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**Thomas**

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(54) **PIN TO REDUCE RELATIVE ROTATIONAL MOVEMENT OF DISK AND SPACER OF TURBINE ENGINE**

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(51) **Int. Cl.**

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| ***F04D 19/02*** | (2006.01) |
| ***F04D 29/32*** | (2006.01) |
| ***F01D 5/06*** | (2006.01) |
| *F04D 29/34* | (2006.01) |

(52) **U.S. Cl.**

CPC .......... ***F04D 29/644*** (2013.01); ***F01D 5/066*** (2013.01); ***F04D 19/02*** (2013.01); ***F04D 29/321*** (2013.01); *F05D 2250/13* (2013.01); *F05D 2250/132* (2013.01); *F05D 2260/36* (2013.01)

(58) **Field of Classification Search**

CPC ... F01D 5/06; F01D 5/066; F01D 5/30; F04D 29/26; F04D 29/321; F04D 29/644

USPC ......... 416/204 R, 215, 216, 220 R, 222, 248

See application file for complete search history.

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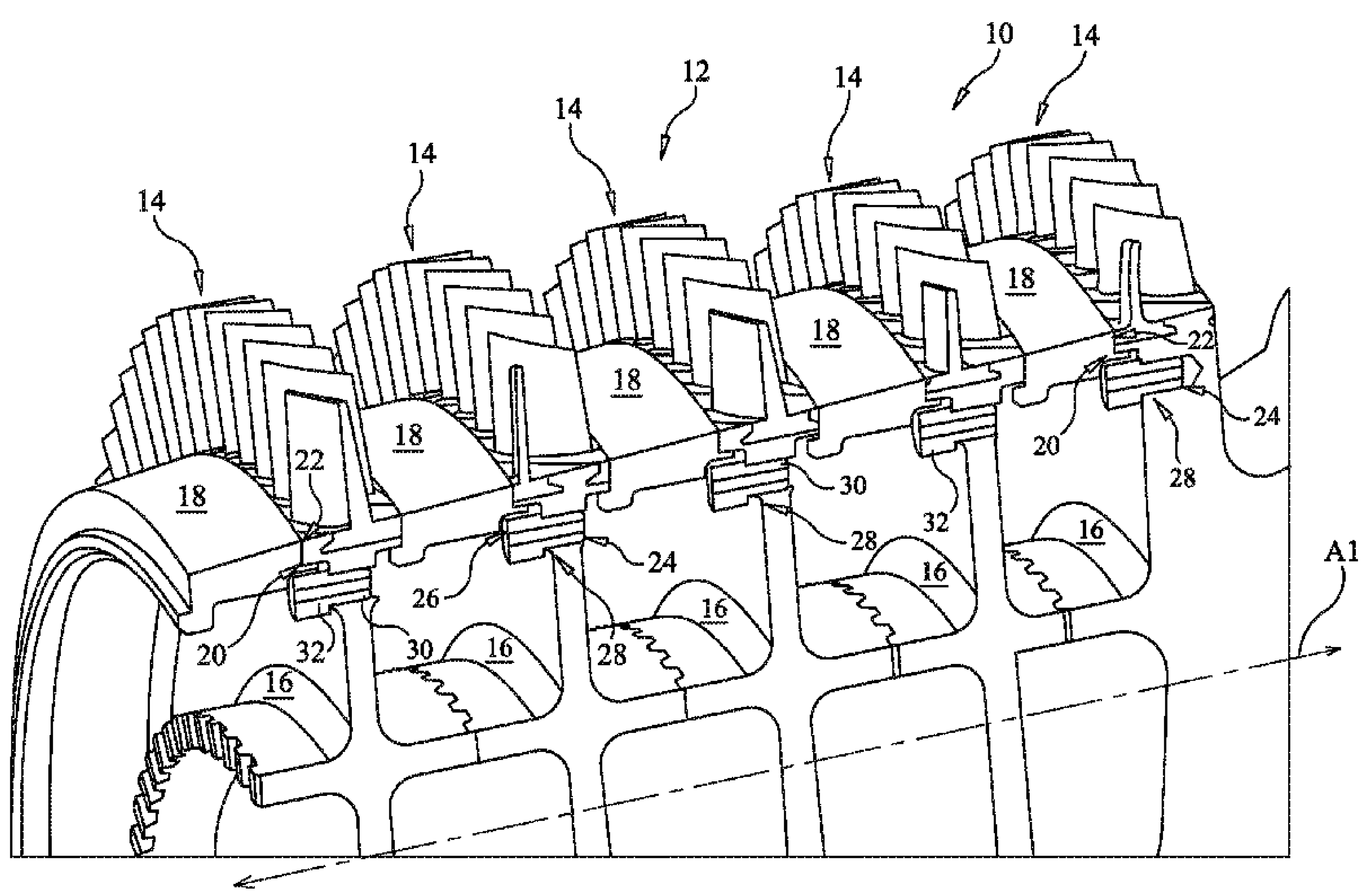
*Primary Examiner* — John Kwon

(57) **ABSTRACT**

An axial compressor of a turbine engine includes a plurality of disk and spacer pairs oriented along a common axis of rotation. Each of a disk and a spacer of the disk and spacer pairs has a contacting face defining an engagement between the disk and the spacer. The contacting face of each of the disk and the spacer includes a recessed area. A pin has a stem received within the recessed area of the disk and a head received within the recessed area of the spacer. The head of the pin includes at least two flats corresponding to complementary surfaces of the recessed area of the spacer.

**20 Claims, 5 Drawing Sheets**



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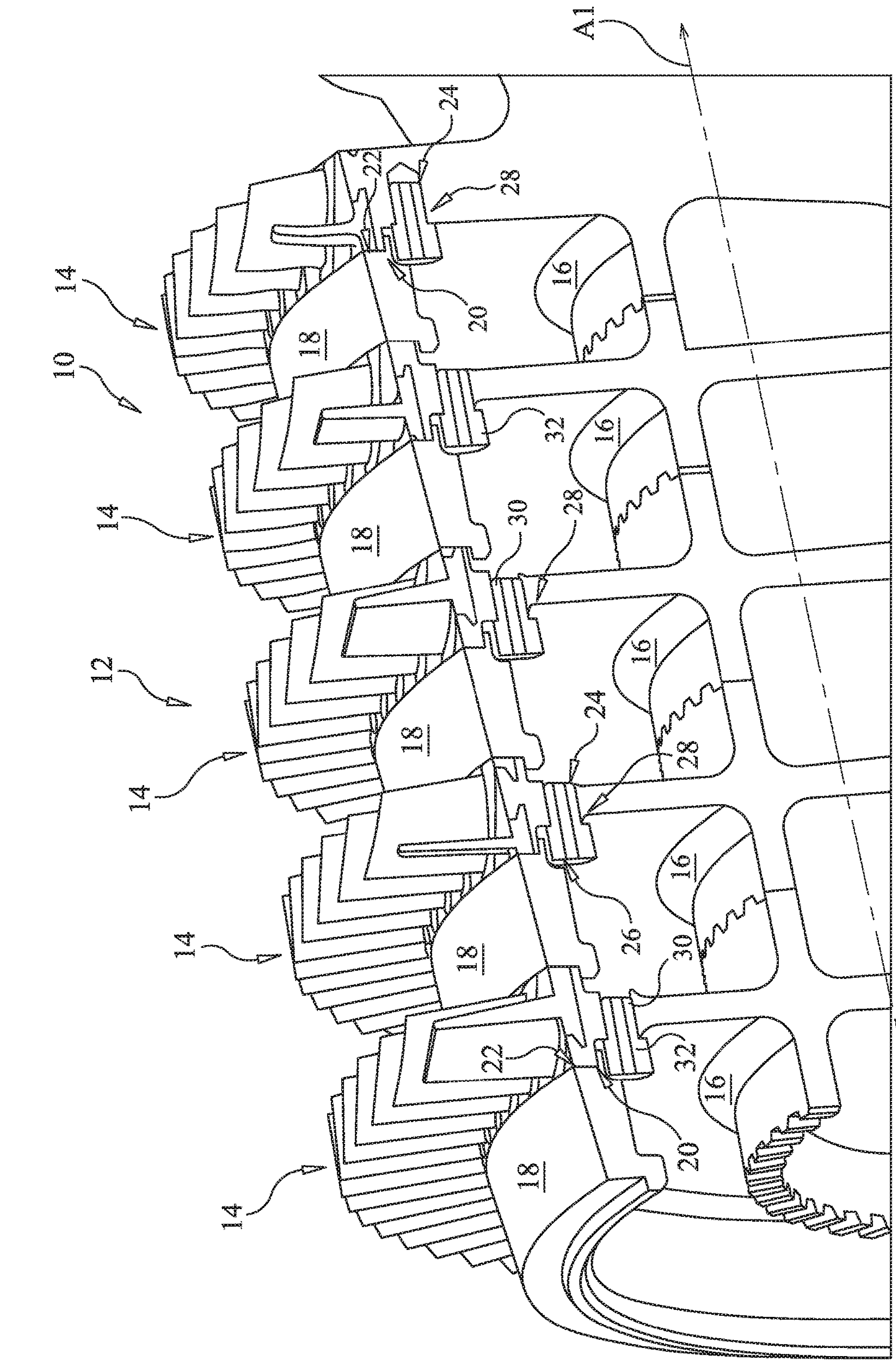


FIG. 1

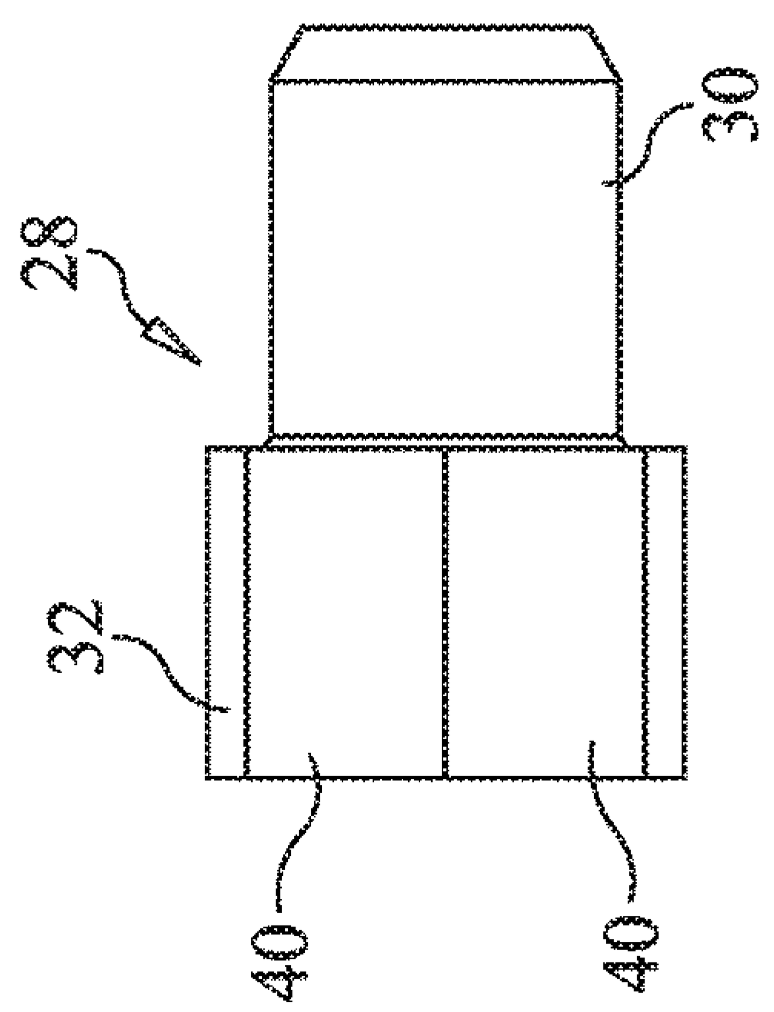


FIG. 3

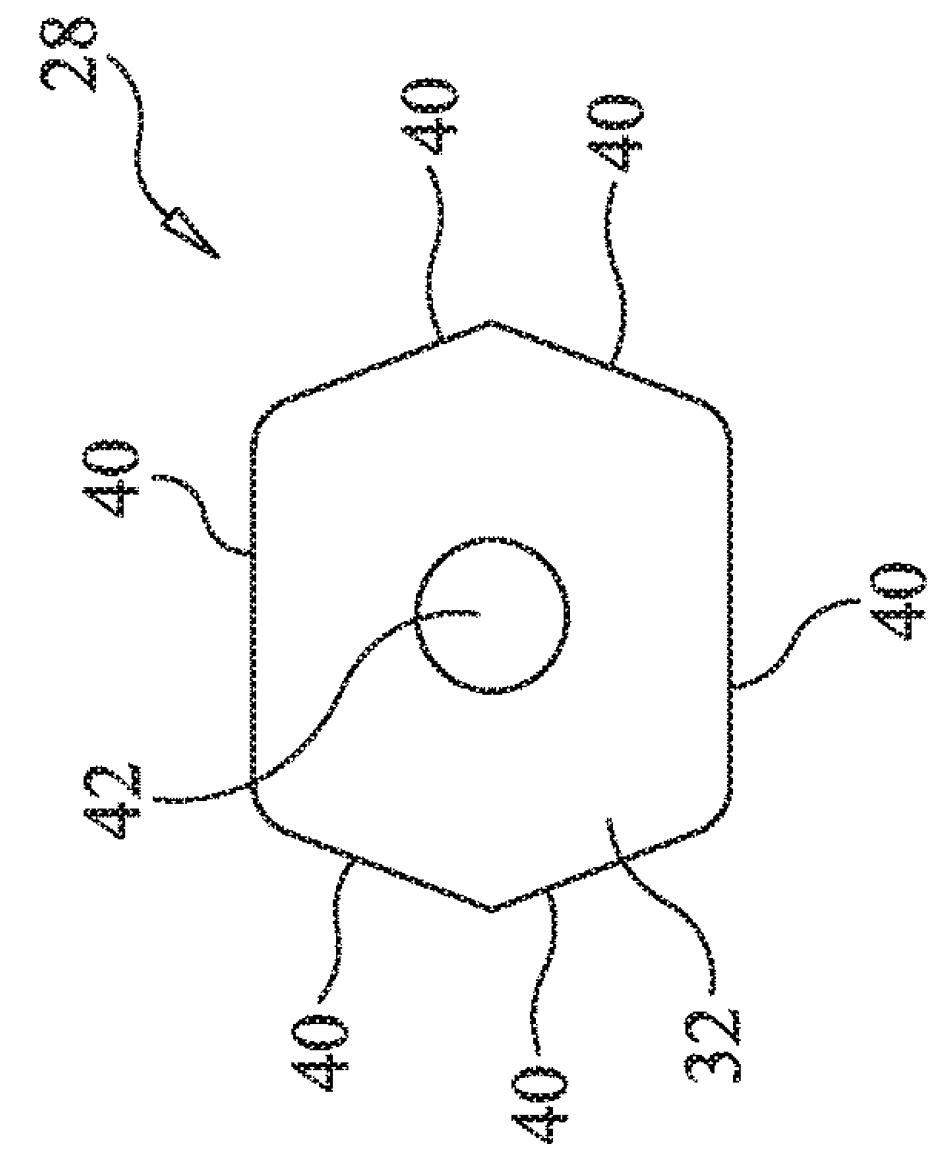


FIG. 5

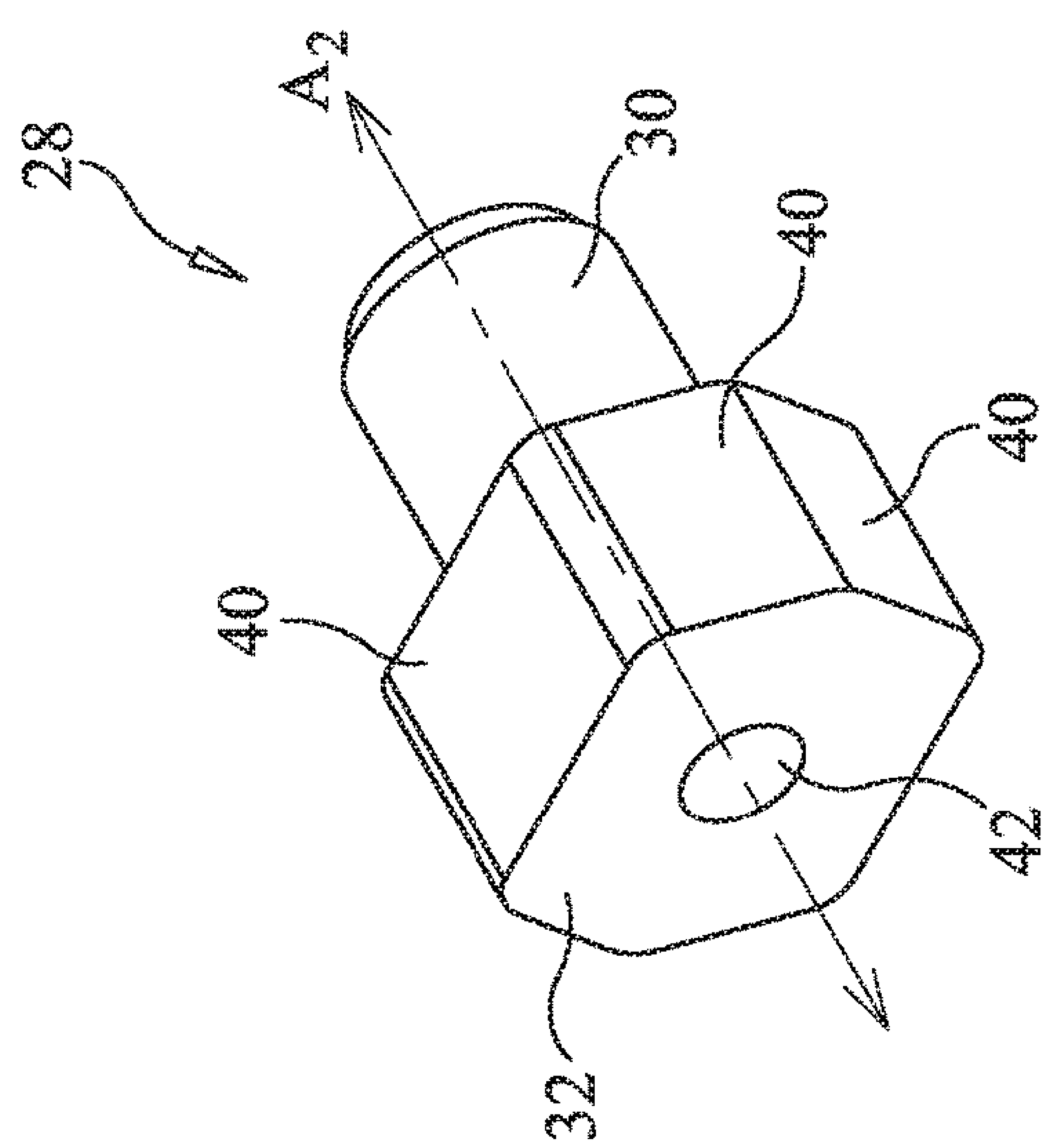


FIG. 2

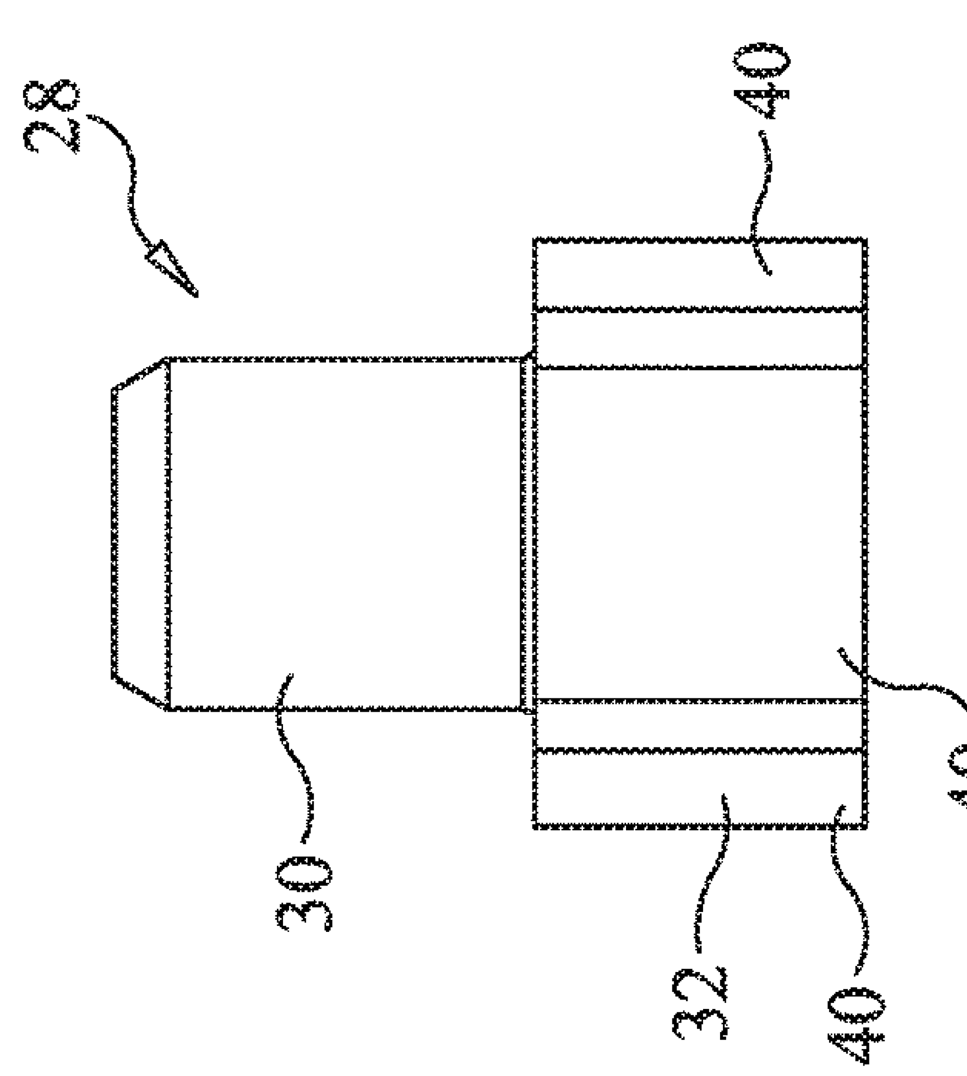


FIG. 4

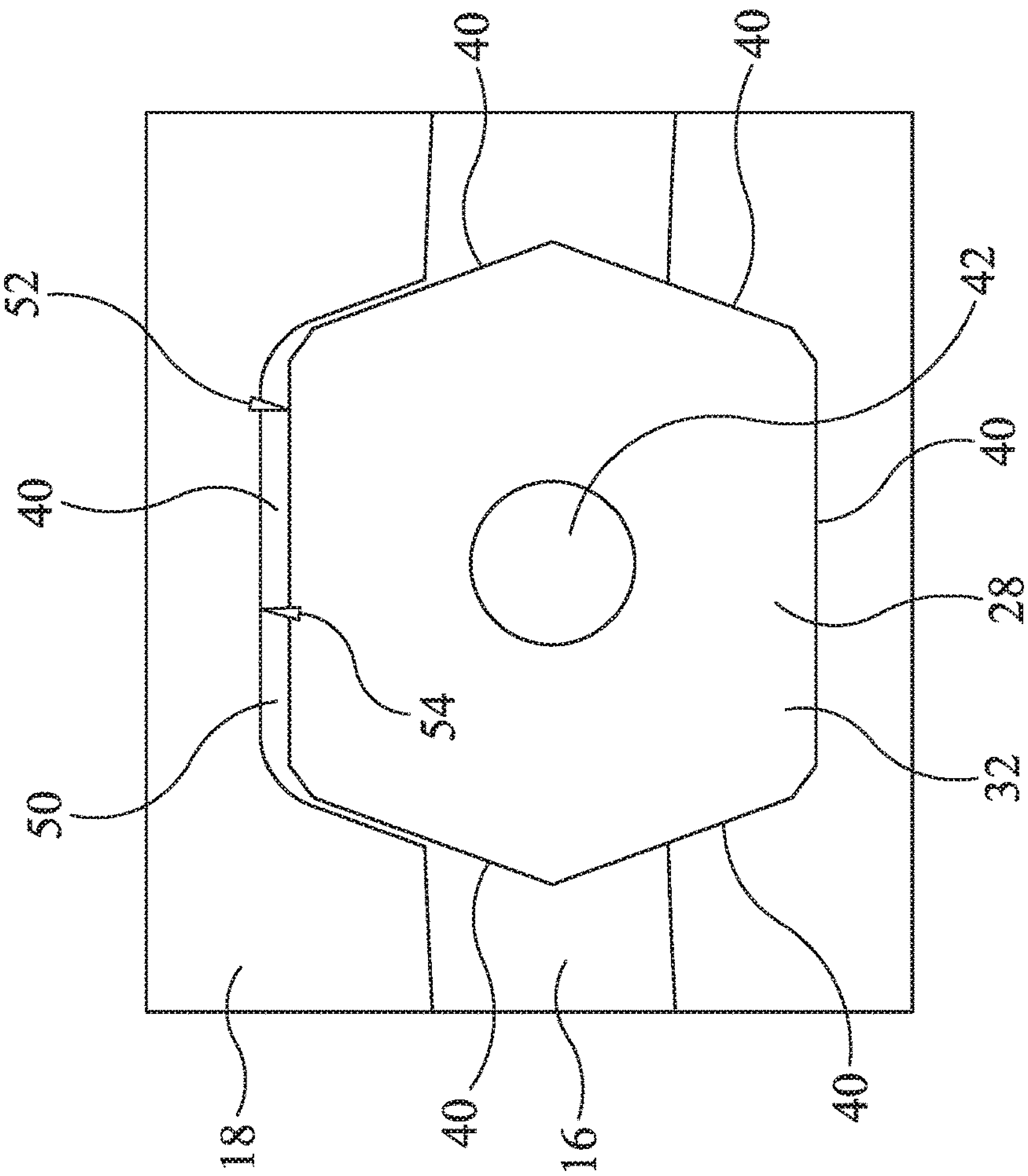
40
40
52
42
40
40
28
54
50
32
18
40
16
40

FIG. 7

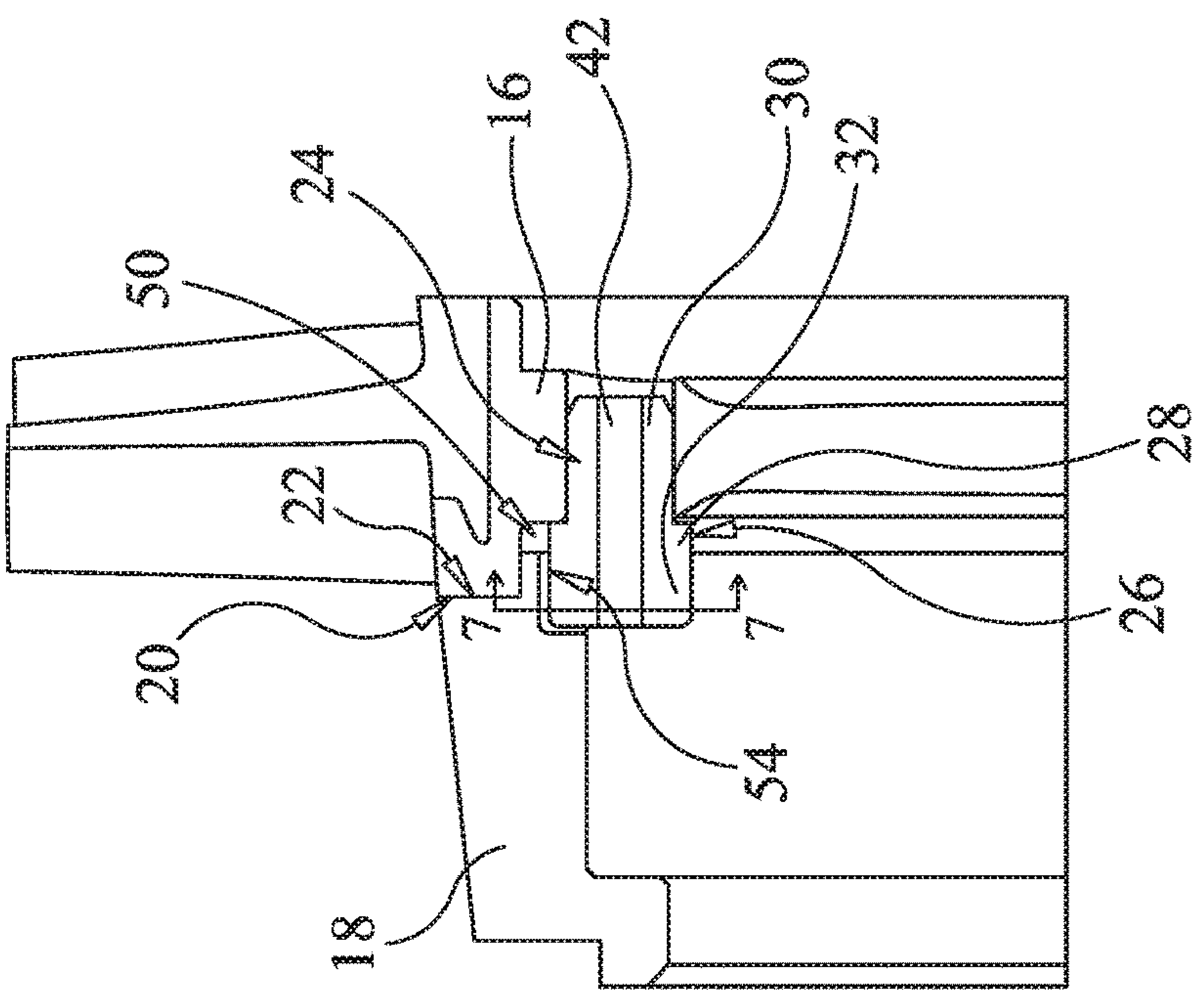
42
16
30
24
32
50
28
22
7
7
26
20
54
18

FIG. 6

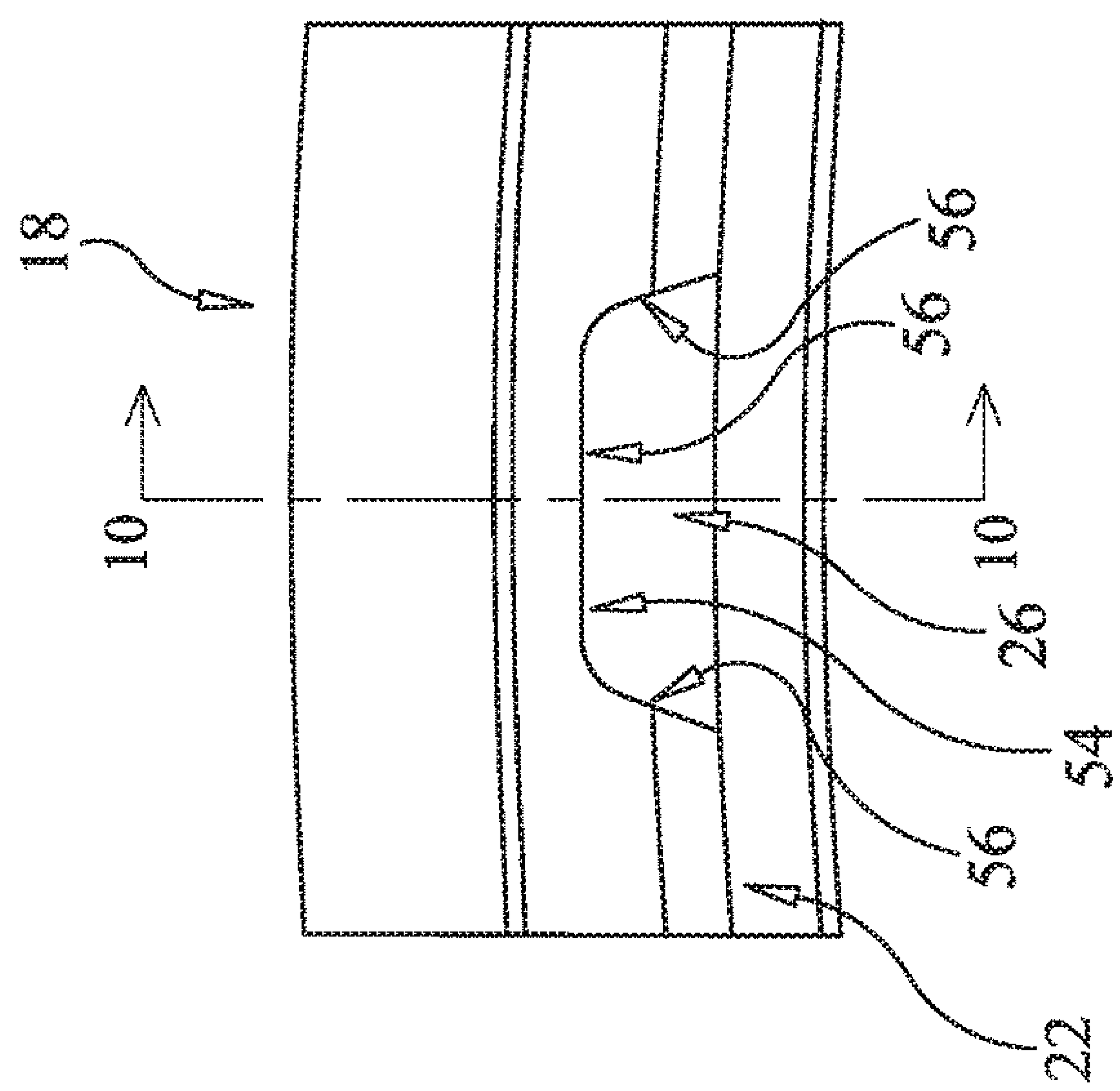


FIG. 9

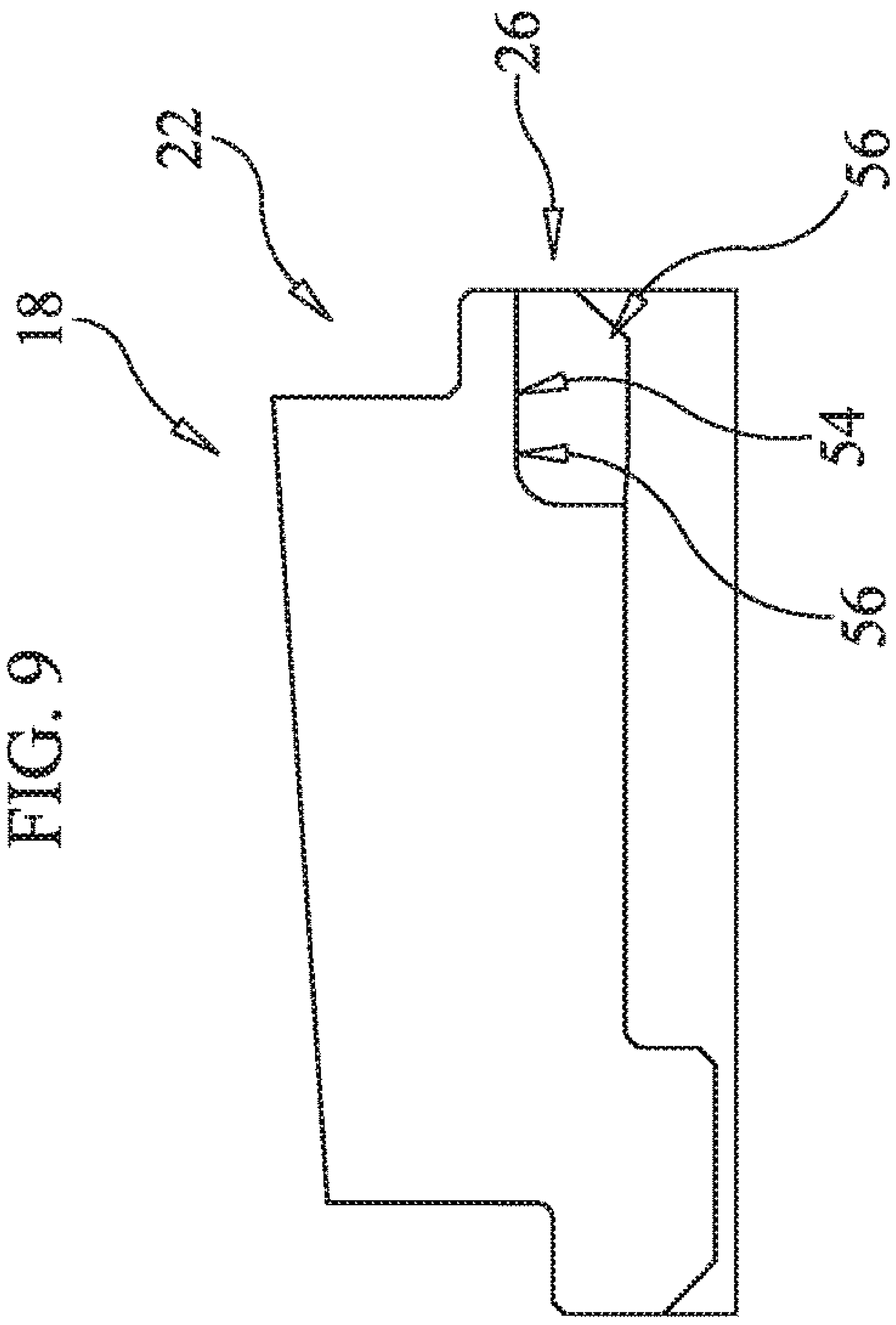


FIG. 10

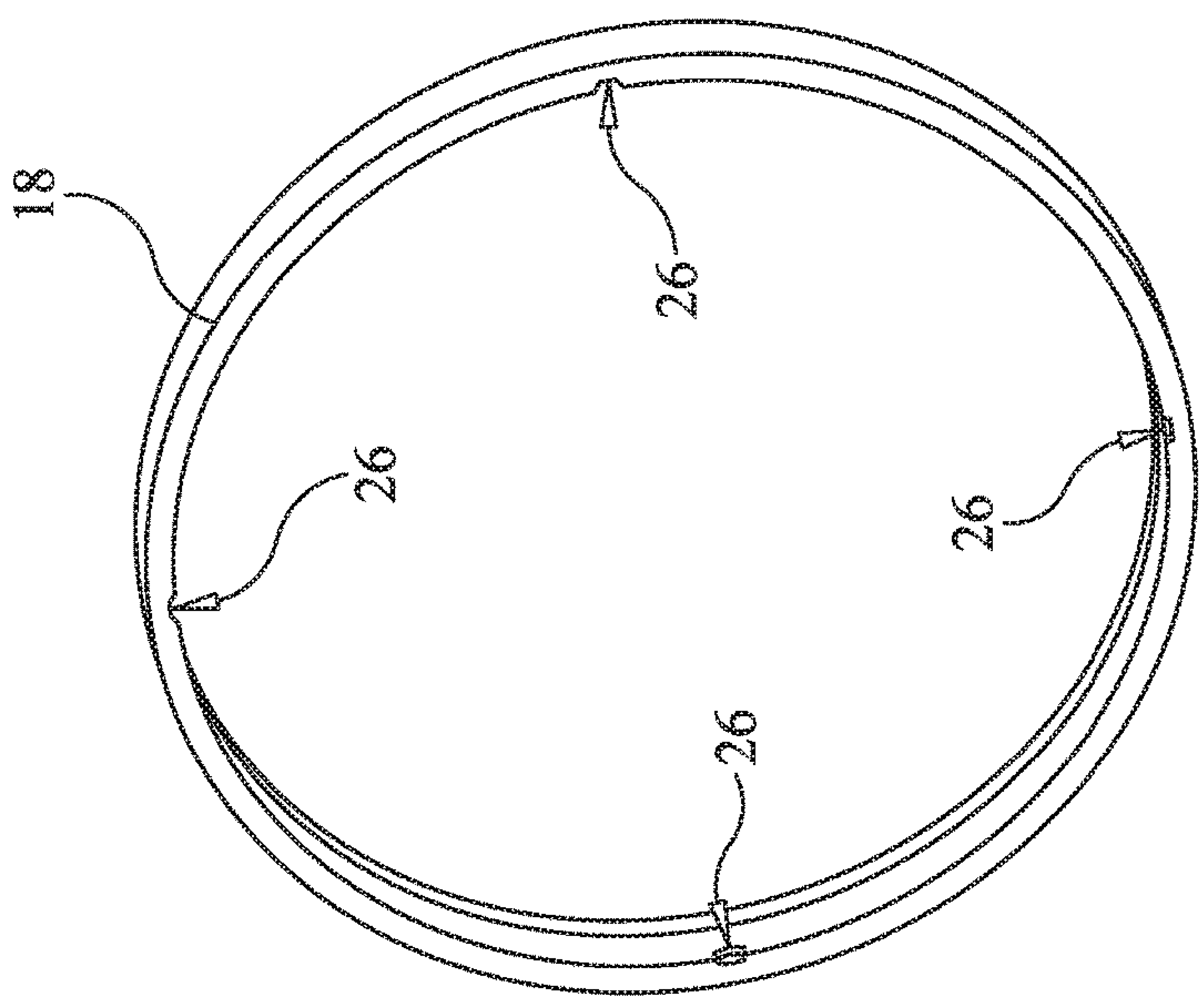


FIG. 8

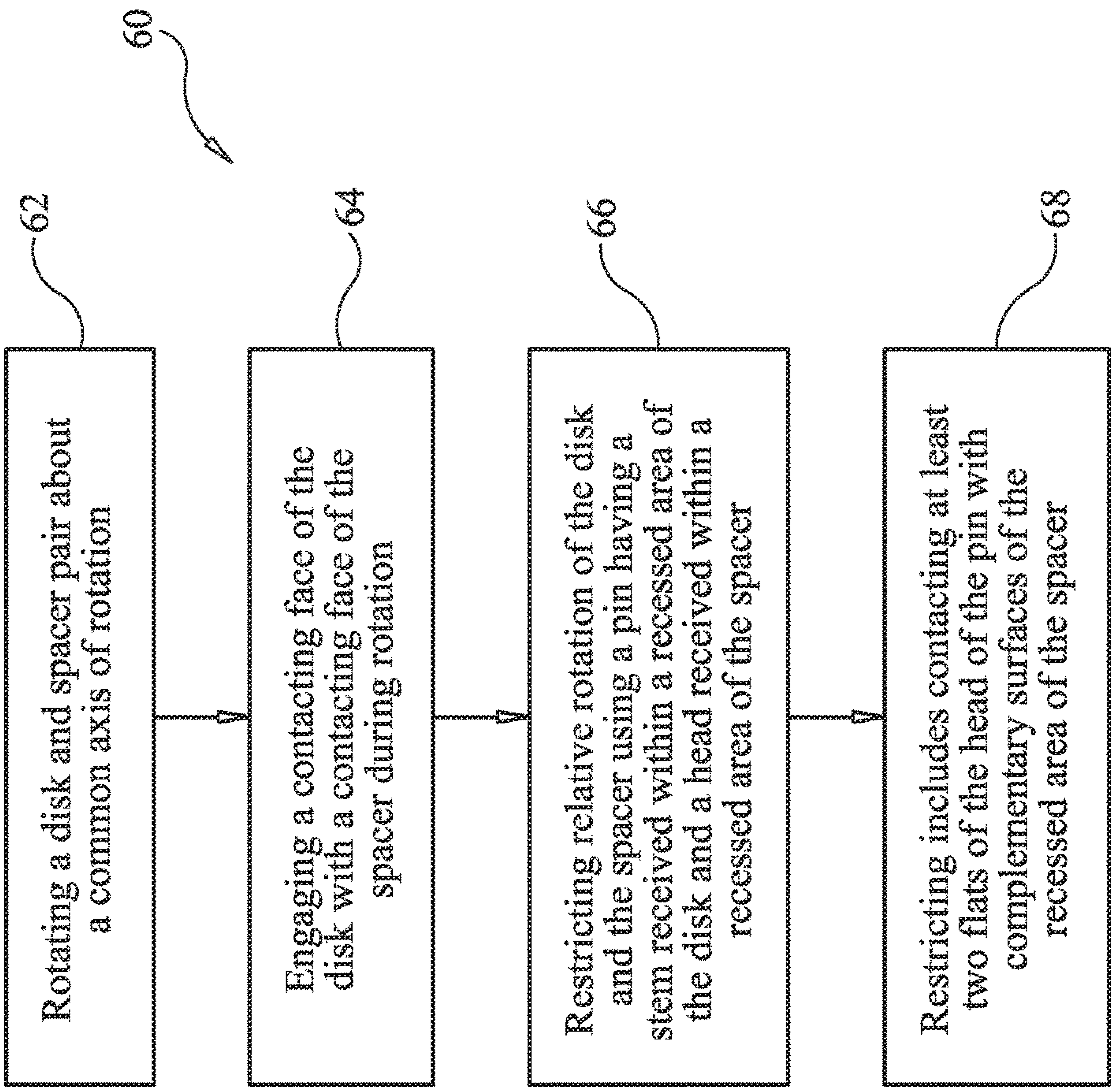
60
62
Rotating a disk and spacer pair about a common axis of rotation
64
Engaging a contacting face of the disk with a contacting face of the spacer during rotation
66
Restricting relative rotation of the disk and the spacer using a pin having a stem received within a recessed area of the disk and a head received within a recessed area of the spacer
68
Restricting includes contacting at least two flats of the head of the pin with complementary surfaces of the recessed area of the spacer

FIG. 11

# PIN TO REDUCE RELATIVE ROTATIONAL MOVEMENT OF DISK AND SPACER OF TURBINE ENGINE

## TECHNICAL FIELD

The present disclosure relates generally to turbine engines and, more particularly, to a pin for reducing relative rotational movement of a disk and a spacer of an axial compressor of the turbine engine.

## BACKGROUND

Some axial compressors of turbine engines use spacers to provide an inner flowpath for working fluid. The spacers are typically thin rings, installed onto each of a plurality of disks of the axial compressor. An interference engagement or, more particularly, a thermal interference engagement and a small cylindrical anti-rotation pin are used to couple each spacer to a corresponding disk. The disk and spacer pairs are oriented along a common rotational axis of the axial compressor. During a hot shutdown of the turbine engine, the spacers typically cool and shrink at a higher rate than the corresponding disks, thereby relieving the thermal interference engagement. The rotational inertia of the spacers often breaks the pins, allowing the spacers to rotationally shift relative to the corresponding disks from the factory set positions. To reset the imbalance, the turbine engine may require removal from service and disassembly.

U.S. Pat. No. 8,840,375 to Virkler discloses a lock assembly for a gas turbine engine. The lock assembly includes a lock body with an undercut slot that receives a retaining wire of a polygon shape. A rotor disk has a circumferentially intermittent slot structure extending radially outward relative to an axis of rotation. A component defined about the axis of rotation has multiple radial tabs extending radially inward relative to the axis of rotation. The radial tabs are engageable with the intermittent slot structure. A lock assembly, which includes the retaining wire, is engaged with at least one opening formed by the intermittent slot structure to provide an anti-rotation interface for the component.

As should be appreciated, there is a continuing need to improve efficiency and reliability of turbine engines and components of turbine engines.

## SUMMARY OF THE INVENTION

In one aspect, an axial compressor of a turbine engine includes a plurality of disk and spacer pairs oriented along a common axis of rotation. Each of a disk of the disk and spacer pairs and a spacer of the disk and spacer pairs have a contacting face defining an engagement between the disk and the spacer. The contacting face of each of the disk and the spacer includes a recessed area. A pin has a stem received within the recessed area of the disk and a head received within the recessed area of the spacer. The head of the pin includes at least two flats corresponding to complementary surfaces of the recessed area of the spacer.

In another aspect, a method of operating a turbine engine includes steps of rotating a disk and spacer pair of a plurality of disk and spacer pairs about a common axis of rotation, and engaging a contacting face of a disk of the disk and spacer pair with a contacting face of a spacer of the disk and spacer pair during rotation. The method also includes a step of restricting relative rotation of the disk and the spacer using a pin having a stem received within a recessed area of the disk and a head received within a recessed area of the spacer. The restricting step includes contacting at least two flats of the head of the pin with complementary surfaces of the recessed area of the spacer.



In yet another aspect, a turbine engine includes an axial compressor. The axial compressor includes a plurality of disk and spacer pairs oriented along a common axis of rotation, with each of a disk of the disk and spacer pairs and a spacer of the disk and spacer pairs having a contacting face defining an engagement between the disk and the spacer. The contacting face of each of the disk and the spacer includes a recessed area. A pin has a stem received within the recessed area of the disk and a hexagonally shaped head received within the recessed area of the spacer.

## BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a partial cross section of an axial compressor of a turbine engine, according to an exemplary embodiment of the present disclosure;

FIG. **2** is a perspective view of an exemplary pin that may be used with the axial compressor of FIG. **1**, according to the present disclosure;

FIG. **3** is a first side view of the exemplary pin of FIG. **2**;

FIG. **4** is a second side view of the exemplary pin of FIG. **2**;

FIG. **5** is a top view of the exemplary pin of FIG. **2**;

FIG. **6** is a partial cross section of the exemplary pin of the previous FIGS., assembled with a disk and a spacer of a turbine engine;

FIG. **7** is a section view taken along lines **7-7** of FIG. **6**;

FIG. **8** is a perspective view of the spacer of the present disclosure;

FIG. **9** is an enlargement of a portion of the spacer of FIG. **8**;

FIG. **10** is a section view taken along lines **10-10** of FIG. **9**; and

FIG. **11** is a flow diagram of an exemplary method of operating a turbine engine, according to the present disclosure.

## DETAILED DESCRIPTION

A portion of an exemplary turbine engine **10** is shown generally in FIG. **1**. In particular, a section view of an axial compressor **12** of the turbine engine **10** is shown. As will be appreciated by those skilled in the art, the turbine engine **10** may also include a combustor and a power turbine and/or a variety of additional or alternative components for compressing gas. The axial compressor **12** may include a plurality of disk and spacer pairs **14** oriented along a common axis of rotation $A_1$. The disk and spacer pairs **14** may all have similar configurations and, as such, only a single disk and spacer pair **14** will be described.

Each of a disk **16** and a spacer **18** of the disk and spacer pairs **14** may have a respective contacting face **20**, **22** defining an engagement between the disk **16** and the spacer **18**. That is, at least some portion of the contacting face **20** of the disk **16** and at least some portion of the contacting face **22** of the spacer **18** may interface or connect to define the engagement. As used herein, the contacting faces **20**, **22** of the disk **16** and the spacer **18** may include surfaces of the respective components that face one another.

The disk **16** may have a generally cylindrical body, which may or may not be hollow, including or supporting a plurality of static blades. The spacer **18** may have a thin ring-shaped body for providing space, along the common axis of rotation $A_1$, between the disks **16** and, thus, providing an inner flowpath for working fluid. Each spacer **18** of the disk and spacer pairs **14** may be the same material as the corresponding disk **16**, which may, for example, include stainless steel. Although a specific embodiment is described, the present disclosure may be applicable to disks and spacers having various shapes, size, materials, and configurations.

The contacting face **20**, **22** of each of the disk **16** and the spacer **18** may include a respective recessed area **24**, **26**. The recessed areas **24**, **26**, which may be recessed relative to the respective contacting face **20**, **22**, may be aligned such that a pin **28** may be positioned as shown. In particular, the recessed areas **24**, **26** may be aligned along an axis parallel to the common axis of rotation $A_1$. The pin **28** may generally include a stem **30** and a head **32** and, as will be discussed below, the stem **30** may be received at least partly within the recessed area **24** of the disk **16** and the head **32** may be received at least partly within the recessed area **26** of the spacer **18**. During operation of the turbine engine **10**, a thermal interference engagement between the disk **16** and the spacer **18** may secure the engagement of the disk **16**, spacer **18**, and pin **28**.

The exemplary pin **28**, including the stem **30** and the head **32**, is shown generally in FIGS. **2-5**. The head **32** of the pin **28** may include a plurality of flats, or planar surfaces, **40**. According to the exemplary embodiment, the head **32** may have a hexagonal shape, including six straight sides and angles. As such, the recessed area **26**, or portions thereof, of the spacer **18** may have a shape corresponding to the hexagonal shape of the head **32**, or a portion of the head **32**, of the pin **28**. As shown, the stem **30** of the pin **28** may have a cylindrical shape, with the recessed area **24**, or portions thereof, of the disk **16** having a shape corresponding to the cylindrical shape of the stem **30**, or a portion of the stem **30**, of the pin **28**. The pin **28** may be made from a variety of different materials, including, for example, the same material as one or both of the disk **16** and the spacer **18**. Further, according to some embodiments, the pin **28** may have a passage **42** therethrough oriented along a longitudinal axis $A_2$ of the pin **28**. The passage **42** may provide an escape of air when the pin **28** is pressed into a blind hole.

As stated above, but referring now to FIGS. **6** and **7**, the stem **30** of the pin **28** is shown received within the recessed area **24** of the disk **16**, and the head **32** of the pin **28** is shown received within the recessed area **26** of the spacer **18**. The stem **30** of the pin **28** may have a substantially cylindrical body, which may be received within a substantially cylindrical opening or cavity of the recessed area **24**. Thus, the recessed area **24** may be shaped, sized, and/or configured to receive the stem **30**, such as with a frictional fit.

The head **32** of the pin **28**, according to the present disclosure, may include at least two flats **40** corresponding to complementary surfaces of the recessed area **26** of the spacer **18**. That is, the recessed area **26** may include planar surfaces having similar angles as corresponding surfaces of the head **32** of the pin **28**. Thus, the recessed area **26** may be shaped, sized, and/or configured such that at least one of the flats **40** contacts or engages a corresponding surface of the recessed area **26** during operation and/or shutdown of the turbine engine **10**.

As shown in FIG. **7**, a predetermined clearance **50** may be provided between a top surface **52** of the head **32** of the pin **28** and an inner surface **54** of the recessed area **26** of the spacer **18**. As will be discussed below, the predetermined clearance **50** may be reduced, such as during a hot shutdown of the turbine engine **10**, as the spacer **18** cools and shrinks more quickly than the corresponding disk **16**. The predetermined clearance **50** may be as small as, for example, 0.005 inch; however, the predetermined clearance **50** may vary, depending on the particular application.

The spacer **18** is shown in FIGS. **8**, **9** and **10** and may include a thin ring-shaped body. The spacer **18** may be sized, shaped, and/or configured to interact with the corresponding disk **16** in the manner described herein. The spacer **18** may include at least one recessed area **26**. As shown more specifically in FIG. **8**, the spacer **18** may include a plurality of recessed areas **26**, such as, for example, four recessed areas **26**, spaced about the spacer **18**. According to such an embodiment, the disk **16** may have a corresponding number of recessed areas **24**, with a corresponding number of pins **28**, such as four pins **28**, configured for receipt within the plurality of recessed areas **24**, **26**.

As stated above, the head **32** of the pin **28** may include a plurality of flats **40**. As such, the recessed area **26** of the spacer **18** may have a shape corresponding to the shape of the head **32** of the pin **28**. During operation of the turbine engine **10** or during a shutdown, such as a hot shutdown, the spacer **18** may cool more quickly than the corresponding disk **16**, thus reducing the predetermined clearance **50** and causing one or more of the flats **40** to engage one or more corresponding surface of the recessed area **26**.

## INDUSTRIAL APPLICABILITY

The present disclosure relates generally to turbine engines and, more particularly, to an axial compressor of a turbine engine. Further, the present disclosure relates to an axial compressor having a plurality of disk and spacer pairs. Yet further, the present disclosure is applicable to a pin for reducing relative rotational movement of a disk and a spacer of the disk and spacer pairs.

Referring generally to FIGS. **1-11**, an exemplary turbine engine **10** includes an axial compressor **12**. The axial compressor **12** includes a plurality of disk and spacer pairs **14** oriented along a common axis of rotation $A_1$. Each of a disk **16** and a spacer **18** of the disk and spacer pairs **14** have a contacting face **20**, **22** defining an engagement between the disk **16** and the spacer **18**. The contacting face **20**, **22** of each of the disk **16** and the spacer **18** includes at least one recessed area **24**, **26** for receiving a pin **28**. The pin **28** has a stem **30** received within the recessed area **24** of the disk **16**, and a head **32**, including a plurality of flats **40**, received within the recessed area **26** of the spacer **18**.

Referring specifically to FIG. **11**, a flow diagram **60** representing primary steps of a method of operating the turbine engine **10** or, more particularly, the axial compressor **12**, according to the present disclosure, is shown. At a first step, at box **62**, the method includes a step of rotating the disk and spacer pair **14** about a common axis of rotation $A_1$. At some point during rotation of the disk and spacer pair **14**, such as during operation and/or shutdown of the turbine engine **10**, a contacting face **20** of the disk **16** may engage a contacting face **22** of the spacer **18**, at box **64**.

During operation of the turbine engine **10**, a thermal interference engagement between the disk **16** and the spacer **18** of the disk and spacer pair **14** may form. That is, the disk **16**, spacer **18**, and pin **28** may be configured to rotate together using a frictional fit or engagement. During a hot shutdown, or other similar condition, of the turbine engine **10**, a predetermined clearance **50** between a top surface **52** of the head **32** of the pin **28**, and an inner surface **54** of the recessed area **26** of the spacer **18** may be reduced.

During the operation and/or shutdown, relative rotation of the disk **16** and the spacer **18** may be reduced or restricted using the pin **28**, which has the stem **30** received within the recessed area **24** of the disk **16**, and the head **32** received within the recessed area **26** of the spacer **18**, at box **66**. The restricting step includes contacting at least two flats **40** of the head **32** of the pin **28** with complementary surfaces of the recessed area **26** of the spacer **18**, at box **68**. According to some embodiments, the restricting step may include engaging four pins **28** with four recessed areas **24**, **26** spaced about each of the disk **16** and the spacer **18**.

Some conventional axial compressors utilize small cylindrical pins having an interference fit with one or both of a disk and spacer. During a hot shutdown of the turbine engine, the spacer may cool and shrink at a higher rate than the corresponding disk. This may relieve the designed interference fit and cause the spacer to become loose on the disk. The small cylindrical pin is often insufficient to restrain the spacer in the circumferential direction. The force exerted on the pin by the rotational inertia of the spacer may cause the pin to break, thereby freeing the spacer to rotate relative to the disk from the factory setting.

The pin of the present disclosure, as described herein, reduces clocking and provides a more durable and robust engagement of the disk and spacer in the context of an axial compressor, or other similar context. In particular, for example, and during a hot shutdown, of the turbine engine, the spacer may cool more quickly than the corresponding disk, thus reducing the predetermined clearance and causing one or more of the flats to engage one or more corresponding surface of the recessed area.

It should be understood that the above description is intended for illustrative purposes only, and is not intended to limit the scope of the present disclosure in any way. Thus, those skilled in the art will appreciate that other aspects of the disclosure can be obtained from a study of the drawings, the disclosure and the appended claims.

What is claimed is:

**1**. An axial compressor of a turbine engine, including:

a plurality of disk and spacer pairs oriented along a common axis of rotation, each of a disk and a spacer of the disk and spacer pairs having a contacting face defining an engagement between the disk and the spacer;

the contacting face of each of the disk and the spacer including a recessed area; and

a pin having a stem received within the recessed area of the disk and a head received within the recessed area of the spacer;

the head of the pin including at least two flats corresponding to complementary surfaces of the recessed area of the spacer.

**2**. The axial compressor of claim **1**, wherein the disk and the spacer have a thermal interference engagement.

**3**. The axial compressor of claim **1**, wherein the head of the pin has a hexagonal shape.

**4**. The axial compressor of claim **3**, wherein the recessed area of the spacer has a shape corresponding to the hexagonal shape of the head of the pin.

**5**. The axial compressor of claim **3**, wherein the stem of the pin has a cylindrical shape.

**6**. The axial compressor of claim **5**, wherein the recessed area of the disk has a shape corresponding to the cylindrical shape of the stem of the pin.

**7**. The axial compressor of claim **3**, wherein the pin has a passage therethrough oriented along a longitudinal axis of the pin.

**8**. The axial compressor of claim **1**, further including a plurality of recessed areas spaced about each of the disk and the spacer, and four pins configured for receipt within the plurality of recessed areas.

**9**. The axial compressor of claim **1**, further including a predetermined clearance between a top surface of the head of the pin and an inner surface of the recessed area of the spacer.

**10**. A method of operating a turbine engine, including steps of:

rotating a disk and spacer pair of a plurality of disk and spacer pairs about a common axis of rotation;

engaging a contacting face of a disk of the disk and spacer pairs with a contacting face of a spacer of the disk and spacer pairs during rotation; and

restricting relative rotation of the disk and the spacer using a pin having a stem received within a recessed area of the disk and a head received within a recessed area of the spacer;

wherein the restricting step includes contacting at least two flats of the head of the pin with complementary surfaces of the recessed area of the spacer.

**11**. The method of claim **10**, further including forming a thermal interference engagement of the disk and the spacer during operation of the turbine engine.

**12**. The method of claim **11**, further including performing a hot shutdown of the turbine engine, and reducing a predetermined clearance between a top surface of the head of the pin and an inner surface of the recessed area of the spacer.

**13**. The method of claim **10**, further including engaging a hexagonally shaped head of the pin with the complementary surfaces of the recessed area of the spacer.

**14**. The method of claim **10**, wherein the restricting step includes engaging four pins with four recessed areas spaced about each of the disk and the spacer.

**15**. A turbine engine, including:

an axial compressor, including:

a plurality of disk and spacer pairs oriented along a common axis of rotation, each of a disk of the disk and spacer pairs and a spacer of the disk and spacer pairs having a contacting face defining an engagement between the disk and the spacer, the contacting face of each of the disk and the spacer including a recessed area; and

a pin having a stem received within the recessed area of the disk and a hexagonally shaped head received within the recessed area of the spacer.

**16**. The turbine engine of claim **15**, wherein the pin has a passage therethrough oriented along a longitudinal axis of the pin.

**17**. The turbine engine of claim **15**, wherein the stem of the pin has a cylindrical shape.

**18**. The turbine engine of claim **15**, wherein the disk and the spacer have a thermal interference engagement.

**19**. The turbine engine of claim **15**, further including a predetermined clearance between a top surface of the head of the pin and an inner surface of the recessed area of the spacer.

**20**. The turbine engine of claim **15**, further including a plurality of recessed areas spaced about each of the disk and the spacer, and four pins configured for receipt within the plurality of recessed areas.

* * * * *