No. 24-1936

UNITED STATES COURT OF APPEALS
FOR THE FEDERAL CIRCUIT

TEVA BRANDED PHARMACEUTICAL PRODUCTS R&D, INC., NORTON (WATERFORD) LTD., and TEVA PHARMACEUTICALS USA, INC.,

Plaintiffs-Appellants,

v.

AMNEAL PHARMACEUTICALS OF NEW YORK, LLC, AMNEAL IRELAND LIMITED, AMNEAL PHARMACEUTICALS LLC, and AMNEAL PHARMACEUTICALS INC.,

Defendants-Appellees.

Appeal from the U.S. District Court
for the District of New Jersey
No. 23-cv-20964 (SRC), Judge Stanley R. Chesler

APPELLANTS' OPENING BRIEF

Daryl L. Wiesen
Christopher T. Holding
Louis L. Lobel
Jordan Bock
Thomas V. McTigue IV
GOODWIN PROCTER LLP
100 Northern Ave.
Boston, MA 02210
(617) 570-1000

William M. Jay
GOODWIN PROCTER LLP
1900 N Street, N.W.
Washington, DC 20036
(202) 346-4000

Natasha E. Daughtrey
GOODWIN PROCTER LLP
601 South Figueroa Street
Los Angeles, CA 90017
(213) 426-2642

July 30, 2024

PATENT CLAIM LANGUAGE

U.S. Patent No. 9,463,289

Claim 1: An inhaler for metered dose inhalation, the inhaler comprising:

a main body having a canister housing,

a medicament canister, which is moveable relative to the canister housing and retained in a central outlet port of the canister housing arranged to mate with a canister fire stem of the medicament canister, and

a dose counter having an actuation member having at least a portion thereof located in the canister housing for operation by movement of the medicament canister,

wherein the canister housing has an inner wall, and a first inner wall canister support formation extending inwardly from a main surface of the inner wall, and

wherein the canister housing has a longitudinal axis X which passes through the center of the central outlet port,

the inner wall canister support formation, the actuation member, and the central outlet port lying in a common plane coincident with the longitudinal axis X.

CERTIFICATE OF INTEREST

Counsel for Teva Branded Pharmaceutical Products R&D, Inc., Norton (Waterford) Ltd., and Teva Pharmaceuticals USA, Inc. (collectively "Teva" or "Plaintiffs"), certifies the following:

1. **Represented Entities.** Provide the full names of all entities represented by undersigned counsel in this case. Fed. Cir. R. 47.4(a)(1).

   Teva Branded Pharmaceutical Products R&D, Inc.; Norton (Waterford) Ltd.; and Teva Pharmaceuticals USA, Inc.

2. **Real Party in Interest.** Provide the full names of all real parties in interest for the entities. Do not list the real parties if they are the same as the entities. Fed. Cir. R. 47.4(a)(2).

   None

3. **Parent Corporations and Stockholders.** Provide the full names of all parent corporations for the entities and all publicly held companies that own 10% or more stock in the entities. Fed. Cir. R. 47.4(a)(3).

   Teva Branded Pharmaceutical Products R&D, Inc.: Teva Pharmaceutical Industries, Ltd.

   Norton (Waterford) Ltd.: Teva Pharmaceutical Industries, Ltd.

   Teva Pharmaceuticals USA, Inc.: Teva Pharmaceutical Industries, Ltd.

4. **Legal Representatives.** List all law firms, partners, and associates that (a) appeared for the entities in the originating court or agency or (b) are expected to appear in this court for the entities. Do not include those who have already entered an appearance in this court. Fed. Cir. R. 47.4(a)(4).

   Williams & Connolly LLP: Kathryn S. Kayali

   Walsh, Pizzi, O'Reilly, Falanga LLP: Liza M. Walsh, Selina M. Ellis, Hector D. Ruiz, Christine P. Clark

5. **Related Cases.** Provide the case titles and numbers of any case known to be pending in this court or any other court or agency that will directly affect or

be directly affected by this court's decision in the pending appeal. Do not include the originating case number(s) for this case. Fed. Cir. R. 47.4(a)(5).

Teva Branded Pharm. Prods. R&D, Inc. v. Deva Holding A.S., No. 2:24-cv-04404 (D.N.J. complaint filed March 29, 2024).

6. Organizational Victims and Bankruptcy Cases. Provide any information required under Fed. R. App. P. 26.1(b) (organizational victims in criminal cases) and 26.1(c) (bankruptcy case debtors and trustees). Fed. Cir. R. 47.4(a)(6).

Not applicable

Dated: July 30, 2024

/s/ *William M. Jay*
William M. Jay

Counsel for Appellants

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STATEMENT OF RELATED CASES

No appeal in or from the same civil action was previously before this or any other appellate court. There is one pending case that will be directly affected by this court's decision in the instant appeal: *Teva Branded Pharm. Prods. R&D, Inc. v. Deva Holding A.S.*, No. 2:24-cv-04404 (D.N.J. complaint filed March 29, 2024).

TABLE OF ABBREVIATIONS

Abbreviation	**Description**
’712 patent	U.S. Patent No. 8,132,712
’289 patent	U.S. Patent No. 9,463,289
’587 patent	U.S. Patent No. 9,808,587
’808 patent	U.S. Patent No. 10,561,808
’889 patent	U.S. Patent No. 11,395,889
Amneal	Defendants-Appellees Amneal Pharmaceuticals of New York, LLC, Amneal Ireland Limited, Amneal Pharmaceuticals LLC, and Amneal Pharmaceuticals Inc.
ANDA	Abbreviated New Drug Application
Asserted Patents	’712, ’289, ’587, ’808, and ’889 patents, collectively
FDA	United States Food and Drug Administration
FDCA	Federal Food, Drug, and Cosmetic Act
FTC	United States Federal Trade Commission
Listing Statute	21 U.S.C. § 355(b)(1)(A)(viii)
MDI	Metered dose inhaler
NDA	New Drug Application
Orange Book	*Approved Drug Products with Therapeutic Equivalence Evaluations*
ProAir HFA	ProAir® HFA (albuterol sulfate) Inhalation Aerosol
PTE	Patent term extension
Teva	Plaintiffs-Appellants Teva Branded Pharmaceutical Products R&D, Inc., Norton (Waterford) Ltd., and Teva Pharmaceuticals USA, Inc.

INTRODUCTION

This is an appeal from an injunction ordering the appellants (collectively "Teva") to delist five patents from FDA's Orange Book. A drug product patent must be listed in the Orange Book for a specific NDA (*i.e.*, a brand-name product) if the patent "claims the drug for which the applicant submitted the application." 21 U.S.C. § 355(b)(1)(A)(viii)(I). The patents at issue are listed as drug product patents that claim Teva's metered dose inhaler ("MDI") product, ProAir® HFA (albuterol sulfate) Inhalation Aerosol ("ProAir HFA"). Without doing any claim construction, the district court granted judgment on the pleadings to the defendants (collectively "Amneal") and ordered the patents removed from the Orange Book. It held that the patents do not claim the drug product for which they are listed because they do not *expressly recite* the active ingredient.

The district court's decision misapplies settled law making clear what it means to "claim" a product: if the patent reads on the drug product, it "claims the drug" as the statute uses that phrase. Put another way, because making, offering, or selling the drug product entails making, offering, or selling the patented invention, the patent must be listed for the drug product. There is no magic-words requirement in claim construction—much less one that justifies *dispensing* with claim construction. The district court's statutory interpretation likewise disregards the applicable statutory definition of the term "drug," which includes not just any "article" that

treats an illness or affects the body's functioning, but also any "component" of such an "article." 21 U.S.C. § 321(g)(1)(B)-(D).

Affirming the district court's decision would shrink the Orange Book dramatically. It would require the delisting of any patent claiming a genus of active ingredients; claiming a novel inactive ingredient or dosage form; or even claiming one of multiple active ingredients, even though each of these patents "claims the drug" as those terms have long been understood and each would be infringed by selling an unauthorized copy. FDA's rulemaking expressly contemplates that patents claiming a "dosage form" will be listed in the Orange Book, and identifies "metered aerosols" like those at issue here as one example of a "dosage form." Nothing in the statute justifies the district court's abrupt departure from settled law and practice.

The district court's injunction should be reversed and this litigation allowed to proceed as an ordinary Hatch-Waxman case. Even if the district court's narrow view of a listable patent were correct, its injunction would still be premature. The court opined that none of the patents "claims the drug" under the Listing Statute, but it never did the claim construction necessary to determine, as a matter of patent law, what each of these patents actually claims.

STATEMENT OF JURISDICTION

The district court entered its injunction on June 10, 2024. Appx24-40. Teva timely appealed on June 11, 2024. Appx1534-1535. The district court had jurisdiction under 28 U.S.C. §§ 1331, 1338(a), 2201, and 2202. This Court has appellate jurisdiction under 28 U.S.C. § 1292(a)(1) and (c)(1).

STATEMENT OF THE ISSUES

1. Whether the statutory requirement to list in the Orange Book any patent that "claims the drug for which the applicant submitted [an NDA] and is a drug product (formulation or composition) patent" excludes drug product patents unless they recite, by name, the active ingredient in the drug product.

2. Whether the district court properly assessed that the five patents at issue do not claim the drug for which the applicant submitted the application without conducting any claim construction.

STATEMENT OF THE CASE

I. Statutory And Regulatory Scheme

A. Drug Applications Under The Hatch-Waxman Act

The FDCA implements a detailed scheme for the manufacture, sale, and labeling of prescription drugs. To market a new drug in the United States, a company must submit an NDA to FDA for approval. *See* 21 U.S.C. § 355(a)-(b). Among other information, the NDA must detail the composition of the drug and attach scientific data demonstrating that the drug is safe and effective. *Id.* § 355(b)(1), (d);

see also Caraco Pharm. Lab'ys, Ltd. v. Novo Nordisk A/S, 566 U.S. 399, 404-05 (2012) (summarizing regulatory scheme).

After FDA has approved an NDA, another company may apply to market a generic version of that drug pursuant to the Hatch-Waxman Act. *See* Drug Price Competition and Patent Term Restoration Act of 1984, Pub. L. No. 98-417, 98 Stat. 1585. The Hatch-Waxman Act allows "a generic competitor to file an abbreviated new drug application (ANDA) piggy-backing on the brand's NDA." *Caraco*, 566 U.S. at 404-05. Rather than provide "independent evidence of safety and efficacy," the generic manufacturer can instead show "that the generic drug has the same active ingredients as, and is biologically equivalent to, the brand-name drug." *Id.* at 405; *see also* 21 U.S.C. § 355(j)(2)(A)(ii), (iv).

B. A Patent Must Be Listed In The Orange Book If It "Claims The Drug"

"Because the FDA cannot authorize a generic drug that would infringe a patent, the timing of an ANDA's approval depends on the scope and duration of the patents covering the brand-name drug." *Caraco*, 566 U.S. at 405. "To facilitate the approval of generic drugs as soon as patents allow, the Hatch-Waxman Amendments and FDA regulations direct brand manufacturers to file information about their patents," which FDA publishes in a volume known as the "Orange Book." *Id.* at 405-06; 21 C.F.R. § 314.53(e). Specifically, the brand manufacturer "shall submit":

> the patent number and expiration date of each patent for which a

> claim of patent infringement could reasonably be asserted if a person not licensed by the owner of the patent engaged in the manufacture, use, or sale of the drug, and that –
>
> (I) claims the drug for which the applicant submitted the application and is a drug substance (active ingredient) patent or a drug product (formulation or composition) patent; or
>
> (II) claims a method of using such drug for which approval is sought or has been granted in the application.

21 U.S.C. § 355(b)(1)(A)(viii) (the "Listing Statute"). FDA regulations mirror this provision, requiring applicants to submit to FDA certain information "for each patent that claims the drug … that is the subject of the NDA … and with respect to which a claim of patent infringement could reasonably be asserted if a person not licensed by the owner of the patent engaged in the manufacture, use, or sale of the drug product." 21 C.F.R. § 314.53(b)(1) (further requiring that "such patents consist of drug substance (active ingredient) patents, drug product (formulation and composition) patents, and method-of-use patents").

The FDCA expressly defines the term "drug" as:

> (A) articles recognized in the official United States Pharmacopoeia, official Homeopathic Pharmacopoeia of the United States, or official National Formulary, or any supplement to any of them; and (B) articles intended for use in the diagnosis, cure, mitigation, treatment, or prevention of disease in man or other animals; and (C) articles (other than food) intended to affect the structure or any function of the body of man or other animals; and (D) articles intended for use as a component of any article specified in clause (A), (B), or (C).

21 U.S.C. § 321(g)(1). Thus, the statute expressly defines "drug" to include not just

the active ingredient, but the entirety—specifically including any "component"—of any "article[]" used for the "treatment[] or prevention of disease" or to "affect … any function of the body," for example. *Id.* § 321(g)(1)(B), (C), (D). It is undisputed that this definition applies "[f]or the purposes of" the entire FDCA, including the Listing Statute. *Id.* § 321; *see* Appx1219 n.3 (Amneal recognizing the same).

For "drug product (formulation or composition) patents," FDA regulations require "the applicant [to] submit information only on those patents that claim the drug product, as is defined in § 314.3, that is described in the pending or approved NDA." 21 C.F.R. § 314.53. The cross-referenced regulation, in turn, defines "drug product" as "a finished dosage form, e.g., tablet, capsule, or solution, that contains a drug substance, generally, but not necessarily, in association with one or more other ingredients." *Id.* § 314.3. And "dosage form" is defined as "the physical manifestation containing the active and inactive ingredients that delivers a dose of the drug product." *Id.*[1] Patents on packaging cannot be listed; patents claiming the "dosage form," by contrast, must be listed. "The key factor is whether the patent being submitted claims the finished dosage form of the approved drug product." 68 Fed. Reg. 36,676, 36,680 (June 18, 2003).

[1] "This includes such factors as: (1) The physical appearance of the drug product; (2) The physical form of the drug product prior to dispensing to the patient; (3) The way the product is administered; and (4) The design features that affect frequency of dosing." 21 C.F.R. § 314.3.

FDA expressly categorizes metered aerosols as a dosage form. *Id.* As FDA has explained, "drug delivery systems used and approved in combination with a drug"—a category that includes "metered dose inhalers"—are distinguishable from the type of "packaging and containers" that are not properly listed in the Orange Book. *Id.* Metered aerosols are therefore included in the Orange Book's list of current dosage forms for approved drug products. Orange Book, Appendix C, at C-1 (44th ed. 2024).

FDA has described its "patent listing role" as "ministerial." 68 Fed. Reg. 36,676, 36,683 (June 18, 2003) (noting that courts have upheld the agency's "determination that [its] role with respect to patent listing is ministerial"). In the agency's view, it lacks both the "expertise" and the "authority" to engage in any substantive review of submitted patents, and is therefore ill-equipped to review patents or assess patent challenges associated with listing decisions. *Id.*

An ANDA applicant that seeks approval to market a drug before the expiration of the patents listed in the Orange Book must take one of several steps to inform FDA that its proposed generic drug will not infringe the listed patents. *Caraco*, 566 U.S. at 406-07; *see also H. Lundbeck A/S v. Lupin Ltd.*, 87 F.4th 1361, 1365 (Fed. Cir. 2023). If the ANDA applicant believes that a listed patent "is invalid or will not be infringed by the manufacture, use, or sale of the new drug for which the application is submitted," the applicant may submit what is known as a "Paragraph

IV" certification. 21 U.S.C. § 355(j)(2)(A)(vii)(IV).[2] The filing of a Paragraph IV certification allows a brand manufacturer immediately to sue the ANDA filer for infringement, paving the way for infringement to be "determined by traditional patent infringement analysis" at the same time that FDA is completing its review of the ANDA. *H. Lundbeck*, 87 F.4th at 1365 (quoting *Warner-Lambert Co. v. Apotex Corp.*, 316 F.3d 1348, 1365 (Fed. Cir. 2003)); *see also* 35 U.S.C. § 271(e)(2)(A); *Caraco*, 566 U.S. at 407 ("The patent statute treats such a [Paragraph IV] filing as itself an act of infringement, which gives the brand an immediate right to sue."). Assuming the brand files suit within 45 days of receiving notice of the ANDA filing, the FDA generally may not approve the ANDA until either the court finds the patent invalid or not infringed, or 30 months pass. *See* 21 U.S.C. § 355(j)(5)(B)(iii).

Under 21 U.S.C. § 355(j)(5)(C)(ii), an ANDA applicant sued for patent infringement "may assert a counterclaim seeking an order requiring the holder to correct or delete the patent information submitted by the [NDA] holder … on the ground that the patent does not claim … the drug for which the application was approved." 21 U.S.C. § 355(j)(5)(C)(ii)(I); *see Caraco*, 566 U.S. at 404-05, 408-09 (discussing this statutory provision). The statute is clear that delisting must be asserted as a counterclaim, and not as an independent cause of action. *See* 21 U.S.C.

[2] Alternatively, the applicant can submit a "section viii" statement, "which asserts that the generic manufacturer will market the drug for one or more methods of use not covered by the brand's patents." *Caraco*, 566 U.S. at 406.

§ 355(j)(5)(C)(ii)(II). An ANDA holder asserting a delisting counterclaim must plausibly allege that each asserted patent "does not claim … the drug" for which the NDA was approved. *Id.* § 355(j)(5)(C)(ii)(I).

II. Procedural History

Teva holds the approved NDA for ProAir HFA. *See* Appx350-356 (Approval Letter for NDA No. 021457). ProAir HFA "is a pressurized metered-dose aerosol unit with a dose counter"; its active ingredient is albuterol sulfate. Appx649.[3] ProAir HFA is indicated for the treatment or prevention of bronchospasm in patients four years of age and older with reversible obstructive airway disease and for the prevention of exercise-induced bronchospasm in patients four years of age and older. Appx642-643.

FDA classifies MDIs like ProAir as "single-entity combination products," meaning a drug and a device "combined or mixed and produced as a single entity." FDA, *Frequently Asked Questions About Combination Products* (Aug. 16, 2022) ("FDA, *Combination Product FAQ*"), *available at* https://bit.ly/3Y4IPSG. Where, as here, the primary mode of action for an MDI is attributable to the drug, FDA regulates the MDI as a drug. *See* 21 U.S.C. § 353(g)(1). FDA thus approved ProAir® HFA, including the inhaler, under the statute and regulations governing NDAs.

[3] "HFA" refers to the propellant used in the MDI.

There are nine unexpired patents in the Orange Book for ProAir HFA. Each is listed as a drug product patent. Appx810.

In August 2023, Amneal notified Teva that it had submitted an ANDA for a purported generic version of ProAir HFA ("Amneal ANDA Product"). Appx916-917. The ANDA included Paragraph IV Certifications for the nine unexpired patents listed in the Orange Book. Appx916. In its letter to Teva, Amneal asserted that it did not infringe the patents listed for ProAir HFA, but did not suggest that any of them were invalid. Appx921-952.

Teva brought suit within 45 days of receiving Amneal's notice letter, initially asserting six of the listed patents. The filing of the suit created a 30-month stay on FDA approval of Amneal's ANDA that would expire in February 2026.[4] *See* 21 U.S.C. § 355(j)(5)(B)(iii).

After further reviewing Amneal's ANDA, Teva amended its complaint, narrowing the asserted patents to five: U.S. Patent Nos. 8,132,712 ("the '712 patent"), 9,463,289 ("the '289 patent"), 9,808,587 ("the '587 patent"), 10,561,808 ("the '808 patent"), and 11,395,889 ("the '889 patent") (collectively, "the Asserted Patents"). Appx56. Amneal counterclaimed for an injunction compelling Teva to

[4] Another generic company, Deva Holding A.S. ("Deva"), has likewise submitted an ANDA with a Paragraph IV certification to the same patents. Teva timely filed a separate suit against Deva, No. 2:24-cv-04404 (D.N.J.), creating a 30-month stay on FDA approval of Deva's ANDA product as well.

delist the Asserted Patents from the Orange Book, *see* 21 U.S.C. § 355(j)(5)(C)(ii)(I). Teva moved to dismiss those counterclaims and the District Court allowed Amneal to move for judgment on the pleadings on those counterclaims under Rule 12(c), even though Teva had not yet answered the counterclaims.[5] FTC moved to file an amicus brief in the case, which the district court granted. Appx1264-1273.

The district court granted judgment on the pleadings for Amneal and entered an injunction ordering Teva to delist the Asserted Patents. Appx24-40. The district court agreed both that the Asserted Patents claim a "drug" under the relevant statutory definition, and further that the subject of Teva's NDA is "ProAir® HFA (albuterol sulfate) Inhalation Aerosol." Appx34-35. The court nonetheless ordered the patents delisted because "they do not claim 'the drug for which the applicant submitted the application,' … ProAir® HFA (albuterol sulfate) Inhalation Aerosol." Appx39-40.

While the district court acknowledged that the word "claims" should be given its meaning under patent law, it found "confusing"—and rejected—Teva's argument that "a patent 'claims' a product if the patent would be infringed by the product." Appx37. The court concluded that "a patent claims *only* that subject matter that it has particularly pointed out as the invention, and no more." *Id.* Thus, rather than

[5] Amneal asserted additional counterclaims beyond the scope of this appeal.

"all products that are infringing," the district court thought, a patent "claims" only products that are expressly recited in the claims of the patent. *See id.*

The court did not engage in any claim construction, but nonetheless concluded that, applying this understanding of "claims," the Asserted Patents "do not claim or even mention albuterol sulfate or the ProAir® HFA." Appx36. The district court alternated between stating that the claims must recite the active ingredient and stating that the claims must recite the full product itself. *Compare* Appx35 ("It is undisputed that no claim in any of the Inhaler Patents discloses albuterol sulfate."), *with* Appx37 (explaining the "Inhaler Patents plainly do not regard an 'albuterol sulfate HFA Inhalation Aerosol' as that which was invented," and therefore "do not claim the drug for which the applicant submitted the NDA application"). The district court's ultimate position appeared to be that, to claim "the drug for which the applicant submitted the application" in this case, the patent would have to recite "albuterol sulfate HFA Inhalation Aerosol." Appx33, Appx38. The court also briefly held that the Asserted Patents were listed as patents on a "drug product," *i.e.*, a "finished dosage form," but "do not claim the 'finished dosage form' that is the subject of [the] NDA" because they do not claim the drug that is the subject of the NDA. Appx38-39.

Teva appealed the injunction. The parties both sought expedited consideration, and Teva moved to stay the injunction pending this appeal. This

Court expedited the appeal and stayed the district court's order "until further notice of this court." The case is proceeding in the district court on Teva's underlying infringement case. The parties have submitted claim-construction positions but the court has not yet held a *Markman* hearing.

SUMMARY OF ARGUMENT

I. A. A patent must be listed in the Orange Book if, among other requirements, it "claims the drug for which the applicant submitted the application." 21 U.S.C. § 355(b)(1)(A)(viii). The verb "claims" is a well-established term of art in patent law. As this Court has long recognized, a patent's claims set the "metes and bounds" of the property rights conferred by the patent. *Corning Glass Works v. Sumitomo Elec. U.S.A., Inc.*, 868 F.2d 1251, 1257 (Fed. Cir. 1989). And the scope of this property right is determined by whether the claim limitations "read on"—*i.e.*, are "found in"—the invention at issue. *See Allen Eng'g Corp. v. Bartell Indus., Inc.*, 299 F.3d 1336, 1344 (Fed. Cir. 2002). Save for a few narrow exceptions not relevant here, a patent "claims" a product if making, using, or selling that product would infringe the patent. *Envirotech Corp. v. Al George, Inc.*, 730 F.2d 753, 759 (Fed. Cir. 1984). Critically, a patent need not read on the entirety of a product to "claim[]" the product. *SunTiger, Inc. v. Sci Rsch. Funding Grp.*, 189 F.3d 1327, 1336 (Fed. Cir. 1999). Nor, in the case of pharmaceuticals, must a patent recite the active ingredient by name in order to claim the drug—a patent claiming a genus of

compounds reads on a drug whose active ingredient is one species within the genus.

Applying these noncontroversial principles, this Court has held that a patent "claims the drug for which the applicant submitted the application"—and therefore "must be listed"—"if it contains a product claim that reads on the drug that is the subject of the NDA." *Apotex, Inc. v. Thompson*, 347 F.3d 1335, 1343-44 (Fed. Cir. 2003). Put slightly differently, "[t]he listing decision thus requires what amounts to a finding of patent infringement, except that the 'accused product' is the drug that is the subject of the NDA." *Id.* Consistent with this approach, this Court has consistently described the listing decision as a "question of patent law," explaining again just last year that the listing inquiry "involves asking the question 'what does the patent claim,'" which "should be derived using the tools and framework of patent law, including claim construction." *Jazz Pharms., Inc. v. Avadel CNS Pharms., LLC*, 60 F.4th 1373 (Fed. Cir. 2023). FDA likewise regards the listing decision as turning on patent law: that is why the agency has consistently emphasized that, given "its acknowledged lack of expertise," it takes only a "ministerial" role in administering the listing determination. *Am. Bioscience, Inc. v. Thompson*, 269 F.3d 1077, 1080, 1084 (D.C. Cir. 2001).

The phrase "claims the drug" in the Listing Statute must also be interpreted based on the express statutory definition of "drug," 21 U.S.C. § 321(g)(1). As relevant here, the term includes not just "(B) articles intended for use in

the … mitigation, treatment, or prevention of disease" or (C) "to affect … any function of the body," but also "(D) articles intended for use as a component of any article specified in" clauses (B) and (C). *Id.* § 321(g)(1). Thus, the term "drug" covers the entirety of the drug product and any component thereof—not just the active ingredient. *See id.* This definition reflects that a patent is listable so long as it claims aspects of the drug product, regardless of whether those aspects include the active ingredient. In other words, a patent "claims [a] drug" if it reads on any aspect of the drug product, such that making, offering, or selling the drug product encompasses making, offering, or selling the patented invention.

B. The Listing Statute requires the patent at issue to specifically "claim[] the drug for which the applicant submitted the application." 21 U.S.C. § 355(b)(1)(A)(viii). Here, there is no dispute that the ProAir HFA inhaler product is the drug that is the subject of the NDA at issue. Appx350-356. The statutory scheme treats combination products like ProAir HFA as drug products where—as is the case with ProAir HFA—the product's "primary mode of action" is that of a drug. 21 U.S.C. § 353(g)(1)(D)(i). Applying this definition, FDA has long classified both MDIs and the dose counters for MDIs as drugs under the FDCA. Appx1418-1419. There is likewise no dispute that the Asserted Patents read on ProAir HFA. Each of the Asserted Patents has claims directed to components that are found in ProAir HFA, and Amneal has not alleged otherwise. The Asserted Patents therefore must

be listed.

The district court came to a contrary conclusion only by interpreting "claims the drug" as "recites" or "mentions" the drug—which, it appears, might mean either recites the active ingredient or recites the drug as a whole, including every component. That approach has no basis in patent law, and would entirely upend the listing scheme. Rather than rely on this Court's caselaw, the district court relied on two out-of-circuit decisions—one that supports *Teva* and one that is wrong. First, while the district court relied heavily on *United Food & Commercial Workers Local 1776 v. Takeda Pharmaceutical Co.*, 11 F.4th 118 (2d Cir. 2021), the Second Circuit held, precisely as Teva argues here, that the scope of what a patent "claims" must be determined through an infringement-type analysis. *Id.* at 132. The district court separately relied on *In re Lantus Direct Purchaser Antitrust Litigation*, 950 F.3d 1 (1st Cir. 2020), but the First Circuit failed to consider the well-established patent-law meaning of the term "claims," instead equating "claims" with "mentions."

At a minimum, the district court could not rule in Amneal's favor without conducting any claim construction. While the Listing Statute does not require that Teva's patents claim the active ingredient, they in fact do incorporate the active ingredient—as Teva would have established had it been provided an opportunity to do so. At a minimum, then, this Court should remand the case to the district court to engage in claim construction.

II. The Asserted Patents are "drug product (formulation or composition) patent[s]," and therefore must be listed. 21 U.S.C. § 355(b)(1)(A)(viii). A "drug product" patent is simply a patent that claims a "drug product," as opposed to a "drug substance (active ingredient)" or a method of using the drug. 21 C.F.R. § 314.53(B)(1). FDA defines a "drug product" as a "finished dosage form, e.g., tablet, capsule, or solution, that contains a drug substance, generally, but not necessarily, in association with one or more other ingredients." 21 C.F.R. § 314.3. And metered aerosols are expressly listed as a "finished dosage form" in the Orange Book. Because the Asserted Patents claim an MDI, they are properly listed as "drug product" patents.

At a minimum, the district court again could not resolve this issue absent claim construction. In other words, even if a "drug product" patent must, as Amneal suggested, claim an active ingredient, the district court could not decide whether *these* patents claim the active ingredient in ProAir HFA merely by skimming the claims to look for the word "albuterol."

III. Listing the Asserted Patents furthers the goals of the Hatch-Waxman Amendments—namely, to facilitate a scheme that allows the parties to obtain patent certainty *before* the launch of a drug, thereby supporting the development of both brand and generic medicines. By contrast, the district court's approach would lead to significant uncertainty and risk. Without the listing scheme, many more

infringement disputes would be resolved only *after* launch of a generic product, including preliminary injunction proceedings, a post-launch jury trial, and an award of money damages. And absent the Orange Book, the launching company might not even know which patents its generic product might infringe, leaving it in the dark as to the size and magnitude of any risk. That scenario is precisely what Congress was trying to avoid through the Hatch-Waxman Amendments.

STANDARD OF REVIEW

The proper interpretation of the Listing Statute is a legal question subject to de novo review. *See Power Integrations, Inc. v. Semiconductor Components Indus., LLC*, 926 F.3d 1306, 1313 (Fed. Cir. 2019) ("Statutory interpretation is an issue of law that [the Court] review[s] de novo."); *Hoechst-Roussel Pharms., Inc. v. Lehman*, 109 F.3d 756, 758 (Fed. Cir. 1997) (this Court decides "the meaning of the statutory term 'claims' … with independence from the trial court's interpretation").

ARGUMENT

The Listing Statute obligates NDA sponsors to list each patent that (1) "claims the drug for which the applicant submitted the application" and, as relevant here, (2) is "a drug product (formulation or composition) patent." 21 U.S.C. § 355(b)(1)(A)(viii). Those requirements create both a ceiling and a floor: a patent either *must* be listed or *may not* be listed. This appeal turns on the meaning of those

requirements.[6]

Questions of statutory interpretation "begin 'with the language of the statute.'" *Power Integrations*, 926 F.3d at 1314 (quoting *Kingdomware Techs., Inc. v. United States*, 579 U.S. 162, 171 (2016)). The "first step is to determine whether the language at issue has a plain and unambiguous meaning with regard to the particular dispute in the case." *Id.* (quoting *Barnhart v. Sigmon Coal Co.*, 534 U.S. 438, 450 (2002)) (internal quotation marks omitted). Where a statute "employs a term of art," the meaning of that term must reflect that Congress "presumably kn[ew] and adopt[ed] the cluster of ideas that were attached" to the word when including it in the statute. *FAA v. Cooper*, 566 U.S. 284, 292 (2012). That is particularly true of patent-law terms whose meaning has been settled by "a substantial body of law" from this Court. *Helsinn Healthcare S.A. v. Teva Pharms. USA, Inc.*, 586 U.S. 123, 130 (2019).

"If the statutory language is unambiguous and 'the statutory scheme is coherent and consistent … [t]he inquiry ceases.'" *Kingdomware Techs.*, 579 U.S. at 171 (citation omitted) (alteration in original). That is the case here. The Asserted Patents read on ProAir HFA, and ProAir HFA is "the drug for which the applicant

[6] Amneal's counterclaims do not challenge whether the Asserted Patents are ones "for which a claim of patent infringement could reasonably be asserted if a person not licensed by the owner of the patent engaged in the manufacture, use, or sale of the drug." *E.g.*, Appx320-323 (¶¶ 134-164). As noted above, Amneal's Paragraph IV notice letter did not assert that any of the Asserted Patents is invalid.

submitted the application." Thus, the Asserted Patents "claim the drug for which the applicant submitted the application." The first clause is therefore satisfied. So is the second, requiring "a drug product (formulation or composition) patent." A "drug product" includes "finished dosage forms," and, as the Orange Book itself recognizes, "metered aerosols" are "dosage forms." The Asserted Patents are thus "drug product" patents under the Listing Statute, and the Asserted Patents are properly listed.

The district court disagreed, alternatively requiring that the patent recite the active ingredient, or perhaps the full scope of the NDA drug. This approach cannot be squared with either the text of the Listing Statute or the extensive caselaw addressing, in particular, the meaning of "claims." The district court's decision would also upend the listing scheme for a host of patents—not only for combination products like ProAir, but also for many patents long deemed properly listed, including genus claims that claim every species without mentioning any of them. The listing decision is a question of patent law, not a word-search exercise that is satisfied only if a patent claim expressly states certain terms. This Court should reverse.

I. The Asserted Patents Claim ProAir HFA, The Drug For Which Teva Submitted Its Application.

A. A patent "claims [a] drug" under the Listing Statute if it "reads on" the drug product or its components.

1. "Claims" is a term of art in patent law.

The term "claims" is "peculiar to patent law." *Markman v. Westview Instruments, Inc.*, 517 U.S. 370, 374 (1996). Patent claims "particularly point out and distinctly claim the subject matter which the applicant regards as his invention." *Corning Glass Works v. Sumitomo Elec. U.S.A., Inc.*, 868 F.2d 1251, 1258 (Fed. Cir. 1989) (citation and alterations omitted); *see also Oak Tech., Inc. v. Int'l Trade Comm'n*, 248 F.3d 1316, 1329 (Fed. Cir. 2001) ("Claims claim."). The claim limitations thus establish the "metes and bounds of the right which the patent confers." *Corning Glass*, 868 F.2d at 1257-58. As a result, a patent "claims" a product if it "reads on" that product. *Apotex, Inc. v. Thompson*, 347 F.3d 1335, 1343-44 (Fed. Cir. 2003); *see also Allen Eng'g Corp. v. Bartell Indus., Inc.*, 299 F.3d 1336, 1344 (Fed. Cir. 2002) (scope of the patent right determined by whether "each of the claim limitations 'reads on,' or in other words is found in, the accused device").

The scope of what a patent "claims" is effectively coterminous with the products that infringe a patent.[7] If a product falls within a patent's claims,

[7] They are not perfectly coterminous mainly because of the doctrine of equivalents: sometimes an accused product can infringe by equivalents even if the claims do not

"infringement is normally made out." *Envirotech Corp. v. Al George, Inc.*, 730 F.2d 753, 759 (Fed. Cir. 1984). Thus, to determine whether a product infringes a patent, the claims must typically "be 'read on' the accused structure to determine whether each of the limitations recited in the claim is present in the accused structure." *Corning Glass*, 868 F.2d at 1258.

Critically, a patent can "claim" a drug or a drug product without claiming the entirety of the product. This Court has "never required that a claim read on the entirety of an accused device in order to infringe." *SunTiger, Inc. v. Sci. Rsch. Funding Grp.*, 189 F.3d 1327, 1336 (Fed. Cir. 1999) (citing cases). Rather, "[i]f a claim reads merely on a part of an accused device, that is enough for infringement." *Id.* That is because (for example) making or selling the accused device is making or selling every element of the patented invention, even if that invention is embodied in a larger unit for sale. *See id.* ("It is fundamental that one cannot avoid infringement merely by adding elements if each element recited in the claims is found in the accused device." (citation omitted)); *accord, e.g.*, *JVW Enters., Inc. v. Interact Accessories, Inc.*, 424 F.3d 1324, 1333-34 (Fed. Cir. 2005) ("limitation need only read on part of" a device for the device to infringe); *Abbott Lab'ys v. Sandoz, Inc.*, 566 F.3d 1282, 1299 (Fed. Cir. 2009) (even a "small amount" of patented substance in defendants' products could result in literal infringement).

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read on the product.

To be sure, the wording of the claim language matters, and some types of claims—*e.g.*, those using closed language to identify the claimed invention as "consisting of" certain elements, and no others—might need to identify the entire product to infringe. *See, e.g.*, Manual of Patent Examining Procedure § 2111.03(II) (discussing "consisting of" phrase). But claims that use open language require no such result. It is black-letter law that a composition of matter "comprising" certain elements may have other elements as well. *See, e.g.*, *CIAS, Inc. v. All Gaming Corp.*, 504 F.3d 1356, 1360 (Fed. Cir. 2007) ("comprising" means "including but not limited to"). Thus, any composition of matter containing *at least* those elements "reads on" the "comprising" claim, and making, selling, or offering any composition of matter containing at least those elements without permission infringes.

Even putting that aside, there is no question that a patent can claim a drug without explicitly reciting the active ingredient by name. That is precisely the case with genus patents. In any number of cases, the patentee has claimed a *class* of substances, without claiming any particular active ingredient by name. *See, e.g.*, *In re Omeprazole Patent Litig.*, 536 F.3d 1361, 1365-66 (Fed. Cir. 2008) (patent directed to an "acid-labile pharmaceutically active substance"). Likewise, claims based on particular novel attributes of the formulation or composition will often claim the active ingredient generically as part of the drug product. *See, e.g.*, *Indivior Inc. v. Dr. Reddy's Lab'ys, S.A.*, 930 F.3d 1325, 1349-50 (Fed. Cir. 2019) ("a desired

amount of at least one active" in a matrix, plus "a particulate active substantially uniformly stationed in the matrix"); *id.* at 1350 (product comprising "an analgesic opiate pharmaceutical active" plus a water-soluble polymer component).

There is similarly no dispute that, for a product with multiple active ingredients, a patent can claim the product without naming *all* of the active ingredients. In other words, a patent for one active ingredient can claim a product with multiple active ingredients. *See, e.g.*, *Novartis Corp. v. Teva Pharms. USA, Inc.*, 565 F. Supp. 2d 595, 600 n.5 (D.N.J. 2008) (Hatch-Waxman challenge involving combination product with multiple active ingredients where brand listed patents for individual actives). In that scenario, too, the patent claims the drug even though no claim recites the full set of active ingredients.

2. Binding precedent establishes that a patent "claims" the NDA product if it "reads on" that product.

Applying these principles to the Listing Statute, this Court held that a patent "claims the drug for which the applicant submitted the application"—and therefore "must be listed"—"if it contains a product claim that reads on the drug that is the subject of the NDA." *Apotex*, 347 F.3d at 1343-44. As this Court explained, "[t]he listing decision thus requires what amounts to a finding of patent infringement, except that the 'accused product' is the drug that is the subject of the NDA." *Id.*[8]

[8] The precise question in *Apotex* was whether certain patents were properly listed under a previous version of 21 U.S.C. § 355(c)(2), which requires an NDA holder to

That holding controls here: the question whether the Asserted Patents "claim[] the drug" requires conducting an infringement-type analysis, where the "offending" product is the NDA drug. *Id.*

In line with this holding, this Court has repeatedly described the listing decision as a "question of patent law," meaning that ordinary claim-construction principles determine what a patent claims—and that there is more to the analysis than whether a claim name-checks the active ingredient or the drug. *Id.* at 1343. In *Apotex*, for example, an ANDA applicant argued that a set of patents were not properly listed in the Orange Book because they did not claim "the drug that was the subject of the … NDA." *Id.* at 1339. In determining that it (rather than a regional circuit) had jurisdiction, this Court explained that the question whether a patent claims a drug is an "issue[] of patent law." *Id.* at 1344. This Court came to the same conclusion in *Hoechst-Roussel Pharmaceuticals v. Lehman*, 109 F.3d 756, 760 (1997), confirming that "claims" in the patent term extension ("PTE") statute, 35 U.S.C. § 156, should be given its "well-known meaning and usage in the patent

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list qualifying patents that issue after an NDA has already been approved. *Apotex*, 347 F.3d at 1338. That subsection has since been amended to simply refer to the Listing Statute, *see* 21 U.S.C. § 355(c)(2) (directing the holder of an approved NDA to list "a patent described in subsection (b)(1)(A)(viii)" that "is issued after the date of approval of an application"), but the version at the time of *Apotex* required the holder of an approved NDA to list any patent that "claims the drug for which the application was submitted." *Apotex*, 347 F.3d at 1351. The Court was thus asked to interpret the same "claims the drug" phrase that is at issue here.

law."[9]

And just last year, this Court expanded on these decisions in *Jazz Pharmaceuticals, Inc. v. Avadel CNS Pharmaceuticals, LLC*, 60 F.4th 1373 (Fed. Cir. 2023), an appeal reviewing an injunction that, like this one, directed an NDA holder to delist a patent. *Id.* at 1378. The Court rejected the brand company's argument that the delisting question could be resolved without reference to patent law, as well as its broader point "that patent law does not provide the correct framework for determining whether a patent should be listed in the Orange Book." *Id.* at 1379. Rather, the Court explained, "analyzing a patent" to determine whether it was properly listed in the Orange Book "involves asking the question, 'what does the patent claim,'" which "should be derived using the tools and framework of patent law, including claim construction." *Id.*; *see also Biogen Int'l GmbH v. Mylan Pharms. Inc.*, 18 F.4th 1333, 1336 (Fed. Cir. 2021) (noting that "[i]f a patent that *covers* the brand-name drug has not expired, the generic-drug manufacturer may file what is known as a paragraph IV certification") (emphasis added).

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[9] The PTE statute provides that the "term of a patent which *claims* a product, a method of using a product, or a method of manufacturing a product shall be extended in accordance with this section from the original expiration date of the patent" in specified circumstances. 35 U.S.C § 156(a). But unlike the Listing Statute, which uses the FDCA's definition of "drug" (including "components" thereof), *see infra*, pp. 28-30, the PTE statute specifically defines "product" so as to limit it to "the active ingredient of" a drug. 35 U.S.C. § 156(f)(1)(A), (f)(2). In *Hoechst*, the asserted patent claimed a metabolite rather than the active ingredient, and therefore did not "claim[]" the drug as the PTE statute uses the latter term. *Id.* at 759 n.3.

Other circuits have likewise recognized that the listing statute requires resort to substantive patent law. Most relevant here, in *Teva Pharmaceuticals USA, Inc. v. Leavitt*, 548 F.3d 103 (D.C. Cir. 2008), the D.C. Circuit described the Listing Statute as "requir[ing] NDA holders to ascertain if, *under substantive patent law*, any patents claim the drugs for which the NDA holder submitted an application." *Id.* at 106 (emphasis added).

These decisions confirm that whether a patent "claims" a drug is not merely a question whether the patent recites the drug or its active ingredient. If it were, there would be no need to resort to "the tools and framework of patent law," *Jazz*, 60 F.4th at 1379, or apply "substantive patent law," *Leavitt*, 548 F.3d at 106. A court could simply look for the name of the drug or the name of the active ingredient in the patent's claims, and that would be the end of the matter.

FDA, too, treats the listing decision as a matter of patent law. "[P]ursuant to longstanding practice and its own regulations, and based on its acknowledged lack of expertise and resources," FDA "has refused to become involved in patent listing disputes, accepting at face value the accuracy of NDA holders' patent declarations and following their listing instructions." *Am. Bioscience, Inc. v. Thompson*, 269 F.3d 1077, 1080 (D.C. Cir. 2001); *see also Apotex*, 347 F.3d at 1347 (explaining that FDA's "duties with respect to Orange Book listings are purely ministerial"). In the 1994 final rule governing ANDAs, FDA stated no fewer than eight times that it

"lacks patent law expertise" and has a "lack of expertise in patent matters." 59 Fed. Reg. 50,338, 50,344, 50,345 (Oct. 3, 1994). The agency therefore leaves it to the applicant to make the listing determination. *Id.* at 50,344; *see also Am. Bioscience*, 269 F.3d at 1084 (noting that the agency "administers the Hatch-Waxman Amendments in a ministerial fashion simply following the intent of the parties that list patents").

For this approach to make sense, the listing decision must require the application of the tools of patent law—*i.e.*, claim construction. If the listing criteria simply turned on whether a patent recited an active ingredient or a brand name, there would be no need for an interpretation of the claim, and likewise no need for patent expertise. FDA's drug-related expertise would allow it to review the text of patent claims to determine whether the name of the active ingredient was recited. But "FDA officials" have explained that "the brand name sponsor is responsible for evaluating whether a patent meets the requirements for listing" precisely because "doing so requires an interpretation of the claim, which can be the subject of litigation." U.S. Gov't Accountability Off., *GAO-23-105477*, *Generic Drugs: Stakeholder Views on Improving FDA's Information on Patents* 23 (Mar. 2023), https://bit.ly/4dcVPtR. FDA's decision to abstain from the listing process confirms that the scope of what a patent "claims" requires the application of patent law to the patents at issue.

3. A "drug" includes all components thereof.

The statutory definition of "drug" includes not just the active ingredient, but the entirety of the drug product and any component thereof. Thus, a patent that claims a portion, or "component," of the drug product claims the "drug" and must be listed.

The FDCA gives the term "drug" an express—and expansive—definition. To start, because the FDCA "includes an explicit definition" of "drug," that definition controls, "even if it varies from [that] term's ordinary meaning." *Digital Realty Tr., Inc. v. Somers*, 583 U.S. 149, 160 (2018) (citation omitted). And that definition includes not just "(B) articles intended for use in the … mitigation, treatment, or prevention of disease," but also "(D) articles intended for use as a component of any article specified in" clause (B). 21 U.S.C. § 321(g)(1). The latter clause ensures that the term "drug" will reach the entirety (any "component") of any drug product (any "article[]" used to treat disease). *Id.* § 321(g)(1)(B), (D). Thus, as FDA has explained, for "drug product" patents like these, what matters is whether the patents "claim the drug product … that is described in the pending or approved NDA." 21 C.F.R. § 314.53(b)(1).

This aspect of the statute ensures that patents are listable if they claim aspects of the drug product, whether or not those aspects include the active ingredient. The Listing Statute recognizes as much: it provides that a patent can "claim the drug"

whether it is a "drug substance (active ingredient) patent or a drug product (formulation or composition) patent." 21 U.S.C. § 355(b)(1)(A)(viii).

But to be listable, a patent must "claim the drug," not something else. Thus, for example, FDA has determined that patents claiming intermediates used in the manufacturing process, or patents claiming metabolites formed in the body after taking the drug, are not listable, because neither an intermediate nor a metabolite is present in the finished drug product. Intermediates are considered "to be 'in-process materials' rather than drug substances or components in the finished drug product." 68 Fed. Reg. 36,676, 36,680-81 (June 18, 2003). Likewise, a "metabolite exists only after the approved drug has been broken down inside the body," so "a patent claiming a metabolite does not claim the approved drug, as required by the act." *Id.* at 36,680. FDA's clarification that patents on intermediates and metabolites are not listable would be unnecessary if the Listing Statute covered only patents that recite the active ingredient. In other words, FDA needed to distinguish intermediates and metabolites because patents otherwise claiming components of an approved drug product *are* listable in the Orange Book.

Thus, in sum, a patent "claims [a] drug" if it reads on any aspect of the drug product, such that making, offering, or selling the drug product encompasses making, offering, or selling the patented invention.

B. The Asserted Patents claim the drug ProAir HFA.

The Listing Statute asks not just whether a patent claims *a* drug, but whether it "claims the *drug for which the applicant submitted the application*." 21 U.S.C. § 355(b)(1)(A)(viii) (emphasis added). Here, there is no dispute that the subject of the NDA at issue is ProAir HFA (albuterol sulfate) Inhalation Aerosol. Appx350-356 (Approval Letter for NDA No. 021457). ProAir HFA is therefore "the drug for which the applicant submitted the application," and the object of the "claims" analysis.

Below Amneal argued that Teva's position is incorrect because the Listing Statute requires that the patent "claim *the drug* for which the applicant submitted the application," and not what it described as a device component of a drug product. But as the governing statutory and regulatory scheme makes clear, ProAir is a drug, as are its component pieces, and the Asserted Patents therefore *do* claim "the drug" for which Teva submitted its application.

1. Combination products like ProAir HFA are drugs.

To start, ProAir HFA is regulated and approved as a "drug" even though it includes both drug and device components, and is therefore a "combination product." Combination products "constitute a combination of a drug, device, or biological product." 21 U.S.C. § 353(g)(1)(A). As relevant here, "single-entity combination products" are those "comprised of two or more regulated components,

i.e., drug/device … that are physically, chemically, or otherwise combined or mixed and produced as a single entity." 21 C.F.R. § 3.2(e); *see also* FDA, *Combination Product FAQ*. FDA has identified MDIs like ProAir as single-entity combination products. *Id.* Combination products are regulated either as a drug or as a device. 21 U.S.C. § 353(g)(1).

A product that combines a drug and device is regulated as a drug where, as here, the combination product meets the definition of "drug." *Id.*; *see also Genus Med. Techs. LLC v. FDA*, 994 F.3d 631, 640 (D.C. Cir. 2021) (describing the regulation of "combination products"). Specifically, the statute directs FDA to "determine the primary mode of action of the combination product," 21 U.S.C. § 353(g)(1)(D), and the agency defines "mode of action" as "the means by which a product achieves an intended therapeutic effect or action," 21 C.F.R. § 3.2(k). While combination products typically have multiple modes of action, *id.*, the FDA identifies "the single mode of action of a combination product expected to make the greatest contribution to the overall intended therapeutic effects of the combination product." 21 U.S.C. § 353(g)(1)(C), (D). If FDA determines that this "primary mode of action" is that of a drug, then the product is regulated as a drug. *Id.* § 353(g)(1)(D)(i).

FDA has long classified MDIs as drug-device combination products for which "the primary mode of action … is attributable to the drug component." Appx1418.

In its 1993 Reviewer Guidance for Nebulizers, Metered Dose Inhalers, Spacers and Actuators, FDA explained that "an aerosol delivery device will be considered a drug product … when the primary purpose of the device is delivering or aiding in the delivery of a drug and the device is distributed with the drug." Appx1052. There is no dispute that MDIs meet this standard, and are therefore regulated as drugs under the Act—as FDA recognized again in 2020. Appx1418.

The same is true for dose counters, which are components of some MDIs that "count the number of doses administered by an MDI and display" that information to the patient. Appx1419. Dose counters are typically "designed to fit a specific MDI, and labeled for use with a specific MDI," and are therefore components of combination products. *Id.* And because FDA has determined that the "primary mode of action" for MDIs is "attributable to its drug component," dose counters are likewise regulated under the drug provisions of the FDCA. *Id.*[10]

2. The Asserted Patents read on ProAir HFA.

There is no dispute that making, offering, or selling ProAir HFA or an exact

[10] Notably, the definition of "drug" previously specified that it "does not include devices or their components, parts, or accessories." 21 U.S.C. § 321(g) (1988); *see also United States v. Article of Drug, Bacto-Unidisk*, 394 U.S. 784, 789 (1969) ("a 'device' expressly cannot be a 'drug' under the last phrase of the drug definition"). But Congress amended the statute in 1990 to remove that exclusion. Safe Medical Devices Act of 1990, Pub. L. No. 101-629, § 16(b)(1), 104 Stat. 4511, 4526 (striking out "but does not include devices or their components, parts or accessories"). These amendments highlight that the current definition of drug includes components of devices that are part of the approved drug.

duplicate would infringe the Asserted Patents if done without the patent owner's authorization. In its 330-paragraph counterclaims, Amneal never alleges that the Asserted Patents do not read on ProAir HFA. Nor could it. Two of the Asserted Patents—the '289 and '587 patents—have claims directed to "[a]n inhaler for metered dose inhalation, the inhaler comprising," among other components, "a medicament canister." *See, e.g.*, Appx140 (claim 1 of the '289 patent) (21:34-37); Appx172 (claims 1, 12, and 13 of the '587 patent) (21:34-37, 22:25-28, 22:49-52). A third patent has claims directed to "[a] metered dose inhaler comprising a medicament canister." *See, e.g.*, Appx109 (claim 16 of the '712 patent) (10:27-28). The remaining patents have claims directed to the dose counter that FDA reviewed and approved as part of ProAir HFA's finished dosage form—specifically, "[a]n incremental dose counter for a metered dose inhaler having a body arranged to retain a canister for movement of the canister relative thereto," Appx237 (claim 1 of the '889 patent) (21:34-36), and "[a] dose counter for an inhaler, the dose counter having a counter display arranged to indicate dosage information," Appx205 (claim 1 of the '808 patent) (21:34-35). Each of these claims "reads on"—*i.e.*, is "found in"—ProAir HFA, "a pressurized metered-dose aerosol unit with a dose counter," Appx649. Amneal has not alleged otherwise.

C. The district court's cramped interpretation is inconsistent with both the Listing Statute and current practice.

1. The district court's interpretation cannot be squared with the statutory text or the overall statutory scheme.

The contours of the district court's decision are not clear. At a minimum, the district court appeared to believe that a patent must expressly recite the active ingredient in the claims in order to qualify as a patent that "claims the" NDA product. In deciding that the Asserted Patents were not properly listed, the district court emphasized "that no claim in any of the Inhaler Patents discloses albuterol sulfate." *See* Appx35; *see also* Appx36 (repeating that the Asserted Patents "do not claim or even mention albuterol sulfate").[11]

Other statements, however, suggest that the decision is even narrower, and requires that a patent recite every aspect of a drug (active ingredients, inactive ingredients, excipients, etc.). The district court stated, for example, that to claim "the drug for which the applicant submitted the application," the patent has to recite "albuterol sulfate HFA Inhalation Aerosol." Appx38. The FTC appeared to take this same position in its amicus brief—*i.e.*, that a patent only "claims" the drug if it explicitly mentions the active ingredient or the name of the drug product. Appx1282-1283, Appx1288, Appx1294-1297. "In the FTC's view, device patents

[11] Among other ambiguities, it is not clear whether the district court would treat a patent that claims a single active ingredient as claiming "the drug" if the NDA product has multiple active ingredients. *See supra*, pp. 23-24.

that do not mention any drug in their claims do not meet the statutory criteria for Orange Book listing …" Appx1282.

This approach requires the patent to claim far more than the active ingredient; HFA is the propellant (an excipient), and there are additional excipients in the formula. Under this approach, only a claim with limitations explicitly directed to every part of the drug product would satisfy the opinion—a dramatic narrowing of the scope of the Listing Statute. It is well-accepted that a patent need not claim all of a drug product's excipients, let alone claim them by name, to be listed. *See, e.g.*, *Cadence Pharms. Inc. v. Exela PharmSci Inc.*, 780 F.3d 1364, 1369 (Fed. Cir. 2015) (Hatch-Waxman litigation involving claims covering only a subset of excipients, and even then only as a general class of, *e.g.*, "buffering agents"). But under the district court's approach, a patent in this category would not recite the drug, and therefore would not be properly listed. While it is not clear which of those readings the district court intended, both are incorrect. Either one of those readings is completely inconsistent with the Listing Statute, including both the long-settled meaning of "claims" and the express definition of "drug." As explained at length above, a patent "claims" a product if it "reads on" the product; there is no requirement that a patent claim every aspect of a product, nor is there a requirement that it expressly recite either the active ingredient or the entirety of the drug. *See supra*, pp. 21-26.

While the district court ostensibly agreed that "the word 'claims' in the Listing

Statute 'should be given its meaning under patent law,'" Appx37, it never applied this meaning. The district court never addressed this Court's holding in *Apotex* that the "listing decision … requires what amounts to a finding of patent infringement," and that "a patent must be listed if it contains a product claim that reads on the drug that is the subject of the NDA." 347 F.3d at 1344. Nor did it cite this Court's explanation that the listing decision turns on "the tools and framework of patent law, including claim construction." *Jazz*, 60 F.4th at 1379. The district court's decision is thus entirely divorced from the meaning of "claims" in patent law.

Notably, the district court's interpretation renders part of the statute surplusage. The Listing Statute requires NDA sponsors to list *both* any "drug substance (active ingredient) patent" *and* any "drug product (formulation or composition) patent." 21 U.S.C. § 355(b)(1)(A)(viii)(I). Construing the "claims the drug" clause to limit listable patents to those that recite the active ingredient would render superfluous the separate requirement to list patents that claim the active ingredient. If patents are listable only if they claim the active ingredient, then the category of "drug substance (active ingredient) patent[s]" would be subsumed entirely into the category of "drug product" patents. *See Facebook, Inc. v. Windy City Innovations, LLC*, 973 F.3d 1321, 1336 (Fed. Cir. 2020) ("[T]he canon against surplusage is strongest when an interpretation would render superfluous another part of the same statutory scheme.") (quoting *Marx v. Gen. Revenue Corp.*, 568 U.S. 371,

386 (2013)). So too with the district court's even more aggressive interpretation suggesting that a patent must claim the drug product in its entirety: if that were the correct interpretation, a drug substance patent (one claiming only the active ingredient) would not even be *listable* because it would not claim the entire "drug." By making clear that both a "drug substance" patent and a "drug product" patent can "claim the drug" in the long-settled patent-law sense, the statute squarely refutes the district court's reading.

2. The district court's cited authority does not support narrowing "claims" to "recites."

The district court relied primarily on two out-of-circuit decisions from the First and Second Circuits, but they do not support adopting the district court's unduly narrow interpretation. The Second Circuit decision strongly supports Teva's position, and the decision from the First Circuit is entirely unmoored from patent law.

As an initial matter, both of the cited decisions were antitrust cases, not patent cases, which is why they were appealed to regional circuits. Various plaintiffs have asserted that NDA sponsors have listed patents in the Orange Book that were ineligible for listing, and have argued that submitting these listings is a violation of the antitrust laws. In considering those claims, courts that do not routinely address patent-related issues have interpreted the Listing Statute. This Court is plainly not bound by those interpretations—nor would it be even if this case had arisen from

one of those circuits, because this Court does not follow regional circuit interpretations of patent law. Rather, this Court should follow the settled understanding of patent law as reflected in the Listing Statute, including its own precedent.

a. The district court simply misread the first of the regional circuit cases, *United Food & Commercial Workers Local 1776 v. Takeda Pharmaceutical Co.*, 11 F.4th 118 (2d Cir. 2021). In rejecting Teva's reading of "claims" as "reads on," the district court claimed to be following *United* in stating that "a patent claims *only* that subject matter that it has particularly pointed out as the invention." Appx37. But the Second Circuit introduced no such disjunction between claiming and infringement. The district court seized on the Second Circuit's unremarkable statement that "patent claims 'are the numbered paragraphs which particularly point out and distinctly claim the subject matter which the applicant regards as his invention.'" *United*, 11 F.4th at 132 (quoting *Corning Glass*, 868 F.2d at 1258); *see* 35 U.S.C. § 112(b). But the remainder of the cited paragraph makes clear that the Second Circuit adopted the same approach Teva proposes here. After the quoted discussion, the Second Circuit proceeded to explain—invoking this Court's caselaw, including *Apotex*—that the claims set the boundaries "of the right which the patent confers": "By extension, a patent 'claims' an invention 'when each of the claim limitations "reads on," or in other words is found in,' the invention." 11 F.4th at 132

(quoting *Allen Eng'g Corp.*, 299 F.3d at 1345); *see id.* (quoting the reference to "reads on the drug" from *Apotex*, 347 F.3d at 1343-44). In other words, a patent claims any product that falls within the bounds of the claim—a determination that must be made through an infringement-type analysis. *See id.* That is precisely what should have happened here.

The district court also misread *United*'s discussion of the relationship between "claims," "reads on," and infringement. *United*, 11 F.4th at 132-33. *United* involved combination patents that required the presence of two active ingredients—but the brand listed those patents in the Orange Book for a drug product *that included only one* of the two. As the Second Circuit recognized, "a combination patent, in general, does not 'claim' its constituent parts." *Id.* at 124, 131. Because the relevant claims in the listed combination patents were "broader than and different from the scope of" the NDA drug, which contained only one of the two constituent parts, the claims did not "read on" the drug—and therefore did not "claim[]" it. *Id.* at 132. In other words, a two-active-ingredient patent does not read on a one-active-ingredient drug. And "permitting a brand manufacturer to list a patent as 'claiming the drug' when it does not read on that drug" would be inconsistent with the Listing Statute. *Id.* at 135; *see id.* at 132 (discussing why metabolite patents are not listable because they do not read on the drug); 68 Fed. Reg. at 36,680 (same); *supra*, pp. 21-26. Thus, the Second Circuit's analysis in no way suggests that "claims" requires an explicit

recitation of the active ingredient or the drug.

The brand in *United* tried to argue for a different reading of "claims," one broader than "reads on." First, it argued that the one-active-ingredient generic would be *used* in combination with other products, together resulting in infringement of the combination. The Second Circuit correctly observed that such an argument would require a method claim—a patent that "claims a method of using [the] drug," not a patent that "claims the drug" at all. *Id.* at 133-34. Second, the brand argued that "claims the drug" had to mean something *more* than "reads on the drug" to avoid redundancy with the "Infringement Clause" (*i.e.*, "and with respect to which a claim of patent infringement could reasonably be asserted if a person not licensed by the owner engaged in the manufacture, use, or sale of the drug"). *Id.* at 133. In other words, in the brand's view, "because *any* unauthorized use of a patent that reads on the drug will *ipso facto* infringe the patent, 'claims the drug' must mean something other than 'reads on the drug' in order to avoid surplusage alongside the Infringement Clause." *Id.* But as the Second Circuit explained, "reads on the drug" and "infringement could reasonably be asserted" are not exactly the same thing,[12] so there is no need to vary the well-established meaning of "claims the drug" to avoid

[12] The doctrine of equivalents means that sometimes infringement can be asserted against a product even if the patent does not read on it; invalidity means that sometimes infringement *cannot* reasonably be asserted against a product even if the patent *does* read on it. *See, e.g.*, 11 F.4th at 133-34 & n.15.

surplusage. Nothing in the Second Circuit's reasoning—holding that "claims" is no *broader* than "reads on"—justifies the district court's view that "claims" is *narrower* than "reads on."[13]

b. In addition to *United*, the district court relied heavily on another out-of-circuit antitrust decision, *In re Lantus Direct Purchaser Antitrust Litigation*, 950 F.3d 1 (1st Cir. 2020). *Lantus* involved a claim that a patent was improperly listed for the drug insulin glargine if it claimed aspects of the "SoloSTAR" disposable injector pen used to deliver an accurate dose of the drug. *Id.* at 5. As the First Circuit explained, the challenged patent "contain[ed] ten claims, all concerning aspects of a 'drive mechanism' that serves as a part of the SoloSTAR drug injector pen." *Id.* This "drive mechanism" enabled "the administration of medicinal products from a pen injector's cartridge." *Id.* In holding that the patent at issue was not properly listed, the court concluded that if a patent "do[es] not *mention* the drug for which the sNDA was submitted, the patent does not 'claim the drug'" under the Listing Statute. *Id.* at 8.

[13] While this Court stated in *Hoechst*, *see supra*, p. 25 & n.9, that "the plain meaning of 'claims' is not the same as the plain meaning of infringement," that statement referred to the possibility of infringement by the doctrine of equivalents. 109 F.3d at 759 & n.2. Here, the drug product is within the metes and bounds of Teva's claims, and the district court's decision thus had nothing to do with the doctrine of equivalents. Rather, the district court insisted the drug was not claimed because the active ingredient was not named—in contrast to the well-established understanding of claims. *See supra*, pp. 21-26.

Lantus is both wrong and inapposite. As with the district court's decision here, it is not clear whether the First Circuit would limit the Listing Statute to patents that recite the active ingredient or patents that recite the entire drug product. *See, e.g.*, *id.* at 6 (noting that the "patent does not mention insulin glargine or the Lantus SoloSTAR at any point"). Regardless, the First Circuit failed to engage with the well-established patent-law meaning of the term "claims." The *Lantus* decision simply equates "claims" with "mentions," with no discussion of what it means for a patent to "claim[]" a product. *Id.* at 8 ("It therefore follows that because the claims of the '864 patent do not *mention* the drug for which the [application] was submitted, the patent does not 'claim the drug' …") (emphasis added).

Significantly, the First Circuit never grappled adequately with the statutory definition of the term "drug," including the clause that extends it to "components" of the drug product. Although the court acknowledged that definition and that it applies to the Listing Statute, *id.* at 9, the court thought that Congress had to *repeat* the word "components" in the Listing Statute if it wanted patents on components to be listable. *Id.* ("[T]he absence of any mention of 'components' in the provisions setting out which patents should be filed cuts against any attempt to interpret the statute and its implementing regulations as requiring or allowing listing of patents that claim only components of a proposed drug."). But that simply misunderstands the purpose of a statutory definition: Congress gave "drug" a four-part definition

that applies *throughout the FDCA*, *see* 21 U.S.C. § 321, precisely so that it would not have to repeat the entire specialized definition every time it used the defined term. The specialized definition applies every time without the need for repetition. *See, e.g.*, *Digital Realty*, 583 U.S. at 160. A patent "claims the drug," as defined, if it claims a "component of any article specified" in the other three clauses of the "drug" definition. *Id.* § 321(g)(1).

Even putting that aside, however, *Lantus*'s reasoning is inapplicable by its own terms to Teva's claims directed to the *entire* inhaler product. The patent at issue in *Lantus* did "not include a claim for an injector pen more broadly," but rather "mention[ed] that the drive mechanism is intended for use in a 'drug delivery device.'" *Lantus*, 950 F.3d at 8. In concluding that the patent was not listable, the First Circuit emphasized that though the patent "claims a device intended for use in an injector pen, it does not claim any injector pen." *Id.* The court saw "nothing in the statute or regulations … whereby an integral part of an injector pen becomes the pen itself, and in turn is a drug." *Id.* Here, however, three of the Asserted Patents plainly claim the entire inhaler, *see supra*, pp. 33-34, and thus claim the equivalent of the injector pen—precisely what the court in *Lantus* thought was missing. 950 F.3d at 7-8 (emphasizing that the patent "d[id] not claim any injector pen," much less the SoloSTAR "for which the [application] was submitted"). If there were any doubt about the scope of Teva's patents, the proper course was to carry out claim

construction *before* granting Amneal relief and ordering the patents delisted, as discussed further in the next section.

3. At a minimum, the district court erred in ruling for Amneal on the pleadings, without claim construction.

Although the district court appears to have relied primarily on the notion that the statute requires an *express* reference to the active ingredient, the court's decision elsewhere appears to assume—and Amneal argued—that Teva's patents do not claim either the active ingredient or the finished dosage form. While the statute, correctly construed, contains no such requirement, at a minimum the district court could not conclude that Teva's patents all *fail* that requirement without claim construction. Instead the district court granted Amneal judgment on its counterclaims at the earliest possible moment—before Teva had even answered the counterclaims. That was error.

The Asserted Patents do in fact incorporate the active ingredient. As described in Teva's proposed claim constructions—which are still being briefed in the district court—each patent has a claim term that requires incorporation of an active ingredient, once the claim is properly construed in light of the plain and ordinary meaning in view of the claims, specification, and prosecution history. Specifically:

- The term "[a]n inhaler for metered dose inhalation" (found in the '289 and '587 patents) is properly construed as an "inhaler for metered dose inhalation

containing *an active drug* capable of being dispensed via the inhaler to the lungs." Appx1589 (emphasis added).

- The term "medicament canister" (found in the '289,'587, and '712 patents) is properly construed as an "a canister containing *an active drug* capable of being dispensed via the inhaler to the lungs." Appx1589 (emphasis added).
- The term "an inhaler" (found in the '808 patent) is properly construed as "an inhaler containing an *active drug* capable of being dispensed via the inhaler to the lungs." Appx1590 (emphasis added).
- The term "a metered dose inhaler" (found in the '889 and '712 patents) is "a metered dose inhaler containing an *active drug* capable of being dispensed via the inhaler to the lungs." Appx1590-1591 (emphasis added).
- The term "canister" (found in the '889 patent) is properly construed as "a canister containing an *active drug* capable of being dispensed via the inhaler to the lungs." Appx1591 (emphasis added).

The district court nevertheless granted Amneal's motion for judgment on the pleadings without making any attempt to construe these claims. Teva expressly asked the district court to "deny Amneal's Rule 12(c) Motion at least to engage in claim construction proceedings if necessary to determine the scope of what the Asserted Patents claim." Appx1376. The district court declined that request and instead determined that the Asserted Patents did not claim an active ingredient on

the basis that it did not *recite* an active ingredient. That is wrong. As discussed at length above, "claims" does not mean "recites." *See supra*, pp. 21-26. Far from it: the proper understanding of the claims must be determined using "the tools and framework of patent law, including claim construction." *Jazz*, 60 F.4th at 1379.

That is precisely what happened in *Jazz*. The defendant there, Avadel, filed a delisting counterclaim like Amneal's here. *See Jazz Pharms., Inc. v. Avadel Pharms.*, No. 1:21-cv-00691 (D. Del. June 3, 2021), ECF No. 11. The district court denied Avadel's motion for judgment on the pleadings, explaining that Avadel's "arguments depend in no small part on claim construction." *Id.*, ECF No. 55, at 5 (Oct. 19, 2021). Avadel then renewed its motion for judgment on the pleadings post-claim construction. *Id.*, ECF No 118. In granting the renewed motion, the district court emphasized that "the Court's construction of the [asserted] patent disposes of the [delisting] inquiry." *Id.*, ECF No. 231, at 6. In line with this conclusion, this Court affirmed the district court's delisting injunction only after concluding "that the claims of the [asserted patent] were properly construed by the district court." 60 F.4th at 1380.

By contrast, the district court here made no attempt to use either the "tools" or the "framework of patent law." *Id.* at 1379. There was therefore no basis for the district court to conclude that the Asserted Patents did not claim the NDA drug. The only conclusion the district court could draw from its approach was that the claims

do not explicit mention albuterol sulfate or ProAir HFA. That is plainly insufficient to order delisting. At a minimum, then, this Court should remand the case to the district court to engage in claim construction.

* * *

Teva's interpretation of "claims" is hardly new or controversial; the FTC previously held the same view. In its amicus brief to the district court in *Jazz*, the FTC argued that "claims" should be given its ordinary meaning in patent law—relying on precisely the same language from *United* (which in turn relied on this Court's decision in *Apotex*). *See* FTC's Br. as Amicus Curiae at 16, *Jazz Pharms., Inc. v. Avadel CNS Pharms., LLC*, No. 1:21-cv-00691 (D. Del. Nov. 15, 2022), ECF No. 227 ("To 'claim[] the drug for which the NDA was submitted,' a patent must 'contain[] a product claim that reads on the drug that is the subject of the NDA …'" (quoting *United*, 11 F.4th at 132)). And yet the FTC suggested in its amicus brief below that a patent "claims" the drug only if it explicitly mentions the name of the drug. Appx1282-1283, Appx1288, Appx1294-1297. The FTC did not explain its about-face.

Nor did Amneal. While Amneal now supports the district court's interpretation, it has only recently taken that position. Amneal itself received a warning letter from the FTC directing it to delist two patents listed in the Orange Book as drug product patents for Amneal's Adrenaclick® (epinephrine injection)

product. Appx1403-1404. Neither patent explicitly mentions the active ingredient, epinephrine, and yet Amneal listed them. It was only in November 2023—*after* Teva filed its Complaint against Amneal and just ten days *before* Amneal filed its Answer and Counterclaims—that Amneal requested delisting. *Id.* Upon delisting the patents, Amneal wrote to Congress to explain that it had listed the patents "[i]n a good faith effort to comply with th[e] statutory requirement," and that "Amneal reasonably believed the patents were properly listed." *Id.* What Amneal did not explain is that it abandoned this "reasonabl[e]" position when it became expedient to take the opposite position in this litigation.

While FTC has adopted a new policy stance—and Amneal has come to a new, litigation-driven position—neither has provided any arguments grounded in either the text of the Listing Statute or black-letter principles of patent law. As this Court has already recognized, a patent "claims" a drug product if it "reads on" the product. Amneal has never argued that the Asserted Patents do not "read on" ProAir HFA. The Asserted Patents thus satisfy the Listing Statute's "claims the drug" requirement.

II. The Asserted Patents Are Drug Product Patents.

Amneal argued separately below that even if the Asserted Patents "claim the drug for which [Teva] submitted the [New Drug A]pplication," they still may not be listed because they are not "drug product (formulation or composition) patent[s]."

21 U.S.C. § 355(b)(1)(A)(viii). That is not a proper basis for a delisting counterclaim, which can only be based "on the ground that the patent does not claim either—(aa) the drug for which the application was approved, or (bb) an approved method of using the drug." 21 U.S.C. § 355(j)(5)(C)(ii)(I). The argument is incorrect in any event. A "drug product" patent is simply a patent that claims a drug product. And in FDA terminology, a "drug product" is a "finished dosage form, e.g., tablet, capsule, or solution, that contains a drug substance, generally, but not necessarily, in association with one or more other ingredients." 21 C.F.R. § 314.3. FDA expressly categorizes MDIs as a finished dosage form. Because the Asserted Patents claim an MDI, they are properly listed as "drug product" patents.

A. A "drug product (formulation or composition) patent" is a patent that claims a drug product.

"Drug product" patents are "patents that claim a drug product," as opposed to a drug substance (active ingredient) or a method of using the drug. 21 C.F.R. § 314.53(b)(1). The Listing Statute identifies two types of "drug product" patents: "formulation" and "composition" patents. FDA regulations take the further step of identifying patents that are *not* drug product patents: "patents claiming packaging, patents claiming metabolites, and patents claiming intermediates." *Id.*

A "drug product" is a "finished dosage form, e.g., tablet, capsule, or solution, that contains a drug substance, generally, but not necessarily, in association with one or more other ingredients." 21 C.F.R. § 314.3. FDA thus identifies the "key factor"

for listing a drug product patent as "whether the patent being submitted claims the finished dosage form of the approved drug product." 68 Fed. Reg. 36,676, 36,680 (June 18, 2003). As a result, a patent is properly understood as a "drug product" patent if it "reads on" the finished dosage form of the NDA product. *See supra*, pp. 21-26.

FDA defines the "[d]osage form" as "the physical manifestation containing the active and inactive ingredients that deliver a dose of the drug product." 21 C.F.R. § 314.3. The "dosage form is generally determined based on the form of the product before dispensing to the patient." 80 Fed. Reg. 6,802, 6,813 (Feb. 6, 2015); *see also Abbott Lab'ys v. Young*, 691 F. Supp. 462, 464 n.1 (D.D.C. 1988) ("The final dosage form of a drug is the form in which it appears prior to administration to the patient."); *remanded on other grounds*, 920 F.2d 984 (D.C. Cir. 1990).

FDA recognizes metered aerosols as a dosage form. 68 Fed. Reg. at 36,680. Specifically, the "appendix in the Orange Book lists current dosage forms for approved drug products," and "[t]he list includes metered aerosols." *Id.*; *see also* Orange Book, Appendix C, at C-1 (44th ed. 2024). The list also includes capsules, tablets, and solutions—*i.e.*, items that are universally understood as drug products. *Id.*; *see also* 21 C.F.R. § 314.53 (defining a "drug product" as a "finished dosage form, e.g., tablet, capsule, or solution"). FDA expressly distinguishes these "drug delivery systems used and approved in combination with a drug"—including

"metered dose inhalers"—from the type of "packaging and containers" that cannot form the basis of an Orange Book listing. 68 Fed. Reg. at 36,680.

As explained above, a patent need not cover the entirety of a product in order for the product to be found infringing. *SunTiger*, 189 F.3d 1327 at 1336. So long as the Asserted Patents read on one or more components of the dosage form approved in the NDA, therefore, they are drug product patents. It does not matter which approved components they claim—active ingredient, propellant, inhaler device—or whether they claim the "entire" inhaler in some sense.

Even if those considerations did matter, though, three of the five Asserted Patents expressly claim the *full* finished dosage form. These patents are directed to the inhaler rather than a component of it: two claim an "inhaler for metered dose inhalation" (the '289 and '587 patents), and a third claims "[a] metered dose inhaler comprising a medicament canister" (the '712 patent). *See supra*, pp. 33-34. To hold that a patent directed to an MDI cannot be listed, when FDA has *expressly* identified that product as exactly the kind of finished dosage form it regards as a basis for a listable drug product patent, would upend settled expectations and set the Hatch-Waxman adjudication system at odds with the agency charged with administering that system.

Despite that, the FTC—which is not involved with administering the Hatch-Waxman scheme—took the view below that patents are only properly understood as

"drug product" patents if they "mention" the drug. Appx1297 (arguing that a patent "that does not mention any drug in its claims is not a 'drug product (formulation or composition) patent'"). To the extent FTC meant that the patent must recite the active ingredient, that argument turns on an improper interpretation of the term "claims" that is untethered from the body of patent law that Congress referred to in adopting the Listing Statute. *See supra*, pp. 21-26. Moreover, under that approach there would be no need for the statute to separately require the listing of "drug substance" patents. *See supra*, pp. 36-37. If patents could qualify as "drug product" patents *only* if they name the NDA drug's active ingredient, then the "drug product" provision itself requires the listing of all "drug substance" patents. To the extent FTC was adopting an even more extreme position—*i.e.*, that the patents must recite the entirety of the drug—that position would, like the district court's approach, work a dramatic narrowing in the listing scheme. *See supra*, pp. 35-36.

B. At a minimum, the district court could not resolve this issue absent claim construction.

While the Asserted Patents are listable as drug product patents regardless of whether they satisfy any of the extra-statutory requirements Amneal seeks to impose, the district court erred in granting delisting without claim construction. *See supra*, pp. 44-47. The court could not simply eyeball the patents and declare that they do not encompass an active ingredient without construing key terms, including "medicament canister," that encompass an active ingredient. Even if the patents

must claim an active ingredient, therefore, it was (and remains) premature to grant judgment on the pleadings to Amneal before completing claim construction on the relevant terms. *See supra*, pp. 44-47.

III. Delisting Would Disserve The Hatch-Waxman System And Clog The Courts.

The Listing Statute leaves no discretion: either a patent *must* be listed or it *must not*. If this Court were to adopt the district court's interpretation and order Teva's patents delisted, it would make bringing generic drugs to market more complicated, more expensive, more risky, and less predictable—including for Teva, the world's largest generic manufacturer by revenue.

Listing patents in the Orange Book for each product that the patents claim not only provides transparency to the public, it allows for the type of early pre-launch determination of patent validity and infringement on which the industry depends. The Orange Book listing of a patent is the predicate step of the notice provisions of the Hatch-Waxman procedure. The Hatch-Waxman Amendments were enacted in the wake of the decision in *Roche Products Inc. v. Bolar Pharmaceutical Co.*, 733 F.2d 858 (Fed. Cir. 1984), which held that the process of conducting the research to submit an application for a generic drug was patent infringement. That decision meant that generic drugs often could not be developed until after patent expiry, making medications more expensive to patients. As a result, Congress enacted the Hatch-Waxman Amendments, which facilitate the development of innovative and

generic medicines alike. In particular, they implement the process of patent listing and the accompanying Paragraph IV procedures, which enable the parties to obtain patent certainty *before* launch. Under the Hatch-Waxman scheme, parties avoid both the expense and the risk of a jury trial and time-consuming preliminary injunction proceedings—both of which will clog the district court dockets, contrary to the express purpose of Hatch-Waxman. *See In re Restasis (Cyclosporine Opthalmic Emulsion) Antitrust Litig.*, 333 F. Supp. 3d 135, 149 (E.D.N.Y. 2018) ("The purpose of listing a patent in the Orange Book is to put potential generic manufacturers on notice that the brand considers the patent to cover its drug.").

Removing patents from the Orange Book merely because they do not recite the active ingredient—or, in the case of products with multiple active ingredients, because they do not recite *all* the active ingredients—will frustrate the Hatch-Waxman Amendments and return brand and generic companies alike to the pre-*Bolar* days. That is, a patent not listed in the Orange Book may not be known to the public at all; may not be asserted until a generic launch is imminent or has already occurred; and may well result in preliminary injunction proceedings, a post-launch jury trial, and an award of money damages—all significant risks that disincentivize generics to challenge patents, which will delay patients' access to lower-cost medicines and likely will not lower prescription drug prices.

This Court should not disrupt the balance Congress struck. All drug product

patents must be listed in the Orange Book for every drug they claim, for as long as a claim of infringement can reasonably be made under those patents. Traditional Paragraph IV invalidity and noninfringement challenges to those listed patents provide an expeditious pathway toward patent certainty. Delisting a patent—but leaving it in the brand-name company's portfolio for assertion at or close to the time of generic launch, in a preliminary-injunction proceeding or a jury trial—does not.

CONCLUSION

The district court's injunction ordering the Asserted Patents delisted should be reversed.

July 30, 2024

Respectfully submitted,

/s/ William M. Jay

William M. Jay
GOODWIN PROCTER LLP
1900 N Street, N.W.
Washington, DC 20036
(202) 346-4000

Counsel for Appellants

Daryl L. Wiesen
Christopher T. Holding
Louis L. Lobel
Jordan Bock
Thomas V. McTigue IV
GOODWIN PROCTER LLP
100 Northern Ave.
Boston, MA 02210
(617) 570-1000
Fax.: 617.523.1231

Natasha E. Daughtrey
GOODWIN PROCTER LLP
601 South Figueroa Street
Los Angeles, CA 90017
(213) 426-2642

CERTIFICATE OF COMPLIANCE

This brief complies with the type-volume limitations of Federal Rule of Appellate Procedure 27(d)(2)(A) because it contains 13,835 words, excluding the parts of the motion exempted by Federal Rule of Appellate Procedure 32(f) and Federal Circuit Rule 32(b)(2).

This brief complies with the typeface requirements of Federal Rule of Appellate Procedure 32(a)(5) and the type style requirements of Federal Rule of Appellate Procedure 32(a)(6). The brief has been prepared in a proportionally spaced typeface using Microsoft Word 365 in 14-point Times New Roman font.

Dated: July 30, 2024

/s/ William M. Jay
William M. Jay

ADDENDUM

INDEX

FOR PUBLICATION

UNITED STATES DISTRICT COURT
DISTRICT OF NEW JERSEY

TEVA BRANDED PHARMACEUTICAL PRODUCTS R&D, INC., NORTON (WATERFORD) LTD., AND TEVA PHARMACEUTICALS USA, INC., Plaintiffs, v. AMNEAL PHARMACEUTICALS OF NEW YORK, LLC, AMNEAL IRELAND LIMITED, AMNEAL PHARMACEUTICALS LLC, AND AMNEAL PHARMACEUTICALS INC. Defendants.	**Civil Action No. 23-20964 (SRC)** **OPINION & ORDER**

CHESLER, U.S.D.J.

This matter comes before the Court on two motions: 1) the motion to dismiss by Plaintiffs Teva Branded Pharmaceutical Products R&D, Inc., Norton (Waterford) Ltd., and Teva Pharmaceuticals USA, Inc. (collectively, "Teva"); and 2) the motion for partial judgment on the pleadings, pursuant to Federal Rule of Civil Procedure 12(c), by Defendants Amneal Pharmaceuticals Of New York, LLC, Amneal Ireland Limited, Amneal Pharmaceuticals LLC, and Amneal Pharmaceuticals Inc. (collectively, "Amneal.") For the reasons that follow, the motion to dismiss will be denied, and the motion for partial judgment on the pleadings will be granted.

This case arises out of a patent infringement dispute under the Hatch-Waxman Act between Teva and Amneal. Teva holds approved NDA No. 021457 for ProAir® HFA (albuterol sulfate) Inhalation Aerosol ("ProAir® HFA"), and owns certain patents listed in the Orange Book as covering this product: U.S. Patent Nos. 8,132,712 (the "'712 patent"), 9,463,289 (the "'289 patent"), 9,808,587 (the "'587 patent"), 10,561,808 (the "'808 patent"), and 11,395,889 (the "'889 patent") (collectively, the "Patents at issue" or the "Inhaler Patents"). Amneal has filed ANDA No. 211600, seeking to make and sell a generic version of ProAir® HFA. The following facts are undisputed. The Amneal ANDA contains a paragraph IV certification that the proposed product will not infringe any valid claim of the Patents at issue. After Amneal sent Teva the required notice letter, Teva filed the instant suit. The Amended Complaint asserts claims for patent infringement of the Patents at issue. Amneal filed an Amended Answer to the Amended Complaint asserting, *inter alia*, twelve counterclaim counts. Counterclaim Counts 1-5 seek declarations ordering Teva to delist the Patents at issue from the Orange Book. Counterclaim Counts 6-9 allege violations of the Sherman Act, and Count 10 alleges a violation of the New Jersey Antitrust Act, N.J.S.A. § 56:9. Counterclaims 11 and 12 are not at issue on these motions.

The Federal Trade Commission ("FTC") requested and was granted leave to file a brief as *amicus curiae*.

I. Teva's motion to dismiss Counterclaim Counts 6-10

Teva moves to dismiss Counterclaim Counts 1-10. The Court first considers the motion to dismiss the antitrust counterclaims, Counterclaim Counts 6-10. Teva contends that the

antitrust counterclaims are premised on two forms of alleged anticompetitive conduct: 1) improper Orange Book listing; and 2) sham litigation.

Teva contends that antitrust law provides no cause of action for improper Orange Book listing. First, Teva argues that because "Teva's patents are properly listed as a matter of law . . . any claim based on purported improper listing necessarily fails." (Pls.' MTD Br. at 25.) Later in this Opinion, this Court will consider and address Amneal's motion for judgment on the pleadings; as will be explained, the Court concludes that Teva's patents are *not* properly listed in the Orange Book as a matter of law. This conclusion does not support a Rule 12(b)(6) dismissal of an antitrust claim for improper Orange Book listing.

Second, Teva argues that, even if the Court were to find that the listings are improper, given the Trinko doctrine, "antitrust law does not create a cognizable claim for Amneal based on purported improper listing in any event." (Pls.' MTD Br. at 25.) In short, Teva argues that the instant case is analogous to Trinko, but this Court is not persuaded. The Supreme Court's syllabus for Trinko states the relevant key points of that case:

> The Telecommunications Act of 1996 imposes upon an incumbent local exchange carrier (LEC) the obligation to share its telephone network with competitors.
> . . .
> *Held:* Respondent's complaint alleging breach of an incumbent LEC's 1996 Act duty to share its network with competitors does not state a claim under § 2 of the Sherman Act.
> . . .
> (c) Traditional antitrust principles do not justify adding the present case to the few existing exceptions from the proposition that there is no duty to aid competitors.

Verizon Communs., Inc. v. Law Offices of Curtis V. Trinko, LLP, 540 U.S. 398, 398-99 (2004). Teva argues that the Listing Statute, 21 U.S.C. § 355, imposes upon an NDA holder an analogous obligation:

> [T]he Hatch-Waxman Act created a statutory obligation on a brand drug company to list patents in the Orange Book in order to help generic drug companies compete with the brand company by getting FDA approval for and launching their competing generic products more quickly. This duty is, for all relevant purposes, indistinguishable from the statutory duty imposed on incumbent service providers at issue in *Trinko*.

(Pls.' MTD Opening Br. at 28.)

Teva has failed to persuade this Court that the statutes at issue in the two cases are analogous. As the statement from the Supreme Court's Syllabus makes clear, the key attribute of the statutory provision at issue was that it "imposes . . . the obligation to share its telephone network with competitors." Trinko, 540 U.S. at 398. The Listing Statute does not impose any analogous obligation on the holder of an NDA. In fact, the Listing Statute says nothing about competitors or other drug companies; it speaks only about certain information that must be submitted "to the Secretary as part of the application." 21 U.S.C. § 355(b)(1)(A). That subsection, 21 U.S.C. § 355(b)(1)(A), lists eight subparagraphs which set forth what must be submitted to the Secretary as part of the application.

Teva offers nothing more than *ipse dixit* in support of its argument that the duty imposed by the Listing Statute is "indistinguishable" from the statutory duty at issue in Trinko. Teva's opening brief quotes the Supreme Court's discussion of the Hatch-Waxman Act in Caraco: "To facilitate the approval of generic drugs as soon as patents allow, the Hatch-Waxman Amendments and FDA regulations direct brand manufacturers to file information about their patents." Caraco Pharm. Labs., Ltd. v. Novo Nordisk A/S, 566 U.S. 399, 405 (2012). This says nothing about anyone helping competitors or cooperating with competitors. Teva has given this Court no basis to find that the Listing Statute imposes on NDA applicants a duty to aid competitors.

Furthermore, the FTC aptly summarizes the bases for distinguishing Trinko from the instant case as follows:

> *Trinko* is inapplicable because Amneal's counterclaims are not an expansion of antitrust law, the FDA does not directly police the Orange Book, and the statutory amendment to add a delisting counterclaim does not transform a patent enforcement framework into an antitrust regulatory scheme.

(FTC *Amicus* Br. at 33.) The FTC contends that the FDA's ministerial role[1] in Orange Book listings differs greatly from the extensive scheme for FCC regulation of telecommunications competition described in Trinko. The Telecommunications Act of 1996 established the regulatory scheme of interest in Trinko:

> The Telecommunications Act of 1996, Pub. L. 104-104, 110 Stat. 56, imposes certain duties upon incumbent local telephone companies in order to facilitate market entry by competitors, and establishes a complex regime for monitoring and enforcement. . .
>
> The 1996 Act sought to uproot the incumbent LECs' monopoly and to introduce competition in its place. Central to the scheme of the Act is the incumbent LEC's obligation under 47 U.S.C. § 251(c) to share its network with competitors.

Trinko, 540 U.S. at 401-2 (citations omitted). Teva does not contend that, in enacting the Orange Book listing provisions of the Hatch-Waxman Act, Congress sought to uproot any monopolies, nor that, as to the Orange Book, the FDA has any enforcement function. The only enforcement mechanism Teva points to is the delisting counterclaim – but this is plainly a judicial remedy[2] (as Teva admits), not an enforcement power entrusted to a regulator.

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[1] See Jazz Pharms., Inc. v. Avadel CNS Pharms., LLC, 60 F.4th 1373, 1378 (Fed. Cir. 2023) ("Notably, the FDA does not verify that submitted patents actually meet statutory listing criteria, nor does the FDA proactively remove improperly listed patents. *See Apotex, Inc. v. Thompson*, 347 F.3d 1335, 1347 (Fed. Cir. 2003) ('[T]he FDA's . . . duties with respect to Orange Book listings are purely ministerial.')")

[2] In Trinko, the Supreme Court expressed skepticism that, where continuing supervision is needed, a court could serve as an effective enforcer. Id. at 415 ("An antitrust court is unlikely to

Compare this judicial remedy to the "regulatory structure" the Supreme Court described in Trinko:

> One factor of particular importance is the existence of a regulatory structure designed to deter and remedy anticompetitive harm. Where such a structure exists, the additional benefit to competition provided by antitrust enforcement will tend to be small, and it will be less plausible that the antitrust laws contemplate such additional scrutiny. Where, by contrast, there is nothing built into the regulatory scheme which performs the antitrust function, the benefits of antitrust are worth its sometimes considerable disadvantages. . . .
>
> The regulatory framework that exists in this case demonstrates how, in certain circumstances, regulation significantly diminishes the likelihood of major antitrust harm.

Id. at 412 (citations omitted). Teva has not demonstrated that the Orange Book listing provisions at issue comprise a regulatory structure designed to deter and remedy anticompetitive harm. In the absence of such a regulatory structure, the Supreme Court stated, it is more plausible that antitrust law provides additional scrutiny.

Having reviewed the enforcement mechanisms established by the Telecommunications Act of 1996, the Supreme Court concluded that "the [regulatory] regime was an effective steward of the antitrust function." Id. at 413. In the instant case, Teva does not even claim that there is any regulator with enforcement powers. This Court is not persuaded that availability of the judicial remedy of delisting significantly diminishes the likelihood of major antitrust harm, nor that this remedy alone is an effective steward of the antitrust function. As the FTC points out, the judicial delisting remedy does not provide for damages; that remedy alone cannot be an effective steward of the antitrust function.

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be an effective day-to-day enforcer of these detailed sharing obligations.")

In sum, *amicus* FTC has persuasively distinguished Trinko. Teva has failed to persuade that Trinko is analogous and forecloses Amneal's antitrust counterclaims.

Teva argues as well that the plain language of the Listing Statute precludes an antitrust claim predicated on improper listing, citing 21 U.S.C. § 355(j)(5)(c)(ii)(II), which states:

> (ii) Counterclaim to infringement action.
>
> > (I) In general. If an owner of the patent or the holder of the approved application under subsection (b) for the drug that is claimed by the patent or a use of which is claimed by the patent brings a patent infringement action against the applicant, the applicant may assert a counterclaim seeking an order requiring the holder to correct or delete the patent information submitted by the holder under subsection (b) or (c) on the ground that the patent does not claim either—
> >
> > (aa) the drug for which the application was approved; or
> > (bb) an approved method of using the drug.
> >
> > (II) No independent cause of action. Subclause (I) does not authorize the assertion of a claim described in subclause (I) in any civil action or proceeding other than a counterclaim described in subclause (I).

Again, Teva presents only an *ipse dixit* conclusion about the meaning of 21 U.S.C. § 355(j)(5)(c)(ii)(II), without analysis or argument. On its face, subclause (II) delimits the authority of subclause (I), which authorizes the assertion of a counterclaim to correct Orange Book information in particular cases. The clear purpose of subclause (II) is to bar an independent suit seeking the relief stated in subsection (I) in the absence of a Hatch-Waxman infringement suit; it is designed to prevent the filing of claims for correction of the Orange Book as independent actions.

Amneal has asserted Counterclaim Counts 1-5, seeking orders of correction, and these appear to be permitted by 21 U.S.C. § 355(j)(5)(c)(ii); Teva does not argue that Counts 1-5 are not permitted by 21 U.S.C. § 355(j)(5)(c)(ii). Teva does not explain how 21 U.S.C. §

355(j)(5)(c)(ii) impacts the assertion of the Counterclaim Counts 6-10 under antitrust law. Counts 6-10 do not seek any order requiring the holder to correct or delete Orange Book information. Counts 6, 9, and 10 reference improper listing in the Orange Book as an example of an anticompetitive act. (Am. Answer at ¶¶ 281, 318, 322.) Count 7 does not mention the Orange Book. Count 8 references improper listing of patents in the Orange Book as an example of "a predatory scheme to monopolize the Relevant Market." (Am. Answer at ¶ 310.) Counterclaim Counts 6-10 do not seek correction or deletion of information in the Orange Book and do not fall within the ambit of 21 U.S.C. § 355(j)(5)(c)(ii)(I).

The Court finds that subsections (I) and (II) neither authorize nor prohibit Counterclaim Counts 6-10. Teva has offered nothing to support its contention that the plain language of these subsections prohibits the assertion of the antitrust counterclaims.

Teva next argues that Counterclaim Count 7, for sham litigation in violation of the Sherman Act, fails to state a valid claim. Teva's arguments for dismissal are all variants of the contention that Count 7 is unlikely to succeed at trial or summary judgment. As the Supreme Court stated in Twombly, "of course, a well-pleaded complaint may proceed even if it strikes a savvy judge that actual proof of those facts is improbable, and 'that a recovery is very remote and unlikely.'" Bell Atl. Corp. v. Twombly, 550 U.S. 544, 556 (2007) (quoting Scheuer v. Rhodes, 416 U.S. 232, 236 (1974).) Teva does no more here than argue that recovery on Count 7 is remote and unlikely; Plaintiff does not argue that Count 7 fails to plead a legally cognizable claim for relief.

Next, Teva argues that Count 6, alleging an anticompetitive scheme, fails to state a claim because the counterclaim components of that scheme all fail to state valid claims. Because this

Court has concluded that Amneal has pled viable claims for anticompetitive conduct, it is not persuaded that Count 6 is invalid because all the other counterclaims are also invalid.

The Court concludes that Teva has failed to persuade that any of the antitrust counterclaims fail to state a legally cognizable claim for relief, and the Rule 12(b)(6) motion to dismiss the antitrust counterclaims will be denied.

II. Counterclaim Counts 1-5 and the Listing Statute

As to the delisting counterclaims, Counts 1-5, Teva moves to dismiss them too. Amneal cross-moves for judgment on the pleadings on Counterclaim Counts 1-5. The Third Circuit has stated:

> We analyze a motion for judgment on the pleadings under Federal Rule of Civil Procedure Rule 12(c) under the same standards that apply to a Rule 12(b)(6) motion. Under Rule 12(c), a court must accept all of the allegations in the pleadings of the party against whom the motion is addressed as true and draw all reasonable inferences in favor of the non-moving party. A court may grant a Rule 12(c) motion if, on the basis of the pleadings, the movant is entitled to judgment as a matter of law. A plaintiff can survive a Rule 12(c) motion if her complaint contains sufficient factual matter to show that the claim is facially plausible, thus enabling the court to draw the reasonable inference that the defendant is liable for [the] misconduct alleged.

Bibbs v. Trans Union LLC, 43 F.4th 331, 339 (3d Cir. 2022) (citations omitted.)

In short, Teva contends that the delisting claims are premised on erroneous interpretations of the Listing Statute. As to Amneal's motion for judgment on the pleadings, Amneal and *amicus* the FTC argue that the listing of the Inhaler Patents in the Orange Book is improper and not authorized by the Listing Statute. Both of these motions turn on issues of interpretation of the Listing Statute.

The Listing Statute states, in relevant part:

(b) Filing application; contents.

> (1)
> (A) Any person may file with the Secretary an application with respect to any drug subject to the provisions of subsection (a). Such persons shall submit to the Secretary as part of the application—
> . . .
> (viii) the patent number and expiration date of each patent for which a claim of patent infringement could reasonably be asserted if a person not licensed by the owner of the patent engaged in the manufacture, use, or sale of the drug, and that—
> (I) claims the drug for which the applicant submitted the application and is a drug substance (active ingredient) patent or a drug product (formulation or composition) patent; or
> (II) claims a method of using such drug for which approval is sought or has been granted in the application.

21 U.S.C. § 355. Although the Orange Book is not mentioned by name in the statute, the parties agree that 21 U.S.C. § 355(b)(1)(A)(viii) states the fundamental requirements to effect the listing of a patent in the Orange Book. Subsection § 355(b)(1)(A)(viii) authorizes the listing of certain patents of three kinds: drug substance patents, drug product patents, and method of use patents. Teva contends that the Inhaler Patents are drug product patents, and that they are properly listed pursuant to § 355(b)(1)(A)(viii)(I).

Subsection § 355(b)(1)(A)(viii)(I) states two requirements: 1) the patent must "claim[] the drug for which the applicant submitted the application;" and 2) the patent must be directed to a drug substance or a drug product. This Court finds that the listing issue in this case turns on the interpretation of the first element and concludes, in short, that the Inhaler Patents do not claim the drug for which the applicant submitted the application.

There is no dispute that the Inhaler Patents contain no claim for the active ingredient at issue, albuterol sulfate. Amneal contends that the Inhaler Patents do not meet the requirement that they claim the relevant drug. The FTC agrees.

Teva points out that the word "drug" in § 355 is expressly defined in 21 U.S.C. § 321(g)(1):

> The term "drug" means (A) articles recognized in the official United States Pharmacopoeia, official Homoeopathic Pharmacopoeia of the United States, or official National Formulary, or any supplement to any of them; and (B) articles intended for use in the diagnosis, cure, mitigation, treatment, or prevention of disease in man or other animals; and (C) articles (other than food) intended to affect the structure or any function of the body of man or other animals; and (D) articles intended for use as a component of any article specified in clause (A), (B), or (C).

The Court acknowledges that this definition includes articles intended for use in the treatment of disease, and that the ProAir® HFA inhaler falls within its scope. The problem for Teva is that this broad statutory definition of drug does not suffice to establish that the Inhaler Patents claim the drug for which Teva submitted its application, NDA No. 021457.[3] Teva offers the FDA approval letter for this NDA, dated October 29, 2004; the first line of this letter states: "Please refer to your new drug application (NDA) dated January 30, 2003, received January 31, 2003, submitted pursuant to section 505(b)(2) of the Federal Food, Drug, and Cosmetic Act for albuterol sulfate HFA Inhalation Aerosol." (Answer Ex. A at 1.) According to the FDA, the drug for which the applicant submitted the NDA is "albuterol sulfate HFA Inhalation Aerosol."

Furthermore, the Amended Complaint states:

> 45. Teva Branded is the holder of New Drug Application ("NDA") No. 021457, under which FDA approved the commercial marketing of ProAir® HFA (albuterol sulfate) Inhalation Aerosol on October 29, 2004. ProAir® HFA (albuterol sulfate) Inhalation Aerosol is indicated for the treatment or prevention of bronchospasm in patients 4 years of age and older with reversible obstructive

[3] It is not sufficient that a patent claim a drug that falls within the scope of the definition of "drug" in 21 U.S.C. § 321(g)(1); the statute requires that the patent claim ***the*** drug for which the applicant submitted ***the*** application. Teva overlooks the significance of the statutory language that modifies the phrase, "the drug."

> airway disease and for the prevention of exercise-induced bronchospasm in patients 4 years of age and older.
>
> 46. On October 1, 2022, the manufacturing of branded ProAir® HFA (albuterol sulfate) Inhalation Aerosol was discontinued. Teva USA currently distributes an authorized generic of ProAir® HFA (albuterol sulfate) Inhalation Aerosol under NDA No. 021457 in the United States.

Teva has thus premised this case on the factual allegation that the subject of NDA No. 021457 was the product, "ProAir® HFA (albuterol sulfate) Inhalation Aerosol." It is undisputed that no claim in any of the Inhaler Patents discloses albuterol sulfate.

The First Circuit construed the phrase, a patent which "claims the drug for which the applicant submitted the application," as used in § 355, in Cesar Castillo, Inc. v. Sanofi-Aventis U.S., LLC (In re Lantus Direct Purchaser Antitrust Litig.), 950 F.3d 1, 3 (1st Cir. 2020). Teva objects that, despite Lantus being a 2020 case, Congress has since changed the language of § 355 with the passage of the Orange Book Transparency Act ("OBTA"). Indeed, the OTBA did make changes to the language of § 355, but the key phrase, "claims the drug for which the applicant submitted the application," has not changed. At the time the First Circuit decided Lantus, the listing provision in § 355 required that the NDA applicant list a patent which "claims the drug for which the applicant submitted the application," and the current Listing Statute contains the same requirement today. Congress may have amended parts of the Listing Statute, but the OTBA did not change this particular requirement for listing a patent in the Orange Book: a listed patent must still claim the drug for which the applicant submitted the application.

In Lantus, Sanofi a filed a supplemental NDA "to sell insulin glargine in a disposable injector pen device called the Lantus SoloSTAR." Lantus, 950 F.3d at 5. The patent at issue, the '864 patent, was directed to drive mechanisms used in drug delivery devices. Id. In short,

the First Circuit found that the '864 patent did not claim the drug for which the applicant submitted the application. Id. at 8. Moreover, the First Circuit rejected the idea that § 355 authorizes the listing of "patents that claim only components of a proposed drug." Id. at 9. The Court concluded:

> More importantly, even assuming that the drive mechanism claimed by the '864 patent is itself a drug, we still find Sanofi falling short of its goal because the drive mechanism is not the "drug for which [Sanofi] submitted" the NDA. 21 U.S.C. § 355(b)(1). For that reason alone the patent for the drive mechanism does not qualify for listing in the Orange Book as claiming the Lantus SoloSTAR.
> . . .
> The statute and regulations clearly require that only patents that claim the drug for which the NDA is submitted should be listed in the Orange Book. The '864 patent, which neither claims nor even mentions insulin glargine or the Lantus SoloSTAR, does not fit the bill.

Id. at 9-10.

The facts of Lantus are parallel to those of the instant case. The Inhaler Patents are directed to components of a metered inhaler device, but do not claim or even mention albuterol sulfate or the ProAir® HFA. The applicant filed an NDA for an albuterol sulfate HFA Inhalation Aerosol. The statutory requirement that each patent "claim[] the drug for which the applicant submitted the application" is not met.

The FTC points out that the Second Circuit followed the relevant reasoning of Lantus in United Food & Commer. Workers Local 1776 v. Takeda Pharm. Co., 11 F.4th 118, 134 (2d Cir. 2021). United is a meaty opinion and much could be said about it, but two points are most relevant: 1) the Second Circuit decided United after passage of the OBTA and agreed with the pre-OBTA Lantus decision about the interpretation of "claims the drug for which the applicant submitted the application" in the Listing Statute; and 2) "claims" in the Listing Statute has the meaning established in patent law: "patent claims 'are the numbered paragraphs which

particularly point out and distinctly claim the subject matter which the applicant regards as his invention" (United, 11 F.4th at 132 (quoting Corning Glass Works v. Sumitomo Elec. U.S.A., Inc., 868 F.2d 1251, 1258 (Fed. Cir. 1989)). Applying the Second Circuit's analysis to the instant case, because the Inhaler Patents plainly do not regard an "albuterol sulfate HFA Inhalation Aerosol" as that which was invented, they do not claim the drug for which the applicant submitted the NDA application.

Teva offers two strategies that attempt to expand the scope of the key phrase in § 355, "claims the drug." First, Teva proffers a confusing set of arguments about the meaning of the word, "claims." Teva begins with the uncontroversial proposition that the word "claims" in the Listing Statute "should be given its meaning under patent law." (Pls.' MJP Opp. Br. at 13.) Somehow, Teva ends up at the position that "a patent 'claims' a product if the patent would be infringed by the product." (Id. at 15.) In support, Teva relies on the Second Circuit's decision in United Food. (Id.) The problem for Teva is that, as just stated, the Second Circuit in United Food based its entire analysis on this fundamental principle: "patent claims 'are the numbered paragraphs which particularly point out and distinctly claim the subject matter which the applicant regards as his invention." (United, 11 F.4th at 132 (quoting Corning Glass Works v. Sumitomo Elec. U.S.A., Inc., 868 F.2d 1251, 1258 (Fed. Cir. 1989)). Thus, a patent claims *only* that subject matter that it has particularly pointed out as the invention, and no more. This is inconsistent with Teva's contention that a patent claims all products that are infringing. Furthermore, the Second Circuit carefully explained the difference between the meaning of "claims" in patent law and "infringement." Id. at 134. In short, Teva has failed to persuade that, applying the common meaning of "claims" in patent law, any claim in any of the Inhaler

Patents particularly identifies the subject of the NDA application, an albuterol sulfate HFA Inhalation Aerosol, as the invention.

Second, Teva points to the broad statutory definition of "drug." The Court agrees with Teva that the statute, 21 U.S.C. § 321(g)(1), expressly gives the term, "drug," a broad scope, and specifically includes "articles intended for use as a component of any article" intended for use for the treatment of disease. Given the broad statutory definition of "drug," the Inhaler Patents do claim articles intended for use as a component of the ProAir® HFA (albuterol sulfate) Inhalation Aerosol, and it is undisputed that the albuterol sulfate HFA Inhalation Aerosol is intended for the treatment of disease. The problem for Teva is that this determination does not suffice to establish that the Inhaler Patents "claim[] the drug for which the applicant submitted the application," as required by the Listing Statute. Teva's arguments overlook the statutory phrase which modifies "drug:" "for which the applicant submitted the application." The drug for which the applicant submitted the application is "albuterol sulfate HFA Inhalation Aerosol." The Inhaler Patents do not contain any claims which claim "albuterol sulfate HFA Inhalation Aerosol." In short, the fact that the statutory definition of "drug" expressly includes devices for treating disease, and their components, does not nullify the restrictive action of the modifying phrase, "for which the applicant submitted the application." Teva tries hard to get around the effect of this modifying phrase, but fails to do so.

Lastly, as already noted, Teva maintains that the Inhaler Patents have been listed as "drug product" patents, within the meaning of § 355. The relevant Regulation defines "drug product" as follows: "Drug product is a finished dosage form, e.g., tablet, capsule, or solution, that contains a drug substance, generally, but not necessarily, in association with one or more other

ingredients." 21 C.F.R. § 314.3(b). As the FTC observes, the Regulations also state: "For patents that claim a drug product, the applicant must submit information only on those patents that claim the drug product, as is defined in § 314.3, *that is described in the pending or approved NDA*." 21 C.F.R. § 314.53(b)(1)(italics added). The Inhaler Patents do not claim the "finished dosage form" that is the subject of NDA No. 021457.

Furthermore, the FTC cites a response to public comments made by the FDA during the 2003 rulemaking process for the Regulation, 21 C.F.R. § 314.53:

> (Comment 3) Most comments agreed that patents claiming packaging should not be submitted for listing. However, some comments stated that patents claiming devices or containers that are "integral" to the drug product or require prior FDA approval should be submitted and listed. These comments distinguished between packaging and devices such as metered dose inhalers and transdermal patches, which are drug delivery systems used and approved in combination with a drug.
>
> (Response) We agree that patents claiming a package or container must not be submitted. Such packaging and containers are distinct from the drug product and thus fall outside of the requirements for patent submission. However, we have clarified the rule to ensure that if the patent claims the drug product as defined in § 314.3, the patent must be submitted for listing.
>
> Section 314.3 defines a "drug product" as "* * * a finished dosage form, for example, tablet, capsule, or solution, that contains a drug substance, generally, but not necessarily, in association with one or more other ingredients." The appendix in the Orange Book lists current dosage forms for approved drug products. The list includes metered aerosols, capsules, metered sprays, gels, and pre-filled drug delivery systems. *The key factor is whether the patent being submitted claims the finished dosage form of the approved drug product.* Patents must not be submitted for bottles or containers and other packaging, as these are not "dosage forms."

68 Fed. Reg. 36676, 36680 (italics added). The Inhaler Patents do not claim the finished dosage form of the approved drug product.

The Court concludes that the Inhaler Patents do not meet a key requirement of the Listing Statute: they do not claim "the drug for which the applicant submitted the application," NDA No.

021457, ProAir® HFA (albuterol sulfate) Inhalation Aerosol. Nor do the Inhaler Patents claim the "finished dosage form" that is the subject of that NDA application. Because the Inhaler Patents fail to meet these requirements, that have been improperly listed in the Orange Book. As to Counterclaim Counts 1-5, Teva's motion to dismiss will be denied. Amneal has demonstrated that, on the basis of the pleadings, it is entitled to judgment as a matter of law on Counterclaim Counts 1-5. Amneal's motion for judgment on the pleadings will be granted.

For these reasons,

IT IS on this 10th day of June, 2024

ORDERED that Plaintiff's motion to dismiss Counterclaim Counts 1-10 (Docket Entry No. 26) is **DENIED**; and it is further

ORDERED that Defendant's motion for partial judgment on the pleadings (Docket Entry No. 41) is **GRANTED**; and it is further

ORDERED that Judgment is entered in Defendants' favor as to Counts 1-5 of Defendants' Counterclaims; and it is further

ORDERED that it is the Judgment of this Court that U.S. Patent Nos. 8,132,712, 9,463,289, 9,808,587, 10,561,808, and 11,395,889 have been improperly listed in the Orange Book in regard to the drug product that is the subject of NDA No. 021457; and it is further

ORDERED that, pursuant to 21 U.S.C. § 355(j)(5)(c)(ii)(I), Teva must correct or delete the relevant Orange Book patent information listings to reflect the Judgment of this Court.

/s Stanley R. Chesler
STANLEY R. CHESLER. U.S.D.J.

Exhibit A

US008132712B2

(12) United States Patent
Fenlon

(10) Patent No.: US 8,132,712 B2
(45) Date of Patent: Mar. 13, 2012

(54) **METERED-DOSE INHALER**

(75) Inventor: **Derek Fenlon**, Waterford (IE)

(73) Assignee: **Ivax Pharmaceuticals Ireland**, Waterford (IE)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 159 days.

(21) Appl. No.: **12/532,762**

(22) PCT Filed: **Apr. 1, 2008**

(86) PCT No.: **PCT/EP2008/002590**

§ 371 (c)(1),
(2), (4) Date: **Sep. 23, 2009**

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PCT Pub. Date: **Oct. 9, 2008**

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Related U.S. Application Data

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Apr. 11, 2007 (GB) 076999.0

(51) **Int. Cl.**
G06M 1/04 (2006.01)
A61M 11/00 (2006.01)

(52) **U.S. Cl.** ..... **235/91 R**; 128/200.23

(58) **Field of Classification Search** 235/91; 128/200.23
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

4,445,404	A *	5/1984	Parker	81/62
5,485,971	A *	1/1996	Nakaya et al.	242/381.1
5,489,143	A *	2/1996	Adachi et al.	297/411.38
5,490,749	A *	2/1996	Arbues	410/103
5,794,978	A *	8/1998	Nishide	280/806
6,070,502	A *	6/2000	Chang	81/63
6,175,994	B1 *	1/2001	Nicoletti	24/68 SK
6,267,315	B1 *	7/2001	Blackadder et al.	242/384
6,446,627	B1 *	9/2002	Bowman et al.	128/200.23
7,252,065	B1 *	8/2007	Keeton	123/185.14
2011/0220450	A1 *	9/2011	Chiang	192/64

FOREIGN PATENT DOCUMENTS

WO	WO 98/28033 A	7/1998
WO	WO 2005/114563 A	12/2005

OTHER PUBLICATIONS

International Search Report dated Jul. 10, 2008, application No. PCT/EP2008/002590.

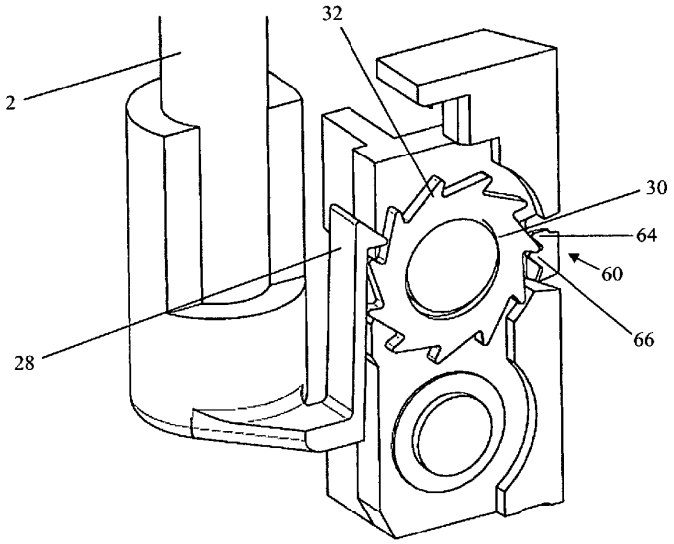
* cited by examiner

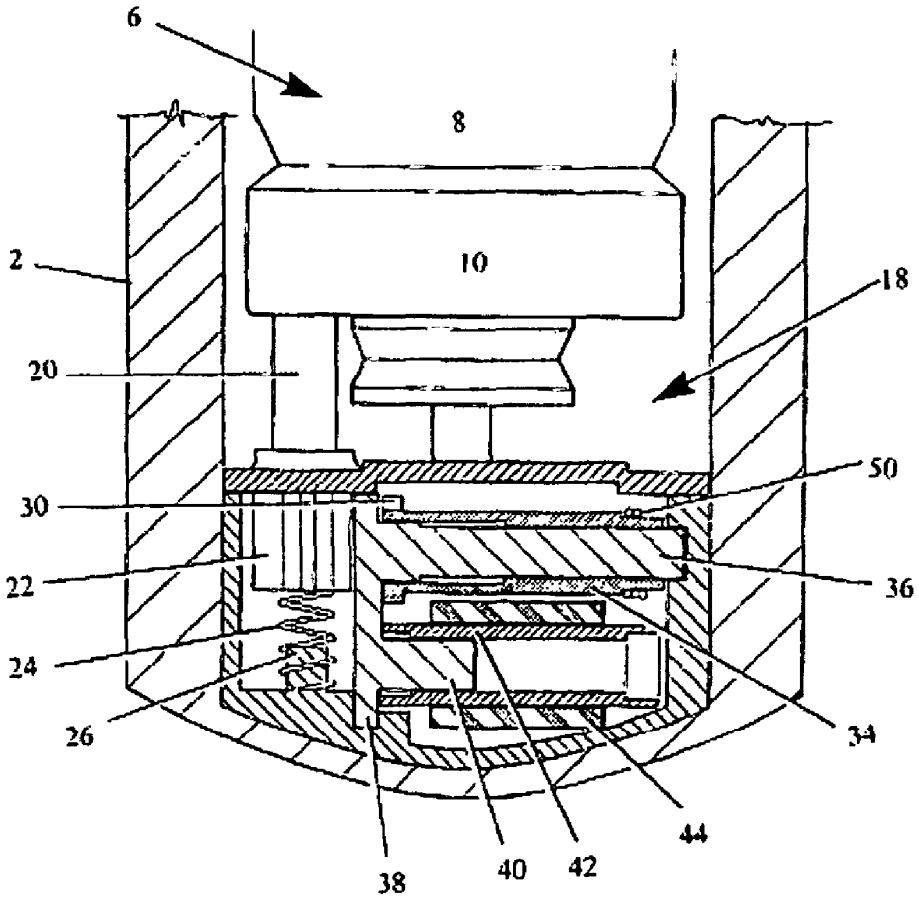
Primary Examiner — Daniel Hess
(74) *Attorney, Agent, or Firm* — RatnerPrestia

(57) **ABSTRACT**

A metered dose inhaler dose counter, the counter includes: an actuator; a rotary gear wheel having a plurality of ratchet teeth; a driver for driving the rotary gear in a step-wise fashion in response to displacement of the actuator; a pawl that prevents reverse rotation of the rotary gear; and a display coupled to the rotary gear.

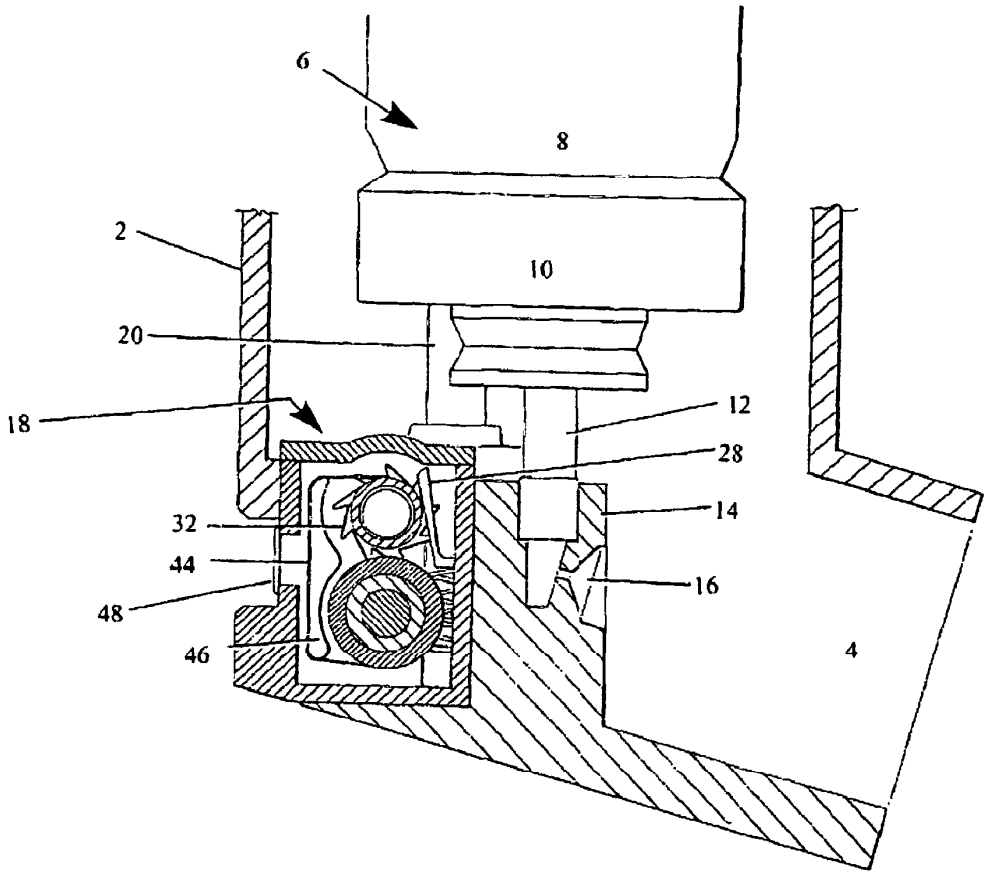
19 Claims, 8 Drawing Sheets





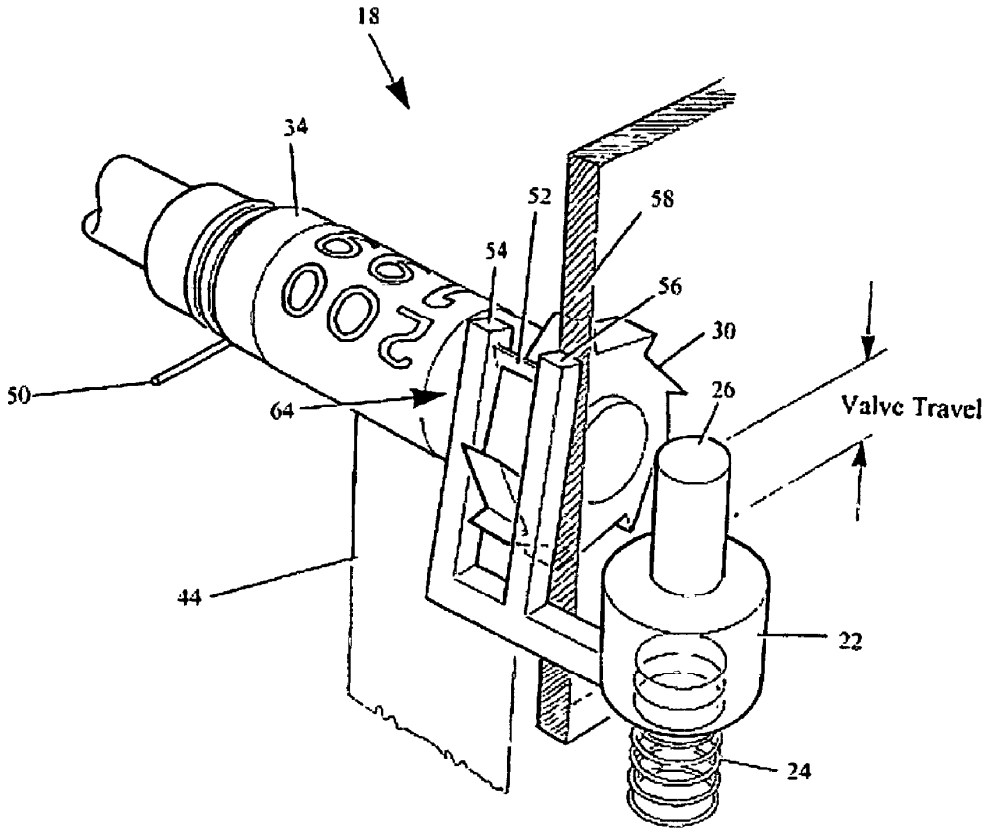
(Prior art)

Fig. 1



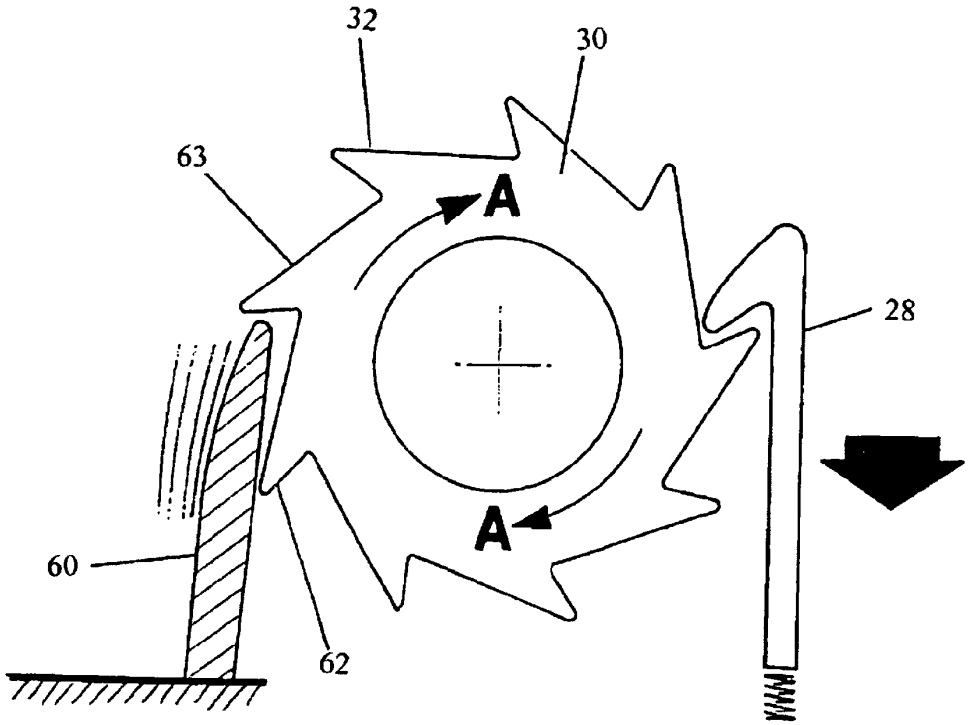
(Prior art)

Fig. 2



(Prior art)

Fig. 3



(Prior art)

Fig. 4

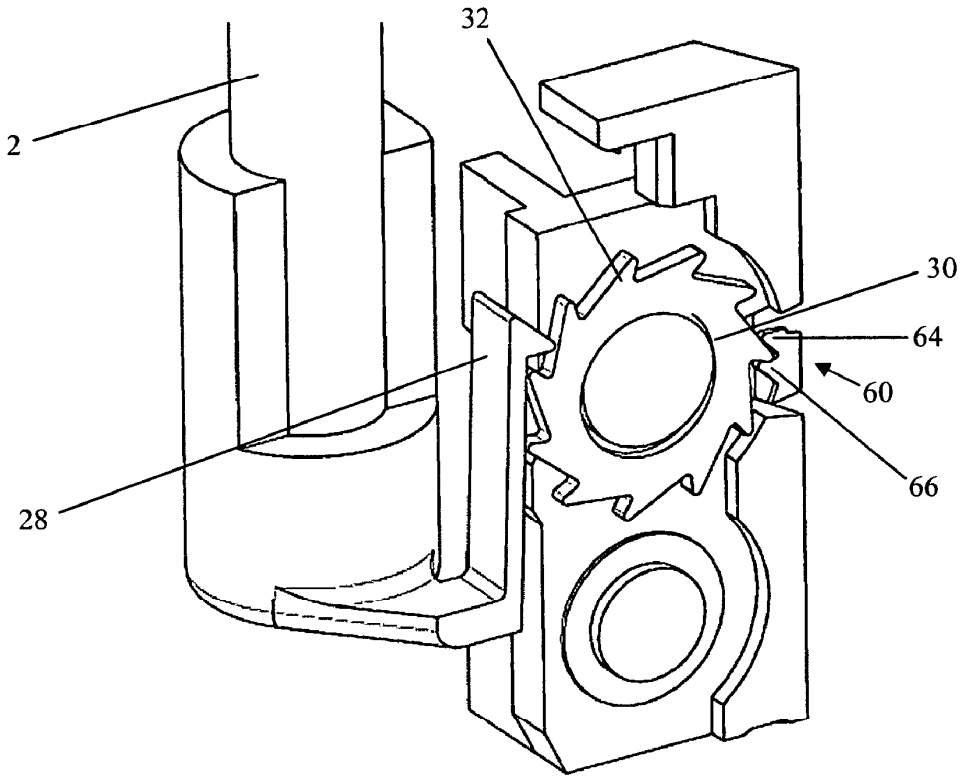


Fig. 5

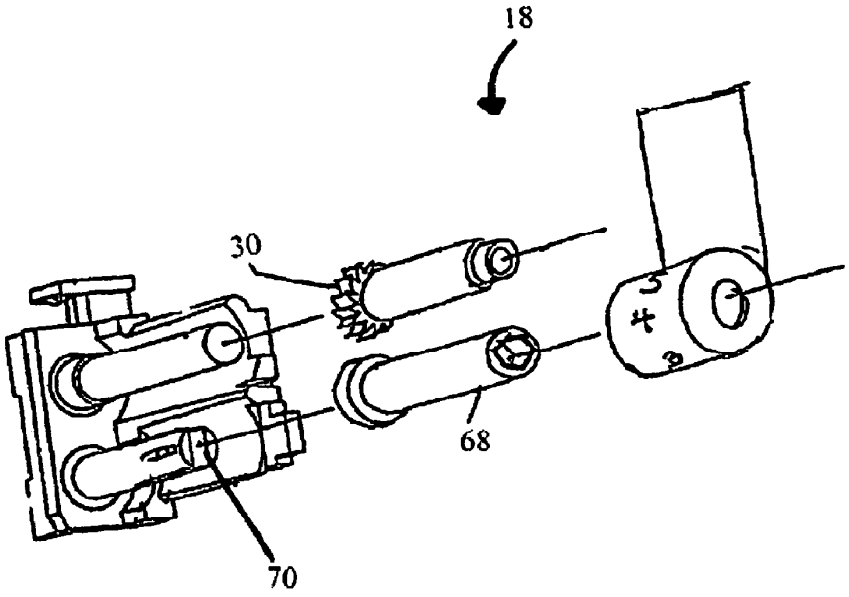

18
30
68
70

Fig. 6

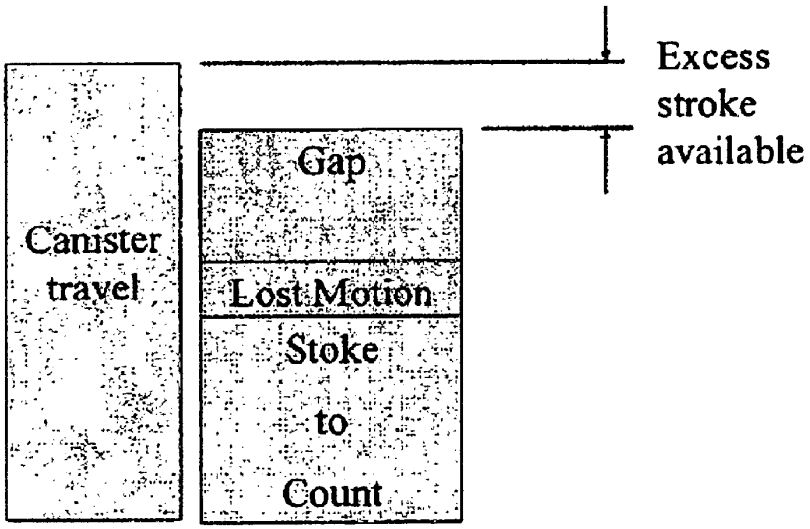

Excess
stroke
available
Gap
Canister
travel
Lost Motion
Stoke
to
Count

Fig. 7

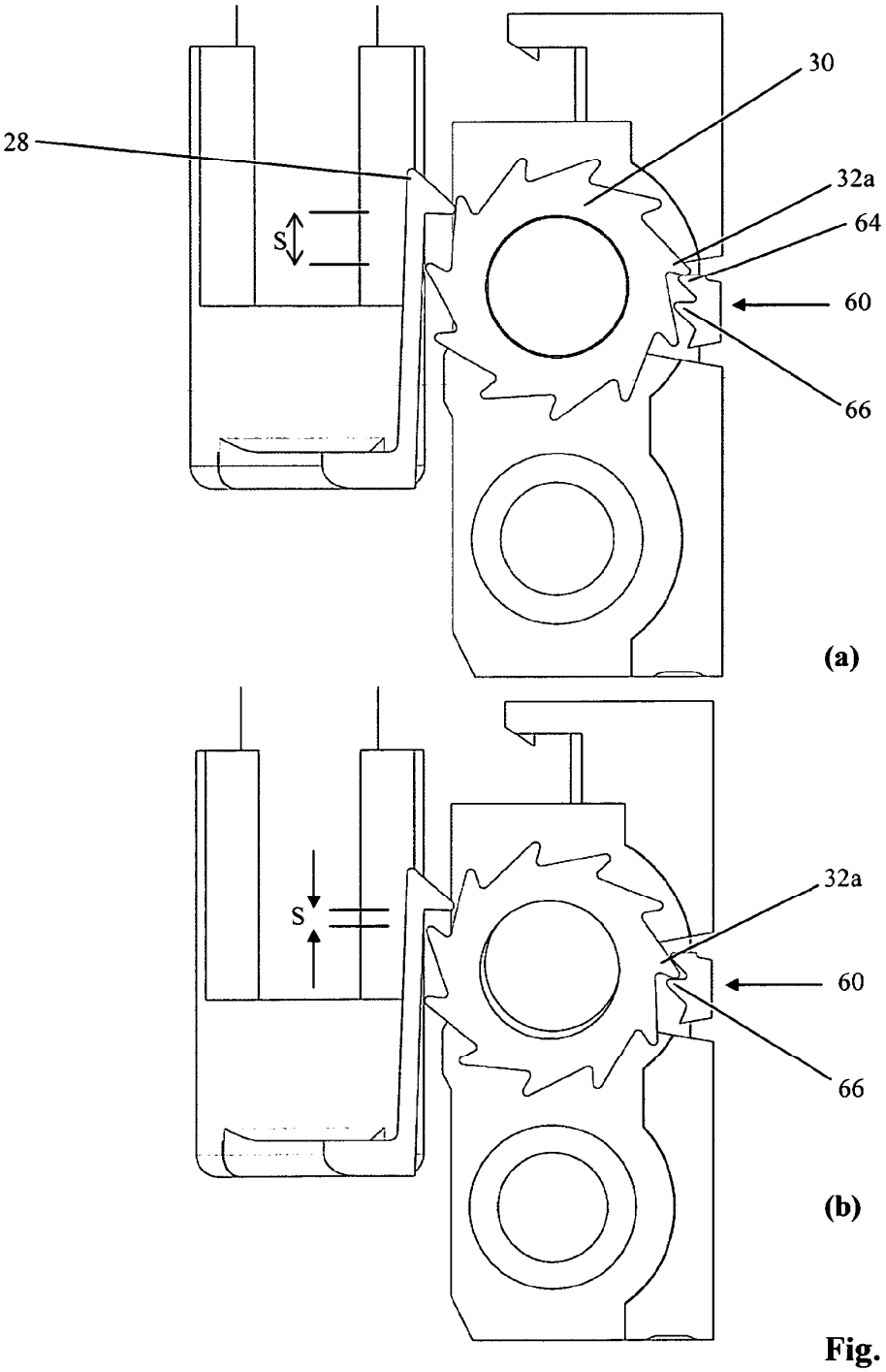


Fig. 8

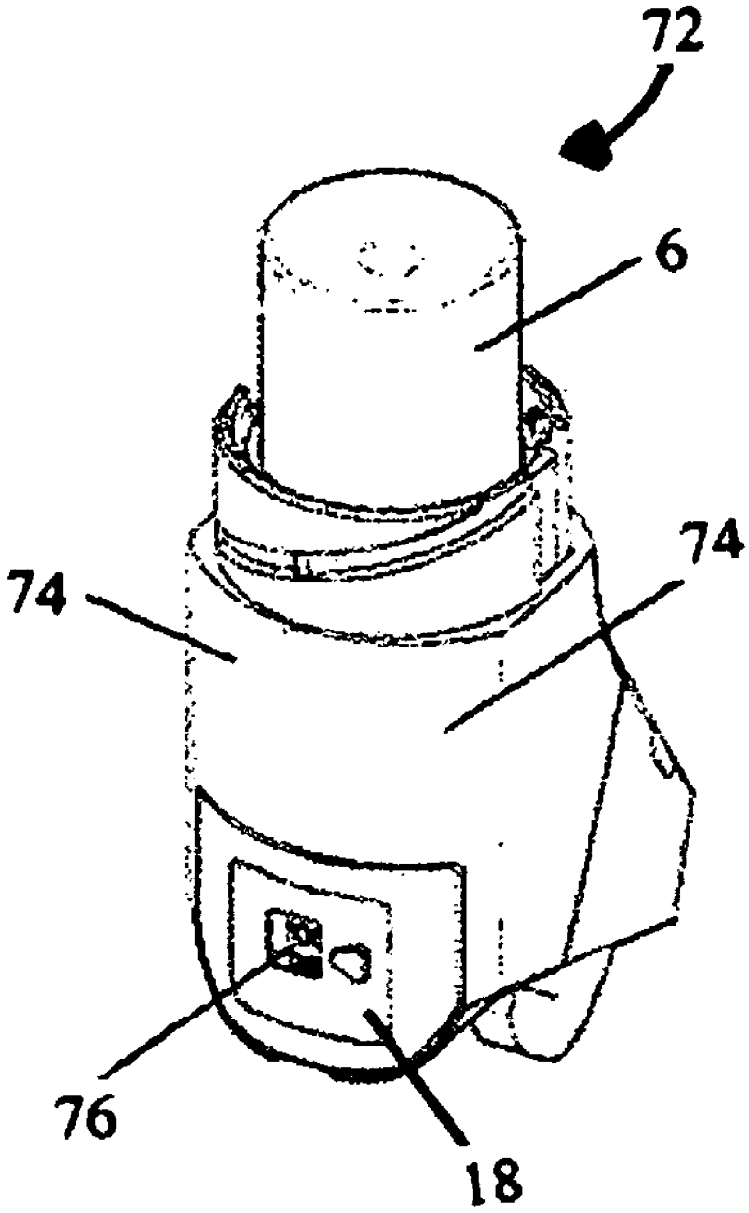


Fig. 9

METERED-DOSE INHALER

CROSS-REFERENCE TO RELATED APPLICATIONS

This application is the U.S. national phase application of PCT International Application No. PCT/EP2008/002590, filed Apr. 1, 2008, which claims priority to U.S. Provisional Patent Application No. 60/921,320, filed Apr. 2, 2007, and GB Application No. 0706999.0, filed Apr. 11, 2007, the contents of such applications being incorporated by reference herein.

FIELD OF THE INVENTION

This invention relates to a metered-dose inhaler and in particular to a dose counter for a metered-dose inhaler, the counter comprising: an actuator; a rotary gear; a driver for driving the rotary gear in a step-wise fashion in response to displacement of the actuator, the rotary gear comprising a wheel mounted on a spindle which wheel having a plurality of ratchet teeth around its periphery; a pawl to prevent reverse rotation of the rotary gear; and a display coupled to the rotary gear, the display having a visible array of incrementing integers on a surface thereof indexable by a single integer in response to each step of the step-wise rotary motion of the rotary gear; wherein the pawl comprises at least two ratchet teeth which are radially spaced such that one of the teeth engages with the ratchet teeth of the wheel following each step of the step-wise rotary motion of the rotary gear.

BACKGROUND OF THE INVENTION

Metered-dose inhalers include pressurised metered-dose inhalers (of both manually operable and breath-actuated types) and dry-powder inhalers. Such metered-dose inhalers typically comprise a medicament-containing vessel and an actuator body having a drug delivery outlet.

The medicament-containing vessel may be a pressurised canister containing a mixture of active drug and propellant. Such canisters are usually formed from a deep-drawn aluminium cup having a crimped lid which carries a metering valve assembly. The metering valve assembly is provided with a protruding valve stem which, in use, is inserted as a tight push fit into a so-called "stem block" in the actuator body.

To actuate the conventional manually operable inhaler, the user applies a compressive force to the closed end of the canister. The internal components of the metering valve assembly are spring loaded so that a compressive force of about 15 to 30 N is required to activate the device.

In response to this compressive force, the canister moves axially with respect to the valve stem by an amount varying from about 2 to 4 mm. This degree of axial movement is sufficient to actuate the metering valve and cause a metered quantity of the drug and propellant to be expelled through the valve stem. This is then released into the mouthpiece via a nozzle in the stem block. A user inhaling through the drug delivery outlet of the device at this point will thus receive a dose of the drug.

Metered-dose inhalers as described above administer an accurate dose of medicament whenever required, which is particularly useful for users whose respiratory difficulties manifest themselves suddenly. Such has been the success of these devices that they are now used throughout the world.

A more recent development is the so-called "breath-operated actuator" which delivers a dose of drug through a mouthpiece in response to inhalation by the user. This type of arrangement is particularly convenient in circumstances where the co-ordination between user inhalation and manual depression of the aerosol canister is imperfect. For example, children sometimes lack the necessary co-ordination to achieve effective self-administration and, at times of respiratory distress, adult users may also experience poor co-ordination.

SUMMARY OF THE INVENTION

One of the drawbacks of self-administration from an inhaler is that users often experience difficulty in determining when the charge in the medicament-containing vessel has nearly run out since the contents of the medicament reservoir are typically invisible to the user. With aerosol canisters, part of the reason for this difficulty is that a surplus of propellant may remain in the canister even though the drug supply is nearly exhausted. Alternatively, the near-exhausted state may result in a surplus of drug in relation to propellant. Thus, the illusion is created that the inhaler is still capable of providing useful doses of medicament simply because the canister contains liquid. This is potentially hazardous for the user since dosing becomes unreliable and because few users routinely carry a back-up device.

Many users have several different inhalers for the treatment of a variety of conditions. Others keep inhalers at a number of different locations such as at school, home, work etc. In these circumstances it is particularly difficult for the user to keep track of the amount of usage extracted from each individual inhaler apparatus.

Clearly there is a need for a counter mechanism which enables users to assess how many doses remain in the obscured canister. Such a counter would ensure that users are warned when the inhaler nears exhaustion so that appropriate measures can be taken to avoid running out of medication. Moreover, if a dose counter can provide readability to a resolution of one dose, this can be used for compliance monitoring, either under hospital supervision or by parents and teachers assessing compliance by children in their care. In addition, there are regulatory requirements for metered-dose inhalers to have a dose counter in a number of countries.

WO 98/28033 discloses a dose counter suitable for use with the above-described metered-dose inhalers. FIGS. **1** and **2** reproduced herein from WO 98/28033 show the lower portion of a metered-dose inhaler. The inhaler comprises an actuator body **2** having a drug delivery outlet **4**. An aerosol canister **6** extends into the lower portion of the actuator **2**. The aerosol canister **6** is formed from a deep-drawn aluminium cup **8** to which a lid **10** is attached by crimping.

The lid **10** carries a metering-valve assembly having a protruding valve stem **12**, the end of which is received as a tight push fit in a stem block **14** of the actuator body **2**. Stem block **14** has a nozzle **16** communicating with the drug delivery outlet **4** so that, upon actuation of the metering-valve assembly, a charge of the drug is emitted through the nozzle **16** into the drug delivery outlet **4**. Actuation of the metering-valve assembly is effected by causing downward movement of the aerosol canister **6** relative to the actuator body **2**. This may be achieved through manual pressure exerted by the user against the upturned base (not shown) of the aerosol canister **6** or by automatic depression of the aerosol canister **6** in response to user inhalation in inhalers of the breath-actuated type. The mechanism of breath actuation does not form part of WO 98/28033 or the present invention and will not be described in further detail. A user inhaling through the drug

delivery outlet **4** when the aerosol canister **6** is depressed will receive a metered dose of the drug.

A counter mechanism **18** includes an actuator **20** moulded from a plastics material, such as nylon, the actuator **20** having a boss **22** integrally formed at its base.

The underside of boss **22** is formed with a blind hole which receives a compression spring **24** mounted on an upstanding spigot **26** formed on a lower element of the counter chassis.

A driver **28** for driving a rotary gear in the form of a ratchet-toothed wheel **30** is integrally moulded with boss **22** of the actuator **20** and comprises a transverse hook element (not shown) mounted between two arms (only one visible in FIG. **2**), the bases of which are conjoined to the boss **22**. The transverse hook is dimensioned and oriented to engage with ratchet teeth **32** formed around the periphery of the ratchet-toothed wheel **30** to rotate it in a forward direction.

The ratchet-toothed wheel **30** is integrally moulded with a first hollow axle **34** which is rotatably supported on a first spindle **36** that projects transversely from a chassis sub-element **38**. Chassis sub-element **38** also has a second spindle **40** projecting transversely therefrom on which a second hollow axle **42** is rotatably supported. A flexible tape **44** is wound around the second hollow axle **42** which serves as a supply spool and passes to the first hollow axle **34** which serves as a take-up spool (stock bobbin). A guide plate **46** forming part of the chassis sub-element **38** helps to guide the tape **44** in a smooth passage from the supply spool to the take-up spool. The surface of the tape **44** is marked with a progression of descending numbers which denote the number of doses remaining in the aerosol canister. Typically, the starting count is 200 and successive markings on the tape decrease by one. The spacing between successive markings is coincident with the indexing motion of the matching wheel **30** so that a new number appears in a window **48** provided in the inhaler housing **2** for each successive actuation.

The ratchet-toothed wheel **30** and integrally formed first hollow axle **34** are restrained from reverse rotation by a wrap-spring clutch **50** surrounding the hollow axle **34** at the end thereof remote from ratchet-toothed wheel **30**. One end (not shown) of the wrap-spring clutch **50** is braced against the counter chassis. The windings of the wrap-spring clutch **50** are oriented such that rotation of the first hollow axle **34** in a forward sense is not resisted by the spring coils. However, reverse rotation of the hollow axle **34** acts so as to tighten the spring coils around it, thereby causing the first hollow axle **34** to be gripped by the internal surface of the wrap-spring clutch **50** and hence restraint from reverse rotation.

FIG. **3** shows a preferred embodiment of the invention set out in WO 98/28033. The dose counter **18** comprises an actuator **20** having a boss **22** integrally formed therewith and driver **28** joined to the boss **22**. The underside of boss **22** is provided with a blind hole which receives a compression spring **24** that serves to return the actuator **20** to its rest position after depression thereof during actuation of the inhaler apparatus (not shown).

The driver **28** comprises a transverse hook **52** mounted between a pair of arms **54**,**56** which are joined at their bases by a web (not shown). The web is connected to the boss **22** of the actuator **20**. A combined actuator and driver assembly may be integrally formed, such as from a plastics material, e.g. as nylon.

In use, the transverse hook **52** engages with ratchet teeth **32** of a ratchet-toothed wheel **30** which is mounted on a hollow axle **34** serving as a take-up spool for a flexible tape display **44**. At the end of the hollow axle **34** remote from the ratchet-toothed wheel **30** is a friction clutch **50** which serves to restrain the axle **34** against reverse rotation and hence prevents reverse travel of the counter tape **44**.

A control surface **58** is depicted here as a see-through element so that the workings of the dose counter may be more clearly seen. The control surface **58** extends parallel to the direction of travel of the actuator **20** and is located adjacent the ratchet-toothed wheel **30** at a position which marks a chordal projection across one of the wheel faces. One of the support arms **56** of the driver **28** is in sliding contact with control surface **58**. This sliding contact serves to inhibit the natural tendency of the driver **28** to flex radially inwardly towards the axis of rotation of the ratchet-toothed wheel **30**. By preventing such radially inward flexure, the control surface **58** restricts the engagement and disengagement of the drive **28** with the ratchet-toothed wheel **30** so that the distance by which the ratchet-toothed wheel **30** rotates is limited to one tooth pitch. This condition is observed regardless of the extent of linear travel, or stroke, of the actuator **20**.

FIG. **4** shows a schematic view of a conventional ratchet gear and drive pawl arrangement which is used in the dose counter described in WO 98/28033. The arrangement uses a reciprocating driver **28** acting in a pushing sense to rotate a ratchet-toothed wheel **30** in the direction shown by the arrows A. A fixed pawl **60** acts to prevent reverse rotation of the ratchet-toothed wheel **30** by engagement against the trailing edge **62** of a ratchet tooth **32**. However, on forward rotation of the ratchet-toothed wheel **30** in the sense of arrows A, the fixed pawl **60** is capable of radially outward deformation, urged by the leading edge **63** of a ratchet-tooth **32**.

In this arrangement, if the ratchet-toothed wheel **30** is rotated by more than a single tooth pitch but by less than two tooth pitches for each reciprocating movement of the driver **28**, there is a degree of reverse rotation until the pawl **60** becomes engaged by the trailing edge **62** (as opposed to the leading edge **63**) of a ratchet tooth **32**. Thus, the rotation of the ratchet-toothed wheel **30** may be said to be "stepped".

The components of metered-dose inhalers are manufactured to a high technical specification. However, inevitable variations in the tolerances of the components can, in some circumstances, lead to failure of the dose counter of the type disclosed in WO 98/28033. The failure of the dose counter, although not common, makes the dose counter of the type disclosed in WO 98/28033 unsuitable for some applications. There is a requirement in the art, therefore, for a dose counter with a reduced failure rate.

Accordingly, a first aspect of the present invention provides a dose counter for a metered-dose inhaler, the counter comprising:

- an actuator;
- a rotary gear;
- a driver for driving the rotary gear in a step-wise fashion in response to displacement of the actuator, the rotary gear comprising a wheel mounted on a spindle which wheel having a plurality of ratchet teeth around its periphery;
- a pawl to prevent reverse rotation of the rotary gear; and
- a display coupled to the rotary gear, the display having a visible array of incrementing integers on a surface thereof indexable by a single integer in response to each step of the step-wise rotary motion of the rotary gear;
- wherein the pawl comprises at least two ratchet teeth which are radially spaced such that one of the teeth engages with the ratchet teeth of the wheel following each step of the step-wise rotary motion of the rotary gear.

The counter of the present invention thus provides a pawl having at least two teeth in which one and the same tooth engages with successive ratchet teeth of the wheel during the step-wise rotary motion of the wheel to prevent reverse rota-

tion of the wheel (and hence the rotary gear). By providing alternative positions for engaging the ratchet teeth of the wheel, the pawl increases the range of tolerances in the manufacture of the various components of the inhaler which can be accommodated. This in turn significantly reduces the failure rate of the dose counter and, in particular, the likelihood of undercounting. Clearly, undercounting is particularly undesirable as it can lead to a patient believing that there are more doses left within the inhaler than there actually are.

BRIEF DESCRIPTION OF THE DRAWINGS

The present invention will now be described with reference to the accompanying drawings, in which:

FIGS. **1** to **4** show a dose counter for a metered-dose inhaler according to the prior art document WO 98/28033;

FIG. **5** shows elements of a dose counter according to the present invention;

FIG. **6** shows further detail of the dose counter according to the present invention;

FIG. **7** shows a schematic representation of journeys undertaken for indexing of the dose counter to occur;

FIG. **8** shows the wheel and pawl of the dose counter of the present invention in which the pawl is (a) operating from the first tooth and (b) operating from the second tooth; and

FIG. **9** shows a metered-dose inhaler containing the dose counter of the present invention.

DETAILED DESCRIPTION OF THE INVENTION

The dose counter of the present invention is based on that set out in FIGS. **3** and **4** described hereinabove except that the pawl **60** has been modified. Modification of the pawl followed an in-depth study of all of the components of the inhaler. Thus, as shown in FIG. **5**, the dose counter **18** of the present invention comprises an actuator **20**; a rotary gear (not shown in full in FIG. **5**); a driver **28** for driving the rotary gear in a step-wise fashion in response to displacement of the actuator **20**, the rotary gear comprising a wheel **30** mounted on a spindle (not shown), the wheel **30** having a plurality of ratchet teeth **32** around its periphery; a pawl **60** to prevent reverse rotation of the rotary gear; and a display (not shown) coupled to the rotary gear, the display having a visible array of incrementing integers on a surface thereof indexable by a single integer in response to each step of the step-wise rotary motion of the rotary gear.

The wheel **30** has a plurality of ratchet teeth **32** and preferably has 8-14 teeth (i.e. 8, 9, 10, 11, 12, 13 or 14), more preferably 9, 10, 11 or 12 teeth, and most preferably 11 teeth.

The radius of the wheel **30** measured from the centre of the wheel **30** to the tip of the teeth **32** will depend on the size of the components of the inhaler. Preferably the radius is from 1.5 to 3.5 mm, more preferably from 2.0 to 3.0 mm and most preferably 2.80±0.05 mm.

As in the dose counter 18 of WO 98/28033, the dose counter **18** of the present invention preferably further comprises a control surface to regulate the position of engagement and disengagement between the driver **28** and the wheel **30**. In addition, the driver **28** comprises a ratchet drive pawl and preferably the ratchet drive pawl is in the form of a straddle drive in which the element that engages the ratchet teeth of the wheel is supported between a pair of spaced apart support arms.

The pawl **60** comprises at least two ratchet teeth **64**,**66**. Preferably, as shown in FIG. **5**, the pawl **60** comprises two ratchet teeth **64**,**66** and no more. The at least two ratchet teeth **64**,**66** are radially spaced with respect to the ratchet-toothed wheel **30** such that one and the same tooth engages with the ratchet teeth **32** of the wheel following each step of the step-wise rotary motion of the rotary gear. Typically, one, and only one, of the ratchet teeth **64**,**66** on pawl **60** ever engages with the ratchet wheel.

FIG. **6** shows an exploded view of the dose counter **18** showing in addition to the previously described components, the stock bobbin **68** which is held taut by the action of the split hub **70**. The split hub **70** avoids the need for a clutch spring as set out in WO 98/28033. Although the clutch spring could be used as an alternative or in addition to the split hub **70**, in a preferred embodiment, the dose counter of the present invention does not include a clutch spring. The display is preferably an elongate counter tape **44** on which the dose count is printed or written, and more preferably the counter tape **44** is located on an indexing spool and the dose counter further comprises a stock bobbin to receive the counter tape as the indexing spool is advanced in a step-wise fashion.

In use, the operation of the dose counter **18** is as follows.

The user depresses the aerosol canister **6** which causes displacement of the actuator **20**. In this embodiment, the actuator **20** is adapted to engage with the rim of the medicament canister **6**. The actuator **20** is operable by linear displacement from a first position to a second position and back to the first position and movement of the rotary gear occurs either during the displacement of the actuator from the first position to the second position or during the displacement of the actuator from the second position to the first position. In the embodiment shown in FIG. **5**, the movement of the rotary gear occurs during the displacement of the actuator from the first position to the second position. In the embodiment shown, the actuator **20** comprises a spring-loaded plunger **22**,**24**, the plunger being depressible against the return force of the spring loading when the actuator is caused to deliver a dose of medicament.

During the movement from the first position to the second position, the actuator **20** causes the driver **28** to engage the trailing edge **62** of the ratchet tooth **32** of the wheel **30**. As the actuator **20** and driver **28** move down the ratchet-toothed wheel **30** rotates.

The spindle of the rotary gear moves the counter tape **44** revealing the next integer. The counter tape **44** is held taut by the action of the split hub **70** on which is mounted the stock bobbin **68**.

The pawl **60** radially outwardly deforms to allow the wheel **30** to rotate by one tooth **32**. The at least two teeth **64**,**66** of pawl **60** may be inherently resilient to allow the required radially outward deformation and return. Alternatively or in addition, the pawl **60** may be mounted on a resilient support capable of radially outward deformation, for example the resilient support may be a resilient flange incorporated in to the chassis of the dose counter **18**.

The driver **28** releases the ratchet-toothed wheel **30** after it has engaged with the pawl **60**. On reset of the inhaler, the canister **6** is allowed to return to its initial (first) position. The compression spring **24** pushes the actuator **20** to follow the canister. The driver **28** on the actuator **20** flexes to pass over the teeth of the ratchet-toothed wheel **30** as the actuator **20** moves from the first to the second position.

The tooth of the at least two teeth **64**,**66** which has engaged tooth **32** of the wheel **30** prevents the rotary gear from rotating backwards.

The counter mechanism of the type described with reference to WO 98/28033 and in accordance with the present invention must rotate the wheel **30** of the rotary gear by exactly one tooth spacing each time the actuator is depressed. By tooth spacing is meant one tooth pitch, i.e. the radial

distance between the same notional point two adjacent teeth **32** on the ratchet-toothed wheel **30**. The stroke available for indexing the rotary gear is equal to the full stroke of the actuator **2**. Where the metered-dose inhaler is a pressurised inhaler, the stroke available for counting is equal to the full stroke of the medicament canister **6**. However, there are three movements (or "journeys") that must be completed within this total distance for indexing of the dose counter to occur. The three journeys are shown schematically in FIG. **7**.

FIG. **7** shows a graphical representation the amount of canister travel and the excess stroke available before the three critical journeys must occur. Firstly, the canister travel must close the start gap which is the sum of the tolerances of the manufactured components in the vertical direction. Secondly, the stroke must take up any lost motion, such as in pivot play, flexing of the pawl and arc motion of the drive pawl. Thirdly, is the so-called "stroke to count", which is the journey which leads to indexing of the rotary gear by one tooth spacing.

The stroke available for counting will clearly depend on the type of metered-dose inhaler used. By way of example, a suitable inhaler is the pressurised metered-dosed inhaler EasiBreathe® which uses a Qvar® canister. The canister stroke in this inhaler was measured as 3.04±0.255 mm. This tolerance represents ±3 standard deviations so that 99.7% of all canister strokes will lie within these limits. The measurements were taken from force versus displacement profiles for Qvar® canisters. One hundred and fifty canisters were measured at the start, middle and end of life giving a total of 450 stroke measurements.

The start gap is the tolerance stack in the vertical direction and includes a first distance between the part of the driver **28** which engages the wheel **30** and the appropriate ratchet tooth **32** of the wheel **30** of the rotary gear, and a second distance between the top of the actuator **20** and the canister **6**. The tolerance in the vertical direction was found to be ±0.47 mm. The nominal start gap for the EasiBreathe® inhaler is set at 0.85 mm and hence the start gap with tolerances is 0.85±0.47 mm.

Thus, since the start gap is 0.85±0.47 mm the maximum start gap (mean plus 3 standard deviations) is 1.32 mm (0.85±0.47). When such a start gap occurs, a short-stroking canister (for example, 2.79 mm) will not rotate the wheel **30** of the rotary gear by a full tooth spacing. This will lead to failure of the dose counter. However, the provision of a first and second ratchet tooth **64**,**66** in the pawl **60** allows the ratchet tooth **32** of the wheel **30** of the rotary gear to rest on the second tooth **66**. In the present embodiment, the second tooth **66** is 0.60 mm away from the first tooth **64**. Thus, for the next actuation, the start gap is reduced to 0.72 mm (1.32−0.60). The stroke is therefore sufficient to rotate the wheel **30** a full index starting from this point. The step-wise rotation of the wheel **30** then continues with all subsequent actuations starting and finishing with the ratchet teeth **32** of the wheel **30** of the rotary gear engaged with the second tooth **66** of the pawl **60**.

FIG. **8** shows a more detailed view of the wheel **30** of the rotary gear, the driver **28** and the pawl **60** to prevent reverse rotation of the rotary gear. In FIG. **8**(*a*) the ratchet tooth **32***a* of the wheel **30** is engaged with the first ratchet tooth **64** of the pawl. In FIG. **8**(*b*) the same tooth **32***a* of the wheel **30** is engaged with the second ratchet tooth **66** of the pawl **60**. It may be seen that the start gap is reduced in the arrangement shown in FIG. **8**(*b*) in comparison with the same distance in FIG. **8**(*a*). The second tooth **66** of the pawl **60** therefore allows the first distance S of the start gap (the between the part of the driver **28** which engages the wheel **30** and the appropriate ratchet tooth **32** of the wheel **30**) to be reduced thereby accommodating a greater tolerance in the canister stroke.

As explained hereinabove, the first and second teeth **64**,**66** provide different starting positions for the wheel **30** of the rotary gear to accommodate different tolerance levels in the components of the inhaler. The teeth **64**,**66** are therefore separated radially with respect to the wheel **30**. The spacing will clearly depend on the precise nature of the components used in the inhaler and hence it would be inappropriate to provide a precise numerical value. It is clear from the mechanism, however, that the radial spacing will be less than the radial distance between adjacent teeth **32** on the wheel **30** of the rotary gear.

In the embodiments shown herein, the dose counter **18** of the present invention incorporates a pawl **60** having two teeth **64**,**66** and only two teeth, i.e. the pawl **60** consists essentially of two teeth **64**,**66**. However, additional teeth could be incorporated to provide additional precision to the start position of the wheel **30** and thus additional precision in the first distance S. For example, the pawl may have 2-6, preferably two, three or four teeth, more preferably two or three and most preferably two teeth.

In a particularly preferred embodiment of the present invention, the dose counter is adapted for a canister stroke of 3.041±0.256 mm: the wheel of the rotary gear has a radius of 2.80±0.05 mm defined as the distance from the centre of the wheel to the tip of the teeth and 11 ratchet teeth around its periphery; and the pawl comprises two ratchet teeth only which have a radial spacing of 0.6 mm. In this embodiment, the total stroke to guarantee a count is 2.372±0.115 mm. The probability of failure to count or resent due to component dimension variations (manufacturing tolerances) is less than 1 in 10 million.

The present invention further provides a metered dose inhaler **72** as shown in FIG. **9**. The inhaler comprises a medicament canister **6**, an actuator body **74** for receiving the canister **6** and having a medicament delivery outlet, and the dose counter as described herein. The inhaler has a window **76** for viewing the integers on the tape **44**. In a preferred embodiment the actuator body **74** comprises a sump and preferably a smooth rounded sump. Typically, a rounded sump is understood to have a substantially cylindrical upper portion and a substantially hemi-spherical lower portion. Typically, smooth is understood to mean that the surface is sufficiently free of surface protrusions to the extent that during normal use medicament will not substantially adhere thereto.

In one embodiment of the invention the vessel contains a medicament in the form of an aerosol. Alternatively in another embodiment of the invention the vessel contains a medicament in the form of a dry powder.

The medicament may be any medicament that is suitable to be delivered to a patient via a metered-dose inhaler. In particular medicaments for the treatment of a wide variety of respiratory disorders are delivered in this manner including anti-allergic agents (e.g. cromoglycate, ketotifen and nedocromil), anti-inflammatory steroids (e.g. beclomethasone dipropionate, fluticasone, budesonide, flunisolide, ciclesonide, triamcinolone acetonide and mometasone furoate); bronchodilators such as: β_2-agonists (e.g. fenoterol, formoterol, pirbuterol, reproterol, salbutamol, salmeterol and terbutaline), non-selective β-stimulants (e.g. isoprenaline), and xanthine bronchodilators (e.g. theophylline, aminophylline and choline theophyllinate); and anticholinergic agents (e.g. ipratropium bromide, oxitropium bromide and tiotropium).

A further aspect of the present invention provides the use of a pawl **60** comprising at least two ratchet teeth **64**,**66** for preventing miscounting in a dose counter of a metered dose inhaler **72**. A still further aspect of the present invention provides the use of a pawl **60** comprising at least two ratchet teeth **64**,**66** for preventing undercounting in a counter of a metered dose inhaler **72**.

In a preferred embodiment the counter comprises an actuator **20**; a rotary gear; a driver **28** for driving the rotary gear in a step-wise fashion in response to displacement of the actuator **20**, the rotary gear comprising a wheel **30** mounted on a spindle **36** which wheel **30** having a plurality of ratchet teeth **32** around its periphery; and a display **44** coupled to the rotary gear, the display having a visible array of incrementing integers on a surface thereof indexable by a single integer in response to each step of the step-wise rotary motion of the rotary gear. Preferably, the pawl **60** prevents reverse rotation of the rotary gear.

Although the invention herein has been described with reference to particular embodiments, it is to be understood that these embodiments are merely illustrative of the principles and applications of the present invention. It is therefore to be understood that numerous modifications may be made to the illustrative embodiments and that other arrangements may be devised without departing from the spirit and scope of the present invention as defined by the appended claims.

The invention claimed is:

1. A dose counter for a metered-dose inhaler, the counter comprising: an actuator; a rotary gear; a driver for driving the rotary gear in a step-wise fashion in response to displacement of the actuator, the rotary gear comprising a wheel mounted on a spindle which wheel having a plurality of ratchet teeth around its periphery; a pawl to prevent reverse rotation of the rotary gear; and a display coupled to the rotary gear, the display having a visible array of incrementing integers on a surface thereof indexable by a single integer in response to each step of the step-wise rotary motion of the rotary gear; wherein the pawl comprises at least two ratchet teeth each for engaging with the ratchet teeth of the wheel to prevent reverse rotation of the rotary gear, the at least two ratchet teeth being radially spaced such that one of the at least two ratchet teeth of the pawl engages with the ratchet teeth of the wheel following each step of the step-wise rotary motion of the rotary gear.

2. A dose counter as claimed in claim **1**, wherein the pawl comprises two ratchet teeth and no more.

3. A dose counter as claimed in claim **1**, wherein the pawl is mounted on a resilient support.

4. A dose counter as claimed in claim **3**, wherein the resilient support is a resilient flange incorporated into the body of the dose counter.

5. A dose counter as claimed in claim **1**, further comprising a control surface to regulate the position of engagement and disengagement between the driver and the wheel.

6. A dose counter as claimed in claim **1**, wherein the actuator is operable by linear displacement from a first position to a second position and back to the first position and wherein movement of the rotary gear occurs either during the displacement of the actuator from the first position to the second position or during the displacement of the actuator from the second position to the first position.

7. A dose counter as claimed in claim **1**, wherein the actuator comprises a spring-loaded plunger, the plunger being depressible against a return force of a spring of the spring-loaded plunger when the actuator is caused to deliver a dose of medicament.

8. A dose counter as claimed in claim **1**, wherein the driver comprises a ratchet drive pawl.

9. A dose counter as claimed in claim **8**, wherein the ratchet drive pawl is in the form of a straddle drive in which an element that engages the ratchet teeth of the wheel is supported between a pair of spaced apart support arms.

10. A dose counter as claimed in claim **1**, wherein the display is an elongate counter tape on which a dose count is printed or written.

11. A dose counter as claimed in claim **10**, wherein the counter tape is located on an indexing spool and the dose counter further comprises a stock bobbin to receive the counter tape as the indexing spool is advanced in a step-wise fashion.

12. A dose counter as claimed in claim **1**, wherein the actuator is adapted to engage with a rim of a medicament canister.

13. A dose counter as claimed in claim **1**, wherein the wheel of the rotary gear has eight to fourteen ratchet teeth around a periphery of the rotary gear.

14. A dose counter as claimed in claim **13**, wherein the wheel of the rotary gear has eleven ratchet teeth around its periphery.

15. A dose counter as claimed in claim **1**, wherein the wheel of the rotary gear has a radius defined as the distance from the centre of the wheel to a tip of the teeth of 2.80+−0.05 mm and eleven ratchet teeth around its periphery, and the pawl comprises two ratchet teeth and no more which have a radial spacing of about 0.6 mm.

16. A metered dose inhaler comprising a medicament canister, an actuator body for receiving the canister and having a medicament delivery outlet, and the dose counter as claimed in claim **1**.

17. A metered dose inhaler according to claim **16** wherein the actuator body comprises a smooth rounded sump.

18. The use of a dose counter for preventing miscounting in a metered dose inhaler, the dose counter comprising: an actuator; a rotary gear; a driver for driving the rotary gear in a step-wise fashion in response to displacement of the actuator, the rotary gear comprising a wheel mounted on a spindle which wheel having a plurality of ratchet teeth around its periphery; a pawl to prevent reverse rotation of the rotary gear; and a display coupled to the rotary gear, the display having a visible array of incrementing integers on a surface thereof indexable by a single integer in response to each step of the step-wise rotary motion of the rotary gear; wherein the pawl comprises at least two ratchet teeth each for engaging with the ratchet teeth of the wheel to prevent reverse rotation of the rotary gear, the at least two ratchet teeth being radially spaced such that one of the at least two ratchet teeth of the pawl engages with the ratchet teeth of the wheel following each step of the step-wise rotary motion of the rotary gear.

19. The use of a dose counter for preventing undercounting in a metered dose inhaler, the dose counter comprising: an actuator; a rotary gear; a driver for driving the rotary gear in a step-wise fashion in response to displacement of the actuator, the rotary gear comprising a wheel mounted on a spindle which wheel having a plurality of ratchet teeth around its periphery; a pawl to prevent reverse rotation of the rotary gear; and a display coupled to the rotary gear, the display having a visible array of incrementing integers on a surface thereof indexable by a single integer in response to each step of the step-wise rotary motion of the rotary gear; wherein the pawl comprises at least two ratchet teeth each for engaging with the ratchet teeth of the wheel to prevent reverse rotation of the rotary gear, the at least two ratchet teeth being radially spaced such that one of the at least two ratchet teeth of the pawl engages with the ratchet teeth of the wheel following each step of the step-wise rotary motion of the rotary gear.

* * * * *

Exhibit B

US009463289B2

(12) **United States Patent**
Walsh et al.

(10) **Patent No.: US 9,463,289 B2**
(45) **Date of Patent: Oct. 11, 2016**

(54) **DOSE COUNTERS FOR INHALERS, INHALERS AND METHODS OF ASSEMBLY THEREOF**

(71) Applicants: **IVAX PHARMACEUTICALS IRELAND**, Utrecht (NL); **NORTON WATERFORD**, Utrecht (NL); **TEVA PHARMACEUTICALS IRELAND**, Utrecht (NL)

(72) Inventors: **Declan Walsh**, County Kilkenny (IE); **Derek Fenlon**, County Wexford (IE); **Simon Kaar**, County Cork (IE); **Jan Geert Hazenberg**, County Kilkenny (IE); **Daniel Buck**, County Waterford (IE); **Paul Clancy**, Waterford (IE); **Robert Charles Uschold**, Leominster, MA (US); **Jeffrey A. Karg**, Hopkinton, MA (US)

(73) Assignees: **IVAX Pharmaceuticals Ireland**, Waterford (IE); **Norton (Waterford) Limited**, Waterford (IE); **Teva Pharmaceuticals Ireland**, Waterford (IE)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

(21) Appl. No.: **14/103,324**

(22) Filed: **Dec. 11, 2013**

(65) **Prior Publication Data**

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Related U.S. Application Data

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(60) Provisional application No. 61/345,763, filed on May 18, 2010, provisional application No. 61/417,659, filed on Nov. 29, 2010.

(51) **Int. Cl.**
G06M 1/06 (2006.01)
A61M 11/00 (2006.01)
(Continued)

(52) **U.S. Cl.**
CPC ***A61M 15/0071*** (2014.02); ***A61M 11/00*** (2013.01); ***A61M 15/009*** (2013.01);
(Continued)

(58) **Field of Classification Search**
USPC 235/8, 103; 128/200.23
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

4,174,890 A 11/1979 Johnson
4,669,838 A 6/1987 Hibbard
(Continued)

FOREIGN PATENT DOCUMENTS

CA 2501726 9/2006
EP 1330280 11/2004
(Continued)

OTHER PUBLICATIONS

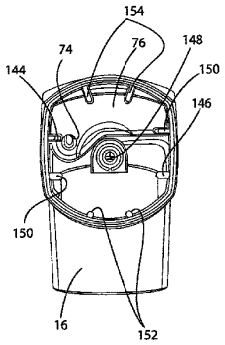
First Examination Report of counterpart New Zealand Patent Application No. 603466, dated Jul. 1, 2013.
(Continued)

Primary Examiner — Daniel Hess
(74) *Attorney, Agent, or Firm* — RatnerPrestia

(57) **ABSTRACT**

A manually operated metered dose inhaler includes a dose counter chamber including a dose display tape driven by a ratchet wheel which is driven in turn by an actuator pawl actuated by movement of a canister, the tape unwinding from a stock bobbin during use of the inhaler, a rotation regulator being provided for the stock bobbin and including a wavelike engagement surface with concavities which engage against control elements in the form of protrusions on resilient forks of a split pin thereby permitting incremental unwinding of the stock bobbin yet resisting excessive rotation if the inhaler is dropped onto a hard surface.

10 Claims, 17 Drawing Sheets



(51) **Int. Cl.**
A61M 15/00 (2006.01)
G06M 1/24 (2006.01)

(52) **U.S. Cl.**
CPC ***A61M15/0025*** (2014.02); ***A61M 15/0026*** (2014.02); ***A61M 15/0065*** (2013.01); ***A61M 15/0078*** (2014.02); ***G06M 1/246*** (2013.01); *A61M 2202/064* (2013.01); *A61M 2205/6063* (2013.01); *A61M 2207/00* (2013.01); *A61M 2207/10* (2013.01); *Y10T 29/49* (2015.01); *Y10T 29/49764* (2015.01); *Y10T 29/49826* (2015.01)

(56) **References Cited**

U.S. PATENT DOCUMENTS

4,687,359	A	8/1987	Barrus	
5,482,030	A	1/1996	Klein	
5,861,911	A	1/1999	Oosaka	
6,446,627	B1	9/2002	Bowman et al.	
6,718,972	B2	4/2004	O'Leary	
8,418,690	B2	4/2013	Power	
8,474,448	B2	7/2013	Oi	
2002/0047021	A1	4/2002	Blacker et al.	
2002/0078949	A1	6/2002	OLeary	
2002/0078950	A1	6/2002	OLeary	
2003/0209239	A1	11/2003	Rand	
2004/0095746	A1	5/2004	Murphy	
2005/0028815	A1	2/2005	Deaton et al.	
2005/0087191	A1	4/2005	Morton et al.	
2006/0096594	A1	5/2006	Bonney et al.	
2006/0107949	A1*	5/2006	Davies et al.	128/200.23
2006/0107979	A1	5/2006	Kim	
2007/0062518	A1	3/2007	Geser	
2008/0242465	A1	10/2008	Strobel	
2009/0178678	A1	7/2009	O'Leary	
2010/0089395	A1	4/2010	Power	
2010/0218759	A1	9/2010	Anderson et al.	
2011/0041845	A1	2/2011	Solomon	
2012/0006322	A1	1/2012	Anderson	

FOREIGN PATENT DOCUMENTS

EP	1486227	12/2004
GB	2320489 A	6/1998
JP	02502129	7/1990
JP	450059	8/1992
JP	07100205	4/1995
JP	10504220	4/1998
JP	2002528144	9/2002
JP	2004501685	1/2004
JP	2008094103	4/2008
JP	2008261423	10/2008
JP	2009233308	10/2009
JP	2009257392	11/2009
JP	2010096308	4/2010
WO	8909078	10/1989
WO	9628205	9/1996
WO	WO 9828033	7/1998
WO	9936115	7/1999
WO	03101514	12/2003
WO	2005102430	11/2005
WO	WO 2006/062449	6/2006
WO	2007012861	2/2007
WO	2007062518	6/2007
WO	WO 2008/023019	2/2008
WO	WO 2008119552	10/2008
WO	2011012325	2/2011
WO	2011012327	2/2011

OTHER PUBLICATIONS

Entire patent prosecution history of U.S. Appl. No. 14/699,567, filed Apr. 29, 2015, entitled, "Dose Counter for Inhaler and Method for Counting Doses."
Entire patent prosecution history of U.S. Appl. No. 14/699,578, filed, Apr. 29, 2015, entitled, "Dose Counter for Inhaler Having a Bore and Shaft Arrangement."
Entire patent prosecution history of U.S. Appl. No., 14/699,584, filed Apr. 29, 2015, entitled, "Dose Counter for Inhaler Having an Anti-Reverse Rotation Actuator."
Entire patent prosecution history of U.S. Appl. No. 14/713,612, filed May 15, 2015, entitled, "Dose Counters for Inhalers, Inhalers and Methods of Assembly Thereof."
Entire patent prosecution history of U.S. Appl. No. 14/713,620, filed May 15, 2015, entitled, "Dose Counters for Inhalers, Inhalers and Methods of Assembly Thereof."
Entire patent prosecution history of U.S. Appl. No. 14/713,633, filed May 15, 2015, entitled, "Dose Counters for Inhalers, Inhalers and Methods of Assembly Thereof."
Entire patent prosecution history of U.S. Appl. No. 14/713,643, filed May 15, 2015, entitled, "Dose Counters for Inhalers, Inhalers and Methods of Assembly Thereof."
Entire patent prosecution history of U.S. Appl. No. 13/110,532, filed May 18, 2011, entitled, "Dose Counters for Inhalers, Inhalers and Methods of Assembly Thereof."
Entire patent prosecution history of U.S. Appl. No. 14/103,343, filed Dec. 11, 2013, entitled, "Dose Counters for Inhalers, Inhalers and Methods of Assembly Thereof."
Entire patent prosecution history of U.S. Appl. No. 14/103,353, filed Dec. 11, 2013, entitled, "Dose Counters for Inhalers, Inhalers and Methods of Assembly Thereof."
Entire patent prosecution history of U.S. Appl. No. 14/103,363, filed Dec. 1, 2013, entitled, "Dose Counters for Inhalers, Inhalers and Methods of Assembly Thereof."
Entire patent prosecution history of U.S. Appl. No. 14/103,392, filed Dec. 11, 2013, entitled, "Dose Counters for Inhalers, Inhalers and Methods of Assembly Thereof."
European Patent Office Communication, dated Apr. 24, 2014 of counterpart European Patent Application No. 11 010 211.8.
European Patent Office Communication, dated Apr. 24, 2014 of counterpart European Patent Application No. 11 010 212.6.

* cited by examiner

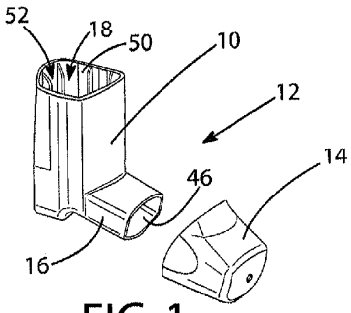


FIG. 1

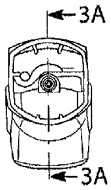


FIG. 2

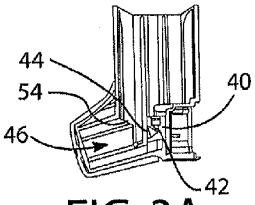


FIG. 3A

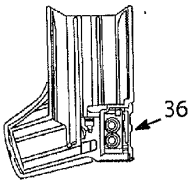


FIG. 3B

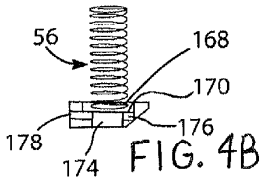


FIG. 4B

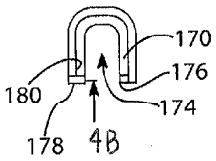


FIG. 4C

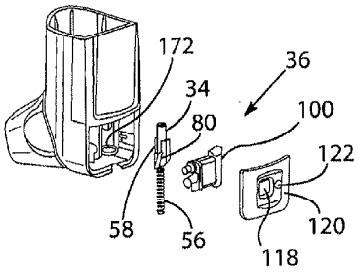


FIG. 4A

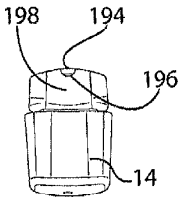


FIG. 5

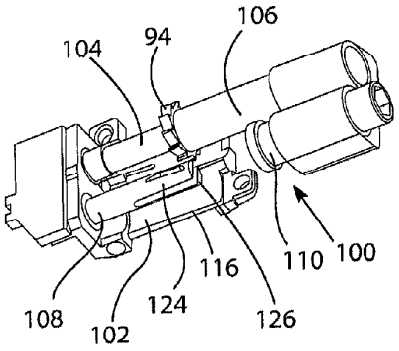


FIG. 6A

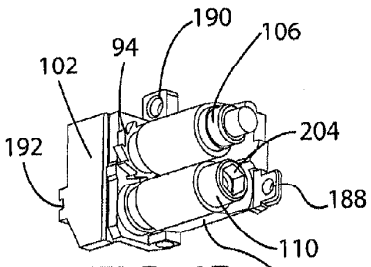


FIG. 6B

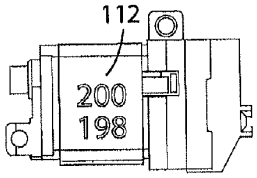


FIG. 6C

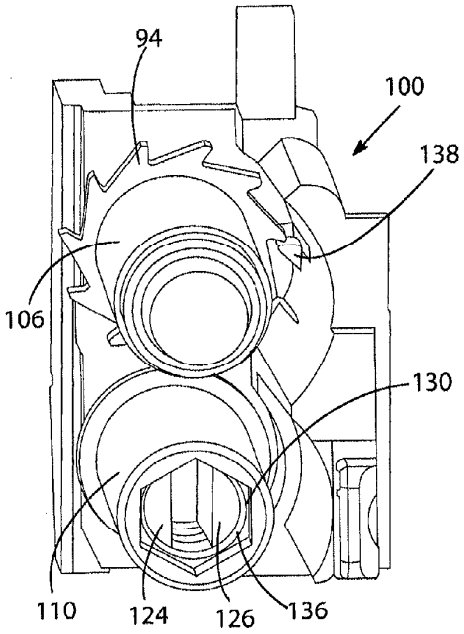


FIG. 6D

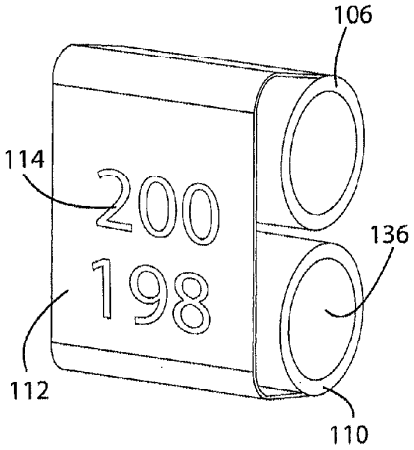


FIG. 6E

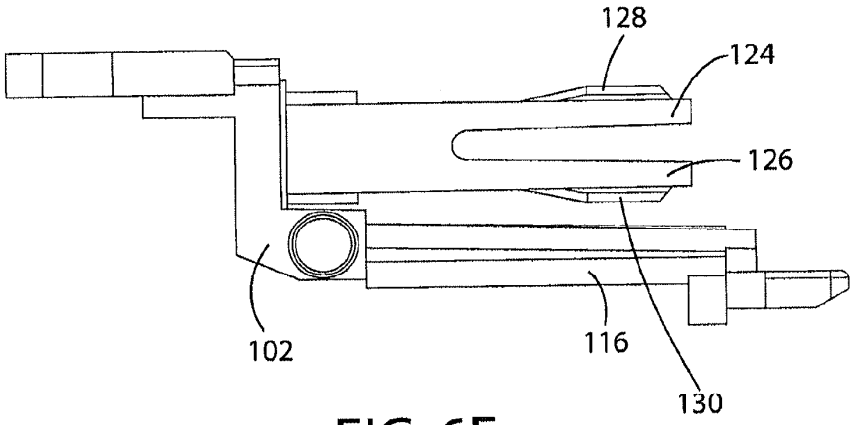


FIG. 6F

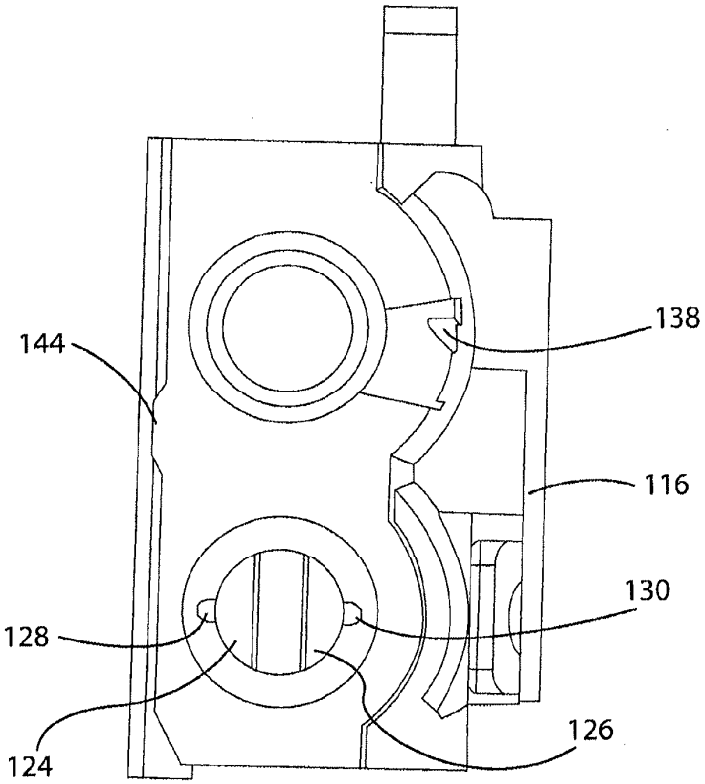


FIG. 6G

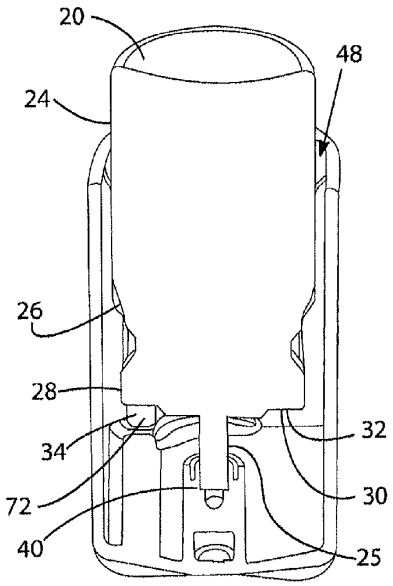


FIG. 7A

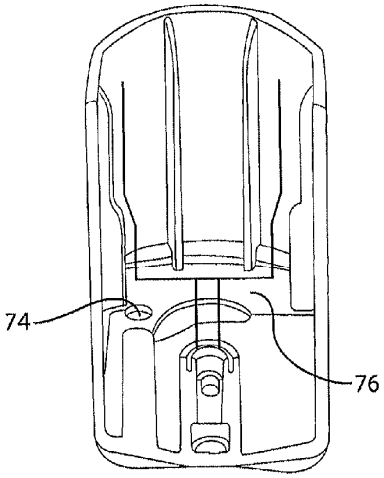


FIG. 7B

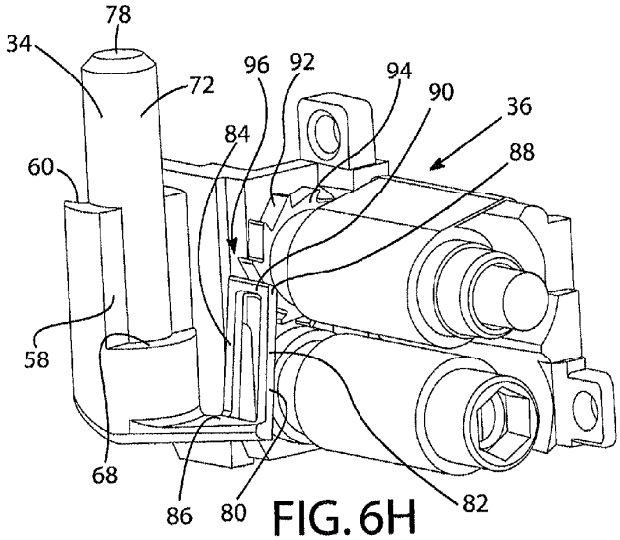


FIG. 6H

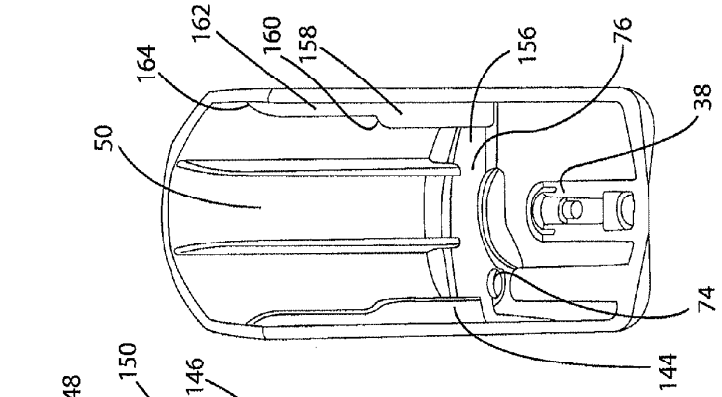


FIG. 7C

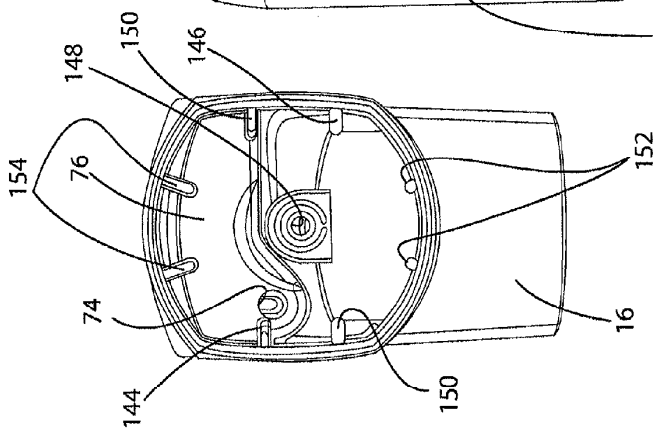


FIG. 7D

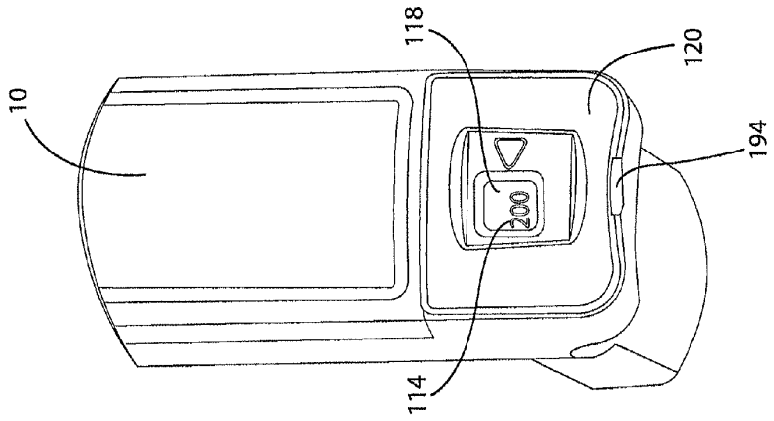


FIG. 8D

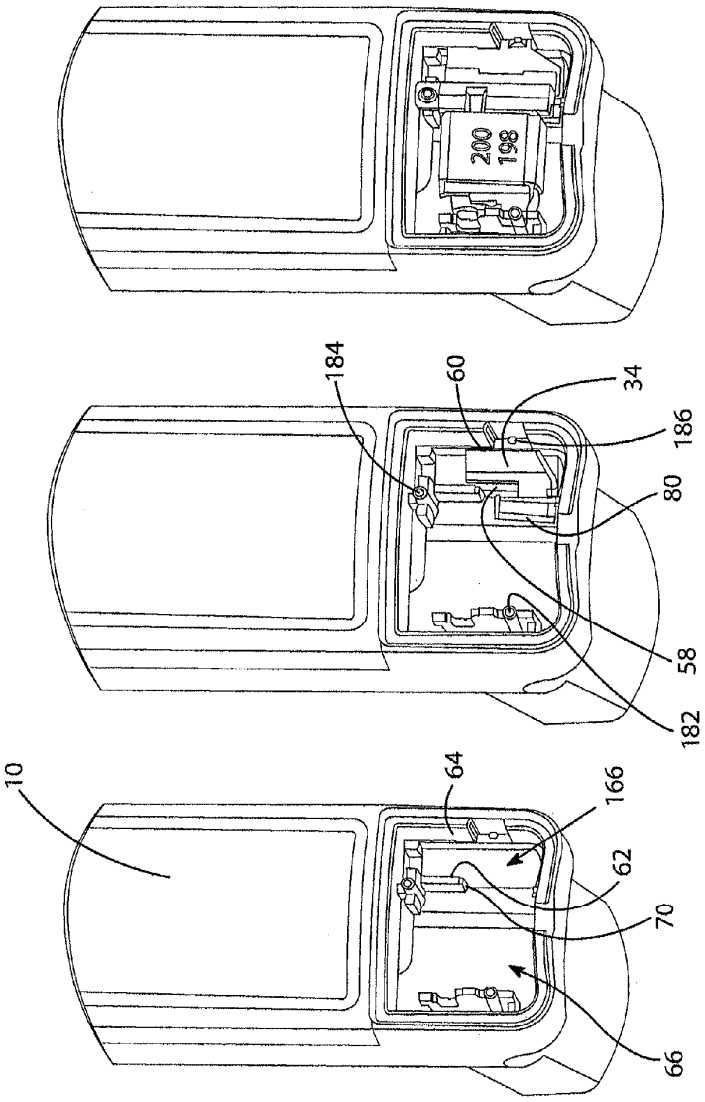


FIG. 8C

FIG. 8B

FIG. 8A

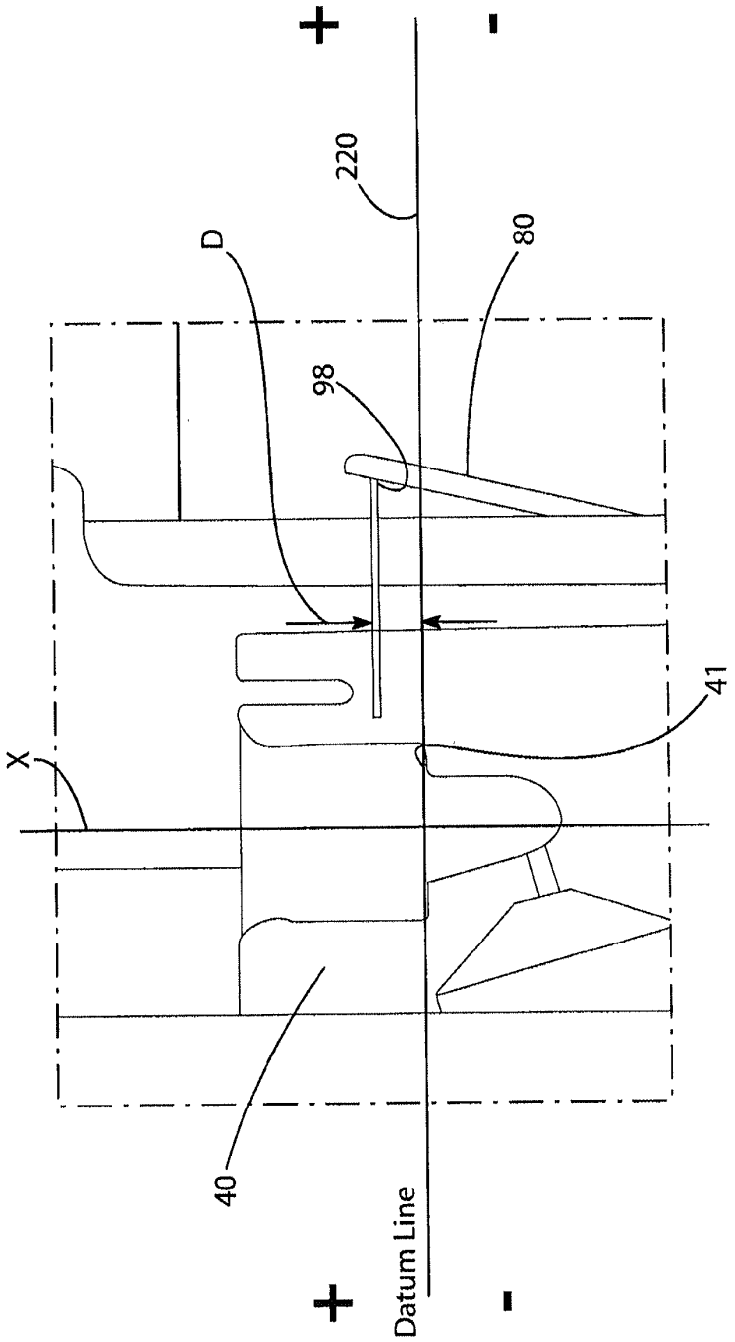


FIG. 9

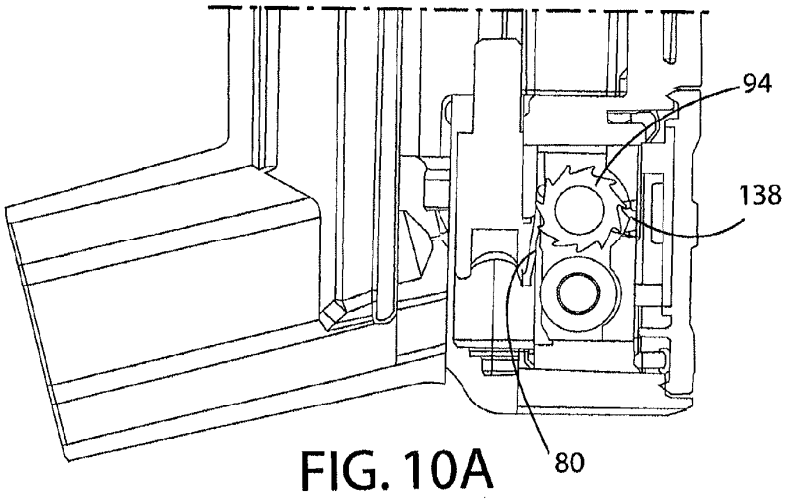


FIG. 10A

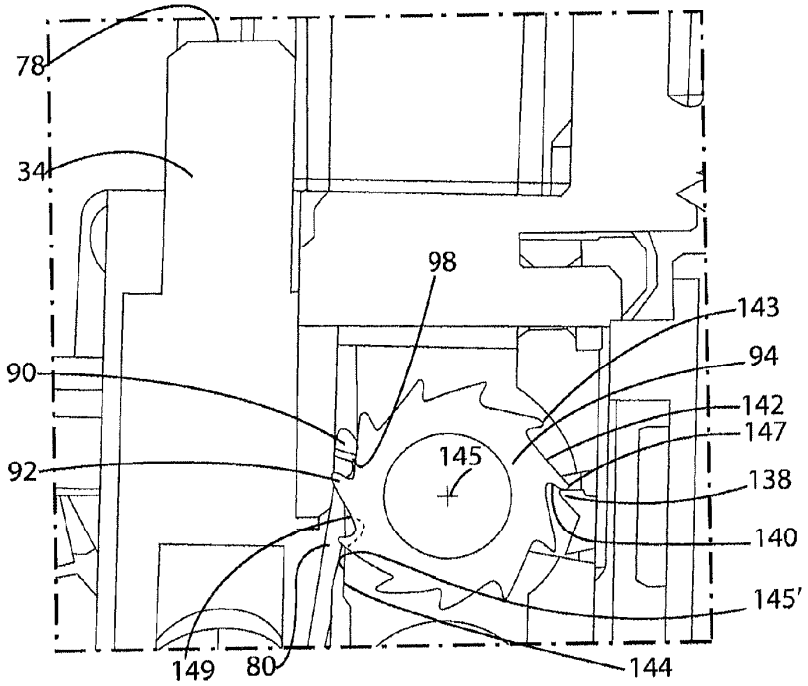


FIG. 10B

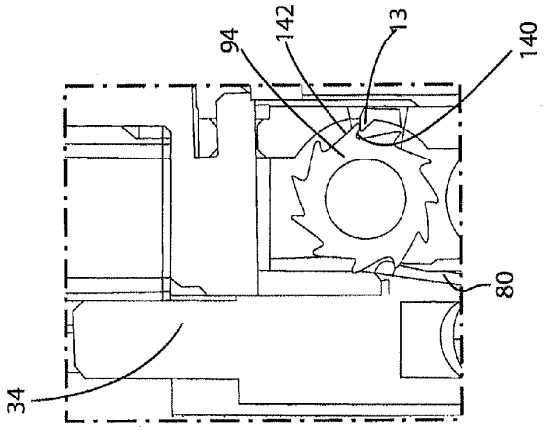


FIG. 10E

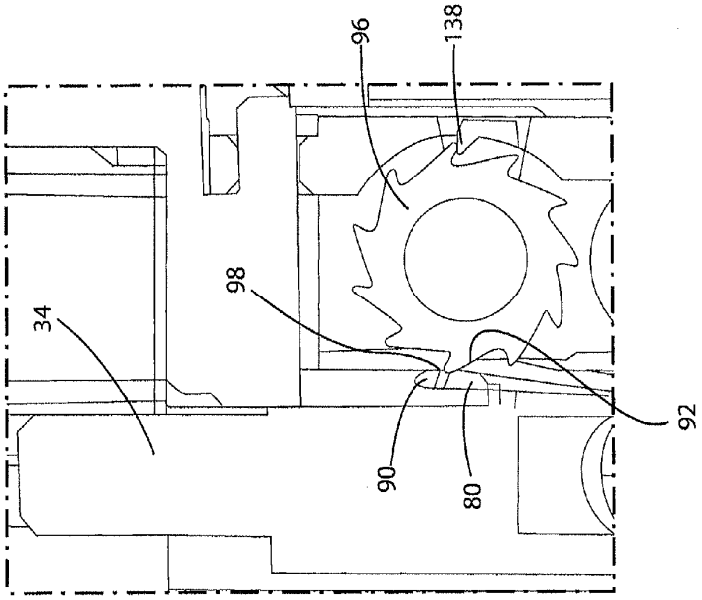


FIG. 10C

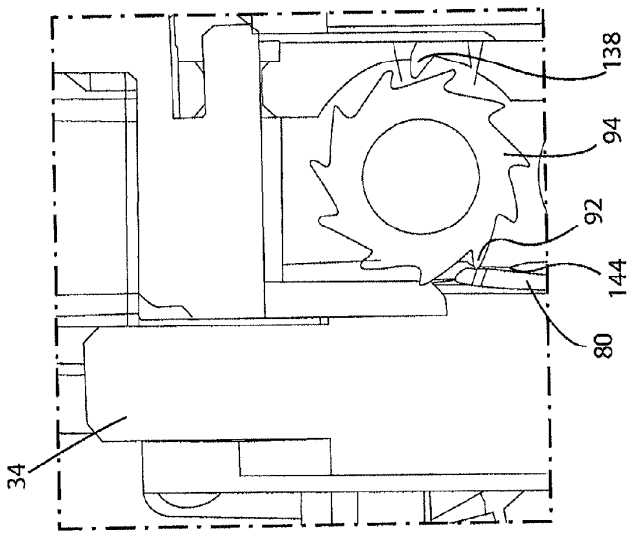


FIG. 10F

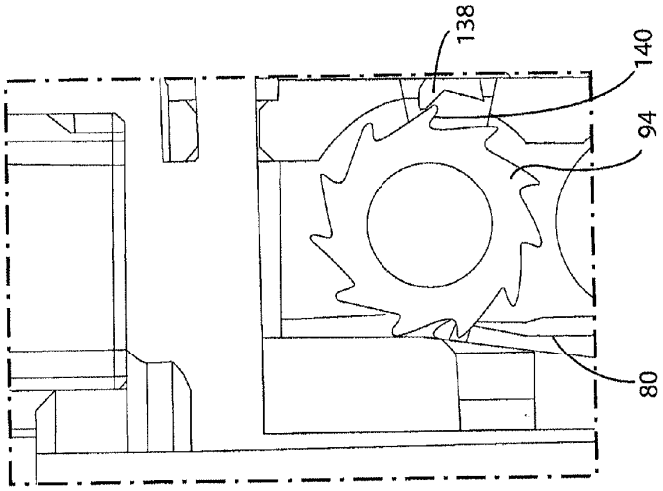


FIG. 10D

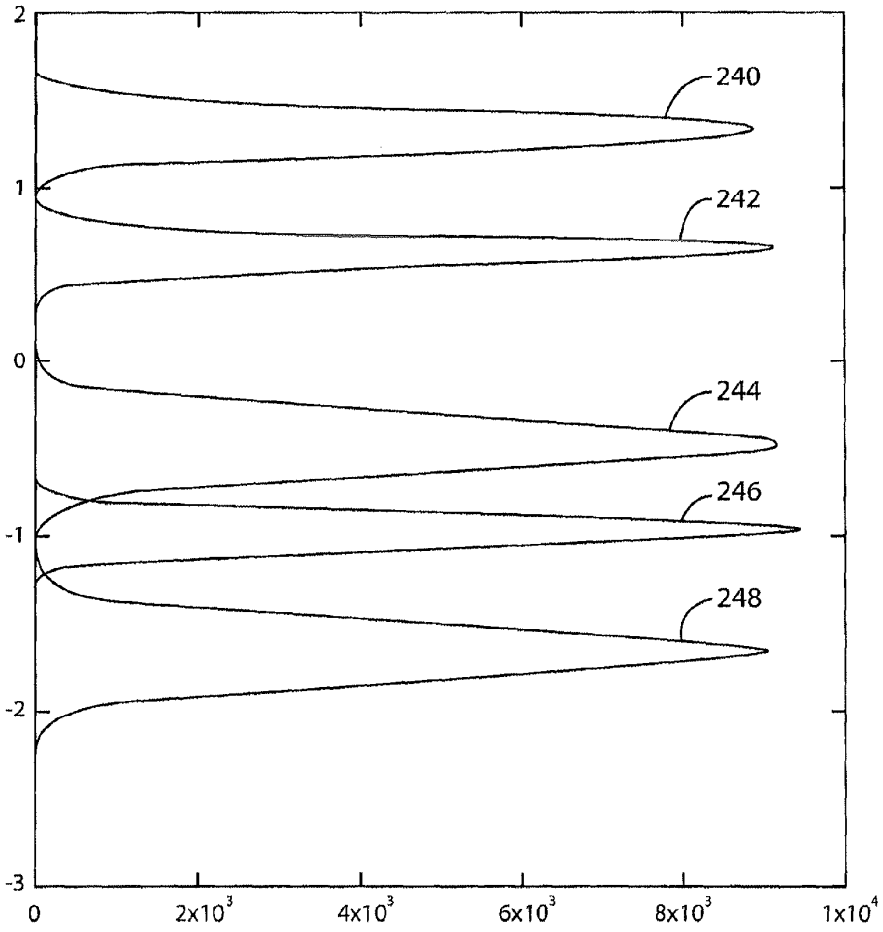
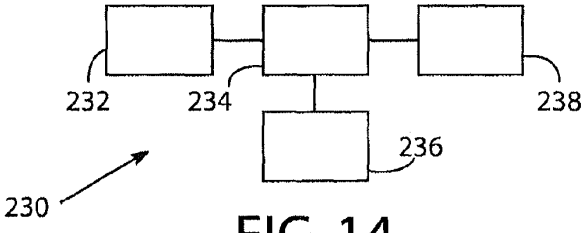

2
1
0
-1
-2
-3
0
2x10^3
4x10^3
6x10^3
8x10^3
1x10^4
240
242
244
246
248

FIG. 11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234
238
236
230

FIG. 14

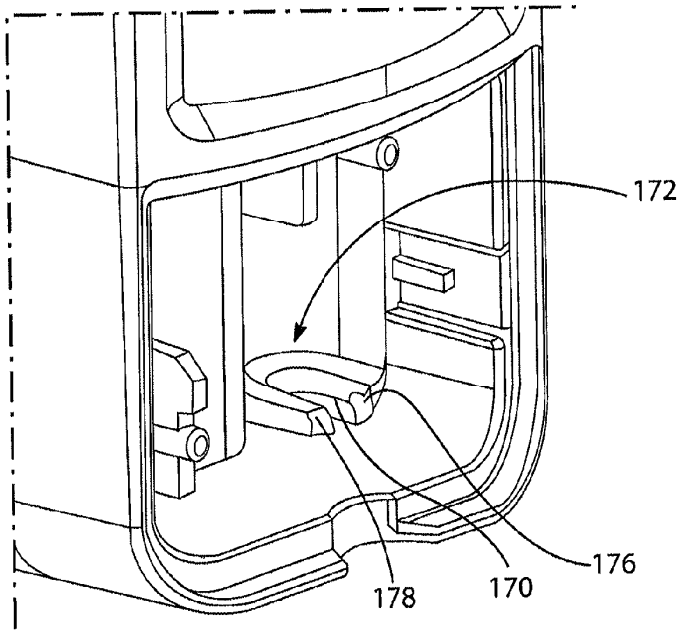


FIG. 12

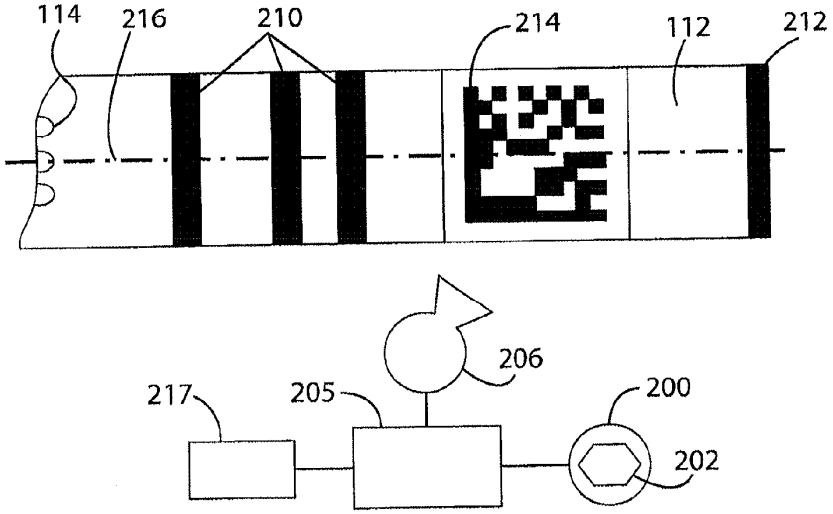


FIG. 13

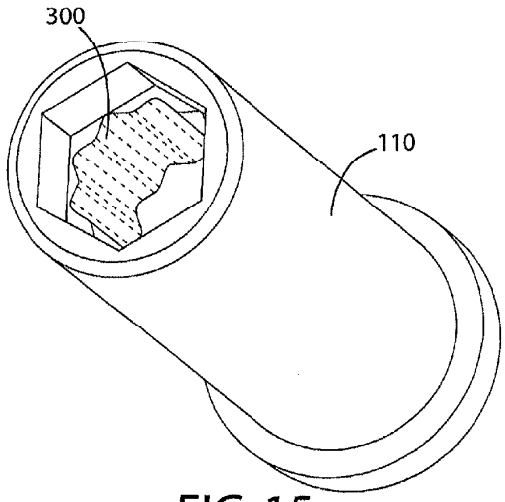


FIG. 15

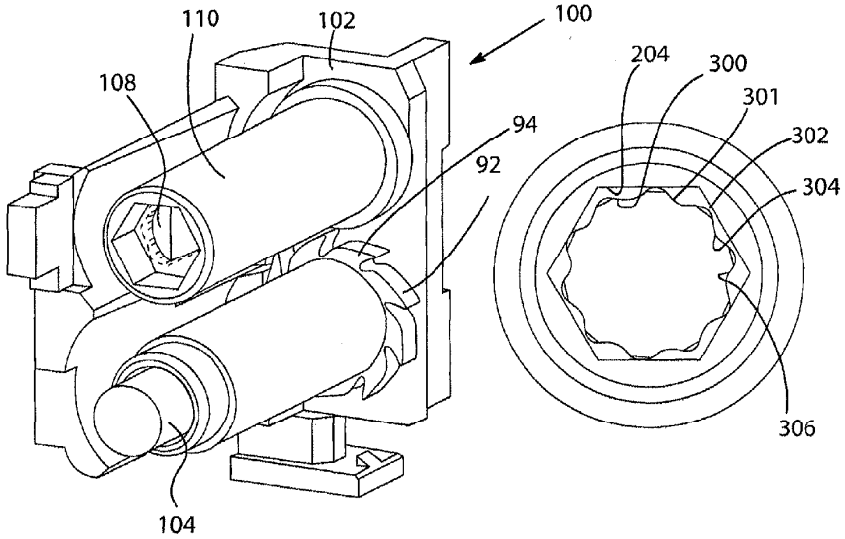


FIG. 20

FIG. 16

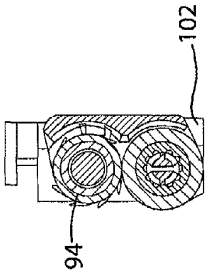


FIG. 19A

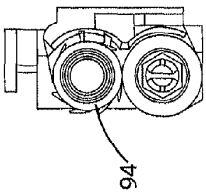


FIG. 19B

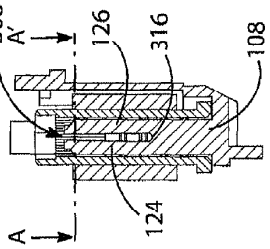


FIG. 19C

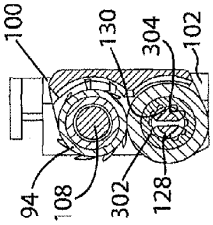


FIG. 18A

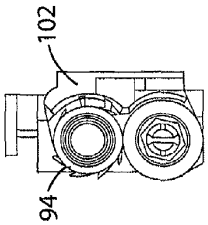


FIG. 18B

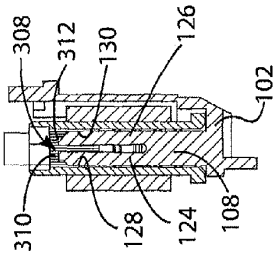


FIG. 18C

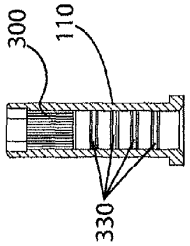
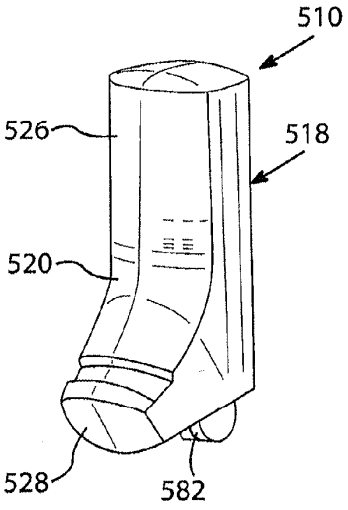


FIG. 17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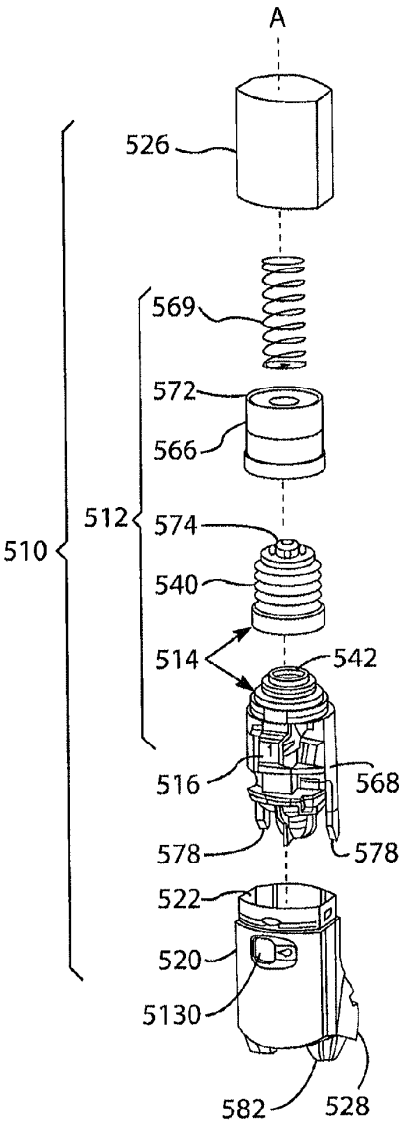
526
518
520
528
582

FIG. 21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526
569
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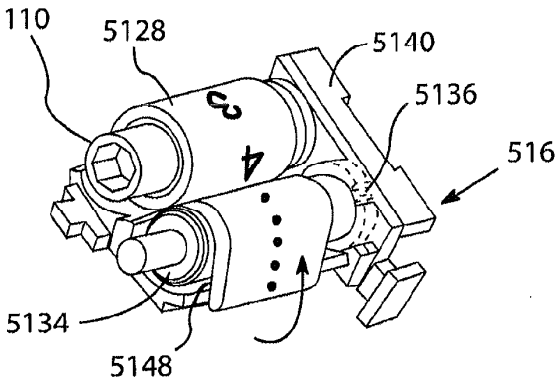
5130
582
528

FIG. 22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516
5134
5148

FIG. 23

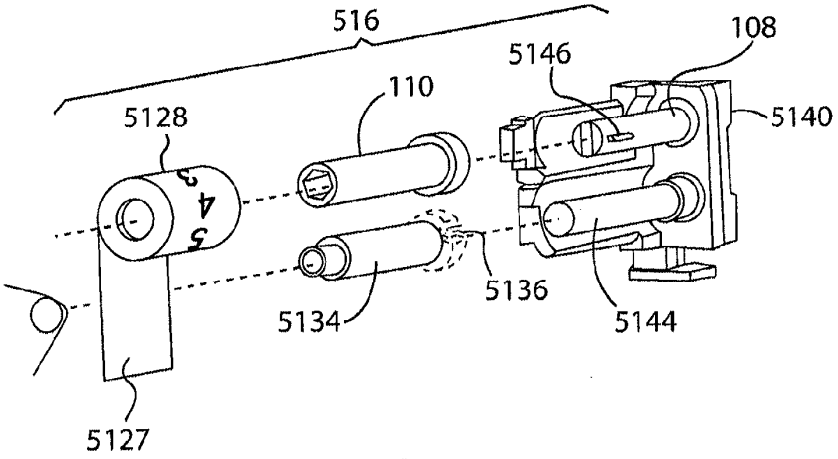
516
108
5146
110
5128
5140
5136
5134
5144
5127

FIG. 24

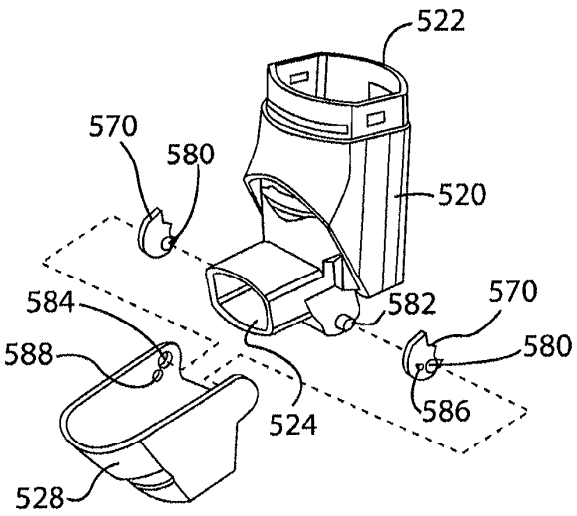

FIG. 25

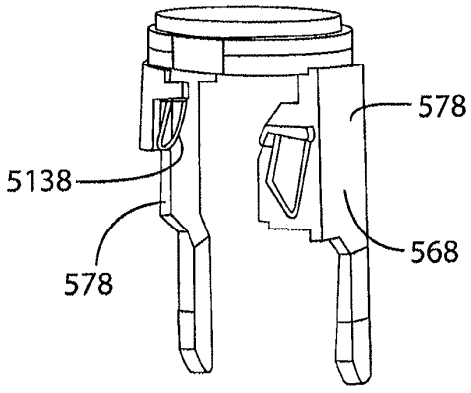

FIG. 26

DOSE COUNTERS FOR INHALERS, INHALERS AND METHODS OF ASSEMBLY THEREOF

CROSS-REFERENCE TO RELATED APPLICATIONS

This patent application is a divisional patent application of U.S. Non-Provisional patent application Ser. No. 13/110,532, filed May 18, 2011, which claims priority to U.S. Provisional Patent Application No. 61/345,763, filed May 18, 2010, and U.S. Provisional Patent Application No. 61/417,659, filed Nov. 29, 2010, each of which is incorporated herein by reference in its entirety for all purposes.

FIELD OF THE INVENTION

The present invention relates to dose counters for inhalers, inhalers and methods of assembly thereof. The invention is particularly applicable to metered dose inhalers including dry power medicament inhalers, breath actuated inhalers and manually operated metered dose medicament inhalers.

BACKGROUND OF THE INVENTION

Metered dose inhalers can comprise a medicament-containing pressurised canister containing a mixture of active drug and propellant. Such canisters are usually formed from a deep-dawn aluminium cup having a crimped lid which carries a metering valve assembly. The metering valve assembly is provided with a protruding valve stem which, in use is inserted as a push fit into a stem block in an actuator body of an inhaler having a drug delivery outlet. In order to actuate a manually operable inhaler, the user applies by hand a compressive force to a closed end of the canister and the internal components of the metering valve assembly are spring loaded so that a compressive force of approximately 15 to 30N is required to activate the device in some typical circumstances.

In response to this compressive force the canister moves axially with respect to the valve stem and the axial movement is sufficient to actuate the metering valve and cause a metered quantity of the drug and the propellant to be expelled through the valve stem. This is then released into a mouthpiece of the inhaler via a nozzle in the stem block, such that a user inhaling through the outlet of the inhaler will receive a dose of the drug.

A drawback of self-administration from an inhaler is that it is difficult to determine how much active drug and/or propellant are left in the inhaler, if any, especially of the active drug and this is potentially hazardous for the user since dosing becomes unreliable and backup devices not always available.

Inhalers incorporating dose counters have therefore become known.

WO 98/280733 discloses an inhaler having a ratchet mechanism for driving a tape drive dose counter. A shaft onto which tape is wound has a friction clutch or spring for restraining the shaft against reverse rotation.

EP-A-1486227 discloses an inhaler for dry powered medicament having a ratchet mechanism for a tape dose counter which is operated when a mouthpiece of the inhaler is closed. Due to the way in which the mouthpiece is opened and closed, and actuation pawl of the device which is mounted on a yoke, travels a known long stroke of consistent length as the mouthpiece is opened and closed.

WO 2008/119552 discloses a metered-dose inhaler which is suitable for breath-operated applications and operates with a known and constant canister stroke length of 3.04 mm+/−0.255 mm. A stock bobbin of the counter, from which a tape is unwound, rotates on a shaft having a split pin intended to hold the stock bobbin taut. However, some dose counters do not keep a particularly reliable count, such as if they are dropped onto a hard surface.

More recently, it has become desirable to improve dose counters further and, in particular, it is felt that it would be useful to provide extremely accurate dose counters for manually-operated canister-type metered dose inhalers. Unfortunately, in these inhalers, it has been found in the course of making the present invention that the stroke length of the canister is to a very large extent controlled on each dose operation by the user, and by hand. Therefore, the stroke length is highly variable and it is found to be extremely difficult to provide a highly reliable dose counter for these applications. The dose counter must not count a dose when the canister has not fired since this might wrongly indicate to the user that a dose has been applied and if done repeatedly the user would throw away the canister or whole device before it is really time to change the device due to the active drug and propellant reaching a set minimum. Additionally, the canister must not fire without the dose counter counting because the user may then apply another dose thinking that the canister has not fired, and if this is done repeatedly the active drug and/or propellant may run out while the user thinks the device is still suitable for use according to the counter. It has also been found to be fairly difficult to assembly some known inhaler devices and the dose counters therefor. Additionally, it is felt desirable to improve upon inhalers by making them easily usable after they have been washed with water.

The present invention aims to alleviate at least to a certain extent one or more of the problems of the prior art.

SUMMARY OF THE INVENTION

According to a first aspect of the present invention there is provided a dose counter for an inhaler, the dose counter having a counter display arranged to indicate dosage information, a drive system arranged to move the counter display incrementally in a first direction from a first station to a second station in response to actuation input, wherein a regulator is provided which is arranged to act upon the counter display at the first station to regulate motion of the counter display at the first station to incremental movements.

The regulator is advantageous in that it helps prevent unwanted motion of the counter display if the counter is dropped.

According to a further aspect of the present invention, the regulator provides a resistance force of greater than 0.1 N against movement of the counter display. According to still a further aspect of the present invention, the resistance force is greater than 0.3 N. According to yet a further aspect of the present invention, the resistance force is from 0.3 to 0.4 N.

Preferably, the counter comprises a tape.

Preferably, the tape has dose counter indicia displayed thereon. The first station may comprise a region of the dose counter where tape is held which is located before a display location, such as a display window, for the counter indicia.

The first station may comprise a first shaft, the tape being arranged on the first shaft and to unwind therefrom upon movement of the counter display.

The first shaft may be mounted for rotation relative to a substantially rotationally fixed element of the dose counter.

The regulator may comprise at least one projection which is arranged on one of the first shaft and the substantially rotationally fixed element and to engage incrementally with one or more formations on the other of the first shaft and the substantially rotationally fixed element.

At least two said projections may be provided. Exactly two said projections maybe provided.

Each projection may comprise a radiused surface.

The at least one projection may be located on the substantially fixed element which may comprise a fixed shaft which is fixed to a main body of the dose counter, the first shaft being rotationally mounted to the fixed shaft.

Preferably, the fixed shaft has at least two resiliently flexible legs (or forks). Each leg may have at least one said projection formed in an outwardly facing direction thereon, said one or more formations being formed on an inwardly facing engagement surface of the first shaft, said at least one projection being arranged to resiliently engage said one or more formations. Preferably, a series of said formations are provided. An even number of said formations may be provided. Eight to twelve of said formations may be provided. In one embodiment, ten said formations are provided.

Each said formation may comprise a concavity formed on an engagement surface. Each concavity may comprise a radiused surface wall portion which preferably merges on at least one side thereof into a flat wall portion surface. The engagement surface may include a series of said concavities, and convex wall portions of the engagement surface may be formed between each adjacent two said concavities, each said convex wall portion comprising a convex radiused wall portion.

Each convex radiused wall portion of each convex wall portion may be connected by said flat wall portion surfaces to each adjacent concavity.

The fixed shaft may comprise a split pin with fork legs and each projection may be located on a said fork leg.

The first shaft may comprise a substantially hollow bobbin.

Said at least one formation may be located on an inner surface of the bobbin. In other embodiments it may be located on an outer surface thereof. Said engagement surface may extend partially along said bobbin, a remainder of the respective inner or outer surface having a generally smooth journal portion along at least a portion thereof.

The drive system may comprise a tooth ratchet wheel arranged to act upon a second shaft which is located at the second station, the second shaft being rotatable to wind the tape onto the second shaft.

The second shaft may be located on a main body of the dose counter spaced from and parallel to the first shaft.

The ratchet wheel may be fixed to the second shaft is arranged to rotate therewith. The ratchet wheel may be secured to an end of the second shaft and aligned coaxially with the second shaft.

The dose counter may include anti-back drive system which is arranged to restrict motion of the second shaft. The anti-back drive system may include a substantially fixed tooth arranged to act upon teeth of the ratchet wheel.

According to a further aspect of the present invention, a dose counter includes an anti-back drive system which is arranged to restrict motion of the second shaft in a tape winding direction.

According to a further aspect of the present invention there is provided a shaft for holding counter tape in a dose counter for an inhaler, the shaft having an engagement surface including incrementally spaced formations located around a periphery thereof, the formations comprising a series of curved concavities and convex portions.

The shaft may comprise a hollow bobbin.

The engagement surface may be a generally cylindrical inwardly directed surface.

The engagement surface may include a flat surface wall portion joining each concavity and convex wall portion.

Each concavity may comprise a radiused wall portion.

Each convex wall portion may comprise a radiused wall portion.

Said concavities may be regularly spaced around a longitudinal axis of the shaft.

Said convex wall portions may be regularly spaced around a longitudinal axis of the shaft.

In some embodiments there may be from eight to twelve said concavities and/or concavities regularly spaced around a longitudinal axis thereof.

One embodiment includes ten said concavities and/or convex wall portions regularly spaced around a longitudinal axis of the shaft.

According to a further aspect of the present invention there is provided a shaft and counter tape assembly for use in a dose counter for an inhaler, the assembly comprising a rotatable shaft and a counter tape which is wound around the shaft and is adapted to unwind therefrom upon inhaler actuation, the shaft having an engagement surface which includes incrementally spaced formations located around a periphery thereof.

According to a further aspect of the present invention there is provided an inhaler for the inhalation of medication and the like, the inhaler including a dose counter as in the first aspect of the present invention.

A preferred construction consists of a manually operated metered dose inhaler including a dose counter chamber including a dose display tape driven by a ratchet wheel which is driven in turn by an actuator pawl actuated by movement of a canister, the tape unwinding from a stock bobbin during use of the inhaler, a rotation regulator being provided for the stock bobbin and comprising a wavelike engagement surface with concavities which engage against control elements in the form of protrusions on resilient forks of a split pin thereby permitting incremental unwinding of the stock bobbin yet resisting excessive rotation if the inhaler is dropped onto a hard surface.

According to another aspect of the present invention there is provided a dose counter for a metered dose inhaler having a body arranged to retain a medicament canister of predetermined configuration for movement of the canister relative thereto; the dose counter comprising: an incremental counting system for counting doses, the incremental counting system having a main body, an actuator arranged to be driven in response to canister motion and to drive an incremental output member in response to canister motion, the actuator and incremental output member being configured to have predetermined canister fire and count configurations in a canister fire sequence, the canister fire configuration being determined by a position of the actuator relative to a datum at which the canister fires medicament and the count configuration being determined by a position of the actuator relative to the datum at which the incremental count system makes an incremental count, wherein the actuator is arranged to reach a position thereof in the count configuration at or after a position thereof in the canister fire configuration.

This arrangement has been found to be highly advantageous since it provides an extremely accurate dose counter

which is suitable for use with manually operated metered dose inhalers. It has been found that dose counters with these features have a failure rate of less than 50 failed counts per million full canister activation depressions. It has been found in the course of making the present invention that highly reliable counting can be achieved with the dose counter counting at or soon after the point at which the canister fires. It has been is covered by the present inventors that momentum and motion involved in firing the canister, and in some embodiments a slight reduction in canister back pressure on the user at the time of canister firing, can very reliably result in additional further motion past the count point.

The actuator and incremental counting system may be arranged such that the actuator is displaced less than 1 mm, typically 0.25 to 0.75 mm, more preferably about 0.4 to 0.6 mm, relative to the body between its location in the count and fire configurations, about 0.48 mm being preferred. The canister, which can move substantially in line with the actuator, can reliably move this additional distance so as to achieve very reliable counting.

The incremental count system may comprise a ratchet mechanism and the incremental output member may comprise a ratchet wheel having a plurality of circumferentially spaced teeth arranged to engage the actuator.

The actuator may comprise an actuator pawl arranged to engage on teeth of the ratchet wheel. The actuator pawl may be arranged to be connected to or integral with an actuator pin arranged to engage and be depressed by a medicament canister bottom flange. The actuator pawl may be generally U-shaped having two parallel arms arranged to pull on a central pawl member arranged substantially perpendicular thereto. This provides a very reliable actuator pawl which can reliably pull on the teeth of the ratchet wheel.

The incremental count system may include a tape counter having tape with incremental dose indicia located thereon, the tape being positioned on a tape stock bobbin and being arranged to unwind therefrom.

The actuator and incremental output member may be arranged to provide a start configuration at which the actuator is spaced from the ratchet output member, a reset configuration at which the actuator is brought into engagement with the incremental output member during a canister fire sequence, and an end configuration at which the actuator disengages from the ratchet output during a canister fire sequence.

The actuator may be arranged to be located about 1.5 to 2.0 mm, from its location in the fire configuration, when in the start configuration, about 1.80 mm being preferred.

The actuator may be arranged to be located about 1.0 to 1.2 mm, from its location in the fire configuration, when in the reset configuration, about 1.11 mm being preferred.

The actuator may be arranged to be located about 1.1 to 1.3 mm, from its location in the fire configuration, when in the end configuration, about 1.18 mm being preferred.

These arrangements provide extremely reliable dose counting, especially with manually operated canister type metered dose inhalers.

The main body may include a formation for forcing the actuator to disengage from the incremental output member when the actuator is moved past the end configuration. The formation may comprise a bumped up portion of an otherwise generally straight surface against which the actuator engages and along which it is arranged to slide during a canister firing sequence.

The dose counter may include a counter pawl, the counter pawl having a tooth arranged to engage the incremental output member, the tooth and incremental output member being arranged to permit one way only incremental relative motion therebetween. When the incremental output member comprises a ratchet wheel, the tooth can therefore serve as an anti-back drive tooth for the ratchet wheel, thereby permitting only one way motion or rotation thereof.

The counter pawl may be substantially fixedly mounted on the main body of the incremental count system and the counter pawl may be arranged to be capable of repeatedly engaging equi-spaced teeth of the incremental output member in anti-back drive interlock configurations as the counter is operated. The counter pawl may be positioned so that the incremental output member is halfway, or substantially halfway moved from one anti-back drive interlock configuration to the next when the actuator and incremental output member are in the end configuration thereof. This is highly advantageous in that it minimises the risk of double counting or non-counting by the dose counter.

According to a further aspect of the invention there is provided an inhaler comprising a main body arranged to retain a medicament canister of predetermined configuration and a dose counter mounted in the main body.

The inhaler main body may include a canister receiving portion and a separate counter chamber, the dose counter being located within the main body thereof, the incremental output member and actuator thereof inside the counter chamber, the main body of the inhaler having wall surfaces separating the canister-receiving portion and the counter chamber, the wall surfaces being provided with a communication aperture, an actuation member extending through the communication aperture to transmit canister motion to the actuator.

According to a further aspect of the present invention there is a provided an inhaler for metered dose inhalation, the inhaler comprising a main body having a canister housing arranged to retain a medicament canister for motion therein, and a dose counter, the dose counter having an actuation member having at least a portion thereof located in the canister housing for operation by movement of a medicament canister, wherein the canister housing has an inner wall, and a first inner wall canister support formation located directly adjacent the actuation member.

This is highly advantageous in that the first inner wall canister support formation can prevent a canister from rocking too much relative to the main body of the inhaler. Since the canister may operate the actuation member of the dose counter, this substantially improves dose counting and avoids counter errors.

The canister housing may have a longitudinal axis which passes through a central outlet port thereof, the central outlet port being arranged to mate with an outer canister fire stem of a medicament canister, the inner wall canister support formation, the actuation member and the outlet port lying in a common plane coincident with the longitudinal axis. Accordingly, this construction may prevent the canister from rocking towards the position of the dose counter actuation member, thereby minimising errors in counting.

The canister housing may have a further inner canister wall support formation located on the inner wall opposite, or substantially opposite, the actuation member. Accordingly, the canister may be supported against rocking motion away from the actuator member so as to minimise count errors.

The canister housing may be generally straight and tubular and may have an arrangement in which each said inner wall support formation comprises a rail extending longitudinally along the inner wall.

Each said rail may be stepped, in that it may have a first portion located towards a medicine outlet end or stem block of the canister housing which extends inwardly a first distance from a main surface of the inner wall and a second portion located toward an opposite end of the canister chamber which extends inwardly a second, smaller distance from the main surface of the inner wall. This may therefore enable easy insertion of a canister into the canister housing such that a canister can be lined up gradually in step wise function as it is inserted into the canister housing.

The inhaler may include additional canister support rails which are spaced around an inner periphery of the inner wall of the canister housing and which extend longitudinally therealong.

At least one of the additional rails may extend a constant distance inwardly from the main surface of the inner wall.

At least one of the additional rails may be formed with a similar configuration to the first inner wall canister support formation.

The dose counter may, apart from said at least a portion of the actuation member, be located in a counter chamber separate from the canister housing, the actuation member comprising a pin extending through an aperture in a wall which separates the counter chamber and the canister housing.

According to a further aspect of the present invention there is provided an inhaler for inhaling medicaments having: a body for retaining a medicament store; the body including a dose counter, the dose counter having a moveable actuator and a return spring for the actuator, the return spring having a generally cylindrical and annular end; the body having a support formation therein for supporting said end of the return spring, the support formation comprising a shelf onto which said end is engageable and a recess below the shelf.

This shelf and recess arrangement is highly advantageous since it allows a tool (such as manual or mechanical tweezers) to be used to place the return spring of the actuator onto the shelf with the tool then being withdrawn at least partially via the recess.

The shelf may be U-shaped.

The support formation may include a U-shaped upstanding wall extending around the U-shaped shelf, the shelf and upstanding wall thereby forming a step and riser of a stepped arrangement.

The recess below the shelf my also be U-shaped.

At least one chamfered surface may be provided at an entrance to the shelf. This may assist in inserting the actuator and return spring into position.

A further aspect of the invention provides a method of assembly of an inhaler which includes the step of locating said end of said spring on the shelf with an assembly tool and then withdrawing the assembly tool at least partly via the recess. This assembly method is highly advantageous compared to prior art methods in which spring insertion has been difficult and in which withdrawal of the tool has sometimes accidentally withdrawn the spring again.

The cylindrical and annular end of the spring may be movable in a direction transverse to its cylindrical extent into the shelf while being located thereon.

According to a further aspect of the present invention there is provided an inhaler for inhaling medicament, the inhaler having a body for retaining a medicament store; and a dose counter, the dose counter having a moveable actuator and a chassis mounted on the body; the chassis being heat staked in position on the body. This is be highly advantageous in that the chassis can be very accurately positioned and held firmly in place, thereby further improving counting accuracy compared to prior art arrangements in which some movement of the chassis relative to the body may be tolerated in snap-fit connections.

The chassis may have at least one of a pin or aperture heat staked to a respective aperture or pin of the body.

The chassis may have a ratchet counter output member mounted thereon.

The ratchet counter output member may comprise a ratchet wheel arranged to reel in incrementally a dose meter tape having a dosage indicia located thereon.

According to a further aspect of the present invention there is provided a method of assembling an inhaler including the step of heat staking the chassis onto the body. The step of heat staking is highly advantageous in fixedly positioning the chassis onto the body in order to achieve highly accurate dose counting in the assembled inhaler.

The method of assembly may include mounting a spring-returned ratchet actuator in the body before heat staking the chassis in place. The method of assembly may include pre-assembling the chassis with a dose meter tape prior to the step of heat staking the chassis in place. The method of assembly may include attaching a dose meter cover onto the body after the heat staking step. The cover may be welded onto the body or may in some embodiments be glued or otherwise attached in place.

According to a further aspect of the present invention there is provided an inhaler for inhaling medicament and having a body, the body have a main part thereof for retaining a medicament store; and a dose counter, the dose counter being located in a dose counter chamber of the body which is separated from the main part of the body, the dose counter chamber of the body having a dosage display and being perforated so as to permit the evaporation of water or aqueous matter in the dose counter chamber into the atmosphere.

This is high advantageous since it enables the inhaler to be thoroughly washed and the dose counting chamber can thereafter dry out fully.

The display may comprise a mechanical counter display inside the dose counter chamber and a window for viewing the mechanical counter display. The mechanical counter display may comprise a tape. The perforated dose counter chamber may therefore enable reliable washing of the inhaler, if desired by the user, and may therefore dry out without the display window misting up.

The dose counter chamber may be perforated by a drain hole formed through an outer hole of the body. The drain hole may be located at a bottom portion of the body of the inhaler, thereby enabling full draining of the inhaler to be encouraged after washing when the inhaler is brought into an upright position.

According to a further aspect of the present invention there is provided a dose counter for an inhaler, the dose counter having a display tape arranged to be incrementally driven from a tape stock bobbin onto an incremental tape take-up drive shaft, the bobbin having an internal bore supported by and for rotation about a support shaft, at least one of the bore and support shaft having a protrusion which is resiliently biased into frictional engagement with the other of the bore and support shaft with longitudinally extending mutual frictional interaction. This arrangement may provide good friction for the bobbin, thereby improving tape counter display accuracy and preventing the bobbin from unwinding undesirably for example if the inhaler is accidentally dropped.

The support shaft may be forked and resilient for resiliently biasing the support shaft and bore into frictional engagement.

The support shaft may have two forks, or more in some cases, each having a radially extending protrusion having a friction edge extending therealong parallel to a longitudinal axis of the support shaft for frictionally engaging the bore of the support shaft with longitudinally extending frictional interaction therebetween.

The bore may be a smooth circularly cylindrical or substantially cylindrical bore.

Each of the above inhalers in accordance with aspects of the present invention may have a medicament canister mounted thereto.

The canister may comprise a pressurised metered dose canister having a reciprocally movable stem extending therefrom and movable into a main canister portion thereof for releasing a metered dose of medicament under pressure, for example by operating a metered dose valve inside the canister body. The canister may be operable by pressing by hand on the main canister body.

In cases in which one or more support rails or inner wall support formations are provided, the canister may at all times when within the canister chamber have a clearance of about 0.25 to 0.35 mm from the first inner wall support formation. The clearance may be almost exactly 0.3 mm. This clearance which may apply to the canister body itself or to the canister once a label has been applied, is enough to allow smooth motion of the canister in the inhaler while at the same time preventing substantial rocking of the canister which could result in inaccurate counting by a dose counter of the inhaler, especially when lower face of the canister is arranged to engage an actuator member of the dose counter for counting purposes.

According to a further aspect of the invention, a method of assembling a dose counter for an inhaler comprises the steps of providing a tape with dosing indicia thereon; providing tape positioning indicia on the tape; and stowing the tape while monitoring for the tape positioning indicia with a sensor. The method advantageously permits efficient and accurate stowing of the tape, e.g. by winding.

The dosing indicia may be provided as numbers, the tape positioning indicia may be provided as one or more lines across the tape. The stowing step comprises winding the tape onto a bobbin or shaft, and, optionally, stopping winding when the positioning indicia are in a predetermined position. The tape may be provided with pixelated indicia at a position spaced along the tape from the positioning indicia. The tape may also be provided with a priming dot.

According to a further aspect of the invention, a tape system for a dose counter for an inhaler has a main elongate tape structure, and dosing indicia and tape positioning indicia located on the tape structure. The tape positioning indicia may comprise at least one line extending across the tape structure. The tape system may comprise pixelated indicia located on the tape structure and spaced from the positioning indicia. The tape system may comprise a priming dot located on the tape structure. The positioning indicia may be located between the timing dot and the pixelated indicia. The main elongate tape structure may have at least one end thereof wound on a bobbin or shaft.

A further aspect of the invention provides a method of designing an incremental dose counter for an inhaler comprising the steps of calculating nominal canister fire and dose counter positions for a dose counter actuator of the inhaler; calculating a failure/success rate for dose counters built to tolerance levels for counting each fire of inhalers in which the dose counter actuators may be applied; and selecting a tolerance level to result in said failure/success rate to be at or below/above a predetermined value. This is highly advantageous in that it allows an efficient and accurate prediction of the reliability of a series of inhaler counters made in accordance with the design.

The method of designing may include selecting the failure/success rate as a failure rate of no more than one in 50 million. The method of designing may include setting an average count position for dose counters built to the tolerances to be at or after an average fire position thereof during canister firing motion. The method of designing may include setting the average count position to be about 0.4 to 0.6 mm after the average fire position, such as about 0.48 mm after. The method of designing may include setting tolerances for the standard deviation of the fire position in dose counters built to the tolerances to be about 0.12 to 0.16 mm, such as about 0.141 mm. The method of designing may include setting tolerances for the standard deviation of the count positions in dose counters built to the tolerances to be about 0.07 to 0.09 mm, such as about 0.08 mm. A further aspect of the invention provides a computer implemented method of designing an incremental dose counter for an inhaler which includes the aforementioned method of designing.

A further aspect of the invention provides a method of manufacturing in a production run a series of incremental dose counters for inhalers which comprises manufacturing the series of dose counters in accordance with the aforementioned method of designing.

A further aspect of the invention provides a method of manufacturing a series of incremental dose counters for inhalers, which comprises manufacturing the dose counters with nominal canister fire and dose count positions of a dose counter actuator relative to a dose counter chassis (or inhaler main body), and which includes building the dose counters with the average dose count position in the series being, in canister fire process, at or after the average canister fire position in the series.

According to a further aspect of the invention, the method provides fitting each dose counter in the series of incremental dose counters to a corresponding main body of an inhaler.

These aspects advantageously provide for the production run of a series of inhalers and dose counters which count reliably in operation.

According to a further aspect of the invention, an incremental dose counter for a metered dose inhaler has a body arranged to retain a canister for movement of the canister relative thereto, the incremental dose counter having a main body, an actuator arranged to be driven and to drive an incremental output member in a count direction in response to canister motion, the actuator being configured to restrict motion of the output member in a direction opposite to the count direction. This advantageously enables an inhaler dose counter to keep a reliable count of remaining doses even if dropped or otherwise jolted.

The output member may comprise a ratchet wheel. The actuator may comprise a pawl and in which the ratchet wheel and pawl are arranged to permit only one-way ratcheting motion of the wheel relative to the pawl. The dose counter may include an anti-back drive member fixed to the main body. In a rest position of the dose counter, the ratchet wheel is capable of adopting a configuration in which a back surface of one tooth thereof engages the anti-back drive member and the pawl is spaced from an adjacent back

surface of another tooth of the ratchet wheel without positive drive/blocking engagement between the pawl and wheel.

BRIEF DESCRIPTION OF THE DRAWINGS

The present invention may be carried out in various ways and preferred embodiment of a dose counter, inhaler and methods of assembly, design and manufacture will now be described with reference to the accompanying drawings in which:

FIG. **1** is an isometric view of a main body of an embodiment of an inhaler related to the invention together with a mouthpiece cap therefor;

FIG. **2** is a top plan view of the components as shown in FIG. **1**;

FIG. **3**A is a section on the plane **3**A-**3**A in FIG. **2**;

FIG. **3**B is a view corresponding to FIG. **3**A but with a dose counter fitted to the main body of the inhaler;

FIG. **4**A is an exploded view of the inhaler main body, mouthpiece cap, dose counter and a dose counter window;

FIG. **4**B is a view in the direction **4**B in FIG. **4**C of a spring retainer of the dose counter;

FIG. **4**C is a top view of the spring retainer of FIG. **4**B;

FIG. **5** is a bottom view of the assembled inhaler main body, mouthpiece cap, dose counter and dose counter window;

FIGS. **6**A, **6**B, **6**C, **6**D, **6**E, **6**F, **6**G and **6**H are various views of dose counter components of the inhaler;

FIGS. **7**A and **7**B are sectional views showing canister clearance inside the main body of the inhaler;

FIG. **7**C is a further sectional view similar to that of FIG. **7**B but with the canister removed;

FIG. **7**D is a top plan view of the inhaler main body;

FIGS. **8**A, **8**B, **8**C and **8**D show the inhaler main body and dose counter components during assembly thereof;

FIG. **9** shows a sectional side view of a datum line for an actuator pawl of the dose counter;

FIGS. **10**A, **10**B, **10**C, **10**D, **10**E and **10**F show various side views of positions and configurations of the actuator pawl, a ratchet wheel, and a count pawl;

FIG. **11** shows distributions for tolerances of start, reset, fire, count and end positions for the actuator of the dose counter;

FIG. **12** is an enlarged version of part of FIG. **4**A;

FIG. **13** shows an end portion of a tape of the dose counter;

FIG. **14** shows a computer system for designing the dose counter;

FIG. **15** is an isometric view of a stock bobbin modified in accordance with the present invention for use in the dose counter of the inhaler of FIGS. **1** to **14**;

FIG. **16** shows an end view of the stock bobbin of FIG. **15**;

FIG. **17** is a section through a longitudinal axis of the stock bobbin of FIGS. **15** and **16**;

FIGS. **18**A to **18**C are views of the stock bobbin of FIGS. **15** to **17** mounted in the dose counter chassis of FIGS. **1** to **14**, with the control elements of the forks of the second shaft (or split pin) having a profile slightly different to that in FIG. **6**F, with the forks in a compressed configuration;

FIGS. **19**A to **19**C are views equivalent to FIGS. **18**A to **18**C but with the forks in a more expanded configuration due to a different rotational position of the stock bobbin;

FIG. **20** is an isometric view of the chassis assembled and including the stock bobbin of FIGS. **15** to **17** but excluding the tape for reasons of clarity;

FIG. **21** is a view of a preferred embodiment of a dry powder inhaler in accordance with the present invention;

FIG. **22** is an exploded view of the inhaler of FIG. **21**;

FIG. **23** is a view of a dose counter of the inhaler of FIG. **21**;

FIG. **24** is an exploded view of the dose counter shown in FIG. **23**;

FIG. **25** is an exploded view of parts of the inhaler of FIG. **21**; and

FIG. **26** is a view of a yoke of the inhaler of FIG. **21**.

DETAILED DESCRIPTION OF THE INVENTION

FIG. **1** shows a main body **10** of a manually operated metered dose inhaler **12** in accordance with an embodiment related to the present invention and having a mouthpiece cap **14** securable over a mouthpiece **16** of the main body.

The main body has a canister chamber **18** into which a canister **20** (FIG. **7**A) is slideable. The canister **20** has a generally cylindrical main side wall **24**, joined by a tapered section **26** to a head portion **28** having a substantially flat lower face **30** which has an outer annular drive surface **32** arranged to engage upon and drive an actuation pin **34** of a dose counter **36** as will be described. Extending centrally and axially from the lower face **30** is a valve stem **38** which is arranged to sealingly engage in a valve stem block **40** of the main body **10** of the inhaler **12**. The valve stem block **40** has a passageway **42** leading to a nozzle **44** for directing the contents of the canister **20**, namely active drug and propellant, towards an air outlet **46** of the inhaler main body **12**. It will be appreciated that due to gaps **48** between the canister **20** and an inner wall **50** of the main body **10** of the inhaler **12** an open top **52** of the main body **10** forms an air inlet into the inhaler **12** communicating via air passageway **54** with the air outlet **46**, such that canister contents exiting nozzle **44** mix with air being sucked by the user through the air passageway **54** in order to pass together through the air outlet and into the mouth of the user (not shown).

The dose counter **36** will now be described. The dose counter **36** includes an actuation pin **34** biased upwardly from underneath by a return spring **56** once installed in the main body **10**. As best shown in FIGS. **4**A, **6**H and **8**A, the pin **34** has side surfaces **58**, **60** arranged to slide between corresponding guide surfaces **62**, **64** located in a dose counter chamber **66** of the main body **10**, as well as an end stop surface **68** arranged to engage a corresponding end stop **70** formed in the dose counter chamber **66** to limit upward movement of the pin **34**. The pin **34** has a top part **72** which is circularly cylindrical and extends through an aperture **74** formed through a separator wall **76** which separates the canister chamber **18** from the dose counter chamber **66**. The top part **72** of the pin **34** has a flat top surface **78** which is arranged to engage the outer annular drive surface **32** of the canister **20**.

The actuation pin **34** is integrally formed with a drive or actuator pawl **80**. The actuator pawl **80** has a generally inverted U-shape configuration, having two mutually spaced and parallel arms **82**, **84** extending from a base portion of the actuation pin **34**, each holding at respective distal ends **88** thereof opposite ends of a pawl tooth member **90** which extends in a direction substantially perpendicular to the arms **82**, **84**, so as to provide what may be considered a "saddle" drive for pulling on each of the 11 drive teeth **92** of a ratchet wheel **94** of an incremental drive system **96** or ratchet mechanism **96** of the dose counter **36**. As shown for example in FIG. **10**B, the pawl tooth member **90** has a sharp lower longitudinal side edge **98** arranged to engage the drive teeth **92**, the edge-to-surface contact provided by this engagement

providing very accurate positioning of the actuator pawl **80** and resultant rotational positioning of the ratchet wheel **94**.

The dose counter **36** also has a chassis preassembly **100** which, as shown in FIGS. **4**A and **6**A, includes a chassis **102** having a first shaft **104** receiving the ratchet wheel **94** which is secured to a tape reel shaft **106**, and a second shaft (or split pin) **108** which is parallel to and spaced from the first shaft **104** and which slidably and rotationally receives a tape stock bobbin **110**.

As shown in FIG. **6**B, when the inhaler has not been used at all, the majority of a tape **112** is wound on the tape stock bobbin **110** and the tape **112** has a series of regularly spaced numbers **114** displayed therealong to indicate a number of remaining doses in the canister **20**. As the inhaler is repeatedly used, the ratchet wheel **94** is rotated by the actuator pawl **80** due to operation of the actuation pin **34** by the canister **20** and the tape **112** is incrementally and gradually wound on to the tape reel shaft **106** from the second shaft **108**. The tape **112** passes around a tape guide **116** of the chassis **102** enabling the numbers **114** to be displayed via a window **118** in a dose counter chamber cover **120** having a dose marker **132** formed or otherwise located thereon.

As shown in FIGS. **6**A and **6**D, the second shaft **108** is forked with two forks **124**, **126**. The forks **124**, **126** are biased away from one another. The forks have located thereon at diametrically opposed positions on the second shaft **108** friction or control elements **128**, **130**, one on each fork. Each control element extends longitudinally along its respective fork **124**, **126** and has a longitudinally extending friction surface **132**, **134** which extends substantially parallel to a longitudinal axis of the second shaft and is adapted to engage inside a substantially cylindrical bore **136** inside the tape stock bobbin **110**. This control arrangement provided between the bore **136** and the control elements **128**, **130** provides good rotational control for the tape stock bobbin **110** such that it does not unwind undesirably such as when the inhaler is dropped. The tape force required to unwind the tape stock bobbin **110** and overcome this friction force is approximately 0.1 N.

As can be seen in FIG. **6**D, as well as FIGS. **6**G and **10**A to **10**F, the chassis **102** is provided with an anti-back drive tooth **138** or count pawl **138** which is resiliently and substantially fixedly mounted thereto. As will be described below and as can be seen in FIGS. **10**A to **10**F, when the actuation pin **34** is depressed fully so as to fire the metered valve (not shown) inside the canister **20**, the actuator pawl **80** pulls down on one of the teeth **92** of the ratchet wheel **94** and rotates the wheel **94** anticlockwise as shown in FIG. **6**D so as to jump one tooth **92** past the count pawl **138**, thereby winding the tape **112** a distance incrementally relative to the dose marker **122** on the dose counter chamber **120** so as to indicate that one dose has been used.

With reference to FIG. **10**B, the teeth of the ratchet wheel **94** have tips **143** which are radiused with a 0.1 mm radius between the flat surfaces **140**, **142**. The ratchet wheel **94** has a central axis **145** which is 0.11 mm above datum plane **220** (FIG. **9**). A top/nose surface **147** of the anti-back drive tooth **138** is located 0.36 mm above the datum plane **220**. The distance vertically (i.e. transverse to datum plane **220**—FIG. **9**) between the top nose surface **147** of the anti-back drive tooth is 0.25 mm from the central axis **145** of the wheel **94**. Bump surface **144** has a lateral extent of 0.20 mm, with a vertical length of a flat **145'** thereof being 1 mm, the width of the bump surface being 1.22 mm (in the direction of the axis **145**), the top **149** of the bump surface **144** being 3.02 mm vertically below the axis **145**, and the flat **145'** being spaced a distance sideways (i.e. parallel to the datum plane **220**) 2.48 mm from the axis **145**. The top surface **78** of the pin **34** (FIG. **6**H) is 11.20 mm above the datum plane **220** (FIG. **9**) when the actuator pawl **80** and pin **34** are in the start configuration. The length of the valve stem **22** is 11.39 mm and the drive surface **32** of the canister **20** is 11.39 mm above the datum plane **220** when the canister is at rest waiting to be actuated, such that there is a clearance of 0.19 mm between the canister **20** and the pin **34** in this configuration.

FIGS. **10**A and **10**B show the actuator pawl **80** and ratchet wheel **94** and count pawl **138** in a start position in which the flat top **78** of the pin **34** has not yet been engaged by the outer annular drive surface **32** of the canister **20** or at least has not been pushed down during a canister depression.

In this "start" position, the count pawl **138** engages on a non-return back surface **140** of one of the teeth **92** of the ratchet wheel **94**. The lower side edge **98** of the actuator pawl is a distance "D" (FIG. **9**) 1.33 mm above datum plane **220** which passes through bottom surface or shoulder **41** of valve stem block **40**, the datum plane **220** being perpendicular to a main axis "X" of the main body **10** of the inhaler **12** which is coaxial with the centre of the valve stem block bore **43** and parallel to a direction of sliding of the canister **20** in the main body **10** of the inhaler **12** when the canister is fired.

As shown in FIG. **10**B, an advantageous feature of the construction is that the pawl tooth/actuator **90** acts as a supplementary anti-back drive member when the inhaler **12** is not being used for inhalation. In particular, if the inhaler **12** is accidentally dropped, resulting in a jolt to the dose counter **36** then, if the wheel **94** would try to rotate clockwise (backwards) as shown in FIG. **10**B, the back surface **140** of a tooth will engage and be blocked by the tooth member **90** of the pawl **80**. Therefore, even if the anti-back drive tooth **138** is temporarily bent or overcome by such a jolt, undesirable backwards rotation of the wheel **94** is prevented and, upon the next canister firing sequence, the pawl **90** will force the wheel **94** to catch up to its correct position so that the dose counter **36** continues to provide correct dosage indication.

FIG. **10**C shows a configuration in which the actuator pawl **80** has been depressed with the pin **34** by the canister **20** to a position in which the side edge **98** of the pawl tooth member **90** is just engaged with one of the teeth **92** and will therefore upon any further depression of the pin **34** begin to rotate the wheel **94**. This is referred to as a "Reset" position or configuration. In this configuration, the lower side edge **98** of the actuator **80** is 0.64 mm above the datum plane **220**.

FIG. **10**D shows a configuration in which the actuator pawl **80** has been moved to a position lower than that shown in FIG. **10**C and in which the metered dose valve (not shown) inside the canister has at this very position fired in order to eject active drug and propellant through the nozzle **44**. It will be noted that in this configuration the count pawl **138** is very slightly spaced from the back surface **140** of the same tooth **92** that it was engaging in the configuration of FIG. **10**D. The configuration shown in FIG. **10**D is known as a "Fire" configuration. In this configuration the lower side edge **98** of the actuator **80** is 0.47 mm below the datum plane **220**.

FIG. **10**E shows a further step in the sequence, called a "Count" position in which the actuator pawl **80** has rotated the ratchet wheel **94** by the distance circumferentially angularly between two of the teeth **92**, such that the count pawl **138** has just finished riding along a forward surface **142** of one of the teeth **92** and has resiliently jumped over the tooth into engagement with the back surface **140** of the next tooth. Accordingly, in this "Count" configuration, a sufficiently

long stroke movement of the pin **34** has occurred that the tape **112** of the dose counter **36** will just have counted down one dose. In this configuration, the lower side edge **98** of the actuator is 0.95 mm below the datum plane **220**. Accordingly, in this position, the actuator **80** generally, including edge **98**, is 0.48 mm lower than in the fire configuration. It has been found that, although the count configuration happens further on than the fire configuration, counting is highly reliable, with less than one in 50 failed counts per million. This is at least partially due to momentum effects and to the canister releasing some back pressure on the user in some embodiments as its internal metering valve fires.

In the configuration of FIG. **10**F, the pawl **80** has been further depressed with the pin **34** by the canister **20** to a position in which it is just disengaging from one of the teeth **92** and the actuator pawl **80** is assisted in this disengagement by engagement of one of the arms **84** with a bump surface **144** on the chassis **102** (see FIG. **6**G) and it will be seen at this point of disengagement, which is called an "End" configuration, the count pawl **138** is positioned exactly halfway or substantially halfway between two of the drive teeth **92**. This advantageously means therefore that there is a minimum chance of any double counting or non-counting, which would be undesirable. In the end configuration, the side edge **98** of the actuator is 1.65 mm below the datum plane **220**. It will be appreciated that any further depression of the actuator pawl **80** and pin **34** past the "End" configuration shown in FIG. **10**F will have no effect on the position of the tape **112** displayed by the dose counter **36** since the actuator pawl **80** is disengaged from the ratchet wheel **94** when it is below the position shown in FIG. **10**F.

As shown in FIGS. **7**C and **7**D, the inner wall **50** of the main body **10** is provided with a two-step support rail **144** which extends longitudinally along inside the main body and is located directly adjacent the aperture **74**. As shown in FIG. **7**B a diametrically opposed two-step support rail **146** is also provided and this diametrically opposed in the sense that a vertical plane (not shown) can pass substantially directly through the first rail **144**, the aperture **74**, a central aperture **148** of the valve stem block **40** (in which canister stem **25** is located) and the second two-step support rail **146**. As shown in FIG. **7**A and schematically in FIG. **7**B, the rails **144**, **146** provide a maximum clearance between the canister **20** and the rails **144**, **146** in a radial direction of almost exactly 0.3 mm, about 0.25 to 0.35 mm being a typical range. This clearance in this plane means that the canister **20** can only rock backwards and forwards in this plane towards away from the actuation pin **34**. A relatively small distance and this therefore prevents the canister wobbling and changing the height of the actuation pin **34** a as to undesirably alter the accuracy of the dose counter **36**. This is therefore highly advantageous.

The inner wall **50** of the main body **10** is provided with two further two-step rails **150** as well as two pairs **152**, **154** of rails extending different constant radial amounts inwardly from the inner wall **50**, so as to generally achieve a maximum clearance of almost exactly 0.3 mm around the canister **20** for all of the rails **144**, **146**, **150**, **152**, **154** spaced around the periphery of the inner wall **50**, in order to prevent undue rocking while still allowing canister motion freely inside the inhaler **12**. It will be clear from FIG. **7**C for example that the two-step rails have a first portion near an outlet end **156** of the canister chamber **18**, the first portion having a substantially constant radial or inwardly-extending width, a first step **160** leading to a second portion **162** of the rail, the second portion **102** having a lesser radial or inwardly extending extent than the first portion **156**, and finally a second step **164** at which the rail merges into the main inner wall **50** main surface.

A method of assembling the inhaler **12** will now be described.

With reference to FIG. **8**A, the main body **10** of the inhaler **12** is formed by two or more plastics mouldings which have been joined together to the configuration shown.

As shown in FIG. **8**B, the actuator pawl **80** and pin **34** are translated forward into position into a pin receiving area **166** in the dose counter chamber **66** and the pin **34** and actuator **80** may then be raised until the pin **34** emerges through the aperture **74**.

Next, the return spring **56** may be inserted below the pin **34** and a generally cylindrical annular lower end **168** of the spring **56** may be moved by a tweezer or tweezer-like assembly tool (not shown) into engagement with a shelf **170** of a spring retainer **172** in the dose counter chamber **66**. The spring retainer **172** is U-shaped and the shelf **170** is U-shaped and has a recess **174** formed below it. As shown in FIGS. **4**B, **4**C and **12** shelf **170** includes three chamfer surfaces **176**, **178**, **180** arranged to assist in moving the lower end of the spring **168** into position onto the shelf using the assembly tool (not shown). Once the lower end of the spring **168** is in place, the assembly tool (not shown) can easily be removed at least partly via the recess **174** below the lower end **168** of the spring **56**.

The tape **112** is attached at one end (not shown) to the tape stock bobbin **110** and is wound onto the bobbin by a motor **200** (FIG. **13**) having a hexagonal output shaft **202** which engages in a hexagonal socket **204** (FIG. **6**B) of the bobbin. During winding, the tape is monitored by a sensor **206**, which may be in the form of a camera or laser scanner, which feeds data to a computer controller **205** for the motor **200**. The controller **205** recognises three positioning markers **210** in the form of lines across the tape **112** and stops the motor **202** when the tape **112** is nearly fully wound onto the bobbin **110**, such that the distal end **212** of the tape **112** can be secured, e.g. by adhesive, to the tape reel shaft **106**. The controller **205** also recognises a pixelated tape size marker **214** observed by the sensor **206** and logs in a stocking system data store **217** details of the tape **112** such as the number of numbers **114** on the tape, such as one hundred and twenty or two hundred numbers **114**. Next, the tape reel shaft is wound until an appropriate position of the lines **210** at which a priming dot **216** will, once the bobbin **110** and reel shaft **106** are slid onto the second shaft **108** and second shaft **104**, be in a position to be located in the window **118** when the inhaler **12** is fully assembled. In the embodiments, the bobbin **110** and reel shaft **106** may be slid onto the shafts **108**, **104** before the tape **112** is secured to the reel shaft **106** and the reel shaft may then be wound to position the priming dot **216**.

Next, the assembled dose counter components of the chassis preassembly **100** shown in FIG. **6**B may as shown in FIG. **8**C be inserted into the dose counter chamber **66**, with pins **182**, **184**, **186** formed on the main body **10** in the dose counter chamber **66** passing through apertures or slots **188**, **190**, **192** formed on the chassis **102**, such that the pins **182**, **184**, **186** extend through (or at least into) the apertures or slots **188**, **190**, **192**. With the chassis **102** being relatively firmly pushed towards the main body **10**, the pins **182**, **184**, **186** are then heat staked and the chassis **102** is therefore after this held very firmly in position in the main body and is unable to move, thereby assisting in providing great accuracy for the dose counter **36**. Next, as shown in FIG. **8**D, the dose counter chamber cover **120** may be fitted over the dose

counter chamber **66** and may be secured in place such as by welding, with the priming dot **216** being displayed through the window.

The user can, when readying the inhaler **12** for first use, prime the inhaler by depressing the canister **20** three times which will bring the first number **114** on the tape into display through the window **118** in place of the priming dot **216**, the number **114** shown in FIG. **8**D being "200", thereby indicating that 200 doses are remaining to be dispensed from the canister **20** and inhaler **12**.

As shown in FIG. **8**D, and in FIG. **5**, an open drain hole **194** is provided at the bottom of the dose counter chamber **66** by a substantially semi-circular cut-out or recess formation **196** in a lower surface **198** of the main body **10** of the inhaler. Accordingly, if the user (not shown) should decide to wash the main body **10** of the inhaler, for example after encountering an unhygienic situation or simply as a matter of choice, the drain hole **194** allows initial draining of water from inside the dose counter chamber **66** and also thereafter evaporation of water or any aqueous matter in the dose counter chamber **66** so that the window **118** does not mist up undesirably.

FIG. **14** shows a computer system **230** for designing the dose counter **36** and in particular for calculating distributions representative of average positions and standard deviations in a production series of inhalers of the start, reset, fire, count and end positions of the actuator lower side edge **98** relative to the datum plane **220** (FIG. **9**) and therefore of the actuator pawl **80** generally relative to the ratchet wheel **94**, chassis **102** and, when the inhaler **12** is fully assembled, the main body **10** of the inhaler **12**. The computer system **230** includes a data store **232**, a CPU **234**, an input device **236** (such as a keyboard or communication port) and an output device **238** (such as a communications port, display screen and/or printer). A user may enter data via the input device **236** which may be used by the CPU **234** in a mathematical calculation to predict count failure rates when the various dose counters are to be built in a series with dose counter positions set with given averages and standard deviations and taking into account any momentum/inertia effects and metering valve user-back-pressure reduction effect which will occur upon canister firing of a given type of canister. The computer system **230** is thus mathematically used to design the distributions. For the inhaler **12** described herein with the dose counter **36** and canister **20**, the distributions are designed as shown in FIG. **11**. The x axis shows distance of the lower side surface **98** of the actuator **80** above the datum plane **220** and the y axis is representative of the distribution. Thus, curve **240** shows that the start configuration has an average 1.33 mm above the datum plane **200** (standard deviation is 0.1 mm), curve **242** shows that the reset configuration has an average of 0.64 mm above the datum plane **220** (standard deviation is 0.082 mm), curve **244** shows the fire configuration has an average 0.47 mm below the datum plane **220** (standard deviation is 0.141 mm), curve **246** shows the count configuration has an average 0.95 mm below the datum plane **220** (standard deviation is 0.080 mm), and curve **248** shows the end configuration has an average of 1.65 mm below the datum plane **220** (standard deviation is 0.144 mm).

FIGS. **15** to **20** show a version of the inhaler modified in accordance with the present invention. In these drawings, the same reference numerals have been used to those in the earlier drawings to denote the equivalent components. The inhaler **12** is the same as that in FIGS. **1** to **14** apart from the following modifications.

First, it can be seen that there is a modification in that the drive teeth **92** of the ratchet wheel **94** have a different profile to that in FIGS. **1** to **14**. There are also only nine ratchet teeth **94** in this embodiment instead of eleven.

Additionally, as shown in FIGS. **18**C and **19**C, the control elements **128**, **130** on the forks **124**, **126** of the second shaft **108** have a tapered profile which is different to the profile of the control elements **128**, **130** shown in FIG. **6**F. Either profile can be used in the embodiment of FIGS. **15** to **20** however.

Furthermore, as shown in FIG. **15**, the tape stock bobbin **110** has an inwardly facing generally cylindrical engagement surface **300** with a wavelike form extending partially therealong. The engagement surface **300** has a cross-section **301** perpendicular to the longitudinal length of the stock bobbin **110** which is constant therealong. This cross-section **301** can be seen in FIG. **16** and consists of a series of ten regularly spaced concavities **302** and ten convex wall portions **304**. The convex wall portions **304** are equi-spaced between the concavities **302**. Each concavity **302** has a radius of 0.2 mm. Each convex wall portion **304** also has a radius of 0.2 mm. Finally, the cross section **301** also includes flat wall portions **306** between all of the radiused wall portions of the concavities **302** and convex wall portions **304**. The geometry of the cross-section **301** is therefore defined by the radii of the concavities **302** and convex wall portions **304**, the flat wall portions **306** and the fact that there are ten concavities **302** and convex wall portions **304**.

The minor diameter of the engagement surface **300**, i.e. between the tips of opposite convex wall portions **304**, is 2.46 mm. The major diameter of the engagement surface **300**, i.e. between the outermost portions of the concavities **302**, is 2.70 mm. The undeformed tip to tip maximum diameter of the forks **124**, **126** of the split pin (the second shaft) **108**, i.e. in the region of the maximum radio extent of the control elements **128**, **130**, is 3.1 millimeters and it will therefore be appreciated that the forks **124**, **126** are resiliently compressed once the stock bobbin **110** has been assembled onto the split pin **108** in all rotational configurations of the stock bobbin **110** relative to the split pin **108**. The minimum gap between the forks **124**, **126** in the plane of the cross sections of FIGS. **18**C and **19**C is 1 mm when the split pin **108** is in the undeformed, pre-inserted state. When the split pin **108** is at maximum compression, as shown in FIGS. **18**A to **18**C when the control elements **128**, **130** are shown to be engaged on top of the convex wall portions **304**, the gap **308** between the tips **310**, **312** of the forks **124**, **126** is 0.36 mm. On the other hand, when the split pin **108** is at minimum compression (once inserted into the stock bobbin) as shown in FIGS. **19**A to **19**C, when the control elements **128**, **130** rest in the concavities **302**, the gap between the tips **310**, **312** of the forks **124**, **126** is 0.6 mm. The control elements **128**, **130** are outwardly radiused with a radius also of 0.2 mm such that they can just rest on the concavities **302** with full surface contact (at least at an axial location on the split pin where the tapered control elements are at their maximum radial extent), without rattling in, locking onto or failing to fit in the concavities **302**. The radii of the control elements **128**, **130** is therefore preferably substantially the same as the radii of the concavities **302**

It will be appreciated that whereas FIGS. **18**B and **19**B are end views along the coaxial axis of the stock bobbin **110** and split pin **108**, FIGS. **18**A and **19**A are cross-sections. FIG. **19**A is a section on the plane A-A' in FIG. **19**C and FIG. **18**A is a section at the same plane, but of course with the stock bobbin **110** rotated relative to the split pin **108**.

As the inhaler **12** is used and the ratchet wheel **94** rotates in order to count used doses, the stock bobbin rotates incrementally through rotational positions in which rotation is resisted, i.e. due to increasing compression of the split pin **108** at such rotational positions, and rotational positions in which rotation is promoted, i.e. due to decreasing compression of the split pin **108** at such rotational positions and this may involve a click forward of the stock bobbin **110** to the next position equivalent to that in FIGS. **19**A to **19**C in which the control elements **128**, **130** of the split pin art located in the concavities **302**. This functionality firstly allows the stock bobbin to unwind during use as required, but also prevents the tape **112** from loosening during transit if the inhaler **12** is dropped, such as onto a hard surface. This is highly advantageous, since the tape **11** is prevented from moving to a position in which it will give an incorrect reading regarding the number of doses in the canister.

During compression and expansion of the forks in the radial direction between the two configurations shown in FIGS. **18**C and **19**C, the forks **124**, **126** rotate about a point **316** on the split pin where the forks **124**, **126** come together. This rotational action means that there is a camming action between the forks **124**, **126** and the engagement surface **300** without significant friction but, nevertheless, the resilient forces provided by the regulator formed by the engagement surface **300** and forks **124**, **126** are able to regulate unwinding of the tape such that it does not easily occur during transit or if the inhaler **12** is dropped. It has been found during testing that a force of 0.3 to 0.4 N needs to be applied to the tape **112** to overcome the regulator at the stock bobbin **110**. 0.32 N is achieved with the control elements **128** having the profile shown in FIG. **19**C and 0.38 N is achieved with the profile of the control elements **128** altered to be as shown as described with reference to FIG. **6**F. These forces are substantially higher than the 0.1 N force mentioned above and undesirable movement of the tape is substantially avoided even if the inhaler is dropped onto a hard surface. The modified arrangement of FIGS. **15** to **20** does not provide this force "constantly" such that there is overall not an undesirably high friction of the tape **112** as it passes over the other components of the dose counter because, due to the incremental nature of the resilient forces at the regulator, the tape **112** can incrementally relax as it slides over the stationary chassis components.

Instead of having ten concavities **302** and convex wall portions **304**, other numbers may be used, such as 8 or 12. However, it is preferred to have an even number, especially since two control elements **128**, **130** are provided, so that all of the control elements **128**, **130** will expand and contract simultaneously. However, other arrangements are envisaged with 3 or more forks and the number of concavities/convex wall portions may be maintained as an integer divisible by the number of forks to maintain a system with simultaneous expansion/contraction. For example, the use of 9, 12 or 15 concavities/convex wall portions with 3 forks is envisaged.

Instead of having the engagement surface **300** on the inside of the stock bobbin **110**, it could be placed on the outside of the stock bobbin **110** so as to be engaged by flexible external legs/pawls or similar.

It will be noted that the regulator provided by the engagement surface **300** and forks **124**, **126** does not only allow rotation of the stock bobbin in one direction as is the case with the ratchet wheel **94**. Rotation in both directions is possible, i.e. forwards and backwards. This means that during assembly, the stock bobbin **110** can be wound backwards during or after fitting the bobbin **100**, shaft **106** and tape **112** onto the carriage **102**, if desired.

The stock bobbin **110** and the carriage **102** including the split pin **108** are both moulded of polypropylene material.

It will be seen from FIG. **16** that the cross-sectional shape **301** is not symmetrical within the hexagonal socket **204**. This has enabled the hexagonal socket **204** to be maintained at a useful size while still allowing the desired size and geometry of the cross section **301** to fit without interfering with the hexagonal shape of the hexagonal socket **204** and also permits moulding to work during manufacture.

As shown in FIG. **17**, the stock bobbin **110** has a series of four circumferential ribs **330** inside it and a spaced therealong. These hold the stock bobbin **110** on the correct side of the mould tool during moulding.

FIGS. **21** and **22** show a preferred embodiment in accordance with the invention of an inhaler **510** for dispensing a dry-powdered medicament in metered doses for patient inhalation. The inhaler **510** is as disclosed in FIGS. **1** to **16** or EP-A-1330280, the contents of which are hereby fully incorporated herein by reference, but with the stock bobbin **110** and second shaft **108** of the dose counter **516** modified so as to be as in FIGS. **15** to **20** hereof. Thus, the dry powder inhaler **510** generally includes a housing **518**, and an assembly **512** received in the housing (see FIG. **21**). The housing **518** includes a case **520** having an open end **522** and a mouthpiece **524** (FIG. **25**) for patient inhalation, a cap **526** secured to and closing the open end **522** of the case **520**, and a cover **528** pivotally mounted to the case **520** for covering the mouthpiece **524**. As shown in FIG. **22**, the inhaler **510** also includes an actuation spring **569**, first yoke **566** with opening **572**, bellows **540** with crown **574**, a reservoir **514**, second yoke **568** with hopper **542** and dose counter **516** mounted thereto, and case **520** has transparent window **5130** thereon for viewing dose counter tape indicia **5128**. The dose metering system also includes two cams **570** mounted on the mouthpiece cover **528** and movable with the cover **528** between open and closed positions. The cams **570** each include an opening **580** for allowing outwardly extending hinges **582** of the case **520** to pass therethrough and be received in first recesses **584** of the cover **528**. The cams **570** also include bosses **586** extending outwardly and received in second recesses **588** of the cover **528**, such that the cover **528** pivots about the hinges **582** and the cams **570** move with the cover **528** about the hinges **582**. As described in EP-A-1330280, cams **570** act upon cam followers **578** to move second yoke **568** up and down and thereby operate dose counter by engagement of pawl **5138** on the second yoke **568** with teeth **5136**. Remaining components of the inhaler are provided as, and operate as described, in EP-A-1330280.

The dose counting system **516** therefore includes a ribbon or tape **5128** (FIGS. **23** & **24**), having successive numbers or other suitable indicia printed thereon, in alignment with a transparent window **5130** provided in the housing **18** (see FIG. **22**). The dose counting system **516** includes the rotatable stock bobbin **110** (as described above), an indexing spool **5134** rotatable in a single direction, and the ribbon **5128** rolled and received on the bobbin **110** and having a first end **5127** secured to the spool **5134**, wherein the ribbon **5128** unrolls from the bobbin **110** so that the indicia are successively displayed as the spool **5134** is rotated or advanced. In FIGS. **23** and **24** the wavelike engagement surface **300** of the bobbin **110** is not shown for the purposes of clarity.

The spool **134** is arranged to rotate upon movement of the yokes **566**, **568** to effect delivery of a dose of medicament from reservoir **514**, such that the number on the ribbon **5128** is advanced to indicate that another dose has been dispensed by the inhaler **510**. The ribbon **5128** can be arranged such that the numbers, or other suitable indicia, increase or

decrease upon rotation of the spool **5134**. For example, the ribbon **5128** can be arranged such that the numbers, or other suitable indicia, decrease upon rotation of the spool **5134** to indicate the number of doses remaining in the inhaler **510**. Alternatively, the ribbon **5128** can be arranged such that the numbers, or other suitable indicia, increase upon rotation of the spool **5134** to indicate the number of doses dispensed by the inhaler **10**.

The indexing spool **5134** includes radially extending teeth **5136**, which are engaged by pawl **5138** extending from a cam follower **578** of the second yoke **568** upon movement of the yoke to rotate, or advance, the indexing spool **5134**. More particularly, the pawl **5138** is shaped and arranged such that it engages the teeth **5136** and advances the indexing spool **5134** only upon the mouthpiece cover **528** being closed and the yokes **566**, **568** moved back towards the cap **526** of the housing **518**.

The dose counting system **516** also includes a chassis **5140** that secures the dose counting system to the hopper **542** and includes shafts **108**, **5144** for receiving the bobbin **110** and the indexing spool **5134**. As described above with reference to FIGS. **1** to **20**, the bobbin shaft **108** is forked and includes radially nubs **5146** for creating a resilient resistance to rotation of the bobbin **110** on the shaft **108** by engaging with the wavelike engagement surface **300** inside the bobbin **110**. A clutch spring **5148** is received on the end of the indexing spool **5134** and locked to the chassis **5140** to allow rotation of the spool **5134** in only a single direction.

Various modifications may be made to the embodiment shown without departing from the scope of the invention as defined by the accompanying claims as interpreted under patent law.

What is claimed:

1. An inhaler for metered dose inhalation, the inhaler comprising:

a main body having a canister housing,

a medicament canister, which is moveable relative to the canister housing and retained in a central outlet port of the canister housing arranged to mate with a canister fire stem of the medicament canister, and

a dose counter having an actuation member having at least a portion thereof located in the canister housing for operation by movement of the medicament canister,

wherein the canister housing has an inner wall, and a first inner wall canister support formation extending inwardly from a main surface of the inner wall, and

wherein the canister housing has a longitudinal axis X which passes through the center of the central outlet port,

the inner wall canister support formation, the actuation member, and the central outlet port lying in a common plane coincident with the longitudinal axis X.

2. The inhaler as claimed in claim **1** wherein the medicament canister is movable relative to the dose counter.

3. The inhaler as claimed in claim **1** further comprising an aperture formed in the inner wall through which the portion of the actuation member extends.

4. The inhaler as claimed in claim **1**, wherein the first inner wall canister support formation comprises a support rail which extends longitudinally along an inside surface of the main body.

5. The inhaler as claimed in claim **4**, wherein the support rail includes a step formed thereon.

6. The inhaler as claimed in claim **4** further comprising a plurality of support rails each of which extends longitudinally along an inside surface of the main body.

7. The inhaler as claimed in claim **6**, wherein two of the plurality of support rails are positioned at opposite ends of the inside surface of the main body to face each other.

8. The inhaler as claimed in claim **4**, wherein the support rail includes two steps formed thereon, the steps being spaced apart longitudinally along an inside surface of the main body.

9. The inhaler as claimed in claim **4**, wherein the support rail merges with the inner wall at a location adjacent the aperture.

10. The inhaler as claimed in claim **9**, wherein a width dimension of the support rail is not constant, and the width dimension is greatest at the location where the support rail merges with the inner wall.

* * * * *

Exhibit C

(12) **United States Patent**
Walsh et al.

(10) **Patent No.: US 9,808,587 B2**
(45) **Date of Patent: *Nov. 7, 2017**

(54) **DOSE COUNTER FOR INHALER HAVING AN ANTI-REVERSE ROTATION ACTUATOR**

(71) Applicants: **IVAX PHARMACEUTICALS IRELAND**, Waterford (IE); **NORTON (WATERFORD) LIMITED**, Waterford (IE); **TEVA PHARMACEUTICALS IRELAND**, Waterford (IE)

(72) Inventors: **Declan Walsh**, Co. Kilkenny (IE); **Derek Fenlon**, Co. Wexford (IE); **Simon Kaar**, Co. Cork (IE); **Jan Geert Hazenberg**, Co. Kilkenny (IE); **Daniel Buck**, Co. Waterford (IE); **Paul Clancy**, Waterford (IE); **Robert Charles Uschold**, Leominster, MA (US); **Jeffrey A. Karg**, Hopkinton, MA (US)

(73) Assignees: **IVAX PHARMACEUTICALS IRELAND** (IE); **TEVA PHARMECUTICALS IRELAND** (IE); **NORTON (WATERFORD) LIMITED** (IE)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

This patent is subject to a terminal disclaimer.

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Related U.S. Application Data

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G06M 1/06 (2006.01)
A61M 11/00 (2006.01)
(Continued)

(52) **U.S. Cl.**
CPC ***A61M 15/0078*** (2014.02); ***A61M 11/00*** (2013.01); ***A61M 15/009*** (2013.01);
(Continued)

(58) **Field of Classification Search**
USPC 235/8, 103; 128/200.23
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

4,174,890 A 11/1979 Johnson
4,669,838 A 6/1987 Hibbard
(Continued)

FOREIGN PATENT DOCUMENTS

CA 2501726 9/2006
EP 1330280 7/2003
(Continued)

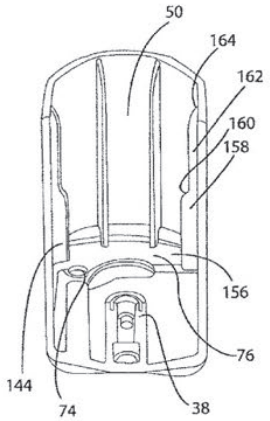
OTHER PUBLICATIONS

Final Office Action dated Oct. 20, 2016 for U.S. Appl. No. 14/699,567.
(Continued)

Primary Examiner — Daniel Hess
(74) *Attorney, Agent, or Firm* — Morgan, Lewis & Bockius LLP

(57) **ABSTRACT**

An inhaler includes a main body having a canister housing, a medicament canister retained in a central outlet port of the canister housing, and a dose counter having an actuation member for operation by movement of the medicament canister. The canister housing has an inner wall, and a first inner wall canister support formation extending inwardly from a main surface of the inner wall. The canister housing
(Continued)



has a longitudinal axis X which passes through the center of the central outlet port. The first inner wall canister support formation, the actuation member, and the central outlet port lie in a common plane coincident with the longitudinal axis X such that the first inner wall canister support formation protects against unwanted actuation of the dose counter by reducing rocking of the medicament canister relative to the main body of the inhaler.

22 Claims, 17 Drawing Sheets

Related U.S. Application Data

division of application No. 13/110,532, filed on May 18, 2011, now Pat. No. 8,978,966.

(60) Provisional application No. 61/417,659, filed on Nov. 29, 2010, provisional application No. 61/345,763, filed on May 18, 2010.

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A61M 15/00 (2006.01)
G06M 1/24 (2006.01)

(52) **U.S. Cl.**
CPC ***A61M 15/0025*** (2014.02); ***A61M 15/0026*** (2014.02); ***A61M 15/0065*** (2013.01); ***A61M 15/0071*** (2014.02); ***G06M 1/246*** (2013.01); *A61M 2202/064* (2013.01); *A61M 2205/6063* (2013.01); *A61M 2207/00* (2013.01); *A61M 2207/10* (2013.01); *Y10T 29/49* (2015.01); *Y10T 29/49764* (2015.01); *Y10T 29/49826* (2015.01)

(56) **References Cited**

U.S. PATENT DOCUMENTS

4,687,359	A	8/1987	Barrus	
5,482,030	A	1/1996	Klein	
5,861,911	A	1/1999	Oosaka	
6,446,627	B1	9/2002	Bowman	
6,718,972	B2	4/2004	OLeary	
8,418,690	B2	4/2013	Power	
8,474,448	B2	7/2013	Oi	
8,978,966	B2	3/2015	Walsh et al.	
9,174,013	B2	11/2015	Walsh et al.	
9,463,289	B2 *	10/2016	Walsh	A61M 15/0065
2002/0047021	A1	4/2002	Blacker	
2002/0078949	A1	6/2002	OLeary	
2002/0078950	A1	6/2002	OLeary	
2002/0084891	A1	7/2002	Mankins et al.	
2003/0209239	A1	11/2003	Rand	
2004/0089298	A1	5/2004	Haikarainen et al.	
2004/0095746	A1	5/2004	Murphy	
2005/0028815	A1	2/2005	Deaton	
2005/0087191	A1 *	4/2005	Morton	A61M 15/0065 128/205.23
2006/0096594	A1	5/2006	Bonney	
2006/0107949	A1 *	5/2006	Davies	A61M 15/0065 128/200.23
2006/0107979	A1	5/2006	Kim	
2007/0062518	A1	3/2007	Geser	
2008/0242465	A1	10/2008	Strobel	
2009/0178678	A1	7/2009	OLeary	
2010/0089395	A1	4/2010	Power	
2010/0218759	A1	9/2010	Anderson	
2011/0041845	A1	2/2011	Solomon	
2012/0006322	A1	1/2012	Anderson	

FOREIGN PATENT DOCUMENTS

EP	1486227	12/2004
GB	2320489	6/1998
IL	201256	11/2014
JP	02502129	7/1990
JP	450059	8/1992
JP	07100205	4/1995
JP	10504220	4/1998
JP	2002528144	9/2002
JP	2004501685	1/2004
JP	2008-94103 A	4/2008
JP	2008094103	4/2008
JP	2008261423	10/2008
JP	2009233308	10/2009
JP	2009257392	11/2009
JP	2010096308	4/2010
WO	8909078	10/1989
WO	9628205	9/1996
WO	9828033	7/1998
WO	9936115	7/1999
WO	02/00281 A2	1/2002
WO	03101514	12/2003
WO	2005102430	11/2005
WO	2006062449	6/2006
WO	2006062449 A1	6/2006
WO	2007012861	2/2007
WO	2007062518	6/2007
WO	2008023019	2/2008
WO	2008119552	2/2008
WO	2011012325	2/2011
WO	2011012327	2/2011

OTHER PUBLICATIONS

Advisory Action dated Mar. 13, 2017 for U.S. Appl. No. 14/699,567.
Non-Final Office Action dated Jan. 12, 2017 for U.S. Appl. No. 14/713,620, 8 pages.
Final Rejection dated Sep. 27, 2016 for U.S. Appl. No. 14/699,578.
Final Office Action dated Aug. 31, 2016 for U.S. Appl. No. 14/713,620, 7 pages.
Advisory action dated Feb. 9, 2017 for U.S. Appl. No. 14/699,584.
Non-final rejection dated Jul. 12, 2016 for U.S. Appl. No. 14/713,643.
File History for U.S. Appl. No. 15/271,738.
File History for U.S. Appl. No. 15/269,102.
File History for U.S. Appl. No. 15/262,818.
File History for U.S. Appl. No. 15/289,553.
File History for U.S. Appl. No. 15/269,249.
Final rejection dated Oct. 20, 2016 or U.S. Appl. No. 14/699,584.
Non-Final Office Action dated Jun. 24, 2016 for U.S. Appl. No. 14/713,620, 7 pages.
Final rejection dated Oct. 20, 2016 or U.S. Appl. No. 14/713,631.
Advisory Action dated Mar. 16, 2017 or U.S. Appl. No. 14/713,633.
Entire patent prosecution history of U.S. Appl. No. 13/110,532, filed May 18, 2011, entitled, "Dose Counters for Inhalers, Inhalers and Methods of Assembly Thereof.".
Entire patent prosecution history of U.S. Appl. No. 14/103,324, filed Dec. 11, 2013, entitled, "Dose Counters for Inhalers, Inhalers and Methods of Assembly Thereof.".
Entire patent prosecution history of U.S. Appl. No. 14/103,343, filed Dec. 11, 2013, entitled, "Dose Counters for Inhalers, Inhalers and Methods of Assembly Thereof.".
Entire patent prosecution history of U.S. Appl. No. 14/103,353, filed Dec. 11, 2013, entitled,"Dose Counters for Inhalers, Inhalers and Methods of Ass Embly Thereof.".
Entire patent prosecution history of U.S. Appl. No. 14/103,363, filed Dec. 1, 2013, entitled, "Dose Counters for Inhalers, Inhalers and Methods of Assembly Thereof.".
Entire patent prosecution history of U.S. Appl. No. 14/103,392, filed Dec. 11, 2013, entitled, "Dose Counters for Inhalers, Inhalers and Methods of Assembly Thereof.".

(56) **References Cited**

OTHER PUBLICATIONS

Entire patent prosecution history of U.S. Appl. No. 14/699,567, filed Apr. 29, 2015, entitled, "Dose Counter for Inhaler and Method for Counting Doses.".
Entire patent prosecution history of U.S. Appl. No. 14/699,578, filed Apr. 29, 2015, entitled, "Dose Counter for Inhaler Having a Bore !and Shaft Arrangement.".
Entire patent prosecution history of U.S. Appl. No. 14/699,584, filed Apr. 29, 2015, entitled, "Dose Counter for Inhaler Having an Antireverse Rotation Actuator.".
Entire patent prosecution history of U.S. Appl. No., 14/713,612, filed May 15, 2015, entitled, "Dose Counters for Inhalers, Inhalers and Methods of Assembly Thereof.".
Entire patent prosecution history of U.S. Appl. No. 14/713,620, filed May 15, 2015, entitled, "Dose Counters for Inhalers, Inhalers and Methods of Assembly Thereof.".
Entire patent prosecution history of U.S. Appl. No. 14/713,643, filed May 15, 2015, entitled, "Dose Counters for Inhalers, Inhalers and Methods of Assembly Thereof.".
European Patent Office Communication, dated Apr. 24, 2014 of counterpart European Patent Application No. 11 010 211.8.
European Patent Office Communication, dated Apr. 24, 2014 of counterpart European Patent Application No. 11 010 212.6.
First Examination Report of counterpart New Zealand Patent Application No. 603466, dated Jul. 1, 2013.
Office Action issued by the Israel Patent Office on Jul. 3, 2017 in reference to Israel Patent Application No. 247396, 3 pages.
Office Action issued by the Israel Patent Office on Jul. 27, 2017 in reference to Israel Patent Application No. 247402, 4 pages.

* cited by examiner

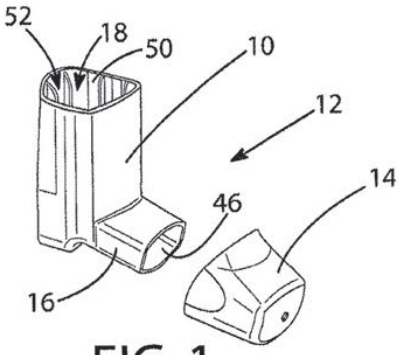


FIG. 1

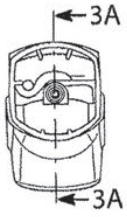


FIG. 2

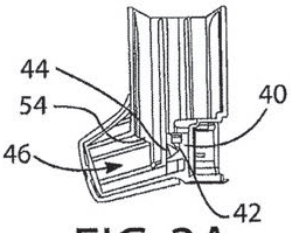


FIG. 3A

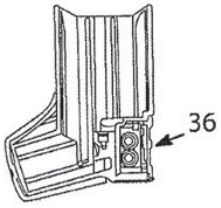


FIG. 3B

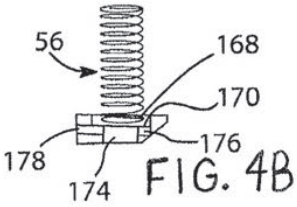


FIG. 4B

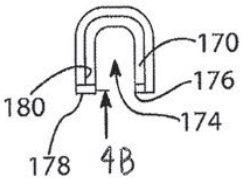


FIG. 4C

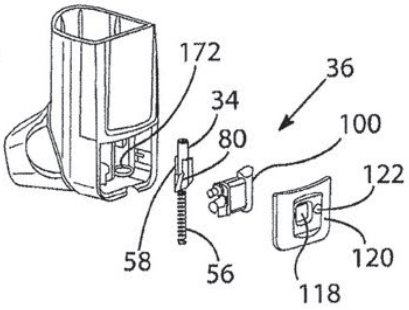


FIG. 4A

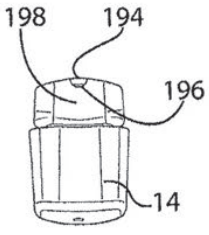


FIG. 5

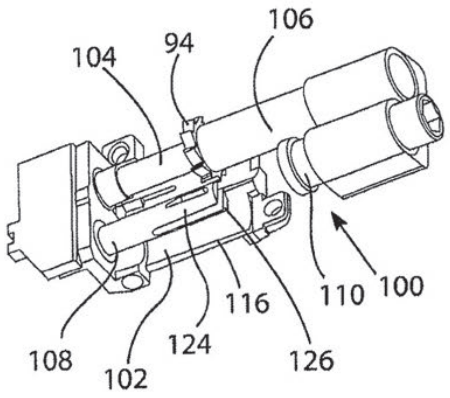


FIG. 6A

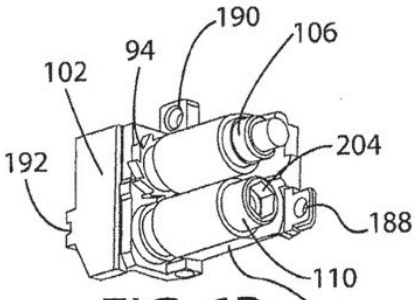


FIG. 6B

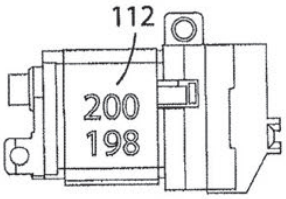


FIG. 6C

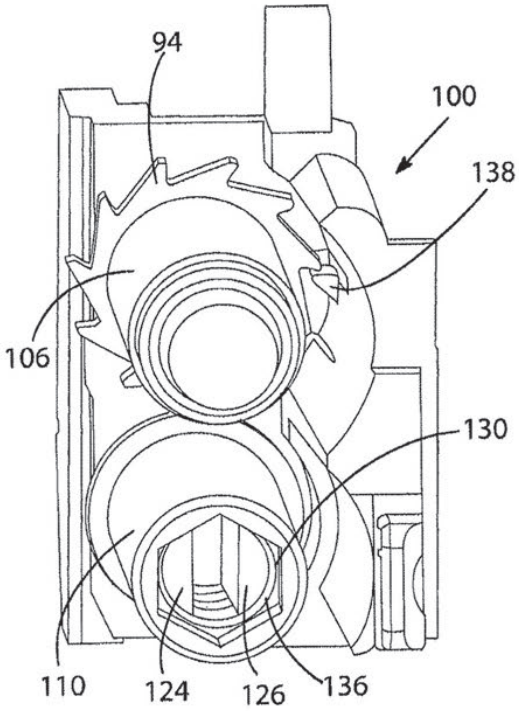


FIG. 6D

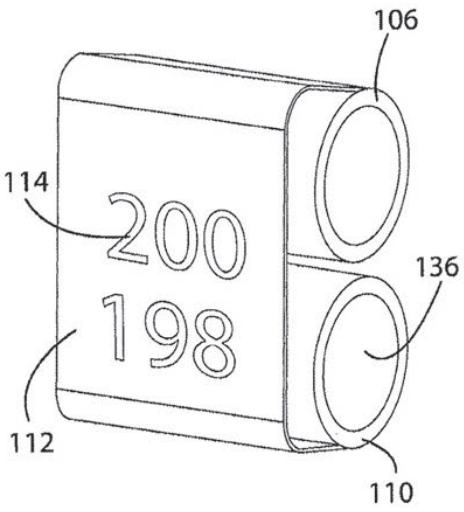


FIG. 6E

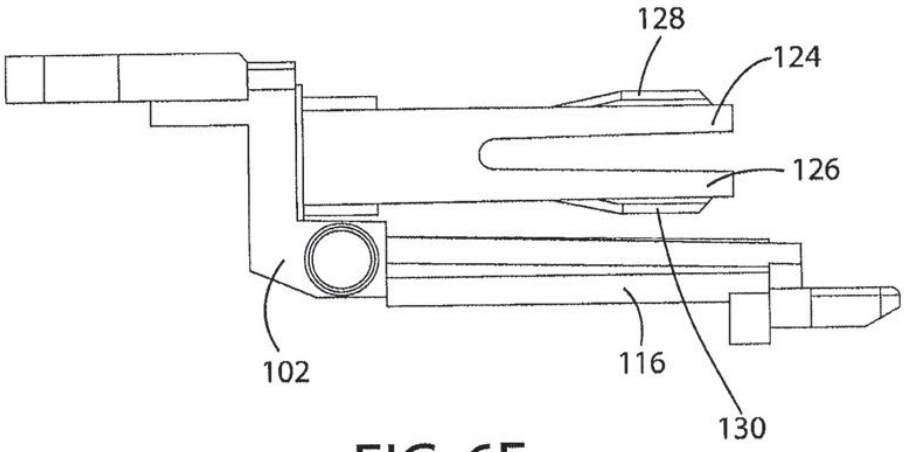


FIG. 6F

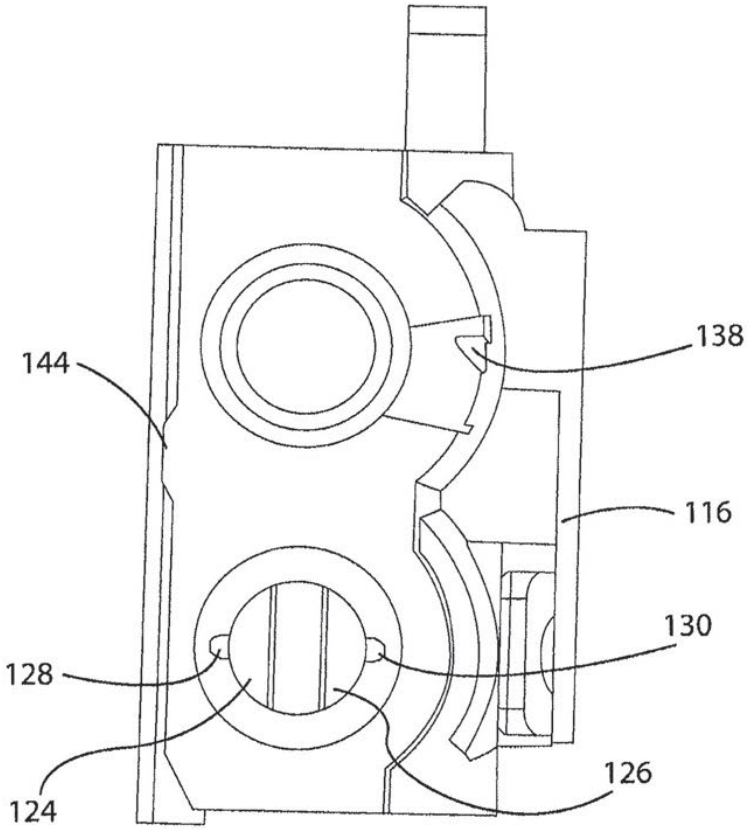


FIG. 6G

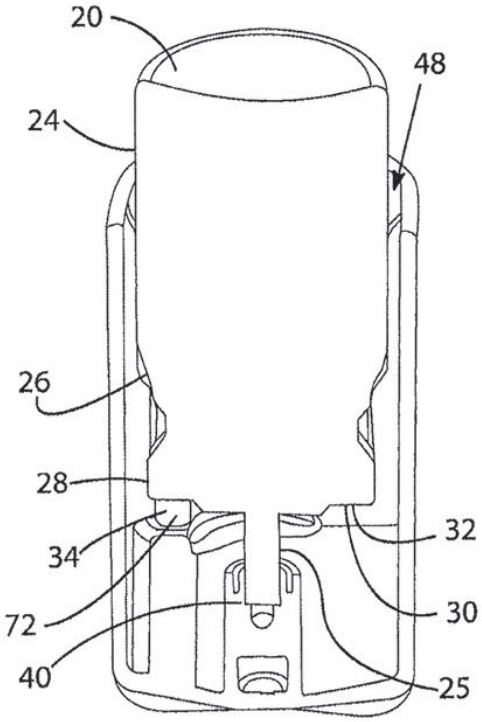


FIG. 7A

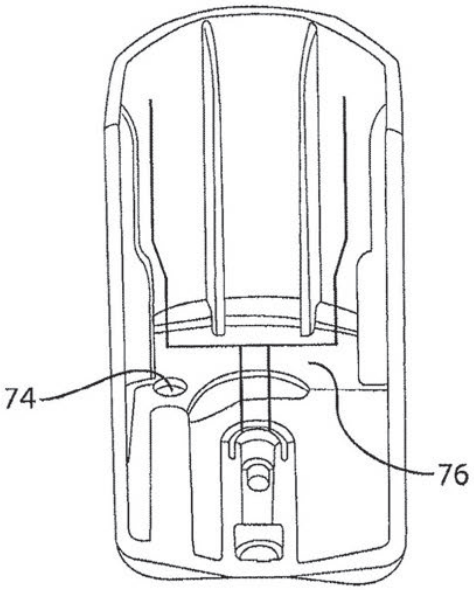


FIG. 7B

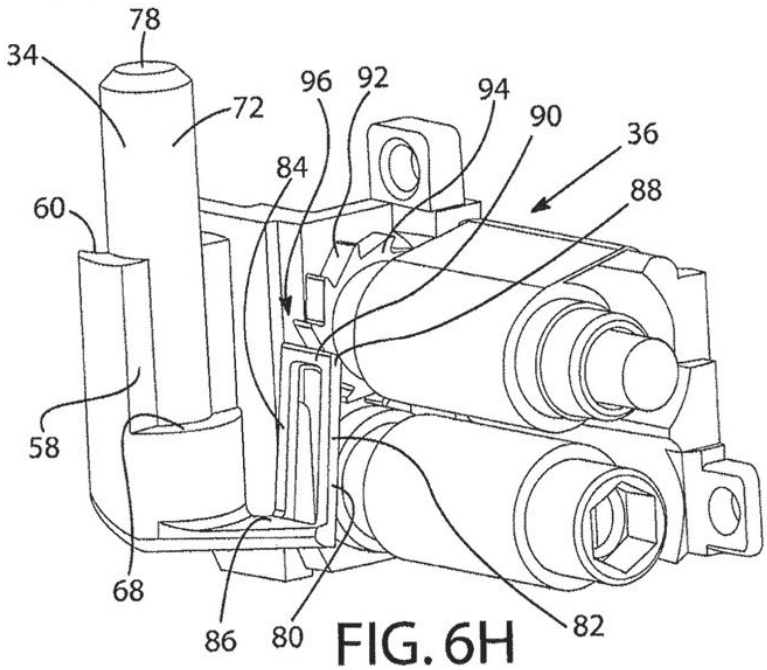


FIG. 6H

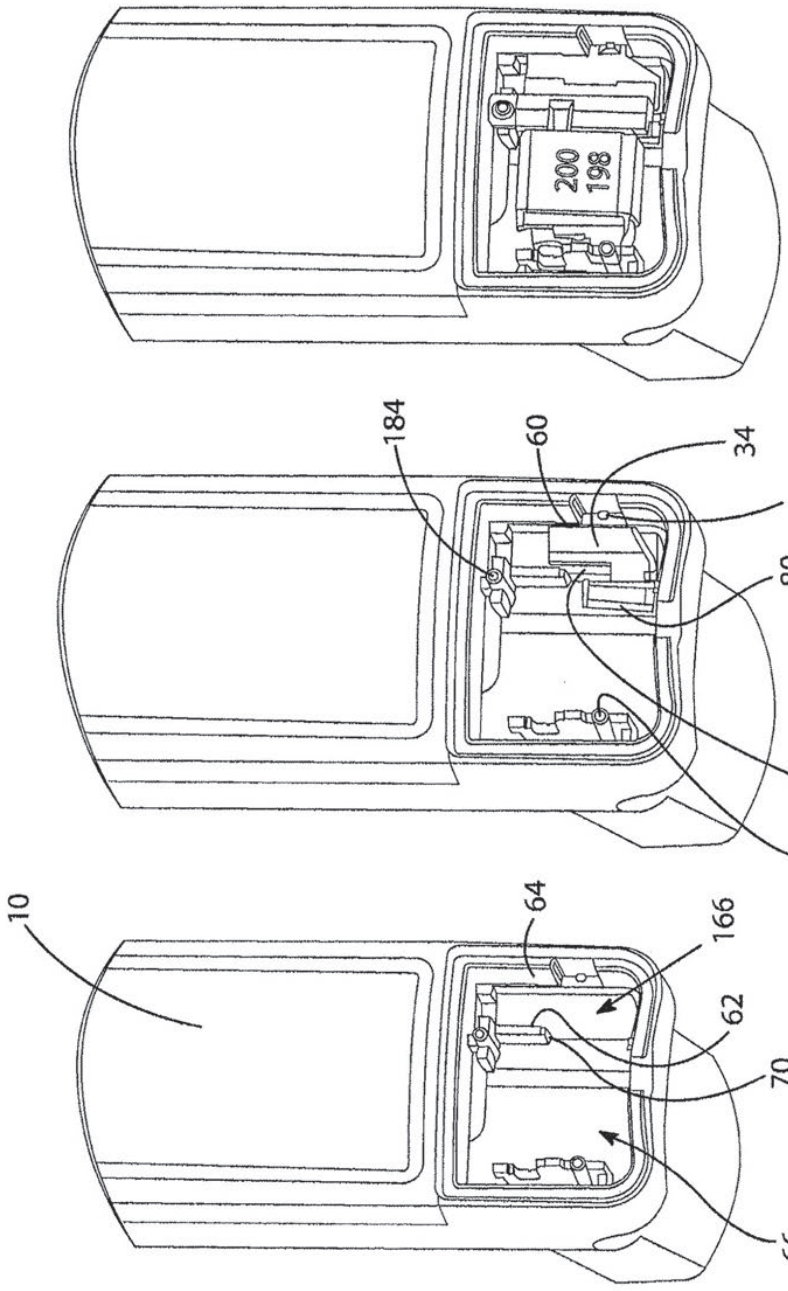


FIG. 8C

FIG. 8B

FIG. 8A

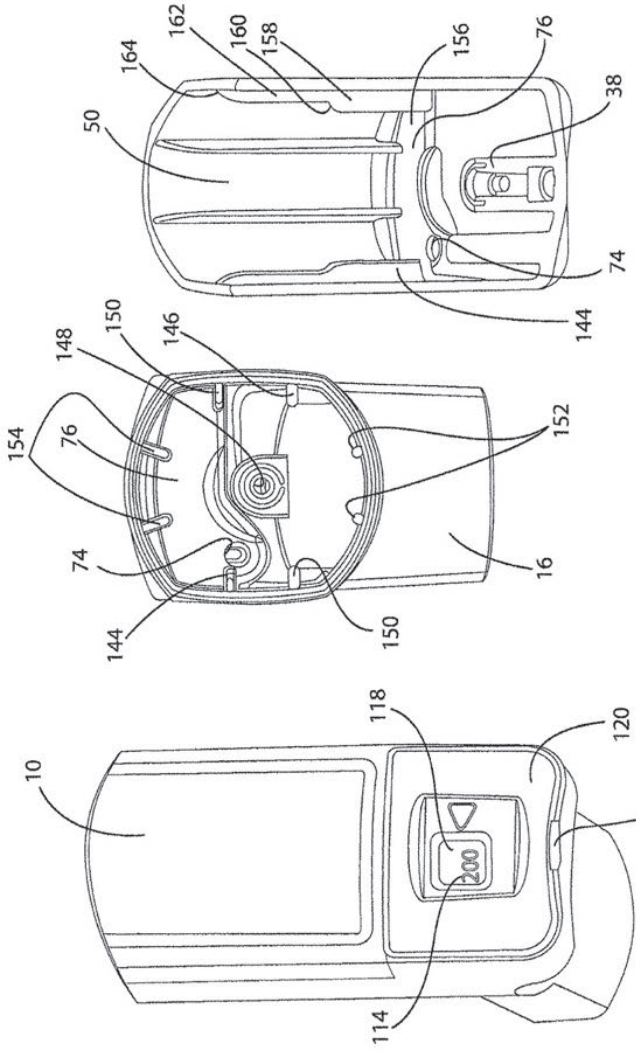


FIG. 7C

FIG. 7D

FIG. 8D

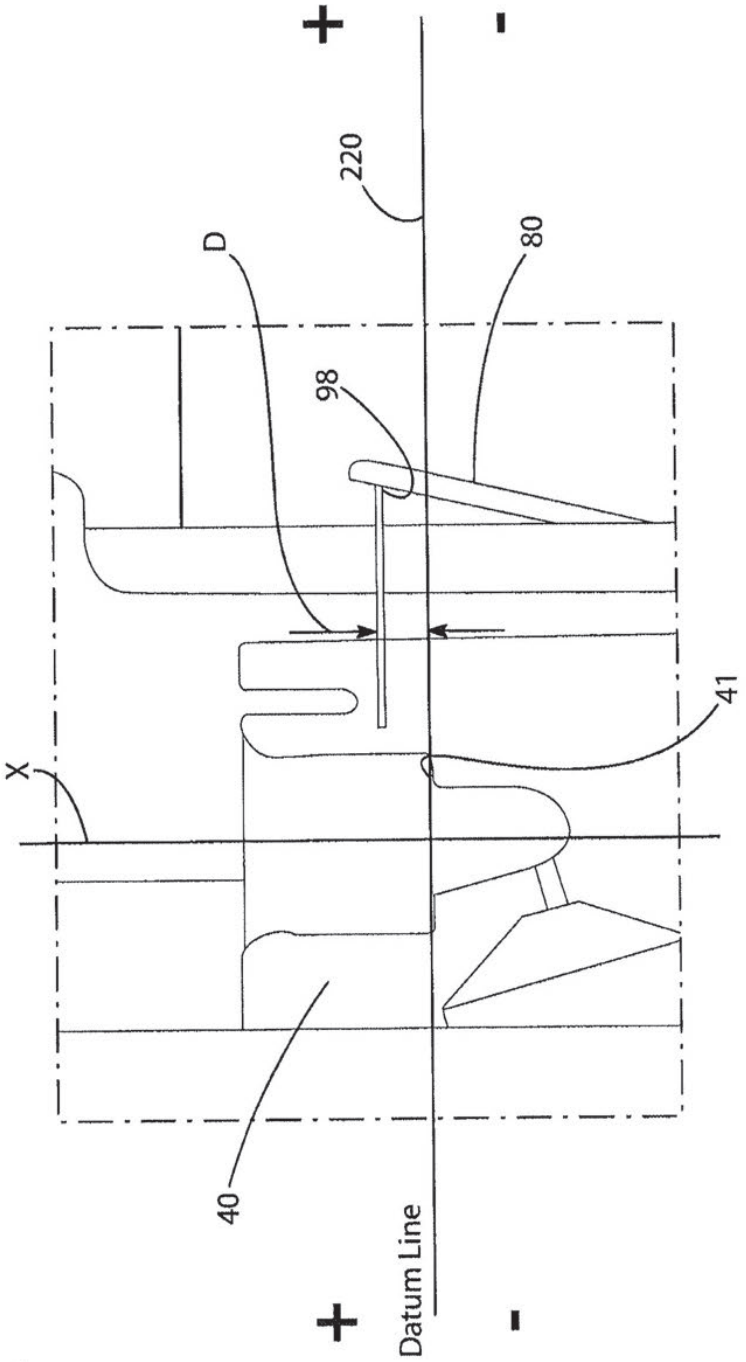


FIG. 9

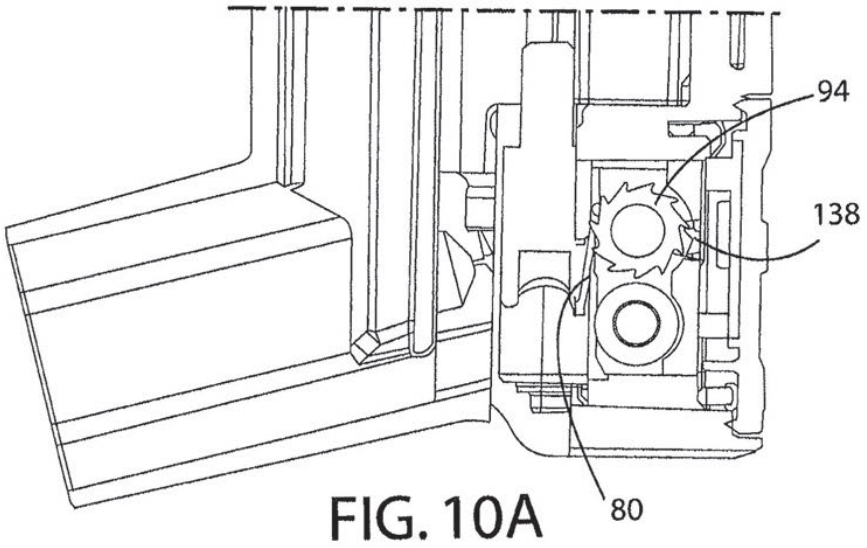


FIG. 10A

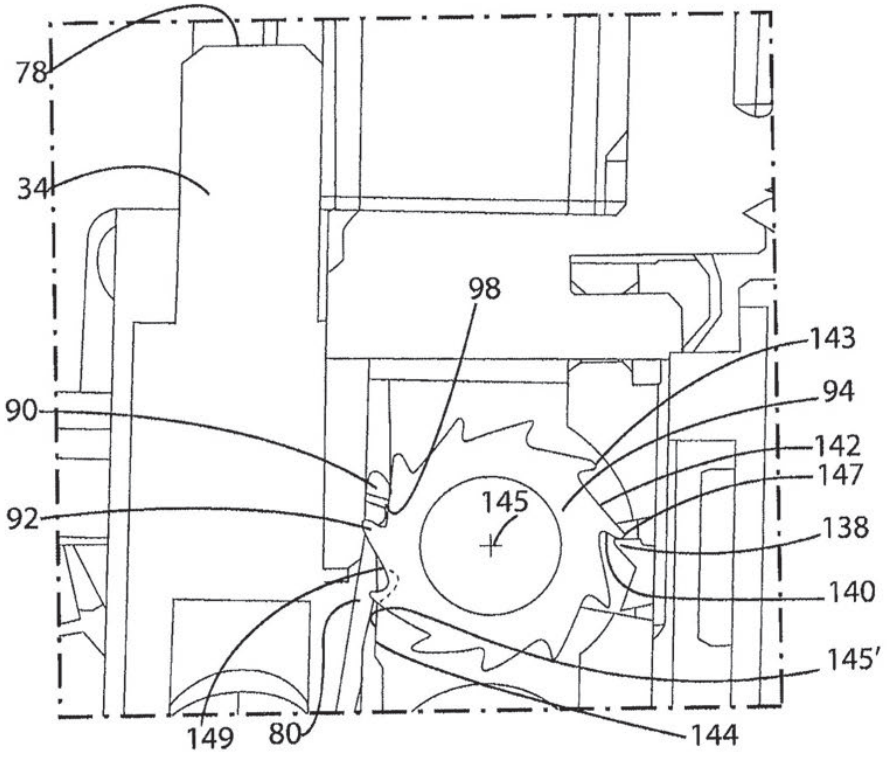


FIG. 10B

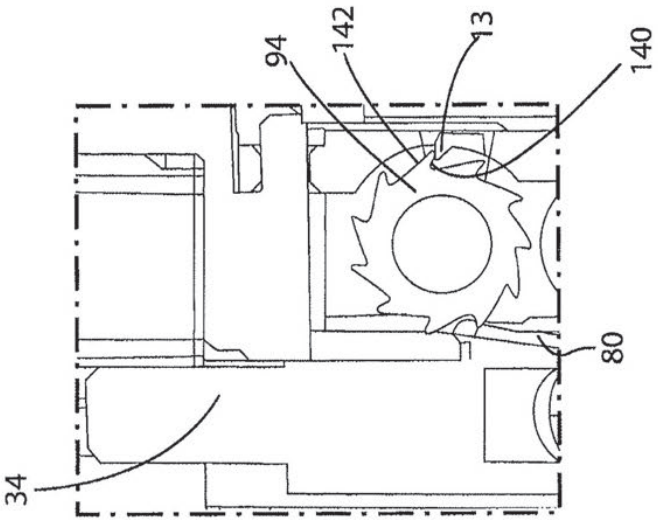


FIG. 10E

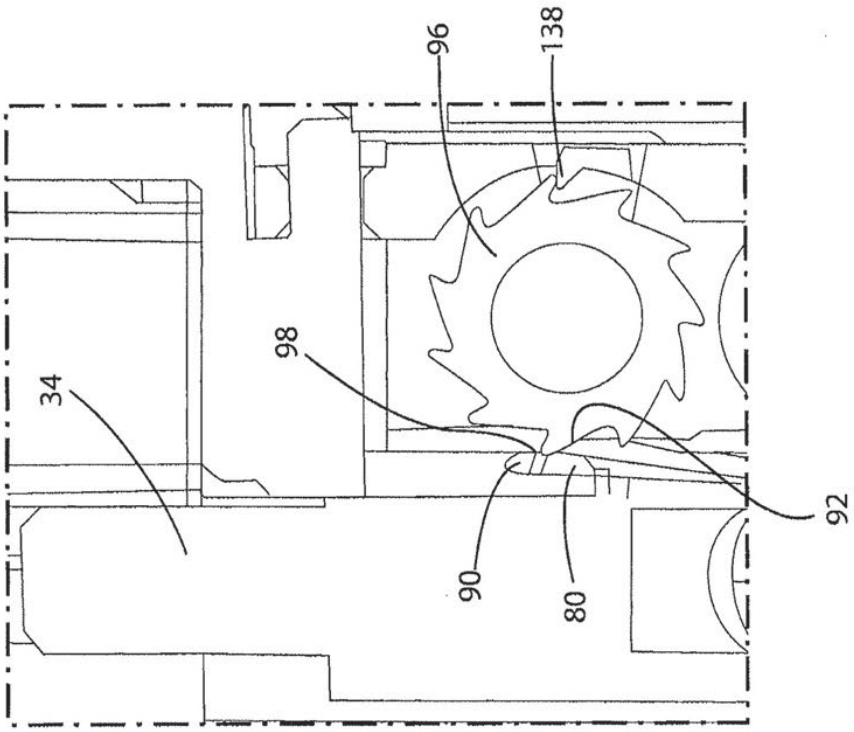
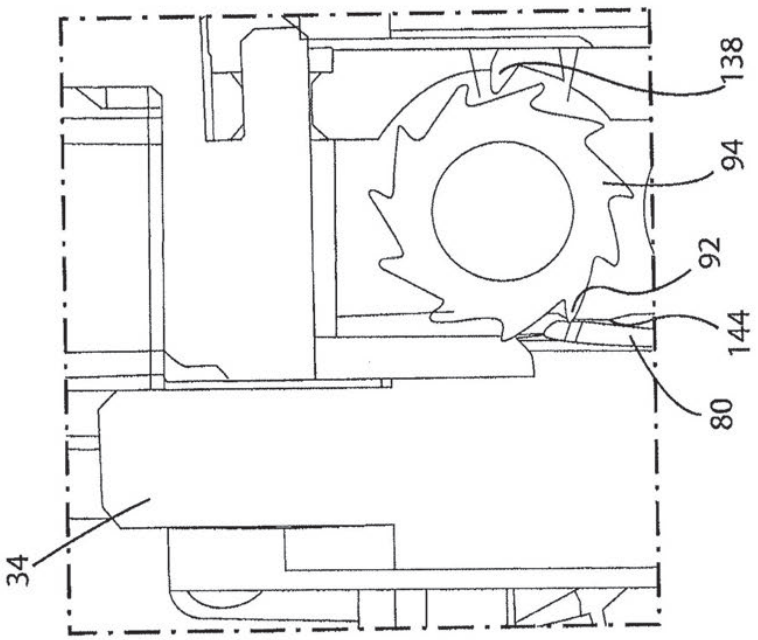


FIG. 10C



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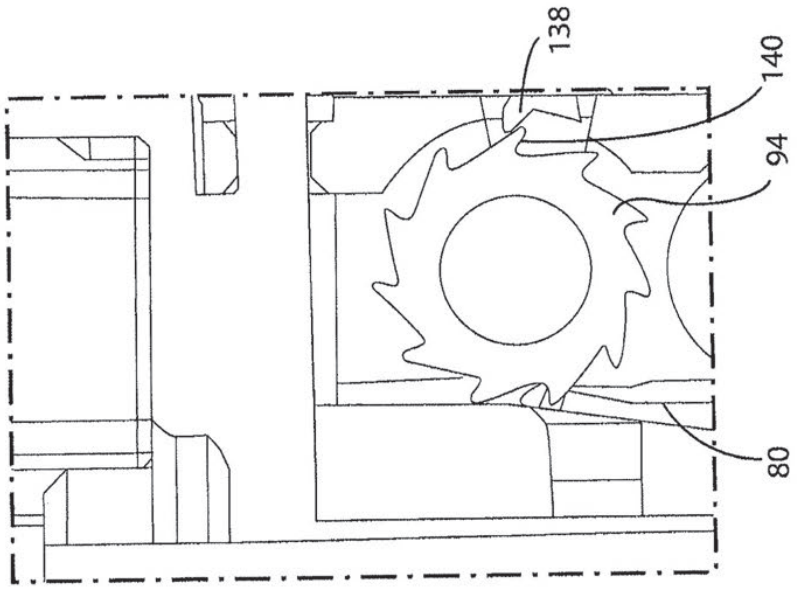


FIG. 10D

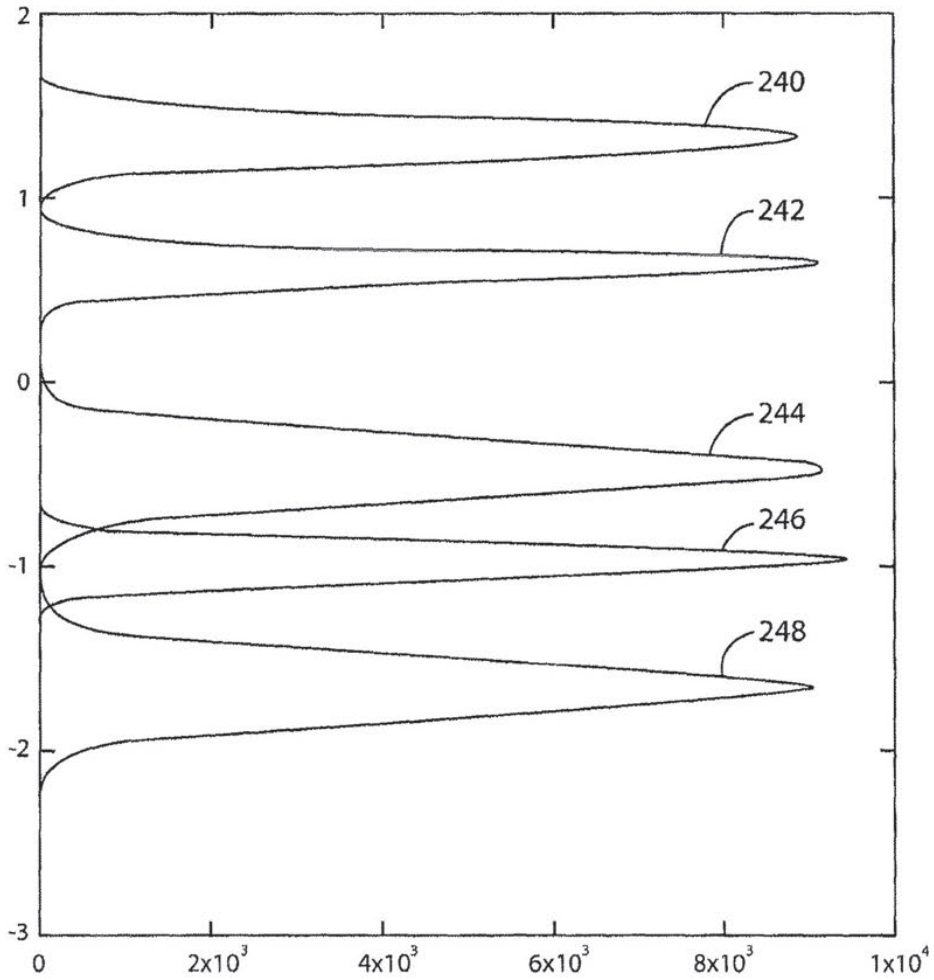

2
1
0
-1
-2
-3
240
242
244
246
248
0
2x10^3
4x10^3
6x10^3
8x10^3
1x10^4

FIG. 11

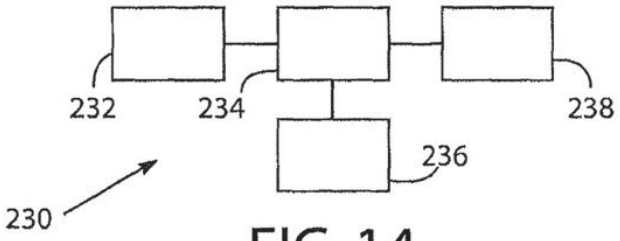

232
234
238
236
230

FIG. 14

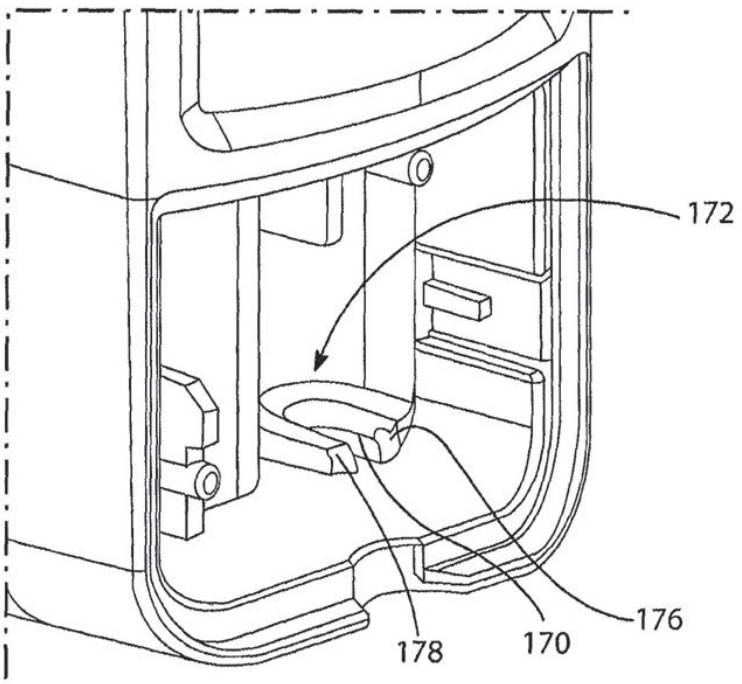
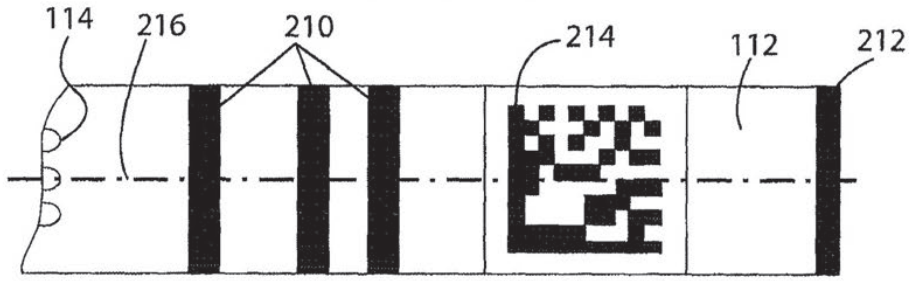


FIG. 12



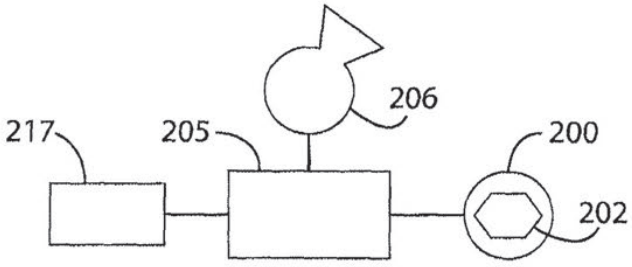


FIG. 13

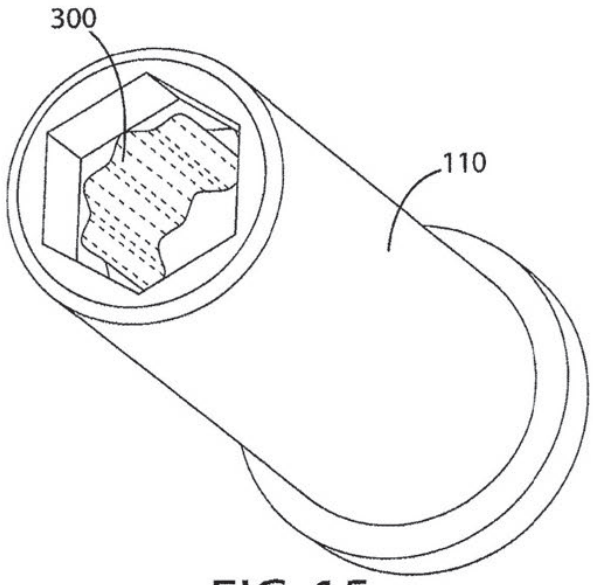


FIG. 15

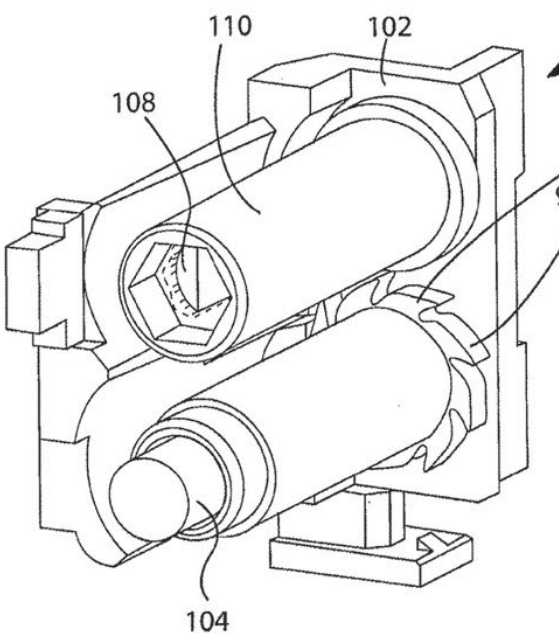


FIG. 20

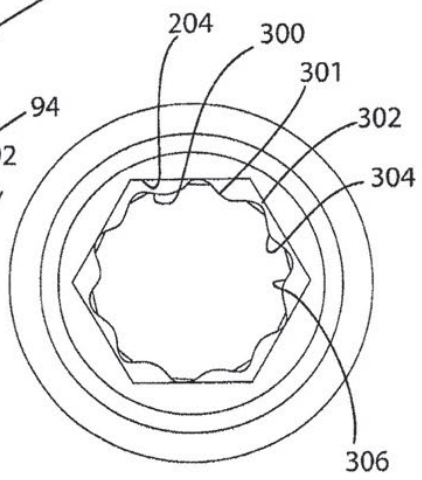


FIG. 16

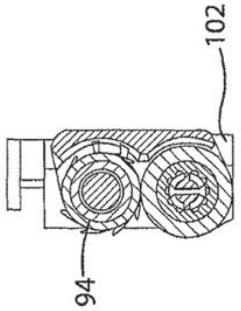


FIG. 19A

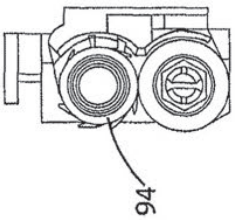


FIG. 19B

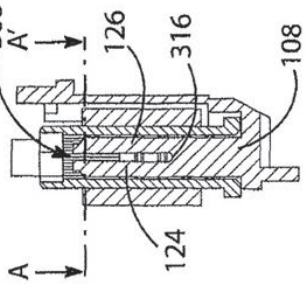


FIG. 19C

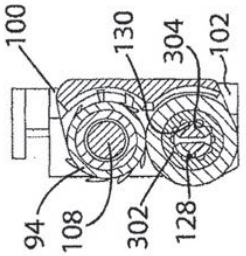


FIG. 18A

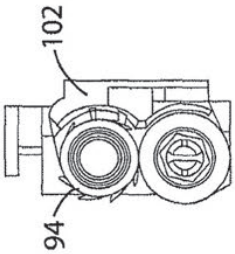


FIG. 18B

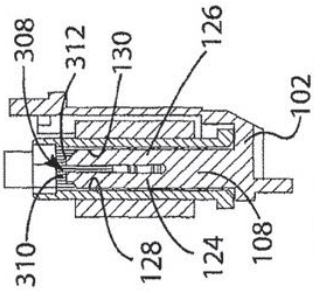


FIG. 18C

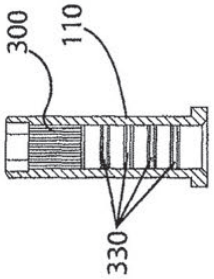


FIG. 17

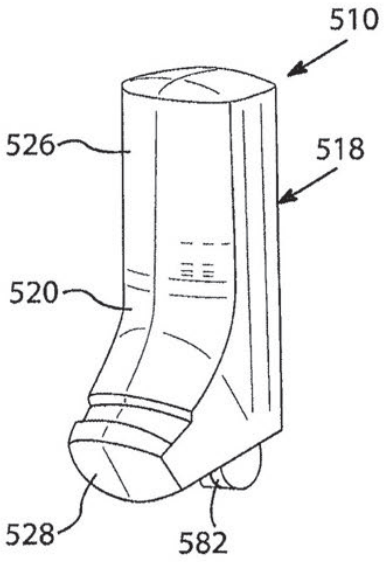

510
526
518
520
528
582

FIG. 21

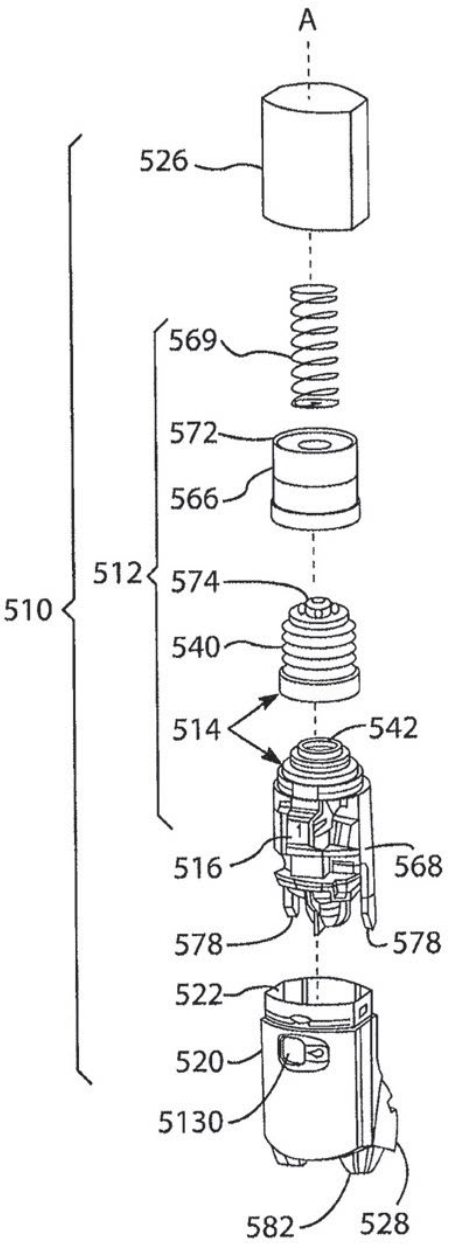

A
526
569
572
566
512
574
510
540
514
542
516
568
578
578
522
520
5130
582
528

FIG. 22

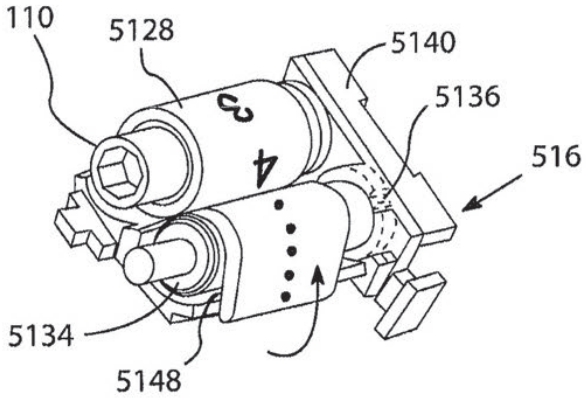

110
5128
5140
5136
516
5134
5148

FIG. 23

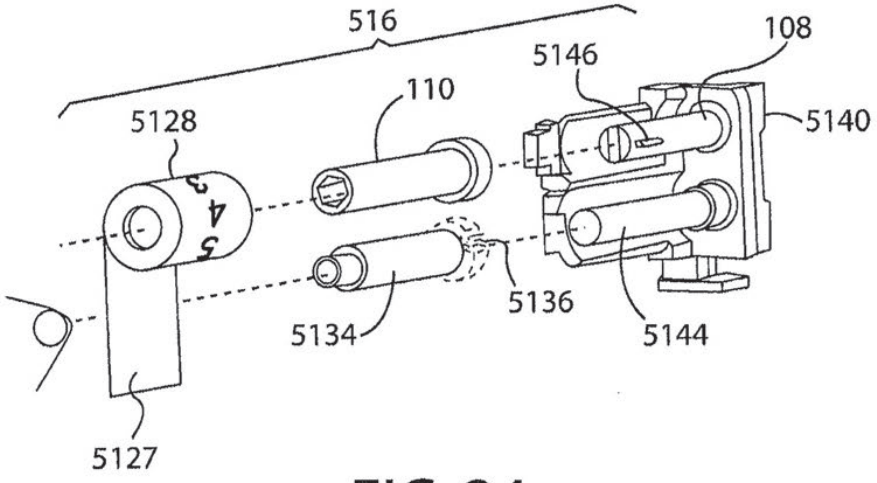

516
108
5146
110
5128
5140
5136
5134
5144
5127

FIG. 24

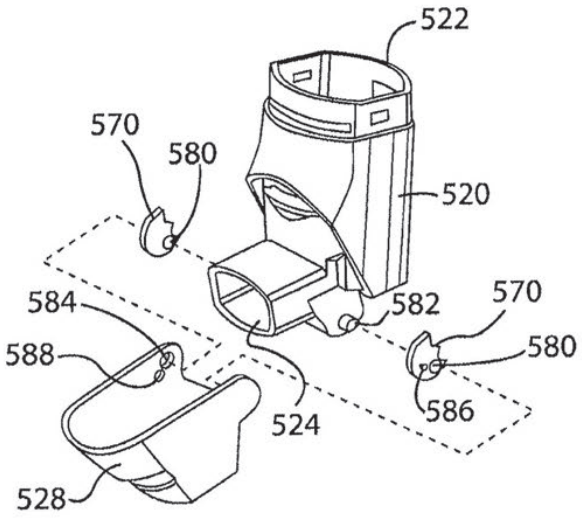


FIG. 25

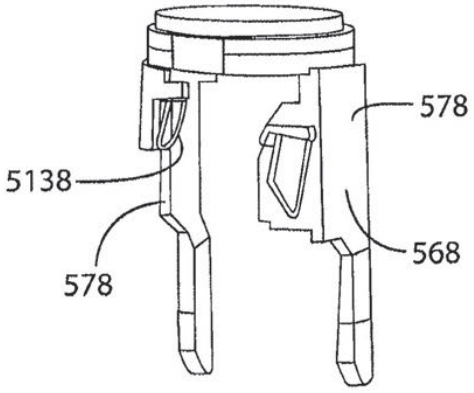


FIG. 26

DOSE COUNTER FOR INHALER HAVING AN ANTI-REVERSE ROTATION ACTUATOR

CROSS-REFERENCE TO RELATED APPLICATIONS

This patent application is a continuation patent application of U.S. Non-Provisional patent application Ser. No. 14/103,324, filed Dec. 11, 2013, which is a divisional patent application of U.S. Non-Provisional patent application Ser. No. 13/110,532, filed May 18, 2011, now U.S. Pat. No. 8,978,966, issued Mar. 17, 2015, which claims priority to U.S. Provisional Patent Application No. 61/345,763, filed May 18, 2010, and U.S. Provisional Patent Application No. 61/417,659, filed Nov. 29, 2010, each of which is incorporated herein by reference in its entirety for any and all purposes.

FIELD OF THE INVENTION

The present invention relates to dose counters for inhalers, inhalers and methods of assembly thereof. The invention is particularly applicable to metered dose inhalers including dry power medicament inhalers, breath actuated inhalers and manually operated metered dose medicament inhalers.

BACKGROUND OF THE INVENTION

Metered dose inhalers can comprise a medicament-containing pressurised canister containing a mixture of active drug and propellant. Such canisters are usually formed from a deep-dawn aluminium cup having a crimped lid which carries a metering valve assembly. The metering valve assembly is provided with a protruding valve stem which, in use is inserted as a push fit into a stem block in an actuator body of an inhaler having a drug delivery outlet. In order to actuate a manually operable inhaler, the user applies by hand a compressive force to a closed end of the canister and the internal components of the metering valve assembly are spring loaded so that a compressive force of approximately 15 to 30 N is required to activate the device in some typical circumstances.

In response to this compressive force the canister moves axially with respect to the valve stem and the axial movement is sufficient to actuate the metering valve and cause a metered quantity of the drug and the propellant to be expelled through the valve stem. This is then released into a mouthpiece of the inhaler via a nozzle in the stem block, such that a user inhaling through the outlet of the inhaler will receive a dose of the drug.

A drawback of self-administration from an inhaler is that it is difficult to determine how much active drug and/or propellant are left in the inhaler, if any, especially of the active drug and this is potentially hazardous for the user since dosing becomes unreliable and backup devices not always available.

Inhalers incorporating dose counters have therefore become known.

WO 98/028033 discloses an inhaler having a ratchet mechanism for driving a tape drive dose counter. A shaft onto which tape is wound has a friction clutch or spring for restraining the shaft against reverse rotation.

EP-A-1486227 discloses an inhaler for dry powered medicament having a ratchet mechanism for a tape dose counter which is operated when a mouthpiece of the inhaler is closed. Due to the way in which the mouthpiece is opened and closed, and actuation pawl of the device which is mounted on a yoke, travels a known long stroke of consistent length as the mouthpiece is opened and closed.

WO 2008/119552 discloses a metered-dose inhaler which is suitable for breath-operated applications and operates with a known and constant canister stroke length of 3.04 mm+/−0.255 mm. A stock bobbin of the counter, from which a tape is unwound, rotates on a shaft having a split pin intended to hold the stock bobbin taut. However, some dose counters do not keep a particularly reliable count, such as if they are dropped onto a hard surface.

More recently, it has become desirable to improve dose counters further and, in particular, it is felt that it would be useful to provide extremely accurate dose counters for manually-operated canister-type metered dose inhalers. Unfortunately, in these inhalers, it has been found in the course of making the present invention that the stroke length of the canister is to a very large extent controlled on each dose operation by the user, and by hand. Therefore, the stroke length is highly variable and it is found to be extremely difficult to provide a highly reliable dose counter for these applications. The dose counter must not count a dose when the canister has not fired since this might wrongly indicate to the user that a dose has been applied and if done repeatedly the user would throw away the canister or whole device before it is really time to change the device due to the active drug and propellant reaching a set minimum. Additionally, the canister must not fire without the dose counter counting because the user may then apply another dose thinking that the canister has not fired, and if this is done repeatedly the active drug and/or propellant may run out while the user thinks the device is still suitable for use according to the counter. It has also been found to be fairly difficult to assembly some known inhaler devices and the dose counters therefor. Additionally, it is felt desirable to improve upon inhalers by making them easily usable after they have been washed with water.

The present invention aims to alleviate at least to a certain extent one or more of the problems of the prior art.

SUMMARY OF THE INVENTION

According to a first aspect of the present invention there is provided a dose counter for an inhaler, the dose counter having a counter display arranged to indicate dosage information, a drive system arranged to move the counter display incrementally in a first direction from a first station to a second station in response to actuation input, wherein a regulator is provided which is arranged to act upon the counter display at the first station to regulate motion of the counter display at the first station to incremental movements.

The regulator is advantageous in that it helps prevent unwanted motion of the counter display if the counter is dropped.

According to a further aspect of the present invention, the regulator provides a resistance force of greater than 0.1 N against movement of the counter display. According to still a further aspect of the present invention, the resistance force is greater than 0.3 N. According to yet a further aspect of the present invention, the resistance force is from 0.3 to 0.4 N.

Preferably, the counter comprises a tape.

Preferably, the tape has dose counter indicia displayed thereon. The first station may comprise a region of the dose counter where tape is held which is located before a display location, such as a display window, for the counter indicia.

The first station may comprise a first shaft, the tape being arranged on the first shaft and to unwind therefrom upon movement of the counter display.

The first shaft may be mounted for rotation relative to a substantially rotationally fixed element of the dose counter.

The regulator may comprise at least one projection which is arranged on one of the first shaft and the substantially rotationally fixed element and to engage incrementally with one or more formations on the other of the first shaft and the substantially rotationally fixed element.

At least two said projections may be provided. Exactly two said projections maybe provided.

Each projection may comprise a radiused surface.

The at least one projection may be located on the substantially fixed element which may comprise a fixed shaft which is fixed to a main body of the dose counter, the first shaft being rotationally mounted to the fixed shaft.

Preferably, the fixed shaft has at least two resiliently flexible legs (or forks). Each leg may have at least one said projection formed in an outwardly facing direction thereon, said one or more formations being formed on an inwardly facing engagement surface of the first shaft, said at least one projection being arranged to resiliently engage said one or more formations. Preferably, a series of said formations are provided. An even number of said formations may be provided. Eight to twelve of said formations may be provided. In one embodiment, ten said formations are provided.

Each said formation may comprise a concavity formed on an engagement surface. Each concavity may comprise a radiused surface wall portion which preferably merges on at least one side thereof into a flat wall portion surface. The engagement surface may include a series of said concavities, and convex wall portions of the engagement surface may be formed between each adjacent two said concavities, each said convex wall portion comprising a convex radiused wall portion.

Each convex radiused wall portion of each convex wall portion may be connected by said flat wall portion surfaces to each adjacent concavity.

The fixed shaft may comprise a split pin with fork legs and each projection may be located on a said fork leg.

The first shaft may comprise a substantially hollow bobbin.

Said at least one formation may be located on an inner surface of the bobbin. In other embodiments it may be located on an outer surface thereof. Said engagement surface may extend partially along said bobbin, a remainder of the respective inner or outer surface having a generally smooth journal portion along at least a portion thereof.

The drive system may comprise a tooth ratchet wheel arranged to act upon a second shaft which is located at the second station, the second shaft being rotatable to wind the tape onto the second shaft.

The second shaft may be located on a main body of the dose counter spaced from and parallel to the first shaft.

The ratchet wheel may be fixed to the second shaft is arranged to rotate therewith. The ratchet wheel may be secured to an end of the second shaft and aligned coaxially with the second shaft.

The dose counter may include anti-back drive system which is arranged to restrict motion of the second shaft. The anti-back drive system may include a substantially fixed tooth arranged to act upon teeth of the ratchet wheel.

According to a further aspect of the present invention, a dose counter includes an anti-back drive system which is arranged to restrict motion of the second shaft in a tape winding direction.

According to a further aspect of the present invention there is provided a shaft for holding counter tape in a dose counter for an inhaler, the shaft having an engagement surface including incrementally spaced formations located around a periphery thereof, the formations comprising a series of curved concavities and convex portions.

The shaft may comprise a hollow bobbin.

The engagement surface may be a generally cylindrical inwardly directed surface.

The engagement surface may include a flat surface wall portion joining each concavity and convex wall portion.

Each concavity may comprise a radiused wall portion.

Each convex wall portion may comprise a radiused wall portion.

Said concavities may be regularly spaced around a longitudinal axis of the shaft.

Said convex wall portions may be regularly spaced around a longitudinal axis of the shaft.

In some embodiments there may be from eight to twelve said concavities and/or convex wall portions regularly spaced around a longitudinal axis thereof.

One embodiment includes ten said concavities and/or convex wall portions regularly spaced around a longitudinal axis of the shaft.

According to a further aspect of the present invention there is provided a shaft and counter tape assembly for use in a dose counter for an inhaler, the assembly comprising a rotatable shaft and a counter tape which is wound around the shaft and is adapted to unwind therefrom upon inhaler actuation, the shaft having an engagement surface which includes incrementally spaced formations located around a periphery thereof.

According to a further aspect of the present invention there is provided an inhaler for the inhalation of medication and the like, the inhaler including a dose counter as in the first aspect of the present invention.

A preferred construction consists of a manually operated metered dose inhaler including a dose counter chamber including a dose display tape driven by a ratchet wheel which is driven in turn by an actuator pawl actuated by movement of a canister, the tape unwinding from a stock bobbin during use of the inhaler, a rotation regulator being provided for the stock bobbin and comprising a wavelike engagement surface with concavities which engage against control elements in the form of protrusions on resilient forks of a split pin thereby permitting incremental unwinding of the stock bobbin yet resisting excessive rotation if the inhaler is dropped onto a hard surface.

According to another aspect of the present invention there is provided a dose counter for a metered dose inhaler having a body arranged to retain a medicament canister of predetermined configuration for movement of the canister relative thereto; the dose counter comprising: an incremental counting system for counting doses, the incremental counting system having a main body, an actuator arranged to be driven in response to canister motion and to drive an incremental output member in response to canister motion, the actuator and incremental output member being configured to have predetermined canister fire and count configurations in a canister fire sequence, the canister fire configuration being determined by a position of the actuator relative to a datum at which the canister fires medicament and the count configuration being determined by a position of the actuator relative to the datum at which the incremental count system makes an incremental count, wherein the actuator is

arranged to reach a position thereof in the count configuration at or after a position thereof in the canister fire configuration.

This arrangement has been found to be highly advantageous since it provides an extremely accurate dose counter which is suitable for use with manually operated metered dose inhalers. It has been found that dose counters with these features have a failure rate of less than 50 failed counts per million full canister activation depressions. It has been found in the course of making the present invention that highly reliable counting can be achieved with the dose counter counting at or soon after the point at which the canister fires. It has been is covered by the present inventors that momentum and motion involved in firing the canister, and in some embodiments a slight reduction in canister back pressure on the user at the time of canister firing, can very reliably result in additional further motion past the count point.

The actuator and incremental counting system may be arranged such that the actuator is displaced less than 1 mm, typically 0.25 to 0.75 mm, more preferably about 0.4 to 0.6 mm, relative to the body between its location in the count and fire configurations, about 0.48 mm being preferred. The canister, which can move substantially in line with the actuator, can reliably move this additional distance so as to achieve very reliable counting.

The incremental count system may comprise a ratchet mechanism and the incremental output member may comprise a ratchet wheel having a plurality of circumferentially spaced teeth arranged to engage the actuator.

The actuator may comprise an actuator pawl arranged to engage on teeth of the ratchet wheel. The actuator pawl may be arranged to be connected to or integral with an actuator pin arranged to engage and be depressed by a medicament canister bottom flange. The actuator pawl may be generally U-shaped having two parallel arms arranged to pull on a central pawl member arranged substantially perpendicular thereto. This provides a very reliable actuator pawl which can reliably pull on the teeth of the ratchet wheel.

The incremental count system may include a tape counter having tape with incremental dose indicia located thereon, the tape being positioned on a tape stock bobbin and being arranged to unwind therefrom.

The actuator and incremental output member may be arranged to provide a start configuration at which the actuator is spaced from the ratchet output member, a reset configuration at which the actuator is brought into engagement with the incremental output member during a canister fire sequence, and an end configuration at which the actuator disengages from the ratchet output during a canister fire sequence.

The actuator may be arranged to be located about 1.5 to 2.0 mm, from its location in the fire configuration, when in the start configuration, about 1.80 mm being preferred.

The actuator may be arranged to be located about 1.0 to 1.2 mm, from its location in the fire configuration, when in the reset configuration, about 1.11 mm being preferred.

The actuator may be arranged to be located about 1.1 to 1.3 mm, from its location in the fire configuration, when in the end configuration, about 1.18 mm being preferred.

These arrangements provide extremely reliable dose counting, especially with manually operated canister type metered dose inhalers.

The main body may include a formation for forcing the actuator to disengage from the incremental output member when the actuator is moved past the end configuration. The formation may comprise a bumped up portion of an otherwise generally straight surface against which the actuator engages and along which it is arranged to slide during a canister firing sequence.

The dose counter may include a counter pawl, the counter pawl having a tooth arranged to engage the incremental output member, the tooth and incremental output member being arranged to permit one way only incremental relative motion therebetween. When the incremental output member comprises a ratchet wheel, the tooth can therefore serve as an anti-back drive tooth for the ratchet wheel, thereby permitting only one way motion or rotation thereof.

The counter pawl may be substantially fixedly mounted on the main body of the incremental count system and the counter pawl may be arranged to be capable of repeatedly engaging equi-spaced teeth of the incremental output member in anti-back drive interlock configurations as the counter is operated. The counter pawl may be positioned so that the incremental output member is halfway, or substantially halfway moved from one anti-back drive interlock configuration to the next when the actuator and incremental output member are in the end configuration thereof. This is highly advantageous in that it minimises the risk of double counting or non-counting by the dose counter.

According to a further aspect of the invention there is provided an inhaler comprising a main body arranged to retain a medicament canister of predetermined configuration and a dose counter mounted in the main body.

The inhaler main body may include a canister receiving portion and a separate counter chamber, the dose counter being located within the main body thereof, the incremental output member and actuator thereof inside the counter chamber, the main body of the inhaler having wall surfaces separating the canister-receiving portion and the counter chamber, the wall surfaces being provided with a communication aperture, an actuation member extending through the communication aperture to transmit canister motion to the actuator.

According to a further aspect of the present invention there is a provided an inhaler for metered dose inhalation, the inhaler comprising a main body having a canister housing arranged to retain a medicament canister for motion therein, and a dose counter, the dose counter having an actuation member having at least a portion thereof located in the canister housing for operation by movement of a medicament canister, wherein the canister housing has an inner wall, and a first inner wall canister support formation located directly adjacent the actuation member.

This is highly advantageous in that the first inner wall canister support formation can prevent a canister from rocking too much relative to the main body of the inhaler. Since the canister may operate the actuation member of the dose counter, this substantially improves dose counting and avoids counter errors.

The canister housing may have a longitudinal axis which passes through a central outlet port thereof, the central outlet port being arranged to mate with an outer canister fire stem of a medicament canister, the inner wall canister support formation, the actuation member and the outlet port lying in a common plane coincident with the longitudinal axis. Accordingly, this construction may prevent the canister from rocking towards the position of the dose counter actuation member, thereby minimising errors in counting.

The canister housing may have a further inner canister wall support formation located on the inner wall opposite, or substantially opposite, the actuation member. Accordingly, the canister may be supported against rocking motion away from the actuator member so as to minimise count errors.

The canister housing may be generally straight and tubular and may have an arrangement in which each said inner wall support formation comprises a rail extending longitudinally along the inner wall.

Each said rail may be stepped, in that it may have a first portion located towards a medicine outlet end or stem block of the canister housing which extends inwardly a first distance from a main surface of the inner wall and a second portion located toward an opposite end of the canister chamber which extends inwardly a second, smaller distance from the main surface of the inner wall. This may therefore enable easy insertion of a canister into the canister housing such that a canister can be lined up gradually in step wise function as it is inserted into the canister housing.

The inhaler may include additional canister support rails which are spaced around an inner periphery of the inner wall of the canister housing and which extend longitudinally therealong.

At least one of the additional rails may extend a constant distance inwardly from the main surface of the inner wall.

At least one of the additional rails may be formed with a similar configuration to the first inner wall canister support formation.

The dose counter may, apart from said at least a portion of the actuation member, be located in a counter chamber separate from the canister housing, the actuation member comprising a pin extending through an aperture in a wall which separates the counter chamber and the canister housing.

According to a further aspect of the present invention there is provided an inhaler for inhaling medicaments having: a body for retaining a medicament store; the body including a dose counter, the dose counter having a moveable actuator and a return spring for the actuator, the return spring having a generally cylindrical and annular end; the body having a support formation therein for supporting said end of the return spring, the support formation comprising a shelf onto which said end is engageable and a recess below the shelf.

This shelf and recess arrangement is highly advantageous since it allows a tool (such as manual or mechanical tweezers) to be used to place the return spring of the actuator onto the shelf with the tool then being withdrawn at least partially via the recess.

The shelf may be U-shaped.

The support formation may include a U-shaped upstanding wall extending around the U-shaped shelf, the shelf and upstanding wall thereby forming a step and riser of a stepped arrangement.

The recess below the shelf my also be U-shaped.

At least one chamfered surface may be provided at an entrance to the shelf. This may assist in inserting the actuator and return spring into position.

A further aspect of the invention provides a method of assembly of an inhaler which includes the step of locating said end of said spring on the shelf with an assembly tool and then withdrawing the assembly tool at least partly via the recess. This assembly method is highly advantageous compared to prior art methods in which spring insertion has been difficult and in which withdrawal of the tool has sometimes accidentally withdrawn the spring again.

The cylindrical and annular end of the spring may be movable in a direction transverse to its cylindrical extent into the shelf while being located thereon.

According to a further aspect of the present invention there is provided an inhaler for inhaling medicament, the inhaler having a body for retaining a medicament store; and a dose counter, the dose counter having a moveable actuator and a chassis mounted on the body; the chassis being heat staked in position on the body. This is be highly advantageous in that the chassis can be very accurately positioned and held firmly in place, thereby further improving counting accuracy compared to prior art arrangements in which some movement of the chassis relative to the body may be tolerated in snap-fit connections.

The chassis may have at least one of a pin or aperture heat staked to a respective aperture or pin of the body.

The chassis may have a ratchet counter output member mounted thereon.

The ratchet counter output member may comprise a ratchet wheel arranged to reel in incrementally a dose meter tape having a dosage indicia located thereon.

According to a further aspect of the present invention there is provided a method of assembling an inhaler including the step of heat staking the chassis onto the body. The step of heat staking is highly advantageous in fixedly positioning the chassis onto the body in order to achieve highly accurate dose counting in the assembled inhaler.

The method of assembly may include mounting a spring-returned ratchet actuator in the body before heat staking the chassis in place. The method of assembly may include pre-assembling the chassis with a dose meter tape prior to the step of heat staking the chassis in place. The method of assembly may include attaching a dose meter cover onto the body after the heat staking step. The cover may be welded onto the body or may in some embodiments be glued or otherwise attached in place.

According to a further aspect of the present invention there is provided an inhaler for inhaling medicament and having a body, the body have a main part thereof for retaining a medicament store; and a dose counter, the dose counter being located in a dose counter chamber of the body which is separated from the main part of the body, the dose counter chamber of the body having a dosage display and being perforated so as to permit the evaporation of water or aqueous matter in the dose counter chamber into the atmosphere.

This is high advantageous since it enables the inhaler to be thoroughly washed and the dose counting chamber can thereafter dry out fully.

The display may comprise a mechanical counter display inside the dose counter chamber and a window for viewing the mechanical counter display. The mechanical counter display may comprise a tape. The perforated dose counter chamber may therefore enable reliable washing of the inhaler, if desired by the user, and may therefore dry out without the display window misting up.

The dose counter chamber may be perforated by a drain hole formed through an outer hole of the body. The drain hole may be located at a bottom portion of the body of the inhaler, thereby enabling full draining of the inhaler to be encouraged after washing when the inhaler is brought into an upright position.

According to a further aspect of the present invention there is provided a dose counter for an inhaler, the dose counter having a display tape arranged to be incrementally driven from a tape stock bobbin onto an incremental tape take-up drive shaft, the bobbin having an internal bore supported by and for rotation about a support shaft, at least one of the bore and support shaft having a protrusion which is resiliently biased into frictional engagement with the other of the bore and support shaft with longitudinally extending mutual frictional interaction. This arrangement may provide good friction for the bobbin, thereby improving tape counter

display accuracy and preventing the bobbin from unwinding undesirably for example if the inhaler is accidentally dropped.

The support shaft may be forked and resilient for resiliently biasing the support shaft and bore into frictional engagement.

The support shaft may have two forks, or more in some cases, each having a radially extending protrusion having a friction edge extending therealong parallel to a longitudinal axis of the support shaft for frictionally engaging the bore of the support shaft with longitudinally extending frictional interaction therebetween.

The bore may be a smooth circularly cylindrical or substantially cylindrical bore.

Each of the above inhalers in accordance with aspects of the present invention may have a medicament canister mounted thereto.

The canister may comprise a pressurised metered dose canister having a reciprocally movable stem extending therefrom and movable into a main canister portion thereof for releasing a metered dose of medicament under pressure, for example by operating a metered dose valve inside the canister body. The canister may be operable by pressing by hand on the main canister body.

In cases in which one or more support rails or inner wall support formations are provided, the canister may at all times when within the canister chamber have a clearance of about 0.25 to 0.35 mm from the first inner wall support formation. The clearance may be almost exactly 0.3 mm. This clearance which may apply to the canister body itself or to the canister once a label has been applied, is enough to allow smooth motion of the canister in the inhaler while at the same time preventing substantial rocking of the canister which could result in inaccurate counting by a dose counter of the inhaler, especially when lower face of the canister is arranged to engage an actuator member of the dose counter for counting purposes.

According to a further aspect of the invention, a method of assembling a dose counter for an inhaler comprises the steps of providing a tape with dosing indicia thereon; providing tape positioning indicia on the tape; and stowing the tape while monitoring for the tape positioning indicia with a sensor. The method advantageously permits efficient and accurate stowing of the tape, e.g. by winding.

The dosing indicia may be provided as numbers, the tape positioning indicia may be provided as one or more lines across the tape. The stowing step comprises winding the tape onto a bobbin or shaft, and, optionally, stopping winding when the positioning indicia are in a predetermined position. The tape may be provided with pixelated indicia at a position spaced along the tape from the positioning indicia. The tape may also be provided with a priming dot.

According to a further aspect of the invention, a tape system for a dose counter for an inhaler has a main elongate tape structure, and dosing indicia and tape positioning indicia located on the tape structure. The tape positioning indicia may comprise at least one line extending across the tape structure. The tape system may comprise pixelated indicia located on the tape structure and spaced from the positioning indicia. The tape system may comprise a priming dot located on the tape structure. The positioning indicia may be located between the timing dot and the pixelated indicia. The main elongate tape structure may have at least one end thereof wound on a bobbin or shaft.

A further aspect of the invention provides a method of designing an incremental dose counter for an inhaler comprising the steps of calculating nominal canister fire and dose counter positions for a dose counter actuator of the inhaler; calculating a failure/success rate for dose counters built to tolerance levels for counting each fire of inhalers in which the dose counter actuators may be applied; and selecting a tolerance level to result in said failure/success rate to be at or below/above a predetermined value. This is highly advantageous in that it allows an efficient and accurate prediction of the reliability of a series of inhaler counters made in accordance with the design.

The method of designing may include selecting the failure/success rate as a failure rate of no more than one in 50 million. The method of designing may include setting an average count position for dose counters built to the tolerances to be at or after an average fire position thereof during canister firing motion. The method of designing may include setting the average count position to be about 0.4 to 0.6 mm after the average fire position, such as about 0.48 mm after. The method of designing may include setting tolerances for the standard deviation of the fire position in dose counters built to the tolerances to be about 0.12 to 0.16 mm, such as about 0.141 mm. The method of designing may include setting tolerances for the standard deviation of the count positions in dose counters built to the tolerances to be about 0.07 to 0.09 mm, such as about 0.08 mm. A further aspect of the invention provides a computer implemented method of designing an incremental dose counter for an inhaler which includes the aforementioned method of designing.

A further aspect of the invention provides a method of manufacturing in a production run a series of incremental dose counters for inhalers which comprises manufacturing the series of dose counters in accordance with the aforementioned method of designing.

A further aspect of the invention provides a method of manufacturing a series of incremental dose counters for inhalers, which comprises manufacturing the dose counters with nominal canister fire and dose count positions of a dose counter actuator relative to a dose counter chassis (or inhaler main body), and which includes building the dose counters with the average dose count position in the series being, in canister fire process, at or after the average canister fire position in the series.

According to a further aspect of the invention, the method provides fitting each dose counter in the series of incremental dose counters to a corresponding main body of an inhaler.

These aspects advantageously provide for the production run of a series of inhalers and dose counters which count reliably in operation.

According to a further aspect of the invention, an incremental dose counter for a metered dose inhaler has a body arranged to retain a canister for movement of the canister relative thereto, the incremental dose counter having a main body, an actuator arranged to be driven and to drive an incremental output member in a count direction in response to canister motion, the actuator being configured to restrict motion of the output member in a direction opposite to the count direction. This advantageously enables an inhaler dose counter to keep a reliable count of remaining doses even if dropped or otherwise jolted.

The output member may comprise a ratchet wheel. The actuator may comprise a pawl and in which the ratchet wheel and pawl are arranged to permit only one-way ratcheting motion of the wheel relative to the pawl. The dose counter may include an anti-back drive member fixed to the main body. In a rest position of the dose counter, the ratchet wheel is capable of adopting a configuration in which a back surface of one tooth thereof engages the anti-back drive member and the pawl is spaced from an adjacent back

surface of another tooth of the ratchet wheel without positive drive/blocking engagement between the pawl and wheel.

BRIEF DESCRIPTION OF THE DRAWINGS

The present invention may be carried out in various ways and preferred embodiment of a dose counter, inhaler and methods of assembly, design and manufacture will now be described with reference to the accompanying drawings in which:

FIG. **1** is an isometric view of a main body of an embodiment of an inhaler related to the invention together with a mouthpiece cap therefor;

FIG. **2** is a top plan view of the components as shown in FIG. **1**;

FIG. **3**A is a section on the plane **3**A-**3**A in FIG. **2**;

FIG. **3**B is a view corresponding to FIG. **3**A but with a dose counter fitted to the main body of the inhaler;

FIG. **4**A is an exploded view of the inhaler main body, mouthpiece cap, dose counter and a dose counter window;

FIG. **4**B is a view in the direction **4**B in FIG. **4**C of a spring retainer of the dose counter;

FIG. **4**C is a top view of the spring retainer of FIG. **4**B;

FIG. **5** is a bottom view of the assembled inhaler main body, mouthpiece cap, dose counter and dose counter window;

FIGS. **6**A, **6**B, **6**C, **6**D, **6**E, **6**F, **6**G and **6**H are various views of dose counter components of the inhaler;

FIGS. **7**A and **7**B are sectional views showing canister clearance inside the main body of the inhaler;

FIG. **7**C is a further sectional view similar to that of FIG. **7**B but with the canister removed;

FIG. **7**D is a top plan view of the inhaler main body;

FIGS. **8**A, **8**B, **8**C and **8**D show the inhaler main body and dose counter components during assembly thereof;

FIG. **9** shows a sectional side view of a datum line for an actuator pawl of the dose counter;

FIGS. **10**A, **10**B, **10**C, **10**D, **10**E and **10**F show various side views of positions and configurations of the actuator pawl, a ratchet wheel, and a count pawl;

FIG. **11** shows distributions for tolerances of start, reset, fire, count and end positions for the actuator of the dose counter;

FIG. **12** is an enlarged version of part of FIG. **4**A;

FIG. **13** shows an end portion of a tape of the dose counter;

FIG. **14** shows a computer system for designing the dose counter;

FIG. **15** is an isometric view of a stock bobbin modified in accordance with the present invention for use in the dose counter of the inhaler of FIGS. **1** to **14**;

FIG. **16** shows an end view of the stock bobbin of FIG. **15**;

FIG. **17** is a section through a longitudinal axis of the stock bobbin of FIGS. **15** and **16**;

FIGS. **18**A, **18**B and **18**C are views of the stock bobbin of FIGS. **15** to **17** mounted in the dose counter chassis of FIGS. **1** to **14**, with the control elements of the forks of the second shaft (or split pin) having a profile slightly different to that in FIG. **6**F, with the forks in a compressed configuration;

FIGS. **19**A, **19**B and **19**C are views equivalent to FIGS. **18**A to **18**C but with the forks in a more expanded configuration due to a different rotational position of the stock bobbin;

FIG. **20** is an isometric view of the chassis assembled and including the stock bobbin of FIGS. **15** to **17** but excluding the tape for reasons of clarity;

FIG. **21** is a view of a preferred embodiment of a dry powder inhaler in accordance with the present invention;

FIG. **22** is an exploded view of the inhaler of FIG. **21**;

FIG. **23** is a view of a dose counter of the inhaler of FIG. **21**;

FIG. **24** is an exploded view of the dose counter shown in FIG. **23**;

FIG. **25** is an exploded view of parts of the inhaler of FIG. **21**; and

FIG. **26** is a view of a yoke of the inhaler of FIG. **21**.

DETAILED DESCRIPTION OF THE INVENTION

FIG. **1** shows a main body **10** of a manually operated metered dose inhaler **12** in accordance with an embodiment related to the present invention and having a mouthpiece cap **14** securable over a mouthpiece **16** of the main body.

The main body has a canister chamber **18** into which a canister **20** (FIG. **7**A) is slideable. The canister **20** has a generally cylindrical main side wall **24**, joined by a tapered section **26** to a head portion **28** having a substantially flat lower face **30** which has an outer annular drive surface **32** arranged to engage upon and drive an actuation pin **34** of a dose counter **36** as will be described. Extending centrally and axially from the lower face **30** is a valve stem **38** which is arranged to sealingly engage in a valve stem block **40** of the main body **10** of the inhaler **12**. The valve stem block **40** has a passageway **42** leading to a nozzle **44** for directing the contents of the canister **20**, namely active drug and propellant, towards an air outlet **46** of the inhaler main body **12**. It will be appreciated that due to gaps **48** between the canister **20** and an inner wall **50** of the main body **10** of the inhaler **12** an open top **52** of the main body **10** forms an air inlet into the inhaler **12** communicating via air passageway **54** with the air outlet **46**, such that canister contents exiting nozzle **44** mix with air being sucked by the user through the air passageway **54** in order to pass together through the air outlet and into the mouth of the user (not shown).

The dose counter **36** will now be described. The dose counter **36** includes an actuation pin **34** biased upwardly from underneath by a return spring **56** once installed in the main body **10**. As best shown in FIGS. **4**A, **6**H and **8**A, the pin **34** has side surfaces **58**, **60** arranged to slide between corresponding guide surfaces **62**, **64** located in a dose counter chamber **66** of the main body **10**, as well as an end stop surface **68** arranged to engage a corresponding end stop **70** formed in the dose counter chamber **66** to limit upward movement of the pin **34**. The pin **34** has a top part **72** which is circularly cylindrical and extends through an aperture **74** formed through a separator wall **76** which separates the canister chamber **18** from the dose counter chamber **66**. The top part **72** of the pin **34** has a flat top surface **78** which is arranged to engage the outer annular drive surface **32** of the canister **20**.

The actuation pin **34** is integrally formed with a drive or actuator pawl **80**. The actuator pawl **80** has a generally inverted U-shape configuration, having two mutually spaced and parallel arms **82**, **84** extending from a base portion of the actuation pin **34**, each holding at respective distal ends **88** thereof opposite ends of a pawl tooth member **90** which extends in a direction substantially perpendicular to the arms **82**, **84**, so as to provide what may be considered a "saddle" drive for pulling on each of the 11 drive teeth **92** of a ratchet wheel **94** of an incremental drive system **96** or ratchet mechanism **96** of the dose counter **36**. As shown for example in FIG. **10**B, the pawl tooth member **90** has a sharp lower

longitudinal side edge **98** arranged to engage the drive teeth **92**, the edge-to-surface contact provided by this engagement providing very accurate positioning of the actuator pawl **80** and resultant rotational positioning of the ratchet wheel **94**.

The dose counter **36** also has a chassis preassembly **100** which, as shown in FIGS. **4**A and **6**A, includes a chassis **102** having a first shaft **104** receiving the ratchet wheel **94** which is secured to a tape reel shaft **106**, and a second shaft (or split pin) **108** which is parallel to and spaced from the first shaft **104** and which slidably and rotationally receives a tape stock bobbin **110**.

As shown in FIG. **6**B, when the inhaler has not been used at all, the majority of a tape **112** is wound on the tape stock bobbin **110** and the tape **112** has a series of regularly spaced numbers **114** displayed therealong to indicate a number of remaining doses in the canister **20**. As the inhaler is repeatedly used, the ratchet wheel **94** is rotated by the actuator pawl **80** due to operation of the actuation pin **34** by the canister **20** and the tape **112** is incrementally and gradually wound on to the tape reel shaft **106** from the second shaft **108**. The tape **112** passes around a tape guide **116** of the chassis **102** enabling the numbers **114** to be displayed via a window **118** in a dose counter chamber cover **120** having a dose marker **132** formed or otherwise located thereon.

As shown in FIGS. **6**A and **6**D, the second shaft **108** is forked with two forks **124**, **126**. The forks **124**, **126** are biased away from one another. The forks have located thereon at diametrically opposed positions on the second shaft **108** friction or control elements **128**, **130**, one on each fork. Each control element extends longitudinally along its respective fork **124**, **126** and has a longitudinally extending friction surface **132**, **134** which extends substantially parallel to a longitudinal axis of the second shaft and is adapted to engage inside a substantially cylindrical bore **136** inside the tape stock bobbin **110**. This control arrangement provided between the bore **136** and the control elements **128**, **130** provides good rotational control for the tape stock bobbin **110** such that it does not unwind undesirably such as when the inhaler is dropped. The tape force required to unwind the tape stock bobbin **110** and overcome this friction force is approximately 0.1 N.

As can be seen in FIG. **6**D, as well as FIGS. **6**G and **10**A to **10**F, the chassis **102** is provided with an anti-back drive tooth **138** or count pawl **138** which is resiliently and substantially fixedly mounted thereto. As will be described below and as can be seen in FIGS. **10**A to **10**F, when the actuation pin **34** is depressed fully so as to fire the metered valve (not shown) inside the canister **20**, the actuator pawl **80** pulls down on one of the teeth **92** of the ratchet wheel **94** and rotates the wheel **94** anticlockwise as shown in FIG. **6**D so as to jump one tooth **92** past the count pawl **138**, thereby winding the tape **112** a distance incrementally relative to the dose marker **122** on the dose counter chamber **120** so as to indicate that one dose has been used.

With reference to FIG. **10**B, the teeth of the ratchet wheel **94** have tips **143** which are radiused with a 0.1 mm radius between the flat surfaces **140**, **142**. The ratchet wheel **94** has a central axis **145** which is 0.11 mm above datum plane **220** (FIG. **9**). A top/nose surface **147** of the anti-back drive tooth **138** is located 0.36 mm above the datum plane **220**. The distance vertically (i.e. transverse to datum plane **220**—FIG. **9**) between the top nose surface **147** of the anti-back drive tooth is 0.25 mm from the central axis **145** of the wheel **94**. Bump surface **144** has a lateral extent of 0.20 mm, with a vertical length of a flat **145'** thereof being 1 mm, the width of the bump surface being 1.22 mm (in the direction of the axis **145**), the top **149** of the bump surface **144** being 3.02 mm vertically below the axis **145**, and the flat **145'** being spaced a distance sideways (i.e. parallel to the datum plane **220**) 2.48 mm from the axis **145**. The top surface **78** of the pin **34** (FIG. **6**H) is 11.20 mm above the datum plane **220** (FIG. **9**) when the actuator pawl **80** and pin **34** are in the start configuration. The length of the valve stem **22** is 11.39 mm and the drive surface **32** of the canister **20** is 11.39 mm above the datum plane **220** when the canister is at rest waiting to be actuated, such that there is a clearance of 0.19 mm between the canister **20** and the pin **34** in this configuration.

FIGS. **10**A and **10**B show the actuator pawl **80** and ratchet wheel **94** and count pawl **138** in a start position in which the flat top **78** of the pin **34** has not yet been engaged by the outer annular drive surface **32** of the canister **20** or at least has not been pushed down during a canister depression.

In this "start" position, the count pawl **138** engages on a non-return back surface **140** of one of the teeth **92** of the ratchet wheel **94**. The lower side edge **98** of the actuator pawl is a distance "D" (FIG. **9**) 1.33 mm above datum plane **220** which passes through bottom surface or shoulder **41** of valve stem block **40**, the datum plane **220** being perpendicular to a main axis "X" of the main body **10** of the inhaler **12** which is coaxial with the centre of the valve stem block bore **43** and parallel to a direction of sliding of the canister **20** in the main body **10** of the inhaler **12** when the canister is fired.

As shown in FIG. **10**B, an advantageous feature of the construction is that the pawl tooth/actuator **90** acts as a supplementary anti-back drive member when the inhaler **12** is not being used for inhalation. In particular, if the inhaler **12** is accidentally dropped, resulting in a jolt to the dose counter **36** then, if the wheel **94** would try to rotate clockwise (backwards) as shown in FIG. **10**B, the back surface **140** of a tooth will engage and be blocked by the tooth member **90** of the pawl **80**. Therefore, even if the anti-back drive tooth **138** is temporarily bent or overcome by such a jolt, undesirable backwards rotation of the wheel **94** is prevented and, upon the next canister firing sequence, the pawl **90** will force the wheel **94** to catch up to its correct position so that the dose counter **36** continues to provide correct dosage indication.

FIG. **10**C shows a configuration in which the actuator pawl **80** has been depressed with the pin **34** by the canister **20** to a position in which the side edge **98** of the pawl tooth member **90** is just engaged with one of the teeth **92** and will therefore upon any further depression of the pin **34** begin to rotate the wheel **94**. This is referred to as a "Reset" position or configuration. In this configuration, the lower side edge **98** of the actuator **80** is 0.64 mm above the datum plane **220**.

FIG. **10**D shows a configuration in which the actuator pawl **80** has been moved to a position lower than that shown in FIG. **10**C and in which the metered dose valve (not shown) inside the canister has at this very position fired in order to eject active drug and propellant through the nozzle **44**. It will be noted that in this configuration the count pawl **138** is very slightly spaced from the back surface **140** of the same tooth **92** that it was engaging in the configuration of FIG. **10**D. The configuration shown in FIG. **10**D is known as a "Fire" configuration. In this configuration the lower side edge **98** of the actuator **80** is 0.47 mm below the datum plane **220**.

FIG. **10**E shows a further step in the sequence, called a "Count" position in which the actuator pawl **80** has rotated the ratchet wheel **94** by the distance circumferentially angularly between two of the teeth **92**, such that the count pawl **138** has just finished riding along a forward surface **142** of one of the teeth **92** and has resiliently jumped over the tooth

into engagement with the back surface **140** of the next tooth. Accordingly, in this "Count" configuration, a sufficiently long stroke movement of the pin **34** has occurred that the tape **112** of the dose counter **36** will just have counted down one dose. In this configuration, the lower side edge **98** of the actuator is 0.95 mm below the datum plane **220**. Accordingly, in this position, the actuator **80** generally, including edge **98**, is 0.48 mm lower than in the fire configuration. It has been found that, although the count configuration happens further on than the fire configuration, counting is highly reliable, with less than 50 failed counts per million. This is at least partially due to momentum effects and to the canister releasing some back pressure on the user in some embodiments as its internal metering valve fires.

In the configuration of FIG. **10**F, the pawl **80** has been further depressed with the pin **34** by the canister **20** to a position in which it is just disengaging from one of the teeth **92** and the actuator pawl **80** is assisted in this disengagement by engagement of one of the arms **84** with a bump surface **144** on the chassis **102** (see FIG. **6**G) and it will be seen at this point of disengagement, which is called an "End" configuration, the count pawl **138** is positioned exactly halfway or substantially halfway between two of the drive teeth **92**. This advantageously means therefore that there is a minimum chance of any double counting or non-counting, which would be undesirable. In the end configuration, the side edge **98** of the actuator is 1.65 mm below the datum plane **220**. It will be appreciated that any further depression of the actuator pawl **80** and pin **34** past the "End" configuration shown in FIG. **10**F will have no effect on the position of the tape **112** displayed by the dose counter **36** since the actuator pawl **80** is disengaged from the ratchet wheel **94** when it is below the position shown in FIG. **10**F.

As shown in FIGS. **7**C and **7**D, the inner wall **50** of the main body **10** is provided with a two-step support rail **144** which extends longitudinally along inside the main body and is located directly adjacent the aperture **74**. As shown in FIG. **7**B a diametrically opposed two-step support rail **146** is also provided and this diametrically opposed in the sense that a vertical plane (not shown) can pass substantially directly through the first rail **144**, the aperture **74**, a central aperture **148** of the valve stem block **40** (in which canister stem **25** is located) and the second two-step support rail **146**. As shown in FIG. **7**A and schematically in FIG. **7**B, the rails **144**, **146** provide a maximum clearance between the canister **20** and the rails **144**, **146** in a radial direction of almost exactly 0.3 mm, about 0.25 to 0.35 mm being a typical range. This clearance in this plane means that the canister **20** can only rock backwards and forwards in this plane towards away from the actuation pin **34**. A relatively small distance and this therefore prevents the canister wobbling and changing the height of the actuation pin **34** a as to undesirably alter the accuracy of the dose counter **36**. This is therefore highly advantageous.

The inner wall **50** of the main body **10** is provided with two further two-step rails **150** as well as two pairs **152**, **154** of rails extending different constant radial amounts inwardly from the inner wall **50**, so as to generally achieve a maximum clearance of almost exactly 0.3 mm around the canister **20** for all of the rails **144**, **146**, **150**, **152**, **154** spaced around the periphery of the inner wall **50**, in order to prevent undue rocking while still allowing canister motion freely inside the inhaler **12**. It will be clear from FIG. **7**C for example that the two-step rails have a first portion near an outlet end **156** of the canister chamber **18**, the first portion having a substantially constant radial or inwardly-extending width, a first step **160** leading to a second portion **162** of the rail, the second portion **102** having a lesser radial or inwardly extending extent than the first portion **156**, and finally a second step **164** at which the rail merges into the main inner wall **50** main surface.

A method of assembling the inhaler **12** will now be described.

With reference to FIG. **8**A, the main body **10** of the inhaler **12** is formed by two or more plastics mouldings which have been joined together to the configuration shown.

As shown in FIG. **8**B, the actuator pawl **80** and pin **34** are translated forward into position into a pin receiving area **166** in the dose counter chamber **66** and the pin **34** and actuator **80** may then be raised until the pin **34** emerges through the aperture **74**.

Next, the return spring **56** may be inserted below the pin **34** and a generally cylindrical annular lower end **168** of the spring **56** may be moved by a tweezer or tweezer-like assembly tool (not shown) into engagement with a shelf **170** of a spring retainer **172** in the dose counter chamber **66**. The spring retainer **172** is U-shaped and the shelf **170** is U-shaped and has a recess **174** formed below it. As shown in FIGS. **4**B, **4**C and **12** shelf **170** includes three chamfer surfaces **176**, **178**, **180** arranged to assist in moving the lower end of the spring **168** into position onto the shelf using the assembly tool (not shown). Once the lower end of the spring **168** is in place, the assembly tool (not shown) can easily be removed at least partly via the recess **174** below the lower end **168** of the spring **56**.

The tape **112** is attached at one end (not shown) to the tape stock bobbin **110** and is wound onto the bobbin by a motor **200** (FIG. **13**) having a hexagonal output shaft **202** which engages in a hexagonal socket **204** (FIG. **6**B) of the bobbin. During winding, the tape is monitored by a sensor **206**, which may be in the form of a camera or laser scanner, which feeds data to a computer controller **205** for the motor **200**. The controller **205** recognises three positioning markers **210** in the form of lines across the tape **112** and stops the motor **202** when the tape **112** is nearly fully wound onto the bobbin **110**, such that the distal end **212** of the tape **112** can be secured, e.g. by adhesive, to the tape reel shaft **106**. The controller **205** also recognises a pixelated tape size marker **214** observed by the sensor **206** and logs in a stocking system data store **217** details of the tape **112** such as the number of numbers **114** on the tape, such as one hundred and twenty or two hundred numbers **114**. Next, the tape reel shaft is wound until an appropriate position of the lines **210** at which a priming dot **216** will, once the bobbin **110** and reel shaft **106** are slid onto the second shaft **108** and second shaft **104**, be in a position to be located in the window **118** when the inhaler **12** is fully assembled. In the embodiments, the bobbin **110** and reel shaft **106** may be slid onto the shafts **108**, **104** before the tape **112** is secured to the reel shaft **106** and the reel shaft may then be wound to position the priming dot **216**.

Next, the assembled dose counter components of the chassis preassembly **100** shown in FIG. **6**B may as shown in FIG. **8**C be inserted into the dose counter chamber **66**, with pins **182**, **184**, **186** formed on the main body **10** in the dose counter chamber **66** passing through apertures or slots **188**, **190**, **192** formed on the chassis **102**, such that the pins **182**, **184**, **186** extend through (or at least into) the apertures or slots **188**, **190**, **192**. With the chassis **102** being relatively firmly pushed towards the main body **10**, the pins **182**, **184**, **186** are then heat staked and the chassis **102** is therefore after this held very firmly in position in the main body and is unable to move, thereby assisting in providing great accuracy for the dose counter **36**. Next, as shown in FIG. **8**D, the

dose counter chamber **120** may be fitted over the dose counter chamber **66** and may be secured in place such as by welding, with the priming dot **216** being displayed through the window.

The user can, when readying the inhaler **12** for first use, prime the inhaler by depressing the canister **20** three times which will bring the first number **114** on the tape into display through the window **118** in place of the priming dot **216**, the number **114** shown in FIG. **8**D being "200", thereby indicating that 200 doses are remaining to be dispensed from the canister **20** and inhaler **12**.

As shown in FIG. **8**D, and in FIG. **5**, an open drain hole **194** is provided at the bottom of the dose counter chamber **66** by a substantially semi-circular cut-out or recess formation **196** in a lower surface **198** of the main body **10** of the inhaler. Accordingly, if the user (not shown) should decide to wash the main body **10** of the inhaler, for example after encountering an unhygienic situation or simply as a matter of choice, the drain hole **194** allows initial draining of water from inside the dose counter chamber **66** and also thereafter evaporation of water or any aqueous matter in the dose counter chamber **66** so that the window **118** does not mist up undesirably.

FIG. **14** shows a computer system **230** for designing the dose counter **36** and in particular for calculating distributions representative of average positions and standard deviations in a production series of inhalers of the start, reset, fire, count and end positions of the actuator lower side edge **98** relative to the datum plane **220** (FIG. **9**) and therefore of the actuator pawl **80** generally relative to the ratchet wheel **94**, chassis **102** and, when the inhaler **12** is fully assembled, the main body **10** of the inhaler **12**. The computer system **230** includes a data store **232**, a CPU **234**, an input device **236** (such as a keyboard or communication port) and an output device **238** (such as a communications port, display screen and/or printer). A user may enter data via the input device **236** which may be used by the CPU **234** in a mathematical calculation to predict count failure rates when the various dose counters are to be built in a series with dose counter positions set with given averages and standard deviations and taking into account any momentum/inertia effects and metering valve user-back-pressure reduction effect which will occur upon canister firing of a given type of canister. The computer system **230** is thus mathematically used to design the distributions. For the inhaler **12** described herein with the dose counter **36** and canister **20**, the distributions are designed as shown in FIG. **11**. The x axis shows distance of the lower side surface **98** of the actuator **80** above the datum plane **220** and the y axis is representative of the distribution. Thus, curve **240** shows that the start configuration has an average 1.33 mm above the datum plane **200** (standard deviation is 0.1 mm), curve **242** shows that the reset configuration has an average of 0.64 mm above the datum plane **220** (standard deviation is 0.082 mm), curve **244** shows the fire configuration has an average 0.47 mm below the datum plane **220** (standard deviation is 0.141 mm), curve **246** shows the count configuration has an average 0.95 mm below the datum plane **220** (standard deviation is 0.080 mm), and curve **248** shows the end configuration has an average of 1.65 mm below the datum plane **220** (standard deviation is 0.144 mm).

FIGS. **15** to **20** show a version of the inhaler modified in accordance with the present invention. In these drawings, the same reference numerals have been used to those in the earlier drawings to denote the equivalent components. The inhaler **12** is the same as that in FIGS. **1** to **14** apart from the following modifications.

First, it can be seen that there is a modification in that the drive teeth **92** of the ratchet wheel **94** have a different profile to that in FIGS. **1** to **14**. There are also only nine ratchet teeth **94** in this embodiment instead of eleven.

Additionally, as shown in FIGS. **18**C and **19**C, the control elements **128**, **130** on the forks **124**, **126** of the second shaft **108** have a tapered profile which is different to the profile of the control elements **128**, **130** shown in FIG. **6**F. Either profile can be used in the embodiment of FIGS. **15** to **20** however.

Furthermore, as shown in FIG. **15**, the tape stock bobbin **110** has an inwardly facing generally cylindrical engagement surface **300** with a wavelike form extending partially therealong. The engagement surface **300** has a cross-section **301** perpendicular to the longitudinal length of the stock bobbin **110** which is constant therealong. This cross-section **301** can be seen in FIG. **16** and consists of a series of ten regularly spaced concavities **302** and ten convex wall portions **304**. The convex wall portions **304** are equi-spaced between the concavities **302**. Each concavity **302** has a radius of 0.2 mm. Each convex wall portion **304** also has a radius of 0.2 mm. Finally, the cross section **301** also includes flat wall portions **306** between all of the radiused wall portions of the concavities **302** and convex wall portions **304**. The geometry of the cross-section **301** is therefore defined by the radii of the concavities **302** and convex wall portions **304**, the flat wall portions **306** and the fact that there are ten concavities **302** and convex wall portions **304**.

The minor diameter of the engagement surface **300**, i.e. between the tips of opposite convex wall portions **304**, is 2.46 mm. The major diameter of the engagement surface **300**, i.e. between the outermost portions of the concavities **302**, is 2.70 mm. The undeformed tip to tip maximum diameter of the forks **124**, **126** of the split pin (the second shaft) **108**, i.e. in the region of the maximum radio extent of the control elements **128**, **130**, is 3.1 millimeters and it will therefore be appreciated that the forks **124**, **126** are resiliently compressed once the stock bobbin **110** has been assembled onto the split pin **108** in all rotational configurations of the stock bobbin **110** relative to the split pin **108**. The minimum gap between the forks **124**, **126** in the plane of the cross sections of FIGS. **18**C and **19**C is 1 mm when the split pin **108** is in the undeformed, pre-inserted state. When the split pin **108** is at maximum compression, as shown in FIGS. **18**A to **18**C when the control elements **128**, **130** are shown to be engaged on top of the convex wall portions **304**, the gap **308** between the tips **310**, **312** of the forks **124**, **126** is 0.36 mm. On the other hand, when the split pin **108** is at minimum compression (once inserted into the stock bobbin) as shown in FIGS. **19**A to **19**C, when the control elements **128**, **130** rest in the concavities **302**, the gap between the tips **310**, **312** of the forks **124**, **126** is 0.6 mm. The control elements **128**, **130** are outwardly radiused with a radius also of 0.2 mm such that they can just rest on the concavities **302** with full surface contact (at least at an axial location on the split pin where the tapered control elements are at their maximum radial extent), without rattling in, locking onto or failing to fit in the concavities **302**. The radii of the control elements **128**, **130** is therefore preferably substantially the same as the radii of the concavities **302**

It will be appreciated that whereas FIGS. **18**B and **19**B are end views along the coaxial axis of the stock bobbin **110** and split pin **108**, FIGS. **18**A and **19**A are cross-sections. FIG. **19**A is a section on the plane A-A' in FIG. **19**C and FIG. **18**A is a section at the same plane, but of course with the stock bobbin **110** rotated relative to the split pin **108**.

As the inhaler **12** is used and the ratchet wheel **94** rotates in order to count used doses, the stock bobbin rotates incrementally through rotational positions in which rotation is resisted, i.e. due to increasing compression of the split pin **108** at such rotational positions, and rotational positions in which rotation is promoted, i.e. due to decreasing compression of the split pin **108** at such rotational positions and this may involve a click forward of the stock bobbin **110** to the next position equivalent to that in FIGS. **19**A to **19**C in which the control elements **128**, **130** of the split pin art located in the concavities **302**. This functionality firstly allows the stock bobbin to unwind during use as required, but also prevents the tape **112** from loosening during transit if the inhaler **12** is dropped, such as onto a hard surface. This is highly advantageous, since the tape **11** is prevented from moving to a position in which it will give an incorrect reading regarding the number of doses in the canister.

During compression and expansion of the forks in the radial direction between the two configurations shown in FIGS. **18**C and **19**C, the forks **124**, **126** rotate about a point **316** on the split pin where the forks **124**, **126** come together. This rotational action means that there is a camming action between the forks **124**, **126** and the engagement surface **300** without significant friction but, nevertheless, the resilient forces provided by the regulator formed by the engagement surface **300** and forks **124**, **126** are able to regulate unwinding of the tape such that it does not easily occur during transit or if the inhaler **12** is dropped. It has been found during testing that a force of 0.3 to 0.4 N needs to be applied to the tape **112** to overcome the regulator at the stock bobbin **110**. 0.32 N is achieved with the control elements **128** having the profile shown in FIG. **19**C and 0.38 N is achieved with the profile of the control elements **128** altered to be as shown as described with reference to FIG. **6**F. These forces are substantially higher than the 0.1 N force mentioned above and undesirable movement of the tape is substantially avoided even if the inhaler is dropped onto a hard surface. The modified arrangement of FIGS. **15** to **20** does not provide this force "constantly" such that there is overall not an undesirably high friction of the tape **112** as it passes over the other components of the dose counter because, due to the incremental nature of the resilient forces at the regulator, the tape **112** can incrementally relax as it slides over the stationary chassis components.

Instead of having ten concavities **302** and convex wall portions **304**, other numbers may be used, such as 8 or 12. However, it is preferred to have an even number, especially since two control elements **128**, **130** are provided, so that all of the control elements **128**, **130** will expand and contract simultaneously. However, other arrangements are envisaged with 3 or more forks and the number of concavities/convex wall portions may be maintained as an integer divisible by the number of forks to maintain a system with simultaneous expansion/contraction. For example, the use of 9, 12 or 15 concavities/convex wall portions with 3 forks is envisaged.

Instead of having the engagement surface **300** on the inside of the stock bobbin **110**, it could be placed on the outside of the stock bobbin **110** so as to be engaged by flexible external legs/pawls or similar.

It will be noted that the regulator provided by the engagement surface **300** and forks **124**, **126** does not only allow rotation of the stock bobbin in one direction as is the case with the ratchet wheel **94**. Rotation in both directions is possible, i.e. forwards and backwards. This means that during assembly, the stock bobbin **110** can be wound backwards during or after fitting the bobbin **100**, shaft **106** and tape **112** onto the carriage **102**, if desired.

The stock bobbin **110** and the carriage **102** including the split pin **108** are both moulded of polypropylene material.

It will be seen from FIG. **16** that the cross-sectional shape **301** is not symmetrical within the hexagonal socket **204**. This has enabled the hexagonal socket **204** to be maintained at a useful size while still allowing the desired size and geometry of the cross section **301** to fit without interfering with the hexagonal shape of the hexagonal socket **204** and also permits moulding to work during manufacture.

As shown in FIG. **17**, the stock bobbin **110** has a series of four circumferential ribs **330** inside it and a spaced therealong. These hold the stock bobbin **110** on the correct side of the mould tool during moulding.

FIGS. **21** and **22** show a preferred embodiment in accordance with the invention of an inhaler **510** for dispensing a dry-powdered medicament in metered doses for patient inhalation. The inhaler **510** is as disclosed in FIGS. **1** to **16** or EP-A-1330280, the contents of which are hereby fully incorporated herein by reference, but with the stock bobbin **110** and second shaft **108** of the dose counter **516** modified so as to be as in FIGS. **15** to **20** hereof. Thus, the dry powder inhaler **510** generally includes a housing **518**, and an assembly **512** received in the housing (see FIG. **21**). The housing **518** includes a case **520** having an open end **522** and a mouthpiece **524** (FIG. **25**) for patient inhalation, a cap **526** secured to and closing the open end **522** of the case **520**, and a cover **528** pivotally mounted to the case **520** for covering the mouthpiece **524**. As shown in FIG. **22**, the inhaler **510** also includes an actuation spring **569**, first yoke **566** with opening **572**, bellows **540** with crown **574**, a reservoir **514**, second yoke **568** with hopper **542** and dose counter **516** mounted thereto, and case **520** has transparent window **5130** thereon for viewing dose counter tape indicia **5128**. The dose metering system also includes two cams **570** mounted on the mouthpiece cover **528** and movable with the cover **528** between open and closed positions. The cams **570** each include an opening **580** for allowing outwardly extending hinges **582** of the case **520** to pass therethrough and be received in first recesses **584** of the cover **528**. The cams **570** also include bosses **586** extending outwardly and received in second recesses **588** of the cover **528**, such that the cover **528** pivots about the hinges **582** and the cams **570** move with the cover **528** about the hinges **582**. As described in EP-A-1330280, cams **570** act upon cam followers **578** to move second yoke **568** up and down and thereby operate dose counter by engagement of pawl **5138** on the second yoke **568** with teeth **5136**. Remaining components of the inhaler are provided as, and operate as described, in EP-A-1330280.

The dose counting system **516** therefore includes a ribbon or tape **5128** (FIGS. **23** & **24**), having successive numbers or other suitable indicia printed thereon, in alignment with a transparent window **5130** provided in the housing **18** (see FIG. **22**). The dose counting system **516** includes the rotatable stock bobbin **110** (as described above), an indexing spool **5134** rotatable in a single direction, and the ribbon **5128** rolled and received on the bobbin **110** and having a first end **5127** secured to the spool **5134**, wherein the ribbon **5128** unrolls from the bobbin **110** so that the indicia are successively displayed as the spool **5134** is rotated or advanced. In FIGS. **23** and **24** the wavelike engagement surface **300** of the bobbin **110** is not shown for the purposes of clarity.

The spool **134** is arranged to rotate upon movement of the yokes **566**, **568** to effect delivery of a dose of medicament from reservoir **514**, such that the number on the ribbon **5128** is advanced to indicate that another dose has been dispensed by the inhaler **510**. The ribbon **5128** can be arranged such that the numbers, or other suitable indicia, increase or

decrease upon rotation of the spool **5134**. For example, the ribbon **5128** can be arranged such that the numbers, or other suitable indicia, decrease upon rotation of the spool **5134** to indicate the number of doses remaining in the inhaler **510**. Alternatively, the ribbon **5128** can be arranged such that the numbers, or other suitable indicia, increase upon rotation of the spool **5134** to indicate the number of doses dispensed by the inhaler **10**.

The indexing spool **5134** includes radially extending teeth **5136**, which are engaged by pawl **5138** extending from a cam follower **578** of the second yoke **568** upon movement of the yoke to rotate, or advance, the indexing spool **5134**. More particularly, the pawl **5138** is shaped and arranged such that it engages the teeth **5136** and advances the indexing spool **5134** only upon the mouthpiece cover **528** being closed and the yokes **566**, **568** moved back towards the cap **526** of the housing **518**.

The dose counting system **516** also includes a chassis **5140** that secures the dose counting system to the hopper **542** and includes shafts **108**, **5144** for receiving the bobbin **110** and the indexing spool **5134**. As described above with reference to FIGS. **1** to **20**, the bobbin shaft **108** is forked and includes radially nubs **5146** for creating a resilient resistance to rotation of the bobbin **110** on the shaft **108** by engaging with the wavelike engagement surface **300** inside the bobbin **110**. A clutch spring **5148** is received on the end of the indexing spool **5134** and locked to the chassis **5140** to allow rotation of the spool **5134** in only a single direction.

Various modifications may be made to the embodiment shown without departing from the scope of the invention as defined by the accompanying claims as interpreted under patent law.

What is claimed is:

1. An inhaler for metered dose inhalation, the inhaler comprising:

a main body having a canister housing,

a medicament canister, which is moveable relative to the canister housing and retained in a central outlet port of the canister housing arranged to mate with a canister fire stem of the medicament canister, and

a dose counter having an actuation member having at least a portion thereof located in the canister housing for operation by movement of the medicament canister,

wherein the canister housing has an inner wall, and a first inner wall canister support formation extending inwardly from a main surface of the inner wall,

wherein the canister housing has a longitudinal axis X which passes through the center of the central outlet port, and

wherein the first inner wall canister support formation, the actuation member, and the central outlet port lie in a common plane coincident with the longitudinal axis X such that the first inner wall canister support formation protects against unwanted actuation of the dose counter by reducing rocking of the medicament canister relative to the main body of the inhaler.

2. The inhaler as claimed in claim **1** wherein the medicament canister is movable relative to the dose counter.

3. The inhaler as claimed in claim **1** further comprising an aperture formed in the inner wall through which the portion of the actuation member extends.

4. The inhaler as claimed in claim **1**, wherein the first inner wall canister support formation comprises a support rail which extends longitudinally along an inside surface of the main body.

5. The inhaler as claimed in claim **4**, wherein the support rail includes a step formed thereon.

6. The inhaler as claimed in claim **4** further comprising a plurality of support rails each of which extends longitudinally along the inside surface of the main body.

7. The inhaler as claimed in claim **6**, wherein two of the plurality of support rails are positioned at opposite ends of the inside surface of the main body to face each other.

8. The inhaler as claimed in claim **4**, wherein the support rail includes two steps formed thereon, the steps being spaced apart longitudinally along an inside surface of the main body.

9. The inhaler as claimed in claim **4**, wherein the support rail merges with the inner wall at a location adjacent the aperture.

10. The inhaler as claimed in claim **9**, wherein a width dimension of the support rail is not constant, and the width dimension is greatest at the location where the support rail merges with the inner wall.

11. The inhaler as claimed in claim **1** further comprising a second inner wall canister support formation and wherein the second inner wall canister support formation, the first inner wall canister support formation, the actuation member and the central outlet port lie in a common plane coincident with longitudinal axis X.

12. An inhaler for metered dose inhalation, the inhaler comprising:

a main body having a canister housing,

a medicament canister, which is moveable relative to the canister housing and retained in a central outlet port of the canister housing arranged to mate with a canister fire stem of the medicament canister, and

a dose counter having an actuation member having at least a portion thereof located in the canister housing for operation by movement of the medicament canister,

wherein the canister housing has an inner wall, and a first inner wall canister support formation extending inwardly from a main surface of the inner wall,

wherein the canister housing has a longitudinal axis X which passes through the center of the central outlet port, and

wherein the first inner wall canister support formation, the actuation member, and the central outlet port lie in a common plane coincident with the longitudinal axis X such that the first inner wall canister support formation protects against dose count errors by reducing rocking of the medicament canister towards or away from the actuation member.

13. An inhaler for metered dose inhalation, the inhaler comprising:

a main body having a canister housing,

a medicament canister retained in the canister housing and movable relative thereto, and a dose counter, the dose counter having an actuation member having at least a portion thereof located in the canister housing for operation by movement of the medicament canister,

wherein the canister housing has an inner wall, and a first inner wall canister support formation extending inwardly from a main surface of the inner wall,

wherein the canister housing has an aperture formed in the inner wall through which the portion of the actuation member extends, and

wherein the first inner wall canister support formation extends from the main surface of the inner wall to the aperture.

14. The inhaler as claimed in claim **13** wherein the medicament canister is movable relative to the dose counter.

15. The inhaler as claimed in claim **13**, wherein the first inner wall canister support formation comprises a support rail which extends longitudinally along an inside surface of the main body.

16. The inhaler as claimed in claim **15**, wherein the support rail includes a step formed thereon.

17. The inhaler as claimed in claim **15** further comprising a plurality of support rails each of which extends longitudinally along the inside surface of the main body.

18. The inhaler as claimed in claim **17**, wherein two of the plurality of support rails are positioned at opposite ends of the inside surface of the main body to face each other.

19. The inhaler as claimed in claim **15**, wherein the support rail includes two steps formed thereon, the steps being spaced apart longitudinally along the inside surface of the main body.

20. The inhaler as claimed in claim **15**, wherein a width dimension of the support rail is not constant, and the width dimension is greatest at the location where the support rail is closest to the aperture.

21. The inhaler as claimed in claim **13**, wherein the first inner wall canister support formation, the aperture, and a central outlet port of the canister housing arranged to mate with a canister fire stem of the medicament canister, all lie in a common plane coincident with a longitudinal axis X which passes through the center of the central outlet port.

22. The inhaler as claimed in claim **21** further comprising a second inner wall canister support formation and wherein the second inner wall canister support formation, the first inner wall canister support formation, the aperture, and the central outlet port lie in a common plane coincident with longitudinal axis X.

* * * * *

Exhibit D

US010561808B2

(12) **United States Patent**
Walsh et al.

(10) **Patent No.: US 10,561,808 B2**
(45) **Date of Patent: Feb. 18, 2020**

(54) **DOSE COUNTER FOR INHALER HAVING AN ANTI-REVERSE ROTATION ACTUATOR**

(71) Applicants: **IVAX PHARMACEUTICALS IRELAND**, Waterford (IE); **NORTON (WATERFORD) LIMITED**, Waterford (IE); **TEVA PHARMACEUTICALS IRELAND**, Waterford (IE)

(72) Inventors: **Declan Walsh**, County Kilkenny (IE); **Derek Fenlon**, County Wexford (IE); **Simon Kaar**, County Cork (IE); **Jan Geert Hazenberg**, County Kilkenny (IE); **Daniel Buck**, County Waterford (IE); **Paul Clancy**, Waterford (IE); **Robert Charles Uschold**, Leominster, MA (US); **Jeffrey A. Karg**, Hopkinton, MA (US)

(73) Assignees: **IVAX PHARMACEUTICALS IRELAND**, Waterford (IE); **NORTON (WATERFORD) LIMITED**, Waterford (IE); **TEVA PHARMACEUTICALS IRELAND**, Waterford (IE)

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A61M 15/00 (2006.01)
G06M 1/24 (2006.01)
A61M 11/00 (2006.01)

(52) **U.S. Cl.**
CPC ..... ***A61M 15/0078*** (2014.02); ***A61M 11/00*** (2013.01); ***A61M 15/007*** (2014.02); (Continued)

(58) **Field of Classification Search**
CPC ..... A61M 15/0078; A61M 15/0025; A61M 15/0026; A61M 15/007; A61M 15/0071; (Continued)

(56) **References Cited**

U.S. PATENT DOCUMENTS

4,174,890 A 11/1979 Johnson
4,669,838 A 6/1987 Hibbard
(Continued)

FOREIGN PATENT DOCUMENTS

CA 2501726 9/2006
EP 1330280 7/2003
(Continued)

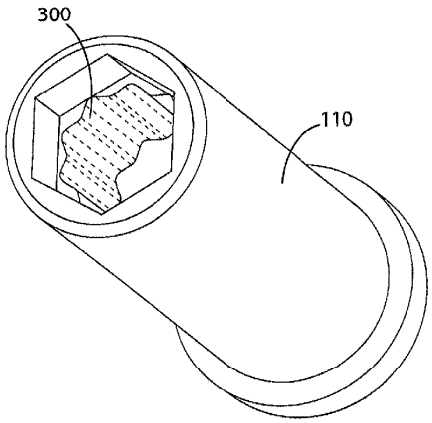
OTHER PUBLICATIONS

Final Office Action dated Oct. 20, 2016 for U.S. Appl. No. 14/699,567.
(Continued)

Primary Examiner — Daniel A Hess
(74) *Attorney, Agent, or Firm* — Morgan, Lewis & Bockius LLP

(57) **ABSTRACT**

A dose counter for an inhaler includes a counter display arranged to indicate dosage information, and a drive system arranged to move the counter display incrementally in a first direction from a first station to a second station in response to actuation input. A regulator is provided which is arranged (Continued)



to act upon the counter display at the first station to regulate motion of the counter display at the first station to incremental movements.

29 Claims, 17 Drawing Sheets

Related U.S. Application Data

No. 14/103,353, filed on Dec. 11, 2013, now Pat. No. 9,526,850, which is a division of application No. 13/110,532, filed on May 8, 2011, now Pat. No. 8,978,966.

(60) Provisional application No. 61/345,763, filed on May 18, 2010, provisional application No. 61/417,659, filed on Nov. 29, 2010.

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(58) **Field of Classification Search**
CPC A61M 11/00; A61M 15/0065; A61M 15/009; G06M 1/246
USPC 235/8
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

4,687,359	A	8/1987	Barrus	
5,482,030	A	1/1996	Klein	
5,861,911	A	1/1999	Oosaka	
6,446,627	B1	9/2002	Bowman	
6,718,972	B2	4/2004	OLeary	
8,418,690	B2	4/2013	Power	
8,474,448	B2	7/2013	Oi	
8,978,966	B2	3/2015	Walsh et al.	
9,174,013	B2	11/2015	Walsh et al.	
9,463,289	B2	10/2016	Walsh et al.	
2002/0047021	A1	4/2002	Blacker	
2002/0078949	A1	6/2002	OLeary	
2002/0078950	A1*	6/2002	O'Leary	A61M 15/0045 128/200.22
2002/0084891	A1	7/2002	Mankins et al.	
2003/0209239	A1	11/2003	Rand	
2004/0089298	A1	5/2004	Haikarainen et al.	
2004/0095746	A1	5/2004	Murphy	
2005/0028815	A1	2/2005	Deaton	
2005/0087191	A1	4/2005	Morton	
2006/0096594	A1	5/2006	Bonney	
2006/0107949	A1	5/2006	Davies	
2006/0107979	A1	5/2006	Kim	
2007/0062518	A1	3/2007	Geser	
2008/0242465	A1	10/2008	Strobel	
2009/0178678	A1	7/2009	OLeary	
2010/0089395	A1	4/2010	Power	
2010/0218759	A1	9/2010	Anderson	
2011/0041845	A1	2/2011	Solomon	
2012/0006322	A1	1/2012	Anderson	

FOREIGN PATENT DOCUMENTS

EP	1486227	12/2004
GB	2320489	6/1998
JP	02502129	7/1990
JP	450059	8/1992
JP	07100205	4/1995
JP	10504220	4/1998
JP	2002528144	9/2002
JP	2004501685	1/2004
JP	2008-94103 A	4/2008
JP	2008094103	4/2008
JP	2008261423	10/2008
JP	2009233308	10/2009
JP	2009257392	11/2009
JP	2010096308	4/2010
WO	8909078	10/1989
WO	9628205	9/1996
WO	9828033	7/1998
WO	9936115	7/1999
WO	02/00281 A2	1/2002
WO	03101514	12/2003
WO	2005102430	11/2005
WO	2006062449	6/2006
WO	2006062449 A1	6/2006
WO	2007012861	2/2007
WO	2007062518	6/2007
WO	2008023019	2/2008
WO	2008119552	2/2008
WO	2011012325	2/2011
WO	2011012327	2/2011

OTHER PUBLICATIONS

Advisory Action dated Mar. 13, 2017 for U.S. Appl. No. 14/699,567.
Non-Final Office Action dated Jan. 12, 2017 for U.S. Appl. No. 14/713,620, 8 pages.
Final Rejection dated Sep. 27, 2016 for U.S. Appl. No. 14/699,578.
Final Office Action dated Aug. 31, 2016 for U.S. Appl. No. 14/713,620, 7 pages.
Advisory action dated Feb. 9, 2017 for U.S. Appl. No. 14/699,584.
Non-final rejection dated Jul. 12, 2016 for U.S. Appl. No. 14/713,643.
File History for U.S. Appl. No. 15/271,738.
File History for U.S. Appl. No. 15/269,102.
File History for U.S. Appl. No. 15/262,818.
File History for U.S. Appl. No. 15/289,553.
File History for U.S. Appl. No. 15/269,249.
Final rejection dated Oct. 20, 2016 or U.S. Appl. No. 14/699,584.
Non-Final Office Action dated Jun. 24, 2016 for U.S. Appl. No. 14/713,620, 7 pages.
Final rejection dated Oct. 20, 2016 or U.S. Appl. No. 14/713,631.
Advisory Action dated Mar. 16, 2017 or U.S. Appl. No. 14/713,633.
Entire patent prosecution history of U.S. Appl. No. 13/110,532, filed May 18, 2011, entitled,"Dose Counters for Inhalers, Inhalers and Methods of Assembly Thereof."
Entire patent prosecution history of U.S. Appl. No. 14/103,324, filed Dec. 11, 2013, entitled, "Dose Counters for Inhalers, Inhalers and Methods of Assembly Thereof."
Entire patent prosecution history of U.S. Appl. No. 14/103,343, filed Dec. 11, 2013, entitled, "Dose Counters for Inhalers, Inhalers and Methods of Assembly Thereof."
Entire patent prosecution history of U.S. Appl. No. 14/103,353, filed Dec. 11, 2013, entitled, "Dose Counters for Inhalers, Inhalers and Methods of Assembly Thereof."
Entire patent prosecution history of U.S. Appl. No. 14/103,363, filed Dec. 1, 2013, entitled, "Dose Counters for Inhalers, Inhalers and Methods of Assembly Thereof."
Entire patent prosecution history of U.S. Appl. No. 14/103,392, filed Dec. 11, 2013, entitled, "Dose Counters for Inhalers, Inhalers and Methods of Assembly Thereof."
Entire patent prosecution history of U.S. Appl. No. 14/699,567, filed Apr. 29, 2015, entitled, "Dose Counter for Inhaler and Method for Counting Doses."
Entire patent prosecution history of U.S. Appl. No. 14/699,578, filed Apr. 29, 2015, entitled, "Dose Counter for Inhaler Having a Bore and Shaft Arrangement."
Entire patent prosecution history of U.S. Appl. No. 14/699,584, filed Apr. 29, 2015, entitled, "Dose Counter for Inhaler Having an Antireverse Rotation Actuator".

(56) **References Cited**

OTHER PUBLICATIONS

Entire patent prosecution history of U.S. Appl. No. 14/713,612, filed May 15, 2015, entitled, "Dose Counters for Inhalers, Inhalers and Methods of Assembly Thereof."
Entire patent prosecution history of U.S. Appl. No. 14/713,620, filed May 15, 2015, entitled, "Dose Counters for Inhalers, Inhalers and Methods of Assembly Thereof."
Entire patent prosecution history of U.S. Appl. No. 14/713,643, filed May 15, 2015, entitled, "Dose Counters for Inhalers, Inhalers and Methods of Assembly Thereof."
European Patent Office Communication, dated Apr. 24, 2014 of counterpart European Patent Application No. 11 010 211.8.
European Patent Office Communication, dated Apr. 24, 2014 of counterpart European Patent Application No. 11 010 212.6.
First Examination Report of counterpart New Zealand Patent Application No. 603466, dated Jul. 1, 2013.

* cited by examiner

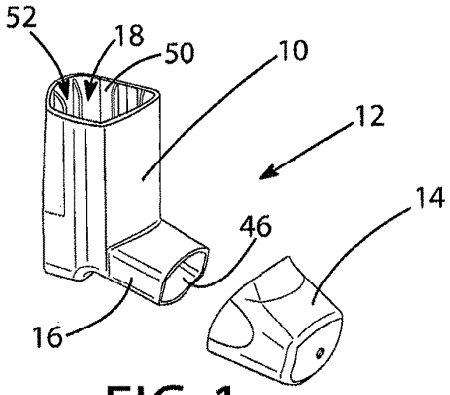


FIG. 1

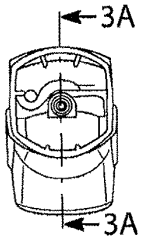


FIG. 2

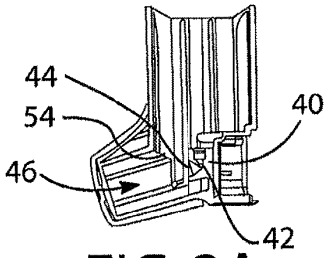


FIG. 3A

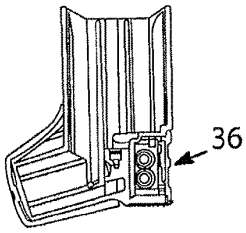


FIG. 3B

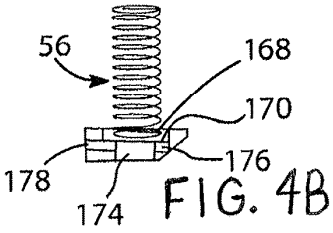


FIG. 4B

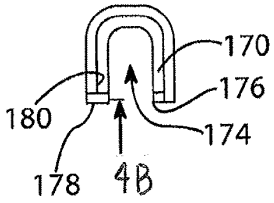


FIG. 4C

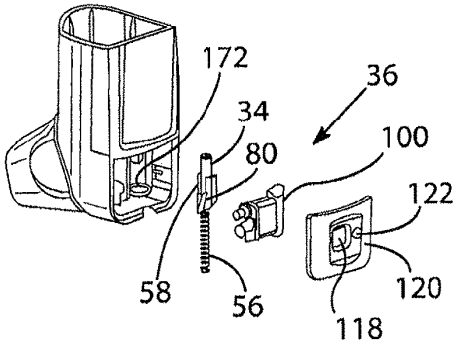


FIG. 4A

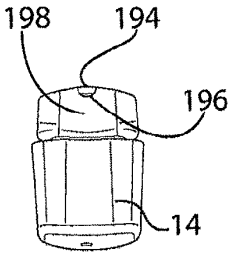


FIG. 5

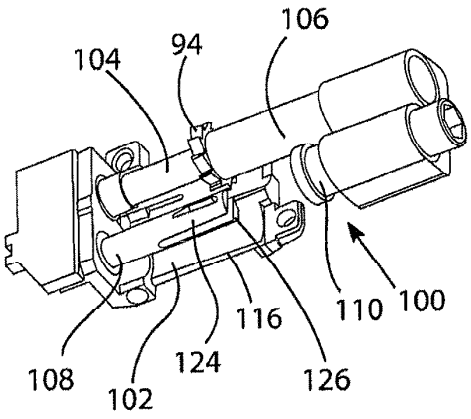


FIG. 6A

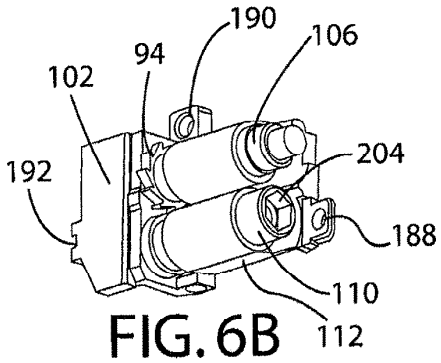
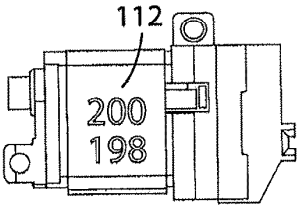


FIG. 6B



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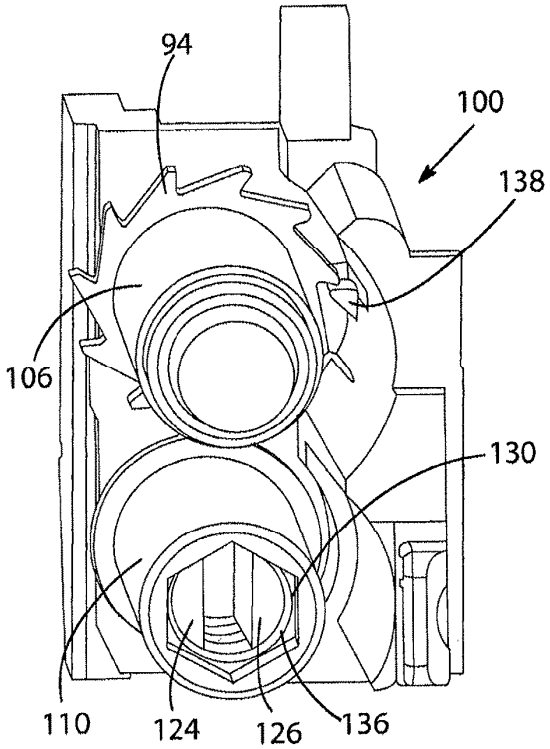


FIG. 6D

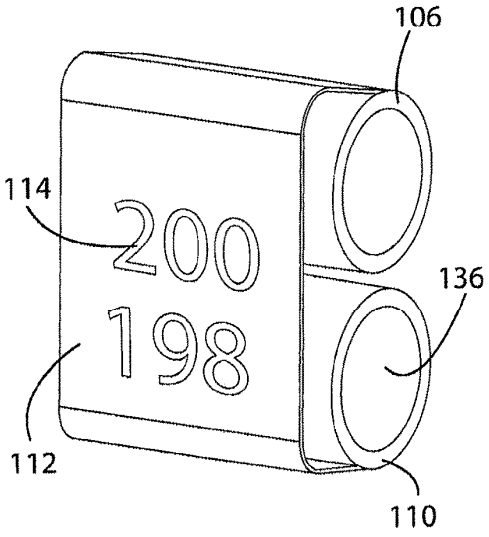


FIG. 6E

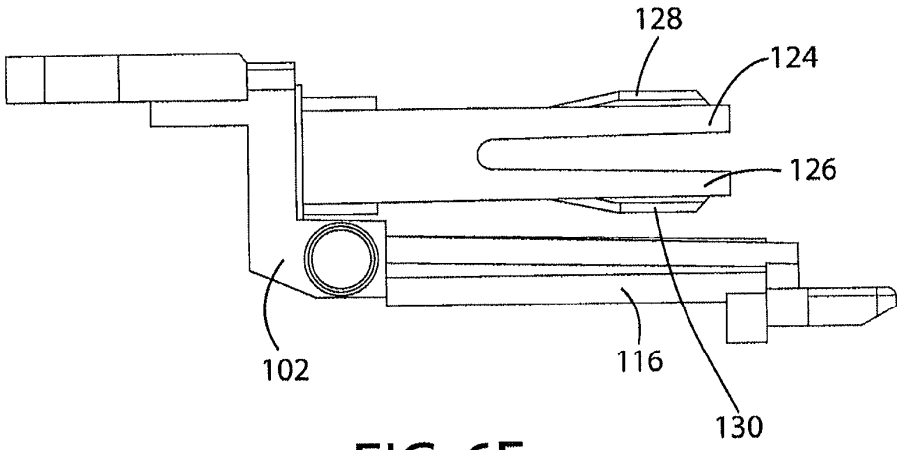


FIG. 6F

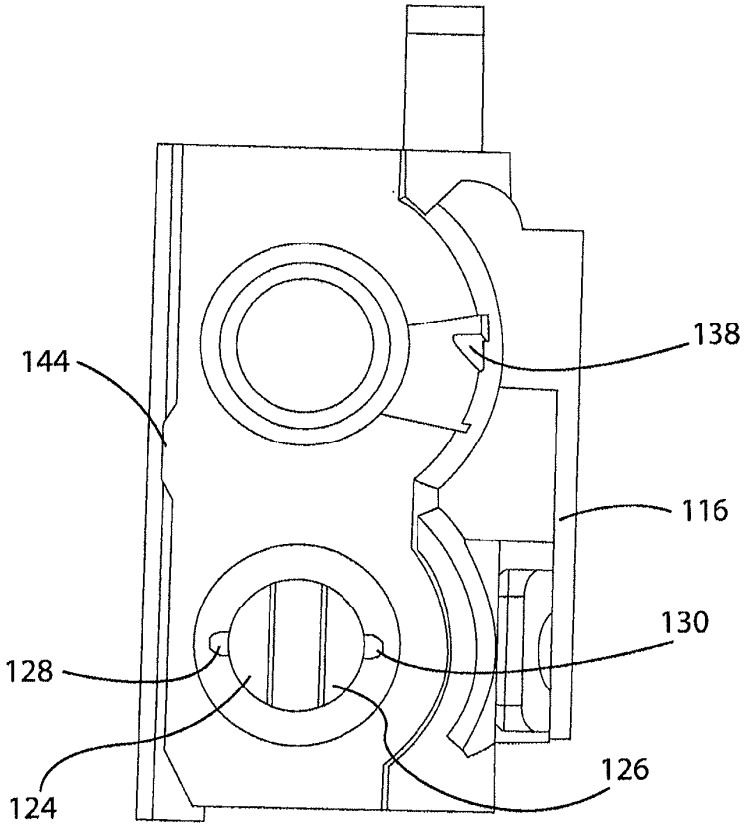


FIG. 6G

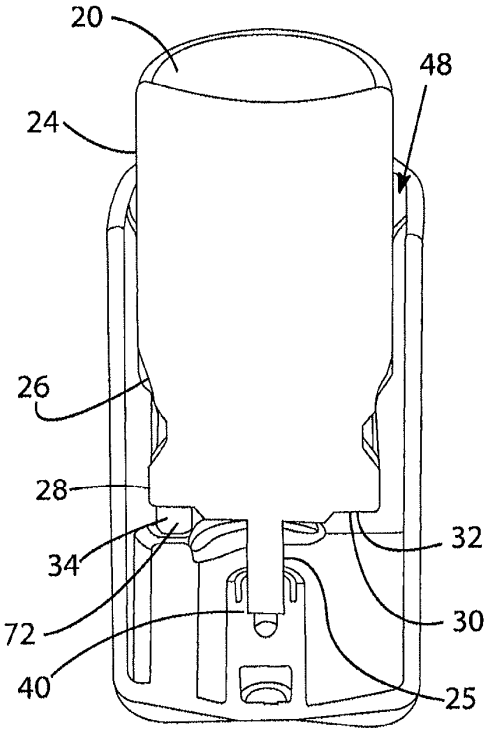


FIG. 7A

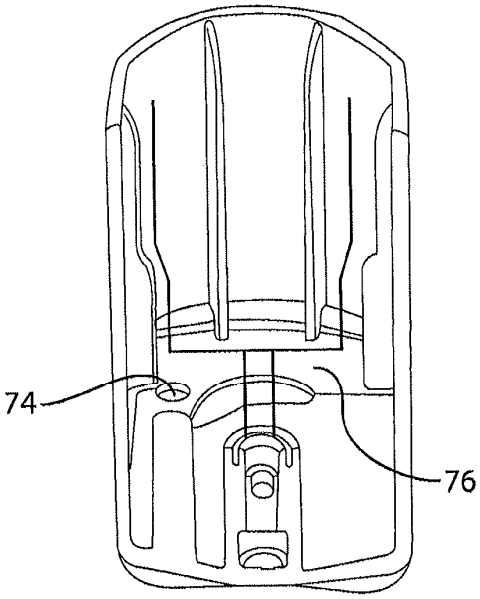


FIG. 7B

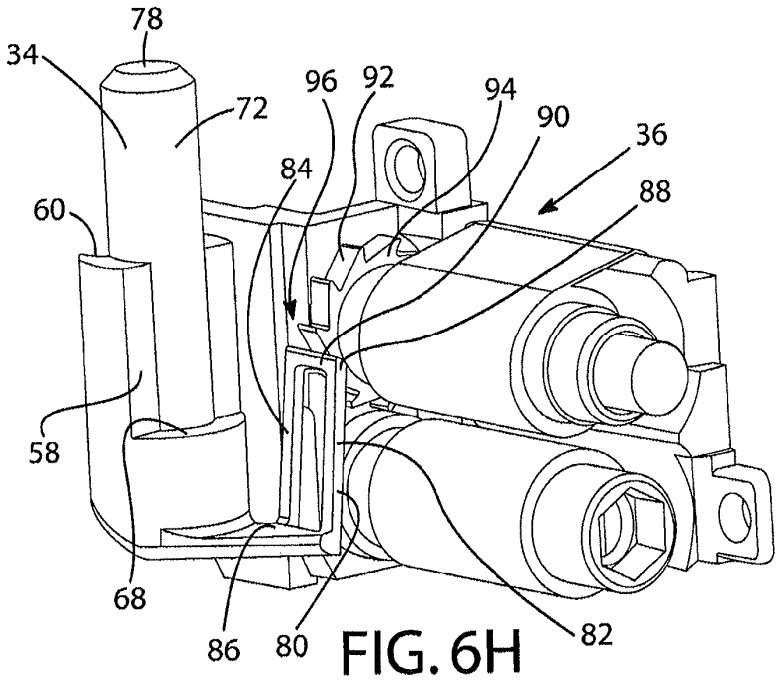


FIG. 6H

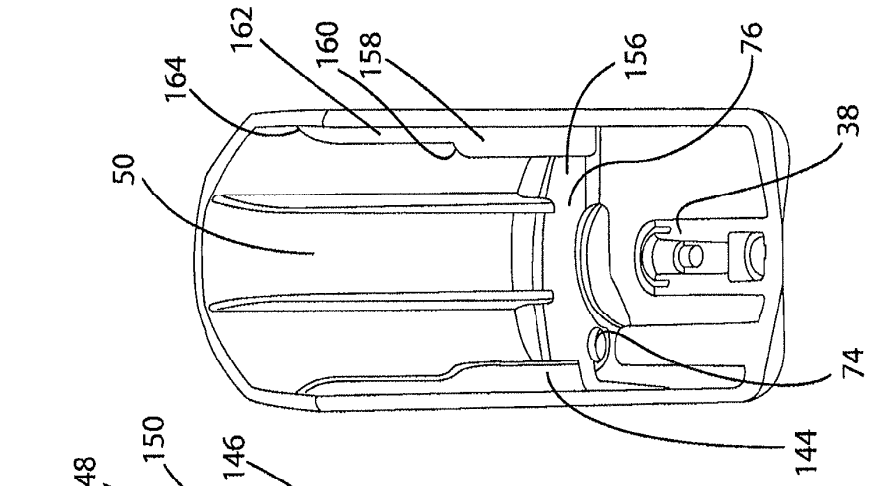


FIG. 7C

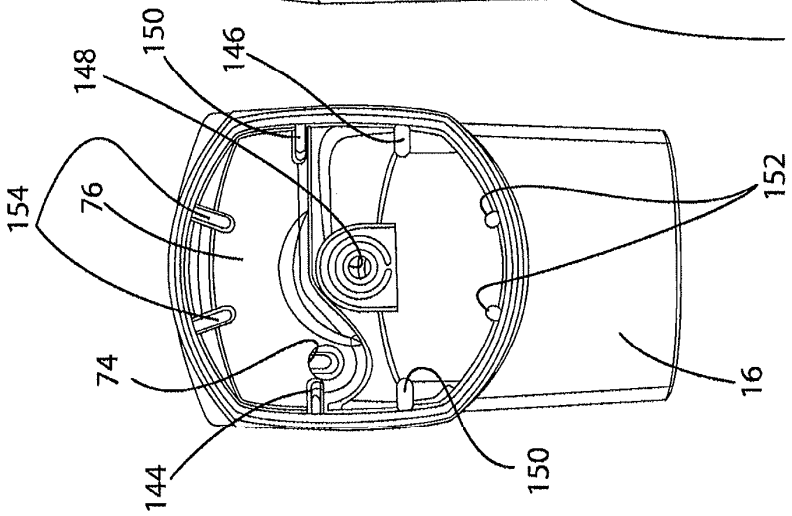


FIG. 7D

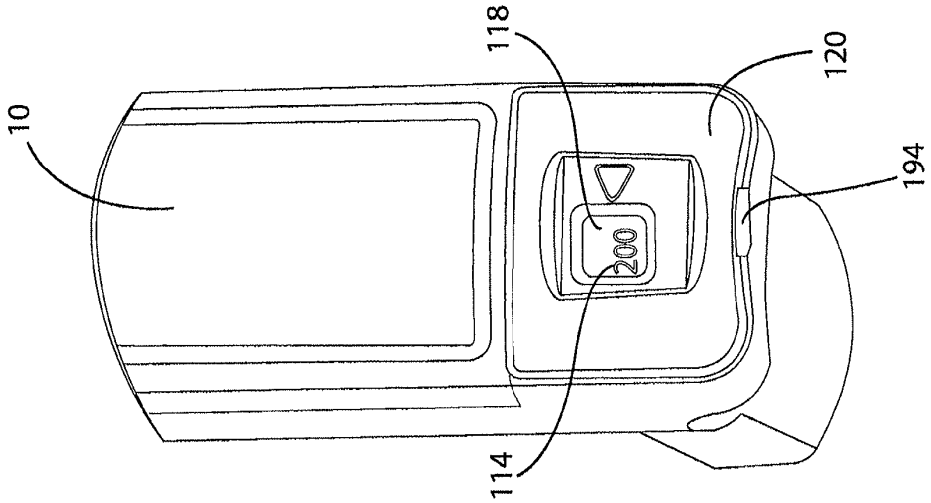


FIG. 8D

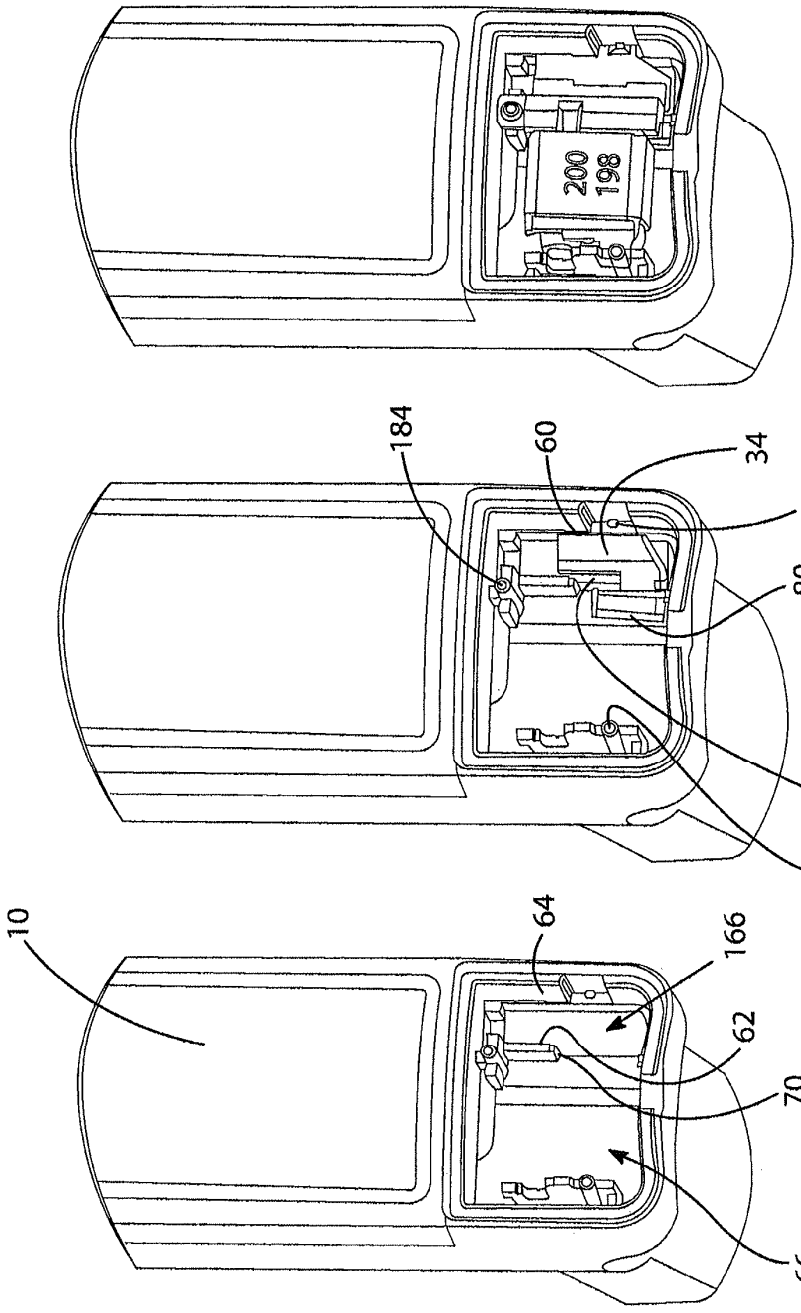


FIG. 8C

FIG. 8B

FIG. 8A

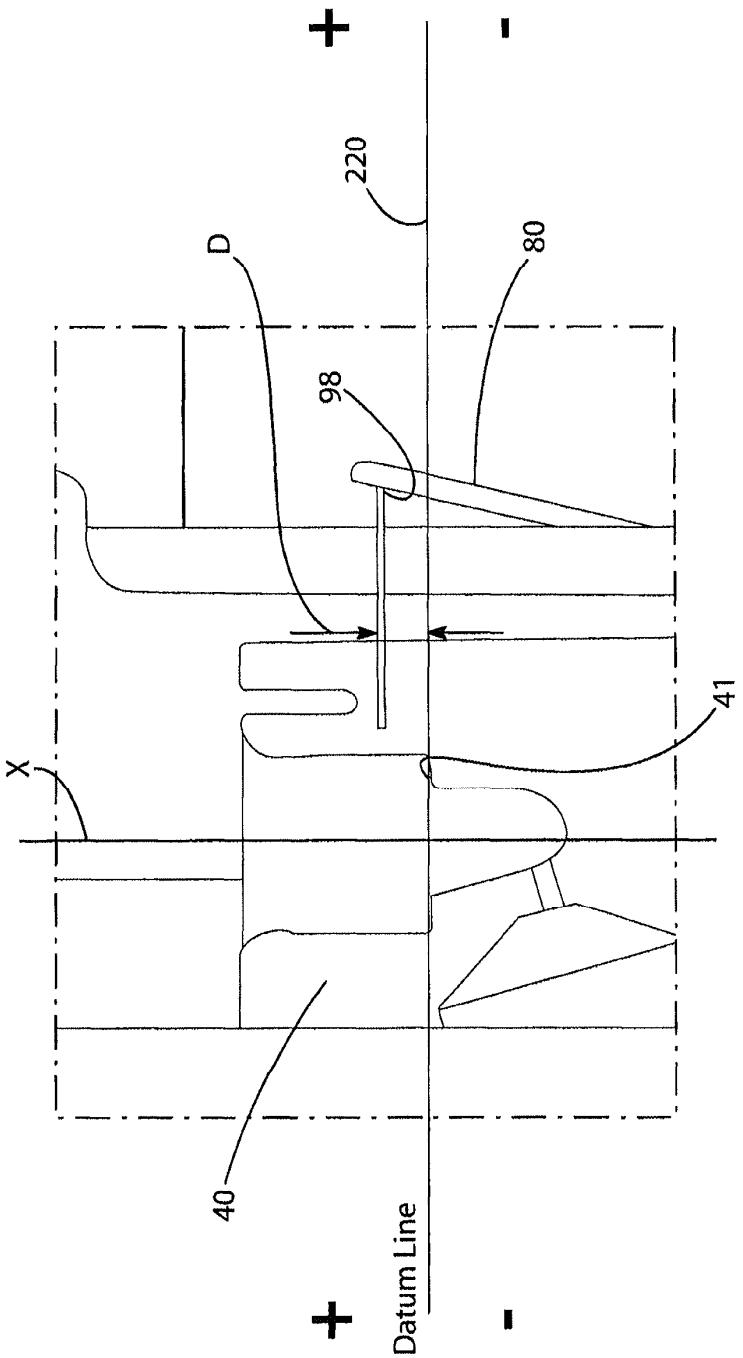


FIG. 9

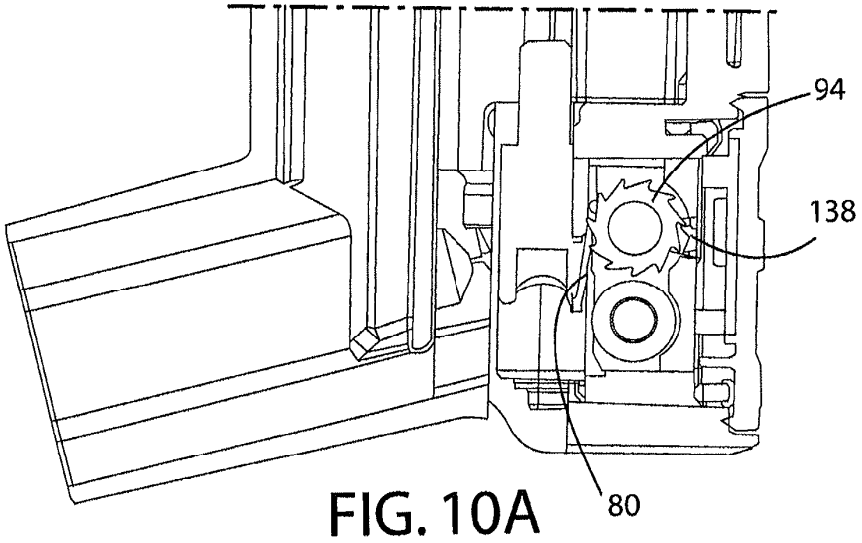


FIG. 10A

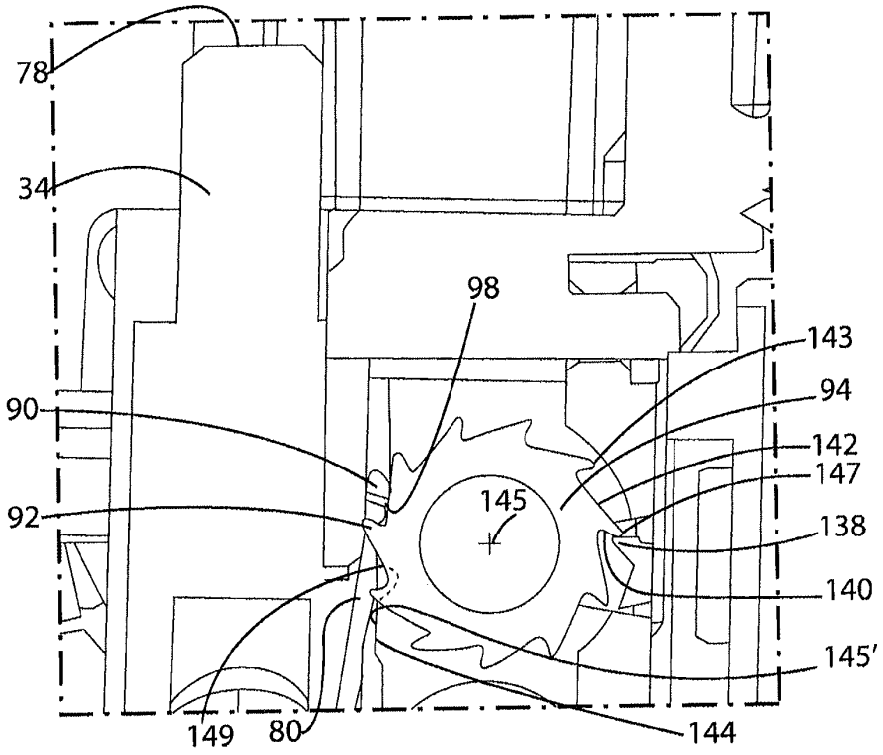


FIG. 10B

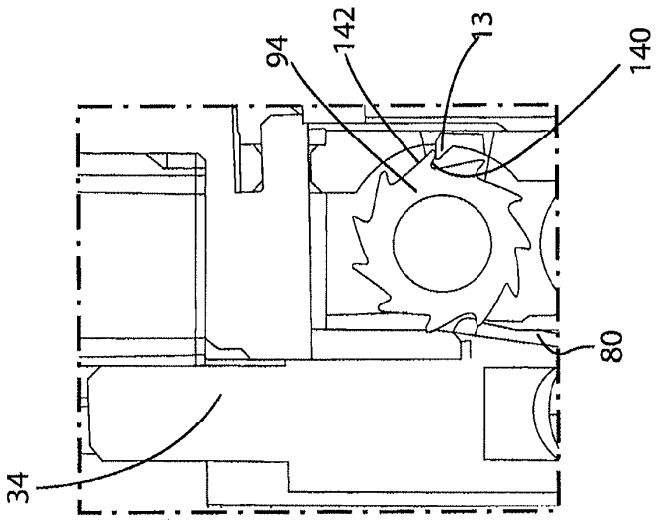


FIG. 10E

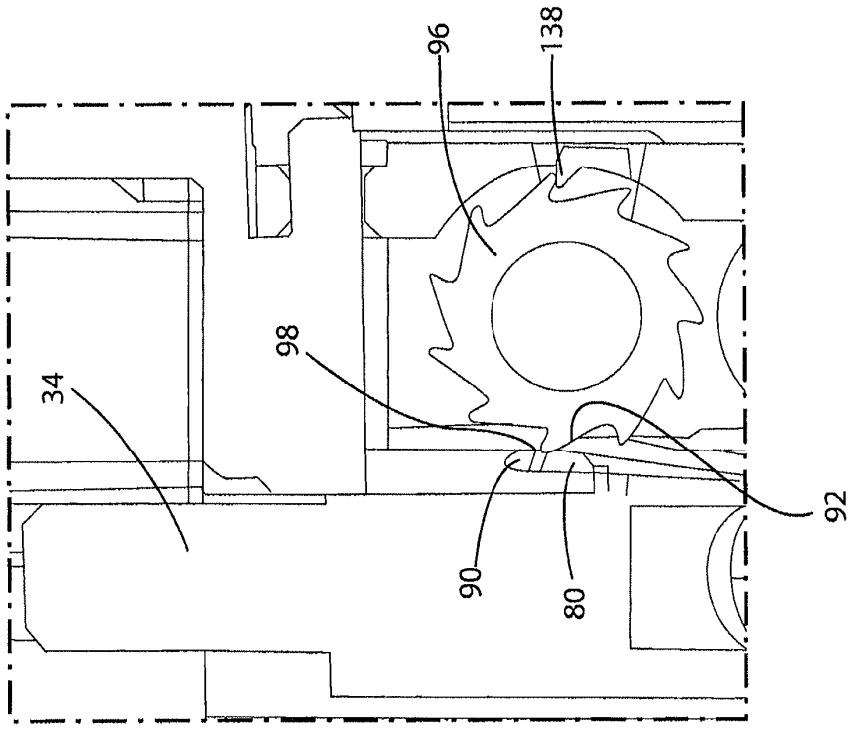


FIG. 10C

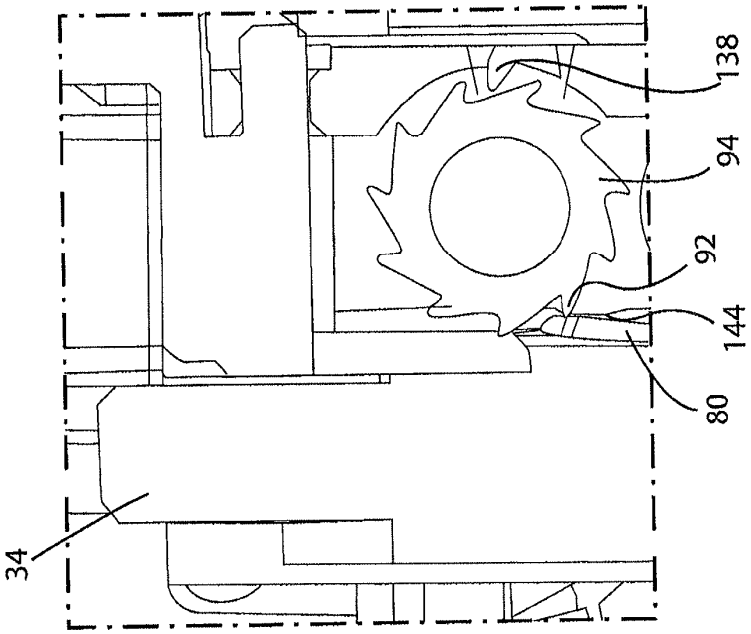


FIG. 10F

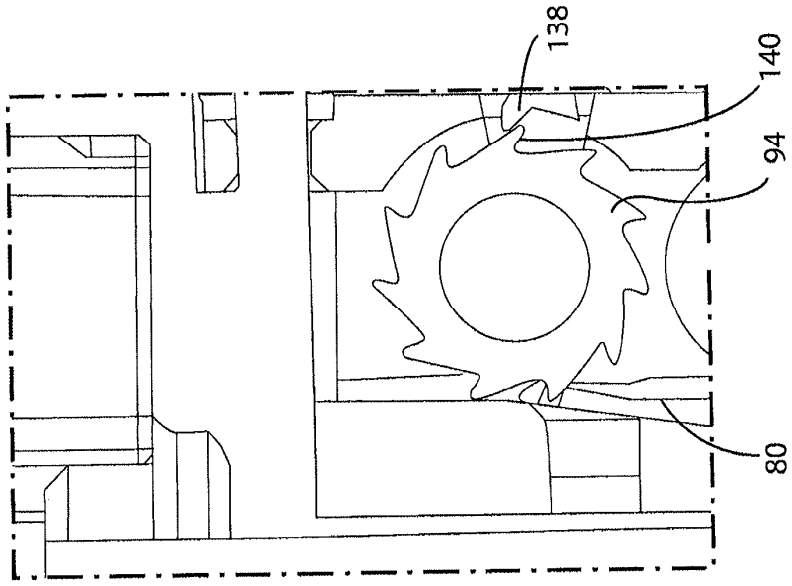
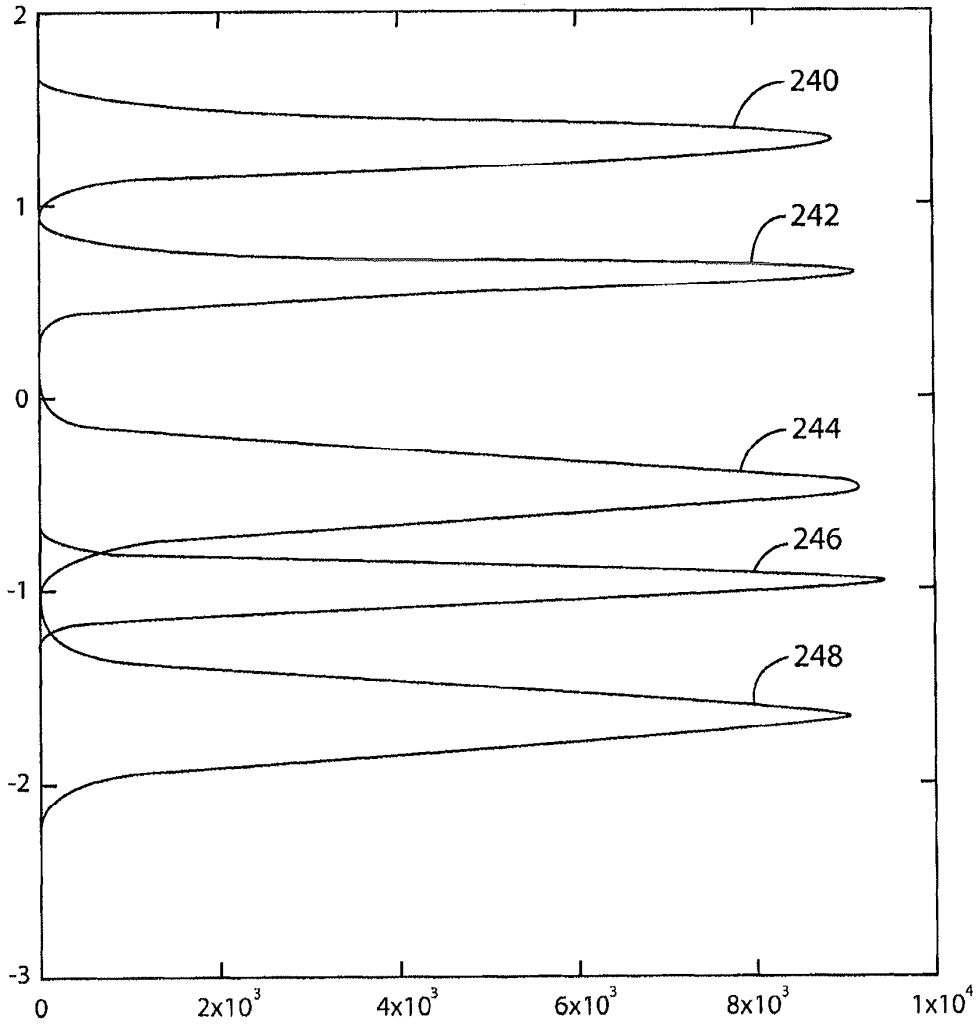


FIG. 10D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-2
-3
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1x10^4

FIG. 11

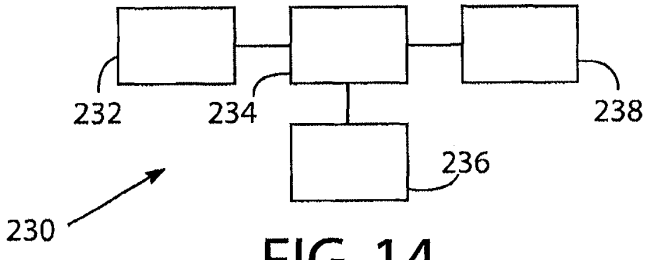
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FIG. 14

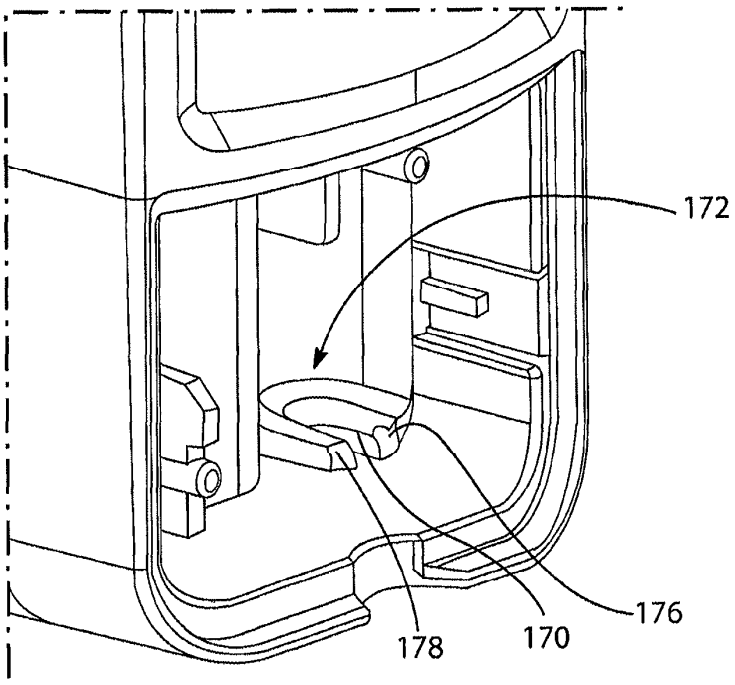

FIG. 12

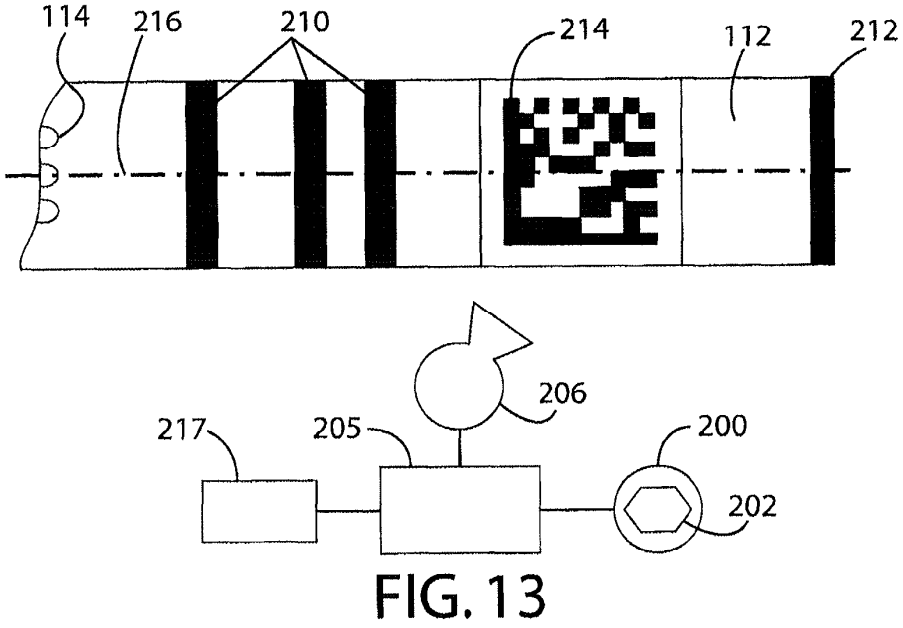

FIG. 13

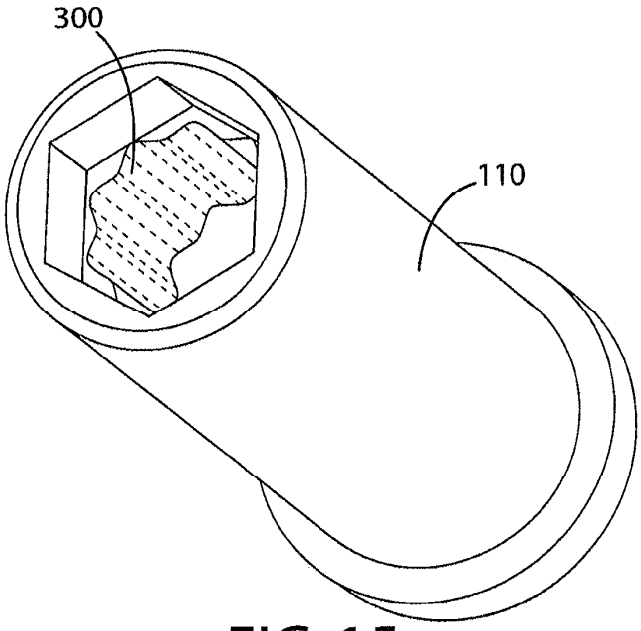

FIG. 15

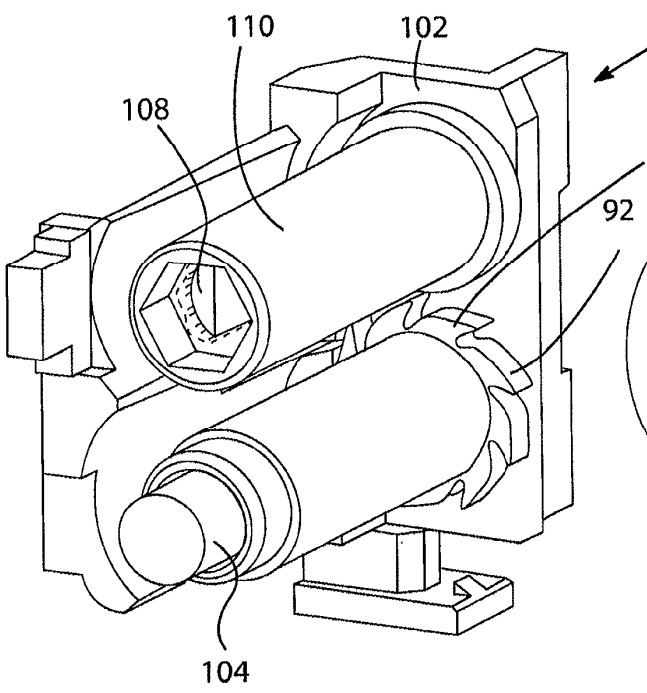

FIG. 20

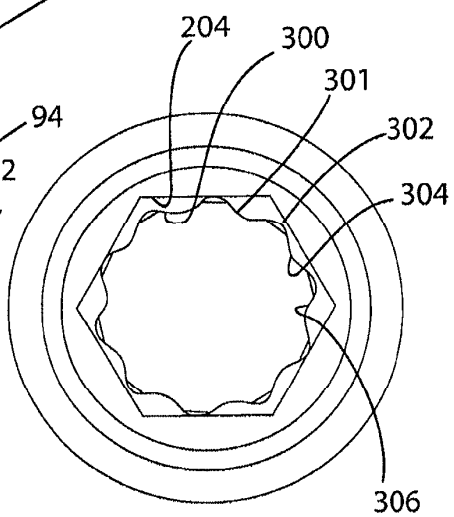

FIG. 16

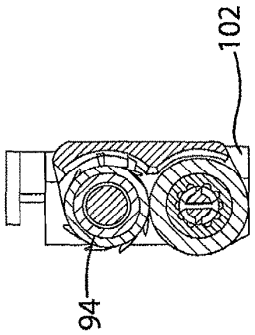

FIG. 19A

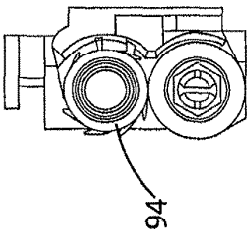

FIG. 19B

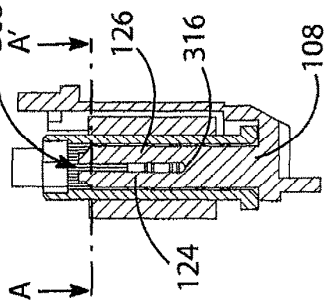

FIG. 19C

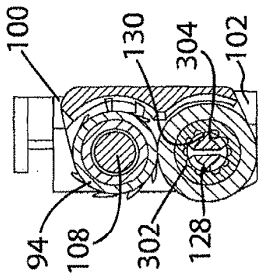

FIG. 18A

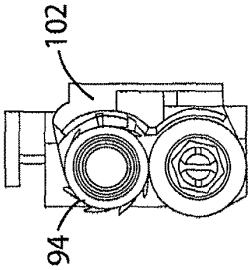

FIG. 18B

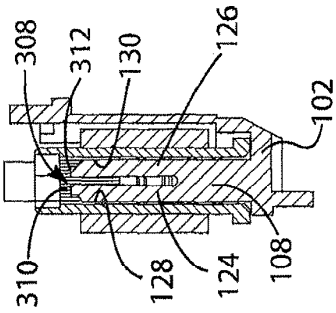

FIG. 18C

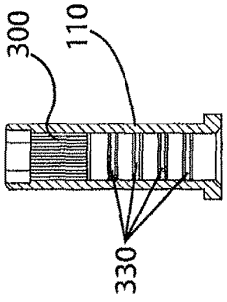

FIG. 17

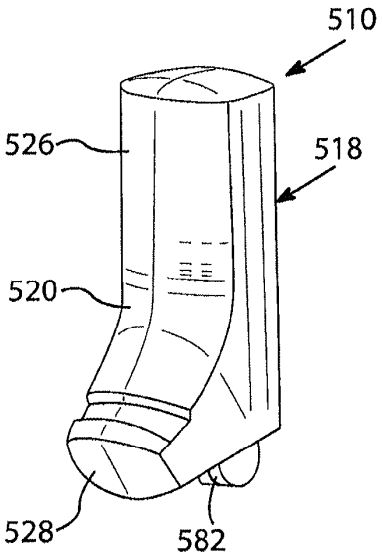
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FIG. 21

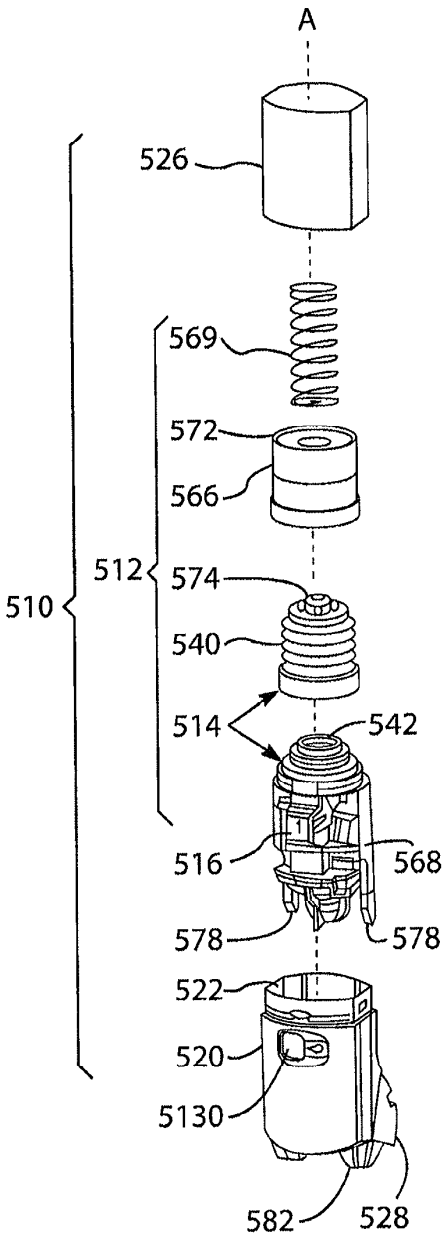
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FIG. 22

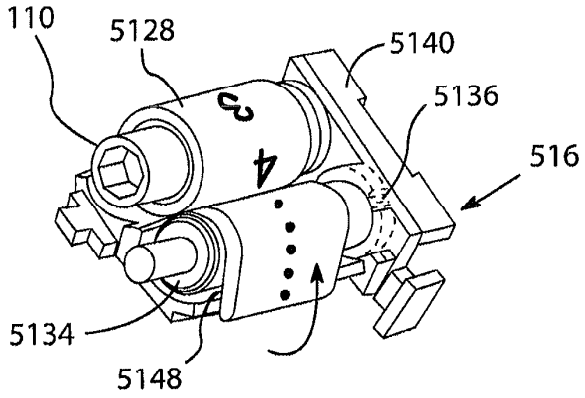
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FIG. 23

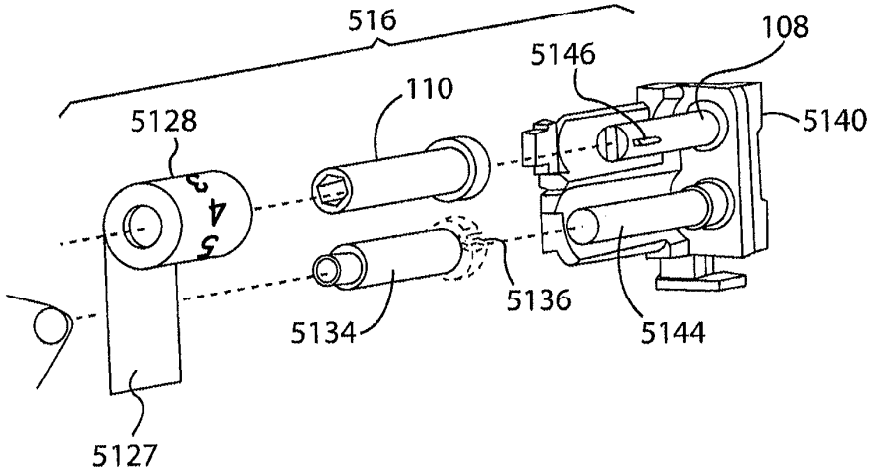
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FIG. 24

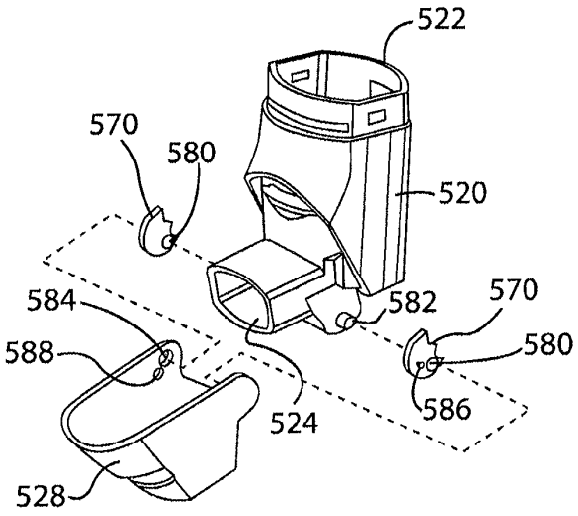

FIG. 25

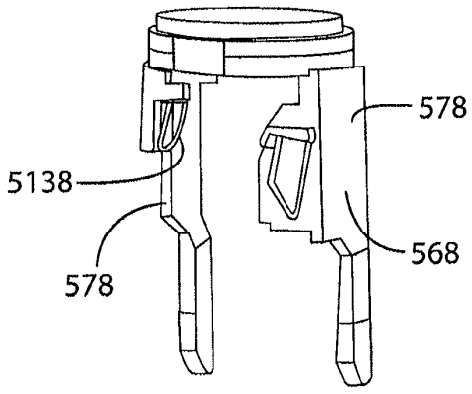

FIG. 26

DOSE COUNTER FOR INHALER HAVING AN ANTI-REVERSE ROTATION ACTUATOR

CROSS-REFERENCE TO RELATED APPLICATIONS

This patent application is a continuation patent application of U.S. Non-Provisional patent application Ser. No. 14/699,584, filed Apr. 29, 2015, which is a continuation patent application of U.S. Non-Provisional patent application Ser. No. 14/103,353, filed Dec. 11, 2013, which is a divisional patent application of U.S. Non-Provisional patent application Ser. No. 13/110,532, filed May 18, 2011, now U.S. Pat. No. 8,978,966, issued Mar. 17, 2015, which claims priority to U.S. Provisional Patent Application No. 61/345,763, filed May 18, 2010, and U.S. Provisional Patent Application No. 61/417,659, filed Nov. 29, 2010, each of which is incorporated herein by reference in its entirety for any and all purposes.

FIELD OF THE INVENTION

The present invention relates to dose counters for inhalers, inhalers and methods of assembly thereof. The invention is particularly applicable to metered dose inhalers including dry power medicament inhalers, breath actuated inhalers and manually operated metered dose medicament inhalers.

BACKGROUND OF THE INVENTION

Metered dose inhalers can comprise a medicament-containing pressurised canister containing a mixture of active drug and propellant. Such canisters are usually formed from a deep-dawn aluminium cup having a crimped lid which carries a metering valve assembly. The metering valve assembly is provided with a protruding valve stem which, in use is inserted as a push fit into a stem block in an actuator body of an inhaler having a drug delivery outlet. In order to actuate a manually operable inhaler, the user applies by hand a compressive force to a closed end of the canister and the internal components of the metering valve assembly are spring loaded so that a compressive force of approximately 15 to 30N is required to activate the device in some typical circumstances.

In response to this compressive force the canister moves axially with respect to the valve stem and the axial movement is sufficient to actuate the metering valve and cause a metered quantity of the drug and the propellant to be expelled through the valve stem. This is then released into a mouthpiece of the inhaler via a nozzle in the stem block, such that a user inhaling through the outlet of the inhaler will receive a dose of the drug.

A drawback of self-administration from an inhaler is that it is difficult to determine how much active drug and/or propellant are left in the inhaler, if any, especially of the active drug and this is potentially hazardous for the user since dosing becomes unreliable and backup devices not always available.

Inhalers incorporating dose counters have therefore become known.

WO 98/028033 discloses an inhaler having a ratchet mechanism for driving a tape drive dose counter. A shaft onto which tape is wound has a friction clutch or spring for restraining the shaft against reverse rotation.

EP-A-1486227 discloses an inhaler for dry powered medicament having a ratchet mechanism for a tape dose counter which is operated when a mouthpiece of the inhaler is closed. Due to the way in which the mouthpiece is opened and closed, and actuation pawl of the device which is mounted on a yoke, travels a known long stroke of consistent length as the mouthpiece is opened and closed.

WO 2008/119552 discloses a metered-dose inhaler which is suitable for breath-operated applications and operates with a known and constant canister stroke length of 3.04 mm+/−0.255 mm. A stock bobbin of the counter, from which a tape is unwound, rotates on a shaft having a split pin intended to hold the stock bobbin taut. However, some dose counters do not keep a particularly reliable count, such as if they are dropped onto a hard surface.

More recently, it has become desirable to improve dose counters further and, in particular, it is felt that it would be useful to provide extremely accurate dose counters for manually-operated canister-type metered dose inhalers. Unfortunately, in these inhalers, it has been found in the course of making the present invention that the stroke length of the canister is to a very large extent controlled on each dose operation by the user, and by hand. Therefore, the stroke length is highly variable and it is found to be extremely difficult to provide a highly reliable dose counter for these applications. The dose counter must not count a dose when the canister has not fired since this might wrongly indicate to the user that a dose has been applied and if done repeatedly the user would throw away the canister or whole device before it is really time to change the device due to the active drug and propellant reaching a set minimum. Additionally, the canister must not fire without the dose counter counting because the user may then apply another dose thinking that the canister has not fired, and if this is done repeatedly the active drug and/or propellant may run out while the user thinks the device is still suitable for use according to the counter. It has also been found to be fairly difficult to assembly some known inhaler devices and the dose counters therefor. Additionally, it is felt desirable to improve upon inhalers by making them easily usable after they have been washed with water.

The present invention aims to alleviate at least to a certain extent one or more of the problems of the prior art.

SUMMARY OF THE INVENTION

According to a first aspect of the present invention there is provided a dose counter for an inhaler, the dose counter having a counter display arranged to indicate dosage information, a drive system arranged to move the counter display incrementally in a first direction from a first station to a second station in response to actuation input, wherein a regulator is provided which is arranged to act upon the counter display at the first station to regulate motion of the counter display at the first station to incremental movements.

The regulator is advantageous in that it helps prevent unwanted motion of the counter display if the counter is dropped.

According to a further aspect of the present invention, the regulator provides a resistance force of greater than 0.1 N against movement of the counter display. According to still a further aspect of the present invention, the resistance force is greater than 0.3 N. According to yet a further aspect of the present invention, the resistance force is from 0.3 to 0.4 N.

Preferably, the counter comprises a tape.

Preferably, the tape has dose counter indicia displayed thereon. The first station may comprise a region of the dose counter where tape is held which is located before a display location, such as a display window, for the counter indicia.

The first station may comprise a first shaft, the tape being arranged on the first shaft and to unwind therefrom upon movement of the counter display.

The first shaft may be mounted for rotation relative to a substantially rotationally fixed element of the dose counter.

The regulator may comprise at least one projection which is arranged on one of the first shaft and the substantially rotationally fixed element and to engage incrementally with one or more formations on the other of the first shaft and the substantially rotationally fixed element.

At least two said projections may be provided. Exactly two said projections maybe provided.

Each projection may comprise a radiused surface.

The at least one projection may be located on the substantially fixed element which may comprise a fixed shaft which is fixed to a main body of the dose counter, the first shaft being rotationally mounted to the fixed shaft.

Preferably, the fixed shaft has at least two resiliently flexible legs (or forks). Each leg may have at least one said projection formed in an outwardly facing direction thereon, said one or more formations being formed on an inwardly facing engagement surface of the first shaft, said at least one projection being arranged to resiliently engage said one or more formations. Preferably, a series of said formations are provided. An even number of said formations may be provided. Eight to twelve of said formations may be provided. In one embodiment, ten said formations are provided.

Each said formation may comprise a concavity formed on an engagement surface. Each concavity may comprise a radiused surface wall portion which preferably merges on at least one side thereof into a flat wall portion surface. The engagement surface may include a series of said concavities, and convex wall portions of the engagement surface may be formed between each adjacent two said concavities, each said convex wall portion comprising a convex radiused wall portion.

Each convex radiused wall portion of each convex wall portion may be connected by said flat wall portion surfaces to each adjacent concavity.

The fixed shaft may comprise a split pin with fork legs and each projection may be located on a said fork leg.

The first shaft may comprise a substantially hollow bobbin.

Said at least one formation may be located on an inner surface of the bobbin. In other embodiments it may be located on an outer surface thereof. Said engagement surface may extend partially along said bobbin, a remainder of the respective inner or outer surface having a generally smooth journal portion along at least a portion thereof.

The drive system may comprise a tooth ratchet wheel arranged to act upon a second shaft which is located at the second station, the second shaft being rotatable to wind the tape onto the second shaft.

The second shaft may be located on a main body of the dose counter spaced from and parallel to the first shaft.

The ratchet wheel may be fixed to the second shaft is arranged to rotate therewith. The ratchet wheel may be secured to an end of the second shaft and aligned coaxially with the second shaft.

The dose counter may include anti-back drive system which is arranged to restrict motion of the second shaft. The anti-back drive system may include a substantially fixed tooth arranged to act upon teeth of the ratchet wheel.

According to a further aspect of the present invention, a dose counter includes an anti-back drive system which is arranged to restrict motion of the second shaft in a tape winding direction.

According to a further aspect of the present invention there is provided a shaft for holding counter tape in a dose counter for an inhaler, the shaft having an engagement surface including incrementally spaced formations located around a periphery thereof, the formations comprising a series of curved concavities and convex portions.

The shaft may comprise a hollow bobbin.

The engagement surface may be a generally cylindrical inwardly directed surface.

The engagement surface may include a flat surface wall portion joining each concavity and convex wall portion.

Each concavity may comprise a radiused wall portion.

Each convex wall portion may comprise a radiused wall portion.

Said concavities may be regularly spaced around a longitudinal axis of the shaft.

Said convex wall portions may be regularly spaced around a longitudinal axis of the shaft.

In some embodiments there may be from eight to twelve said concavities and/or convex wall portions regularly spaced around a longitudinal axis thereof.

One embodiment includes ten said concavities and/or convex wall portions regularly spaced around a longitudinal axis of the shaft.

According to a further aspect of the present invention there is provided a shaft and counter tape assembly for use in a dose counter for an inhaler, the assembly comprising a rotatable shaft and a counter tape which is wound around the shaft and is adapted to unwind therefrom upon inhaler actuation, the shaft having an engagement surface which includes incrementally spaced formations located around a periphery thereof.

According to a further aspect of the present invention there is provided an inhaler for the inhalation of medication and the like, the inhaler including a dose counter as in the first aspect of the present invention.

A preferred construction consists of a manually operated metered dose inhaler including a dose counter chamber including a dose display tape driven by a ratchet wheel which is driven in turn by an actuator pawl actuated by movement of a canister, the tape unwinding from a stock bobbin during use of the inhaler, a rotation regulator being provided for the stock bobbin and comprising a wavelike engagement surface with concavities which engage against control elements in the form of protrusions on resilient forks of a split pin thereby permitting incremental unwinding of the stock bobbin yet resisting excessive rotation if the inhaler is dropped onto a hard surface.

According to another aspect of the present invention there is provided a dose counter for a metered dose inhaler having a body arranged to retain a medicament canister of predetermined configuration for movement of the canister relative thereto; the dose counter comprising: an incremental counting system for counting doses, the incremental counting system having a main body, an actuator arranged to be driven in response to canister motion and to drive an incremental output member in response to canister motion, the actuator and incremental output member being configured to have predetermined canister fire and count configurations in a canister fire sequence, the canister fire configuration being determined by a position of the actuator relative to a datum at which the canister fires medicament and the count configuration being determined by a position of the actuator relative to the datum at which the incremental count system makes an incremental count, wherein the actuator is

arranged to reach a position thereof in the count configuration at or after a position thereof in the canister fire configuration.

This arrangement has been found to be highly advantageous since it provides an extremely accurate dose counter which is suitable for use with manually operated metered dose inhalers. It has been found that dose counters with these features have a failure rate of less than 50 failed counts per million full canister activation depressions. It has been found in the course of making the present invention that highly reliable counting can be achieved with the dose counter counting at or soon after the point at which the canister fires. It has been is covered by the present inventors that momentum and motion involved in firing the canister, and in some embodiments a slight reduction in canister back pressure on the user at the time of canister firing, can very reliably result in additional further motion past the count point.

The actuator and incremental counting system may be arranged such that the actuator is displaced less than 1 mm, typically 0.25 to 0.75 mm, more preferably about 0.4 to 0.6 mm, relative to the body between its location in the count and fire configurations, about 0.48 mm being preferred. The canister, which can move substantially in line with the actuator, can reliably move this additional distance so as to achieve very reliable counting.

The incremental count system may comprise a ratchet mechanism and the incremental output member may comprise a ratchet wheel having a plurality of circumferentially spaced teeth arranged to engage the actuator.

The actuator may comprise an actuator pawl arranged to engage on teeth of the ratchet wheel. The actuator pawl may be arranged to be connected to or integral with an actuator pin arranged to engage and be depressed by a medicament canister bottom flange. The actuator pawl may be generally U-shaped having two parallel arms arranged to pull on a central pawl member arranged substantially perpendicular thereto. This provides a very reliable actuator pawl which can reliably pull on the teeth of the ratchet wheel.

The incremental count system may include a tape counter having tape with incremental dose indicia located thereon, the tape being positioned on a tape stock bobbin and being arranged to unwind therefrom.

The actuator and incremental output member may be arranged to provide a start configuration at which the actuator is spaced from the ratchet output member, a reset configuration at which the actuator is brought into engagement with the incremental output member during a canister fire sequence, and an end configuration at which the actuator disengages from the ratchet output during a canister fire sequence.

The actuator may be arranged to be located about 1.5 to 2.0 mm, from its location in the fire configuration, when in the start configuration, about 1.80 mm being preferred.

The actuator may be arranged to be located about 1.0 to 1.2 mm, from its location in the fire configuration, when in the reset configuration, about 1.11 mm being preferred.

The actuator may be arranged to be located about 1.1 to 1.3 mm, from its location in the fire configuration, when in the end configuration, about 1.18 mm being preferred.

These arrangements provide extremely reliable dose counting, especially with manually operated canister type metered dose inhalers.

The main body may include a formation for forcing the actuator to disengage from the incremental output member when the actuator is moved past the end configuration. The formation may comprise a bumped up portion of an otherwise generally straight surface against which the actuator engages and along which it is arranged to slide during a canister firing sequence.

The dose counter may include a counter pawl, the counter pawl having a tooth arranged to engage the incremental output member, the tooth and incremental output member being arranged to permit one way only incremental relative motion therebetween. When the incremental output member comprises a ratchet wheel, the tooth can therefore serve as an anti-back drive tooth for the ratchet wheel, thereby permitting only one way motion or rotation thereof.

The counter pawl may be substantially fixedly mounted on the main body of the incremental count system and the counter pawl may be arranged to be capable of repeatedly engaging equi-spaced teeth of the incremental output member in anti-back drive interlock configurations as the counter is operated. The counter pawl may be positioned so that the incremental output member is halfway, or substantially halfway moved from one anti-back drive interlock configuration to the next when the actuator and incremental output member are in the end configuration thereof. This is highly advantageous in that it minimises the risk of double counting or non-counting by the dose counter.

According to a further aspect of the invention there is provided an inhaler comprising a main body arranged to retain a medicament canister of predetermined configuration and a dose counter mounted in the main body.

The inhaler main body may include a canister receiving portion and a separate counter chamber, the dose counter being located within the main body thereof, the incremental output member and actuator thereof inside the counter chamber, the main body of the inhaler having wall surfaces separating the canister-receiving portion and the counter chamber, the wall surfaces being provided with a communication aperture, an actuation member extending through the communication aperture to transmit canister motion to the actuator.

According to a further aspect of the present invention there is a provided an inhaler for metered dose inhalation, the inhaler comprising a main body having a canister housing arranged to retain a medicament canister for motion therein, and a dose counter, the dose counter having an actuation member having at least a portion thereof located in the canister housing for operation by movement of a medicament canister, wherein the canister housing has an inner wall, and a first inner wall canister support formation located directly adjacent the actuation member.

This is highly advantageous in that the first inner wall canister support formation can prevent a canister from rocking too much relative to the main body of the inhaler. Since the canister may operate the actuation member of the dose counter, this substantially improves dose counting and avoids counter errors.

The canister housing may have a longitudinal axis which passes through a central outlet port thereof, the central outlet port being arranged to mate with an outer canister fire stem of a medicament canister, the inner wall canister support formation, the actuation member and the outlet port lying in a common plane coincident with the longitudinal axis. Accordingly, this construction may prevent the canister from rocking towards the position of the dose counter actuation member, thereby minimising errors in counting.

The canister housing may have a further inner canister wall support formation located on the inner wall opposite, or substantially opposite, the actuation member. Accordingly, the canister may be supported against rocking motion away from the actuator member so as to minimise count errors.

The canister housing may be generally straight and tubular and may have an arrangement in which each said inner wall support formation comprises a rail extending longitudinally along the inner wall.

Each said rail may be stepped, in that it may have a first portion located towards a medicine outlet end or stem block of the canister housing which extends inwardly a first distance from a main surface of the inner wall and a second portion located toward an opposite end of the canister chamber which extends inwardly a second, smaller distance from the main surface of the inner wall. This may therefore enable easy insertion of a canister into the canister housing such that a canister can be lined up gradually in step wise function as it is inserted into the canister housing.

The inhaler may include additional canister support rails which are spaced around an inner periphery of the inner wall of the canister housing and which extend longitudinally therealong.

At least one of the additional rails may extend a constant distance inwardly from the main surface of the inner wall.

At least one of the additional rails may be formed with a similar configuration to the first inner wall canister support formation.

The dose counter may, apart from said at least a portion of the actuation member, be located in a counter chamber separate from the canister housing, the actuation member comprising a pin extending through an aperture in a wall which separates the counter chamber and the canister housing.

According to a further aspect of the present invention there is provided an inhaler for inhaling medicaments having: a body for retaining a medicament store; the body including a dose counter, the dose counter having a moveable actuator and a return spring for the actuator, the return spring having a generally cylindrical and annular end; the body having a support formation therein for supporting said end of the return spring, the support formation comprising a shelf onto which said end is engageable and a recess below the shelf.

This shelf and recess arrangement is highly advantageous since it allows a tool (such as manual or mechanical tweezers) to be used to place the return spring of the actuator onto the shelf with the tool then being withdrawn at least partially via the recess.

The shelf may be U-shaped.

The support formation may include a U-shaped upstanding wall extending around the U-shaped shelf, the shelf and upstanding wall thereby forming a step and riser of a stepped arrangement.

The recess below the shelf my also be U-shaped.

At least one chamfered surface may be provided at an entrance to the shelf. This may assist in inserting the actuator and return spring into position.

A further aspect of the invention provides a method of assembly of an inhaler which includes the step of locating said end of said spring on the shelf with an assembly tool and then withdrawing the assembly tool at least partly via the recess. This assembly method is highly advantageous compared to prior art methods in which spring insertion has been difficult and in which withdrawal of the tool has sometimes accidentally withdrawn the spring again.

The cylindrical and annular end of the spring may be movable in a direction transverse to its cylindrical extent into the shelf while being located thereon.

According to a further aspect of the present invention there is provided an inhaler for inhaling medicament, the inhaler having a body for retaining a medicament store; and a dose counter, the dose counter having a moveable actuator and a chassis mounted on the body; the chassis being heat staked in position on the body. This is be highly advantageous in that the chassis can be very accurately positioned and held firmly in place, thereby further improving counting accuracy compared to prior art arrangements in which some movement of the chassis relative to the body may be tolerated in snap-fit connections.

The chassis may have at least one of a pin or aperture heat staked to a respective aperture or pin of the body.

The chassis may have a ratchet counter output member mounted thereon.

The ratchet counter output member may comprise a ratchet wheel arranged to reel in incrementally a dose meter tape having a dosage indicia located thereon.

According to a further aspect of the present invention there is provided a method of assembling an inhaler including the step of heat staking the chassis onto the body. The step of heat staking is highly advantageous in fixedly positioning the chassis onto the body in order to achieve highly accurate dose counting in the assembled inhaler.

The method of assembly may include mounting a spring-returned ratchet actuator in the body before heat staking the chassis in place. The method of assembly may include pre-assembling the chassis with a dose meter tape prior to the step of heat staking the chassis in place. The method of assembly may include attaching a dose meter cover onto the body after the heat staking step. The cover may be welded onto the body or may in some embodiments be glued or otherwise attached in place.

According to a further aspect of the present invention there is provided an inhaler for inhaling medicament and having a body, the body have a main part thereof for retaining a medicament store; and a dose counter, the dose counter being located in a dose counter chamber of the body which is separated from the main part of the body, the dose counter chamber of the body having a dosage display and being perforated so as to permit the evaporation of water or aqueous matter in the dose counter chamber into the atmosphere.

This is high advantageous since it enables the inhaler to be thoroughly washed and the dose counting chamber can thereafter dry out fully.

The display may comprise a mechanical counter display inside the dose counter chamber and a window for viewing the mechanical counter display. The mechanical counter display may comprise a tape. The perforated dose counter chamber may therefore enable reliable washing of the inhaler, if desired by the user, and may therefore dry out without the display window misting up.

The dose counter chamber may be perforated by a drain hole formed through an outer hole of the body. The drain hole may be located at a bottom portion of the body of the inhaler, thereby enabling full draining of the inhaler to be encouraged after washing when the inhaler is brought into an upright position.

According to a further aspect of the present invention there is provided a dose counter for an inhaler, the dose counter having a display tape arranged to be incrementally driven from a tape stock bobbin onto an incremental tape take-up drive shaft, the bobbin having an internal bore supported by and for rotation about a support shaft, at least one of the bore and support shaft having a protrusion which is resiliently biased into frictional engagement with the other of the bore and support shaft with longitudinally extending mutual frictional interaction. This arrangement may provide good friction for the bobbin, thereby improving tape counter

display accuracy and preventing the bobbin from unwinding undesirably for example if the inhaler is accidentally dropped.

The support shaft may be forked and resilient for resiliently biasing the support shaft and bore into frictional engagement.

The support shaft may have two forks, or more in some cases, each having a radially extending protrusion having a friction edge extending therealong parallel to a longitudinal axis of the support shaft for frictionally engaging the bore of the support shaft with longitudinally extending frictional interaction therebetween.

The bore may be a smooth circularly cylindrical or substantially cylindrical bore.

Each of the above inhalers in accordance with aspects of the present invention may have a medicament canister mounted thereto.

The canister may comprise a pressurised metered dose canister having a reciprocally movable stem extending therefrom and movable into a main canister portion thereof for releasing a metered dose of medicament under pressure, for example by operating a metered dose valve inside the canister body. The canister may be operable by pressing by hand on the main canister body.

In cases in which one or more support rails or inner wall support formations are provided, the canister may at all times when within the canister chamber have a clearance of about 0.25 to 0.35 mm from the first inner wall support formation. The clearance may be almost exactly 0.3 mm. This clearance which may apply to the canister body itself or to the canister once a label has been applied, is enough to allow smooth motion of the canister in the inhaler while at the same time preventing substantial rocking of the canister which could result in inaccurate counting by a dose counter of the inhaler, especially when lower face of the canister is arranged to engage an actuator member of the dose counter for counting purposes.

According to a further aspect of the invention, a method of assembling a dose counter for an inhaler comprises the steps of providing a tape with dosing indicia thereon; providing tape positioning indicia on the tape; and stowing the tape while monitoring for the tape positioning indicia with a sensor. The method advantageously permits efficient and accurate stowing of the tape, e.g. by winding.

The dosing indicia may be provided as numbers, the tape positioning indicia may be provided as one or more lines across the tape. The stowing step comprises winding the tape onto a bobbin or shaft, and, optionally, stopping winding when the positioning indicia are in a predetermined position. The tape may be provided with pixelated indicia at a position spaced along the tape from the positioning indicia. The tape may also be provided with a priming dot.

According to a further aspect of the invention, a tape system for a dose counter for an inhaler has a main elongate tape structure, and dosing indicia and tape positioning indicia located on the tape structure. The tape positioning indicia may comprise at least one line extending across the tape structure. The tape system may comprise pixelated indicia located on the tape structure and spaced from the positioning indicia. The tape system may comprise a priming dot located on the tape structure. The positioning indicia may be located between the timing dot and the pixelated indicia. The main elongate tape structure may have at least one end thereof wound on a bobbin or shaft.

A further aspect of the invention provides a method of designing an incremental dose counter for an inhaler comprising the steps of calculating nominal canister fire and dose counter positions for a dose counter actuator of the inhaler; calculating a failure/success rate for dose counters built to tolerance levels for counting each fire of inhalers in which the dose counter actuators may be applied; and selecting a tolerance level to result in said failure/success rate to be at or below/above a predetermined value. This is highly advantageous in that it allows an efficient and accurate prediction of the reliability of a series of inhaler counters made in accordance with the design.

The method of designing may include selecting the failure/success rate as a failure rate of no more than one in 50 million. The method of designing may include setting an average count position for dose counters built to the tolerances to be at or after an average fire position thereof during canister firing motion. The method of designing may include setting the average count position to be about 0.4 to 0.6 mm after the average fire position, such as about 0.48 mm after. The method of designing may include setting tolerances for the standard deviation of the fire position in dose counters built to the tolerances to be about 0.12 to 0.16 mm, such as about 0.141 mm. The method of designing may include setting tolerances for the standard deviation of the count positions in dose counters built to the tolerances to be about 0.07 to 0.09 mm, such as about 0.08 mm. A further aspect of the invention provides a computer implemented method of designing an incremental dose counter for an inhaler which includes the aforementioned method of designing.

A further aspect of the invention provides a method of manufacturing in a production run a series of incremental dose counters for inhalers which comprises manufacturing the series of dose counters in accordance with the aforementioned method of designing.

A further aspect of the invention provides a method of manufacturing a series of incremental dose counters for inhalers, which comprises manufacturing the dose counters with nominal canister fire and dose count positions of a dose counter actuator relative to a dose counter chassis (or inhaler main body), and which includes building the dose counters with the average dose count position in the series being, in canister fire process, at or after the average canister fire position in the series.

According to a further aspect of the invention, the method provides fitting each dose counter in the series of incremental dose counters to a corresponding main body of an inhaler.

These aspects advantageously provide for the production run of a series of inhalers and dose counters which count reliably in operation.

According to a further aspect of the invention, an incremental dose counter for a metered dose inhaler has a body arranged to retain a canister for movement of the canister relative thereto, the incremental dose counter having a main body, an actuator arranged to be driven and to drive an incremental output member in a count direction in response to canister motion, the actuator being configured to restrict motion of the output member in a direction opposite to the count direction. This advantageously enables an inhaler dose counter to keep a reliable count of remaining doses even if dropped or otherwise jolted.

The output member may comprise a ratchet wheel. The actuator may comprise a pawl and in which the ratchet wheel and pawl are arranged to permit only one-way ratcheting motion of the wheel relative to the pawl. The dose counter may include an anti-back drive member fixed to the main body. In a rest position of the dose counter, the ratchet wheel is capable of adopting a configuration in which a back surface of one tooth thereof engages the anti-back drive member and the pawl is spaced from an adjacent back

surface of another tooth of the ratchet wheel without positive drive/blocking engagement between the pawl and wheel.

BRIEF DESCRIPTION OF THE DRAWINGS

The present invention may be carried out in various ways and preferred embodiment of a dose counter, inhaler and methods of assembly, design and manufacture will now be described with reference to the accompanying drawings in which:

FIG. **1** is an isometric view of a main body of an embodiment of an inhaler related to the invention together with a mouthpiece cap therefor;

FIG. **2** is a top plan view of the components as shown in FIG. **1**;

FIG. **3**A is a section on the plane **3**A-**3**A in FIG. **2**;

FIG. **3**B is a view corresponding to FIG. **3**A but with a dose counter fitted to the main body of the inhaler;

FIG. **4**A is an exploded view of the inhaler main body, mouthpiece cap, dose counter and a dose counter window;

FIG. **4**B is a view in the direction **4**B in FIG. **4**C of a spring retainer of the dose counter;

FIG. **4**C is a top view of the spring retainer of FIG. **4**B;

FIG. **5** is a bottom view of the assembled inhaler main body, mouthpiece cap, dose counter and dose counter window;

FIGS. **6**A, **6**B, **6**C, **6**D, **6**E, **6**F, **6**G and **6**H are various views of dose counter components of the inhaler;

FIGS. **7**A and **7**B are sectional views showing canister clearance inside the main body of the inhaler;

FIG. **7**C is a further sectional view similar to that of FIG. **7**B but with the canister removed;

FIG. **7**D is a top plan view of the inhaler main body;

FIGS. **8**A, **8**B, **8**C and **8**D show the inhaler main body and dose counter components during assembly thereof;

FIG. **9** shows a sectional side view of a datum line for an actuator pawl of the dose counter;

FIGS. **10**A, **10**B, **10**C, **10**D, **10**E and **10**F show various side views of positions and configurations of the actuator pawl, a ratchet wheel, and a count pawl;

FIG. **11** shows distributions for tolerances of start, reset, fire, count and end positions for the actuator of the dose counter;

FIG. **12** is an enlarged version of part of FIG. **4**A;

FIG. **13** shows an end portion of a tape of the dose counter;

FIG. **14** shows a computer system for designing the dose counter;

FIG. **15** is an isometric view of a stock bobbin modified in accordance with the present invention for use in the dose counter of the inhaler of FIGS. **1** to **14**;

FIG. **16** shows an end view of the stock bobbin of FIG. **15**;

FIG. **17** is a section through a longitudinal axis of the stock bobbin of FIGS. **15** and **16**;

FIGS. **18**A, **18**B and **18**C are views of the stock bobbin of FIGS. **15** to **17** mounted in the dose counter chassis of FIGS. **1** to **14**, with the control elements of the forks of the second shaft (or split pin) having a profile slightly different to that in FIG. **6**F, with the forks in a compressed configuration;

FIGS. **19**A, **19**B and **19**C are views equivalent to FIGS. **18**A to **18**C but with the forks in a more expanded configuration due to a different rotational position of the stock bobbin;

FIG. **20** is an isometric view of the chassis assembled and including the stock bobbin of FIGS. **15** to **17** but excluding the tape for reasons of clarity;

FIG. **21** is a view of a preferred embodiment of a dry powder inhaler in accordance with the present invention;

FIG. **22** is an exploded view of the inhaler of FIG. **21**;

FIG. **23** is a view of a dose counter of the inhaler of FIG. **21**;

FIG. **24** is an exploded view of the dose counter shown in FIG. **23**;

FIG. **25** is an exploded view of parts of the inhaler of FIG. **21**; and

FIG. **26** is a view of a yoke of the inhaler of FIG. **21**.

DETAILED DESCRIPTION OF THE INVENTION

FIG. **1** shows a main body **10** of a manually operated metered dose inhaler **12** in accordance with an embodiment related to the present invention and having a mouthpiece cap **14** securable over a mouthpiece **16** of the main body.

The main body has a canister chamber **18** into which a canister **20** (FIG. **7**A) is slideable. The canister **20** has a generally cylindrical main side wall **24**, joined by a tapered section **26** to a head portion **28** having a substantially flat lower face **30** which has an outer annular drive surface **32** arranged to engage upon and drive an actuation pin **34** of a dose counter **36** as will be described. Extending centrally and axially from the lower face **30** is a valve stem **38** which is arranged to sealingly engage in a valve stem block **40** of the main body **10** of the inhaler **12**. The valve stem block **40** has a passageway **42** leading to a nozzle **44** for directing the contents of the canister **20**, namely active drug and propellant, towards an air outlet **46** of the inhaler main body **12**. It will be appreciated that due to gaps **48** between the canister **20** and an inner wall **50** of the main body **10** of the inhaler **12** an open top **52** of the main body **10** forms an air inlet into the inhaler **12** communicating via air passageway **54** with the air outlet **46**, such that canister contents exiting nozzle **44** mix with air being sucked by the user through the air passageway **54** in order to pass together through the air outlet and into the mouth of the user (not shown).

The dose counter **36** will now be described. The dose counter **36** includes an actuation pin **34** biased upwardly from underneath by a return spring **56** once installed in the main body **10**. As best shown in FIGS. **4**A, **6**H and **8**A, the pin **34** has side surfaces **58**, **60** arranged to slide between corresponding guide surfaces **62**, **64** located in a dose counter chamber **66** of the main body **10**, as well as an end stop surface **68** arranged to engage a corresponding end stop **70** formed in the dose counter chamber **66** to limit upward movement of the pin **34**. The pin **34** has a top part **72** which is circularly cylindrical and extends through an aperture **74** formed through a separator wall **76** which separates the canister chamber **18** from the dose counter chamber **66**. The top part **72** of the pin **34** has a flat top surface **78** which is arranged to engage the outer annular drive surface **32** of the canister **20**.

The actuation pin **34** is integrally formed with a drive or actuator pawl **80**. The actuator pawl **80** has a generally inverted U-shape configuration, having two mutually spaced and parallel arms **82**, **84** extending from a base portion of the actuation pin **34**, each holding at respective distal ends **88** thereof opposite ends of a pawl tooth member **90** which extends in a direction substantially perpendicular to the arms **82**, **84**, so as to provide what may be considered a "saddle" drive for pulling on each of the 11 drive teeth **92** of a ratchet wheel **94** of an incremental drive system **96** or ratchet mechanism **96** of the dose counter **36**. As shown for example in FIG. **10**B, the pawl tooth member **90** has a sharp lower

longitudinal side edge **98** arranged to engage the drive teeth **92**, the edge-to-surface contact provided by this engagement providing very accurate positioning of the actuator pawl **80** and resultant rotational positioning of the ratchet wheel **94**.

The dose counter **36** also has a chassis preassembly **100** which, as shown in FIGS. **4**A and **6**A, includes a chassis **102** having a first shaft **104** receiving the ratchet wheel **94** which is secured to a tape reel shaft **106**, and a second shaft (or split pin) **108** which is parallel to and spaced from the first shaft **104** and which slidably and rotationally receives a tape stock bobbin **110**.

As shown in FIG. **6**B, when the inhaler has not been used at all, the majority of a tape **112** is wound on the tape stock bobbin **110** and the tape **112** has a series of regularly spaced numbers **114** displayed therealong to indicate a number of remaining doses in the canister **20**. As the inhaler is repeatedly used, the ratchet wheel **94** is rotated by the actuator pawl **80** due to operation of the actuation pin **34** by the canister **20** and the tape **112** is incrementally and gradually wound on to the tape reel shaft **106** from the second shaft **108**. The tape **112** passes around a tape guide **116** of the chassis **102** enabling the numbers **114** to be displayed via a window **118** in a dose counter chamber cover **120** having a dose marker **132** formed or otherwise located thereon.

As shown in FIGS. **6**A and **6**D, the second shaft **108** is forked with two forks **124**, **126**. The forks **124**, **126** are biased away from one another. The forks have located thereon at diametrically opposed positions on the second shaft **108** friction or control elements **128**, **130**, one on each fork. Each control element extends longitudinally along its respective fork **124**, **126** and has a longitudinally extending friction surface **132**, **134** which extends substantially parallel to a longitudinal axis of the second shaft and is adapted to engage inside a substantially cylindrical bore **136** inside the tape stock bobbin **110**. This control arrangement provided between the bore **136** and the control elements **128**, **130** provides good rotational control for the tape stock bobbin **110** such that it does not unwind undesirably such as when the inhaler is dropped. The tape force required to unwind the tape stock bobbin **110** and overcome this friction force is approximately 0.1 N.

As can be seen in FIG. **6**D, as well as FIGS. **6**G and **10**A to **10**F, the chassis **102** is provided with an anti-back drive tooth **138** or count pawl **138** which is resiliently and substantially fixedly mounted thereto. As will be described below and as can be seen in FIGS. **10**A to **10**F, when the actuation pin **34** is depressed fully so as to fire the metered valve (not shown) inside the canister **20**, the actuator pawl **80** pulls down on one of the teeth **92** of the ratchet wheel **94** and rotates the wheel **94** anticlockwise as shown in FIG. **6**D so as to jump one tooth **92** past the count pawl **138**, thereby winding the tape **112** a distance incrementally relative to the dose marker **122** on the dose counter chamber **120** so as to indicate that one dose has been used.

With reference to FIG. **10**B, the teeth of the ratchet wheel **94** have tips **143** which are radiused with a 0.1 mm radius between the flat surfaces **140**, **142**. The ratchet wheel **94** has a central axis **145** which is 0.11 mm above datum plane **220** (FIG. **9**). A top/nose surface **147** of the anti-back drive tooth **138** is located 0.36 mm above the datum plane **220**. The distance vertically (i.e. transverse to datum plane **220**—FIG. **9**) between the top nose surface **147** of the anti-back drive tooth is 0.25 mm from the central axis **145** of the wheel **94**. Bump surface **144** has a lateral extent of 0.20 mm, with a vertical length of a flat **145'** thereof being 1 mm, the width of the bump surface being 1.22 mm (in the direction of the axis **145**), the top **149** of the bump surface **144** being 3.02 mm vertically below the axis **145**, and the flat **145'** being spaced a distance sideways (i.e. parallel to the datum plane **220**) 2.48 mm from the axis **145**. The top surface **78** of the pin **34** (FIG. **6**H) is 11.20 mm above the datum plane **220** (FIG. **9**) when the actuator pawl **80** and pin **34** are in the start configuration. The length of the valve stem **22** is 11.39 mm and the drive surface **32** of the canister **20** is 11.39 mm above the datum plane **220** when the canister is at rest waiting to be actuated, such that there is a clearance of 0.19 mm between the canister **20** and the pin **34** in this configuration.

FIGS. **10**A and **10**B show the actuator pawl **80** and ratchet wheel **94** and count pawl **138** in a start position in which the flat top **78** of the pin **34** has not yet been engaged by the outer annular drive surface **32** of the canister **20** or at least has not been pushed down during a canister depression.

In this "start" position, the count pawl **138** engages on a non-return back surface **140** of one of the teeth **92** of the ratchet wheel **94**. The lower side edge **98** of the actuator pawl is a distance "D" (FIG. **9**) 1.33 mm above datum plane **220** which passes through bottom surface or shoulder **41** of valve stem block **40**, the datum plane **220** being perpendicular to a main axis "X" of the main body **10** of the inhaler **12** which is coaxial with the centre of the valve stem block bore **43** and parallel to a direction of sliding of the canister **20** in the main body **10** of the inhaler **12** when the canister is fired.

As shown in FIG. **10**B, an advantageous feature of the construction is that the pawl tooth/actuator **90** acts as a supplementary anti-back drive member when the inhaler **12** is not being used for inhalation. In particular, if the inhaler **12** is accidentally dropped, resulting in a jolt to the dose counter **36** then, if the wheel **94** would try to rotate clockwise (backwards) as shown in FIG. **10**B, the back surface **140** of a tooth will engage and be blocked by the tooth member **90** of the pawl **80**. Therefore, even if the anti-back drive tooth **138** is temporarily bent or overcome by such a jolt, undesirable backwards rotation of the wheel **94** is prevented and, upon the next canister firing sequence, the pawl **90** will force the wheel **94** to catch up to its correct position so that the dose counter **36** continues to provide correct dosage indication.

FIG. **10**C shows a configuration in which the actuator pawl **80** has been depressed with the pin **34** by the canister **20** to a position in which the side edge **98** of the pawl tooth member **90** is just engaged with one of the teeth **92** and will therefore upon any further depression of the pin **34** begin to rotate the wheel **94**. This is referred to as a "Reset" position or configuration. In this configuration, the lower side edge **98** of the actuator **80** is 0.64 mm above the datum plane **220**.

FIG. **10**D shows a configuration in which the actuator pawl **80** has been moved to a position lower than that shown in FIG. **10**C and in which the metered dose valve (not shown) inside the canister has at this very position fired in order to eject active drug and propellant through the nozzle **44**. It will be noted that in this configuration the count pawl **138** is very slightly spaced from the back surface **140** of the same tooth **92** that it was engaging in the configuration of FIG. **10**D. The configuration shown in FIG. **10**D is known as a "Fire" configuration. In this configuration the lower side edge **98** of the actuator **80** is 0.47 mm below the datum plane **220**.

FIG. **10**E shows a further step in the sequence, called a "Count" position in which the actuator pawl **80** has rotated the ratchet wheel **94** by the distance circumferentially angularly between two of the teeth **92**, such that the count pawl **138** has just finished riding along a forward surface **142** of one of the teeth **92** and has resiliently jumped over the tooth

into engagement with the back surface **140** of the next tooth. Accordingly, in this "Count" configuration, a sufficiently long stroke movement of the pin **34** has occurred that the tape **112** of the dose counter **36** will just have counted down one dose. In this configuration, the lower side edge **98** of the actuator is 0.95 mm below the datum plane **220**. Accordingly, in this position, the actuator **80** generally, including edge **98**, is 0.48 mm lower than in the fire configuration. It has been found that, although the count configuration happens further on than the fire configuration, counting is highly reliable, with less than 50 failed counts per million. This is at least partially due to momentum effects and to the canister releasing some back pressure on the user in some embodiments as its internal metering valve fires.

In the configuration of FIG. **10**F, the pawl **80** has been further depressed with the pin **34** by the canister **20** to a position in which it is just disengaging from one of the teeth **92** and the actuator pawl **80** is assisted in this disengagement by engagement of one of the arms **84** with a bump surface **144** on the chassis **102** (see FIG. **6**G) and it will be seen at this point of disengagement, which is called an "End" configuration, the count pawl **138** is positioned exactly halfway or substantially halfway between two of the drive teeth **92**. This advantageously means therefore that there is a minimum chance of any double counting or non-counting, which would be undesirable. In the end configuration, the side edge **98** of the actuator is 1.65 mm below the datum plane **220**. It will be appreciated that any further depression of the actuator pawl **80** and pin **34** past the "End" configuration shown in FIG. **10**F will have no effect on the position of the tape **112** displayed by the dose counter **36** since the actuator pawl **80** is disengaged from the ratchet wheel **94** when it is below the position shown in FIG. **10**F.

As shown in FIGS. **7**C and **7**D, the inner wall **50** of the main body **10** is provided with a two-step support rail **144** which extends longitudinally along inside the main body and is located directly adjacent the aperture **74**. As shown in FIG. **7**B a diametrically opposed two-step support rail **146** is also provided and this diametrically opposed in the sense that a vertical plane (not shown) can pass substantially directly through the first rail **144**, the aperture **74**, a central aperture **148** of the valve stem block **40** (in which canister stem **25** is located) and the second two-step support rail **146**. As shown in FIG. **7**A and schematically in FIG. **7**B, the rails **144**, **146** provide a maximum clearance between the canister **20** and the rails **144**, **146** in a radial direction of almost exactly 0.3 mm, about 0.25 to 0.35 mm being a typical range. This clearance in this plane means that the canister **20** can only rock backwards and forwards in this plane towards away from the actuation pin **34**. A relatively small distance and this therefore prevents the canister wobbling and changing the height of the actuation pin **34** a as to undesirably alter the accuracy of the dose counter **36**. This is therefore highly advantageous.

The inner wall **50** of the main body **10** is provided with two further two-step rails **150** as well as two pairs **152**, **154** of rails extending different constant radial amounts inwardly from the inner wall **50**, so as to generally achieve a maximum clearance of almost exactly 0.3 mm around the canister **20** for all of the rails **144**, **146**, **150**, **152**, **154** spaced around the periphery of the inner wall **50**, in order to prevent undue rocking while still allowing canister motion freely inside the inhaler **12**. It will be clear from FIG. **7**C for example that the two-step rails have a first portion near an outlet end **156** of the canister chamber **18**, the first portion having a substantially constant radial or inwardly-extending width, a first step **160** leading to a second portion **162** of the rail, the second portion **102** having a lesser radial or inwardly extending extent than the first portion **156**, and finally a second step **164** at which the rail merges into the main inner wall **50** main surface.

A method of assembling the inhaler **12** will now be described.

With reference to FIG. **8**A, the main body **10** of the inhaler **12** is formed by two or more plastics mouldings which have been joined together to the configuration shown.

As shown in FIG. **8**B, the actuator pawl **80** and pin **34** are translated forward into position into a pin receiving area **166** in the dose counter chamber **66** and the pin **34** and actuator **80** may then be raised until the pin **34** emerges through the aperture **74**.

Next, the return spring **56** may be inserted below the pin **34** and a generally cylindrical annular lower end **168** of the spring **56** may be moved by a tweezer or tweezer-like assembly tool (not shown) into engagement with a shelf **170** of a spring retainer **172** in the dose counter chamber **66**. The spring retainer **172** is U-shaped and the shelf **170** is U-shaped and has a recess **174** formed below it. As shown in FIGS. **4**B, **4**C and **12** shelf **170** includes three chamfer surfaces **176**, **178**, **180** arranged to assist in moving the lower end of the spring **168** into position onto the shelf using the assembly tool (not shown). Once the lower end of the spring **168** is in place, the assembly tool (not shown) can easily be removed at least partly via the recess **174** below the lower end **168** of the spring **56**.

The tape **112** is attached at one end (not shown) to the tape stock bobbin **110** and is wound onto the bobbin by a motor **200** (FIG. **13**) having a hexagonal output shaft **202** which engages in a hexagonal socket **204** (FIG. **6**B) of the bobbin. During winding, the tape is monitored by a sensor **206**, which may be in the form of a camera or laser scanner, which feeds data to a computer controller **205** for the motor **200**. The controller **205** recognises three positioning markers **210** in the form of lines across the tape **112** and stops the motor **202** when the tape **112** is nearly fully wound onto the bobbin **110**, such that the distal end **212** of the tape **112** can be secured, e.g. by adhesive, to the tape reel shaft **106**. The controller **205** also recognises a pixelated tape size marker **214** observed by the sensor **206** and logs in a stocking system data store **217** details of the tape **112** such as the number of numbers **114** on the tape, such as one hundred and twenty or two hundred numbers **114**. Next, the tape reel shaft is wound until an appropriate position of the lines **210** at which a priming dot **216** will, once the bobbin **110** and reel shaft **106** are slid onto the second shaft **108** and second shaft **104**, be in a position to be located in the window **118** when the inhaler **12** is fully assembled. In the embodiments, the bobbin **110** and reel shaft **106** may be slid onto the shafts **108**, **104** before the tape **112** is secured to the reel shaft **106** and the reel shaft may then be wound to position the priming dot **216**.

Next, the assembled dose counter components of the chassis preassembly **100** shown in FIG. **6**B may as shown in FIG. **8**C be inserted into the dose counter chamber **66**, with pins **182**, **184**, **186** formed on the main body **10** in the dose counter chamber **66** passing through apertures or slots **188**, **190**, **192** formed on the chassis **102**, such that the pins **182**, **184**, **186** extend through (or at least into) the apertures or slots **188**, **190**, **192**. With the chassis **102** being relatively firmly pushed towards the main body **10**, the pins **182**, **184**, **186** are then heat staked and the chassis **102** is therefore after this held very firmly in position in the main body and is unable to move, thereby assisting in providing great accuracy for the dose counter **36**. Next, as shown in FIG. **8**D, the

dose counter chamber **120** may be fitted over the dose counter chamber **66** and may be secured in place such as by welding, with the priming dot **216** being displayed through the window.

The user can, when readying the inhaler **12** for first use, prime the inhaler by depressing the canister **20** three times which will bring the first number **114** on the tape into display through the window **118** in place of the priming dot **216**, the number **114** shown in FIG. **8**D being "200", thereby indicating that 200 doses are remaining to be dispensed from the canister **20** and inhaler **12**.

As shown in FIG. **8**D, and in FIG. **5**, an open drain hole **194** is provided at the bottom of the dose counter chamber **66** by a substantially semi-circular cut-out or recess formation **196** in a lower surface **198** of the main body **10** of the inhaler. Accordingly, if the user (not shown) should decide to wash the main body **10** of the inhaler, for example after encountering an unhygienic situation or simply as a matter of choice, the drain hole **194** allows initial draining of water from inside the dose counter chamber **66** and also thereafter evaporation of water or any aqueous matter in the dose counter chamber **66** so that the window **118** does not mist up undesirably.

FIG. **14** shows a computer system **230** for designing the dose counter **36** and in particular for calculating distributions representative of average positions and standard deviations in a production series of inhalers of the start, reset, fire, count and end positions of the actuator lower side edge **98** relative to the datum plane **220** (FIG. **9**) and therefore of the actuator pawl **80** generally relative to the ratchet wheel **94**, chassis **102** and, when the inhaler **12** is fully assembled, the main body **10** of the inhaler **12**. The computer system **230** includes a data store **232**, a CPU **234**, an input device **236** (such as a keyboard or communication port) and an output device **238** (such as a communications port, display screen and/or printer). A user may enter data via the input device **236** which may be used by the CPU **234** in a mathematical calculation to predict count failure rates when the various dose counters are to be built in a series with dose counter positions set with given averages and standard deviations and taking into account any momentum/inertia effects and metering valve user-back-pressure reduction effect which will occur upon canister firing of a given type of canister. The computer system **230** is thus mathematically used to design the distributions. For the inhaler **12** described herein with the dose counter **36** and canister **20**, the distributions are designed as shown in FIG. **11**. The x axis shows distance of the lower side surface **98** of the actuator **80** above the datum plane **220** and the y axis is representative of the distribution. Thus, curve **240** shows that the start configuration has an average 1.33 mm above the datum plane **200** (standard deviation is 0.1 mm), curve **242** shows that the reset configuration has an average of 0.64 mm above the datum plane **220** (standard deviation is 0.082 mm), curve **244** shows the fire configuration has an average 0.47 mm below the datum plane **220** (standard deviation is 0.141 mm), curve **246** shows the count configuration has an average 0.95 mm below the datum plane **220** (standard deviation is 0.080 mm), and curve **248** shows the end configuration has an average of 1.65 mm below the datum plane **220** (standard deviation is 0.144 mm).

FIGS. **15** to **20** show a version of the inhaler modified in accordance with the present invention. In these drawings, the same reference numerals have been used to those in the earlier drawings to denote the equivalent components. The inhaler **12** is the same as that in FIGS. **1** to **14** apart from the following modifications.

First, it can be seen that there is a modification in that the drive teeth **92** of the ratchet wheel **94** have a different profile to that in FIGS. **1** to **14**. There are also only nine ratchet teeth **94** in this embodiment instead of eleven.

Additionally, as shown in FIGS. **18**C and **19**C, the control elements **128**, **130** on the forks **124**, **126** of the second shaft **108** have a tapered profile which is different to the profile of the control elements **128**, **130** shown in FIG. **6**F. Either profile can be used in the embodiment of FIGS. **15** to **20** however.

Furthermore, as shown in FIG. **15**, the tape stock bobbin **110** has an inwardly facing generally cylindrical engagement surface **300** with a wavelike form extending partially therealong. The engagement surface **300** has a cross-section **301** perpendicular to the longitudinal length of the stock bobbin **110** which is constant therealong. This cross-section **301** can be seen in FIG. **16** and consists of a series of ten regularly spaced concavities **302** and ten convex wall portions **304**. The convex wall portions **304** are equi-spaced between the concavities **302**. Each concavity **302** has a radius of 0.2 mm. Each convex wall portion **304** also has a radius of 0.2 mm. Finally, the cross section **301** also includes flat wall portions **306** between all of the radiused wall portions of the concavities **302** and convex wall portions **304**. The geometry of the cross-section **301** is therefore defined by the radii of the concavities **302** and convex wall portions **304**, the flat wall portions **306** and the fact that there are ten concavities **302** and convex wall portions **304**.

The minor diameter of the engagement surface **300**, i.e. between the tips of opposite convex wall portions **304**, is 2.46 mm. The major diameter of the engagement surface **300**, i.e. between the outermost portions of the concavities **302**, is 2.70 mm. The undeformed tip to tip maximum diameter of the forks **124**, **126** of the split pin (the second shaft) **108**, i.e. in the region of the maximum radio extent of the control elements **128**, **130**, is 3.1 millimetres and it will therefore be appreciated that the forks **124**, **126** are resiliently compressed once the stock bobbin **110** has been assembled onto the split pin **108** in all rotational configurations of the stock bobbin **110** relative to the split pin **108**. The minimum gap between the forks **124**, **126** in the plane of the cross sections of FIGS. **18**C and **19**C is 1 mm when the split pin **108** is in the undeformed, pre-inserted state. When the split pin **108** is at maximum compression, as shown in FIGS. **18**A to **18**C when the control elements **128**, **130** are shown to be engaged on top of the convex wall portions **304**, the gap **308** between the tips **310**, **312** of the forks **124**, **126** is 0.36 mm. On the other hand, when the split pin **108** is at minimum compression (once inserted into the stock bobbin) as shown in FIGS. **19**A to **19**C, when the control elements **128**, **130** rest in the concavities **302**, the gap between the tips **310**, **312** of the forks **124**, **126** is 0.6 mm. The control elements **128**, **130** are outwardly radiused with a radius also of 0.2 mm such that they can just rest on the concavities **302** with full surface contact (at least at an axial location on the split pin where the tapered control elements are at their maximum radial extent), without rattling in, locking onto or failing to fit in the concavities **302**. The radii of the control elements **128**, **130** is therefore preferably substantially the same as the radii of the concavities **302**

It will be appreciated that whereas FIGS. **18**B and **19**B are end views along the coaxial axis of the stock bobbin **110** and split pin **108**, FIGS. **18**A and **19**A are cross-sections. FIG. **19**A is a section on the plane A-A' in FIG. **19**C and FIG. **18**A is a section at the same plane, but of course with the stock bobbin **110** rotated relative to the split pin **108**.

As the inhaler **12** is used and the ratchet wheel **94** rotates in order to count used doses, the stock bobbin rotates incrementally through rotational positions in which rotation is resisted, i.e. due to increasing compression of the split pin **108** at such rotational positions, and rotational positions in which rotation is promoted, i.e. due to decreasing compression of the split pin **108** at such rotational positions and this may involve a click forward of the stock bobbin **110** to the next position equivalent to that in FIGS. **19**A to **19**C in which the control elements **128**, **130** of the split pin art located in the concavities **302**. This functionality firstly allows the stock bobbin to unwind during use as required, but also prevents the tape **112** from loosening during transit if the inhaler **12** is dropped, such as onto a hard surface. This is highly advantageous, since the tape **11** is prevented from moving to a position in which it will give an incorrect reading regarding the number of doses in the canister.

During compression and expansion of the forks in the radial direction between the two configurations shown in FIGS. **18**C and **19**C, the forks **124**, **126** rotate about a point **316** on the split pin where the forks **124**, **126** come together. This rotational action means that there is a camming action between the forks **124**, **126** and the engagement surface **300** without significant friction but, nevertheless, the resilient forces provided by the regulator formed by the engagement surface **300** and forks **124**, **126** are able to regulate unwinding of the tape such that it does not easily occur during transit or if the inhaler **12** is dropped. It has been found during testing that a force of 0.3 to 0.4 N needs to be applied to the tape **112** to overcome the regulator at the stock bobbin **110**. 0.32 N is achieved with the control elements **128** having the profile shown in FIG. **19**C and 0.38 N is achieved with the profile of the control elements **128** altered to be as shown as described with reference to FIG. **6**F. These forces are substantially higher than the 0.1 N force mentioned above and undesirable movement of the tape is substantially avoided even if the inhaler is dropped onto a hard surface. The modified arrangement of FIGS. **15** to **20** does not provide this force "constantly" such that there is overall not an undesirably high friction of the tape **112** as it passes over the other components of the dose counter because, due to the incremental nature of the resilient forces at the regulator, the tape **112** can incrementally relax as it slides over the stationary chassis components.

Instead of having ten concavities **302** and convex wall portions **304**, other numbers may be used, such as 8 or 12. However, it is preferred to have an even number, especially since two control elements **128**, **130** are provided, so that all of the control elements **128**, **130** will expand and contract simultaneously. However, other arrangements are envisaged with 3 or more forks and the number of concavities/convex wall portions may be maintained as an integer divisible by the number of forks to maintain a system with simultaneous expansion/contraction. For example, the use of 9, 12 or 15 concavities/convex wall portions with 3 forks is envisaged.

Instead of having the engagement surface **300** on the inside of the stock bobbin **110**, it could be placed on the outside of the stock bobbin **110** so as to be engaged by flexible external legs/pawls or similar.

It will be noted that the regulator provided by the engagement surface **300** and forks **124**, **126** does not only allow rotation of the stock bobbin in one direction as is the case with the ratchet wheel **94**. Rotation in both directions is possible, i.e. forwards and backwards. This means that during assembly, the stock bobbin **110** can be wound backwards during or after fitting the bobbin **100**, shaft **106** and tape **112** onto the carriage **102**, if desired.

The stock bobbin **110** and the carriage **102** including the split pin **108** are both moulded of polypropylene material.

It will be seen from FIG. **16** that the cross-sectional shape **301** is not symmetrical within the hexagonal socket **204**. This has enabled the hexagonal socket **204** to be maintained at a useful size while still allowing the desired size and geometry of the cross section **301** to fit without interfering with the hexagonal shape of the hexagonal socket **204** and also permits moulding to work during manufacture.

As shown in FIG. **17**, the stock bobbin **110** has a series of four circumferential ribs **330** inside it and a spaced thereabout. These hold the stock bobbin **110** on the correct side of the mould tool during moulding.

FIGS. **21** and **22** show a preferred embodiment in accordance with the invention of an inhaler **510** for dispensing a dry-powdered medicament in metered doses for patient inhalation. The inhaler **510** is as disclosed in FIGS. **1** to **16** or EP-A-1330280, the contents of which are hereby fully incorporated herein by reference, but with the stock bobbin **110** and second shaft **108** of the dose counter **516** modified so as to be as in FIGS. **15** to **20** hereof. Thus, the dry powder inhaler **510** generally includes a housing **518**, and an assembly **512** received in the housing (see FIG. **21**). The housing **518** includes a case **520** having an open end **522** and a mouthpiece **524** (FIG. **25**) for patient inhalation, a cap **526** secured to and closing the open end **522** of the case **520**, and a cover **528** pivotally mounted to the case **520** for covering the mouthpiece **524**. As shown in FIG. **22**, the inhaler **510** also includes an actuation spring **569**, first yoke **566** with opening **572**, bellows **540** with crown **574**, a reservoir **514**, second yoke **568** with hopper **542** and dose counter **516** mounted thereto, and case **520** has transparent window **5130** thereon for viewing dose counter tape indicia **5128**. The dose metering system also includes two cams **570** mounted on the mouthpiece cover **528** and movable with the cover **528** between open and closed positions. The cams **570** each include an opening **580** for allowing outwardly extending hinges **582** of the case **520** to pass therethrough and be received in first recesses **584** of the cover **528**. The cams **570** also include bosses **586** extending outwardly and received in second recesses **588** of the cover **528**, such that the cover **528** pivots about the hinges **582** and the cams **570** move with the cover **528** about the hinges **582**. As described in EP-A-1330280, cams **570** act upon cam followers **578** to move second yoke **568** up and down and thereby operate dose counter by engagement of pawl **5138** on the second yoke **568** with teeth **5136**. Remaining components of the inhaler are provided as, and operate as described, in EP-A-1330280.

The dose counting system **516** therefore includes a ribbon or tape **5128** (FIGS. **23** & **24**), having successive numbers or other suitable indicia printed thereon, in alignment with a transparent window **5130** provided in the housing **18** (see FIG. **22**). The dose counting system **516** includes the rotatable stock bobbin **110** (as described above), an indexing spool **5134** rotatable in a single direction, and the ribbon **5128** rolled and received on the bobbin **110** and having a first end **5127** secured to the spool **5134**, wherein the ribbon **5128** unrolls from the bobbin **110** so that the indicia are successively displayed as the spool **5134** is rotated or advanced. In FIGS. **23** and **24** the wavelike engagement surface **300** of the bobbin **110** is not shown for the purposes of clarity.

The spool **134** is arranged to rotate upon movement of the yokes **566**, **568** to effect delivery of a dose of medicament from reservoir **514**, such that the number on the ribbon **5128** is advanced to indicate that another dose has been dispensed by the inhaler **510**. The ribbon **5128** can be arranged such that the numbers, or other suitable indicia, increase or

decrease upon rotation of the spool **5134**. For example, the ribbon **5128** can be arranged such that the numbers, or other suitable indicia, decrease upon rotation of the spool **5134** to indicate the number of doses remaining in the inhaler **510**. Alternatively, the ribbon **5128** can be arranged such that the numbers, or other suitable indicia, increase upon rotation of the spool **5134** to indicate the number of doses dispensed by the inhaler **10**.

The indexing spool **5134** includes radially extending teeth **5136**, which are engaged by pawl **5138** extending from a cam follower **578** of the second yoke **568** upon movement of the yoke to rotate, or advance, the indexing spool **5134**. More particularly, the pawl **5138** is shaped and arranged such that it engages the teeth **5136** and advances the indexing spool **5134** only upon the mouthpiece cover **528** being closed and the yokes **566**, **568** moved back towards the cap **526** of the housing **518**.

The dose counting system **516** also includes a chassis **5140** that secures the dose counting system to the hopper **542** and includes shafts **108**, **5144** for receiving the bobbin **110** and the indexing spool **5134**. As described above with reference to FIGS. **1** to **20**, the bobbin shaft **108** is forked and includes radially nubs **5146** for creating a resilient resistance to rotation of the bobbin **110** on the shaft **108** by engaging with the wavelike engagement surface **300** inside the bobbin **110**. A clutch spring **5148** is received on the end of the indexing spool **5134** and locked to the chassis **5140** to allow rotation of the spool **5134** in only a single direction.

Various modifications may be made to the embodiment shown without departing from the scope of the invention as defined by the accompanying claims as interpreted under patent law.

What is claimed is:

1. A dose counter for an inhaler, the dose counter having a counter display arranged to indicate dosage information, a drive system arranged to move the counter display incrementally in a first direction from a first station to a second station in response to actuation input, wherein a regulator is provided which is arranged to act upon the counter display at the first station to regulate motion of the counter display at the first station to incremental movements.

2. The dose counter as claimed in claim **1** in which the counter display comprises a tape.

3. The dose counter as claimed in claim **2** in which the tape has dose counter indicia displayed thereon.

4. The dose counter as claimed in claim **2** wherein the first station comprises a first shaft, the tape being arranged on the first shaft and to unwind therefrom upon movement of the counter display.

5. The dose counter as claimed in claim **4** in which the first shaft is mounted for rotation relative to a substantially rotationally fixed element of the dose counter.

6. The dose counter as claimed in claim **5** in which the regulator comprises at least one projection on one of the first shaft and the substantially rotationally fixed element, which is arranged to engage incrementally with one or more formations on the other of the substantially rotationally fixed element and the first shaft.

7. The dose counter as claimed in claim **6** in which at least two said projections are provided.

8. The dose counter as claimed in claim **6** in which exactly two said projections are provided.

9. The dose counter as claimed in claim **6** in which each projection comprises a radiused surface.

10. The dose counter as claimed in claim **6** in which the at least one projection is located on the substantially rotationally fixed element which comprises a fixed shaft which is fixed to the main body of the dose counter, the first shaft being rotationally mounted to the fixed shaft.

11. The dose counter as claimed in claim **10** in which the fixed shaft has at least two flexible legs, and each leg has at least one said projection formed in an outwardly facing direction thereon, said one or more formations being formed on an inwardly facing engagement surface of the first shaft, said at least one projection being arranged to resiliently engage said one or more formations.

12. The dose counter as claimed in claim **10** in which the fixed shaft comprises a split pin with fork legs and in which each projection is located on a said fork leg.

13. The dose counter as claimed in claim **6** in which a series of said formations are provided.

14. The dose counter as claimed in claim **6** in which an even number of said formations is provided.

15. The dose counter as claimed in claim **6** in which from eight to twelve of said formations are provided.

16. The dose counter as claimed in claim **15** in which ten of said formations are provided.

17. The dose counter as claimed in claim **6** in which each said formation comprises a concavity formed on an engagement surface.

18. The dose counter as claimed in claim **17** in which each concavity comprises a radiused surface wall portion which merges on at least one side thereof into a flat wall portion surface.

19. The dose counter as claimed in claim **18** in which the engagement surface includes a series of said concavities and in which convex wall portions of the engagement surface are formed between each adjacent two said concavities, each said convex wall portion comprising a convex radiused wall portion.

20. The dose counter as claimed in claim **19** in which each convex radiused wall portion of each convex wall portion is connected by said flat wall portion surfaces to each concavity which is adjacent thereto.

21. The dose counter as claimed in claim **4** in which the first shaft comprises a substantially hollow bobbin.

22. The dose counter as claimed in claim **21** in which said one or more formations are located on an inner surface of the bobbin.

23. The dose counter as claimed in claim **4** wherein the drive system comprises a tooth ratchet wheel arranged to act upon a second shaft which is located at the second station, the second shaft being rotatable to wind the tape onto the second shaft.

24. The dose counter as claimed in claim **23** in which the second shaft is located on the main body of the dose counter spaced from and parallel to the first shaft.

25. The dose counter as claimed in claim **23** in which the tooth ratchet wheel is fixed to the second shaft and is arranged to rotate therewith.

26. The dose counter as claimed in claim **23** which includes an anti-back drive system which is arranged to restrict motion of the second shaft in a tape winding direction.

27. The dose counter as claimed in claim **1** in which the regulator provides a resistance force of greater than 0.1 N against movement of the counter display.

28. The dose counter as claimed in claim **27** in which the resistance force is greater than 0.3 N.

29. The dose counter as claimed in claim **27** in which the resistance force is from 0.3 to 0.4 N.

* * * * *

Exhibit E

US011395889B2

(12) **United States Patent**
Walsh et al.

(10) **Patent No.: US 11,395,889 B2**
(45) **Date of Patent: Jul. 26, 2022**

(54) **DOSE COUNTER FOR INHALER HAVING AN ANTI-REVERSE ROTATION ACTUATOR**

(71) Applicants: **Ivax Pharmaceuticals Ireland**, Waterford (IE); **Norton (Waterford) Limited**, Waterford (IE); **Teva Pharmaceuticals Ireland**, Waterford (IE)

(72) Inventors: **Declan Walsh**, County Kilkenny (IE); **Derek Fenlon**, County Wexford (IE); **Simon Kaar**, County Cork (IE); **Jan Geert Hazenberg**, County Kilkenny (IE); **Daniel Buck**, County Waterford (IE); **Paul Clancy**, Waterford (IE); **Robert Charles Uschold**, Leominster, MA (US); **Jeffrey A. Karg**, Hopkinton, MA (US)

(73) Assignees: **Ivax Pharmaceuticals Ireland**, Waterford (IE); **Norton (Waterford) Limited**, Waterford (IE); **Teva Pharmaceuticals Ireland**, Waterford (IE)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

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(Continued)

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G06M 1/24 (2006.01)
A61M 11/00 (2006.01)

(52) **U.S. Cl.**
CPC ***A61M 15/0078*** (2014.02); ***A61M 11/00*** (2013.01); ***A61M 15/007*** (2014.02);
(Continued)

(58) **Field of Classification Search**
CPC A61M 15/0078; A61M 15/0025; A61M 15/0026; A61M 15/007; A61M 15/0071;
(Continued)

(56) **References Cited**

U.S. PATENT DOCUMENTS

4,174,890 A 11/1979 Johnson
4,669,838 A 6/1987 Hibbard
(Continued)

FOREIGN PATENT DOCUMENTS

CA 2501726 9/2006
CN 1265601 9/2000
(Continued)

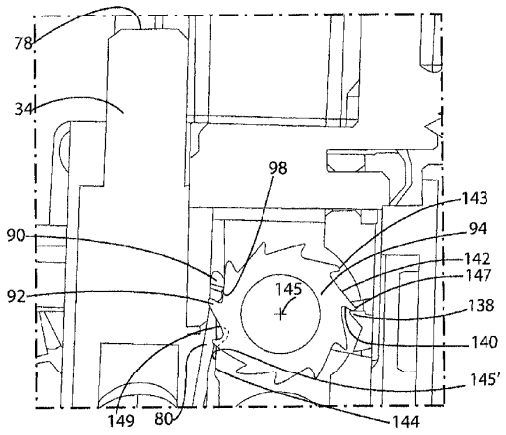
OTHER PUBLICATIONS

Advisory Action dated Mar. 13, 2017 for U.S. Appl. No. 14/699,567.
(Continued)

Primary Examiner — Daniel A Hess
(74) *Attorney, Agent, or Firm* — Morgan, Lewis & Bockius LLP

(57) **ABSTRACT**

An inhaler includes a main body having a canister housing, a medicament canister retained in a central outlet port of the canister housing, and a dose counter having an actuation member for operation by movement of the medicament canister. The canister housing has an inner wall, and a first inner wall canister support formation extending inwardly from a main surface of the inner wall. The canister housing
(Continued)



has a longitudinal axis X which passes through the center of the central outlet port. The first inner wall canister support formation, the actuation member, and the central outlet port lie in a common plane coincident with the longitudinal axis X such that the first inner wall canister support formation protects against unwanted actuation of the dose counter by reducing rocking of the medicament canister relative to the main body of the inhaler.

6 Claims, 17 Drawing Sheets

Related U.S. Application Data

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CPC ***A61M 15/009*** (2013.01); ***A61M 15/0025*** (2014.02); ***A61M 15/0026*** (2014.02); ***A61M 15/0065*** (2013.01); ***A61M 15/0071*** (2014.02); ***G06M 1/246*** (2013.01); *A61M 2202/064* (2013.01); *A61M 2205/6063* (2013.01); *A61M 2207/00* (2013.01); *A61M 2207/10* (2013.01); *Y10T 29/49* (2015.01); *Y10T 29/49764* (2015.01); *Y10T 29/49826* (2015.01)

(58) **Field of Classification Search**
CPC A61M 11/00; A61M 15/0065; A61M 15/009; G06M 1/246
USPC 128/203.12
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

4,687,359	A	8/1987	Barrus	
5,349,945	A	9/1994	Wass et al.	
5,482,030	A	1/1996	Klein	
5,861,911	A	1/1999	Oosaka	
6,142,339	A	11/2000	Blacker et al.	
6,446,627	B1 *	9/2002	Bowman	A61M 15/009 128/200.23
6,659,307	B1	12/2003	Stradella	
6,718,972	B2	4/2004	OLeary	
6,907,876	B1	6/2005	Clark et al.	
7,107,986	B2	9/2006	Rand et al.	
7,156,258	B2	1/2007	Eckert	
7,587,988	B2	9/2009	Bowman et al.	
7,661,423	B2	2/2010	Brand et al.	
7,819,075	B2	10/2010	Bowman et al.	
7,832,351	B2	11/2010	Bonney et al.	
8,418,690	B2	4/2013	Power	
8,459,253	B2	6/2013	Howgill	
8,474,448	B2	7/2013	Oi	
8,511,302	B2	8/2013	Parkes	
8,662,381	B2	3/2014	Kaar et al.	
8,978,966	B2	3/2015	Walsh et al.	
9,174,013	B2	11/2015	Walsh et al.	
9,216,261	B2	12/2015	Kaar et al.	
9,265,901	B2	2/2016	Lawrence et al.	
9,463,289	B2	10/2016	Walsh et al.	
9,533,111	B2	1/2017	Walsh et al.	
9,737,674	B2	8/2017	Walsh et al.	
9,808,587	B2	11/2017	Walsh et al.	
2002/0047021	A1	4/2002	Blacker	
2002/0078949	A1	6/2002	OLeary	
2002/0078950	A1	6/2002	OLeary	
2002/0084891	A1	7/2002	Mankins et al.	
2003/0209239	A1	11/2003	Rand	
2004/0089298	A1	5/2004	Haikarainen et al.	
2004/0095746	A1	5/2004	Murphy	
2005/0028815	A1	2/2005	Deaton	
2005/0087191	A1	4/2005	Morton	
2005/0126469	A1	6/2005	Lu	
2006/0096594	A1	5/2006	Bonney	
2006/0107949	A1	5/2006	Davies	
2006/0107979	A1	5/2006	Kim	
2007/0062518	A1	3/2007	Geser	
2007/0240712	A1	10/2007	Fleming et al.	
2007/0241025	A1	10/2007	Parkes	
2007/0246042	A1	10/2007	Purkins	
2008/0035144	A1	2/2008	Bowman et al.	
2008/0156321	A1	7/2008	Bowman et al.	
2008/0242465	A1	10/2008	Strobel	
2009/0178678	A1	7/2009	OLeary	
2010/0078490	A1	4/2010	Fenlon	
2010/0089395	A1	4/2010	Power	
2010/0218759	A1	9/2010	Anderson	
2011/0041845	A1	2/2011	Solomon	
2012/0006322	A1	1/2012	Anderson	
2012/0247458	A1	10/2012	Lawrence et al.	

FOREIGN PATENT DOCUMENTS

CN	1956448		5/2007
CN	101198972		6/2008
EP	1330280		7/2003
EP	1486227		12/2004
GB	2320489		6/1998
GB	2348928		10/2001
IL	201256		11/2014
JP	02502129		7/1990
JP	450059		8/1992
JP	07100205		4/1995
JP	10504220		4/1998
JP	2002528144		9/2002
JP	2004501685		1/2004
JP	2007534378		11/2007
JP	2008-94103	A	4/2008
JP	2008094103		4/2008
JP	2008261423		10/2008
JP	2009233308		10/2009
JP	2009257392		11/2009
JP	2010096308		4/2010
WO	8909078		10/1989
WO	9209324		6/1992
WO	9628205		9/1996
WO	9828033		7/1998
WO	9856444		12/1998
WO	9936115		7/1999
WO	01/28887		4/2001
WO	2001087391		11/2001
WO	02/00281	A2	1/2002
WO	03101514		12/2003
WO	2005060535		7/2005
WO	2005060917		7/2005
WO	2005102430		11/2005
WO	2006062449		6/2006
WO	2006062449	A1	6/2006
WO	2006110080		10/2006
WO	2007012861		2/2007
WO	2007062518		6/2007
WO	2008023019		2/2008
WO	2008119552		2/2008
WO	2008121459		10/2008
WO	2011012325		2/2011
WO	2011012327		2/2011

OTHER PUBLICATIONS

English Translation of Chinese Office Action, corresponds to CN201080041218.1.
English Translation of Chinese Office Action, corresponds to CN201080040988.4.
European Search report for EP Application No. 13004775.6.
European Search report for EP Application No. 13005367.1.
File History for U.S. Appl. No. 14/713,633.

(56) **References Cited**

OTHER PUBLICATIONS

Final OA for U.S. Appl. No. 13/387,532.
Final OA for U.S. Appl. No. 14/876,190.
International Search Report for PCT/EP10/04790.
International Search Report for PCT/EP10/04791.
International Search Report for PCT/EP10/04792.
Office Action issued by the Israel Patent Office dated Jul. 3, 2017 in reference to Israel Patent Application No. 247396, 3 pages.
Office Action issued by the Israel Patent Office dated Jul. 27, 2017 in reference to Israel Patent Application No. 247402, 4 pages.
Final Office Action dated Oct. 20, 2016 for U.S. Appl. No. 14/699,567.
Non-Final Office Action dated Jan. 12, 2017 for U.S. Appl. No. 14/713,620, 8 pages.
Final Rejection dated Sep. 27, 2016 for U.S. Appl. No. 14/699,578.
Final Office Action dated Aug. 31, 2016 for U.S. Appl. No. 14/713,620, 7 pages.
Advisory action dated Feb. 9, 2017 for U.S. Appl. No. 14/699,584.
Non-final rejection dated Jul. 12, 2016 for U.S. Appl. No. 14/713,643.
File History for U.S. Appl. No. 15/271,738.
File History for U.S. Appl. No. 15/269,102.
File History for U.S. Appl. No. 15/262,818.
File History for U.S. Appl. No. 15/289,553.
File History for U.S. Appl. No. 15/269,249.
Final rejection dated Oct. 20, 2016 or U.S. Appl. No. 14/699,584.
Non-Final Office Action dated Jun. 24, 2016 for U.S. Appl. No. 14/713,620, 7 pages.
Final rejection dated Oct. 20, 2016 or U.S. Appl. No. 14/713,633.
Advisory Action dated Mar. 16, 2017 or U.S. Appl. No. 14/713,633.
Entire patent prosecution history of U.S. Appl. No. 13/110,532, filed, May 18, 2011, entitled, "Dose Counters for Inhalers, Inhalers and Methods of Assembly Thereof.".
Entire patent prosecution history of U.S. Appl. No. 14/103,324, filed, Dec. 11, 2013, entitled, "Dose Counters for Inhalers, Inhalers and Methods of Assembly Thereof.".
Entire patent prosecution history of U.S. Appl. No. 14/103,343, filed, Dec. 11, 2013, entitled, "Dose Counters for Inhalers, Inhalers and Methods of Assembly Thereof.".
Entire patent prosecution history of U.S. Appl. No. 14/103,353, filed, Dec. 11, 2013, entitled, "Dose Counters for Inhalers, Inhalers and Methods of Assembly Thereof.".
Entire patent prosecution history of U.S. Appl. No. 14/103,363, filed, Dec. 1, 2013, entitled, "Dose Counters for Inhalers, Inhalers and Methods of Assembly Thereof.".
Entire patent prosecution history of U.S. Appl. No. 14/103,392, filed, Dec. 11, 2013, entitled, "Dose Counters for Inhalers, Inhalers and Methods of Assembly Thereof.".
Entire patent prosecution history of U.S. Appl. No. 14/699,567, filed, Apr. 29, 2015, entitled, "Dose Counter for Inhaler and Method for Counting Doses.".
Entire patent prosecution history of U.S. Appl. No. 14/699,578, filed, Apr. 29, 2015, entitled, "Dose Counter for Inhaler Having a Bore !And Shaft Arrangement.".
Entire patent prosecution history of U.S. Appl. No. 14/699,584, filed, Apr. 29, 2015, entitled, "Dose Counter for Inhaler Having an Antireverse Rotation Actuator.".
Entire patent prosecution history of U.S. Appl. No. 14/713,612, filed, May 15, 2015, entitled, "Dose Counters for Inhalers, Inhalers and Methods of Assembly Thereof.".
Entire patent prosecution history of U.S. Appl. No. 14/713,620, filed, May 15, 2015, entitled, "Dose Counters for Inhalers, Inhalers and Methods of Assembly Thereof.".
Entire patent prosecution history of U.S. Appl. No. 14/713,643, filed, May 15, 2015, entitled, "Dose Counters for Inhalers, Inhalers and Methods of Assembly Thereof.".
European Patent Office Communication, dated Apr. 24, 2014 of counterpart European Patent Application No. 11 010 211.8.
European Patent Office Communication, dated Apr. 24, 2014 of counterpart European Patent Application No. 11 010 212.6.
First Examination Report of counterpart New Zealand Patent Application No. 603466, dated Jul. 1, 2013.
File history for U.S. Appl. No. 13/387,508.
File history for U.S. Appl. No. 13/387,532.
File history for U.S. Appl. No. 13/388,535.
File history for U.S. Appl. No. 14/132,918.
File history for U.S. Appl. No. 14/876,190.
File history for U.S. Appl. No. 14/967,905.
Office Action, Israel Application No. IL263904 dated Sep. 14, 2021, 4 pgs.

* cited by examiner

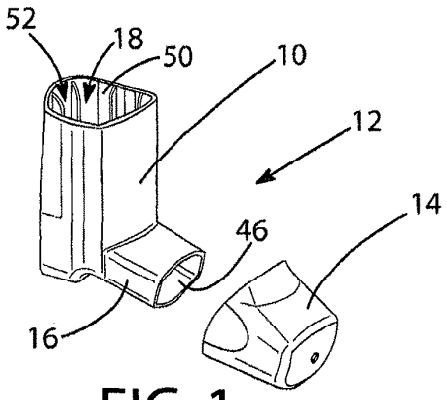


FIG. 1

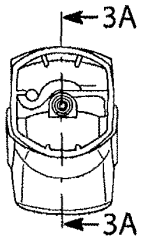


FIG. 2

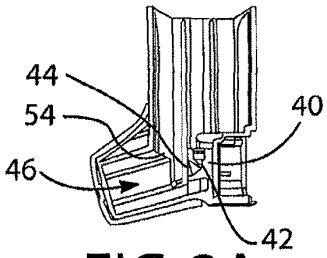


FIG. 3A

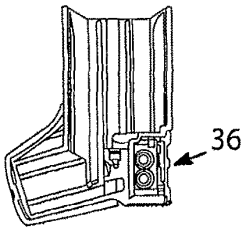


FIG. 3B

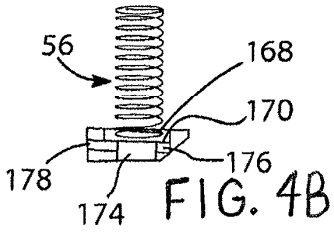


FIG. 4B

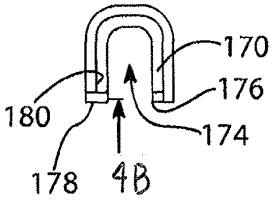


FIG. 4C

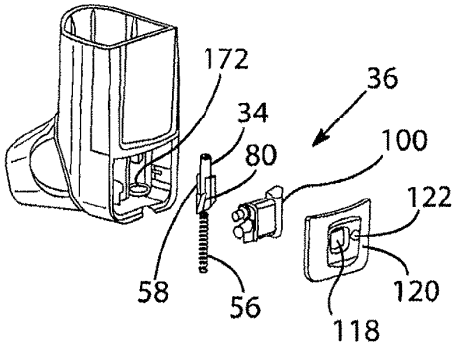


FIG. 4A

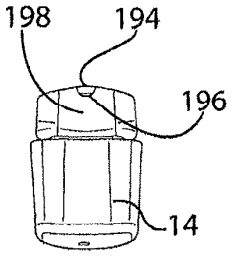


FIG. 5

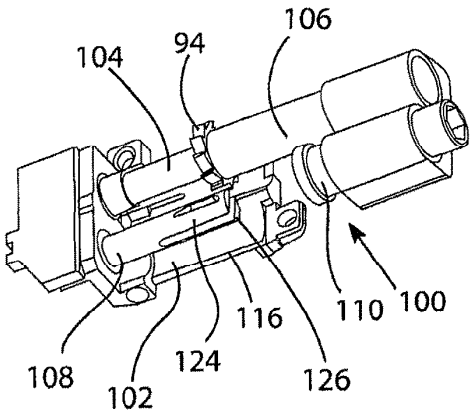


FIG. 6A

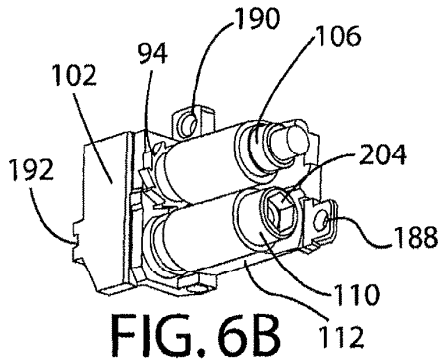


FIG. 6B

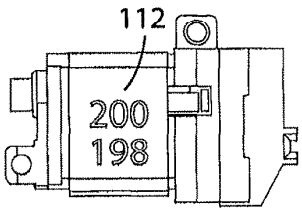


FIG. 6C

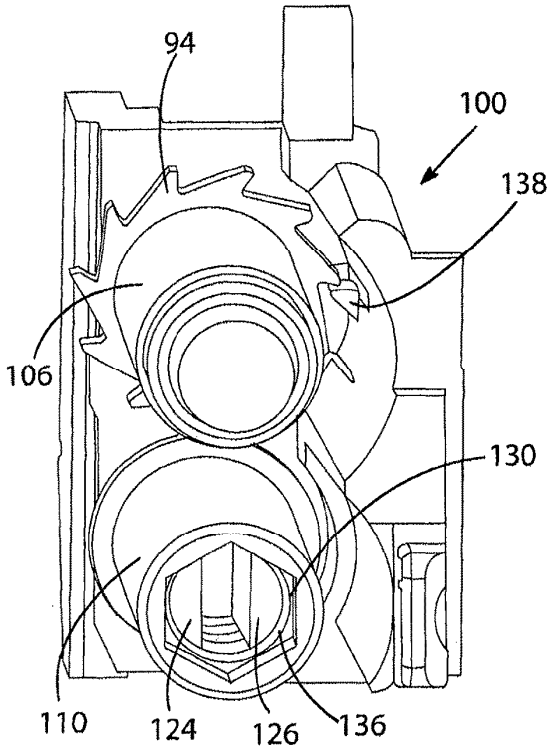


FIG. 6D

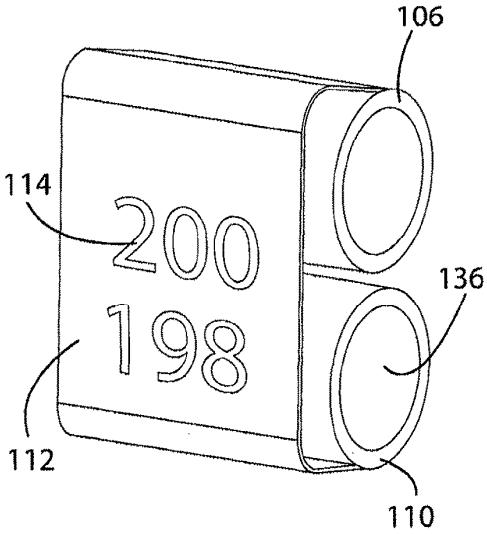


FIG. 6E

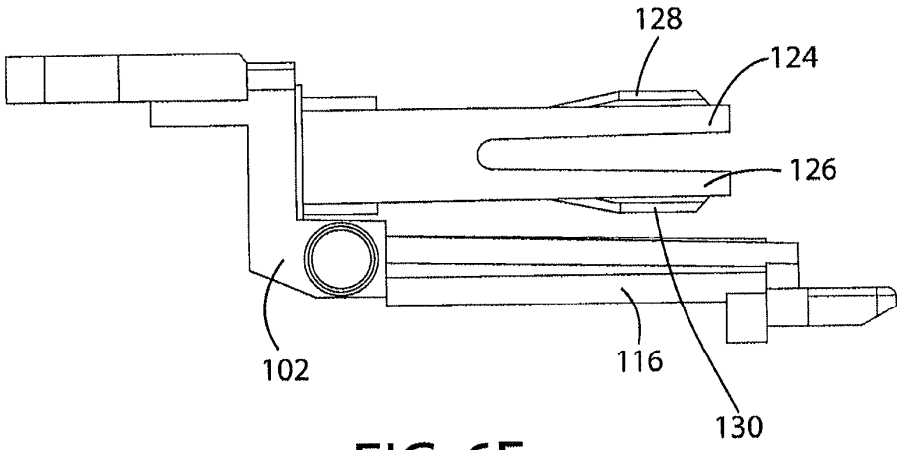


FIG. 6F

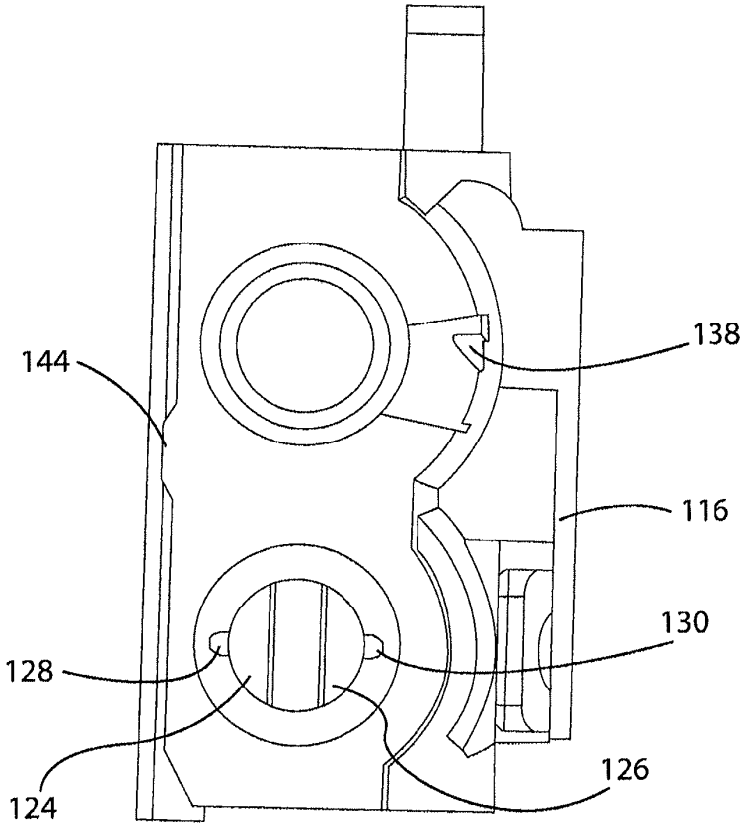


FIG. 6G

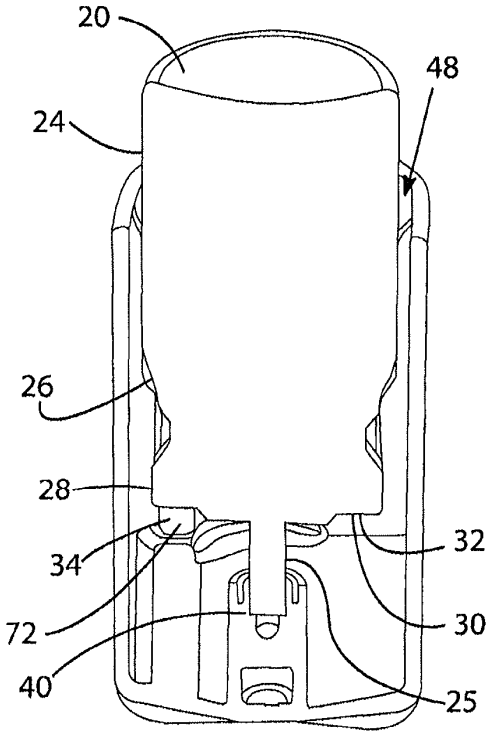


FIG. 7A

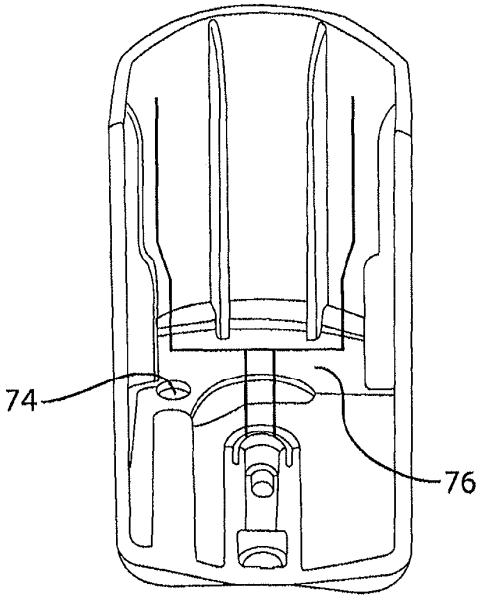


FIG. 7B

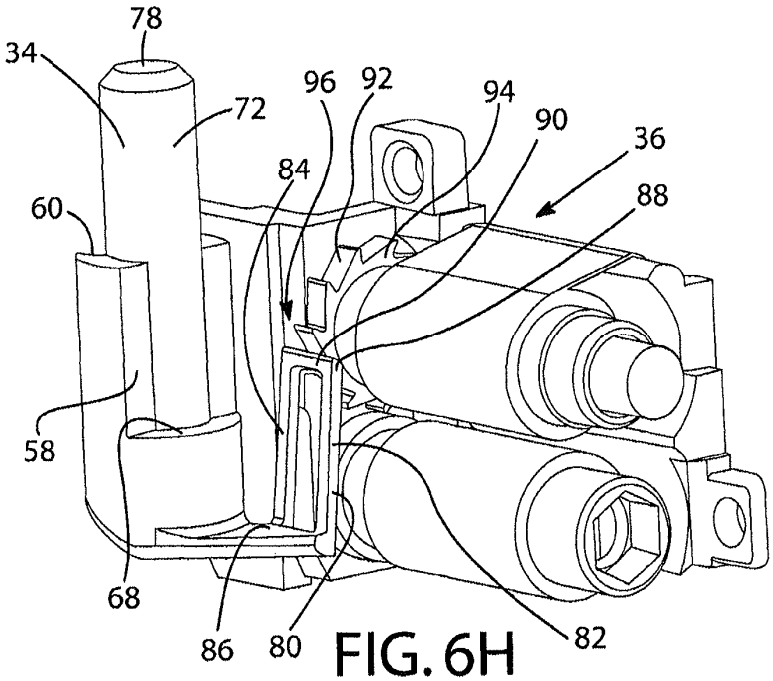


FIG. 6H

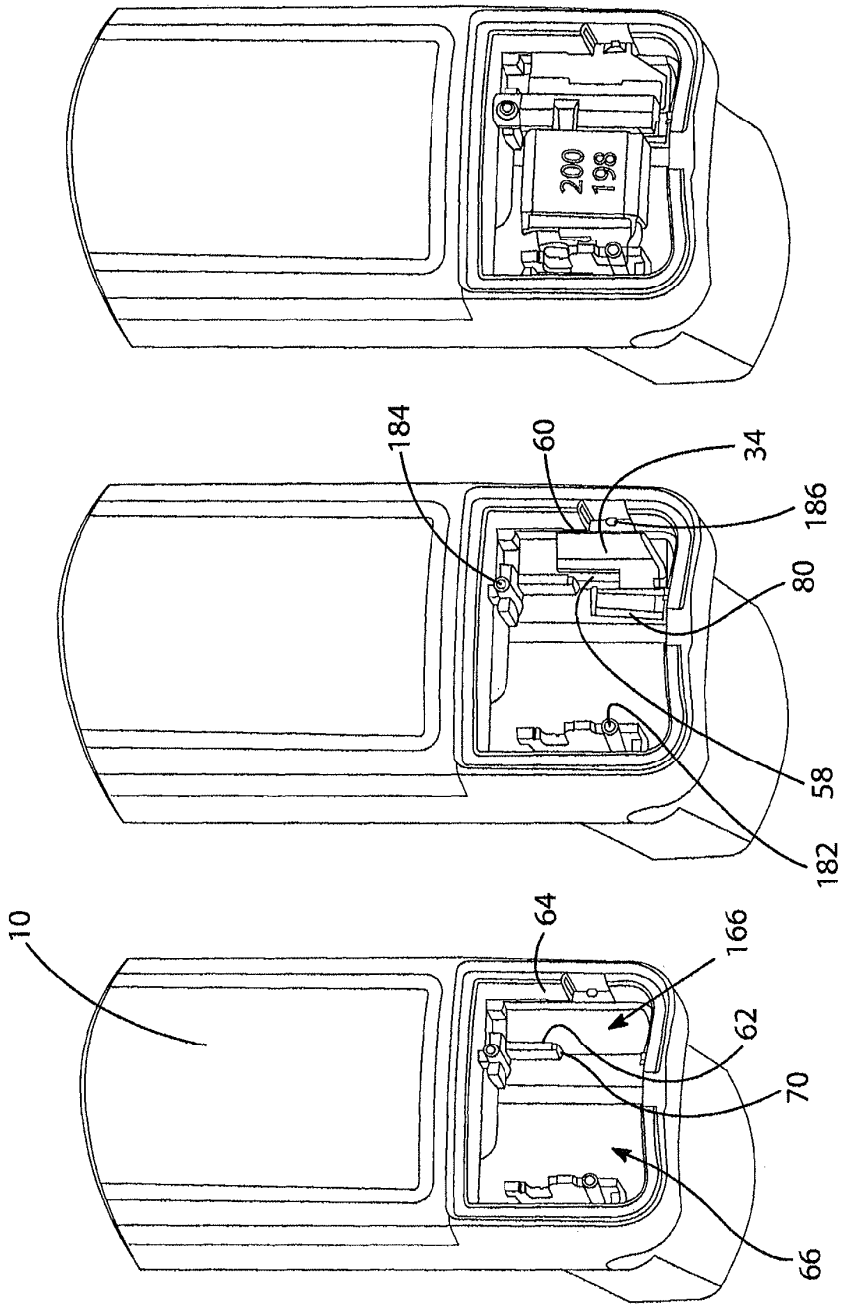


FIG. 8C

FIG. 8B

FIG. 8A

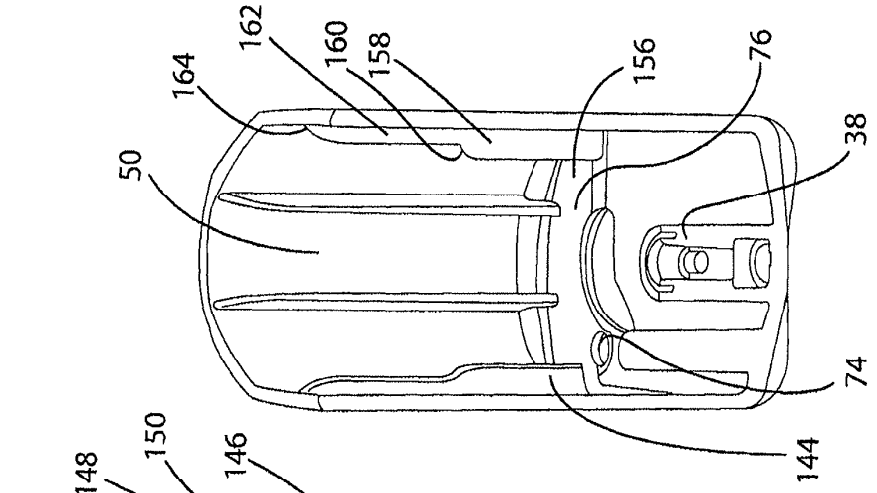


FIG. 7C

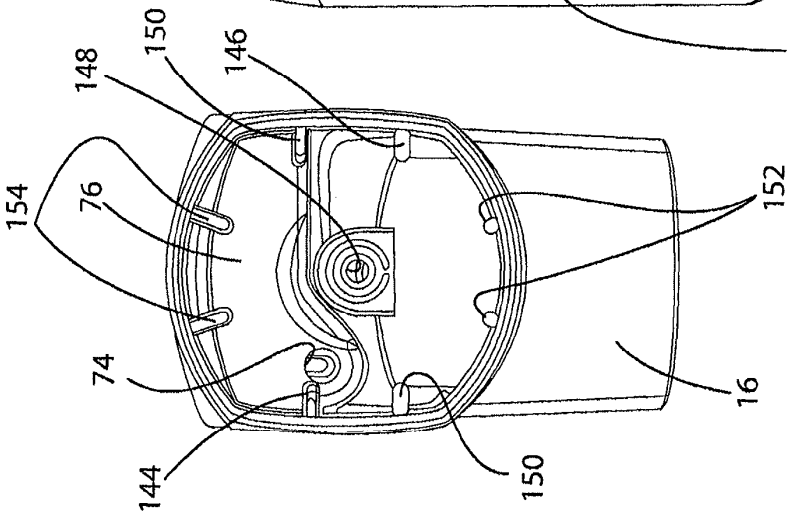


FIG. 7D

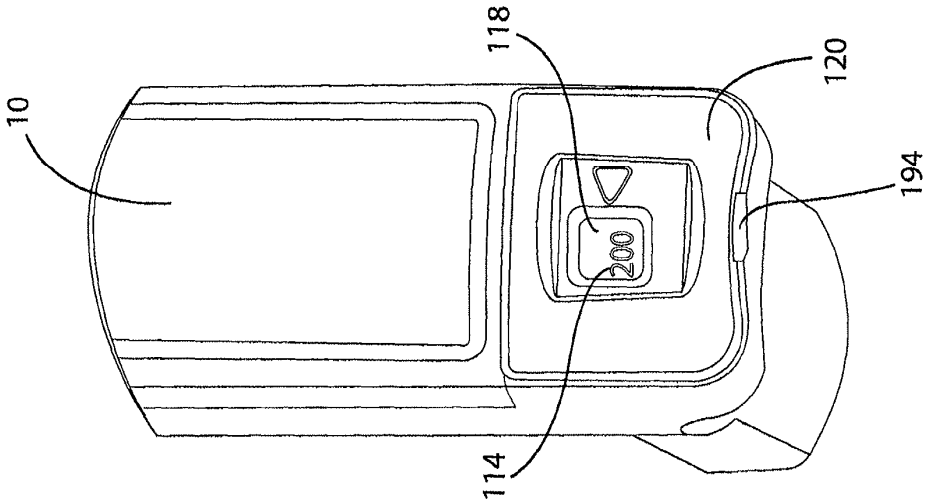


FIG. 8D

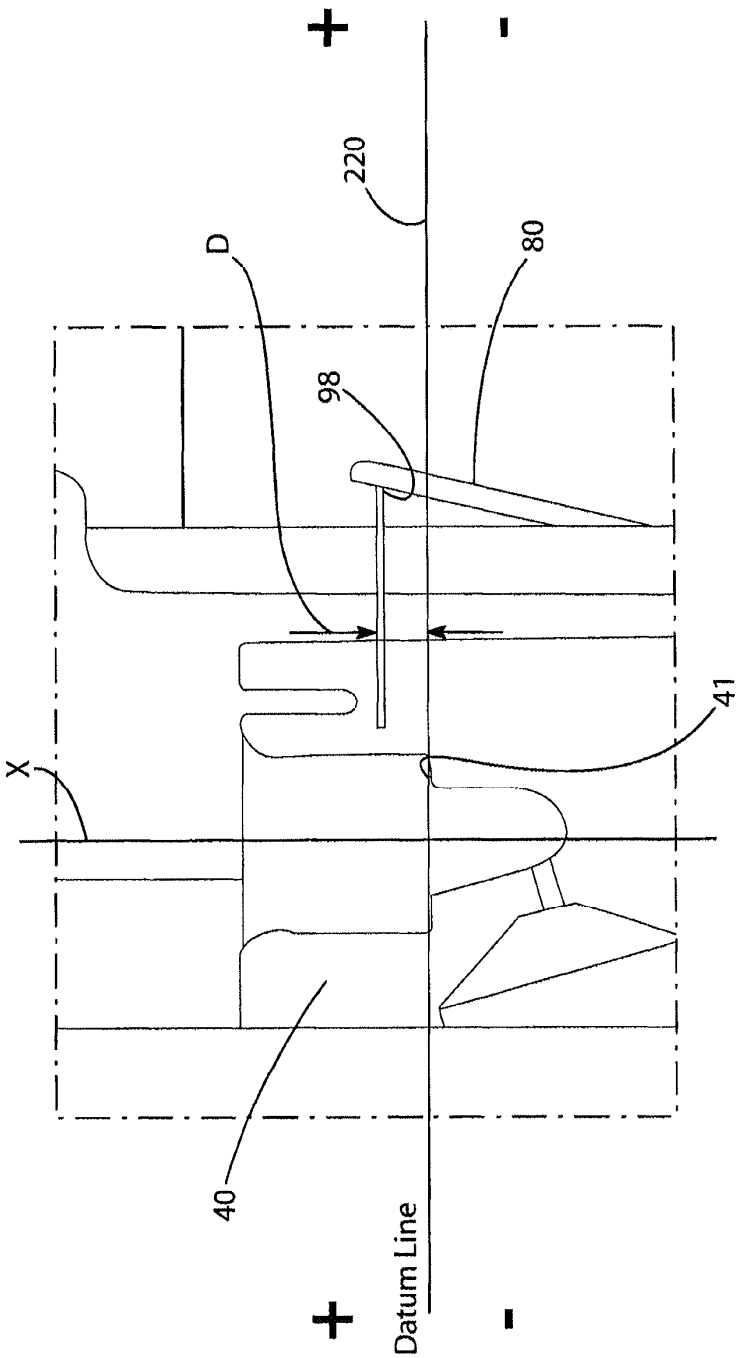


FIG. 9

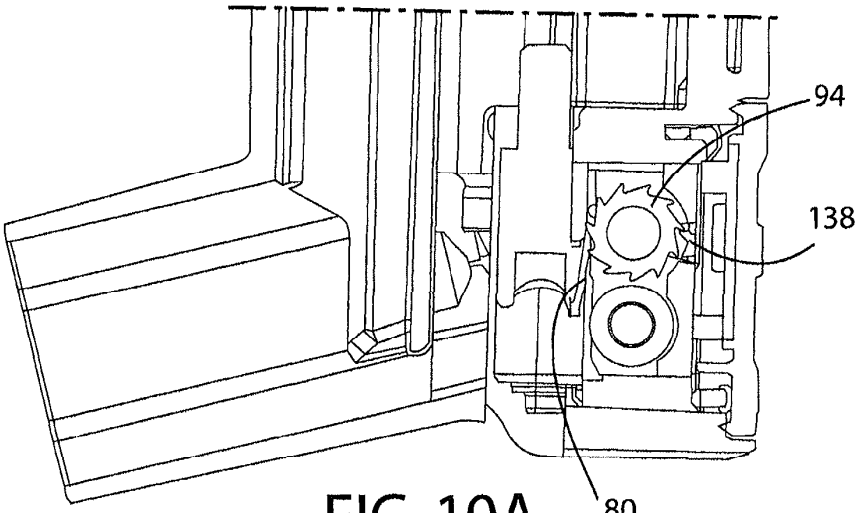


FIG. 10A

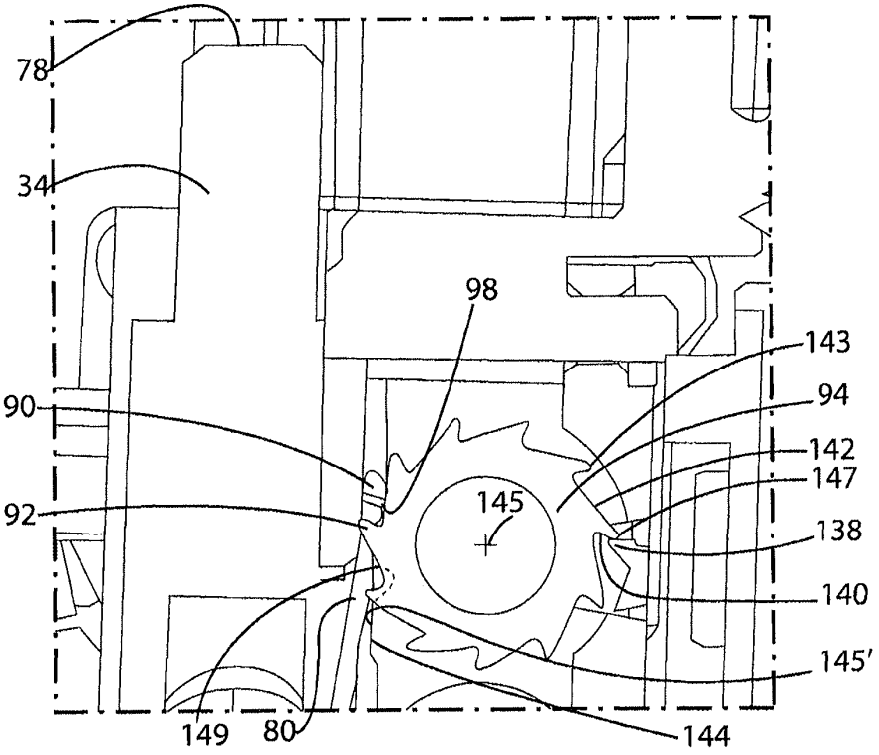


FIG. 10B

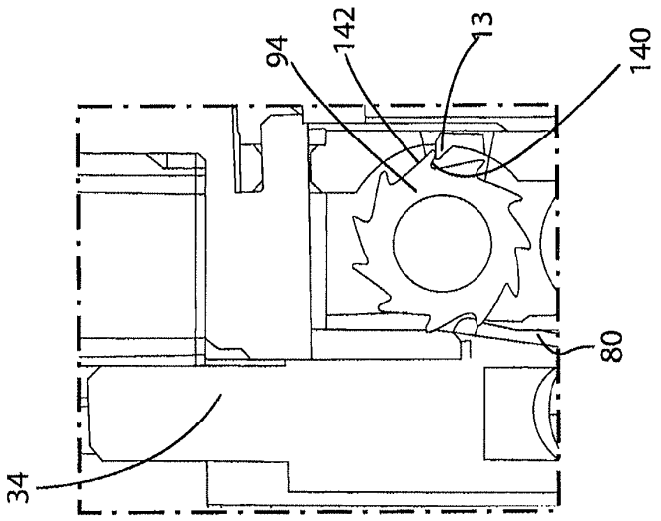


FIG. 10E

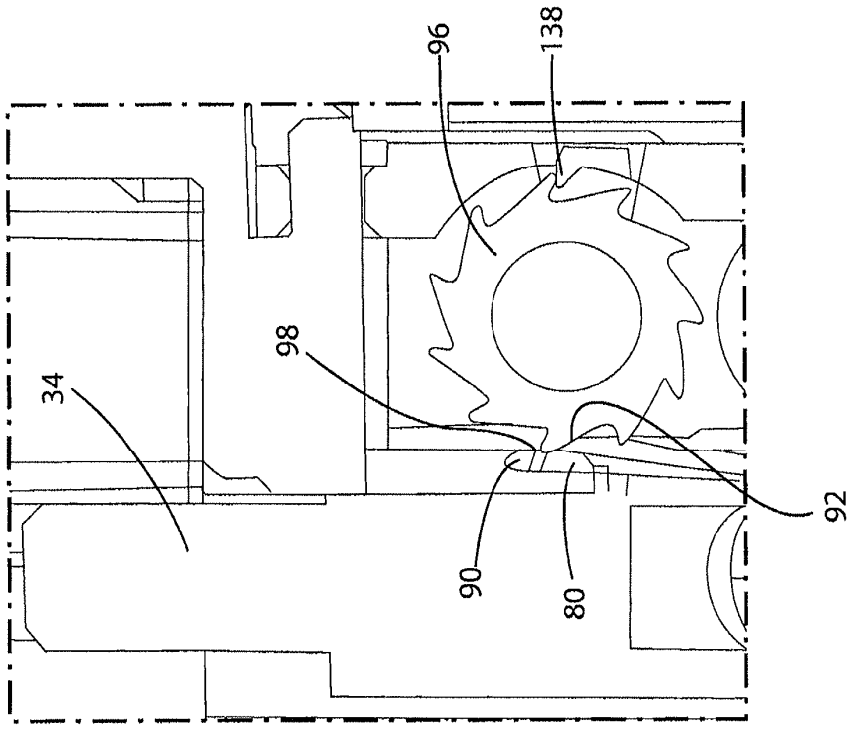


FIG. 10C

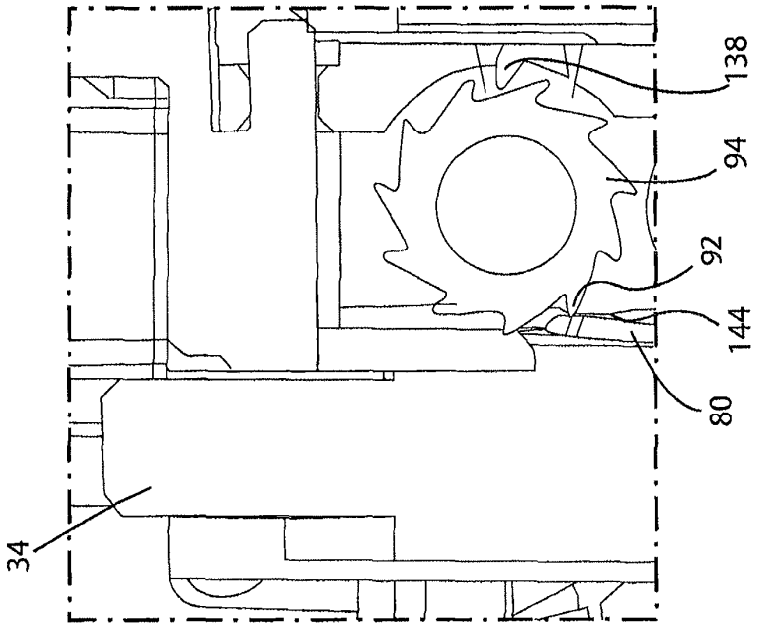


FIG. 10F

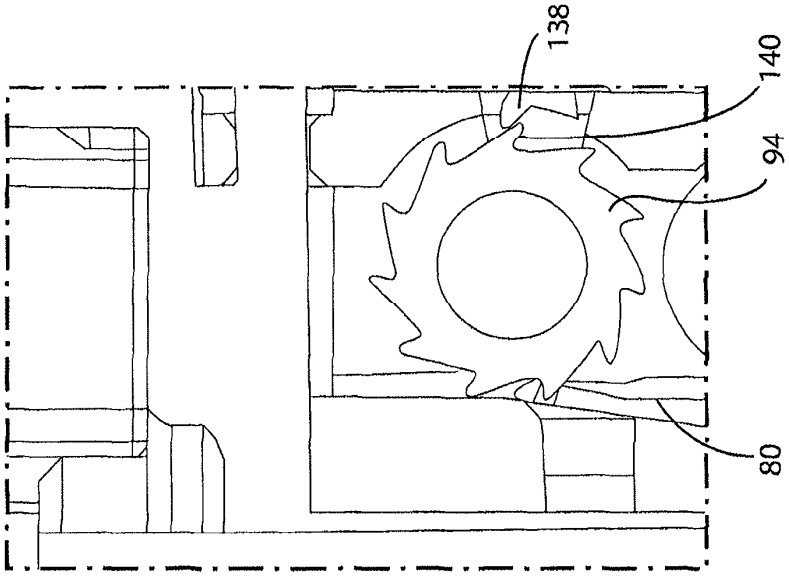


FIG. 10D

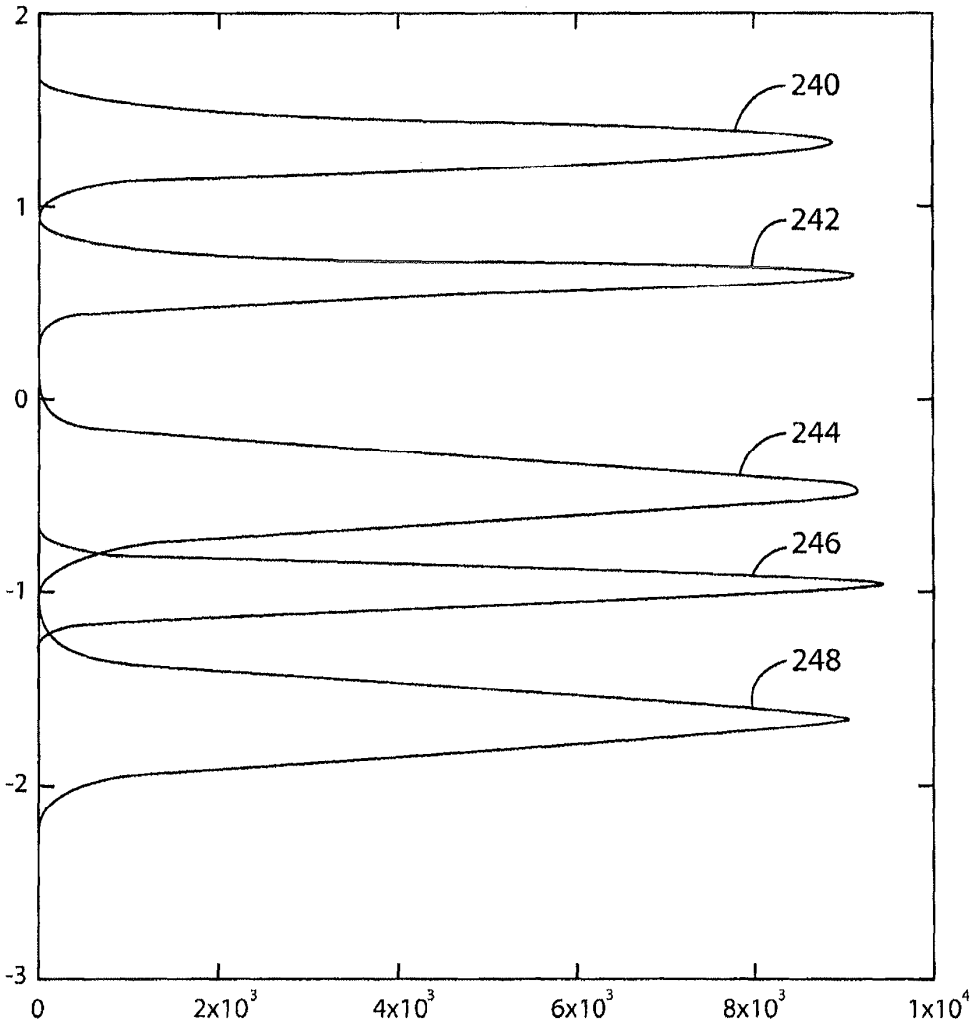
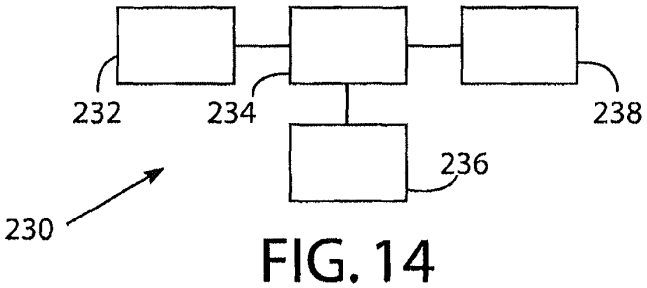

2
1
0
-1
-2
-3
240
242
244
246
248
0
2x10^3
4x10^3
6x10^3
8x10^3
1x10^4

FIG. 11


232
234
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230

FIG. 14

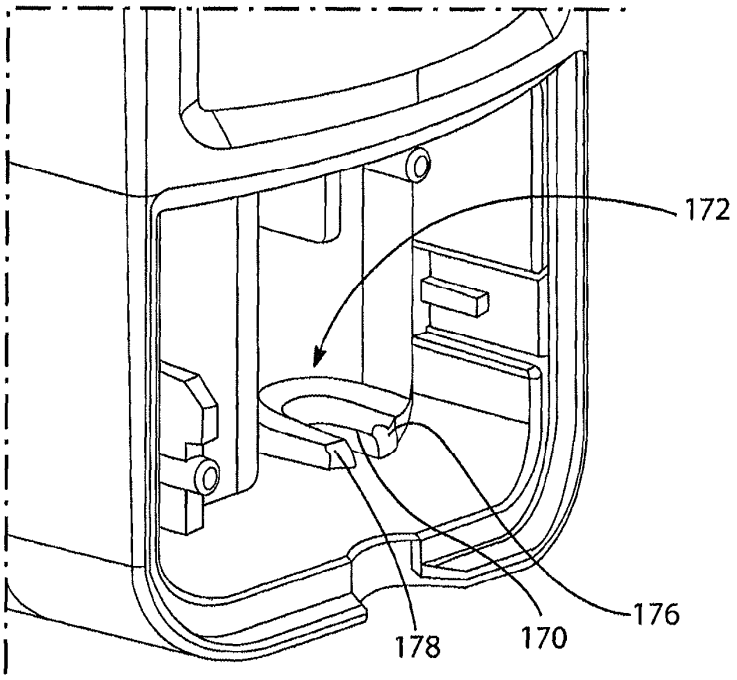


FIG. 12

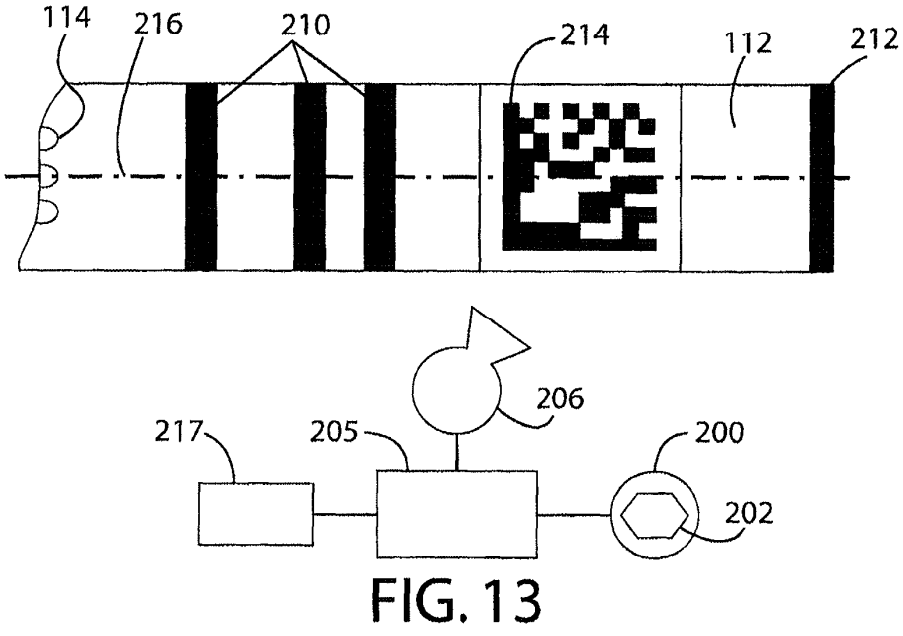


FIG. 13

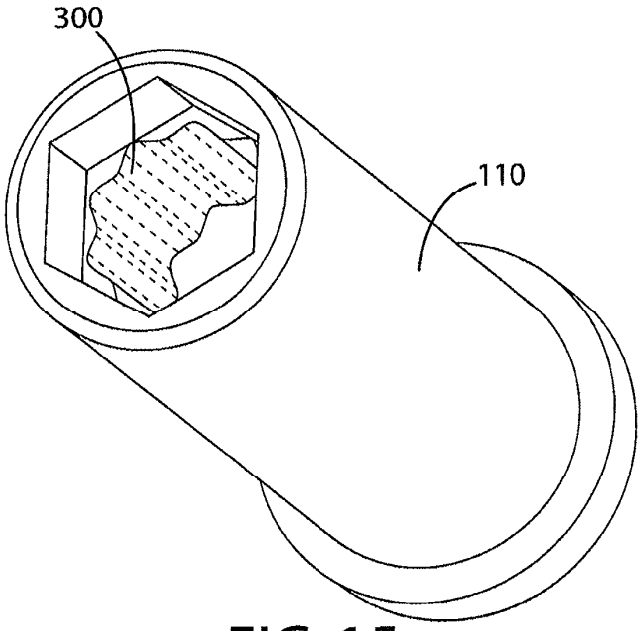


FIG. 15

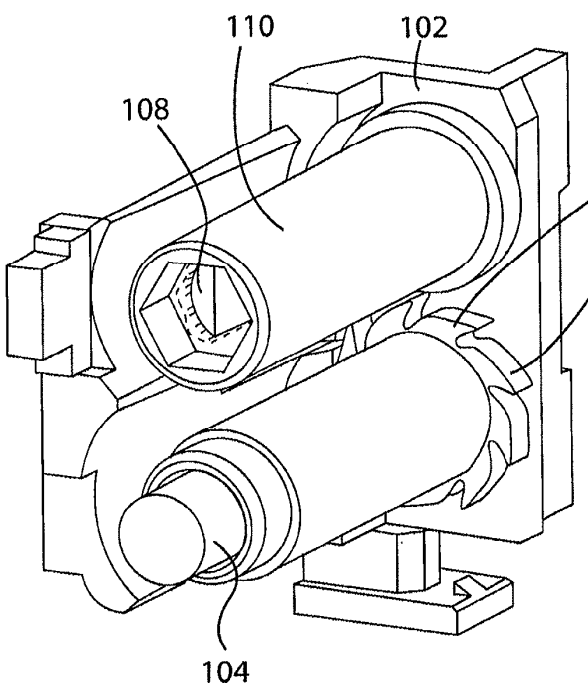


FIG. 20

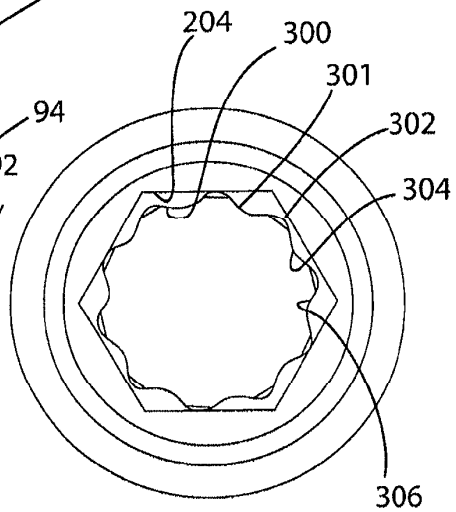


FIG. 16

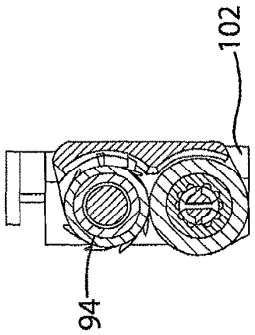


FIG. 19A

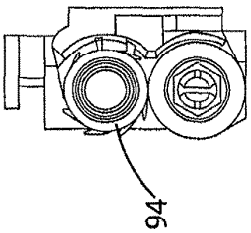


FIG. 19B

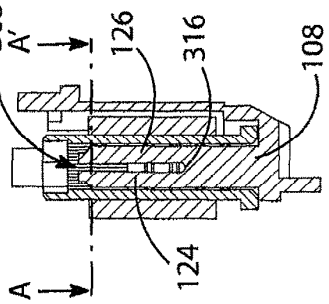


FIG. 19C

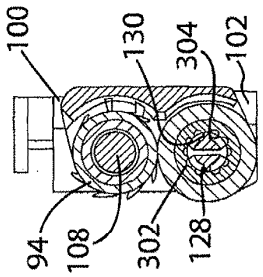


FIG. 18A

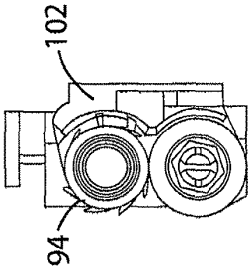


FIG. 18B

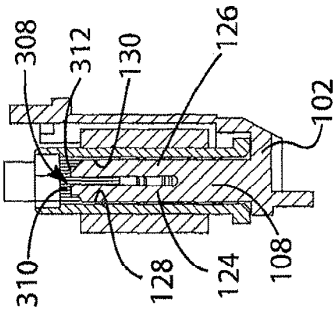


FIG. 18C

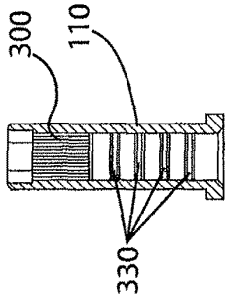
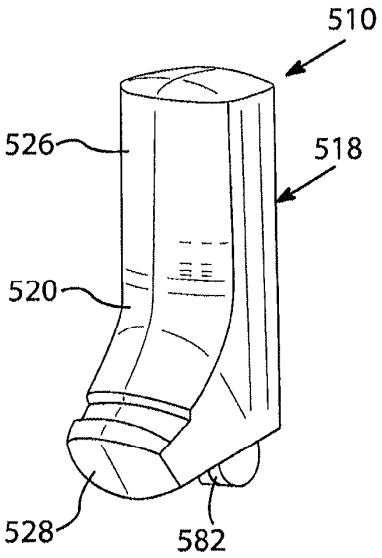


FIG. 17


510
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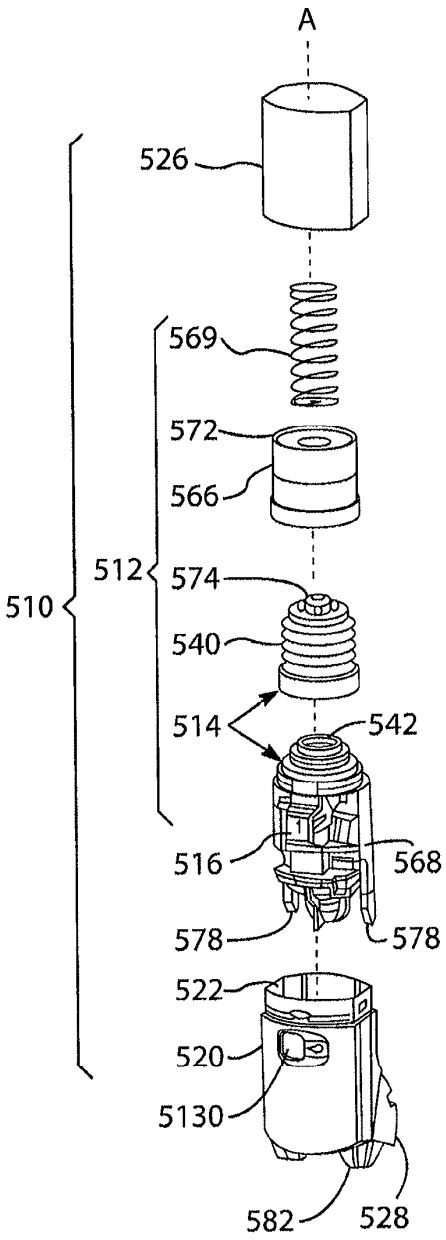
518
520
528
582

FIG. 21


A
526
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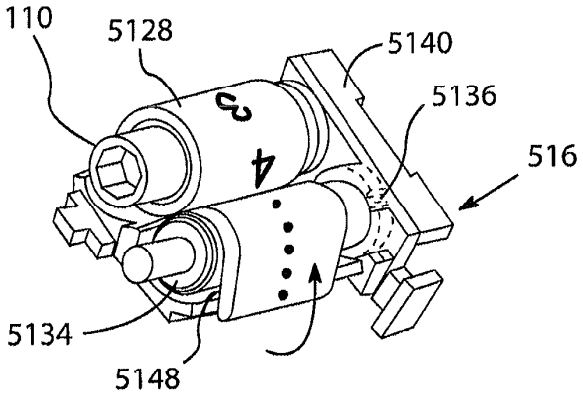
582
528

FIG. 22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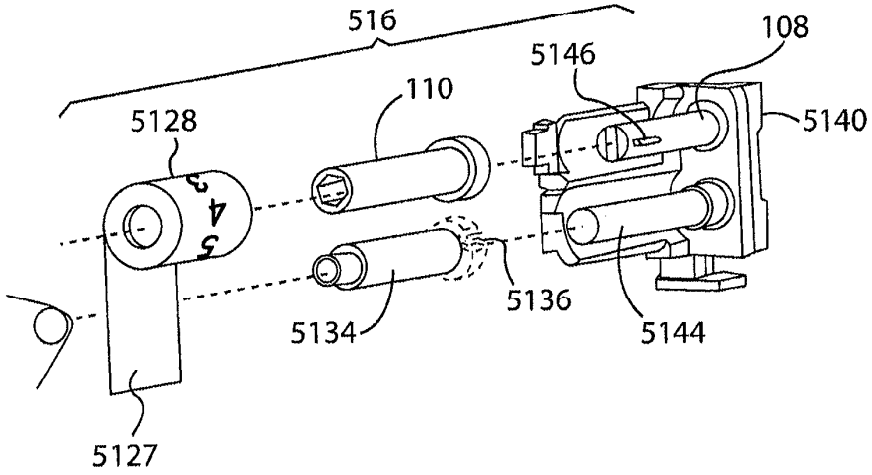
5140
5136
516
5134
5148

FIG. 23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5144
5127

FIG. 24

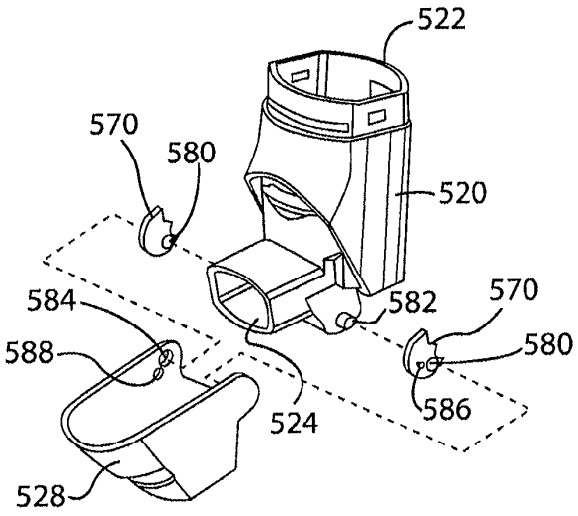

FIG. 25

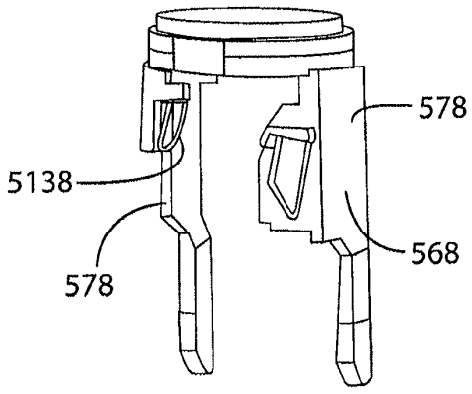

FIG. 26

DOSE COUNTER FOR INHALER HAVING AN ANTI-REVERSE ROTATION ACTUATOR

CROSS-REFERENCE TO RELATED APPLICATIONS

This patent application is a continuation patent application of U.S. patent application Ser. No. 15/804,735 filed Nov. 6, 2017, which is a continuation of U.S. patent application Ser. No. 15/269,249, filed Sep. 19, 2016, now U.S. Pat. No. 9,808,587, which is a continuation of U.S. patent application Ser. No. 14/103,324, filed Dec. 11, 2013, now U.S. Pat. No. 9,463,289, which is a divisional patent application of U.S. patent application Ser. No. 13/110,532, filed May 18, 2011, now U.S. Pat. No. 8,978,966, which claims priority to U.S. Patent Application No. 61/345,763, filed May 18, 2010, and U.S. Patent Application No. 61/417,659, filed Nov. 29, 2010, each of which is incorporated herein by reference in its entirety for any and all purposes.

FIELD OF THE INVENTION

The present invention relates to dose counters for inhalers, inhalers and methods of assembly thereof. The invention is particularly applicable to metered dose inhalers including dry power medicament inhalers, breath actuated inhalers and manually operated metered dose medicament inhalers.

BACKGROUND OF THE INVENTION

Metered dose inhalers can comprise a medicament-containing pressurised canister containing a mixture of active drug and propellant. Such canisters are usually formed from a deep-dawn aluminium cup having a crimped lid which carries a metering valve assembly. The metering valve assembly is provided with a protruding valve stem which, in use is inserted as a push fit into a stem block in an actuator body of an inhaler having a drug delivery outlet. In order to actuate a manually operable inhaler, the user applies by hand a compressive force to a closed end of the canister and the internal components of the metering valve assembly are spring loaded so that a compressive force of approximately 15 to 30N is required to activate the device in some typical circumstances.

In response to this compressive force the canister moves axially with respect to the valve stem and the axial movement is sufficient to actuate the metering valve and cause a metered quantity of the drug and the propellant to be expelled through the valve stem. This is then released into a mouthpiece of the inhaler via a nozzle in the stem block, such that a user inhaling through the outlet of the inhaler will receive a dose of the drug.

A drawback of self-administration from an inhaler is that it is difficult to determine how much active drug and/or propellant are left in the inhaler, if any, especially of the active drug and this is potentially hazardous for the user since dosing becomes unreliable and backup devices not always available.

Inhalers incorporating dose counters have therefore become known.

WO 98/028033 discloses an inhaler having a ratchet mechanism for driving a tape drive dose counter. A shaft onto which tape is wound has a friction clutch or spring for restraining the shaft against reverse rotation.

EP-A-1486227 discloses an inhaler for dry powered medicament having a ratchet mechanism for a tape dose counter which is operated when a mouthpiece of the inhaler is closed. Due to the way in which the mouthpiece is opened and closed, and actuation pawl of the device which is mounted on a yoke, travels a known long stroke of consistent length as the mouthpiece is opened and closed.

WO 2008/119552 discloses a metered-dose inhaler which is suitable for breath-operated applications and operates with a known and constant canister stroke length of 3.04 mm+/−0.255 mm. A stock bobbin of the counter, from which a tape is unwound, rotates on a shaft having a split pin intended to hold the stock bobbin taut. However, some dose counters do not keep a particularly reliable count, such as if they are dropped onto a hard surface.

More recently, it has become desirable to improve dose counters further and, in particular, it is felt that it would be useful to provide extremely accurate dose counters for manually-operated canister-type metered dose inhalers. Unfortunately, in these inhalers, it has been found in the course of making the present invention that the stroke length of the canister is to a very large extent controlled on each dose operation by the user, and by hand. Therefore, the stroke length is highly variable and it is found to be extremely difficult to provide a highly reliable dose counter for these applications. The dose counter must not count a dose when the canister has not fired since this might wrongly indicate to the user that a dose has been applied and if done repeatedly the user would throw away the canister or whole device before it is really time to change the device due to the active drug and propellant reaching a set minimum. Additionally, the canister must not fire without the dose counter counting because the user may then apply another dose thinking that the canister has not fired, and if this is done repeatedly the active drug and/or propellant may run out while the user thinks the device is still suitable for use according to the counter. It has also been found to be fairly difficult to assembly some known inhaler devices and the dose counters therefor. Additionally, it is felt desirable to improve upon inhalers by making them easily usable after they have been washed with water.

The present invention aims to alleviate at least to a certain extent one or more of the problems of the prior art.

SUMMARY OF THE INVENTION

According to a first aspect of the present invention there is provided a dose counter for an inhaler, the dose counter having a counter display arranged to indicate dosage information, a drive system arranged to move the counter display incrementally in a first direction from a first station to a second station in response to actuation input, wherein a regulator is provided which is arranged to act upon the counter display at the first station to regulate motion of the counter display at the first station to incremental movements.

The regulator is advantageous in that it helps prevent unwanted motion of the counter display if the counter is dropped.

According to a further aspect of the present invention, the regulator provides a resistance force of greater than 0.1 N against movement of the counter display. According to still a further aspect of the present invention, the resistance force is greater than 0.3 N. According to yet a further aspect of the present invention, the resistance force is from 0.3 to 0.4 N.

Preferably, the counter comprises a tape.

Preferably, the tape has dose counter indicia displayed thereon. The first station may comprise a region of the dose counter where tape is held which is located before a display location, such as a display window, for the counter indicia.

The first station may comprise a first shaft, the tape being arranged on the first shaft and to unwind therefrom upon movement of the counter display.

The first shaft may be mounted for rotation relative to a substantially rotationally fixed element of the dose counter.

The regulator may comprise at least one projection which is arranged on one of the first shaft and the substantially rotationally fixed element and to engage incrementally with one or more formations on the other of the first shaft and the substantially rotationally fixed element.

At least two said projections may be provided. Exactly two said projections maybe provided.

Each projection may comprise a radiused surface.

The at least one projection may be located on the substantially fixed element which may comprise a fixed shaft which is fixed to a main body of the dose counter, the first shaft being rotationally mounted to the fixed shaft.

Preferably, the fixed shaft has at least two resiliently flexible legs (or forks). Each leg may have at least one said projection formed in an outwardly facing direction thereon, said one or more formations being formed on an inwardly facing engagement surface of the first shaft, said at least one projection being arranged to resiliently engage said one or more formations. Preferably, a series of said formations are provided. An even number of said formations may be provided. Eight to twelve of said formations may be provided. In one embodiment, ten said formations are provided.

Each said formation may comprise a concavity formed on an engagement surface. Each concavity may comprise a radiused surface wall portion which preferably merges on at least one side thereof into a flat wall portion surface. The engagement surface may include a series of said concavities, and convex wall portions of the engagement surface may be formed between each adjacent two said concavities, each said convex wall portion comprising a convex radiused wall portion.

Each convex radiused wall portion of each convex wall portion may be connected by said flat wall portion surfaces to each adjacent concavity.

The fixed shaft may comprise a split pin with fork legs and each projection may be located on a said fork leg.

The first shaft may comprise a substantially hollow bobbin.

Said at least one formation may be located on an inner surface of the bobbin. In other embodiments it may be located on an outer surface thereof. Said engagement surface may extend partially along said bobbin, a remainder of the respective inner or outer surface having a generally smooth journal portion along at least a portion thereof.

The drive system may comprise a tooth ratchet wheel arranged to act upon a second shaft which is located at the second station, the second shaft being rotatable to wind the tape onto the second shaft.

The second shaft may be located on a main body of the dose counter spaced from and parallel to the first shaft.

The ratchet wheel may be fixed to the second shaft is arranged to rotate therewith. The ratchet wheel may be secured to an end of the second shaft and aligned coaxially with the second shaft.

The dose counter may include anti-back drive system which is arranged to restrict motion of the second shaft. The anti-back drive system may include a substantially fixed tooth arranged to act upon teeth of the ratchet wheel.

According to a further aspect of the present invention, a dose counter includes an anti-back drive system which is arranged to restrict motion of the second shaft in a tape winding direction.

According to a further aspect of the present invention there is provided a shaft for holding counter tape in a dose counter for an inhaler, the shaft having an engagement surface including incrementally spaced formations located around a periphery thereof, the formations comprising a series of curved concavities and convex portions.

The shaft may comprise a hollow bobbin.

The engagement surface may be a generally cylindrical inwardly directed surface.

The engagement surface may include a flat surface wall portion joining each concavity and convex wall portion.

Each concavity may comprise a radiused wall portion.

Each convex wall portion may comprise a radiused wall portion.

Said concavities may be regularly spaced around a longitudinal axis of the shaft.

Said convex wall portions may be regularly spaced around a longitudinal axis of the shaft.

In some embodiments there may be from eight to twelve said concavities and/or convex wall portions regularly spaced around a longitudinal axis thereof.

One embodiment includes ten said concavities and/or convex wall portions regularly spaced around a longitudinal axis of the shaft.

According to a further aspect of the present invention there is provided a shaft and counter tape assembly for use in a dose counter for an inhaler, the assembly comprising a rotatable shaft and a counter tape which is wound around the shaft and is adapted to unwind therefrom upon inhaler actuation, the shaft having an engagement surface which includes incrementally spaced formations located around a periphery thereof.

According to a further aspect of the present invention there is provided an inhaler for the inhalation of medication and the like, the inhaler including a dose counter as in the first aspect of the present invention.

A preferred construction consists of a manually operated metered dose inhaler including a dose counter chamber including a dose display tape driven by a ratchet wheel which is driven in turn by an actuator pawl actuated by movement of a canister, the tape unwinding from a stock bobbin during use of the inhaler, a rotation regulator being provided for the stock bobbin and comprising a wavelike engagement surface with concavities which engage against control elements in the form of protrusions on resilient forks of a split pin thereby permitting incremental unwinding of the stock bobbin yet resisting excessive rotation if the inhaler is dropped onto a hard surface.

According to another aspect of the present invention there is provided a dose counter for a metered dose inhaler having a body arranged to retain a medicament canister of predetermined configuration for movement of the canister relative thereto; the dose counter comprising: an incremental counting system for counting doses, the incremental counting system having a main body, an actuator arranged to be driven in response to canister motion and to drive an incremental output member in response to canister motion, the actuator and incremental output member being configured to have predetermined canister fire and count configurations in a canister fire sequence, the canister fire configuration being determined by a position of the actuator relative to a datum at which the canister fires medicament and the count configuration being determined by a position of the actuator relative to the datum at which the incremental count system makes an incremental count, wherein the actuator is

arranged to reach a position thereof in the count configuration at or after a position thereof in the canister fire configuration.

This arrangement has been found to be highly advantageous since it provides an extremely accurate dose counter which is suitable for use with manually operated metered dose inhalers. It has been found that dose counters with these features have a failure rate of less than 50 failed counts per million full canister activation depressions. It has been found in the course of making the present invention that highly reliable counting can be achieved with the dose counter counting at or soon after the point at which the canister fires. It has been is covered by the present inventors that momentum and motion involved in firing the canister, and in some embodiments a slight reduction in canister back pressure on the user at the time of canister firing, can very reliably result in additional further motion past the count point.

The actuator and incremental counting system may be arranged such that the actuator is displaced less than 1 mm, typically 0.25 to 0.75 mm, more preferably about 0.4 to 0.6 mm, relative to the body between its location in the count and fire configurations, about 0.48 mm being preferred. The canister, which can move substantially in line with the actuator, can reliably move this additional distance so as to achieve very reliable counting.

The incremental count system may comprise a ratchet mechanism and the incremental output member may comprise a ratchet wheel having a plurality of circumferentially spaced teeth arranged to engage the actuator.

The actuator may comprise an actuator pawl arranged to engage on teeth of the ratchet wheel. The actuator pawl may be arranged to be connected to or integral with an actuator pin arranged to engage and be depressed by a medicament canister bottom flange. The actuator pawl may be generally U-shaped having two parallel arms arranged to pull on a central pawl member arranged substantially perpendicular thereto. This provides a very reliable actuator pawl which can reliably pull on the teeth of the ratchet wheel.

The incremental count system may include a tape counter having tape with incremental dose indicia located thereon, the tape being positioned on a tape stock bobbin and being arranged to unwind therefrom.

The actuator and incremental output member may be arranged to provide a start configuration at which the actuator is spaced from the ratchet output member, a reset configuration at which the actuator is brought into engagement with the incremental output member during a canister fire sequence, and an end configuration at which the actuator disengages from the ratchet output during a canister fire sequence.

The actuator may be arranged to be located about 1.5 to 2.0 mm, from its location in the fire configuration, when in the start configuration, about 1.80 mm being preferred.

The actuator may be arranged to be located about 1.0 to 1.2 mm, from its location in the fire configuration, when in the reset configuration, about 1.11 mm being preferred.

The actuator may be arranged to be located about 1.1 to 1.3 mm, from its location in the fire configuration, when in the end configuration, about 1.18 mm being preferred.

These arrangements provide extremely reliable dose counting, especially with manually operated canister type metered dose inhalers.

The main body may include a formation for forcing the actuator to disengage from the incremental output member when the actuator is moved past the end configuration. The formation may comprise a bumped up portion of an otherwise generally straight surface against which the actuator engages and along which it is arranged to slide during a canister firing sequence.

The dose counter may include a counter pawl, the counter pawl having a tooth arranged to engage the incremental output member, the tooth and incremental output member being arranged to permit one way only incremental relative motion therebetween. When the incremental output member comprises a ratchet wheel, the tooth can therefore serve as an anti-back drive tooth for the ratchet wheel, thereby permitting only one way motion or rotation thereof.

The counter pawl may be substantially fixedly mounted on the main body of the incremental count system and the counter pawl may be arranged to be capable of repeatedly engaging equi-spaced teeth of the incremental output member in anti-back drive interlock configurations as the counter is operated. The counter pawl may be positioned so that the incremental output member is halfway, or substantially halfway moved from one anti-back drive interlock configuration to the next when the actuator and incremental output member are in the end configuration thereof. This is highly advantageous in that it minimises the risk of double counting or non-counting by the dose counter.

According to a further aspect of the invention there is provided an inhaler comprising a main body arranged to retain a medicament canister of predetermined configuration and a dose counter mounted in the main body.

The inhaler main body may include a canister receiving portion and a separate counter chamber, the dose counter being located within the main body thereof, the incremental output member and actuator thereof inside the counter chamber, the main body of the inhaler having wall surfaces separating the canister-receiving portion and the counter chamber, the wall surfaces being provided with a communication aperture, an actuation member extending through the communication aperture to transmit canister motion to the actuator.

According to a further aspect of the present invention there is a provided an inhaler for metered dose inhalation, the inhaler comprising a main body having a canister housing arranged to retain a medicament canister for motion therein, and a dose counter, the dose counter having an actuation member having at least a portion thereof located in the canister housing for operation by movement of a medicament canister, wherein the canister housing has an inner wall, and a first inner wall canister support formation located directly adjacent the actuation member.

This is highly advantageous in that the first inner wall canister support formation can prevent a canister from rocking too much relative to the main body of the inhaler. Since the canister may operate the actuation member of the dose counter, this substantially improves dose counting and avoids counter errors.

The canister housing may have a longitudinal axis which passes through a central outlet port thereof, the central outlet port being arranged to mate with an outer canister fire stem of a medicament canister, the inner wall canister support formation, the actuation member and the outlet port lying in a common plane coincident with the longitudinal axis. Accordingly, this construction may prevent the canister from rocking towards the position of the dose counter actuation member, thereby minimising errors in counting.

The canister housing may have a further inner canister wall support formation located on the inner wall opposite, or substantially opposite, the actuation member. Accordingly, the canister may be supported against rocking motion away from the actuator member so as to minimise count errors.

The canister housing may be generally straight and tubular and may have an arrangement in which each said inner wall support formation comprises a rail extending longitudinally along the inner wall.

Each said rail may be stepped, in that it may have a first portion located towards a medicine outlet end or stem block of the canister housing which extends inwardly a first distance from a main surface of the inner wall and a second portion located toward an opposite end of the canister chamber which extends inwardly a second, smaller distance from the main surface of the inner wall. This may therefore enable easy insertion of a canister into the canister housing such that a canister can be lined up gradually in step wise function as it is inserted into the canister housing.

The inhaler may include additional canister support rails which are spaced around an inner periphery of the inner wall of the canister housing and which extend longitudinally therealong.

At least one of the additional rails may extend a constant distance inwardly from the main surface of the inner wall.

At least one of the additional rails may be formed with a similar configuration to the first inner wall canister support formation.

The dose counter may, apart from said at least a portion of the actuation member, be located in a counter chamber separate from the canister housing, the actuation member comprising a pin extending through an aperture in a wall which separates the counter chamber and the canister housing.

According to a further aspect of the present invention there is provided an inhaler for inhaling medicaments having: a body for retaining a medicament store; the body including a dose counter, the dose counter having a moveable actuator and a return spring for the actuator, the return spring having a generally cylindrical and annular end; the body having a support formation therein for supporting said end of the return spring, the support formation comprising a shelf onto which said end is engageable and a recess below the shelf.

This shelf and recess arrangement is highly advantageous since it allows a tool (such as manual or mechanical tweezers) to be used to place the return spring of the actuator onto the shelf with the tool then being withdrawn at least partially via the recess.

The shelf may be U-shaped.

The support formation may include a U-shaped upstanding wall extending around the U-shaped shelf, the shelf and upstanding wall thereby forming a step and riser of a stepped arrangement.

The recess below the shelf my also be U-shaped.

At least one chamfered surface may be provided at an entrance to the shelf. This may assist in inserting the actuator and return spring into position.

A further aspect of the invention provides a method of assembly of an inhaler which includes the step of locating said end of said spring on the shelf with an assembly tool and then withdrawing the assembly tool at least partly via the recess. This assembly method is highly advantageous compared to prior art methods in which spring insertion has been difficult and in which withdrawal of the tool has sometimes accidentally withdrawn the spring again.

The cylindrical and annular end of the spring may be movable in a direction transverse to its cylindrical extent into the shelf while being located thereon.

According to a further aspect of the present invention there is provided an inhaler for inhaling medicament, the inhaler having a body for retaining a medicament store; and a dose counter, the dose counter having a moveable actuator and a chassis mounted on the body; the chassis being heat staked in position on the body. This is be highly advantageous in that the chassis can be very accurately positioned and held firmly in place, thereby further improving counting accuracy compared to prior art arrangements in which some movement of the chassis relative to the body may be tolerated in snap-fit connections.

The chassis may have at least one of a pin or aperture heat staked to a respective aperture or pin of the body.

The chassis may have a ratchet counter output member mounted thereon.

The ratchet counter output member may comprise a ratchet wheel arranged to reel in incrementally a dose meter tape having a dosage indicia located thereon.

According to a further aspect of the present invention there is provided a method of assembling an inhaler including the step of heat staking the chassis onto the body. The step of heat staking is highly advantageous in fixedly positioning the chassis onto the body in order to achieve highly accurate dose counting in the assembled inhaler.

The method of assembly may include mounting a spring-returned ratchet actuator in the body before heat staking the chassis in place. The method of assembly may include pre-assembling the chassis with a dose meter tape prior to the step of heat staking the chassis in place. The method of assembly may include attaching a dose meter cover onto the body after the heat staking step. The cover may be welded onto the body or may in some embodiments be glued or otherwise attached in place.

According to a further aspect of the present invention there is provided an inhaler for inhaling medicament and having a body, the body have a main part thereof for retaining a medicament store; and a dose counter, the dose counter being located in a dose counter chamber of the body which is separated from the main part of the body, the dose counter chamber of the body having a dosage display and being perforated so as to permit the evaporation of water or aqueous matter in the dose counter chamber into the atmosphere.

This is high advantageous since it enables the inhaler to be thoroughly washed and the dose counting chamber can thereafter dry out fully.

The display may comprise a mechanical counter display inside the dose counter chamber and a window for viewing the mechanical counter display. The mechanical counter display may comprise a tape. The perforated dose counter chamber may therefore enable reliable washing of the inhaler, if desired by the user, and may therefore dry out without the display window misting up.

The dose counter chamber may be perforated by a drain hole formed through an outer hole of the body. The drain hole may be located at a bottom portion of the body of the inhaler, thereby enabling full draining of the inhaler to be encouraged after washing when the inhaler is brought into an upright position.

According to a further aspect of the present invention there is provided a dose counter for an inhaler, the dose counter having a display tape arranged to be incrementally driven from a tape stock bobbin onto an incremental tape take-up drive shaft, the bobbin having an internal bore supported by and for rotation about a support shaft, at least one of the bore and support shaft having a protrusion which is resiliently biased into frictional engagement with the other of the bore and support shaft with longitudinally extending mutual frictional interaction. This arrangement may provide good friction for the bobbin, thereby improving tape counter

display accuracy and preventing the bobbin from unwinding undesirably for example if the inhaler is accidentally dropped.

The support shaft may be forked and resilient for resiliently biasing the support shaft and bore into frictional engagement.

The support shaft may have two forks, or more in some cases, each having a radially extending protrusion having a friction edge extending therealong parallel to a longitudinal axis of the support shaft for frictionally engaging the bore of the support shaft with longitudinally extending frictional interaction therebetween.

The bore may be a smooth circularly cylindrical or substantially cylindrical bore.

Each of the above inhalers in accordance with aspects of the present invention may have a medicament canister mounted thereto.

The canister may comprise a pressurised metered dose canister having a reciprocally movable stem extending therefrom and movable into a main canister portion thereof for releasing a metered dose of medicament under pressure, for example by operating a metered dose valve inside the canister body. The canister may be operable by pressing by hand on the main canister body.

In cases in which one or more support rails or inner wall support formations are provided, the canister may at all times when within the canister chamber have a clearance of about 0.25 to 0.35 mm from the first inner wall support formation. The clearance may be almost exactly 0.3 mm. This clearance which may apply to the canister body itself or to the canister once a label has been applied, is enough to allow smooth motion of the canister in the inhaler while at the same time preventing substantial rocking of the canister which could result in inaccurate counting by a dose counter of the inhaler, especially when lower face of the canister is arranged to engage an actuator member of the dose counter for counting purposes.

According to a further aspect of the invention, a method of assembling a dose counter for an inhaler comprises the steps of providing a tape with dosing indicia thereon; providing tape positioning indicia on the tape; and stowing the tape while monitoring for the tape positioning indicia with a sensor. The method advantageously permits efficient and accurate stowing of the tape, e.g. by winding.

The dosing indicia may be provided as numbers, the tape positioning indicia may be provided as one or more lines across the tape. The stowing step comprises winding the tape onto a bobbin or shaft, and, optionally, stopping winding when the positioning indicia are in a predetermined position. The tape may be provided with pixelated indicia at a position spaced along the tape from the positioning indicia.

The tape may also be provided with a priming dot.

According to a further aspect of the invention, a tape system for a dose counter for an inhaler has a main elongate tape structure, and dosing indicia and tape positioning indicia located on the tape structure. The tape positioning indicia may comprise at least one line extending across the tape structure. The tape system may comprise pixelated indicia located on the tape structure and spaced from the positioning indicia. The tape system may comprise a priming dot located on the tape structure. The positioning indicia may be located between the timing dot and the pixelated indicia. The main elongate tape structure may have at least one end thereof wound on a bobbin or shaft.

A further aspect of the invention provides a method of designing an incremental dose counter for an inhaler comprising the steps of calculating nominal canister fire and dose counter positions for a dose counter actuator of the inhaler; calculating a failure/success rate for dose counters built to tolerance levels for counting each fire of inhalers in which the dose counter actuators may be applied; and selecting a tolerance level to result in said failure/success rate to be at or below/above a predetermined value. This is highly advantageous in that it allows an efficient and accurate prediction of the reliability of a series of inhaler counters made in accordance with the design.

The method of designing may include selecting the failure/success rate as a failure rate of no more than one in 50 million. The method of designing may include setting an average count position for dose counters built to the tolerances to be at or after an average fire position thereof during canister firing motion. The method of designing may include setting the average count position to be about 0.4 to 0.6 mm after the average fire position, such as about 0.48 mm after. The method of designing may include setting tolerances for the standard deviation of the fire position in dose counters built to the tolerances to be about 0.12 to 0.16 mm, such as about 0.141 mm. The method of designing may include setting tolerances for the standard deviation of the count positions in dose counters built to the tolerances to be about 0.07 to 0.09 mm, such as about 0.08 mm. A further aspect of the invention provides a computer implemented method of designing an incremental dose counter for an inhaler which includes the aforementioned method of designing.

A further aspect of the invention provides a method of manufacturing in a production run a series of incremental dose counters for inhalers which comprises manufacturing the series of dose counters in accordance with the aforementioned method of designing.

A further aspect of the invention provides a method of manufacturing a series of incremental dose counters for inhalers, which comprises manufacturing the dose counters with nominal canister fire and dose count positions of a dose counter actuator relative to a dose counter chassis (or inhaler main body), and which includes building the dose counters with the average dose count position in the series being, in canister fire process, at or after the average canister fire position in the series.

According to a further aspect of the invention, the method provides fitting each dose counter in the series of incremental dose counters to a corresponding main body of an inhaler.

These aspects advantageously provide for the production run of a series of inhalers and dose counters which count reliably in operation.

According to a further aspect of the invention, an incremental dose counter for a metered dose inhaler has a body arranged to retain a canister for movement of the canister relative thereto, the incremental dose counter having a main body, an actuator arranged to be driven and to drive an incremental output member in a count direction in response to canister motion, the actuator being configured to restrict motion of the output member in a direction opposite to the count direction. This advantageously enables an inhaler dose counter to keep a reliable count of remaining doses even if dropped or otherwise jolted.

The output member may comprise a ratchet wheel. The actuator may comprise a pawl and in which the ratchet wheel and pawl are arranged to permit only one-way ratcheting motion of the wheel relative to the pawl. The dose counter may include an anti-back drive member fixed to the main body. In a rest position of the dose counter, the ratchet wheel is capable of adopting a configuration in which a back surface of one tooth thereof engages the anti-back drive member and the pawl is spaced from an adjacent back

surface of another tooth of the ratchet wheel without positive drive/blocking engagement between the pawl and wheel.

BRIEF DESCRIPTION OF THE DRAWINGS

The present invention may be carried out in various ways and preferred embodiment of a dose counter, inhaler and methods of assembly, design and manufacture will now be described with reference to the accompanying drawings in which:

FIG. **1** is an isometric view of a main body of an embodiment of an inhaler related to the invention together with a mouthpiece cap therefor;

FIG. **2** is a top plan view of the components as shown in FIG. **1**;

FIG. **3**A is a section on the plane **3**A-**3**A in FIG. **2**;

FIG. **3**B is a view corresponding to FIG. **3**A but with a dose counter fitted to the main body of the inhaler;

FIG. **4**A is an exploded view of the inhaler main body, mouthpiece cap, dose counter and a dose counter window;

FIG. **4**B is a view in the direction **4**B in FIG. **4**C of a spring retainer of the dose counter;

FIG. **4**C is a top view of the spring retainer of FIG. **4**B;

FIG. **5** is a bottom view of the assembled inhaler main body, mouthpiece cap, dose counter and dose counter window;

FIGS. **6**A, **6**B, **6**C, **6**D, **6**E, **6**F, **6**G and **6**H are various views of dose counter components of the inhaler;

FIGS. **7**A and **7**B are sectional views showing canister clearance inside the main body of the inhaler;

FIG. **7**C is a further sectional view similar to that of FIG. **7**B but with the canister removed;

FIG. **7**D is a top plan view of the inhaler main body;

FIGS. **8**A, **8**B, **8**C and **8**D show the inhaler main body and dose counter components during assembly thereof;

FIG. **9** shows a sectional side view of a datum line for an actuator pawl of the dose counter;

FIGS. **10**A, **10**B, **10**C, **10**D, **10**E and **10**F show various side views of positions and configurations of the actuator pawl, a ratchet wheel, and a count pawl;

FIG. **11** shows distributions for tolerances of start, reset, fire, count and end positions for the actuator of the dose counter;

FIG. **12** is an enlarged version of part of FIG. **4**A;

FIG. **13** shows an end portion of a tape of the dose counter;

FIG. **14** shows a computer system for designing the dose counter;

FIG. **15** is an isometric view of a stock bobbin modified in accordance with the present invention for use in the dose counter of the inhaler of FIGS. **1** to **14**;

FIG. **16** shows an end view of the stock bobbin of FIG. **15**;

FIG. **17** is a section through a longitudinal axis of the stock bobbin of FIGS. **15** and **16**;

FIGS. **18**A, **18**B and **18**C are views of the stock bobbin of FIGS. **15** to **17** mounted in the dose counter chassis of FIGS. **1** to **14**, with the control elements of the forks of the second shaft (or split pin) having a profile slightly different to that in FIG. **6**F, with the forks in a compressed configuration;

FIGS. **19**A, **19**B and **19**C are views equivalent to FIGS. **18**A to **18**C but with the forks in a more expanded configuration due to a different rotational position of the stock bobbin;

FIG. **20** is an isometric view of the chassis assembled and including the stock bobbin of FIGS. **15** to **17** but excluding the tape for reasons of clarity;

FIG. **21** is a view of a preferred embodiment of a dry powder inhaler in accordance with the present invention;

FIG. **22** is an exploded view of the inhaler of FIG. **21**;

FIG. **23** is a view of a dose counter of the inhaler of FIG. **21**;

FIG. **24** is an exploded view of the dose counter shown in FIG. **23**;

FIG. **25** is an exploded view of parts of the inhaler of FIG. **21**; and

FIG. **26** is a view of a yoke of the inhaler of FIG. **21**.

DETAILED DESCRIPTION OF THE INVENTION

FIG. **1** shows a main body **10** of a manually operated metered dose inhaler **12** in accordance with an embodiment related to the present invention and having a mouthpiece cap **14** securable over a mouthpiece **16** of the main body.

The main body has a canister chamber **18** into which a canister **20** (FIG. **7**A) is slideable. The canister **20** has a generally cylindrical main side wall **24**, joined by a tapered section **26** to a head portion **28** having a substantially flat lower face **30** which has an outer annular drive surface **32** arranged to engage upon and drive an actuation pin **34** of a dose counter **36** as will be described. Extending centrally and axially from the lower face **30** is a valve stem **38** which is arranged to sealingly engage in a valve stem block **40** of the main body **10** of the inhaler **12**. The valve stem block **40** has a passageway **42** leading to a nozzle **44** for directing the contents of the canister **20**, namely active drug and propellant, towards an air outlet **46** of the inhaler main body **12**. It will be appreciated that due to gaps **48** between the canister **20** and an inner wall **50** of the main body **10** of the inhaler **12** an open top **52** of the main body **10** forms an air inlet into the inhaler **12** communicating via air passageway **54** with the air outlet **46**, such that canister contents exiting nozzle **44** mix with air being sucked by the user through the air passageway **54** in order to pass together through the air outlet and into the mouth of the user (not shown).

The dose counter **36** will now be described. The dose counter **36** includes an actuation pin **34** biased upwardly from underneath by a return spring **56** once installed in the main body **10**. As best shown in FIGS. **4**A, **6**H and **8**A, the pin **34** has side surfaces **58**, **60** arranged to slide between corresponding guide surfaces **62**, **64** located in a dose counter chamber **66** of the main body **10**, as well as an end stop surface **68** arranged to engage a corresponding end stop **70** formed in the dose counter chamber **66** to limit upward movement of the pin **34**. The pin **34** has a top part **72** which is circularly cylindrical and extends through an aperture **74** formed through a separator wall **76** which separates the canister chamber **18** from the dose counter chamber **66**. The top part **72** of the pin **34** has a flat top surface **78** which is arranged to engage the outer annular drive surface **32** of the canister **20**.

The actuation pin **34** is integrally formed with a drive or actuator pawl **80**. The actuator pawl **80** has a generally inverted U-shape configuration, having two mutually spaced and parallel arms **82**, **84** extending from a base portion of the actuation pin **34**, each holding at respective distal ends **88** thereof opposite ends of a pawl tooth member **90** which extends in a direction substantially perpendicular to the arms **82**, **84**, so as to provide what may be considered a "saddle" drive for pulling on each of the 11 drive teeth **92** of a ratchet wheel **94** of an incremental drive system **96** or ratchet mechanism **96** of the dose counter **36**. As shown for example in FIG. **10**B, the pawl tooth member **90** has a sharp lower

longitudinal side edge **98** arranged to engage the drive teeth **92**, the edge-to-surface contact provided by this engagement providing very accurate positioning of the actuator pawl **80** and resultant rotational positioning of the ratchet wheel **94**.

The dose counter **36** also has a chassis preassembly **100** which, as shown in FIGS. **4**A and **6**A, includes a chassis **102** having a first shaft **104** receiving the ratchet wheel **94** which is secured to a tape reel shaft **106**, and a second shaft (or split pin) **108** which is parallel to and spaced from the first shaft **104** and which slidably and rotationally receives a tape stock bobbin **110**.

As shown in FIG. **6**B, when the inhaler has not been used at all, the majority of a tape **112** is wound on the tape stock bobbin **110** and the tape **112** has a series of regularly spaced numbers **114** displayed therealong to indicate a number of remaining doses in the canister **20**. As the inhaler is repeatedly used, the ratchet wheel **94** is rotated by the actuator pawl **80** due to operation of the actuation pin **34** by the canister **20** and the tape **112** is incrementally and gradually wound on to the tape reel shaft **106** from the second shaft **108**. The tape **112** passes around a tape guide **116** of the chassis **102** enabling the numbers **114** to be displayed via a window **118** in a dose counter chamber cover **120** having a dose marker **132** formed or otherwise located thereon.

As shown in FIGS. **6**A and **6**D, the second shaft **108** is forked with two forks **124**, **126**. The forks **124**, **126** are biased away from one another. The forks have located thereon at diametrically opposed positions on the second shaft **108** friction or control elements **128**, **130**, one on each fork. Each control element extends longitudinally along its respective fork **124**, **126** and has a longitudinally extending friction surface **132**, **134** which extends substantially parallel to a longitudinal axis of the second shaft and is adapted to engage inside a substantially cylindrical bore **136** inside the tape stock bobbin **110**. This control arrangement provided between the bore **136** and the control elements **128**, **130** provides good rotational control for the tape stock bobbin **110** such that it does not unwind undesirably such as when the inhaler is dropped. The tape force required to unwind the tape stock bobbin **110** and overcome this friction force is approximately 0.1 N.

As can be seen in FIG. **6**D, as well as FIGS. **6**G and **10**A to **10**F, the chassis **102** is provided with an anti-back drive tooth **138** or count pawl **138** which is resiliently and substantially fixedly mounted thereto. As will be described below and as can be seen in FIGS. **10**A to **10**F, when the actuation pin **34** is depressed fully so as to fire the metered valve (not shown) inside the canister **20**, the actuator pawl **80** pulls down on one of the teeth **92** of the ratchet wheel **94** and rotates the wheel **94** anticlockwise as shown in FIG. **6**D so as to jump one tooth **92** past the count pawl **138**, thereby winding the tape **112** a distance incrementally relative to the dose marker **122** on the dose counter chamber **120** so as to indicate that one dose has been used.

With reference to FIG. **10**B, the teeth of the ratchet wheel **94** have tips **143** which are radiused with a 0.1 mm radius between the flat surfaces **140**, **142**. The ratchet wheel **94** has a central axis **145** which is 0.11 mm above datum plane **220** (FIG. **9**). A top/nose surface **147** of the anti-back drive tooth **138** is located 0.36 mm above the datum plane **220**. The distance vertically (i.e. transverse to datum plane **220**—FIG. **9**) between the top nose surface **147** of the anti-back drive tooth is 0.25 mm from the central axis **145** of the wheel **94**. Bump surface **144** has a lateral extent of 0.20 mm, with a vertical length of a flat **145'** thereof being 1 mm, the width of the bump surface being 1.22 mm (in the direction of the axis **145**), the top **149** of the bump surface **144** being 3.02 mm vertically below the axis **145**, and the flat **145'** being spaced a distance sideways (i.e. parallel to the datum plane **220**) 2.48 mm from the axis **145**. The top surface **78** of the pin **34** (FIG. **6**H) is 11.20 mm above the datum plane **220** (FIG. **9**) when the actuator pawl **80** and pin **34** are in the start configuration. The length of the valve stem **22** is 11.39 mm and the drive surface **32** of the canister **20** is 11.39 mm above the datum plane **220** when the canister is at rest waiting to be actuated, such that there is a clearance of 0.19 mm between the canister **20** and the pin **34** in this configuration.

FIGS. **10**A and **10**B show the actuator pawl **80** and ratchet wheel **94** and count pawl **138** in a start position in which the flat top **78** of the pin **34** has not yet been engaged by the outer annular drive surface **32** of the canister **20** or at least has not been pushed down during a canister depression.

In this "start" position, the count pawl **138** engages on a non-return back surface **140** of one of the teeth **92** of the ratchet wheel **94**. The lower side edge **98** of the actuator pawl is a distance "D" (FIG. **9**) 1.33 mm above datum plane **220** which passes through bottom surface or shoulder **41** of valve stem block **40**, the datum plane **220** being perpendicular to a main axis "X" of the main body **10** of the inhaler **12** which is coaxial with the centre of the valve stem block bore **43** and parallel to a direction of sliding of the canister **20** in the main body **10** of the inhaler **12** when the canister is fired.

As shown in FIG. **10**B, an advantageous feature of the construction is that the pawl tooth/actuator **90** acts as a supplementary anti-back drive member when the inhaler **12** is not being used for inhalation. In particular, if the inhaler **12** is accidentally dropped, resulting in a jolt to the dose counter **36** then, if the wheel **94** would try to rotate clockwise (backwards) as shown in FIG. **10**B, the back surface **140** of a tooth will engage and be blocked by the tooth member **90** of the pawl **80**. Therefore, even if the anti-back drive tooth **138** is temporarily bent or overcome by such a jolt, undesirable backwards rotation of the wheel **94** is prevented and, upon the next canister firing sequence, the pawl **90** will force the wheel **94** to catch up to its correct position so that the dose counter **36** continues to provide correct dosage indication.

FIG. **10**C shows a configuration in which the actuator pawl **80** has been depressed with the pin **34** by the canister **20** to a position in which the side edge **98** of the pawl tooth member **90** is just engaged with one of the teeth **92** and will therefore upon any further depression of the pin **34** begin to rotate the wheel **94**. This is referred to as a "Reset" position or configuration. In this configuration, the lower side edge **98** of the actuator **80** is 0.64 mm above the datum plane **220**.

FIG. **10**D shows a configuration in which the actuator pawl **80** has been moved to a position lower than that shown in FIG. **10**C and in which the metered dose valve (not shown) inside the canister has at this very position fired in order to eject active drug and propellant through the nozzle **44**. It will be noted that in this configuration the count pawl **138** is very slightly spaced from the back surface **140** of the same tooth **92** that it was engaging in the configuration of FIG. **10**D. The configuration shown in FIG. **10**D is known as a "Fire" configuration. In this configuration the lower side edge **98** of the actuator **80** is 0.47 min below the datum plane **220**.

FIG. **10**E shows a further step in the sequence, called a "Count" position in which the actuator pawl **80** has rotated the ratchet wheel **94** by the distance circumferentially angularly between two of the teeth **92**, such that the count pawl **138** has just finished riding along a forward surface **142** of one of the teeth **92** and has resiliently jumped over the tooth

into engagement with the back surface **140** of the next tooth. Accordingly, in this "Count" configuration, a sufficiently long stroke movement of the pin **34** has occurred that the tape **112** of the dose counter **36** will just have counted down one dose. In this configuration, the lower side edge **98** of the actuator is 0.95 mm below the datum plane **220**, Accordingly, in this position, the actuator **80** generally, including edge **98**, is 0.48 mm lower than in the fire configuration. It has been found that, although the count configuration happens further on than the fire configuration, counting is highly reliable, with less than 50 failed counts per million. This is at least partially due to momentum effects and to the canister releasing some back pressure on the user in some embodiments as its internal metering valve fires.

In the configuration of FIG. **10**F, the pawl **80** has been further depressed with the pin **34** by the canister **20** to a position in which it is just disengaging from one of the teeth **92** and the actuator pawl **80** is assisted in this disengagement by engagement of one of the arms **84** with a bump surface **144** on the chassis **102** (see FIG. **6**G) and it will be seen at this point of disengagement, which is called an "End" configuration, the count pawl **138** is positioned exactly halfway or substantially halfway between two of the drive teeth **92**. This advantageously means therefore that there is a minimum chance of any double counting or non-counting, which would be undesirable. In the end configuration, the side edge **98** of the actuator is 1.65 mm below the datum plane **220**. It will be appreciated that any further depression of the actuator pawl **80** and pin **34** past the "End" configuration shown in FIG. **10**F will have no effect on the position of the tape **112** displayed by the dose counter **36** since the actuator pawl **80** is disengaged from the ratchet wheel **94** when it is below the position shown in FIG. **10**F.

As shown in FIGS. **7**C and **7**D, the inner wall **50** of the main body **10** is provided with a two-step support rail **144** which extends longitudinally along inside the main body and is located directly adjacent the aperture **74**. As shown in FIG. **7**B a diametrically opposed two-step support rail **146** is also provided and this diametrically opposed in the sense that a vertical plane (not shown) can pass substantially directly through the first rail **144**, the aperture **74**, a central aperture **148** of the valve stem block **40** (in which canister stem **25** is located) and the second two-step support rail **146**. As shown in FIG. **7**A and schematically in FIG. **7**B, the rails **144**, **146** provide a maximum clearance between the canister **20** and the rails **144**, **146** in a radial direction of almost exactly 0.3 mm, about 0.25 to 0.35 mm being a typical range. This clearance in this plane means that the canister **20** can only rock backwards and forwards in this plane towards away from the actuation pin **34**. A relatively small distance and this therefore prevents the canister wobbling and changing the height of the actuation pin **34** *a* as to undesirably alter the accuracy of the dose counter **36**. This is therefore highly advantageous.

The inner wall **50** of the main body **10** is provided with two further two-step rails **150** as well as two pairs **152**, **154** of rails extending different constant radial amounts inwardly from the inner wall **50**, so as to generally achieve a maximum clearance of almost exactly 0.3 mm around the canister **20** for all of the rails PH, **146**, **150**, **152**, **154** spaced around the periphery of the inner wall **50**, in order to prevent undue rocking while still allowing canister motion freely inside the inhaler **12**. It will be clear from FIG. **7**C for example that the two-step rails have a first portion near an outlet end **156** of the canister chamber **18**, the first portion having a substantially constant radial or inwardly-extending width, a first step **160** leading to a second portion **162** of the rail, the second portion **102** having a lesser radial or inwardly extending extent than the first portion **156**, and finally a second step **164** at which the rail merges into the main inner wall **50** main surface.

A method of assembling the inhaler **12** will now be described.

With reference to FIG. **8**A, the main body **10** of the inhaler **12** is formed by two or more plastics mouldings which have been joined together to the configuration shown.

As shown in FIG. **8**B, the actuator pawl **80** and pin **34** are translated forward into position into a pin receiving area **166** in the dose counter chamber **66** and the pin **34** and actuator **80** may then be raised until the pin **34** emerges through the aperture **74**.

Next, the return spring **56** may be inserted below the pin **34** and a generally cylindrical annular lower end **168** of the spring **56** may be moved by a tweezer or tweezer-like assembly tool (not shown) into engagement with a shelf **170** of a spring retainer **172** in the dose counter chamber **66**. The spring retainer **172** is U-shaped and the shelf **170** is U-shaped and has a recess **174** formed below it. As shown in FIGS. **4**B, **4**C and **12** shelf **170** includes three chamfer surfaces **176**, **178**, **180** arranged to assist in moving the lower end of the spring **168** into position onto the shelf using the assembly tool (not shown). Once the lower end of the spring **168** is in place, the assembly tool (not shown) can easily be removed at least partly via the recess **174** below the lower end **168** of the spring **56**.

The tape **112** is attached at one end (not shown) to the tape stock bobbin **110** and is wound onto the bobbin by a motor **200** (FIG. **13**) having a hexagonal output shaft **202** which engages in a hexagonal socket **204** (FIG. **6**B) of the bobbin. During winding, the tape is monitored by a sensor **206**, which may be in the form of a camera or laser scanner, which feeds data to a computer controller **205** for the motor **200**. The controller **205** recognises three positioning markers **210** in the form of lines across the tape **112** and stops the motor **202** when the tape **112** is nearly fully wound onto the bobbin **110**, such that the distal end **212** of the tape **112** can be secured, e.g. by adhesive, to the tape reel shaft **106**. The controller **205** also recognises a pixelated tape size marker **214** observed by the sensor **206** and logs in a stocking system data store **217** details of the tape **112** such as the number of numbers **114** on the tape, such as one hundred and twenty or two hundred numbers **114**. Next, the tape reel shaft is wound until an appropriate position of the lines **210** at which a priming dot **216** will, once the bobbin **110** and reel shaft **106** are slid onto the second shaft **108** and second shaft **104**, be in a position to be located in the window **118** when the inhaler **12** is fully assembled. In the embodiments, the bobbin **110** and reel shaft **106** may be slid onto the shafts **108**, **104** before the tape **112** is secured to the reel shaft **106** and the reel shaft may then be wound to position the priming dot **216**.

Next, the assembled dose counter components of the chassis preassembly **100** shown in FIG. **6**B may as shown in FIG. **8**C be inserted into the dose counter chamber **66**, with pins **182**, **184**, **186** formed on the main body **10** in the dose counter chamber **66** passing through apertures or slots **188**, **190**, **192** formed on the chassis **102**, such that the pins **182**, **184**, **186** extend through (or at least into) the apertures or slots **188**, **190**, **192**. With the chassis **102** being relatively firmly pushed towards the main body **10**, the pins **182**, **184**, **186** are then heat staked and the chassis **102** is therefore after this held very firmly in position in the main body and is unable to move, thereby assisting in providing great accuracy for the dose counter **36**. Next, as shown in FIG. **8**D, the

dose counter chamber **120** may be fitted over the dose counter chamber **66** and may be secured in place such as by welding, with the priming dot **216** being displayed through the window.

The user can, when readying the inhaler **12** for first use, prime the inhaler by depressing the canister **20** three times which will bring the first number **114** on the tape into display through the window **118** in place of the priming dot **216**, the number **114** shown in FIG. **8**D being "200", thereby indicating that 200 doses are remaining to be dispensed from the canister **20** and inhaler **12**.

As shown in FIG. **8**D, and in FIG. **5**, an open drain hole **194** is provided at the bottom of the dose counter chamber **66** by a substantially semi-circular cut-out or recess formation **196** in a lower surface **198** of the main body **10** of the inhaler. Accordingly, if the user (not shown) should decide to wash the main body **10** of the inhaler, for example after encountering an unhygienic situation or simply as a matter of choice, the drain hole **194** allows initial draining of water from inside the dose counter chamber **66** and also thereafter evaporation of water or any aqueous matter in the dose counter chamber **66** so that the window **118** does not mist up undesirably.

FIG. **14** shows a computer system **230** for designing the dose counter **36** and in particular for calculating distributions representative of average positions and standard deviations in a production series of inhalers of the start, reset, fire, count and end positions of the actuator lower side edge **98** relative to the datum plane **220** (FIG. **9**) and therefore of the actuator pawl **80** generally relative to the ratchet wheel **94**, chassis **102** and, when the inhaler **12** is fully assembled, the main body **10** of the inhaler **12**. The computer system **230** includes a data store **232**, a CPU **234**, an input device **236** (such as a keyboard or communication port) and an output device **238** (such as a communications port, display screen and/or printer). A user may enter data via the input device **236** which may be used by the CPU **234** in a mathematical calculation to predict count failure rates when the various dose counters are to be built in a series with dose counter positions set with given averages and standard deviations and taking into account any momentum/inertia effects and metering valve user-back-pressure reduction effect which will occur upon canister firing of a given type of canister. The computer system **230** is thus mathematically used to design the distributions. For the inhaler **12** described herein with the dose counter **36** and canister **20**, the distributions are designed as shown in FIG. **11**. The x axis shows distance of the lower side surface **98** of the actuator **80** above the datum plane **220** and the y axis is representative of the distribution. Thus, curve **240** shows that the start configuration has an average 1.33 mm above the datum plane **200** (standard deviation is 0.1 mm), curve **242** shows that the reset configuration has an average of 0.64 mm above the datum plane **220** (standard deviation is 0.082 mm), curve **244** shows the fire configuration has an average 0.47 mm below the datum plane **220** (standard deviation is 0.141 mm), curve **246** shows the count configuration has an average 0.95 mm below the datum plane **220** (standard deviation is 0.080 mm), and curve **248** shows the end configuration has an average of 1.65 mm below the datum plane **220** (standard deviation is 0.144 mm).

FIGS. **15** to **20** show a version of the inhaler modified in accordance with the present invention. In these drawings, the same reference numerals have been used to those in the earlier drawings to denote the equivalent components. The inhaler **12** is the same as that in FIGS. **1** to **14** apart from the following modifications.

First, it can be seen that there is a modification in that the drive teeth **92** of the ratchet wheel **94** have a different profile to that in FIGS. **1** to **14**. There are also only nine ratchet teeth **94** in this embodiment instead of eleven.

Additionally, as shown in FIGS. **18**C and **19**C, the control elements **128**, **130** on the forks **124**, **126** of the second shaft **108** have a tapered profile which is different to the profile of the control elements **128**, **130** shown in FIG. **6**F. Either profile can be used in the embodiment of FIGS. **15** to **20** however.

Furthermore, as shown in FIG. **15**, the tape stock bobbin **110** has an inwardly facing generally cylindrical engagement surface **300** with a wavelike form extending partially therealong. The engagement surface **300** has a cross-section **301** perpendicular to the longitudinal length of the stock bobbin **110** which is constant therealong. This cross-section **301** can be seen in FIG. **16** and consists of a series of ten regularly spaced concavities **302** and ten convex wall portions **304**. The convex wall portions **304** are equi-spaced between the concavities **302**. Each concavity **302** has a radius of 0.2 mm. Each convex wall portion **304** also has a radius of 0.2 mm. Finally, the cross section **301** also includes flat wall portions **306** between all of the radiused wall portions of the concavities **302** and convex wall portions **304**. The geometry of the cross-section **301** is therefore defined by the radii of the concavities **302** and convex wall portions **304**, the flat wall portions **306** and the fact that there are ten concavities **302** and convex wall portions **304**.

The minor diameter of the engagement surface **300**, i.e. between the tips of opposite convex wall portions **304**, is 2.46 mm. The major diameter of the engagement surface **300**, i.e. between the outermost portions of the concavities **302**, is 2.70 mm. The undeformed tip to tip maximum diameter of the forks **124**, **126** of the split pin (the second shaft) **108**, i.e. in the region of the maximum radio extent of the control elements **128**, **130**, is 3.1 millimetres and it will therefore be appreciated that the forks **124**, **126** are resiliently compressed once the stock bobbin **110** has been assembled onto the split pin **108** in all rotational configurations of the stock bobbin **110** relative to the split pin **108**. The minimum gap between the forks **124**, **126** in the plane of the cross sections of FIGS. **18**C and **19**C is 1 mm when the split pin **108** is in the undeformed, pre-inserted state. When the split pin **108** is at maximum compression, as shown in FIGS. **18**A to **18**C when the control elements **128**, **130** are shown to be engaged on top of the convex wall portions **304**, the gap **308** between the tips **310**, **312** of the forks **124**, **126** is 0.36 mm. On the other hand, when the split pin **108** is at minimum compression (once inserted into the stock bobbin) as shown in FIGS. **19**A to **19**C, when the control elements **128**, **130** rest in the concavities **302**, the gap between the tips **310**, **312** of the forks **124**, **126** is 0.6 mm. The control elements **128**, **130** are outwardly radiused with a radius also of 0.2 mm such that they can just rest on the concavities **302** with full surface contact (at least at an axial location on the split pin where the tapered control elements are at their maximum radial extent), without rattling in, locking onto or failing to fit in the concavities **302**. The radii of the control elements **128**, **130** is therefore preferably substantially the same as the radii of the concavities **302**

It will be appreciated that whereas FIGS. **18**B and **19**B are end views along the coaxial axis of the stock bobbin **110** and split pin **108**, FIGS. **18**A and **19**A are cross-sections. FIG. **19**A is a section on the plane A-A' in FIG. **19**C and FIG. **18**A is a section at the same plane, but of course with the stock bobbin **110** rotated relative to the split pin **108**.

As the inhaler **12** is used and the ratchet wheel **94** rotates in order to count used doses, the stock bobbin rotates incrementally through rotational positions in which rotation is resisted, i.e. due to increasing compression of the split pin **108** at such rotational positions, and rotational positions in which rotation is promoted, i.e. due to decreasing compression of the split pin **108** at such rotational positions and this may involve a click forward of the stock bobbin **110** to the next position equivalent to that in FIGS. **19**A to **19**C in which the control elements **128**, **130** of the split pin art located in the concavities **302**. This functionality firstly allows the stock bobbin to unwind during use as required, but also prevents the tape **112** from loosening during transit if the inhaler **12** is dropped, such as onto a hard surface. This is highly advantageous, since the tape **11** is prevented from moving to a position in which it will give an incorrect reading regarding the number of doses in the canister.

During compression and expansion of the forks in the radial direction between the two configurations shown in FIGS. **18**C and **19**C, the forks **124**, **126** rotate about a point **316** on the split pin where the forks **124**, **126** come together. This rotational action means that there is a camming action between the forks **124**, **126** and the engagement surface **300** without significant friction but, nevertheless, the resilient forces provided by the regulator formed by the engagement surface **300** and forks **124**, **126** are able to regulate unwinding of the tape such that it does not easily occur during transit or if the inhaler **12** is dropped. It has been found during testing that a force of 0.3 to 0.4 N needs to be applied to the tape **112** to overcome the regulator at the stock bobbin **110**. 0.32 N is achieved with the control elements **128** having the profile shown in FIG. **19**C and 0.38 N is achieved with the profile of the control elements **128** altered to be as shown as described with reference to FIG. **6**F. These forces are substantially higher than the 0.1 N force mentioned above and undesirable movement of the tape is substantially avoided even if the inhaler is dropped onto a hard surface. The modified arrangement of FIGS. **15** to **20** does not provide this force "constantly" such that there is overall not an undesirably high friction of the tape **112** as it passes over the other components of the dose counter because, due to the incremental nature of the resilient forces at the regulator, the tape **112** can incrementally relax as it slides over the stationary chassis components.

Instead of having ten concavities **302** and convex wall portions **304**, other numbers may be used, such as 8 or 12. However, it is preferred to have an even number, especially since two control elements **128**, **130** are provided, so that all of the control elements **128**, **130** will expand and contract simultaneously. However, other arrangements are envisaged with 3 or more forks and the number of concavities/convex wall portions may be maintained as an integer divisible by the number of forks to maintain a system with simultaneous expansion/contraction. For example, the use of 9, 12 or 15 concavities/convex wall portions with 3 forks is envisaged.

Instead of having the engagement surface **300** on the inside of the stock bobbin **110**, it could be placed on the outside of the stock bobbin **110** so as to be engaged by flexible external legs/pawls or similar.

It will be noted that the regulator provided by the engagement surface **300** and forks **124**, **126** does not only allow rotation of the stock bobbin in one direction as is the case with the ratchet wheel **94**. Rotation in both directions is possible, i.e. forwards and backwards. This means that during assembly, the stock bobbin **110** can be wound backwards during or after fitting the bobbin **100**, shaft **106** and tape **112** onto the carriage **102**, if desired.

The stock bobbin **110** and the carriage **102** including the split pin **108** are both moulded of polypropylene material.

It will be seen from FIG. **16** that the cross-sectional shape **301** is not symmetrical within the hexagonal socket **204**. This has enabled the hexagonal socket **204** to be maintained at a useful size while still allowing the desired size and geometry of the cross section **301** to fit without interfering with the hexagonal shape of the hexagonal socket **204** and also permits moulding to work during manufacture.

As shown in FIG. **17**, the stock bobbin **110** has a series of four circumferential ribs **330** inside it and a spaced thereabout. These hold the stock bobbin **110** on the correct side of the mould tool during moulding.

FIGS. **21** and **22** show a preferred embodiment in accordance with the invention of an inhaler **510** for dispensing a dry-powdered medicament in metered doses for patient inhalation. The inhaler **510** is as disclosed in FIGS. **1** to **16** or EP-A-1330280, the contents of which are hereby fully incorporated herein by reference, but with the stock bobbin **110** and second shaft **108** of the dose counter **516** modified so as to be as in FIGS. **15** to **20** hereof. Thus, the dry powder inhaler **510** generally includes a housing **518**, and an assembly **512** received in the housing (see FIG. **21**). The housing **518** includes a case **520** having an open end **522** and a mouthpiece **524** (FIG. **25**) for patient inhalation, a cap **526** secured to and closing the open end **522** of the case **520**, and a cover **528** pivotally mounted to the case **520** for covering the mouthpiece **524**. As shown in FIG. **22**, the inhaler **510** also includes an actuation spring **569**, first yoke **566** with opening **572**, bellows **540** with crown **574**, a reservoir **514**, second yoke **568** with hopper **542** and dose counter **516** mounted thereto, and case **520** has transparent window **5130** thereon for viewing dose counter tape indicia **5128**. The dose metering system also includes two cams **570** mounted on the mouthpiece cover **528** and movable with the cover **528** between open and closed positions. The cams **570** each include an opening **580** for allowing outwardly extending hinges **582** of the case **520** to pass therethrough and be received in first recesses **584** of the cover **528**. The cams **570** also include bosses **586** extending outwardly and received in second recesses **588** of the cover **528**, such that the cover **528** pivots about the hinges **582** and the cams **570** move with the cover **528** about the hinges **582**. As described in EP-A-1330280, cams **570** act upon cam followers **578** to move second yoke **568** up and down and thereby operate dose counter by engagement of pawl **5138** on the second yoke **568** with teeth **5136**. Remaining components of the inhaler are provided as, and operate as described, in EP-A-1330280.

The dose counting system **516** therefore includes a ribbon or tape **5128** (FIGS. **23** & **24**), having successive numbers or other suitable indicia printed thereon, in alignment with a transparent window **5130** provided in the housing **18** (see FIG. **22**). The dose counting system **516** includes the rotatable stock bobbin **110** (as described above), an indexing spool **5134** rotatable in a single direction, and the ribbon **5128** rolled and received on the bobbin **110** and having a first end **5127** secured to the spool **5134**, wherein the ribbon **5128** unrolls from the bobbin **110** so that the indicia are successively displayed as the spool **5134** is rotated or advanced. In FIGS. **23** and **24** the wavelike engagement surface **300** of the bobbin **110** is not shown for the purposes of clarity.

The spool **134** is arranged to rotate upon movement of the yokes **566**, **568** to effect delivery of a dose of medicament from reservoir **514**, such that the number on the ribbon **5128** is advanced to indicate that another dose has been dispensed by the inhaler **510**. The ribbon **5128** can be arranged such that the numbers, or other suitable indicia, increase or

decrease upon rotation of the spool **5134**. For example, the ribbon **5128** can be arranged such that the numbers, or other suitable indicia, decrease upon rotation of the spool **5134** to indicate the number of doses remaining in the inhaler **510**. Alternatively, the ribbon **5128** can be arranged such that the numbers, or other suitable indicia, increase upon rotation of the spool **5134** to indicate the number of doses dispensed by the inhaler **10**.

The indexing spool **5134** includes radially extending teeth **5136**, which are engaged by pawl **5138** extending from a cam follower **578** of the second yoke **568** upon movement of the yoke to rotate, or advance, the indexing spool **5134**. More particularly, the pawl **5138** is shaped and arranged such that it engages the teeth **5136** and advances the indexing spool **5134** only upon the mouthpiece cover **528** being closed and the yokes **566**, **568** moved back towards the cap **526** of the housing **518**.

The dose counting system **516** also includes a chassis **5140** that secures the dose counting system to the hopper **542** and includes shafts **108**, **5144** for receiving the bobbin **110** and the indexing spool **5134**. As described above with reference to FIGS. **1** to **20**, the bobbin shaft **108** is forked and includes radially nubs **5146** for creating a resilient resistance to rotation of the bobbin **110** on the shaft **108** by engaging with the wavelike engagement surface **300** inside the bobbin **110**. A clutch spring **5148** is received on the end of the indexing spool **5134** and locked to the chassis **5140** to allow rotation of the spool **5134** in only a single direction.

Various modifications may be made to the embodiment shown without departing from the scope of the invention as defined by the accompanying claims as interpreted under patent law.

What is claimed is:

1. An incremental dose counter for a metered dose inhaler having a body arranged to retain a canister for movement of the canister relative thereto, the incremental dose counter having a main body, an actuator arranged to be driven and to drive an incremental output member in a count direction in response to canister motion, the actuator being configured to restrict motion of the output member in a direction opposite to the count direction, such that the actuator acts as an anti-back drive member when the actuator is in a non-depressed position, and wherein the incremental dose counter further comprises a second anti-back member configured to restrict motion of the output member in a direction opposite to the count direction when the actuator is disengaged from the output member by a bump surface.

2. The incremental dose counter as claimed in claim **1** in which the output member comprises a ratchet wheel.

3. The incremental dose counter as claimed in claim **2** in which the actuator comprises a pawl and in which the ratchet wheel and pawl are arranged to permit only one way ratcheting motion of the ratchet wheel relative to the pawl.

4. The incremental dose counter as claimed in claim **3** wherein the second anti-back member is fixed to the main body.

5. The incremental dose counter as claimed in claim **4** in which, when in a rest position of the dose counter, the ratchet wheel is capable of adopting a configuration in which a back surface of one tooth thereof engages the second anti-back member and the pawl is spaced from an adjacent back surface of another tooth of the ratchet wheel without positive drive/blocking engagement between the pawl and ratchet wheel.

6. A dose counter as claimed in claim **1** wherein an incremental counting system is arranged to move a counter display incrementally in a first direction from a first station to a second station in response to actuation input, wherein a regulator is provided which is arranged to act upon the counter display at the first station to regulate motion of the counter display at the first station to incremental movements.

* * * * *

Section 505 of the Federal Food, Drug, and Cosmetic Act (21 U.S.C. § 355) provides in relevant part:

New drugs

* * * *

(b) Filing application; contents

(1)(A) Any person may file with the Secretary an application with respect to any drug subject to the provisions of subsection (a). Such persons shall submit to the Secretary as part of the application—

> * * * (viii) the patent number and expiration date of each patent for which a claim of patent infringement could reasonably be asserted if a person not licensed by the owner of the patent engaged in the manufacture, use, or sale of the drug, and that—
>
> (I) claims the drug for which the applicant submitted the application and is a drug substance (active ingredient) patent or a drug product (formulation or composition) patent; or
>
> (II) claims a method of using such drug for which approval is sought or has been granted in the application.

CERTIFICATE OF SERVICE

I hereby certify that on July 30, 2024, I electronically filed the foregoing using the Court's CM/ECF system, which will send notifications to all counsel registered to receive electronic notices.

/s/ William M. Jay
William M. Jay