



(51) International Patent Classification:

B01F 15/04 (2006.01) **B01F 15/00** (2006.01)
B01F 5/00 (2006.01) **B01F 15/02** (2006.01)

(21) International Application Number:

PCT/US2016/044046

(22) International Filing Date:

26 July 2016 (26.07.2016)

(25) Filing Language:

English

(26) Publication Language:

English

(30) Priority Data:

62/197,350 27 July 2015 (27.07.2015) US

(71) Applicant: GRACO MINNESOTA INC. [US/US]; 88
11th Avenue NE, Minneapolis, Minnesota 55413 (US).(72) Inventors: MCCORMICK, Martin, P.; 21830 Iden Avenue,
Forest Lake, Minnesota 55025 (US). TIX, Joseph,
E.; 2446 Brooke Lane, Hastings, Minnesota 55033 (US).(74) Agents: FAIRBAIRN, David, R. et al.; Kinney & Lange,
P.A., 312 South Third Street, Minneapolis, Minnesota
55415 (US).(81) Designated States (unless otherwise indicated, for every
kind of national protection available): AE, AG, AL, AM,

AO, AT, AU, AZ, BA, BB, BG, BH, BN, BR, BW, BY,
BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DK, DM,
DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT,
HN, HR, HU, ID, IL, IN, IR, IS, JP, KE, KG, KN, KP, KR,
KZ, LA, LC, LK, LR, LS, LU, LY, MA, MD, ME, MG,
MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM,
PA, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SA, SC,
SD, SE, SG, SK, SL, SM, ST, SV, SY, TH, TJ, TM, TN,
TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

(84) Designated States (unless otherwise indicated, for every
kind of regional protection available): ARIPO (BW, GH,
GM, KE, LR, LS, MW, MZ, NA, RW, SD, SL, ST, SZ,
TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, RU,
TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ, DE,
DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU,
LV, MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK,
SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ,
GW, KM, ML, MR, NE, SN, TD, TG).

Declarations under Rule 4.17:

— of inventorship (Rule 4.17(iv))

Published:

— with international search report (Art. 21(3))

(54) Title: PASSIVE FLOW SYNCHRONIZER

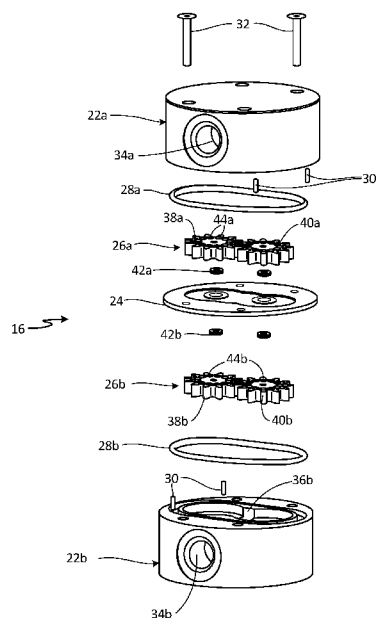


Fig. 2A

(57) Abstract: A passive flow synchronizer maintains a set ratio between a first flow and a second flow. A first component material flows through a first flow path, and a second component material flows through a second flow path that runs parallel to and is separate from the first flow path. A first gear set is disposed in the first flow path and meters the flow of the first fluid through the first flow path. A second gear set is disposed in the second flow path and meters the flow of the second fluid through the second flow path. The first gear set is linked to the second gear set such that both the first gear set and the second gear set rotate synchronously.

PASSIVE FLOW SYNCHRONIZER

CROSS-REFERENCE TO RELATED APPLICATION

This application claims priority to U.S. Provisional Application No. 62/197,350 filed on July 27, 2015, and entitled "PASSIVE VOLUMETRIC FLUID
5 FLOW SYNCHRONIZER," the disclosure of which is incorporated by reference in its entirety.

BACKGROUND

This disclosure relates generally to multiple component applicators, and more particularly to a passive component synchronizer for a multiple component
10 applicator.

Multiple component applicators apply a resultant material, such as a foam insulation, that is formed from multiple component materials. The component materials react with each other in a short time period, so the component materials are stored separately until application. The component materials are mixed in a mixing manifold,
15 which is generally attached to the applicator gun, immediately prior to application of the resultant material. To ensure that the quality of the resultant material, the component materials must be mixed at a constant predetermined ratio. To ensure that the correct ratio is being provided to the mixing manifold, the user takes samples of each component material and compares the weights of multiple samples to determine a ratio. Typically, a
20 ratio between the first component material and the second component material is determined by taking a sample flow of the first component material and measuring the sample flow against a sample flow of the second component material. If the ratio is incorrect, then the pressure in the material tanks is adjusted and additional samples are taken until the desired ratio is achieved. Measuring the ratio samples by hand wastes
25 component materials, creates chemical waste, and is time consuming.

SUMMARY

According to an aspect of the disclosure, a passive fluid flow synchronizer includes a first component meter housing, a second component meter housing, a barrier plate disposed between the first component meter housing and the second component
30 meter housing, a first gear set, and a second gear set. The first component meter housing has a first inlet, a first outlet, and a first flow path extending between the first inlet and the first outlet. The second component meter housing has a second inlet, a second outlet, and a second flow path extending between the second inlet and the second outlet. The barrier plate is configured to separate the first flow path and the second flow path. The first gear

set is disposed within the first flow path between the first inlet and the first outlet. The second gear set is disposed within the second flow path between the second inlet and the second outlet. The first gear set is coupled to the second gear set such that the first gear set and the second gear set rotate synchronously to provide a set volumetric ratio of a first component material to a second component material through the first outlet and the second outlet.

According to another aspect of the disclosure, a multiple component dispenser includes a first material tank, a second material tank, a passive fluid flow synchronizer connected to the first material tank with a first supply hose and connected to the second material tank with a second supply hose, a first nozzle hose, a second nozzle hose, and a material applicator. The passive flow synchronizer includes a first component meter housing having a first inlet, a first outlet, and a first flow path extending between the first inlet and the first outlet, a second component meter housing having a second inlet, a second outlet, and a second flow path extending between the second inlet and the second outlet, a barrier plate disposed between the first component meter housing and the second component meter housing and isolating the first flow path from the second flow path, a first gear set disposed within the first flow path between the first inlet and the first outlet, and a second gear set disposed within the second flow path between the second inlet and the second outlet. The first supply hose is attached to the first inlet and the second supply hose is attached to the second inlet. The first nozzle hose is connected to the first outlet and configured to receive the first material from the first flow path. The second nozzle hose is connected to the first outlet and configured to receive the second material from the second flow path. The first gear set is configured to meter the flow of a first material through the first flow path. The second gear set is configured to meter the flow of a second material through the second flow path. The first gear set is coupled to the second gear set such that the first gear set and the second gear set rotate synchronously. The material applicator is configured to receive the first material from the first nozzle hose and the second material from the second nozzle hose.

According to yet another aspect of the disclosure, a method of synchronizing multiple flows includes coupling a first gear set disposed on a first side of a barrier plate to a second gear set disposed on a second side of the barrier plate such that the first gear set and the second gear set rotate synchronously, flowing a first material through a first flow path and the first gear set, flowing a second material through a second flow path and the second gear set, and providing a set volumetric ratio of the first material

to the second material by the synchronous rotation of the first gear set and the second gear set.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a schematic view of a multiple component dispensing system.

5 FIG. 2A is an exploded view of a passive flow synchronizer.

FIG. 2B is a top cross-sectional view of a passive flow synchronizer.

FIG. 2C is an isometric cross-sectional view of a passive flow synchronizer.

10 FIG. 2D is a side elevation cross-sectional view of a passive flow synchronizer.

FIG. 3 is a cross-sectional view of a passive flow synchronizer.

DETAILED DESCRIPTION

FIG. 1 is a schematic view of multiple component dispensing system 10. Multiple component dispensing system 10 includes material tank 12a, material tank 12b, 15 supply hose 14a, supply hose 14b, passive flow synchronizer 16, nozzle hose 18a, nozzle hose 18b, and material applicator 20.

Supply hose 14a extends between material tank 12a and passive flow synchronizer 16. Supply hose 14a provides a first component material from material tank 12a to passive flow synchronizer 16. Similarly, supply hose 14b extends between 20 material tank 12b and passive flow synchronizer 16. Supply hose 14b provides a second component material from material tank 12b to passive flow synchronizer 16. Passive flow synchronizer 16 receives both the first component material and the second material and provides the first material and the second material downstream. Nozzle hose 18a is connected to passive flow synchronizer 16 and receives the first component material from 25 passive flow synchronizer 16. Nozzle hose 18a provides the first component material to material applicator 20. Nozzle hose 18b is also connected to passive flow synchronizer 16, and nozzle hose 18b receives the second component material from passive flow synchronizer 16 and provides the second component material to material applicator 20.

Material tank 12a stores the first component material under pressure and 30 material tank 12b stores the second component material under pressure. The first component material and the second component material may be components in a two-component, quick-cure polyurethane foam, whereby the first component material reacts with the second component material to create the polyurethane foam. The first component material is stored separate from the second component material until the time of

application, as the first component material and the second component material react quickly to form the resultant foam. As such, the first component material is maintained separate from the second component material until application of the resultant material. To ensure that the resultant material has the desired properties, the first component material and the second component material are combined at a set ratio.

Triggering material applicator 20 causes the pressure within nozzle hoses 18a and 18b to drop. The pressure within material tank 12a then drives the first component material downstream through supply hose 14a, passive flow synchronizer 16, and nozzle hose 18a. Similarly, the pressure within material tank 12b drives the second component material downstream through supply hose 14b, passive flow synchronizer 16, and nozzle hose 18b. Passive flow synchronizer 16 meters the flow of the first component material and the second component material such that the first component material and the second component material are provided downstream from passive flow synchronizer 16 at a set ratio. The first component material flows downstream from passive flow synchronizer 16 through nozzle hose 18a and to material applicator 20. The second component material flows downstream from passive flow synchronizer 16 through nozzle hose 18b and to material applicator 20. The first component material and the second component material are combined at material applicator 20 and applied to a desired surface.

Passive flow synchronizer 16 ensures that the ratio of the first component material to the second component material provided to material applicator 20 remains constant. By ensuring a constant ratio of the first component material to the second component material at material applicator 20, passive flow synchronizer 16 reduces chemical waste, ensures that the resultant material has the desired properties, and reduces the time requirement needed to prepare multiple component dispensing system 10. Passive flow synchronizer 16 ensures a constant ratio between the first component material and the second component material, thereby eliminating the need to sample the first component material and the second component material. Eliminating sampling reduces chemical waste and reduces the time necessary to set up multiple component dispensing system, thereby saving time and money.

FIG. 2A is an exploded view of passive flow synchronizer 16. FIG. 2B is a top cross-sectional view of passive flow synchronizer 16. FIG. 2C is an isometric cross-sectional view of passive flow synchronizer 16. FIG. 2D is a side-elevation cross-sectional view of passive flow synchronizer 16. FIGS. 2A–2D are substantially similar

and will be discussed together. Passive flow synchronizer 16 includes component meter housing 22a, component meter housing 22b, barrier plate 24, gear set 26a, gear set 26b, static seal 28a, static seal 28b, aligning pins 30, and fasteners 32. Component meter housing 22a includes inlet 34a and outlet 36a. Component meter housing 22b includes inlet 34b and outlet 36b. Gear set 26a includes first gear 38a, second gear 40a, bearings 42a, and aligning mechanism 44a. Similarly, gear set 26b includes first gear 38b, second gear 40b, bearings 42b, and aligning mechanism 44b. Aligning mechanism 44a includes magnets 46a. Aligning mechanism 44b includes magnets 46b. First gear 38a includes first gear teeth 48a, and first gear 38b includes first gear teeth 48b. Second gear 40a includes second gear teeth 50a, and second gear 40b includes second gear teeth 50b.

Barrier plate 24 is disposed between component meter housing 22a and component meter housing 22b. Fasteners 32 extend through component meter housing 22a, barrier plate 24, and component meter housing 22b to secure component meter housing 22a, barrier plate 24, and component meter housing 22b together. Aligning pins 30 are configured to extend through barrier plate 24 and into component meter housing 22a and component meter housing 22b. Aligning pins 30 ensure that component meter housing 22a, barrier plate 24, and component meter housing 22b are properly aligned. Static seal 28a is disposed between barrier plate 24 and component meter housing 22a and is configured to prevent a fluid flowing through component meter housing 22a from leaking between component meter housing 22a and barrier plate 24. Similarly, static seal 28b is disposed between barrier plate 24 and component meter housing 22b and is configured to prevent a fluid flowing through component meter housing 22b from leaking between component meter housing 22b and barrier plate 24.

Gear set 26a is disposed within component meter housing 22a and adjacent barrier plate 24. First gear 38a is intermeshed with second gear 40a such that first gear 38a and second gear 40a rotate synchronously, in opposite directions of rotation. The meshing of first gear 38a and second gear 40a prevents the first component material from flowing between first gear 38a and second gear 40a, such that the first component material must instead flow around first gear 38a and second gear 40a, as shown by flow lines F1 in FIG. 2D. Thrust bearings 42a are disposed between barrier plate 24 and first gear 38a and second gear 40a. Similar to gear set 26a, gear set 26b is disposed within component meter housing 22b and adjacent barrier plate 24. First gear 38b is intermeshed with second gear 40b such that first gear 38b and second gear 40b rotate synchronously, in opposite directions of rotation. The meshing of first gear 38b and

second gear 40b prevents the second component material from flowing between first gear 38b and second gear 40b, and as such, the second component material must instead flow around first gear 38b and second gear 40b, similar to the first component material flowing around first gear 38a and second gear 40a. Thrust bearings 42b are disposed between
5 barrier plate and first gear 38b and second gear 40b. Bearings 42a and bearings 42b may be of any suitable configuration for supporting gear set 26a and gear set 26b on barrier plate 24. For example, bearings 42a and bearings 42b may be ball-type thrust bearings, needle-type thrust bearings, a carbide pin pressed through barrier plate 24, carbide shell bearings, or any other suitable bearing.

10 Aligning mechanism 44a is disposed on first gear 38a and second gear 40a. Aligning mechanism 44b is disposed on first gear 38b and second gear 40b. Aligning mechanism 44a includes magnets 46a that extend through first gear 38a and second gear 40a. Magnets 46a are disposed on first gear 38a in an alternating north-south manner, best seen in FIG. 2B. Magnets 46a are also disposed on second gear 40a in an
15 alternating north-south manner, best seen in FIG. 2B. Similarly, aligning mechanism 44b is disposed on first gear 38b and second gear 40b. Aligning mechanism 44b includes magnets 46b that extend through first gear 38b and second gear 40b. Similar to magnets 46a, magnets 46b are disposed on first gear 38b in an alternating north-south manner. Magnets 46b are also disposed on second gear 40b in an alternating north-south manner.

20 Aligning mechanism 44a is configured to couple to aligning mechanism 44b such that gear set 26a is coupled to gear set 26b. With first gear 38a coupled to first gear 38b and with second gear 40a coupled to second gear 40b, gear set 26a and gear set 26b are coupled for synchronous rotation. Gear set 26a is coupled to gear set 26b by aligning mechanisms 44a and 44b for synchronous rotation of gear set 26a and gear set
25 26b. Magnets 46a and magnets 46b are attracted to each other such that first gear 38a and first gear 38b rotate synchronously. As such, the rotation of either first gear 38a or first gear 38b will simultaneously drive the rotation of the other of first gear 38a and first gear 38b. Utilizing an equal number of magnets 46a as first gear teeth 48a allows gear set 26a to line up with gear set 26b without requiring the gears to be clocked to a specific gear
30 tooth. It is understood, however, that magnets 46a may be arranged on first gear 38a and second gear 40a in any suitable manner for linking gear set 26a and gear set 26b; for example, magnets 46a may include multiple, round neodymium magnets, radial magnets, or any other suitable configuration. Where aligning mechanism 44a and aligning mechanism 44b include magnets 46a and 46b, barrier plate 24 is preferably made of a

non-ferrous material, such as plastic or aluminum, suitable for providing a barrier between a first component material flowing through component meter housing 22a and a second component material flowing through component meter housing 22b.

During operation, passive flow synchronizer 16 is configured to meter the
5 first component material and the second component material such that a fixed ratio of the first component material to the second component material is provided downstream. The first component material is provided to component meter housing 22a through supply hose 14a (shown in FIG. 1) and inlet 34a. Simultaneously, the second component material is provided to component meter housing 22b through supply hose 14b (shown in
10 FIG. 1) and inlet 34b. The first component material and the second component material are stored under pressure in material tank 12a (shown in FIG. 1) and material tank 12b (shown in FIG. 1), respectively. To mix and apply the first component material and the second component material, an applicator is triggered. Triggering the applicator causes the pressure in nozzle hose 18a and nozzle hose 18b to drop, creating a pressure
15 differential between inlet 34a and outlet 36a, and between inlet 34b and outlet 36b. The storage pressure within material tank 12a causes the first component material to flow downstream through passive flow synchronizer 16 and to the applicator, and the storage pressure within material tank 12b causes the second component material to flow downstream through passive flow synchronizer 16 and to applicator 20. Aligning
20 mechanism 44a and aligning mechanism 44b couple gear set 26a to gear set 26b such that gear set 26a and gear set 26b rotate synchronously and thus meter the first component material and the second component material at the same rate. As such, even where a difference exists between the first pressure differential and the second pressure differential, passive flow synchronizer 16 ensures that a ratio of the first component
25 material to the second component material provided downstream through outlets 36a and 36b is constant.

In FIG. 2B, a flow of a component material is shown through component meter housing 22a and gear set 26a. As discussed above, gear set 26a and gear set 26b meter fluid in substantially the same manner, and as such, while the discussion of FIG. 3A
30 is directed towards gear set 26a, it is understood that the discussion of gear set 26a is equally applicable to gear set 26b. Component meter housing 22a includes inlet 34a and outlet 36a. Gear set 26a is disposed within component meter housing 22a between inlet 34a and outlet 36a. Gear set 26a includes first gear 38a, second gear 40a, and magnets

46a. First gear 38a includes first gear teeth 48a, and second gear 40a includes second gear teeth 50a.

First gear teeth 48a are intermeshed with second gear teeth 50a such that first gear 38a and second gear 40a rotate synchronously. The component material enters
5 component meter housing 22a through inlet 34a, is metered by gear set 26a, and exits component meter housing 22a through outlet 36a. An upstream pressure drives the component material through component meter housing 22a. When a material applicator
20 (shown in FIG. 1) is triggered, the downstream pressure drops, and the upstream pressure drives the component material through component meter housing 22a. Magnets
10 46a extend through first gear 38a and second gear 40a. Preferably, first gear 38a includes the same number of magnets 46a as first gear teeth 48a, and second gear 40a includes the same number of magnets 46a as second gear teeth 50a.

Due to the meshing of first gear teeth 48a and second gear teeth 50a, the component material cannot flow between first gear 38a and second gear 40a. Instead, the
15 component material causes first gear 38a to rotate in direction R1 and second gear 40a to simultaneously rotate in direction R2. As first gear 38a and second gear 40a rotate, the component material is captured in a first volume defined between adjacent first gear teeth 48a and in a second volume defined between adjacent second gear teeth 50a. The component material fills the first volume and the second volume proximate inlet 34a.
20 The component material is retained in the first volume and the second volume as first gear 38a and second gear 40a rotate. The component material exits the first volume and the second volume proximate outlet 36a and continues downstream through outlet 36a. The first volume and the second volume are known, and as such, a set, known volume of component material is provided to outlet 36a for each rotation of first gear 38a and
25 second gear 40a. The greater the pressure differential, the greater the rate of rotation for both first gear 38a and second gear 40a. Gear set 26a provides a set, known volume of the component material, however, regardless of the rate of rotation.

In FIG. 2C, a connection of gear set 26a and gear set 26b is shown. Gear set 26a is disposed within component meter housing 22a between inlet 34a and outlet 36a.
30 Gear set 26b is disposed within component meter housing 22b between inlet 34b and outlet 36b. Barrier plate 24 is disposed between and separates gear set 26a and gear set 26b, and barrier plate 24 prevents the first component material, flowing through component meter housing 22a, from interacting with the second component material, flowing through component meter housing 22b, as the first component material and the

second component material pass through passive flow synchronizer 16. Aligning mechanism 44a extends through gear set 26a, and aligning mechanism 44b extends through gear set 26b. More particularly, magnets 46a extend through first gear 38a and second gear 40a, and magnets 46b extend through first gear 38b and second gear 40b.

5 Aligning mechanism 44a is coupled to aligning mechanism 44b, such that gear set 26a is coupled to gear set 26b for synchronous rotation. Magnets 46a are positioned on first gear 38a and second gear 40a in an alternating, north-south manner. As such, each magnet 46a extending through first gear 38a and second gear 40a preferably has an opposite polarity from any adjacent magnet 46a. Similarly, magnets
10 46b are positioned on first gear 38b and second gear 40b in an alternating, north-south manner, such that each magnet 46b has an opposite polarity from any adjacent magnet 46b. Arranging magnets 46a and magnets 46b in an alternating north-south manner increases the overall locking power of magnets 46a and increases the ease of assembly.

 Gear set 26a is disposed on an opposite side of barrier plate 24 from gear
15 set 26b. However, gear set 26a is magnetically coupled to gear set 26b by magnets 46a and magnets 46b. Due to the magnetic coupling of gear set 26a and gear set 26b, barrier plate 24 is preferably made from a non-ferrous material, such as thermoplastic, aluminum, or any other suitable material. Magnets 46a extend about first gear 38a and second gear 40a in an alternating, north-south manner. Arranging magnets 46a in an
20 alternating north-south manner increases the overall locking power of magnets 46a and increases the ease of assembly.

 Magnets 46a are attracted to magnets 46b such that first gear 38a is magnetically coupled to first gear 38b and second gear 40a is magnetically coupled to second gear 40b, such that gear set 26a and gear set 26b rotate synchronously. As such,
25 the rotation of either second gear 40a or second gear 40b will simultaneously drive the rotation of the other of second gear 40a and second gear 40b. While magnets 46a are described as extending through both first gear 38a and second gear 40a, it is understood that magnets 46a may extend through only one of first gear 38a or second gear 40a. In such a case, magnets 46b may also extend through one of first gear 38b or second gear
30 40b. For example, where magnets 46a extend through only first gear 38a, magnets 46b may extend through only first gear 38b such that first gear 38a and first gear 38b are magnetically coupled. Even where second gear 40a and second gear 40b do not include magnets, second gear 40a and second gear 40b maintain synchronous rotation due to second gear 40a meshing with first gear 38a and second gear 40b meshing with first gear

38b. The magnetic coupling of gear set 26a and gear set 26b ensures synchronous rotation of both gear set 26a and gear set 26b, thereby ensuring that a set ratio of the first component material to the second component material is provided downstream by passive flow synchronizer 16. In addition, magnetically coupling gear set 26a and gear set 26b eliminates over-pressure and vacuum concerns, because gear set 26a may decouple from gear set 26b where the difference between the first pressure differential and the second pressure differential is too high. The magnetic coupling prevents any damage to either gear set 26a or gear set 26b, as gear set 26a and gear set 26b are not mechanically coupled.

As discussed above, a set volume of the first component material is provided to outlet 36a for each rotation of first gear 38a and second gear 40a. A set volume of the second component material is provided to outlet 36b for each rotation of first gear 38b and second gear 40b. The first pressure differential drives the first component material through gear set 26a, and the second pressure differential drives the second component material through gear set 26b.

Coupling gear set 26a and gear set 26b for synchronous rotation ensures a known, steady ratio of the first component material to the second component material is provided by passive flow synchronizer 16. Gear set 26a provides a set volume of the first component material to outlet 36a for each rotation of first gear 38a and second gear 40a, and gear set 26b provides a set volume of the second component material to outlet 36b for each rotation of first gear 38b and second gear 40b. As such, coupling gear set 26a and gear set 26b for synchronous rotation ensures that a set ratio is provided downstream. Where gear set 26a is not coupled to gear set 26b, gear sets 26a and 26b may rotate at different rates where the first pressure differential differs from the second pressure differential. Rotating gear set 26a at a different rate than gear set 26b causes an unknown ratio of the first component material to the second component material at material applicator 20, thus leading to undesirable properties in the resultant material. However, gear set 26a is magnetically coupled to gear set 26b such that the rotation of one of gear set 26a or gear set 26b causes synchronous rotation of the other of gear set 26a and gear set 26b. By ensuring that gear set 26a and gear set 26b rotate synchronously, a set ratio of the first component material to the second component material is provided.

Passive flow synchronizer 16 may meter the first component material and the second component material such that any desired ratio of the first component material to the second component material is provided downstream. For example, a 1:1 ratio may

be provided by having first gear 38a and second gear 40a be identical to first gear 38a and second gear 40a, thereby ensuring that the same volume of the component material is provided for each rotation. A 2:1 ratio may be provided by utilizing a gear set 26a where first gear 38a and second gear 40a have a gear height twice that of first gear 38b and second gear 40b. The greater height of first gear 38a and second gear 40a provides more volume between the first gear teeth and the second gear teeth, and thus a greater volume of the first component material is provided downstream for each rotation of first gear 38a and second gear 40a. Any desired ratio of the first component material to the second component material may be achieved by varying the gear configuration.

In FIG. 2D, a flow of a first component material and of a second component material through passive flow synchronizer 16. Component meter housing 22a includes inlet 34a and outlet 36a. Component meter housing 22b includes inlet 34b and outlet 36b. Component meter housing 22a is attached to component meter housing 22b, with barrier plate 24 disposed between and separating component meter housing 22a and component meter housing 22b. Gear set 26a is disposed within component meter housing 22a between inlet 34a and outlet 36a. Gear set 26b is disposed within component meter housing 22b between inlet 34b and outlet 36b on an opposite side of barrier plate 24 from gear set 26a. Static seal 28a is disposed between component meter housing 22a and barrier plate 24. Static seal 28b is disposed between component meter housing 22b and barrier plate 24.

When a downstream material applicator is triggered, a first downstream pressure, at outlet 36a, and a second downstream pressure, at outlet 36b, drop. The drop in the first downstream pressure and the second downstream pressure creates a first pressure differential between inlet 34a and outlet 36a and a second pressure differential between inlet 34b and outlet 36b. The first pressure differential drives the first component material into component meter housing 22a through inlet 34a, through gear set 26a, and downstream through outlet 36a, as shown by flow lines F1. The second pressure differential simultaneously drives the second component material into component meter housing 22b through inlet 34b, through gear set 26b, and downstream through outlet 36b, as shown by flow lines F2.

As discussed above, gear set 26a is coupled to gear set 26b such that gear set 26a and gear set 26b rotate synchronously, regardless of a difference between the first pressure differential and the second pressure differential. As such, passive flow synchronizer 16, synchronizes the flow of the first component material and the second

component material without requiring extensive adjustments to the first upstream pressure and the second upstream pressure. Instead, regardless of the difference between the first pressure differential and the second pressure differential, aligning mechanism 44a and aligning mechanism 44b maintain the coupling of gear set 26a and gear set 26b. As such, gear set 26a and gear set 26b meter the flow of the first component material and the second component material to provide a set ratio of the first component material to the second component material to a downstream applicator.

Coupling gear set 26a and gear set 26b for synchronous rotation provides significant advantages. Coupling gear set 26a and gear set 26b ensures a set ratio of the first component material to the second component material is provided to material applicator 20. Because the ratio is set, regardless of the difference between the first pressure differential and the second pressure differential, passive flow synchronizer 16 eliminates the needs to take samples of the first component material and the second component material with special nozzles into separate containers to verify the mix ratio. As such, passive flow synchronizer 16 reduces waste and makes application of the resultant material more efficient, as the time required to verify the mix ratio is eliminated. In addition, where aligning mechanisms 44a and 44b are magnets, the use of external or internal dynamic seals is eliminated, thereby reducing the complexity of the system. Furthermore, magnetic coupling eliminates over-pressure and vacuum concerns, as the magnets will decouple where the difference between the first pressure and the second pressure is undesirably high.

FIG. 3 is a cross-sectional view of passive flow synchronizer 16'. Passive flow synchronizer 16' differs from passive flow synchronizer 16 in that passive flow synchronizer 16' includes mechanical coupling while passive flow synchronizer 16 includes magnetic coupling. Passive flow synchronizer 16' includes component meter housing 22a', component meter housing 22b', barrier plate 24', gear set 26a', gear set 26b', static seal 28a', static seal 28b', fasteners 32', and aligning mechanism 44'. Gear set 26a' includes first gear 38a', second gear 40a', and bearing 42a'. Gear set 26b' includes first gear 38b', second gear 40b', and bearing 42b'.

Barrier plate 24' is disposed between component meter housing 22a' and component meter housing 22b'. Fasteners 32' extend through component meter housing 22a', component meter housing 22b', and barrier plate 24' to connect component meter housing 22a', component meter housing 22b', and barrier plate 24' together. Gear set 26a' is disposed between component meter housing 22a' and barrier plate 24' and is configured

to meter a flow of a first component material through component meter housing 22a'. Gear set 26b' is disposed between component meter housing 22b' and barrier plate 24' and is configured to meter a flow of a second component material through component meter housing 22b'. Bearing 42a' extends into barrier plate 24' and second gear 40a'. Similarly, 5 bearing 42b' extends into barrier plate 24' and second gear 40b'. Aligning mechanism 44' extends through barrier plate 24' between first gear 38a' and second gear 40a' and connects first gear 38a' and first gear 38b'.

During operation, the first component material is driven through component meter housing 22a' by a first upstream pressure. Similarly, the second 10 component material is driven through component meter housing 22b' by a second upstream pressure. The first component material flows through gear set 26a' and is metered by first gear 38a' and second gear 40a' such that a set first volume of the first component material is provided downstream for each rotation of first gear 38a' and second gear 40a'. Similarly, the second component material is metered by gear set 26b', 15 such that a set second volume of the second component material is provided downstream for each rotation of first gear 38b' and second gear 40b'.

Aligning mechanism 44' connects first gear 38a' and first gear 38b' such that the rotation of one of first gear 38a' and first gear 38b' simultaneously drives the other of first gear 38a' and first gear 38b'. In this way, aligning mechanism 44' ensures 20 that gear set 26a and gear set 26b will maintain the same rotational rate, thereby ensuring that a constant ratio of the first component material to the second component material is provided downstream by passive flow synchronizer 16'.

Although the present invention has been described with reference to preferred embodiments, workers skilled in the art will recognize that changes may be 25 made in form and detail without departing from the spirit and scope of the invention.

CLAIMS:

1. A passive fluid flow synchronizer includes:
 - a first component meter housing having a first inlet, a first outlet, and a first flow path extending between the first inlet and the first outlet;
 - 5 a second component meter housing having a second inlet, a second outlet, and a second flow path extending between the second inlet and the second outlet;
 - a barrier plate disposed between the first component meter housing and the second component meter housing and configured to separate the first flow path and the second flow path;
 - 10 a first gear set disposed within the first flow path between the first inlet and the first outlet;
 - a second gear set disposed within the second flow path between the second inlet and the second outlet;
 - 15 wherein the first gear set is coupled to the second gear set such that the first gear set and the second gear set rotate synchronously to provide a set volumetric ratio of a first component material to a second component material through the first outlet and the second outlet.
- 20 2. The passive fluid flow synchronizer of claim 1, and wherein:
 - the first gear set includes a first gear meshed with a second gear, wherein the first gear and the second gear are disposed adjacent a first side of the barrier plate; and
 - the second gear set includes a third gear meshed with a fourth gear,
 - 25 wherein the third gear and the fourth gear are disposed adjacent a second side of the barrier plate.
3. The passive fluid flow synchronizer of claim 2, and further comprising:
 - an aligning mechanism coupling the first gear to the third gear and coupling the second gear to the fourth gear.
- 30 4. The passive fluid flow synchronizer of claim 3, wherein the aligning mechanism comprises a plurality of magnets.
5. The passive fluid flow synchronizer of claim 4, wherein the plurality of magnets comprises:

- a first magnetic ring attached to the first gear and disposed about an axis of rotation of the first gear;
- a second magnetic ring attached to the second gear and disposed about an axis of rotation of the second gear;
- 5 a third magnetic ring attached to the third gear and disposed about an axis of rotation of the third gear;
- a fourth magnetic ring attached to the fourth gear and disposed about an axis of rotation of the fourth gear;
- 10 wherein the first magnetic ring is attracted to the third magnetic ring such that the first gear and the third gear rotate synchronously; and
- wherein the second magnetic ring is attracted to the fourth magnetic ring such that the second gear and the fourth gear rotate synchronously.
6. The passive fluid flow synchronizer of claim 5, wherein the first magnetic ring, the second magnetic ring, the third magnetic ring, and the fourth magnetic ring each
- 15 comprise an even number of magnets.
7. The passive fluid flow synchronizer of claim 6, wherein the first magnetic ring and the third magnetic ring comprise the same number of magnets, and wherein the second magnetic ring and the fourth magnetic ring comprise the same number of magnets.
8. The passive fluid flow synchronizer of claim 2, wherein the first gear and
- 20 the second gear are identical, and wherein the third gear and the fourth gear are identical.
9. The passive fluid flow synchronizer of claim 8, wherein the first gear and the second gear each have a first height, wherein the third gear and the fourth gear each have a second height, and wherein the first height is different from the second height.
10. The passive fluid flow synchronizer of claim 3, wherein the aligning
- 25 mechanism comprises a first pin extending through the barrier plate and coupling the first gear to the third gear, and a second pin extending through the barrier plate and coupling the second gear to the fourth gear.
11. A multiple component dispenser comprising:
- a first material tank;
- 30 a second material tank;
- a passive fluid flow synchronizer connected to the first material tank with a first supply hose and connected to the second material tank with a second supply hose, wherein the passive fluid flow synchronizer comprises:

- a first component meter housing having a first inlet, a first outlet,
and a first flow path extending between the first inlet and
the first outlet, wherein the first supply hose is attached to
the first inlet;
- 5 a second component meter housing having a second inlet, a second
outlet, and a second flow path extending between the
second inlet and the second outlet, wherein the second
supply hose is attached to the second inlet;
- 10 a barrier plate disposed between the first component meter housing
and the second component meter housing and isolating the
first flow path from the second flow path;
- a first gear set disposed within the first flow path between the first
inlet and the first outlet and configured to meter the flow of
a first material through the first flow path;
- 15 a second gear set disposed within the second flow path between the
second inlet and the second outlet and configured to meter
the flow of a second material through the second flow path;
and
- 20 wherein the first gear set is coupled to the second gear set such that
the first gear set and the second gear set rotate
synchronously;
- a first nozzle hose connected to the first outlet and configured to receive
the first material from the first flow path;
- 25 a second nozzle hose connected to the first outlet and configured to receive
the second material from the second flow path; and
- 30 a material applicator disposed downstream of the passive fluid flow
synchronizer and connected to the first nozzle hose and the second
nozzle hose, wherein the material applicator is configured to
receive the first material from the first nozzle hose and the second
material from the second nozzle hose.
12. The multiple component dispenser of claim 11, and wherein:
the first gear set includes a first gear meshed with a second gear, wherein
the first gear and the second gear are disposed adjacent a first side
of the barrier plate; and

the second gear set includes a third gear meshed with a fourth gear, wherein the third gear and the fourth gear are disposed adjacent a second side of the barrier plate.

13. The multiple component dispenser of claim 12, and further comprising:
5 an aligning mechanism coupling the first gear to the third gear and coupling the second gear to the fourth gear.
14. The multiple component dispenser of claim 13, wherein the aligning mechanism comprises a plurality of magnets.
15. The multiple component dispenser of claim 14, wherein the barrier plate
10 comprises a non-ferrous material.
16. The multiple component dispenser of claim 12, and further comprising:
a first bearing disposed between the first gear and the barrier plate;
a second bearing disposed between the second gear and the barrier plate;
a third bearing disposed between the third gear and the barrier plate; and
15 a fourth bearing disposed between the fourth gear and the barrier plate.
17. The multiple component dispenser of claim 13, wherein the aligning mechanism comprises a first pin extending through the barrier plate and coupling the first gear to the third gear, and a second pin extending through the barrier plate and coupling the second gear to the fourth gear.
- 20 18. A method of synchronizing multiple flows, the method comprising:
flowing a first material through a first flow path and a first gear set disposed on a first side of a barrier plate; and
flowing a second material through a second flow path and the second gear set disposed on a second side of the barrier plate and coupled to the
25 first gear set such that the first gear set and the second gear set rotate synchronously to provide a set volumetric ratio of the first material to the second material by the synchronous rotation of the first gear set and the second gear set.
19. The method of claim 18, and further comprising:
30 providing a first synchronizing mechanism on the first gear set;
providing a second synchronizing mechanism on the second gear set;
linking the first gear set to the second gear set with the first synchronizing mechanism and the second synchronizing mechanism such that rotation of the first gear set drives the rotation of the second gear

set, and rotation of the second gear set drives the rotation of the first gear set.

20. The method of claim 19, wherein the first synchronizing mechanism comprises a first magnet and the second synchronizing mechanism comprises a second magnet.
- 5

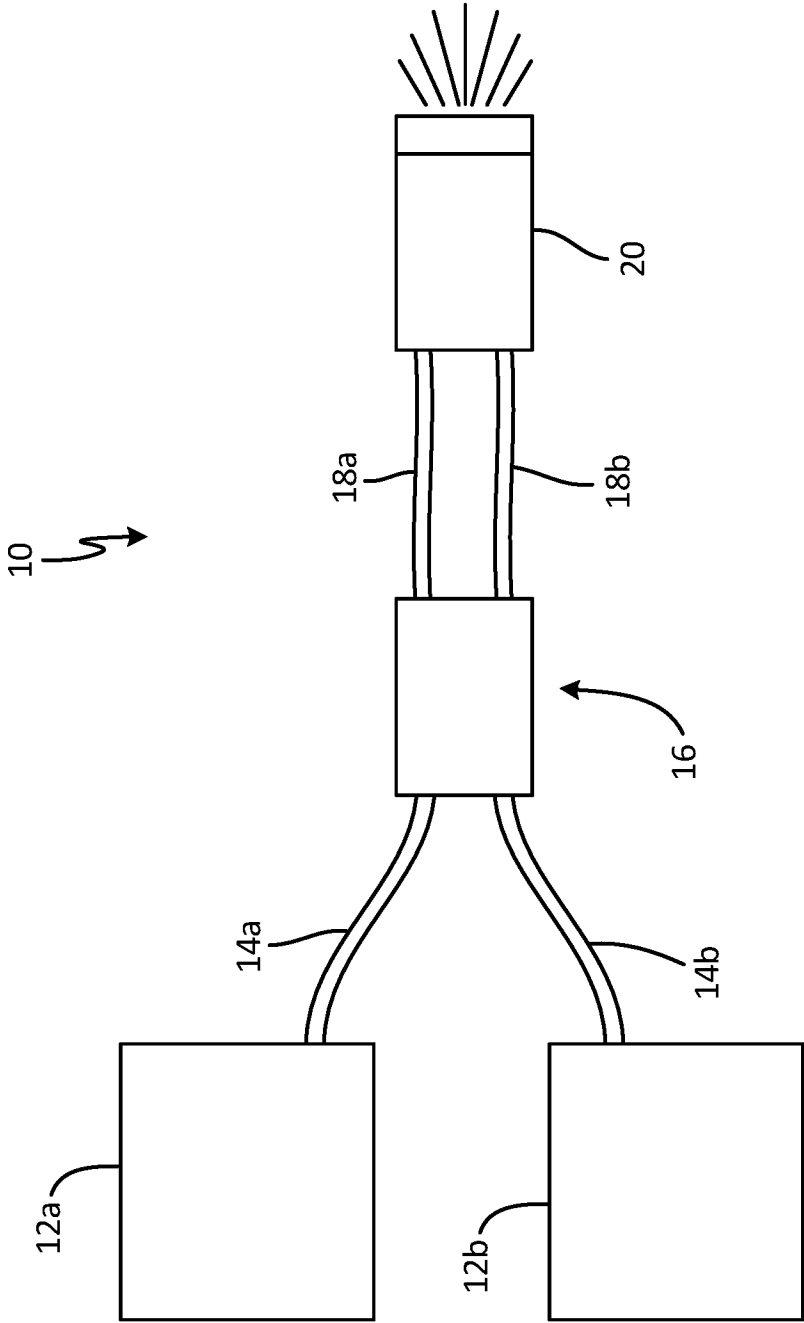


Fig. 1

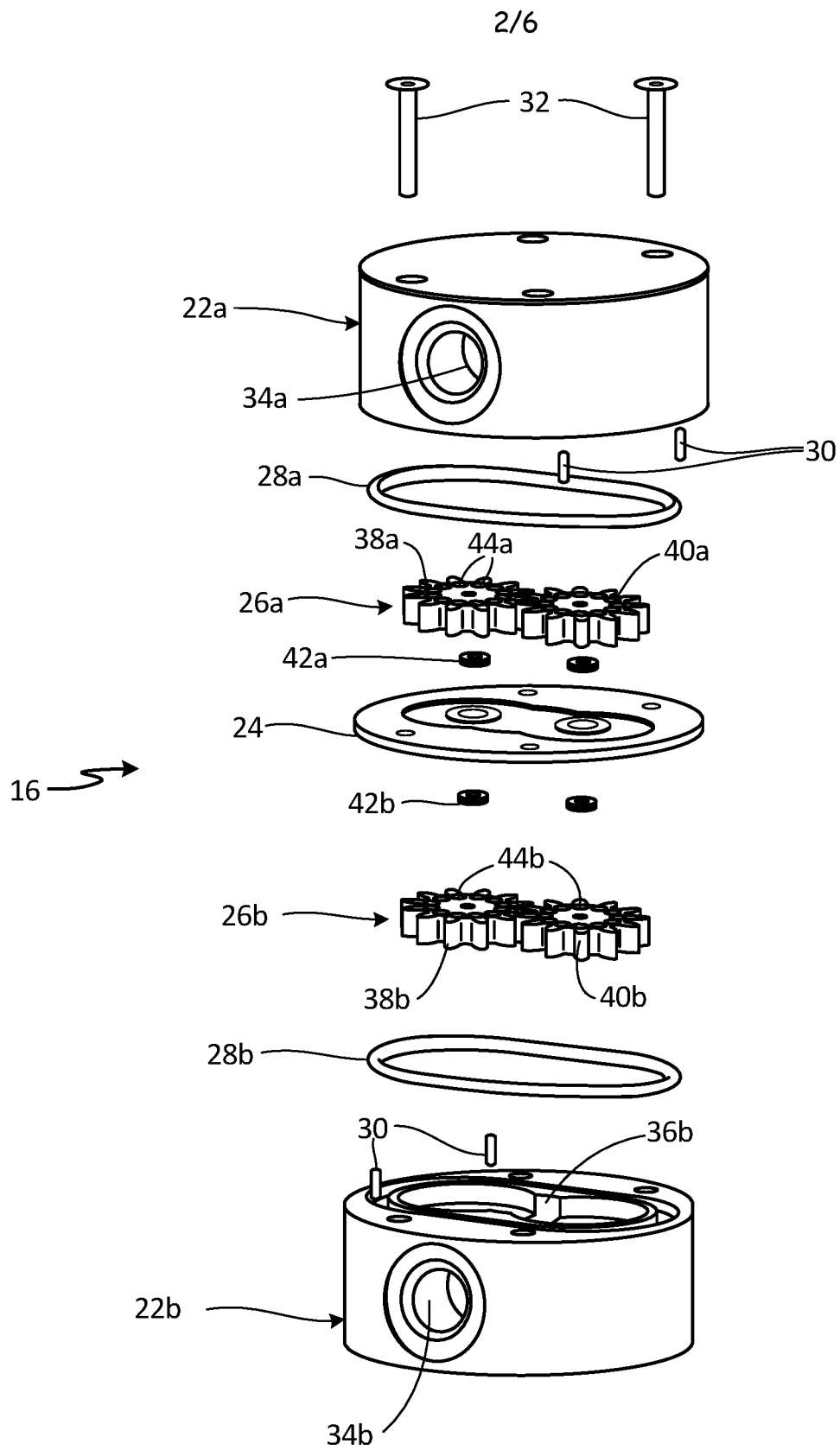


Fig. 2A

3/6

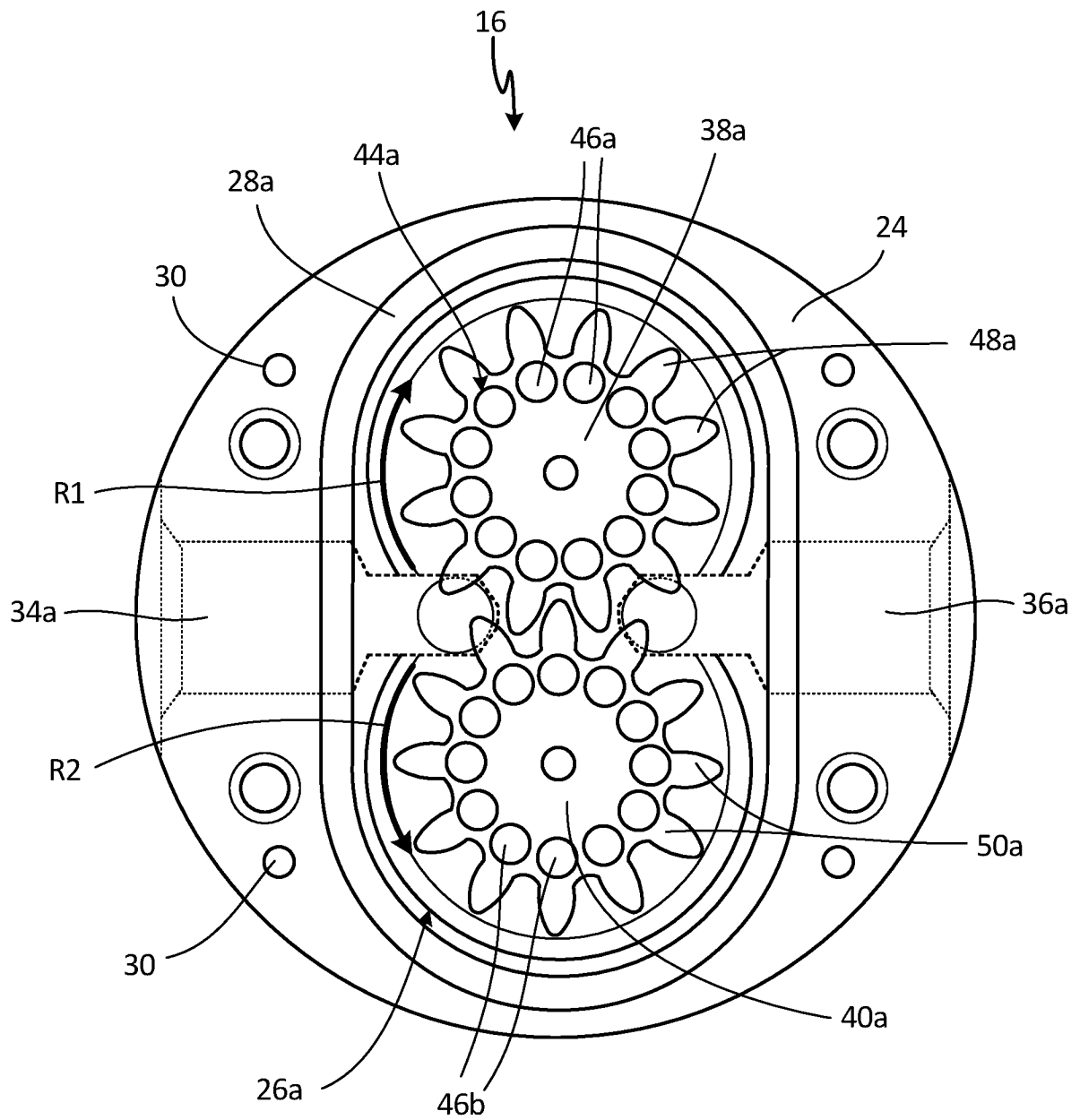


Fig. 2B

4/6

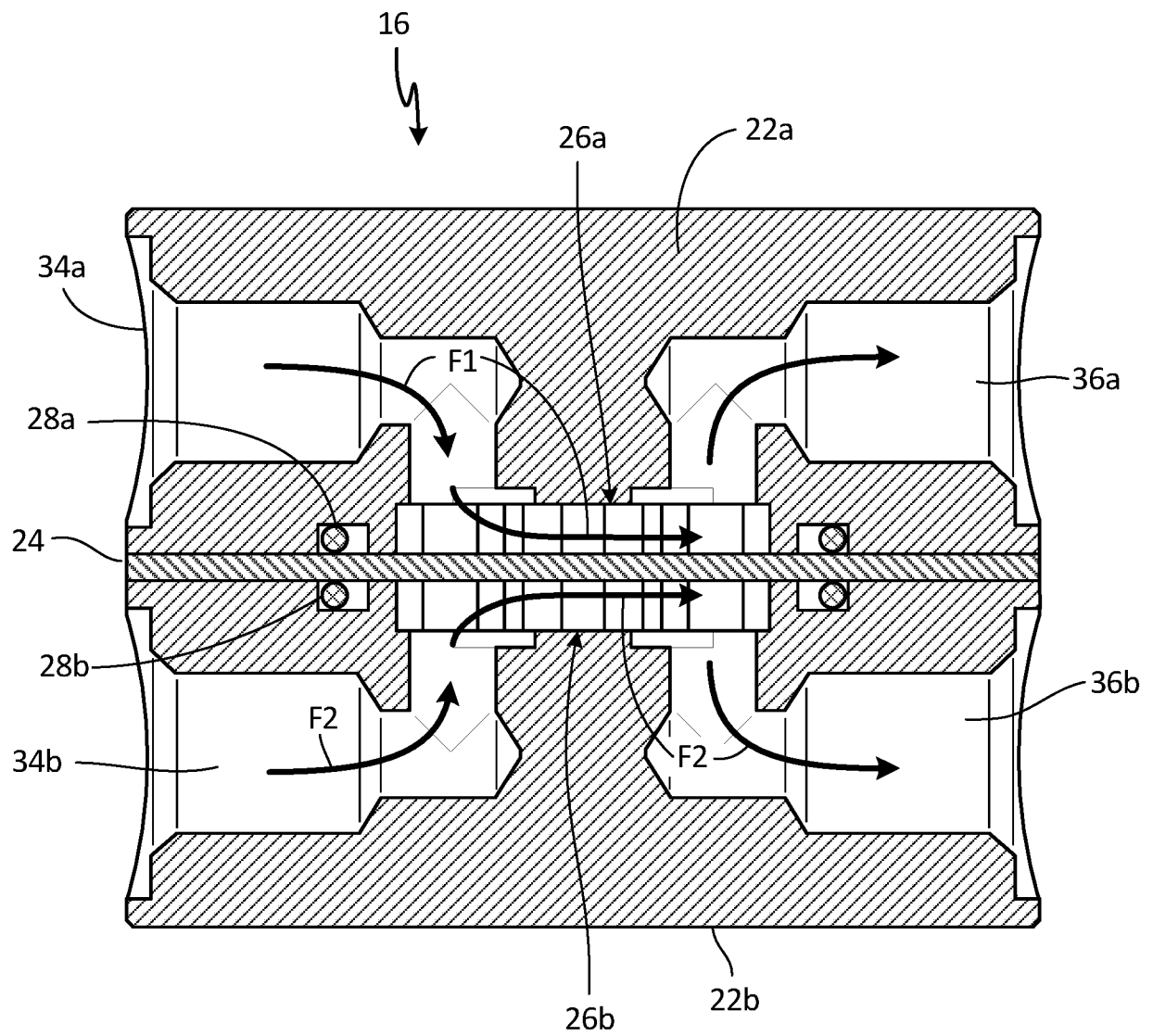


Fig. 2C

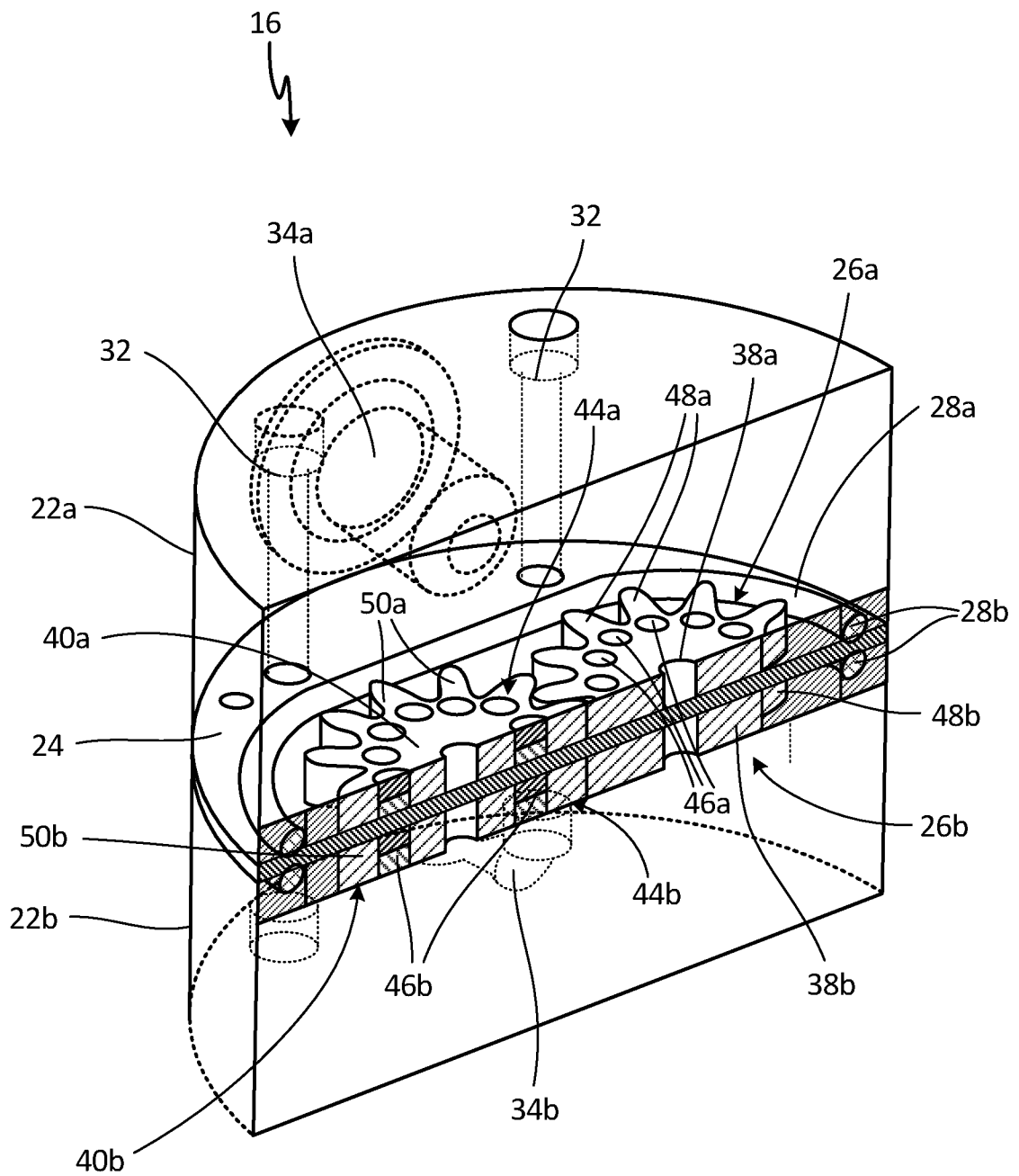


Fig. 2D

6/6

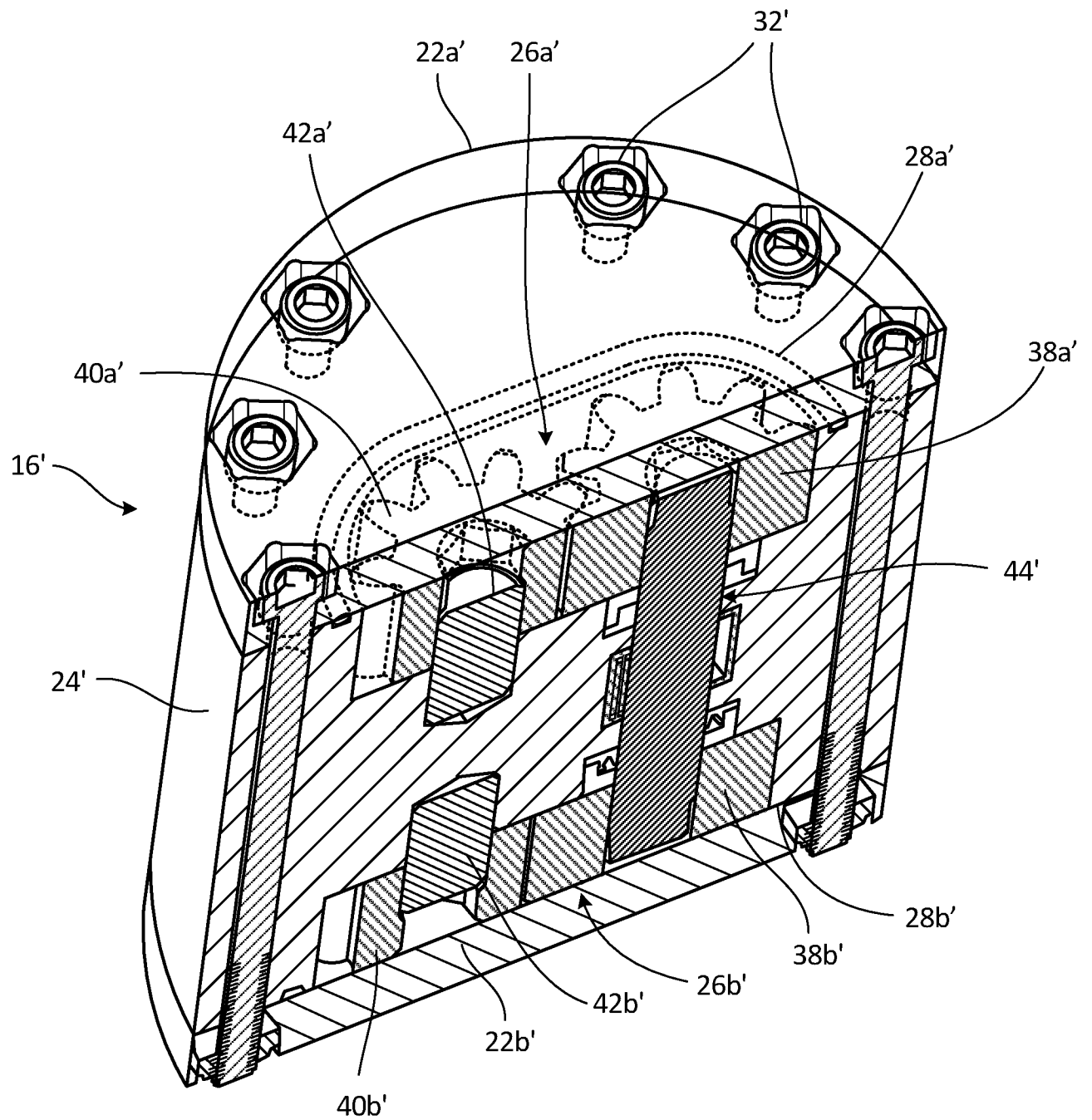


Fig. 3

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US2016/044046**A. CLASSIFICATION OF SUBJECT MATTER****B01F 15/04(2006.01)i, B01F 5/00(2006.01)i, B01F 15/00(2006.01)i, B01F 15/02(2006.01)i**

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

B01F 15/04; B01F 3/08; B01F 15/14; B01F 15/06; B01F 15/02; B01F 7/04; B01F 5/00; B01F 15/00

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Korean utility models and applications for utility models

Japanese utility models and applications for utility models

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

eKOMPASS(KIPO internal) & keywords: synchronizer, meter housing, barrier plate, gear, magnet

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 2013-0175290 A1 (VOGT, S. et al.) 11 July 2013	1, 18-20
A	See abstract; paragraphs [0017], [0060]; figure 1; and claims 1-7, 18-23.	2-17
A	US 2005-0219946 A1 (MONTI, G.) 6 October 2005	1-20
A	See abstract; figure 1; and claims 1-8.	
A	US 5505539 A (LEE, C. S. et al.) 9 April 1996	1-20
A	See abstract; figures 6-7; and claims 1-4.	
A	US 4090262 A (SCHNEIDER, F. W. et al.) 16 May 1978	1-20
A	See abstract; figures 1-4; and claims 1-2.	
A	US 4176969 A (WALLACE, R. A. et al.) 4 December 1979	1-20
A	See abstract; figures 1-5; and claims 1-8.	



Further documents are listed in the continuation of Box C.



See patent family annex.

* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier application or patent but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search

03 November 2016 (03.11.2016)

Date of mailing of the international search report

03 November 2016 (03.11.2016)

Name and mailing address of the ISA/KR

International Application Division

Korean Intellectual Property Office

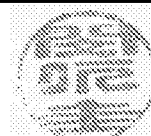
189 Cheongsa-ro, Seo-gu, Daejeon, 35208, Republic of Korea

Facsimile No. +82-42-481-8578

Authorized officer

MIN, In Gyou

Telephone No. +82-42-481-3326



INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.

PCT/US2016/044046

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 2013-0175290 A1	11/07/2013	EP 2618923 A1 EP 2618923 B1 JP 2013-544624 A US 9073020 B2 WO 2012-038005 A1	31/07/2013 13/01/2016 19/12/2013 07/07/2015 29/03/2012
US 2005-0219946 A1	06/10/2005	EP 1584581 A1	12/10/2005
US 5505539 A	09/04/1996	EP 0789618 A1 EP 0789618 B1 JP 09-507430 A KR 10-0213846 B1 US 5455076 A WO 96-14144 A1	07/01/1998 18/07/2001 29/07/1997 02/08/1999 03/10/1995 17/05/1996
US 4090262 A	16/05/1978	DE 2526215 A1 FR 2313971 A1	30/12/1976 07/01/1977
US 4176969 A	04/12/1979	None	