July 11, 1944. T. J. DIETZ 2,353,150

BULLET SPINNING MACHINE

Filed April 23, 1943

Fig. 1.

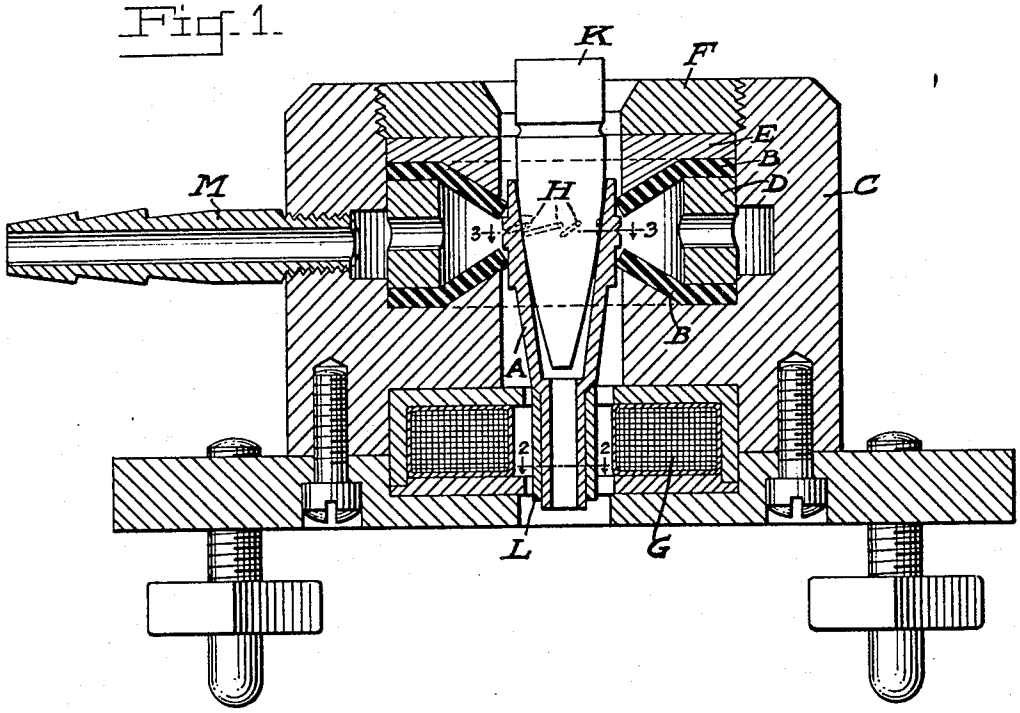


Fig. 2.

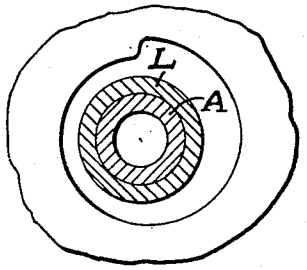


Fig. 3.

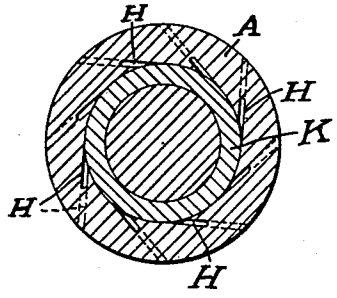
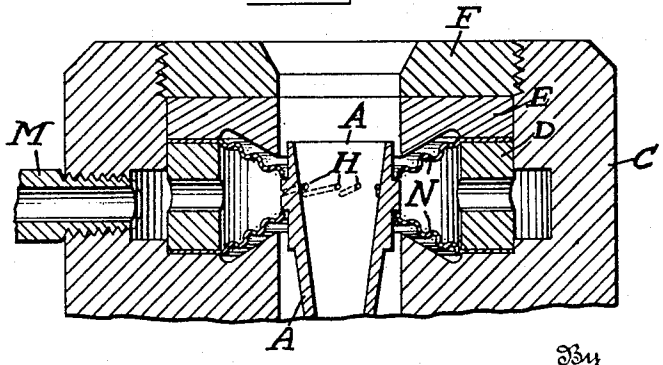


Fig. 4.



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2,353,150

BULLET SPINNING MACHINE

Thomas J. Dietz, Philadelphia, Pa.

Application April 23, 1943, Serial No. 484,319

6 Claims. (Cl. 73—53)

(Granted under the act of March 3, 1883, as amended April 30, 1928; 370 O. G. 757)

The invention described herein may be manufactured and used by or for the Government for governmental purposes without the payment to me of any royalty thereon.

This invention relates to a pneumatic device for the spinning of objects such as bullets of small-arms ammunition and artillery shells on an axis of symmetry, free of any mechanical thrust, under conditions such that the moment of inertia about the axis of rotation is less than that about another axis, especially a perpendicular axis.

A purpose of this invention is to spin at high speed on their geometric axis bullets of small-arms ammunition or artillery shells in order to separate the bullets or shells possessing less than an objectionable amount of dynamic unbalance from those dynamically unbalanced to an objectionable degree, so as to select dynamically balanced bullets or shells for special ammunition of high accuracy.

A further purpose is to spin at high speed on their geometric axis bullets of small-arms ammunition or projectiles of artillery ammunition as the basic feature of a dynamic unbalance gage of sufficient simplicity and ruggedness to be useful in routine inspection.

A further purpose is to spin at right speed on its geometric axis any substantially cylindrical object or assembly of such external dimensions that the moment of inertia about the axis of rotation is not as great as the moment of inertia about another axis, especially a perpendicular axis, so as to yield desirable information on dynamic unbalance.

A further purpose is to spin at high speed on their geometric axis, artillery shell fuses so as to permit study or routine inspection of the action of the arming pin at high rotational speed.

Further purposes will appear in the specifications and in the claims.

The present best use of the present invention appears to be in the selection of high grade bullets for small-arms ammunition, the selection being made on the basis of dynamical asymmetry about the geometric axis. A bullet which is dynamically asymmetrical about its geometric axis is considered to be dynamically unbalanced so that its axis of spin in flight is not coincident with its geometric axis. There is ample evidence to support the contention that the "spread" of a pattern of bullets fired at a target can be correlated with the amount of dynamic unbalance of the individual bullets. It is, therefore, important, when special accuracy of fire is required, that the bullets used be in substantial dynamic balance.

In the prior art the amount of dynamic unbalance of a bullet has been determined by placing the bullet in a sleeve or socket and then driving the sleeve or socket by an electric motor or by compressed air, and measuring the resulting vibrations of the rotating system. The motor driven system suffers from cumbersomeness and lack of sensitivity, while the air driven system is limited in its application by the necessity of spinning with its axis of rotation in a horizontal position. Attempts have been made by responsible investigators to spin .30 caliber bullets on compressed air with the axis of rotation in a vertical position without success. These attempts were based on the well-known principle of the diminution of pressure in the contracted portion of a stream, the classical example of which is the maintaining of a light weight ball in the air against the force of gravity by means of a jet of air directed vertically against the ball from below. The principle was adapted to the spinning of small top-like conical rotors by Henriot and Huguenard (Comptes rendus, 180: 1389, 1925) and later modified by Beams, Weed, and Pickels (Science 78: 338, 1933), and Beams (J. App. Phys. 8: 797, 1937).

In the prior art, the rotor is supported entirely on air and is driven by a set of obliquely directed air jets placed equi-distantly in a circle about the inside of a conical cup-like stator in which the rotor spins. The ring of jets is placed at a level which is approximately ⅔ of the vertical distance up from the vertex of the stator cone. As mentioned above, the rotor is also conical in shape so as to fit in the stator. However, the solid angle included within the rotor cone is greater than that of the cone of the stator by roughly from 5° to 10° so that when the system is at rest the rotor makes contact with the stator only at its periphery, or what would be, in other words, the base of the cone. When compressed air is supplied to the air jets, the rotor is lifted free of the stator and supported on a cushion of escaping air. The peripheral area of minimum clearance between rotor and stator then becomes a region within which the air reaches its highest velocity during escape producing the associated diminution in pressure mentioned above. This diminution of air pressure unbalances the force of atmospheric pressure so that it tends to force the spinning rotor deeper into the stator. This force, however, comes to equilibrium with the component being exerted upward by the positive pressure at the jets, and as a result, the rotor spins in a stabilized position.

The device of Henriot and Huguenard and Beams et al. is highly satisfactory for spinning rotors whose greatest moment of inertia is in the plane of rotation. However, the present inventor, as well as others, has found that this device as originally designed will not permit the spinning of rotors whose moment of inertia about the axis of rotation is substantially less than that about another axis, particularly a perpendicular axis, for reasons of instability.

The present inventor has discovered that the difficulties of the prior art of spinning cylindrical objects in an unstable position may be avoided by redesigning the stator and rotor so that the ring of jets coincides with the annular line of minimum clearance between rotor and stator. This is achieved by providing the rotor with an ellipsoidal (spherical is special case) surface in place of a conical surface as in the prior art. The elevation of the ring of driving air jets is adjusted to correspond to the ring of minimum clearance between the ellipsoidal surface of the rotor and the concave cone of the stator. Consequently, the positive pressure at the jets is bordered both above and below by zones of stabilizing diminished pressure resulting from the high velocity of the contracted stream of escaping air.

The alteration of position of maximum pressure and the counter-balancing by diminished pressure makes possible the spinning of rotors, such as bullets of small-arms ammunition, on a vertical axis which is the axis of revolution but not the axis of maximum moment of inertia. The geometry of the adjoining surfaces of rotor and stator are not limited to the case of the spheroidal rotor and the conical stator; these are presented to conform in text to the application of the invention to the spinning of bullets of small-arms ammunition or artillery shells. More generally, the adjoining surfaces of rotor and stator may be any pair of the class of surfaces of revolution known as quadrics, provided that when at rest the surfaces of rotor and stator make contact only at one right section and do not diverge so rapidly from annular line of contact as to destroy the zones of stabilizing diminished pressure adjacent to the air jets.

The accompanying drawing illustrates the details of embodiments of this invention and is diagrammatically correct as specified for the spinning of .30 caliber bullets.

In the drawing,

Fig. 1 is a vertical section through the central vertical axis of the device.

Fig. 2 is an enlarged section on the line 2—2 of Fig. 1, and also showing in plan a part of the sheath of the pick-up coil.

Fig. 3 is an enlarged section on the line 3—3 of Fig. 1.

Fig. 4 is a fragmentary illustration of Figure 1 showing the use of concentrically corrugated diaphragms of metal instead of diaphragms of rubber.

In the several views of the drawing, the same reference character indicates the same or corresponding part.

Referring more specifically to Figures 1, 2 and 3, the invention consists of the following necessary parts: a conical stator A containing any number, preferably an even number, of equi-distant, obliquely directed air jets H for spinning the bullets K; a pair of flexible diaphragms B to support the stator as well as carry the compressed air to the driving jets; and a housing and manifold C for completing the assembly.

The stator A is made of duralumin, to reduce inertia. When a record of the behavior of the spinning bullet is desired, the lower part of the stator is made of a magnetic material L such as steel and is supplied with a pick-up coil G, as shown in the drawing. The cone of the stator has an included angle of 15°, and is provided with a vent at its vertex. The diameter of the vent is not critical but .082" diameter or larger is desirable so as to avoid the possibility of creating a back pressure which would tend to force the bullet out of the stator. The driving air jets H may be of any number, but particularly the number may be 4, 8, or 16, depending upon the rate of acceleration desired. The diameter of the jets may be varied but preferably should not be less than .025" diameter. The center line of each jet is directed obliquely upward, making an angle of approximately 15° with the horizontal and making such an angle with a radial line as to be nearly tangent to the bullet at the point of contact on the ogive.

The flexible supports B in the drawing are made of rubber and are held in the position shown by means of the retaining ring D, the housing C, the backing washer E, and the threaded backing nut F. The supports B, are made of .065" thickness rubber of a standard tube stock, having a hardness (Shore A) of 38. The stator must be flexibly supported or the rotor will not spin but it is not necessary for the flexible supports to be constructed of rubber. The rubber diaphragms may be replaced by metal ones N, preferably made of phosphor bronze, as shown in Figure 4. The metal diaphragms should be thin and have concentric convolutions to improve flexibility.

The pick-up coil G consists of an iron encased coil of #38 enameled covered copper magnet wire having a D. C. resistance of approximately 1700 ohms. The armature of the pick-up coil is the steel tubular tail piece L on the stator which is permanently magnetized. Alternately the whole stator may be permanently magnetized.

The magnetized armature passes through the iron sheath of the pick-up coil as shown in the drawing and the hole through the bottom face of the iron sheath has a semi-circular enlargement so that any movement of the armature in a circular path will be detected by the pick-up coil. The output of the pick-up coil is of the order of 100 millivolts, and may be fed through an amplifier and studied on an oscilloscope.

In operation, compressed air to a stabilized pressure of 25 to 30 pounds per square inch is fed from inlet M into the manifold of the apparatus and a .30 caliber bullet is placed nose down in the conical cup of the stator A. The bullet will react in one of three ways to the torque of the impelling air, depending upon the degree of dynamic unbalance possessed. If it is badly unbalanced, for example, 0.1 gm. cm. or more, it will make a few revolutions and then will be ejected, automatically, from the stator. If the bullet is dynamically unbalanced to a degree less than 0.1 gm. cm., but more than 0.01 gm. cm., it will accelerate under the influence of the driving air until it reaches a speed of about 1200 R. P. S., equal to the critical frequency of the vibrating system, and then be ejected, automatically, from the stator. Finally, if the bullet is dynamically unbalanced to a degree less than 0.01 gm. cm., it will pass through the first critical speed and continue to spin indefinitely at a speed depending upon the torque of the air pressure applied.

The bullet may be ejected at will by momentarily closing the vent at the bottom of the stator.

In checking the dynamic balance of a number of .30 caliber bullets with this form of the apparatus, it was found that about 85 per cent of cupro-nickel jacket, standard length or brass jacket, boat-tail bullets would spin up to the first critical speed and of these, 20 per cent would pass through the critical speed without being ejected. In another group of steel jacket, standard length bullets, only 14 per cent would spin up to the first critical speed and of these only 2 per cent would traverse the first critical speed without being ejected.

It will be seen that the present invention provides means for differentiating between bullets of small-arms ammunition which are in reasonable dynamic balance from those which are dynamically unbalanced to an objectionable degree, that the means provided is readily applicable to the inspection of dynamic asymmetry of artillery shell bodies, and other cylindrical shapes.

Further, it will be seen that the present invention provides means for spinning cylindrically shaped objects such as artillery shell fuses in order to inspect the action of the arming pin.

In view of my invention and disclosure, variations and modifications will doubtless become evident to others skilled in the art, to obtain all or part of the benefits of my invention without utilizing the specific details of construction shown, and I, therefore, claim all variations and modifications insofar as they fall within the reasonable spirit and scope of my invention.

I claim:

1. A device of the character described comprising: a stator having an inner surface which is a quadric of revolution, of sufficient concavity to receive a rotor having a surface of revolution such that when rotor and stator are fitted together making contact, there can be but one right section of minimum clearance between the two, and for increasing deviation from this plane in either direction, the said surfaces being slowly, mutually, and increasingly divergent; jets carried by said stator and obliquely directed toward the rotor at the said section of minimum clearance; means by which the stator is flexibly supported; and means by which a gas under pressure may be conducted to the jets without objectionable reduction in flexibility of the stator.

2. A device of the character described comprising: a stator having an inner surface which is a quadric of revolution, of sufficient concavity to receive a rotor having a surface of revolution such that when rotor and stator are fitted together making contact, there can be but one right section of minimum clearance between the two, and for increasing deviation from this plane in either direction, the said surfaces being slowly, mutually, and increasingly divergent; jets in said stator substantially equidistantly placed and obliquely directed toward the rotor at the section of minimum clearance; means by which the stator is flexibly supported; and means by which a gas under pressure may be conducted to the jets without objectionable reduction in flexibility of the stator.

3. A device of the character described comprising: a stator having an inner surface which is a quadric of revolution, of sufficient concavity to receive a rotor having a surface of revolution such that when rotor and stator are fitted together making contact, there can be but one right section of minimum clearance between the two, and for increasing deviation from this plane in either direction, the said surfaces being slowly, mutually, and increasingly divergent; a number of small passages in said stator and obliquely directed toward the rotor at the section of minimum clearance; means by which the stator is flexibly supported; and means by which a gas under pressure may be conducted to the said passages without objectionable reduction in flexibility of the stator.

4. A device, according to claim 1, in which at least a part of the stator is permanently magnetized and adapted to act as the armature of a pick-up coil capable of converting the vibration of the stator to an electrical signal of varying electromotive force.

5. A device, according to claim 2, in which at least a part of the stator is permanently magnetized and adapted to act as the armature of a pick-up coil capable of converting the vibration of the stator to an electrical signal of varying electromotive force.

6. A device, according to claim 3, in which at least a part of the stator is permanently magnetized and adapted to act as the armature of a pick-up coil capable of converting the vibration of the stator to an electrical signal of varying electromotive force.

THOMAS J. DIETZ.

CERTIFICATE OF CORRECTION.

Patent No. 2,353,150. July 11, 1944.

THOMAS J. DIETZ.

It is hereby certified that error appears in the printed specification of the above numbered patent requiring correction as follows: Page 1, first column, line 27, for "right" read --high--; and that the said Letters Patent should be read with this correction therein that the same may conform to the record of the case in the Patent Office.

Signed and sealed this 29th day of August, A. D. 1944.

Leslie Frazer

(Seal) Acting Commissioner of Patents.