United States Patent

[11] **3,613,655**

[72] Inventors **Joseph M. Tobin McMurray; Peter O. Tauson, Bradford Woods; Leonard R. Fleischer, Pittsburgh; Harry F. Ebner, Clairton, all of Pa.**

[21] Appl. No. **837,441**
[22] Filed **June 30, 1969**
[45] Patented **Oct. 19, 1971**

[73] Assignee **Westinghouse Electric Corporation Pittsburgh, Pa.**

[54] **CENTRIFUGAL GUN**
5 Claims, 7 Drawing Figs.

[52] **U.S. Cl.** **124/6,** 124/50
[51] **Int. Cl.** **F41b 15/00**
[50] **Field of Search** 124/6, 40, 49, 50

[56] **References Cited**

UNITED STATES PATENTS

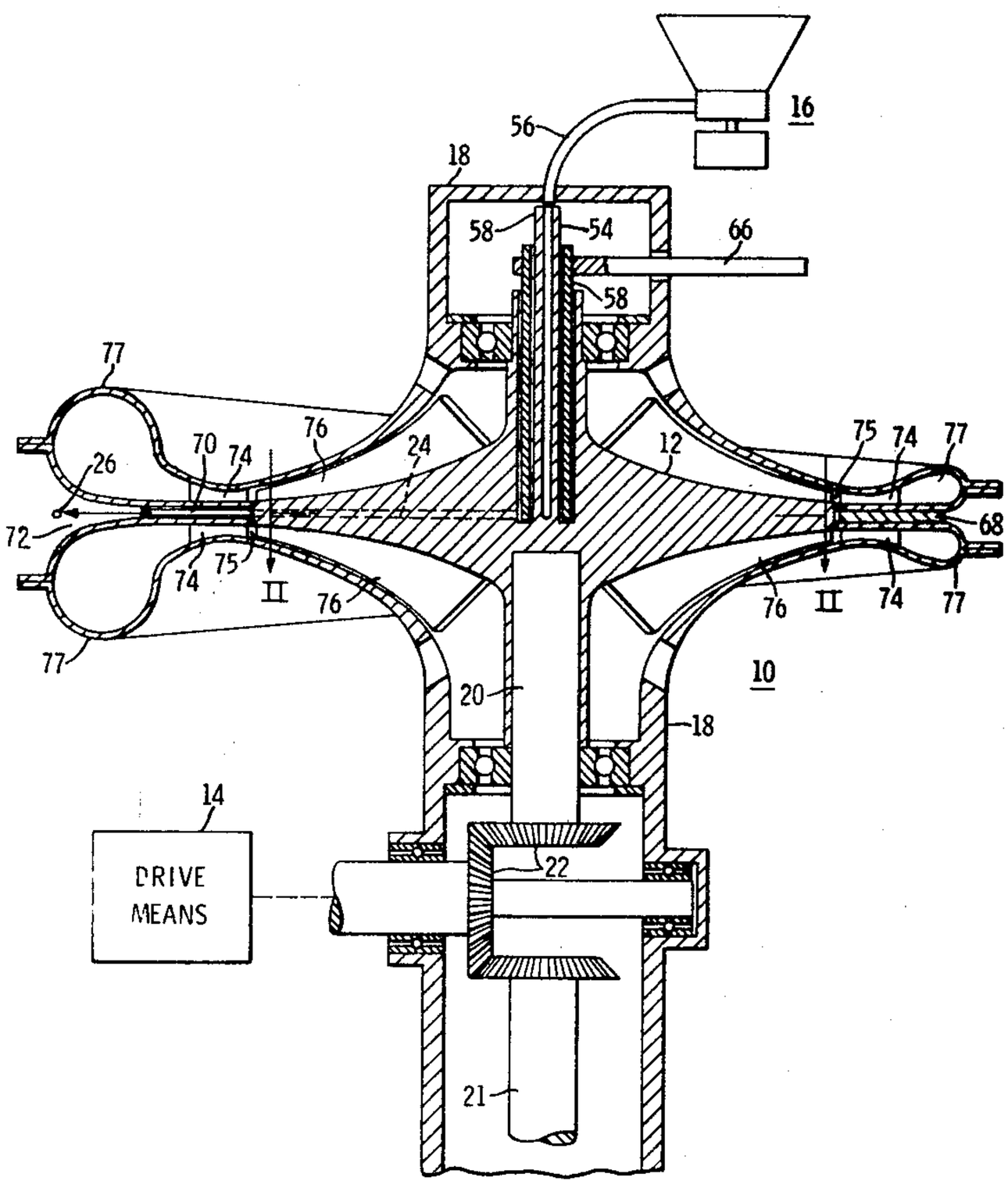
1,152,447	9/1915	Sproull	124/50 X
1,408,137	2/1922	Parsons	124/6
1,420,660	6/1922	Lombard	124/6
1,472,080	10/1923	McNaier	124/6

FOREIGN PATENTS

67,091	3/1940	Czechoslovakia	124/50

Primary Examiner—Richard C. Pinkham
Assistant Examiner—William R. Browne
Attorneys—F. Shapoe and Lee P. Johns

ABSTRACT: A centrifugal gun for discharging projectiles at very rapid velocities which gun includes a rotatable impeller having a center of rotation and a peripheral path of movement and having a continuous trackway along which the objects are propelled and which leads from the point of insertion at or near the rotation center to the exit point at the peripheral path. The trackway has an outer concave section and an inner convex section, with the outer peripheral portion of the concave section facing the direction of rotation of the impeller.



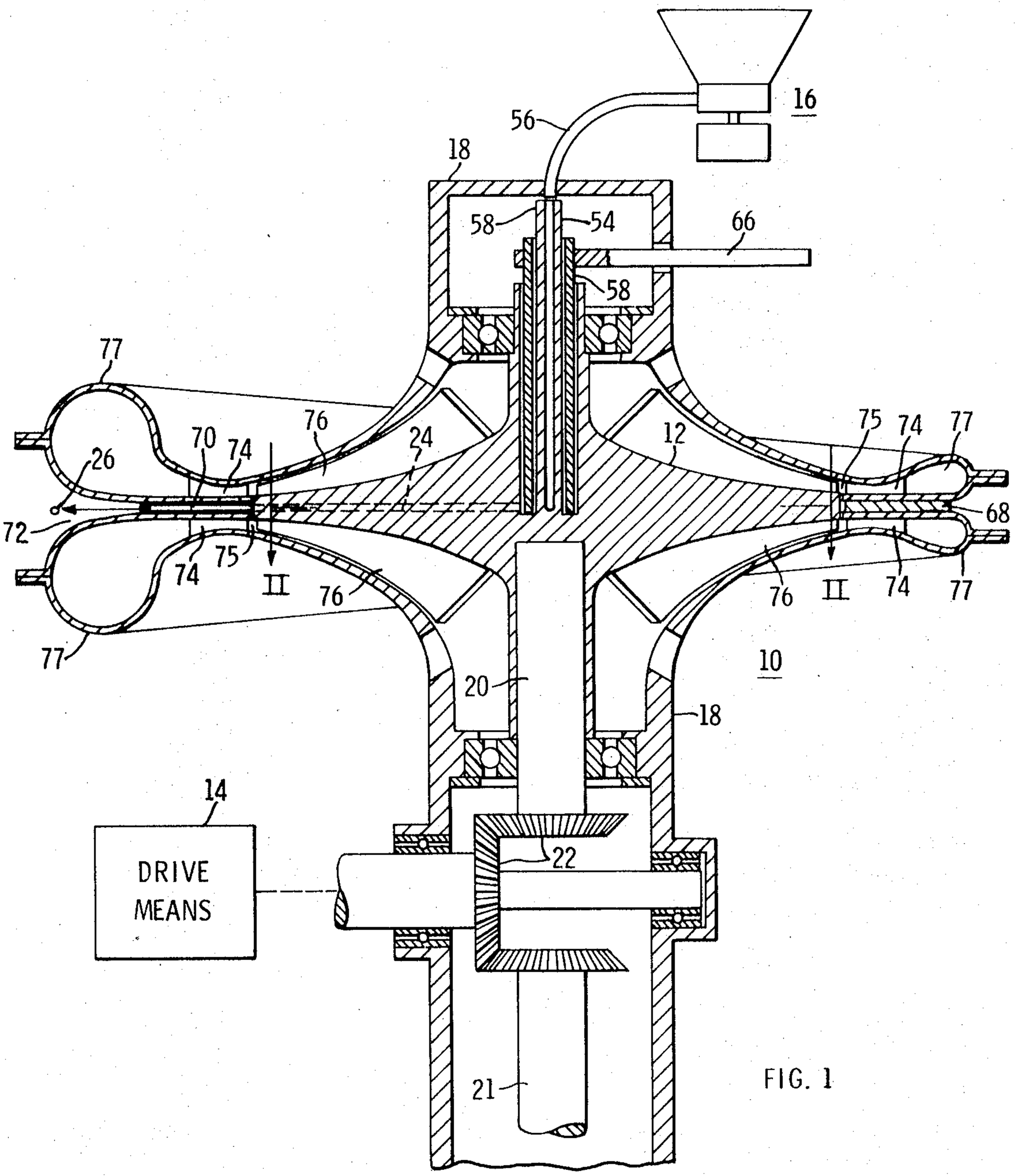


FIG. 1

WITNESSES

Wm. B. Sellers

James F. Young

INVENTORS

JOSEPH M. TOBIN, PETER O. TAUSON,
LEONARD R. FLEISCHER, AND HARRY F. EBNER

BY Lee Johnson

ATTORNEY

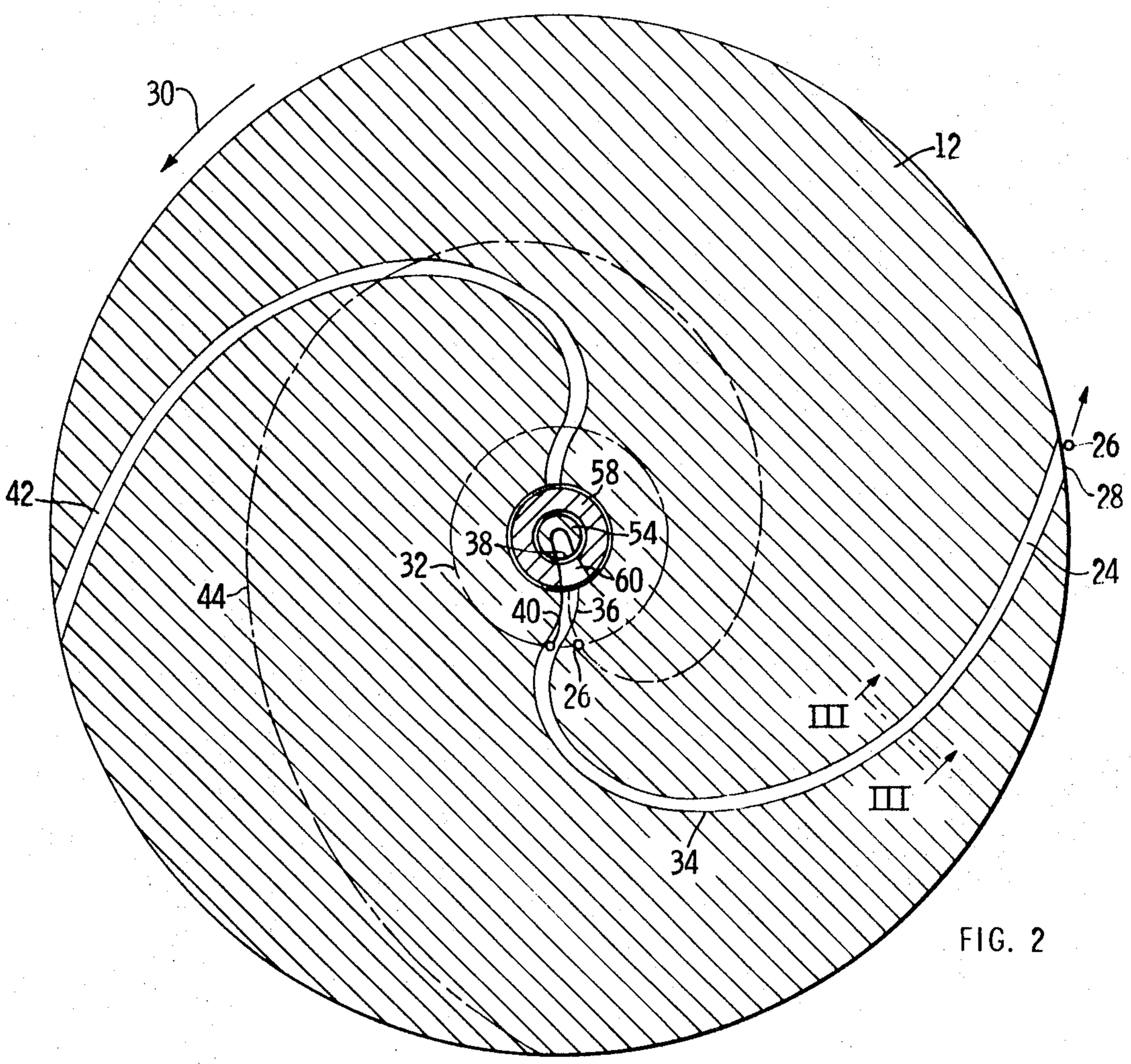


FIG. 2

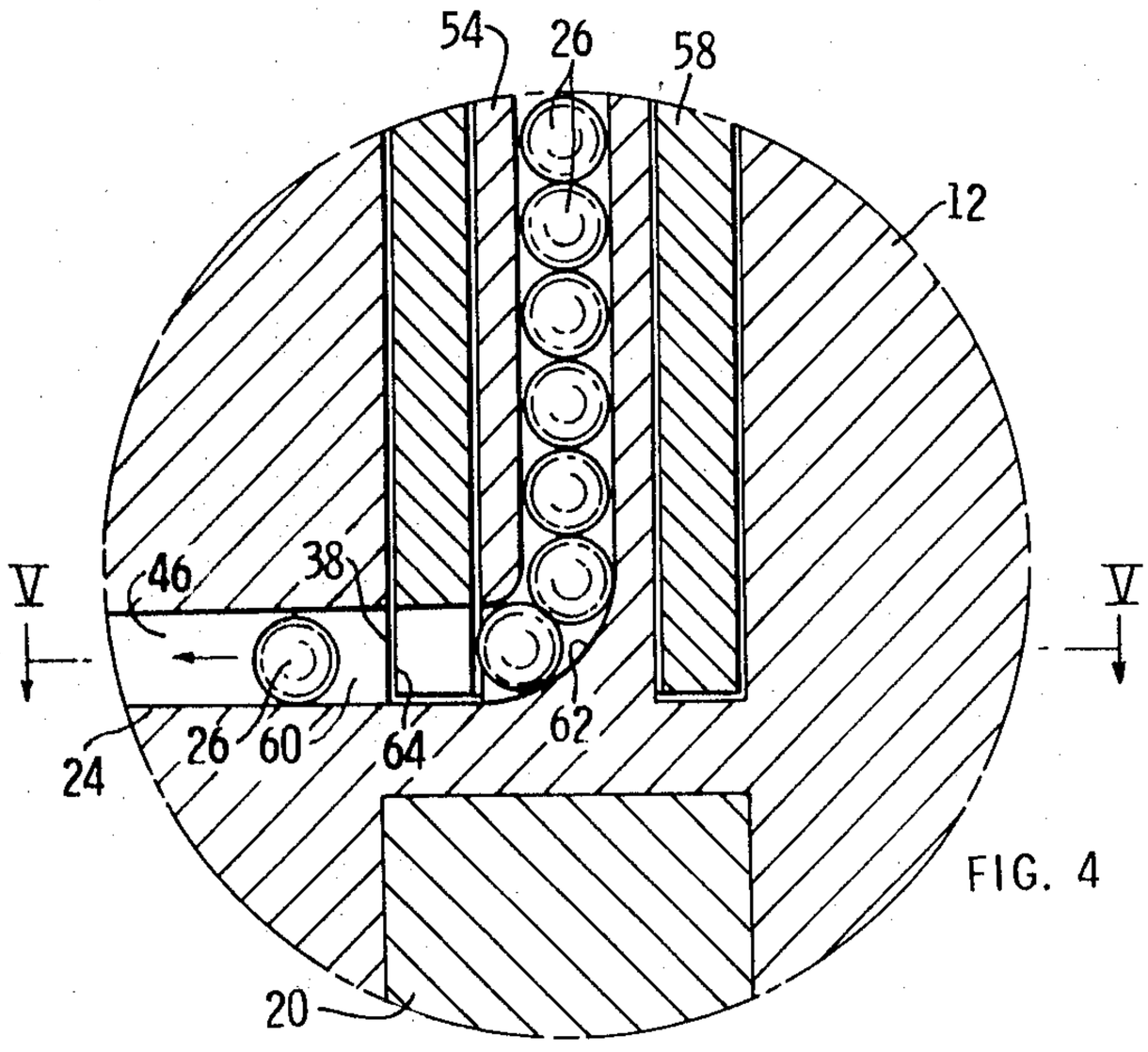


FIG. 4

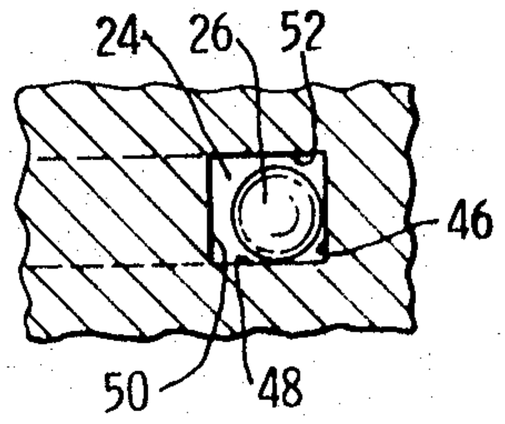


FIG. 3

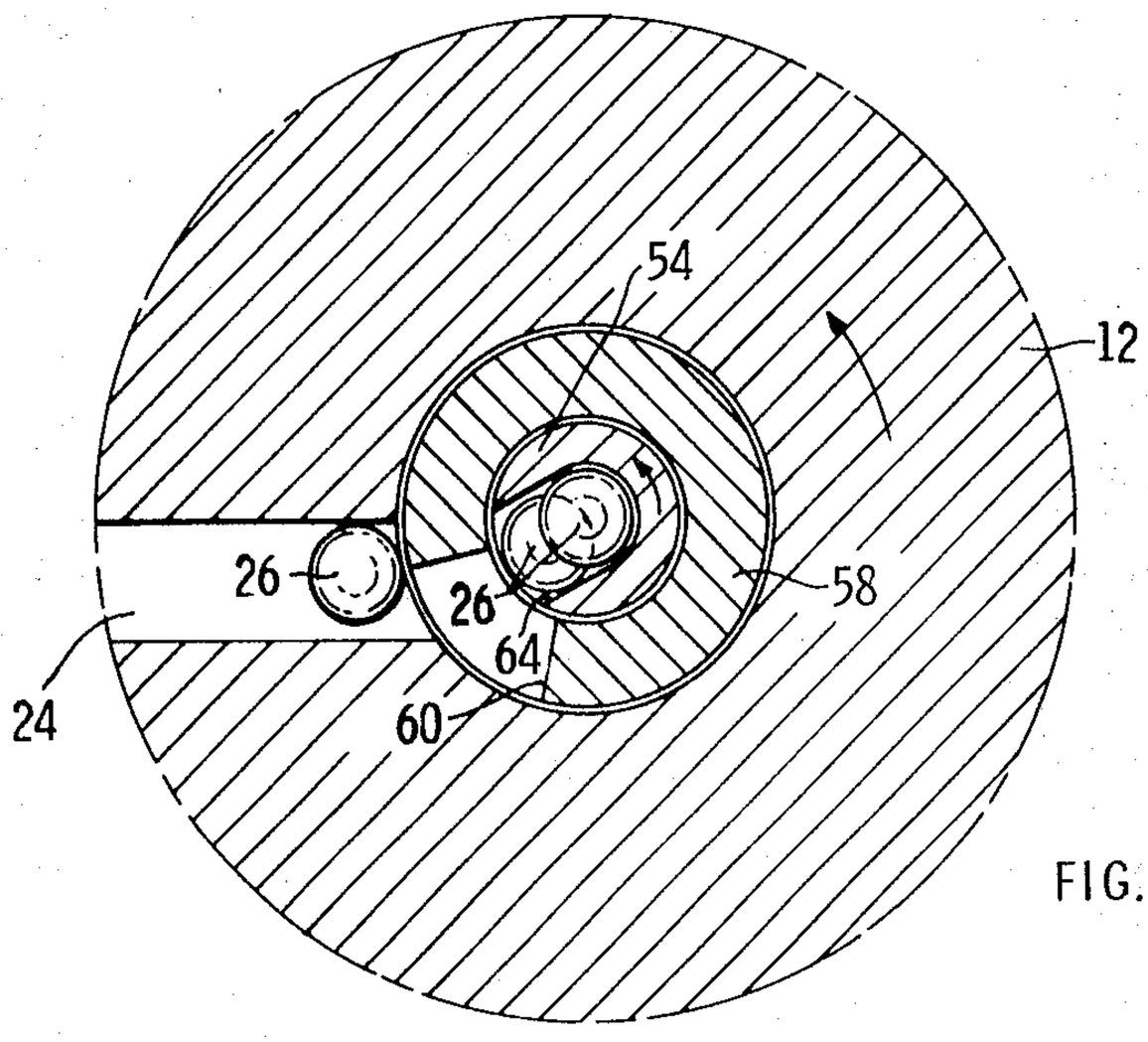

54
12
26
26
64
58
24
60

FIG. 5

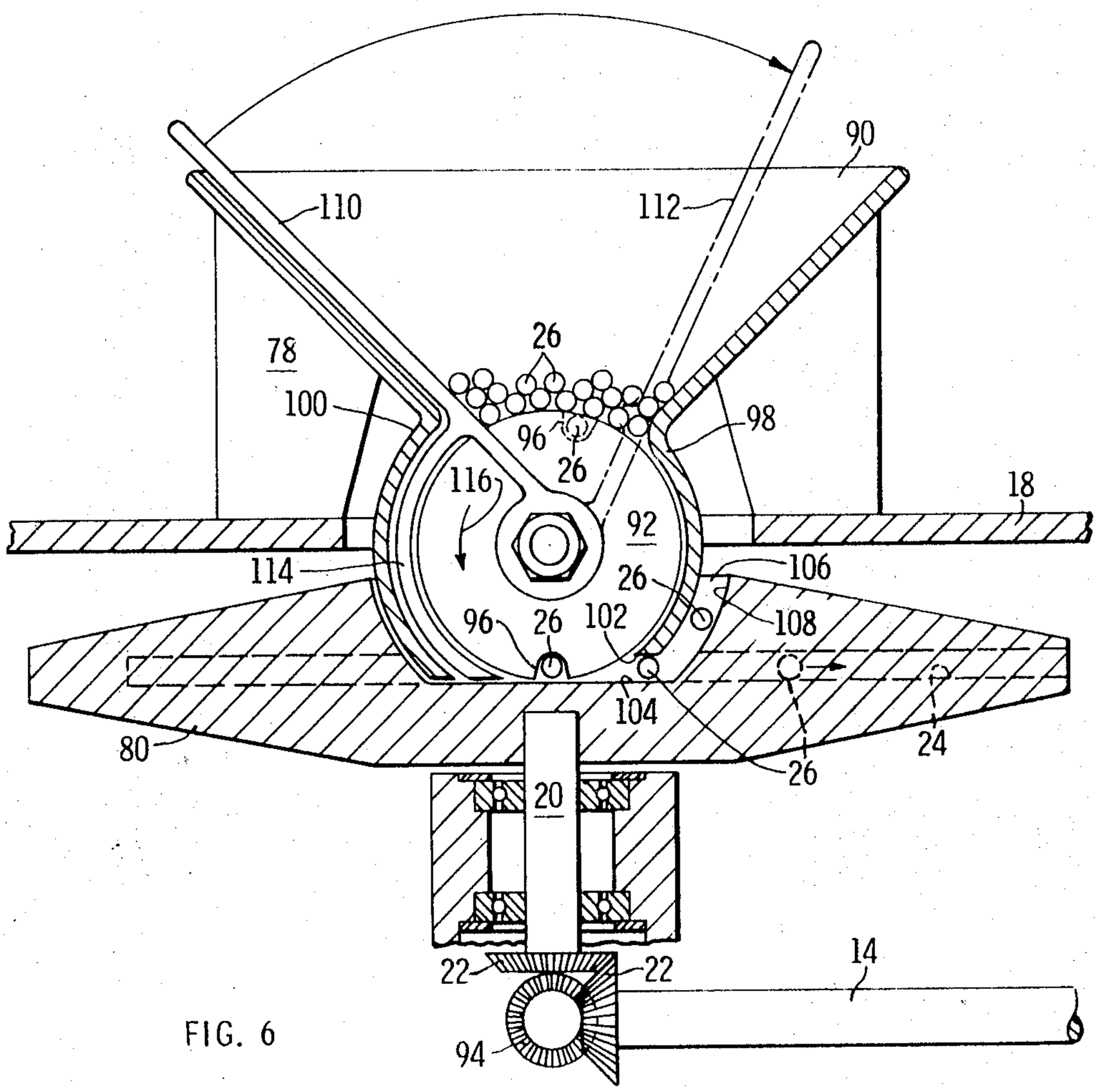

90
110
112
78
26
100
96
26
98
116
18
92
114
106
26
108
96
26
102
104
80
24
26
20
22
22
14
94

FIG. 6

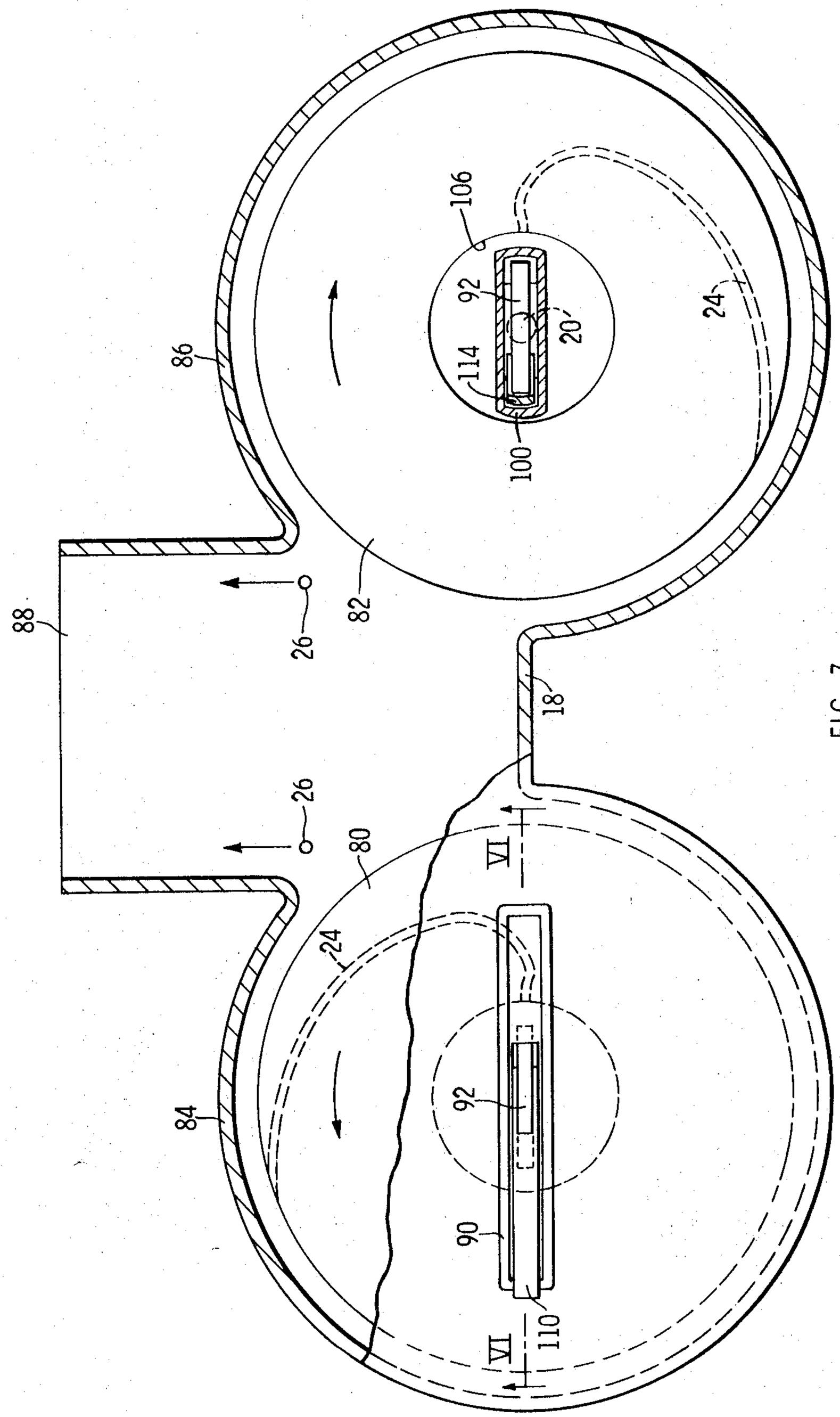


FIG. 7

CENTRIFUGAL GUN

BACKGROUND OF THE INVENTION

1. Field of the Invention

This invention pertains to a rapid-fire mechanical gun. More particularly, it pertains to a centrifugal gun capable of continuously firing at a rate of thousands of rounds of ammunition per minute without overheating.

2. Description of the Prior Art

A gradual evolution in small-caliber weapon requirements has occurred during the Korean and Vietnam Wars. The change in emphasis has been from accurate slow-fire weapons to rapid-fire automatic weapons. Often the enemy is never seen, but is attacked with "saturation" fire in the direction of his proximate position. The object of saturation firing is to put as many small-caliber bullets as possible into a broad target area.

Prior efforts have been made for increasing the rate of fire of small caliber guns. Most machine guns are mechanized with gas or electrically driven machines to automatically and rapidly charge projectiles into the breech and to eject empty cartridge cases. The energy for firing the projectiles comes from the small explosive charge attached to each projectile in a cartridge case. Mechanizing the cartridge transport devices has increased firing rates very significantly. However, the firing burst has been limited by the large amount of heat released by the exploding charges, causing overheating of gun barrels. Efforts to minimize or improve the effect of temperature on gun barrels have included water cooling, the development of alloys having high-temperature strength as well as the so-called Gatling gun. However, such efforts have not been completely satisfactory, particularly where sustained rapid firing is necessary.

Guns that use centrifugal force instead of an explosive charge for shooting a projectile have been known in the prior art. One type of centrifugally operated gun involves straight radially extending barrels, such as shown in U.S. Pat. Nos. 1,472,080 and 3,177,862. A limitation of such constructions is that the power required to rotate the radial barrel is too great to develop an economically feasible rapid-fire device. Moreover, in U.S. Pat. No. 3,177,862 radial gun barrels are incorporated with the helicopter blades which slows down the speed of rotation of the blades due to the absorption of energy by the projectile bullets, or missile as they pass through the barrels.

Another type of centrifugal gun includes a gun barrel having an arcuate rather than radial construction. Such constructions however have limited the speed of the projectile for various reasons including (1) rotation of the barrel in a direction reverse to travel direction of the projectile and (2) the provision of a peripheral barrier which prevents emission of the projectile at the precise moment that it achieves its maximum speed at the exit end of the barrel. Such devices are shown in U.S. Pat. Nos. 1,240,815; 1,284,999; 1,408,137; and 1,662,629.

Associated with the foregoing has been the problem of overcoming a strong gyroscopic reaction force of a rotating impeller that resists turning and moving of a gun when aiming in a plane that is not perpendicular to the axis of rotation of the impeller. One solution to the problem has been the use of gears and levers of sufficient mechanical advantage to overcome the gyroscopic force and thereby facilitate aiming a gun in the directions that are out of the plane of impeller rotation. However, the problem can be better solved by providing a second impeller which is rotated, say clockwise, to offset the gyroscopic force of the first (counterclockwise) impeller. Such a solution has the added advantage of increasing the maneuverability of the gun.

A related problem with centrifugal guns of prior construction has been accuracy of aiming. Guns of prior construction have been provided with peripheral rims having an opening outlet which was directed in the direction of fire of a projectile. That construction has limited the speed of travel of a projectile to the peripheral speed of rotation of the impeller.

A problem related to aiming of a projectile is that of feeding the projectile to an impeller with proper synchronization. If a projectile is to be emitted from the impeller at speeds greatly in excess of the peripheral speed of rotation of the impeller, it is necessary that the projectile be emitted at the precise moment when it arrives at the periphery of the impeller. For that purpose the feed mechanism for the projectiles at the center of the impeller must be synchronized to the moment when the projectile arrives at the periphery of the impeller. Centrifugal guns of prior construction have not been provided with adequate feed means and feed control for such synchronization.

SUMMARY OF THE INVENTION

It has been found in accordance with this invention that the foregoing problems may be overcome by providing a centrifugal gun having at least one impeller which includes a continuous trackway along which a projectile is propelled from the center of rotation to the periphery of the impeller; the configuration of the trackway including a convex section near the center and a concave section adjacent the periphery with the outer peripheral portion of the concave section extending in the direction of rotation of the impeller.

Accordingly, it is a general object of this invention to provide a centrifugal gun which propels projectiles at velocities greatly exceeding the rotational peripheral velocity of a centrifugal impeller,

It is another object of this invention to provide a centrifugal gun having a contrarotating impeller for the mutual cancellation of gyroscopic torque forces.

It is another object of this invention to provide a centrifugal gun having improved accuracy of aiming and reduced dispersion of shot at the target by means of synchronization of projectile feed means and the exit position of the projectile at the periphery of the impeller.

It is a further object of this invention to provide a centrifugal gun having an impeller which accelerates projectiles to exit velocities exceeding the peripheral velocity of the impeller.

Finally, it is an object of this invention to satisfy the foregoing objects and desiderata in a simple and effective manner.

BRIEF DESCRIPTION OF THE DRAWINGS

For a better understanding of the invention reference is made to the drawings, in which similar numerals refer to similar parts throughout the several views of the drawings, and in which:

FIG. **1** is a vertical sectional view of one embodiment of a centrifugal gun;

FIG. **2** is a horizontal sectional view of an impeller, taken on the line II—II of FIG. **1**;

FIG. **3** is a cross-sectional view of the trackway in an impeller, taken on the line III—III of FIG. **2**;

FIG. **4** is an enlarged fragmentary vertical sectional view of a feed control for the impeller;

FIG. **5** is an enlarged horizontal sectional view of the feed control, taken on the line IV—IV of FIG. **4**;

FIG. **6** is a vertical sectional view of another embodiment of a feed control for the impeller; and

FIG. **7** is a plan view of another embodiment of a pair of counterbalanced impellers in coplanar positions.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

One embodiment of a centrifugal gun **10** is shown substantially schematically in FIG. **1**. It includes an impeller **12**, impeller drive means **14**, projectile feed means **16**, and a housing **18**.

The impeller **12** is a rotatable member, such as a disc, wheel, or an arm, which is mounted on a driven shaft **20** which, by means of intermediate gears **22**, is operatively connected to the drive means **14** that may consist of a prime mover such as an electric motor, or a combustion engine.

The impeller **12** is shown more particularly at FIG. **2** as being a wheel or disc having at least one, and preferably two,

trackways **24** along which an object such as a projectile **26** is propelled from the center of rotation to the periphery **28** of the impeller. The trackway **24** has a curved configuration. More particularly, when the impeller **12** is rotated counterclockwise, as indicated by the arrow **30**, the trackway **24** includes an outer portion **34** extending from a circle **32** (broken line) to the periphery **28**, which portion is concave in the direction of rotation of the impeller. The trackway **24** also includes an inner portion **36**, located within the circle **32**, which portion has a reverse turn with respect to the outer portion **34**. The inner portion **36** may be either linear or curved between its inner extremity **38** and the circle **32**; or it may be curved convexly with respect to the direction of rotation of the impeller **12**. Where the portion **36** is curved convexly, there is a point of inflection **40** at the circle **32** where the portion **36** joins the portion **34**. Thus, the inner end portion **36** of the trackway **24** has a reverse inclination with regard to the outer portion **34**, whereby the overall effect of the trackway greatly increases the speed of a projectile **26** as it leaves the trackway at the periphery **28**. The effect of such configuration of the trackway **24** is similar to that of a cesta curve.

More particularly, as a spherical projectile **26** enters the trackway at the inner extremity **38**, it has a rotational velocity of substantially zero. Due to the reverse direction, or inner portion **36**, of the trackway which reverse direction is contra to the direction of rotation of the impeller **12**, the projectile quickly achieves the rotational velocity of the impeller when the projectile reaches the zone of the circle **32**, or point **40** of inflection. Beyond the point **40** of inflection the rolling projectile **24** is influenced by the outer portion **34** of the trackway to an extent that its exit velocity at the periphery **28** greatly exceeds the rotational velocity of the impeller **12**. The inner portion **36** of the trackway has a center of curvature on the side of the trackway opposite the center of curvature of the outer portion **34**.

Although a single trackway **24** is sufficient for operation of the centrifugal gun **10**, it is preferred that a pair of trackways be provided such as trackway **24** and a trackway **42**. In that manner a more balanced weight distribution is provided on the impeller **12** during its operation.

As shown in FIG. **2** when the impeller **12** is rotated at operating peripheral speeds at continuous rapid firing rates, a spherical projectile **26** in the trackway **24** actually travels in an absolute path **44** of travel having the form of a spiral as shown by the broken line.

As shown in FIG. **3** the trackway **24** has a cross-sectional opening which is sufficiently greater than the diameter of a spherical projectile **26** to guide the projectile throughout the length of the trackway. For that purpose the trackway includes a backwall **46** and a bottom wall **48**. In addition, where the trackway is completely enclosed, it may include a front wall **50** and a top wall **52**.

Although the trackway **24** is preferably disposed in a circular impeller **12**, the latter may be of any other configuration and may include noncircular, armlike members extending from opposite sides of the center of rotation of sufficient width to include a single trackway or pair of trackways. Moreover, inasmuch as the backwall **46** (FIG. **3**) has a dominant influence upon the projectile **26** (because of the centrifugal force involved as the impeller rotates), the trackway need not include a front wall **50** or top wall **52**. The bottom wall **48** serves the purpose of supporting the projectile **26** and holding it against the backwall **46**.

One means for feeding spherical projectiles **26** to the trackway **24** is shown in FIGS. **4** and **5**. In order that all projectiles exit at the same angle of rotation for each turn of the impeller **12**, each projectile is fed to the trackway at precisely the same angle of rotation as prior and subsequent projectiles. The preferred curvature for the trackway **24** requires that a projectile **26** be fed preferably at 252° before the projectile leaves the trackway at the peripheral exit **28**. That is accomplished by means of an axial feed tube **54** (FIG. **4**) which rotates with the impeller **12**.

As shown in FIG. **1**, the upper end of the feed tube **54** communicates with a conduit **56** extending from the feed means **16** where the projectiles are stored in a hopper and fed by gravity or by mechanical means in alignment and into the tube **54**. A gate tube **58** is concentrically disposed around the feed tube **54** and is provided with an opening **60** having a size at least slightly greater than the diameter of a projectile **26**. Accordingly, as shown in FIG. **4**, as the projectiles **26** reach the lower end of the feed tube **54**, they roll radially outwardly over a curved surface **62** at the lower end of the tube and through an opening **64** in the gate tube **58** which opening is alignable with the opening **60**. The inner end of the trackway **24** comes into alignment with the aligned openings **60** and **64** upon each rotation of the impeller **12**. When the openings **60** and **64** are aligned, one projectile **26** moves by gravity into the trackway **24**. Accordingly, a single projectile **26** is fired over the trackway upon each rotation of the impeller.

In order to aim the gun in the desired direction, an aiming arm **66** (FIG. **1**) is provided at the upper end of the gun **10**, whereby the housing **18** as well as the tube gate **58** are rotated on the rotational axis of the impeller **12** to change the position of the opening **60** at the lower end of the gate tube. The aiming arm **66** provides for control of aiming on an azimuth with ease and rapid response. In addition, control of the range may be obtained by providing gun-mounting means (not shown) such as bearings or gimbals on an axis perpendicular to that of the shaft **20** in a conventional manner. Where gimbal mounting is used, both azimuth muth and range control of aiming is obtained in a manner conventional with machine guns, whereby the aiming arm is mounted in a fixed position of the housing.

Inasmuch as the position of the opening **60** determines the direction in which a projectile **26** is ultimately fired, the housing **18** is also rotated. As shown in FIG. **1** the housing **18** includes a cylindrical portion **68** which is provided with an arcuate opening **70** through which the projectiles **26** are fired. The purpose of the cylindrical portion **68** is a safety measure and serves no other function; it does not coact with the impeller **12** and trackway **24** for the purpose of firing the projectiles **26**.

As indicated the gate tube **58** remains stationary except for manual movement by the operator to position the opening **60** for aiming the gun. One projectile **26** per revolution enters the trackway **24**. Where two or more trackways **24** are provided in the impeller **12**, for increasing rate of fire and for balancing operation of rotation of the impeller, a projectile **26** is fed into each trackway as its inner end moves into alignment with the opening **60** of the gate tube **58**. For example, if two trackways are provided, two projectiles per revolution are fed into the impeller. Moreover, the projectile feed means **16** may be adapted to fire a projectile less often than one per revolution of the impeller, thereby reducing the power required without sacrificing projectile velocity. Once a projectile **26** enters the trackway it is fired because no means are provided for preventing its being fired. The angle at which the projectile is fired is controlled for following a target by turning the gate tube **58** to enable the projectile **26** to enter the impeller slightly earlier or later in the period of a single rotation.

For a better understanding of the device, reference is made to the following example:

EXAMPLE

Although the embodiment described and shown in the drawings is substantially disclosed schematically, a suggested design for purposes of illustration is intended for firing a spherical projectile of iron shot having a diameter of about 0.5 inch. This is approximately equivalent to the commonly used 50-caliber size shot. The spherical volume is 0.0655 in.^{3} and its weight is 0.0185 lb. The firing rate selected for illustration is about 6,000 rounds per minute. The gun will require 111 lbs. of shot of ammunition for each minute of continuous fire. The gun may be fired for at least 15 minutes without excessive heating.

The exit velocity selected for the defensive application is about 1,415 feet/second. The kinetic energy for each round is 575 foot-pound/second. At 100 rounds/sec., the power required to provide the kinetic energy alone is 105 hp. Because the ball or spherical projectile rolls on one surface of the track of the impeller, it also acquires a spin velocity. This increases its total energy by as much as 30 percent. The maximum spin velocity is 153,000 r.p.m.

The impeller is one of two necessary moving parts outside of the motor-drive subsystem or drive means **14**. It provides flywheel action (rotational inertia) to transfer kinetic energy through the ball with less than 0.1 percent variation in the rotation speed. A second rotor is provided to rotate in the opposite direction to cancel the gyroscopic reaction incurred when the weapon is turned at an angle to the plane of rotation to follow a target. ACcordingly, as shown in FIG. **1**, the shaft **61** is operatively connected to an impeller (not shown in the drawing) having a construction substantially equal to that of the impeller **12**. Thus, the gun is preferably a "double-barreled" weapon.

By proper shaping of the curve of the trackway **24** a spherical projectile **26** accelerates to at least 50 percent greater velocity than the peripheral speed of the impeller. The preferred diameter of the impeller **12** is about 3.82 feet. An impeller firing 6,000 shots per minute at 1,415 ft./sec. requires an engine of about 200 hp. such as a gas turbine which weighs approximately 300 lbs.

With the impeller rotating counterclockwise at 100 revolutions/second (6,000 revolutions/min.), a constant accelerating force of 652 pounds is applied to a spherical projectile having a diameter of 0.5 inch. The peripheral velocity of the impeller is 1,200 feet per second and the velocity of the projectile at the exit is 1,800 feet per second with an acceleration of 198,500 ft./sec.^{2}. The impeller rotates about 252° between the time the projectile enters the trackway and the time it exits which is 0.01 second later. In FIG. **2** the actual path of the projectile during its acceleration in the impeller is indicated by the broken line **44**. The spaced positions on the actual path are disposed at equal time intervals.

During operation of the gun some heat is generated due to friction between the impeller and the projectile. The heat generated in imparting the desired velocity to the projectile is substantially evaluated from the power input which is 74 B.t.u./sec. For an impeller having a diameter of 3.82 feet the impeller area is approximately 23 sq. ft. Assuming all of the heat is removed by air cooling using a 20° F. temperature rise the mass flow of air required for cooling is about 15.4 pounds per sec. Stator vanes **74** are provided within the housing **18**. Rotor vanes **76** are provided on the upper and lower surfaces of the impeller. The vanes **74** and **76** operate as centrifugal blowers for providing the necessary cooling air which will require an additional 16.8 hp.

The air is pulled by the vanes from the upper and lower sides of the impeller **12** as well as from the trackways **24** via a clearance space **75** between the periphery of the impeller and the housing. The air is then directed into a scroll-like portion **77** (similar to hydraulic turbines) of the housing **18**, from where it is exhausted.

The impeller drive means **14** includes the bevel gears **22** for the purpose of driving the impeller **12** as set forth above as well as a contrarotating impeller not shown at the lower end of the shaft **21**. In order to start the high-inertia impeller, a hydrodynamic drive may be used. This type of drive may be used to control speed up to ±10 percent of speed, maintaining a variation within 1 percent, and couple the power to the impeller with an efficiency of approximately 90 percent.

The power required for the gun **10** using the indicated parameters for the impeller in the spherical projectile having a diameter of 0.5 in., can be summarized for one impeller as follows:

105-hp. Kinetic energy
31-hp. Spin energy
102-hp. Loss (assuming 60 percent efficiency)
17-hp. Air-cooling
255-hp. Engine Drive

This power may be delivered at high horsepower to weight ratio and a high r.p.m. using a small gas turbine. The estimated total weight of the weapon system for the above unit is under 400 lbs.

The weapon in its simplest form consists of one moving part, the impeller. The preferred ammunition is a spherical steel ball. By suitable modifications to the gun, it is capable of firing at rates up to 12,000 rounds per minute with shot velocities up to 3,500 feet per second for shot having a size up to 35 mm.

Another embodiment of the invention is shown in FIGS. **6** and **7** in which feed means generally indicated at **78** replace the feed means **16** of the embodiment of FIG. **1**, and in which a pair of impellers **80** and **82** (FIG. **7**) are disposed in coplanar positions with respect to each other instead of coaxial positions as described for the embodiment of FIG. **1**. As shown in FIGS. **6** and **7** the housing **18** is modified to provide for a pair of circular housing portions **84** and **86** surrounding the impellers **80** and **82**, and for providing a projectile exit port **88** by which spherical projectiles **26** are shot from the gun. Thus, two streams of projectiles **26** are emitted when the gun is fired through the exit port **88**.

The feed means **78** which is identical for both impellers **80** and **82**, is described herein for the impeller **80** as shown in FIG. **6**. The means includes a hopper **90** where spherical projectiles **26** are stored over a rotatable thrower **92** which is a disc mounted on a driven axis connected to the drive means **14** by connecting drive shafts and bevel gears including a bevel gear **94**. The thrower **92** is synchronized to rotate one turn for each turn of the impeller **80**. A notch **96** is provided at the periphery of the thrower **92** so that as the notch passes through the lower portion of the hopper **90** a projectile **26** enters the notch and is brought to the lower position from where it is thrown to the right as viewed in FIG. **6**, and into the trackway **24** of the impeller **80**. The trackway in all other respects is constructed in a manner similar to that shown in FIG. **2**.

The hopper **90** includes a lower arcuate portion **98** on one side of the thrower **92** and an arcuate portion **100** on the other side of the thrower **92**. The lower end **102** of the hopper portion **98** is disposed above a surface **104** of the impeller **80** by a distance sufficient to permit clearance of a projectile **26** as it passes from the thrower **92** into the trackway **24**. The arrival of the projectile **26** as controlled by the thrower **92** is synchronized with the position of the inner end of the trackway **24** to enable the projectile to enter the trackway. If for any reason there is a misfire so that the projectile does not enter the trackway, the projectile which misfires passes upwardly through a clearance space **106** between a curved surface **108** of the impeller and the hopper portion **98**. Thus the misfired projectile **26** moves out of interference with subsequently delivered projectiles.

Operation of the feed means **78** is controlled by a manually operated lever **110** which is moved between the solid line position and a broken line position **112** as shown in FIG. **6**. An arcuate member **114** which in the firing position is disposed between the hopper portion **100** and the thrower **92** so that projectiles **26** are free to drop into the notch **96** as the filler rotates in the counterclockwise direction as indicated by the arrow **116**. When however the lever **110** is in the alternate position **112** the arcuate member **114** is disposed over the lower portion of the hopper **90** to prevent projectiles **26** from entering the notch **96**.

In operation the embodiment of the gun shown in FIGS. **6** and **7** is operated by filling the hoppers **90** with spherical projectiles **26**. The throwers **92** and the impellers **80** and **82** are then actuated and brought to operating speed. Firing is initiated by moving the lever **110** from the closed position **112** so that a projectile **26** is free to engage the notches **96** in the thrower **92**. A properly synchronized projectile **26** enters the trackway **24** of each impeller **80** and **82** and is accelerated thereby in the manner described with regard to the first embodiment, to an absolute speed that is approximately 50 percent greater than the peripheral velocity of the impeller under

constant acceleration the projectile is released at a constant angle of rotation of the impellers **80** and **82** and passed through the exit port **88** at the outer extremity of the trackways. The direction of firing is constant when the projectiles are inserted in the trackway with precise synchronization with the throwers **92**.

Accordingly the device of the present invention provides for a centrifugally operated rapidly firing mechanical gun which may use spherical or a nonspherical projectile as well as explosive or nonexplosive bullets. Moreover, although the apparatus is described as providing a centrifugally operated gun, the apparatus may also be used for sandblasting or metal peening with appropriate modifications.

It is understood that the above specification and drawings are merely exemplary and not in limitation of the invention.

What is claimed is:

1. Apparatus for firing a projectile by track-controlled radial and tangential accelerations utilizing centrifugal force, comprising a rotatable impeller having a center of rotation and a periphery, means for rotating the impeller, the impeller having a continuous trackway along which the projectile is propelled and which leads from the center of rotation to the periphery, the trackway having an outer concave section and an inner convex section adjacent to the center of rotation, the concave section facing the direction of rotation of the impeller and having a peripheral extremity extending into the direction of rotation of the impeller, there being a point of inflection between the convex and concave sections which point is nearer the center of rotation than the periphery, and means for feeding projectiles to the trackway at the center of rotation, whereby projectiles are emitted from the periphery of the trackway at velocities exceeding the peripheral velocity of rotation of the impeller.

2. The apparatus of claim **1** wherein the projectile-feeding means are intermittently operative for releasing projectiles into the trackway and includes means for controlling release of projectiles.

3. The apparatus of claim **1** wherein the outer end portion of the trackway is substantially a spiral.

4. The apparatus of claim **1** wherein the inner end portion of the trackway extends substantially radially.

5. The apparatus of claim **1** wherein the center of curvature of the concave section is on one side of the trackway and the center of curvature of the convex section is on the other side of the trackway.