United States Patent Office
3,204,320
Patented Sept. 7, 1965

1

2

3,204,320

BALL AND SHOT MANUFACTURE BY IMPACTING PROCESS

George R. Eckstein, Fairfield, and Donald S. Foote, Greens Farms, Conn., assignors to Remington Arms Company, Inc., Bridgeport, Conn., a corporation of Delaware

Filed Aug. 29, 1962, Ser. No. 220,222
12 Claims. (Cl. 29—1.22)

This invention relates in general to an economical method and apparatus for mechanically producing small, substantially spherical balls from non-spherical metal blanks.

In general, there are two classes of methods by which shot or small metal balls are mainly produced today: (1) thermal and (2) mechanical.

In the thermal methods of producing shot, various operations are performed with the metal while the metal is in the molten stage. The most common method and one which is still in widespread use after approximately 180 years is the "dropping" process. This process consists of dropping molten lead down a very long shot tower where the falling molten lead is broken up into particles and received in a pool of water at the bottom to solidify the shot.

Although the cost of manufacturing lead shot by this process is low, the process is not adaptable for producing shot of different metals, e.g., iron, aluminum, etc. Iron, for example, has a high melting point and other properties which do not permit economical dropping. In addition, shot towers for the dropping process must be built very high (150–180 feet) in order to provide enough falling distance in order to produce substantially spherical shot. These and other limitations have resulted in a widespread search in the past for an economical method of producing shot which would eliminate the very high and expensive tower structure and which is adaptable to produce shot of metals other than of lead.

Other thermal methods of producing shot include: (1) dropping of molten metal in an inert atmosphere, or (2) dropping through liquid coolants or some special materials to change the properties of the metal, or (3) directing a stream of air, water, steam, etc., at molten metal to break the metal stream up into small spherical particles. Of course, there are other processes which are not mentioned here.

In the mechanical methods of producing snot, some operation is performed on a solid pellet, slug or blank until the solid particle is rounded off into substantial sphericity.

It must be appreciated that the problem here is not merely to produce round shot. There are many methods shown in the prior art and in use today which will produce very fine, spherical metal balls from cylindrical or cubical blanks. The problem is to produce very large amounts of satisfactory metal shot economically. It became apparent from the prior art that if the vast daily requirements of shot were to be produced mechanically at a permissible cost, a new concept of forming shot would be necessary.

The general object of this invention is to produce by novel and mechanical means substantially spherical balls from non-spherical, deformable, metallic pellets.

Another object of this invention is to provide a novel method of producing large quantities of shot efficiently and economically.

Another object of this invention is to provide a novel low-cost method of providing accurately-sized, substantially-spherical shot of any desired diameter and composition. e.g., lead, steel, aluminum, etc.

Other objects and advantages of the invention will become apparent after reading the following specification, the claims, and the accompanying drawings in which:

FIGURE 1 shows a schematic of the rotating chamber with the impeller assembly inside.

FIGURES 2 and 3 are similar to FIGURE 1 except that the blanks are being hit at different points on the impeller with resulting different patterns.

FIGURE 4 shows a perspective view of a production model encompassing the invention.

FIGURE 5 shows a cross-sectional view taken on line 4—4 in FIGURE 4.

FIGURE 6 shows an end view of the discharge end of the drum container of FIGURE 4.

FIGURE 7 shows a graph showing generally the relationship of impact speed, impact time and ball roundness.

In the following description of the present invention, reference will be made to the production of lead shot. It should be appreciated, however, that the process and apparatus is the same for other materials. As explained below, the speed of the rotating impeller will vary with the physical characteristics of the blanks but otherwise the following discussion will also apply to making steel, aluminum and other metallic shot.

The method of the present invention includes the feeding of non-spherical lead pellets into a substantially enclosed chamber, projecting the lead pellets into the path of a high-speed impeller mounted within the chamber, striking said pellets with the impeller to cause the pellets to become deformed and subsequently impacted against the chamber walls for further impacts and deformation, maintaining successive impacts until the blanks have attained the necessary sphericity at which time they are removed from the chamber.

The embodiment of FIGURE 1 shows a cylindrical container **10** in which non-spherical metallic blanks **12** are placed. The blanks are preferably cylindrical although cubes also will perform satisfactorily. The container is mounted by means not shown to rotate slowly about its longitudinal axis **14**. Rigidly mounted on the inner wall **16** of the container **10** and rotating therewith are a plurality of scoops **18**. As the blanks fall to the bottom of the container by gravity, the scoops **18** pick them up and elevate them to approximately the 11 o'clock position shown in FIGURE 1 where the blanks fall by gravity into the central interior area of the container.

Centrally positioned within the container **10** to rotate therein at relatively high speed about the longitudinal center axis **14** of the container is a shaft **20** to which is secured an impeller assembly **22** having vanes or blades **24** and **26**. Vanes **24** and **26** have rearwardly directed, streamlined end portions **28** and **30** for a purpose to be explained later.

As the blanks **12** fall from the scoops **18**, they are impinged by the impeller **22** which is rotating at a predetermined high speed sufficient to deform the blanks to the desired sphericity. In delivering the first impact and deformation to the non-spherical blank, the impeller changes both the direction and magnitude of the velocity of the blank so that the blank is projected against the inside wall **16** of the container **10** for a second impact and deformation. Then, depending on various factors mentioned below, the blank either bounces back into the path of the impeller for another impact (FIGURE 3) or it ricochets and bounces off the inside wall **16** until it is stopped by the scoops **18** (see FIGURES 1 and 2).

In a matter of minutes (see FIGURE 6), (depending on the various factors explained below), cylindrical or cubical blanks can be deformed and reshaped into substantially spherical balls. Depending on ultimate use, the balls can then be run through a second finishing drum or container having a slower rotating impeller or run through any well-known ball finishing machine to attain the roundness or sphericity required.

FIGURES 4 and 5 show the inventive concept embodied in a production model adapted to be run as a continuous process but which can also be operated as a batch process. This embodiment shows an elongated cylindrical drum **34** supported on spaced rollers **36** and **38** and rotated slowly by a chain **40** which is connected to a power means (not shown) and which operatively engages a sprocket **42** mounted at one end **44** of the drum.

Extending through the drum on the longitudinal axis thereof is a shaft **46** which is rotatably mounted in bearing blocks **48** and **50**. Attached to the shaft **46** in order to provide rigidity thereto is a spider member **52** on which are mounted impeller vanes **54**, **56**, **58**, and **60** having arcuate end portions **54*a***, **56*a***, **58*a***, and **60*a***. The shaft and impeller assembly are rotated independently of the drum by belt **62**.

The arcuate end portions of the impeller vanes have been found to be necessary in order to prevent marking of the finished ball which would be caused by any sharp corners of the impacting vanes travelling at high speed. The degree of curvature of the vane end portions can be varied to control the direction in which the blank is projected after being hit by the rotating impeller. However, in order to prevent marking of the ball when hit by the impeller, the radius of curvature of the rounded vane end portion must be greater than the maximum radius of ball which is to be produced.

A feed hopper **64** is positioned at one end of the drum with a mouth portion **66** extending into the interior of the drum. At the opposite end of the drum, an opening **68** is provided in the drum end plate **70** for withdrawing the finished shot from the drum. It can be seen that nonspherical blanks can be fed continuously to the drum through hopper **64** and finished balls withdrawn through opening **68**.

It should be appreciated that it is possible to provide more or fewer impeller vanes as well as scoop elevating means than are shown in the drawings.

The following results are characteristic of what was achieved by processing various samples of metallic blanks with the apparatus shown in FIGURES 1–3 using a 9 inch diameter impeller and with the drum rotating at 36 r.p.m. at room temperature. The percent sphericity is arbitrarily defined as

$$\frac{\text{maximum diameter minus minimum diameter}}{\text{maximum diameter}} \times 100$$

The yield strengths are typical values of similar material tested under static tensile conditions at 0.2% offset and are not necessarily the actual yield strengths of the mate-

rial under the conditions within the impact drum. Yield strengths for lead and zinc are not given since they are under creep condition at room temperature. Obviously, the results can be varied by varying any of the following: the diameter of the impeller, the number of impeller vanes; the number of lifting scoops; and the speed of the rotating drum container.

Metal	SAE	Yield strength, p.s.i.	Impeller speed, r.p.m.	Time (min.)	Percent spher.[1]	Original shape and Dimensions
Lead	----------	----------	500	10	7.5	Cyl. 0.016C x 0.137.
	----------	----------	250	15	5.3	Cyl. 0.160 x 0.137.
	----------	----------	500	15	4.7	Cyl. 0.160 x 0.137.
	----------	----------	500	10	7.8	Cyl. 0.257 x 0.215.
	----------	----------	250	15	5.7	Cyl. 0.257 x 0.215.
	----------	----------	500	15	6.1	Cyl. 0.257 x .0215.
Steel	1018	48,000	1,000	25	5.9	Cube 0.250.
	1018	48,000	1,500	10	5.4	Cube 0.250.
	4130	60,000	1,000	35	6.5	Cyl. 0.310 x 0.265.
	4130	60,000	1,500	15	7.4	Cyl. 0.310 x 0.265.
	52,100	80,000	1,000	35	4.5	Cyl. 0.156 x 0.137.
	52,100	80,000	1,500	15	5.7	Cyl. 0.156 x 0.137.
Aluminum	1100–0	5,500	1,000	10	6.9	Cyl. 0.0250 x 0.215.
	1100–0	5,500	1,500	5	7.7	Cyl. 0.0250 x 0.215.
	2017	10,000	1,000	15	5.9	Cube 0.187.
	2017	10,000	1,500	10	5.2	Cube 0.187.
	2024	11,000	1,000	15	8.3	Cyl. 0.250 x 0.215.
	2024	11,000	1,500	10	6.4	Cyl. 0.250 x 0.215.
	6061	8,000	1,000	15	4.0	Cyl. 0.250 x 0.215.
	6061	8,000	1,500	10	7.1	Cyl. 0.250 x 0.215.
Zinc	----------	----------	500	35	4.7	Cyl. 0.250 x 0.215.
	----------	----------	750	3	10.1	Cyl. 0.250 x 0.215.

[1] Maximum diameter minus minimum diameter/maximum diameter.

It should be appreciated that the above data are not intended to indicate the optimum conditions under which shot can or would be made. For each type of material, an optimum speed can be determined which will produce a substantially spherical ball. Obviously, various combinations are also possible whereby the initial rounding of the ball can be achieved by running the impeller at very high speeds and then running at lower speeds for the final rounding off.

Experience has shown certain physical relationships which permit a certain degree of predictability in regards to the forming of metallic shot by the impact process of the present invention. For example, the higher the yield strength, the higher the impact velocity and time required to deform the blanks.

It is known that a higher impact velocity will produce larger flat areas on a metallic blank than a low impact velocity. It is also known (see FIGURE 7) that a blank impacted at high velocity will reach substantial sphericity sooner than a blank impacted at low velocity. However, the ultimate degree of sphericity of the high-velocity produced ball will be lower than the low-velocity produced ball.

It was found that certain defects existed in balls formed by the present method which was objectionable for some uses. These defects, "leafing" and "poling," are caused by the mechanical movement of the metal in being transformed from a cylindrical or cubical blank into a rounded ball. The "leafing" results in thin laminations of metal on the outer ball periphery which can be peeled off much like layers of skin and is believed to be caused by the skidding action of the blanks on the chamber or drum walls. The "poling" is caused when angular corners are impacted together so that two masses of metal are physically forced together without being fused together. For a ball formed from a cylindrical blank, two lines or "poles" can be seen under a microscope whereas a cubical blank produces six. (Thus, the preference for using cylindrical blanks.) Either of these defects may prevent the user of the balls (in some instances) while they obviously are satisfactory for many other uses.

Since it was believed that the skidding action of the blank on the drum walls was causing the undesirable "leafing," various efforts were made to eliminate or at least to lessen the skidding. One effort which was successful in greatly reducing the "leafing" was the introduction of lubricating oil in the drum so that the blanks would deformed by the direct impacts of the impeller and the drum but the abrasive action of the skidding blanks would be eliminated or substantially decreased.

The "poling" situation was materially improved by impacting aluminum blanks at elevated temperatures. Since it would be difficult to heat the blanks and maintain them at a constant temperature, the drum or container was heated and kept at approximately 850° F. and the impacting carried out as previously explained. It was found that the impacting process at higher temperatures does not only eliminate the "leafing" but also greatly reduces the size of the voids in the "pole" areas.

The "hot-working" of the aluminum blanks was found to produce a thin oxide layer on the surface of the balls, which resulted in a dark color finish instead of the bright shiny finish produced by the cold impacting. However, if this is found to be undesirable for any reason, the blanks can be impacted at elevated temperatures in an inert atmosphere in order to eliminate this discoloration.

Although the heating of the drum is not shown on the drawings, this can be done by any means well known today. For example, cement kilns and other drums are kept at constant elevated temperatures.

It was found that some blanks, which were made by chopping extruded or drawn wire into small slugs, were difficult to impact into substantially spherical balls. This problem was attributed to the difficulty in reshaping the metal blanks, which had been initially stressed a greater degree in the axial direction than in radial or transverse direction during the wire-forming operation.

This situation was improved, however, by heating the blanks to a sufficiently high temperature prior to impacting in order to relieve the intial stresses caused by the wire drawing. The annealing of the blanks can be done prior to cold impacting or hot impacting for improved results.

Although the specification shows and explains one experimental model and one production embodiment, it is obvious that the inventive concepts expressed herein can be utilized in various other embodiments.

What is claimed is:

1. Apparatus for forming substantially spherical balls from non-spherical deformable blanks comprising: an elongated drum mounted to rotate at a relatively slow speed on its axial center line, carrier means rigidly mounted on the inside wall of the drum to move with the drum and lift the blanks to an elevated position until the blanks fall by gravity into the path of impeller means mounted within said drum and rotating at a predetermined relatively high speed, said impeller means impinging against and causing the blanks to be thrown against the drum inside wall repeatedly at high speed to cause the non-spherical edges of the blanks to be rounded off.

2. In apparatus for forming balls from angular, deformable blanks, the combination comprising means to feed the deformable blanks to a relatively slowly rotatable cylindrical container, means within said container and rotating therewith to elevate the blanks to a point where the blanks fall by gravity into the path of impeller means rotating at a relatively high speed within said container whereby said impeller means impinges and changes both the direction and magnitude of the velocity of the blanks to cause the blanks to undergo a series of impacts against the inside wall of the container, and means to draw off the rounded balls.

3. The combination recited in claim 2 wherein said impeller means includes radially extending vane means having end portions which are curved rearwardly, said curved portions having a radius of curvature greater than the maximum radius of ball to be produced.

4. Apparatus for mechanically forming shot from non-spherical deformable blanks comprising an elongated, cylindrical container which revolves at a relatively slow speed on its axial center line, scoop means mounted on the inside wall of said container and adapted to pick up and elevate said blanks from a point near the lower end of a circle formed by the revolving container to a point near the top of the circle where the blanks fall by gravity into the interior of the container, and impeller means rotatable within said container on said axial center line of said container at a predetermined relatively high speed to strike the blanks and change both the direction and magnitude of the velocity of said blanks and cause the blanks to be impacted at high velocities against the inside container wall and become rounded off.

5. Apparatus as recited in claim 4 wherein means are provided to heat the rotating container and the blanks therein to an elevated temperature greater than normal room temperature but less than the melting point of the metal blanks.

6. An apparatus for mechanically rounding off non-spherical deformable particles comprising a substantially enclosed chamber having an inlet whereby non-spherical particles are continuously fed into said chamber and an outlet whereby rounded balls are continuously withdrawn, elevating means within said chamber to continuously pick up, elevate and discharge said particles into the path of a continuously-rotating, high-speed vane assembly which throws the particles against the inside chamber wall, thus rounding off said non-spherical particles and resulting in substantially spherical balls.

7. The apparatus recited in claim 6 wherein means are provided to maintain the blanks at an elevated temperature above room temperature but below the melting point of the blanks while being impacted.

8. In an apparatus for mechanically forming shot by impacting non-spherical blanks in order to produce rounded balls, the combination of a rotatable cylinder container, means to elevate and recirculate the blanks within said container, and rotatable impact means within said container to change the direction and provide a velocity of sufficient magnitude thereto to deform the blanks upon being impacted against the container inner wall.

9. The combination recited in claim 8 wherein said elevating means comprises at least one scoop attached to the inner container wall to pick up, lift and discharge by gravity the blanks into the interior of said container whereby said impact means strikes the blanks and changes both the direction and magnitude of the velocity thereof.

10. The combination recited in claim 9 wherein said means within the container to change both the direction and magnitude of the velocity of the blanks comprises a vane assembly which rotates at high speed on the same axis as the rotating container.

11. The combination recited in claim 10 wherein said rotatable vane means includes a curved end portion which is swept back opposite to the direction of vane rotation in order to prevent marking of the finished ball.

12. The combination recited in claim 9 wherein said drum rotates at a relatively slow speed and said elevating means comprises scoop means mounted on said rotatable drum.

References Cited by the Examiner

UNITED STATES PATENTS

1,601,252	9/26	Lines.	
2,758,360	8/56	Shetler	29—1.22
2,815,560	12/57	Buxton	29—1.22
2,946,115	7/60	Firm.	

FOREIGN PATENTS

13,537	6/11	Great Britain.
75,373	7/49	Norway.

OTHER REFERENCES

"Finishing Springs by Shot Peening," Machinery, June 18, 1954, p. 1300.

RICHARD H. EANES, Jr., *Primary Examiner.*

Sept. 7, 1965 G. R. ECKSTEIN ETAL 3,204,320

BALL AND SHOT MANUFACTURE BY IMPACTING PROCESS

Filed Aug. 29, 1962 2 Sheets-Sheet 1

Fig. 1.

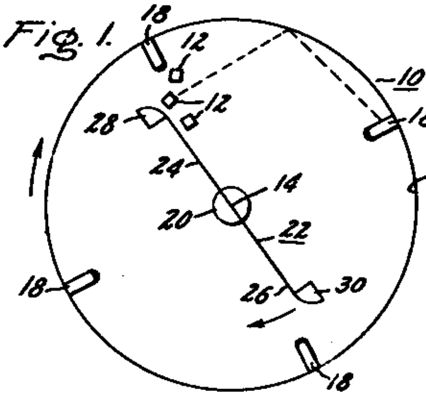


Fig. 2.

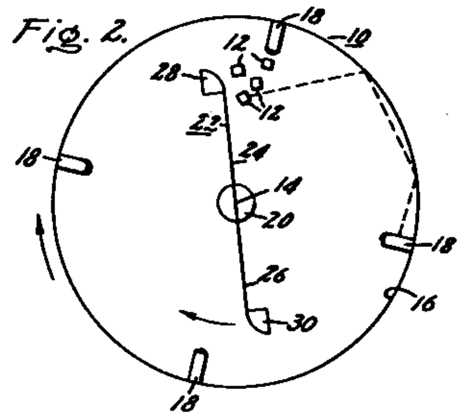


Fig. 3.

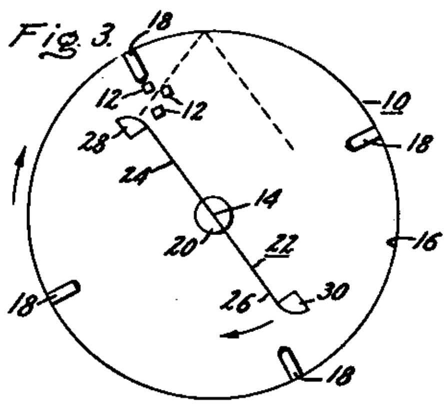


Fig. 5.

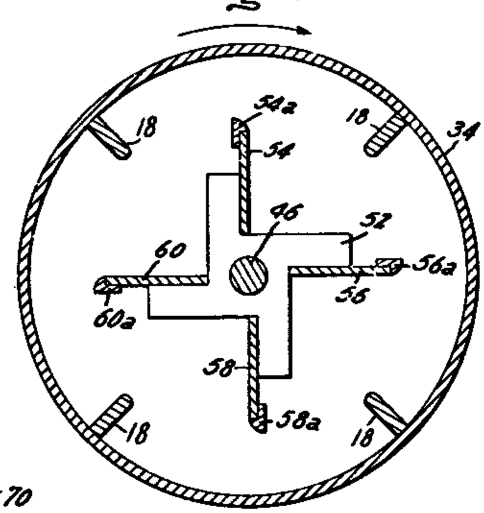
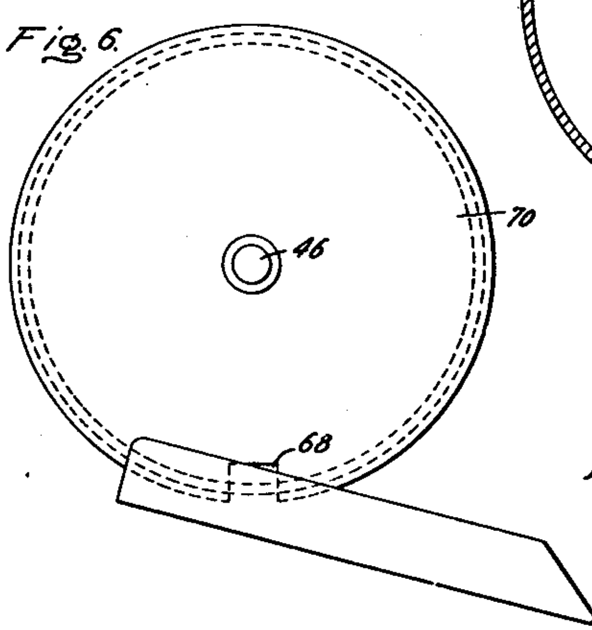


Fig. 6.



Inventors:
George R. Eckstein,
Donald S. Foote,
by John W. Phippi
Nicholas Skovran
Their Attorneys.

BALL AND SHOT MANUFACTURE BY IMPACTING PROCESS

Filed Aug. 29, 1962 2 Sheets-Sheet 2

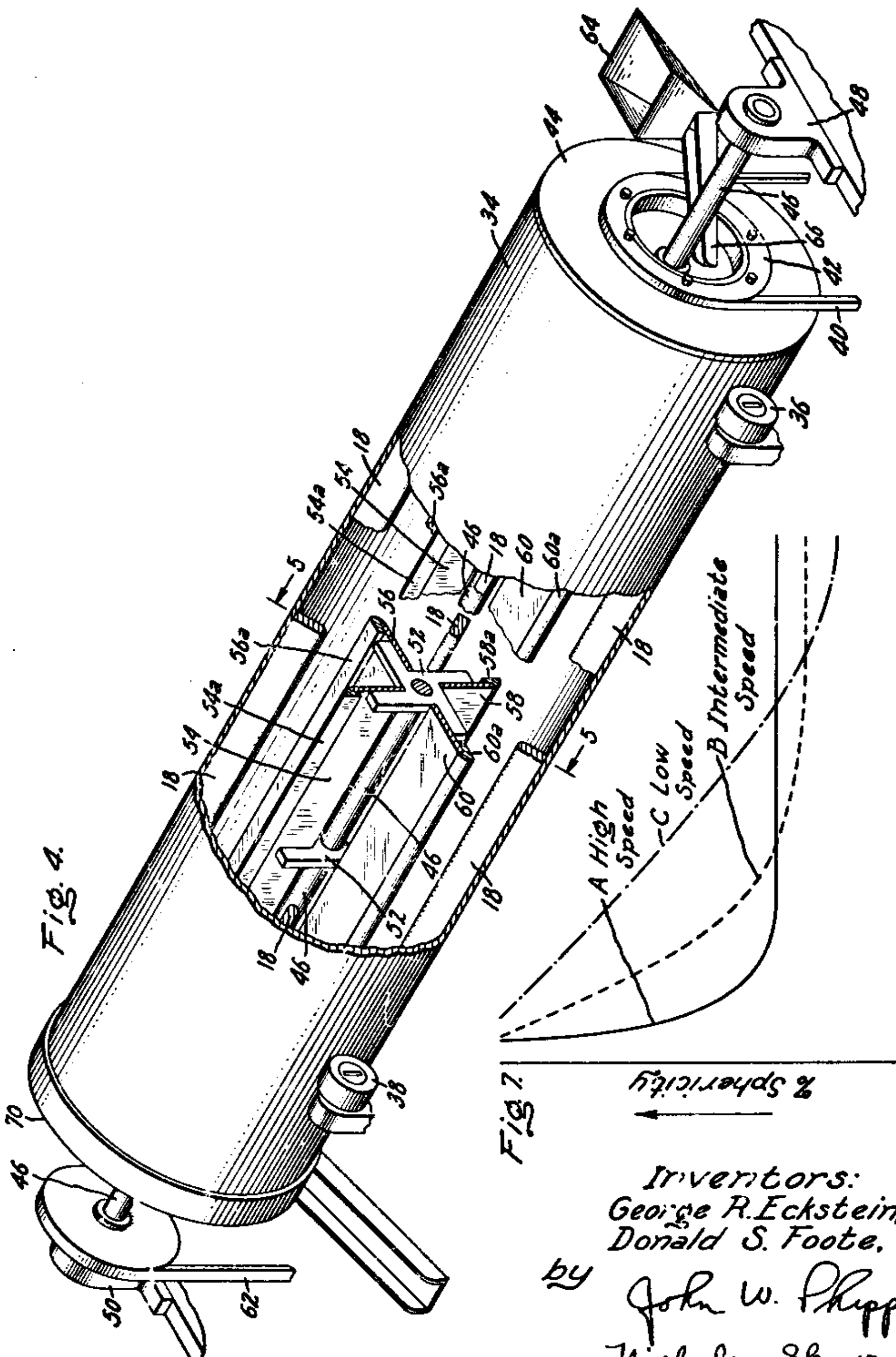


Fig. 4.

Fig. 7

Inventors:
George R. Eckstein,
Donald S. Foote,
by John W. Phippi
Nicholas Skovran
Their Attorneys.