machines of this type are capable of molding 1250 bullets per minute when operating and two machines of this type can be expected to produce about a half million bullets per shift.

Machines of this type provide for retracting the top punch to clear the upper opening to the die cavity for a substantial portion of the rotation of the table. During part of this rotation, the open die pockets are moved through a zone in which the molding powder is only laterally confined on the face of the table and tends to flow into the die cavity. During the initial portion of this cycle, the bottom punch is retracted to its lower limit, giving maximum capacity to the die pocket. As the table rotates, the bottom punch raises slightly to compact the mix and take up any voids, and a wiper clears the top of the table, leaving a precisely measured charge in the pocket. The top punch then descends into the cavity while the lower punch ascends, further compressing the powder between them into the desired form determined by the end shape of the punches and the dimensions of the die cavity. At the end of the cycle, the upper punch is retracted completely and the lower punch ascends to eject the finished compact which may be delivered into suitable conveying equipment for further continuous processing or into tote boxes for batch processing. The green compact has adequate strength to withstand any normal amount of handling in either manner.

3. *Baking*

To complete the bonding of the cold molded bullet, it is necessary to bake at a temperature approximately 100° F. above the softening point of the particular plastic used as a binder. It is not necessary to hold at this temperature for any particular length of time provided that the rate of temperature rise and the method of applying the heat are such that an equilibrium temperature is reached throughout a bullet or a mass of bullets. In some instances it has been found that a rapid rate of heating or close packing of bullets in a deep mass will initiate a low level exothermic reaction having sufficient heat output to cause the temperature to rise excessively and even burn bullets, although the application of heat by the oven may have been stopped completely, and it is therefore desirable to control the method of packing and baking the bullets.

In the laboratory, sample batches have been baked in 4" x 4" cardboard boxes containing a layer of bullets one inch thick. These boxes have been placed in an oven preheated to 350° F. and held there for two hours to insure reaching an equilibrium temperature, after which they are removed and, still in the boxes, permitted to cool to room temperature. The time and temperature for all binders tested and found to yield good bullets is noted in the table appearing hereafter.

In large scale production, several methods have been employed, but the preferred technique is to spread the molded bullets in a layer of about 1½" depth on a mesh belt which is moved into a furnace at room temperature and there subjected to a down draft of recirculated heated air. Temperature of the heated air is controlled so that until the temperature reaches 200° F., the rate of temperature increase is about 9 degrees F. per minute. This rate of rise is not critical at this stage as the exothermic reaction referred to above has not been noted unless the rate of heating is fast, or the rate of heat dissipation slow, at temperatures above 220° F. To maintain equilibrium temperatures throughout the mass of bullets, the down draft of heated air passes through the mass at a speed of 300 feet per minute or higher, actually 450 feet per minute in an exemplary installation. In the temperature range from 200° F. to 300° F., the rate of temperature rise must be controlled more closely and temperature increase at a rate of 3° F. per minute ±0.5° F. per minute has proven satisfactory in production operations. Once the indicated maximum temperature has been reached, there is no necessity to retain the bullets at that temperature as the high rate of circulation of heated air assures that equilibrium temperatures will be maintained throughout a reasonable thickness of bullets on the mesh belt. No harm, however, will come from holding bullets at that temperature for periods up to one hour except for the unnecessary waste of power for heating and circulating the air. For maximum efficiency in production, the heat is turned off on reaching 300° F. and air at room temperature is circulated through the oven and discharged outside the building to rapidly cool the mass of bullets and the furnace to permit the loading of subsequent batches. The temperatures referred to in this example are those used with polyethylene and other binders having similar softening temperature.

In an exemplary installation, the heating oven is built around an eight foot section of wire mesh belt two feet wide. This belt is a continuous belt arranged with an eight foot loading section outside the furnace to permit loading of one batch while a second batch is being baked, and at the completion of a baking cycle the belt is driven to discharge the baked load and transfer that just loaded into the oven zone. 500 pounds of bullets (about 232,750 bullets) may be loaded at a depth of 1½″ on the belt. With the 65 minute average cycle time capacity is about 3,500 pounds or 1,630,000 bullets per eight-hour shift. For additional peak capacity, the belt may be loaded to 2″ depth with a resulting ⅓ increase in an output, although at some sacrifice in life of the wire mesh belt.

Care should be taken to avoid exposing the bullets during baking to any substantially degree of moisture, for the iron powder appears to be particularly susceptible to rusting under these conditions. Although production operations have never demanded it, the application of controlled atmospheres is contemplated if rusting of the iron content due to particular humidity conditions, or air oxidation of some particular plastic binder, becomes a serious problem.

4. *Tumble*

To facilitate handling in conventional loading equipment such as shaker plates and transfer plates, the otherwise finished bullets may be self-polished by tumbling in suitable tumbling barrels for a short time. Otherwise, the iron-plastic bullet seems to tend to occasionally stick in the transfer plate and does not always orient itself in the shaker plates with the desired facility. In the interval between tumbling and loading, it is usually desirable to protect the bullets from atmospheric moisture by the use of closed containers. As an additional protection, such containers may be lined with paper or other material impregnated with a suitable rust inhibitor. The vapour phase inhibitor which is a product of the Shell Development Corporation is suitable.

LOADING

Bullets prepared as described above may be loaded into finished cartridges by any standard production loading equipment with no changes from the procedure employed with lead bullets other than those noted below.

The powder charge should preferably be adjusted to produce a higher velocity and a momentum at usual gallery ranges comparable with the prior art lead gallery bullets. Since the new bullet weighs only about 16 grains, this usually requires a muzzle velocity in the range of 1500 to 1600 feet per second.

In crimping the cartridge case to the new bullet, care should be taken to avoid the use of techniques which tend to score or notch the surface of the bullet. With the lead bullet the crimping operation usually involves rolling the loaded cartridge between a rotating wheel and the arcuate blade of a crimping knife which engages the mouth of the cartridge case at an angle of about 55° to the cartridge axis and turns in the mouth of the case. A lead knife is also sometimes employed to turn up a burr on the bullet and the loaded cartridge then rolled against a sizing block to iron the burr down over the mouth of the case and to insure that the case has not bulged to an extent which would interfere with chambering.

The iron plastic bullet may be successfully crimped in this equipment, providing its heel diameter is slightly less than that of a lead bullet and a crimping knife working on an angle of 30° to 35° to the axis of the cartridge is employed. The lead knife should not be used and with the reduced heel diameter and flatter crimp there is no material tendency to case bulging. The sizing block may therefore also be dispensed with. It is, however, desirable to use brass cartridge cases which are somewhat harder than are ordinarily used for standard velocity .22 Short cartridges. For example, the .22 Short Standard velocity cartridge is relief annealed at 525° F. For the high velocity Short cartridge, the case is relief annealed at 475° F. and is hence harder and stronger. The high velocity cartridge case has proven to be satisfactory for this application and effectively resists any tendency to bulging at the crimping operation or to head bulges on firing. Any operation which tends to notch the iron plastic bullet weakens it sufficiently to cause occasional fractures in the notched region and the crimping operation should therefore be carefully controlled.

Lubrication of the finished ammunition is necessary and desirable both from the standpoint of protecting the bullet against rusting when stored under adverse conditions and the gun barrel against abrasive wear under the severe conditions of conventional commercial gallery use. Experimentally, such bullets have been copper plated, lacquered, and then lubricated with the usual wax lubricants, and so treated, can be stored under almost any conditions without noticeable deterioration. Commercially, only the conventional wax lubrication with mixtures such as those disclosed in the patent to Schilling and Curran, No. 2,298,844, appears to be justifiable. Particularly, when such lubricants are extended over the mouth of the cartridge case they afford substantially complete protection against bullet rusting and they have long since been proven to be highly effective in reducing barrel wear. If desired, the loaded cartridges may be further protected by impregnating some part of the packaging with rust inhibitors such as the vapour phase inhibitor previously mentioned herein.

MATERIAL REQUIREMENTS

From a performance standpoint, powders of most of the metals which do not tend to be poisonous in dusty form should be satisfactory. For ballistic reasons it is desirable to avoid the light metals. Iron powder, however, and particularly Swedish sponge iron powder, is highly satisfactory both from the standpoint of its low cost and good performance in service. Of the iron powders which have been investigated, all appear to function satisfactorily, with the exception that those of smooth regular particle form, either as small spheres, or wire-like bodies, etc., are somewhat lower in strength. A rough irregularly surfaced particle which may afford some mechanical keying between the compressed particles appears to be desirable and these characteristics are found to a high degree in the preferred Swedish iron powder.

As noted before, iron powders show some tendency to rust and, if desired, a small amount of zinc powder may be incorporated with the iron powder with some improvement in rust-resisting properties of the finished bullets. Presumably, this improvement is due to electro-galvanic action and up to 5% zinc powder has been added with a reasonable improvement in rusting characteristics.

Of the available thermoplastic binders, polyethylene appears to be the most economical and generally satisfactory binder which can be cited as an example. Another excellent binder is nylon, examples of specific nylons being Type 6 nylon, identified as a co-polymer of the reaction product of adipic acid and hexamethylene diamine, the reaction product of sebacic acid and hexamethylene diamine, and E-amino caproic acid, and Type 8 A–1 nylon, identified as the reaction product of polyhexamethylene-adipamide, formaldehyde, and methanol in the presence of an acid catalyst in such a fashion as to introduce methoxy methyl groups in place of hydrogen on some of the amide nitrogen of the polyhexamethylene-adipamide. The essential properties of the binder with examples appear hereinafter.

In general, the basic requirements for a satisfactory binder appear to be thermoplasticity and the ability to be greatly elongated without fracture. If a plasticizer is used, it should be a plasticizer of great stability or one which will not appreciably decompose or volatilize when exposed for short period to the temperatures employed in baking and lubricating bullets or when exposed for long periods of time to storage in hot warehouses.

In order to process economically, a satisfactory binder should form a highly fluid solution with some convenient, inexpensive or recoverable solvent of fairly low boiling point.

In an extensive investigation of the suitability of thermoplastic binders, it has been determined that the percentage of elongation at room temperature, as measured by ASTM Standard Test D–368–49T, correlates most closely with performance of finished bullets. No thermoplastic binder material having a high percentage of elongation has been noted which does not produce good bullets in the practice of the preferred process. Conversely, no thermoplastic binder having a low percentage of elongation has been found to produce a good bullet, even though some of the low elongation materials tested exhibit high tensile strength and high impact strength. In general, a percentage of elongation in excess of 200 is desirable from a production standpoint. However, bullets have been produced without difficulty from materials having a percentage of elongation of about 150.

For the purpose of testing finished bullets, both baked and as a green compact, a special impact test machine has been constructed. In this machine a bullet is clamped by the heel portion and the protruding nose and bearing band section are struck by a pendulum which is tripped to swing from a fixed height. If the bullet breaks, the pendulum swings on beyond the bullet position and the height to which it rises is in inverse ratio to the energy absorbed in breaking the bullet. In the arbitrary scale applied to such a machine, zero is applied to the height to which the pendulum will rise after falling in the absence of a test bullet and ten is applied to the position of the test bullet, between these points the scale is divided equiangularly. Thus, a bullet which does break but, in doing so, absorbs all the energy in the pendulum, is rated as having a strength of ten. Similarly, a bullet which breaks without absorbing much energy from the pendulum, would be rated as having a strength of one or less. Bullets which could not be broken with this machine were rated as 10 plus, although it should be noted that all bullets tested in service tests pulverize on impact with hard targets in the manner desired. Bullets rated as having a baked strength of 3.0 or greater by this test have proven to have adequate strength to resist bullet break-up in factory handling operations, in loading and firing in conventional firearms, and in flight to a target.

The energy which is absorbed in breaking the bullets at each scale division of this tester is shown in the following table.

Scale reading:	Energy absorbed—inch pounds
0	0
1	.27
2	.55
3	.84
4	1.10
5	1.35
6	1.57
7	1.75
8	1.89
9	1.98
10	2.00

In the table following, suitable binders are listed with their physical properties, with certain data pertaining to their processing and with the results of bullet tests. In explanation, it may be stated that Percentage Elongation reported is as determined by ASTM D–638–49T. Izod Impact Strength is as determined by ASTM D–256–47T and Flow Temperature is as determined by ASTM D–569–48. Flow Temperature is of significance in determining baking temperature, it being desirable in baking the bullet to insure that all portions thereof have the binder brought to such a condition of fluidity that the binder coating adjacent particles of metal powder flows together in a firm bond, assuring adequate impact strength in the baked bullet. It has been found that an appropriate baking temperature should exceed the flow temperature by some small amount. For production control, a baking temperature about 100° F. above flow temperature is preferable, and baking time or baking conditions should be such as to insure that an equilibrium temperature is reached throughout each individual bullet. Bullet green strength and bullet baked strength are as determined by the special test referred to above.

TABULATION OF PROPERTIES OF BINDERS FOR IRON-PLASTIC BULLETS

Material	Percent Elong.	Izod Impact	° F. Flow Temp.	Baking Temp., degrees	Baking Time, hrs.	Solvent	Bullet Green Strength	Bullet Baked Strength	Bullet Break-Up On Firing
Polyethylene	600	16+	223	350	2	Tri-Chlor-Ethylene	.88	4.8	None.
Nylon 6 (A co-polymer of the reaction product of adipic acid and hexamethylene diamine, the reaction product of sebacic acid and hexamethylene diamine, and E-amino caproic acid.)	300	1.8	276	450	1	Ethyl Alcohol	2.1	10+	Do.
Nylon 8 A-1 (The reaction product of polyhexamethylene-adipamide, formaldehyde and methanol in the presence of an acid catalyst in such a fashion as to introduce methoxy methyl groups in place of hydrogen on some of the amide nitrogen of the polyhexamethylene-adipamide.)	6-800	16+	300	450	2	do	.96	10+	Do.
Polyvinyl acetate 71% plasticized with 29% of Arochlor 1254 (chlorinated biphenyl).	3-400	.75	212	350	2	Benzene	1.99	8.35	Do.
S-Polymer-Resin (A product of low temperature copolymerization of 60% styrene and 40% isobutylene.)	2-300	.3	120	350	2	do	1.65	7.45	Do.
Ethylene-Vinyl Acetate Co-polymer in 3-1 mol ratio.	600+	16+	200	350	2	do	1.57	6.61	Do.
Vinylite VYNW 60% plasticized with 40% di-octyl phthalate. (Vinylite VYNW is Vinyl chloride-vinyl acetate co-polymer.)	150	16+	250	350	½	Methyl Ethyl Ketone	1.81	4.3	Do.

It thus appears that the requisites of a suitable binder and bullet are an elongation not less than about 150 and a bullet baked strength not less than 3.0. The binders which have been found to meet these requirements are found in the class of organic thermoplastic resins, which are soluble in a volatile solvent. Some such thermoplastic materials (e.g., vinylites) tend to decompose at temperatures above their softening point, and such decomposition may be catalyzed by the iron powder. Such substances may require the use of stabilizer. For example, vinylite VYNW with 40% of di-octyl phthalate as a plasticizer decomposes somewhat during baking, and the hydrogen chloride evolved in decomposition produces severe rusting of the iron powder. The incorporation of 5% of white lead as a stabilizer reduces decomposition to a degree permitting the production of acceptable bullets.

In common with most molding problems, some dimensional changes are encountered through the process. In a typical case, the cold molded compact will expand or spring back slightly on release from the dies and in most cases the bullet will undergo further slight expansion in baking, although in some cases a slight contraction accompanies baking. In all cases, however, a test molding and baking under the desired conditions will establish the expansion or contraction ratio which will permit manufacturing production dies to form bullets of the desired finished dimensions. Once the expansion ratio has been established for a particular thermoplastic binder and set of processing conditions, no difficulty is experienced in satisfactorily controlling product dimensions.

SUMMARY

The bullet may have a thermoplastic binder content between about 2.5% and about 4%, but we prefer to operate within a range of 3.25% to 3.75%.

As shown in FIG. 2, the finished bullet is a solid body comprising many small grains or flakes of iron powder, each enclosed by and bonded to its neighbors by a thin film of the plastic binder. In that figure the white sections are the granules of iron powder, while the black sections and the black filaments separating adjacent grains are the plastic binder. In this micro-photograph there are shown several relatively large grains of iron powder, the largest of which has an actual major dimension of approximately .005 inch. Some of these larger granules are porous and, to the extent that the porosities are open to the surface of the granule, these holes are also filled with the plastic binder accounting for the black islands within these larger grains. The gray areas in the micro-photograph appear to be impurities, perhaps manganese sulfide, in the iron powder.

This new bullet contains no poisonous ingredients and may be manufactured, loaded, and used with no hazard of toxicity. Although the bullet has adequate strength to resist breakup in handling and shooting in autoloading weapons, and will penetrate wood and other relatively soft material, as well as a lead bullet, it is completely reduced to fine powder on impact with a metal or other resistant surface. The particles produced are so small and their energy so completely absorbed in pulverizing that back spatter cannot be detected on tissue paper suspended within one to two feet of a metal target. With a lead bullet of the type discussed in the patents noted, such a test would result in shredding the paper and many of the fragments would be of appreciable size and possess considerable kinetic energy.

The resulting bullet weighs about 15 to 16 grains by comparison with 28 grains for a lead bullet and may be loaded to higher velocities such as 1600 f.p.s., with resulting greater accuracy, flatter trajectory, and a clean sharp report which appeals to the shooter. The harder cartridge case previously referred to is desirable in that it resists any tendency to bulge at the head due to the

pressures used to achieve these higher velocities. At the higher velocities, the new bullet has sufficient momentum to knock down any of the usual type of mechanical gallery targets and the reaction upon the gun mechanism is great enough to function any of the conventional autoloading rifles designed for the short cartridge. The new bullet produces a shower of brilliant sparks on impact with metal targets, and in this way, also appeals to the shooter in assisting him in spotting his shots.

Although the new bulletin and the process of manufacturing it have been quite specifically described herein, it is not intended that the invention be considered limited to the specific examples. Reference to the following claims will show the limitations upon the scope of the invention.

I claim:

1. A bullet for gallery shooting adapted to completely disintegrate on impact with a hard target, said bullet consisting essentially of a coherent but disintegrable compact of a multiplicity of discrete particles of a metallic powder, each particle of said powder being substantially completely coated with a binder material which also substantially completely fills the interstices between said metallic powder particles, said binder material being selected from those organic thermoplastic resins which are soluble in volatile solvents and have an elongation of not less than about 150% at room temperature; said bullet comprising between 17% and 27½% by volume of said binder material, balance substantially all metallic powder.

2. A bullet according to claim 1, in which said metallic powder is iron.

3. A bullet according to claim 2, in which said thermoplastic resin is polyethlyene.

4. A bullet according to claim 2, in which said thermoplastic resin is nylon.

5. A bullet according to claim 2, in which said thermoplastic resin is plasticized polyvinyl acetate.

6. A bullet according to claim 2, in which said thermoplastic resin is the product of low temperature co-polymerization of isobutylene and styrene.

7. A bullet according to claim 2, in which said thermoplastic resin is a co-polymer of ethylene and vinyl acetate.

8. A bullet according to claim 2, in which said thermoplastic resin is plasticized vinyl chloride-vinyl acetate co-polymer.

9. A bullet according to claim 1, in which said metallic powder comprises about 5% zinc by weight, balance substantially all iron.

10. A bullet for gallery shooting, adapted to completely disintegrate on impact with a hard target, said bullet consisting essentially of a coherent but disintegrable compact of a multiplicity of discrete particles of a metallic powder, each particle of said powder being substantially completely coated with a binder material which also substantially completely fills the interstices between said metallic powder particles, said binder material being selected from those organic thermoplastic resins which are soluble in volatile solvents and have an elongation of not less than about 150% at room temperature; said bullet comprising between 17% and 27½% by volume of said binder material, balance substantially all metallic powder; said metallic powder being iron, substantially all of which will pass a 100-mesh screen.

11. A bullet according to claim 10, in which said metallic powder is Swedish sponge iron.

References Cited in the file of this patent

UNITED STATES PATENTS

2,292,047	Calhoun	Aug. 4, 1942
2,409,307	Patch et al.	Oct. 15, 1946
2,593,637	Weldin	Apr. 22, 1952
2,593,943	Wainer	Apr. 22, 1952