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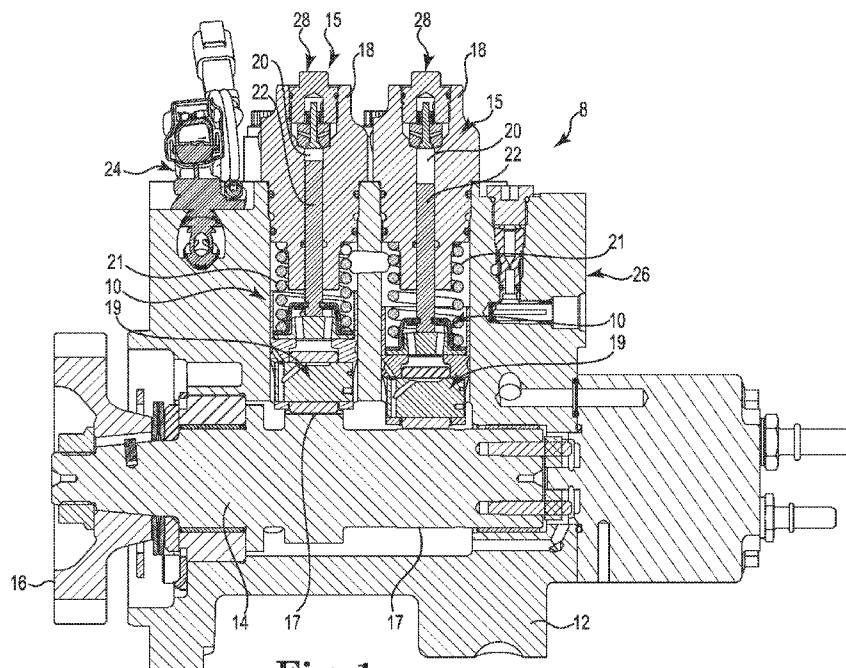


Fig. 1

(57) Abstract: An assembly comprising a fuel pump plunger and a plunger retractor. The plunger retractor includes a spring retainer, a metal retainer coupler connected to the spring retainer, and a polymer lock collar. The retainer coupler has an inner diameter portion with a tapered surface, 5 and is configured for limited movement with respect to the spring retainer about an axis perpendicular to a longitudinal axis of the pump plunger.

RELEASABLE PUMPING PLUNGER RETRACTOR FOR FUEL INJECTION PUMP

FIELD OF THE INVENTION

5 The invention relates generally to releasable mechanical assemblies. Embodiments of the invention include a releasable pumping plunger retractor for fuel injection pumps.

BACKGROUND

10 Fuel injection pumps are generally known and disclosed, for example, in the Grant et al. U.S. Patent 8,070,464 and the Aritomi et al. U.S. Patent 8,671,914. Pumps of these types include several cylinders, each having a spring-driven pumping plunger that reciprocates in a barrel bore. The spring surrounds a portion of the pumping plunger and is coupled to the pumping plunger by a retractor assembly mounted to an end portion of the plunger. During a fill cycle the spring acts on the retractor assembly and pulls the plunger from the barrel. A roller tappet driven by a lobe of a rotating camshaft engages the retractor assembly on a side opposite
15 the pumping plunger and limits the motion of the retractor assembly and plunger during the fill cycle stroke (i.e., the spring and retractor assembly act to keep the roller tappet in contact with and following the camshaft lobe profile during the fill cycle). During a pumping cycle the camshaft lobe and roller tappet act on the retractor assembly against the spring force to push the pumping plunger into the barrel.

20 In pumps of these types the pumping plunger occasionally becomes stuck in the barrel bore. A number of different failure scenarios are possible during a seizure of this type. One scenario involves the retractor assembly breaking and pulling from the pumping plunger. If the seizure is mid-stroke, the plunger and retractor can continue to create debris. Such a failure can lead to tappet damage, camshaft damage and lower bearing damage. It is also possible that
25 damage from the lower end of the pump can enter the engine oil sump and create further complications. In another scenario the retractor does not break and is able to retain the spring load instead of transferring that load to the roller tappet. The roller tappet is then in a no-follow condition which may lead to damage of the roller tappet and camshaft lobe, which can continue with progressive damage to the lower pump assembly.

30 There remains, therefore, a continuing need for improved fuel injection pumps and components. In particular, there is a need for a pump that is not susceptible to further or progressive damage in the event of a pumping plunger seizure. Such a pump that can continue to

operate on another cylinder and enable the vehicle on which the pump is present to be driven to a repair facility would be especially desirable.

SUMMARY

Embodiments of the invention include an assembly comprising a fuel pump plunger
5 having a longitudinal axis and a plunger retractor connected to the fuel pump plunger. The
plunger retractor can release from the plunger without generating debris that might cause
progressive damage. In embodiments, the plunger retractor comprises a spring retainer, a
retainer coupler connected to the spring retainer, and a lock collar. The spring retainer has an
10 inner diameter portion with a tapered surface. The retainer coupler is configured for limited
movement with respect to the spring retainer about an axis perpendicular to the longitudinal axis
of the pump plunger, and is formed from a first material such as metal. The lock collar has an
inner diameter portion surrounding and engaging the fuel pump plunger and an outer diameter
portion with a tapered surface engaging the tapered surface of the inner diameter portion of the
retainer coupler to form a locking taper coupling the lock collar and the retainer coupler. The
15 lock collar is formed from a second material, such as a polymer, that is relatively compressible
or otherwise deformable with respect to the first material of the retainer coupler. Upon the
application of forces less than a release force between the fuel pump plunger and the spring
retainer in a direction causing the locking taper to couple the lock collar and retainer coupler, the
lock collar retains engagement to both the fuel pump plunger and the retainer coupler. Upon the
20 application of forces greater than or equal to the release force between the fuel pump plunger and
the retainer coupler in a direction causing the locking taper to couple the lock collar and retainer
coupler, the lock collar compresses or otherwise deforms, engages the fuel pump plunger and
releases from the retainer coupler.

Other embodiments of the invention include a fuel pump body including a barrel bore, a
25 camshaft having a cam lobe, a roller tappet coupling the cam lobe to the plunger retractor, and a
return spring. The fuel pump plunger is located in the barrel bore, and the fuel pump plunger
and plunger retractor reciprocally move between a retracted position and an extended position.
The return spring is engaged with the spring retainer to bias the plunger retractor and fuel pump
plunger from the extended position toward the retracted position with a force greater than the
30 release force.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a cross sectional view of a multi-cylinder fuel pump including releasable pumping plunger retractors in accordance with embodiments of the invention.

FIG. 2 is a detailed illustration of a portion of the fuel pump shown in FIG. 1, showing the pumping plunger retractor engaged with the pumping plunger.

FIG. 3 is an isometric view of the spring retainer shown in FIG. 2.

FIG. 4 is an isometric view of the lock collar shown in FIG. 2.

FIG. 5 is an isometric view of the retainer coupler shown in FIG. 2.

FIG. 6 is a detailed illustration of the portion of the fuel pump and pumping plunger shown in FIG. 2, showing the pumping plunger retractor released from the pumping plunger.

FIG. 7 is a detailed illustration of a portion of a fuel pump showing a pumping plunger retractor in accordance with other embodiments of the invention.

FIG. 8 is an isometric view of the lock collar shown in FIG. 7.

DETAILED DESCRIPTION

A fuel injection pump 8 including releasable pumping plunger retractor assemblies 10 in accordance with embodiments of the invention is shown in FIG. 1. With the exception of the pumping plunger retractor assemblies 10, fuel injection pump 8 can be of conventional or otherwise known design. For example, the illustrated embodiment of pump 8 includes a body 12 in which a camshaft 14 is rotatably mounted. Camshaft 14 includes lobes 17 and is driven by a drive gear 16 mounted to an end thereof. Motion provided by the profiles of the lobes 17 during rotation of the camshaft 14 is coupled to the pumping plunger retractor assemblies 10 by roller tappet assemblies 19. The embodiment shown in FIG. 1 has two fuel pump cylinders 15, although other embodiments can have more or fewer cylinders. Each fuel pump cylinder 15 includes a pumping plunger retractor assembly 10 mounted within a pumping barrel 18 that includes a pumping chamber 20 and a pumping plunger 22. The pumping plungers 22, which can for example be metal or ceramic members, are driven by pumping plunger retractor assemblies 10 and reciprocate within the pumping chambers 20 between retracted and extended positions during fill and pumping strokes. A biasing member such as return spring 21 in each cylinder 15 applies a return force to the pumping plunger retractor assembly 10 with respect to

the pumping barrel 18 to urge the pumping plunger retractor assembly toward the retracted position and into engagement with the roller tappet assembly 19. During normal operation of the pump 8, the return springs 2 cause the pumping plunger retractors 10 to contact the roller tappet assemblies 19 as the roller tappet assemblies move in response to the rotation of the camshaft 14 and its lobes 17. In the embodiment shown in FIG. 1, the pumping plunger 22 in the left pump cylinder 15 is in the extended position, and the pumping plunger 22 in the right pump cylinder 15 is in the retracted position. An inlet metering valve 24, low pressure supply pump 26 and an inlet and outlet check valve assembly 28 on each cylinder 15, are also shown in FIG. 1. Other embodiments (not shown) have metering valves located in place of the inlet check valves (i.e., active inlet metering).

FIG. 2 is a detailed illustration of a portion of the injection pump 8, showing a pumping plunger retractor assembly 10, roller tappet assembly 19, pumping plunger 22 and return spring 21. Roller tappet assembly 19 includes a roller 30 rotatably secured to a shell 32 by a pin 34. The roller tappet shell 32 is a cup-shaped member that receives the pumping plunger retractor assembly 10. The illustrated embodiment of pumping plunger retractor assembly 10 includes a spring retainer 40, lower spring retainer 42, retainer ring or coupler 44 and lock wedge or collar 46. The spring retainer 40 is located within the roller tappet shell 32 and includes a side wall 48, an inwardly extending lip 50, and an outwardly extending flange 54. As shown in FIGs. 2 and 3, the lip 50 on the spring retainer 40 defines a central opening 52 having an inner diameter. The lower spring retainer 42 includes a central portion 56 within the spring retainer 40, and an outwardly extending flange 58 that extends between the flange 54 of the spring retainer 40 and the bottom of the roller tappet shell 32. As shown, the end of the return spring 21 extends around the side wall 48 and engages the flange 54 of the spring retainer 40. Spring retainer 40 is a metal member in some embodiments. Other embodiments of the spring retainer 40 are formed from other materials, such as polymers.

The retainer coupler 44 and lock collar 46 releasably connect the pumping plunger 22 to the spring retainer 40. In the embodiment shown in FIGs. 2 and 5, the retainer coupler 44 is an annular member having a neck 60 with an inner surface 62 defining an inner diameter, and an outwardly extending flange 64. As discussed in greater detail below, the outer diameter of the retainer coupler neck 60 is less than the inner diameter of the spring retainer central opening 52, and the outer diameter of the retainer coupler flange 64 is greater than the inner diameter of the spring retainer central opening and less than the inner diameter of the spring retainer side wall

48. Retainer coupler 44 is formed from material that has elasticity, compliance and other parameters that characterize its resistance to being deformed (either permanently or non-permanently) in response to the application of force. The retainer coupler 44 is a metal member (e.g., steel) in some embodiments. Other embodiments of the retainer coupler 44 are formed from other materials such as polymers.

In the embodiment shown in FIGs. 2 and 4, the lock collar 46 is an annular member having an outer surface 70 defining an outer diameter and an inner surface 72 defining an inner diameter that engages an outer wall of the pumping plunger 22. As is discussed in greater detail below, the outer diameter of the lock collar outer surface 70 is about equal to the inner diameter of the retainer coupler inner surface 62. In the illustrated embodiment, the inner surface 72 includes a flat walled portion 74 that engages a flat walled portion 75 on the outer diameter portion of the pumping plunger 22, and an inwardly extending lip 76 that is received in and engages a complimentary-shaped annular recess 77 in the outer diameter portion of the pumping plunger. The lock collar 46 is formed from a material that has elasticity, compliance and other parameters that characterize its resistance to being compressed or otherwise deformed (either permanently or non-permanently) in response to the application of force. As described in greater detail below, lock collar 46 is formed from material that enables the structure to be more compressible or otherwise deformable than the retainer coupler 44. The lock collar 46 is a polymer (e.g., Nylon or poly ether ketone (PEEK)) in some embodiments, and is formed from other materials in other embodiments. In the embodiment shown in FIG. 4, the lock collar 46 has a gap 79 extending therethrough to facilitate assembly of the lock collar onto the pumping plunger 22. In yet other embodiments (not shown), the entire inner surface 72 of the lock collar 46 is flat and engaged with flat walled portions such as 75 on the outer diameter portion of the pumping plunger 22 (i.e., these embodiments do not have the complimentary shaped lip 76 and recess 77).

The interface between the retainer coupler inner surface 62 and the lock collar outer surface 70 forms a releasable connection between the components. In the embodiment shown in FIG. 2, the surfaces 62 and 70 are complimentary flat and tapered surfaces that extend at non-zero angles with respect to an axis parallel the longitudinal axis of the pumping plunger 22. By this configuration of the surfaces 62 and 70, the retainer coupler 44 and lock collar 46 form a locking taper or self-holding coupler. In response to the application of forces less than a release force between the retainer coupler 44 and lock collar 46 in a direction tending to cause

the locking taper to engage and couple the spring retainer and lock collar (i.e., in a direction causing the retainer coupler to move toward the roller tappet assembly 19 with respect to the lock collar in the illustrated embodiment), the lock collar retains engagement to both the fuel pump plunger 22 and the retainer coupler. However, because of the relative deformation characteristics of the components, upon the application of forces greater than or equal to the release force between the retainer coupler 44 and lock collar 46 in a direction causing the locking taper to couple the spring retainer and lock collar, the lock collar compresses or otherwise deforms with respect to the retainer coupler, engages the fuel pump plunger 22, and releases from the spring retainer. In embodiments, the taper angle of the surfaces 62 and 70 of the retainer coupler 44 and lock collar 46, respectively, is about 7° with respect to the longitudinal axis of the pumping plunger 22. Other embodiments have other taper angles. The taper angle can, for example, depend upon factors such as the shapes, sizes, and materials (i.e., and therefore elasticities and deformation characteristics) of the retainer coupler 44 and lock collar 46 and the desired release force. For example, in some embodiments the taper angle is between 6° and 8° . Yet other embodiments have larger and smaller taper angles.

The operation of plunger retractor assemblies 10 can be described with reference to FIG. 6. Pumping plunger retractor assemblies 10 are configured to provide a release force that is less than the return force provided by the return springs 21, but greater than the forces required of the pumping plunger 22 when moving from the extended position to the retracted position during fill cycles of the pump 8. During the operation of fuel injection pump 8, a pumping plunger 22 may stick or seize within a barrel 18 at a location between the extended and retracted positions. On the occurrence of a failure of this type, the return force of the return spring 21 acting on the spring retainer 40 will be greater than the release force provided by the retainer coupler 44 and lock collar 46. The lock collar 46 will therefore engage the pumping plunger 22 and compress or otherwise deform as described above, allowing the retainer coupler 44 to and release from and be pulled away from the lock collar. The retainer coupler 44 and spring retainer 40 will then continue to follow the roller tappet assembly 19 and camshaft lobe 17 as shown in FIG. 6. As is also shown in FIG. 6, the lock collar 46 is retained on the pumping plunger 22, and during the next pumping stroke of the spring retainer 40 and retainer coupler 44, the lock collar will be pushed up the pumping plunger and away from the spring retainer. The retainer coupler 44 is contained within the spring retainer 40 by the lower spring retainer 42. Separation of the pumping plunger 22 from the spring retainer 40 occurs without the breakage of metal parts and the generation of metallic debris.

Releasable pumping plunger retractor assembly 10 offers a number of important advantages. Although the associated pump cylinder 15 is dead and non-functional upon the release of the retractor assembly 10 from the plunger 22, all the components of the plunger retractor assembly are contained, so further damage to the pump 8 or the engine (not shown) with which the pump is mounted, including possible progressive damage, is minimized or eliminated. In fuel pumps such as 8 having several pump cylinders 15, other remaining and operative pump cylinders can provide sufficient fuel to enable vehicles on which the pump is located to operate and be driven to a service center. Furthermore, it has been demonstrated that lock collars formed from non-metallic material, such as polymer, will not damage the lower assembly. Such a material, if destroyed into debris during operation of the pump, would be captured by the engine lube filter.

Another advantage of retractor assembly 10 is that the spring retainer 40 and the retainer coupler 44 are configured for limited movement with respect to one another about an axis perpendicular to the longitudinal axis of the pump plunger 22. In particular, the range of movement between the spring retainer 40 and the retainer coupler 44 is constrained by the engagement of either or both of the retainer coupler neck 60 and the spring retainer lip 50 and the retainer coupler flange 64 and the spring retainer side wall 48. The limited or constrained movement of the retainer coupler 44 with respect to the spring retainer 40 provides a degree of “float” to minimize or reduce side loading of the pumping plunger 22 within the pumping barrel 18 by any horizontal motion the spring retainer (i.e., in a direction perpendicular to the longitudinal axis of the plunger) during operation of the pump 8. This feature can be particularly advantageous in pumps 8 having ceramic pumping plungers 22. Yet another advantage of the pumping plunger retractor assembly 10 is that the locking taper provided by the retainer coupler 44 and the lock collar 46 can hold the components together sufficiently well during assembly of pump 8 to enhance the manufacturability of the pump.

FIGs. 7 and 8 illustrate portions of a fuel injection pump 108 having a releasable pumping plunger retractor assembly 110 in accordance with yet other embodiments of the invention. As shown, unlike retractor assembly 10 described above, the releasable pumping plunger assembly 110 does not have a retainer coupler 44. Instead, the releasable locking taper coupler functionality is provided by the lip 151 of the spring retainer 140 and the lock collar 146. Other than these differences which are described in greater detail below, the fuel injection pump

108 can be the same as or similar to that of pump 8, and similar components are identified by similar reference numbers.

As shown, the spring retainer 140 includes a neck 151 that extends upwardly from a shoulder 150. The neck 151 has an inner surface 162 defining an inner diameter. Lock collar 146 is an annular member having an outer surface 170 defining an outer diameter and an inner surface 172 defining an inner diameter that engages an outer wall of the pumping plunger 122. The outer diameter of the lock collar outer surface 170 is about equal to the inner diameter of the spring retainer inner surface 162. In the illustrated embodiment, the inner surface 172 includes inwardly extending, annular lips 173 that engage a flat walled portion 175 on the outer diameter portion of the pumping plunger 122. Like the lock collar 46 described in connection with pump 8, lock collar 146 is formed from a material that has elasticity, compliance and other parameters that characterize its resistance to being deformed (either permanently or non-permanently) in response to the application of force. Lock collar 146 is formed from material that enables the structure to be more compressible or otherwise deformable than the neck 151 or other portions of the spring retainer 140. The lock collar 146 is a polymer (e.g., Nylon or poly ether ketone (PEEK)) in some embodiments, and is formed from other materials in other embodiments. In the embodiment shown in FIG. 8, the lock collar 146 is split and has a gap 179 extending therethrough to facilitate assembly of the lock collar onto the pumping plunger 122.

The interface between the spring retainer inner surface 162 and the lock collar outer surface 170 forms a releasable connection between the components. In the embodiment shown in FIGs. 7 and 8, the surfaces 162 and 170 are complimentary flat and tapered surfaces that extend at non-zero angles with respect to an axis parallel the longitudinal axis of the pumping plunger 122. By this configuration the surfaces 162 and 170 of the spring retainer 140 and lock collar 146, respectively, form a locking taper or self-holding coupler. In response to the application of forces less than a release force between the spring retainer 140 and lock collar 146 in a direction causing the locking taper to couple the spring retainer and lock collar (i.e., in a direction causing the spring retainer to move toward the roller tappet assembly 119 with respect to the lock collar in the illustrated embodiment), the lock collar retains engagement to both the fuel pump plunger 122 and the spring retainer. However, because of the relative deformation characteristics of the components, upon the application of forces greater than or equal to the release force between the spring retainer 140 and lock collar 146 in a direction causing the locking taper to couple the spring retainer and lock collar, the lock collar compresses or

otherwise deforms with respect to the spring retainer, engages the fuel pump plunger 122 and releases from the spring retainer. In embodiments, the taper angle of the surfaces 162 and 170 are about 7° with respect to the longitudinal axis of the pumping plunger 122. Other embodiments have other taper angles. The taper angle can, for example, depend upon factors
5 such as the shapes, sizes, and materials (i.e., and therefore elasticities and deformation characteristics) of the spring retainer 140 and lock collar 146 and the desired release force. For example, in some embodiments the taper angle is between 6° and 8° . Yet other embodiments have larger and smaller taper angles. Releasable pumping plunger retractor assembly 110 provides advantages similar to those of retractor assembly 10 described above.

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

CLAIMS

What is claimed is:

- 5 1. An assembly, comprising:
a fuel pump plunger; and
a plunger retractor connected to the fuel pump plunger, comprising:
a spring retainer having an inner diameter portion with a tapered surface, the
spring retainer formed from a first material; and
10 a lock collar having an inner diameter portion surrounding and engaging the fuel
pump plunger and an outer diameter portion with a tapered surface
engaging the tapered surface of the inner diameter portion of the spring
retainer to form a locking taper coupling the collar and the spring retainer,
the lock collar formed from a second material that is relatively deformable
15 with respect to the first material of the spring retainer; and
wherein upon application of forces less than a release force between the fuel pump
plunger and the spring retainer in a direction causing the locking taper to couple
the lock collar and spring retainer, the lock collar retains engagement to both the
fuel pump plunger and the spring retainer; and
20 wherein upon application of forces greater than or equal to the release force between the
fuel pump plunger and the spring retainer in a direction causing the locking taper
to couple the lock collar and spring retainer, the lock collar deforms, engages the
fuel pump plunger and releases from the spring retainer.
- 25 2. The assembly of claim 1 and further including:
a fuel pump body including a barrel bore, wherein the fuel pump plunger is located in the
barrel bore, and the fuel pump plunger and plunger retractor reciprocally move
between a retracted position and an extended position;
a camshaft having a cam lobe;
30 a roller tappet coupling the cam lobe to the plunger retractor; and
a return spring engaged with the spring retainer to bias the plunger retractor and fuel
pump plunger from the extended position toward the retracted position with a
force greater than the release force.

3. The assembly of claim 2 wherein:
the inner diameter portion of the spring retainer is circular with a flat tapered surface; and
the outer diameter portion of the lock collar is circular with a flat tapered surface.

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4. The assembly of claim 3 wherein:
the inner diameter portion of the spring retainer is metal; and
the lock collar is polymer.

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5. The assembly of claim 4 wherein:
the inner diameter portion of the lock collar has a flat wall; and
an outer diameter portion of the fuel pump plunger engaged by the inner diameter portion
of the lock collar has a flat wall.

6. The assembly of claim 4 wherein the inner diameter portion of the lock collar has
15 a non-flat gripping surface.

7. The assembly of claim 6 wherein an outer diameter portion of the fuel pump
plunger engaged by the inner diameter portion of the lock collar has a flat wall.

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8. The assembly of claim 6 wherein an outer diameter portion of the fuel pump
plunger engaged by the inner diameter portion of the lock collar has a non-flat wall.

9. The assembly of claim 4 wherein:
the inner diameter portion of the lock collar includes:

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a portion with a flat wall; and
a portion with an inwardly extending projection such as an annular lip; and
an outer diameter portion of the fuel pump plunger engaged by the inner diameter portion
of the lock collar includes:

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a portion with flat wall engaged by the flat wall of the lock collar; and
a recessed portion, such as an annular groove, engaged by the inwardly extending
projection.

10. An assembly, comprising:

a fuel pump plunger having a longitudinal axis; and

a plunger retractor connected to the fuel pump plunger, comprising:

a spring retainer;

a retainer coupler connected to the spring retainer and having an inner diameter
5 portion with a tapered surface, the retainer coupler configured for limited
movement with respect to the spring retainer about an axis perpendicular
to the longitudinal axis of the pump plunger, and formed from a first
material; and

a lock collar having an inner diameter portion surrounding and engaging the fuel
10 pump plunger and an outer diameter portion with a tapered surface
engaging the tapered surface of the inner diameter portion of the retainer
coupler to form a locking taper coupling the lock collar and the retainer
coupler, the lock collar formed from a second material that is relatively
deformable with respect to the first material of the retainer coupler; and

15 wherein upon application of forces less than a release force between the fuel pump
plunger and the spring retainer in a direction causing the locking taper to couple
the lock collar and retainer coupler, the lock collar retains engagement to both the
fuel pump plunger and the retainer coupler; and

20 wherein upon application of forces greater than or equal to the release force between the
fuel pump plunger and the retainer coupler in a direction causing the locking taper
to couple the lock collar and retainer coupler, the lock collar compresses or
otherwise deforms, engages the fuel pump plunger and releases from the retainer
coupler.

25 11. The assembly of claim 10 and further including:

a fuel pump body including a barrel bore, wherein the fuel pump plunger is located in the
barrel bore, and the fuel pump plunger and plunger retractor reciprocally move
between a retracted position and an extended position;

a camshaft having a cam lobe;

30 a roller tappet coupling the cam lobe to the plunger retractor; and

a return spring engaged with the spring retainer to bias the plunger retractor and fuel
pump plunger from the extended position toward the retracted position with a
force greater than the release force.

12. The assembly of claim 11 wherein:
the inner diameter portion of the retainer coupler is circular with a flat tapered surface;
and

the outer diameter portion of the lock collar is circular with a flat tapered surface.

13. The assembly of claim 12 wherein:
the inner diameter portion of the retainer coupler is metal; and
the lock collar is polymer.

14. The assembly of claim 13 wherein:
the inner diameter portion of the lock collar has a flat wall; and
an outer diameter portion of the fuel pump plunger engaged by the inner diameter portion
of the lock collar has a flat wall.

15. The assembly of claim 13 wherein the inner diameter portion of the lock collar
has a non-flat gripping surface.

16. The assembly of claim 15 wherein an outer diameter portion of the fuel pump
plunger engaged by the inner diameter portion of the lock collar has a flat wall.

17. The assembly of claim 15 wherein an outer diameter portion of the fuel pump
plunger engaged by the inner diameter portion of the lock collar has a non-flat wall.

18. The assembly of claim 13 wherein:
the inner diameter portion of the lock collar includes:
a portion with a flat wall; and
a portion with an inwardly extending projection such as an annular lip; and
an outer diameter portion of the fuel pump plunger engaged by the inner diameter portion
of the lock collar includes:
a portion with flat wall engaged by the flat wall of the lock collar; and
a recessed portion, such as an annular groove, engaged by the inwardly extending
projection.

19. The assembly of claim 13 wherein:

the spring retainer includes a side wall and a lip extending inwardly from the side wall
and defining a central opening having a diameter; and

the retainer coupler includes a neck extending into the central opening and a shoulder
having an outer diameter that is greater than the diameter of the central opening;
and

wherein the limited movement between the retainer coupler and the spring retainer is
constrained by one or both of (1) engagement of the retainer coupler neck with
the spring retainer lip, and (2) engagement of the retainer coupler shoulder with
the spring retainer side wall.

20. The assembly of claim 10 and including structures on one or both of the retainer
coupler and the spring retainer to constrain the range of movement of the retainer coupler with
respect to the spring retainer.

21. The assembly of claim 10 wherein:

the spring retainer includes a side wall and a lip extending inwardly from the side wall
and defining a central opening having a diameter; and

the retainer coupler includes a neck extending into the central opening and a shoulder
having an outer diameter that is greater than the diameter of the central opening;
and

wherein the limited movement between the retainer coupler and the spring retainer is
constrained by one or both of (1) engagement of the retainer coupler neck with
the spring retainer lip, and (2) engagement of the retainer coupler shoulder with
the spring retainer side wall.

22. An assembly, comprising:

a first element having a first axis; and

a second element connected to the first element, comprising:

a retainer;

a retainer coupler connected to the retainer and having an inner diameter portion
with a tapered surface, the retainer coupler configured for limited

movement with respect to the retainer about a second axis perpendicular to the first axis of the first element, and formed from a first material; and a lock collar having an inner diameter portion surrounding and engaging a portion of the first element and an outer diameter portion with a tapered surface engaging the tapered surface of the inner diameter portion of the retainer coupler to form a locking taper coupling the lock collar and the retainer coupler, the lock collar formed from a second material that is relatively compressible or otherwise deformable with respect to the first material of the retainer coupler; and

wherein upon application of forces less than a release force along the first axis between the first element and the retainer in a direction causing the locking taper to couple the lock collar and retainer coupler, the lock collar retains engagement to both the first element and the retainer coupler; and

wherein upon application of forces greater than or equal to the release force along the first axis between the first element and the retainer coupler in a direction causing the locking taper to couple the lock collar and retainer coupler, the lock collar compresses, engages the first element and releases from the retainer coupler.

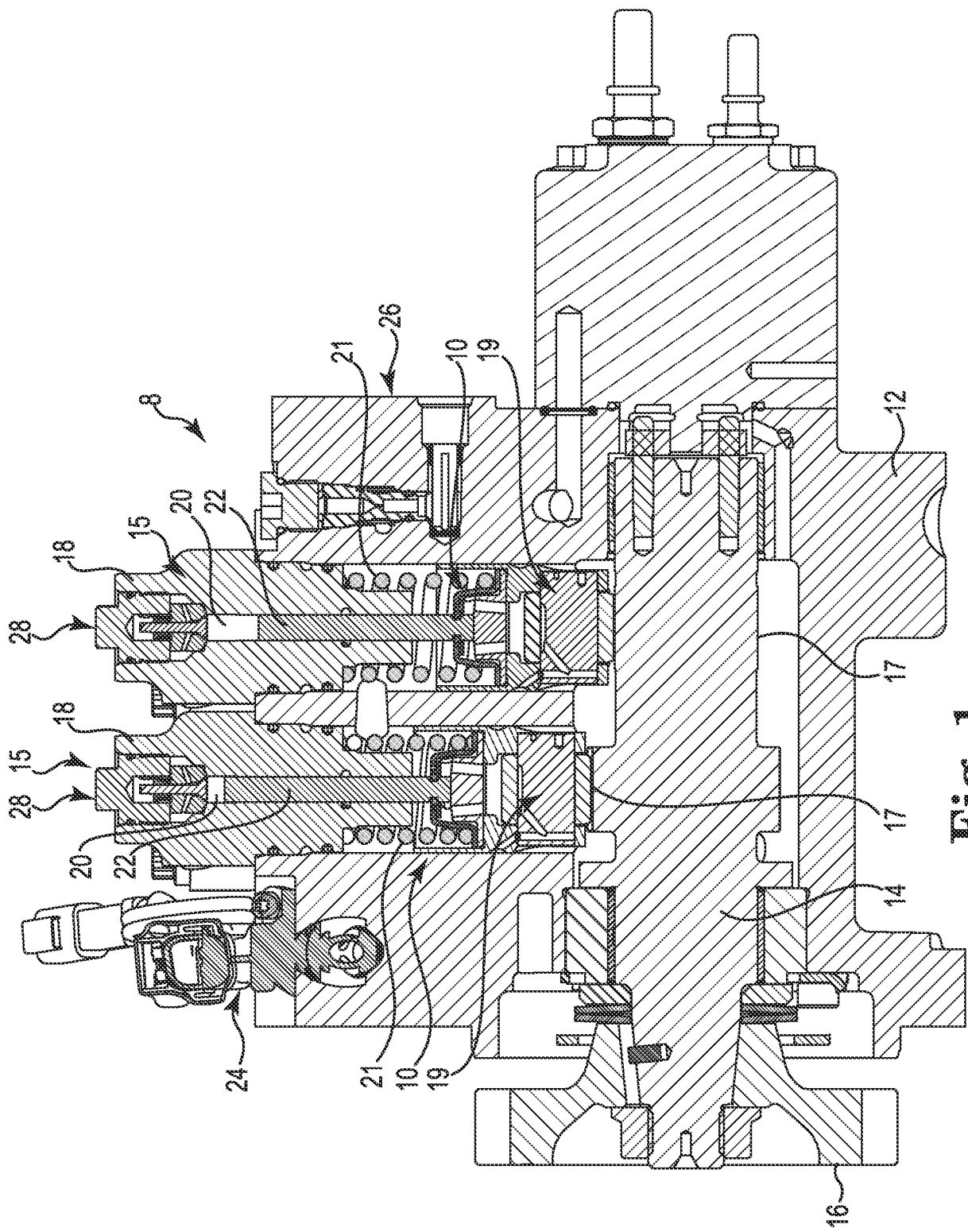


Fig. 1

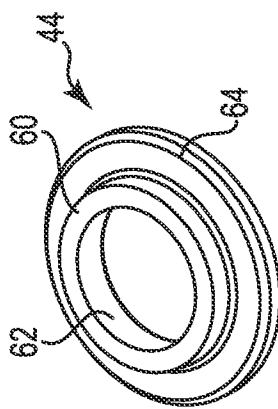


Fig. 5

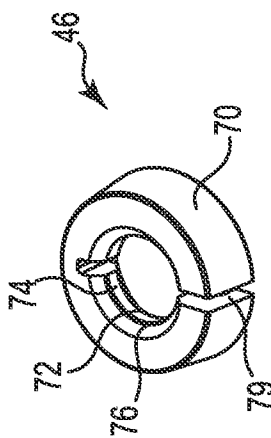


Fig. 4

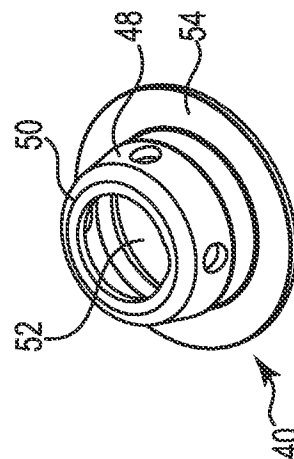


Fig. 3

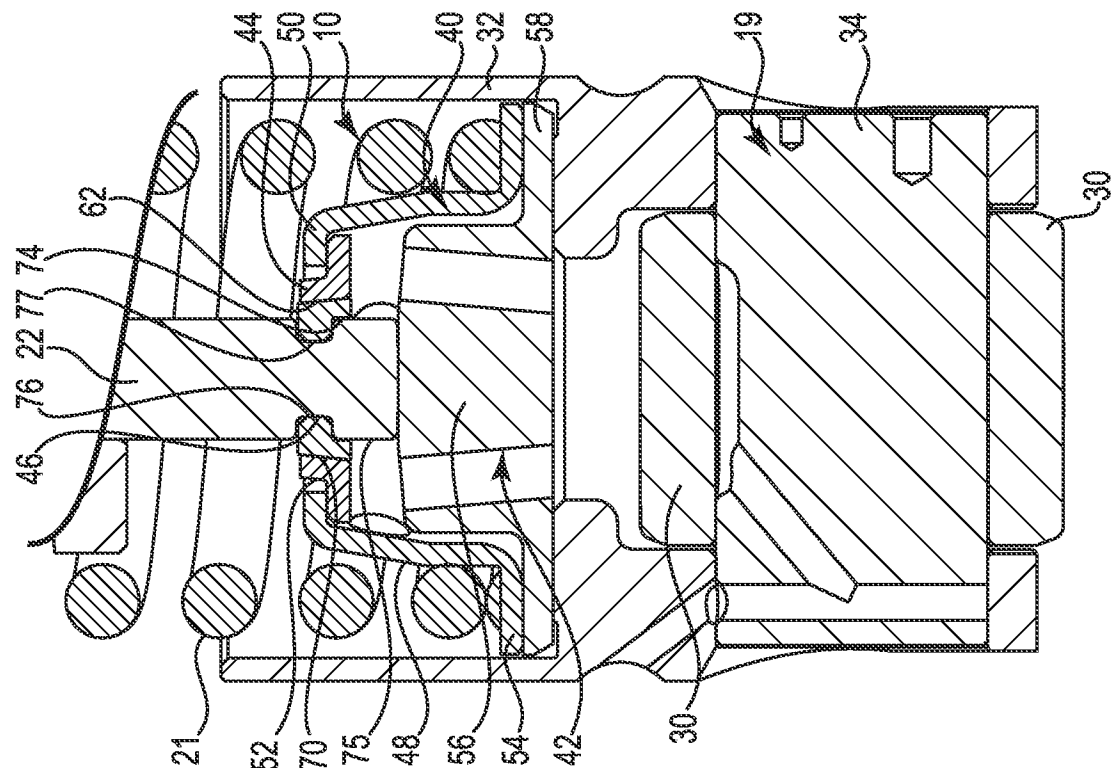


Fig. 2

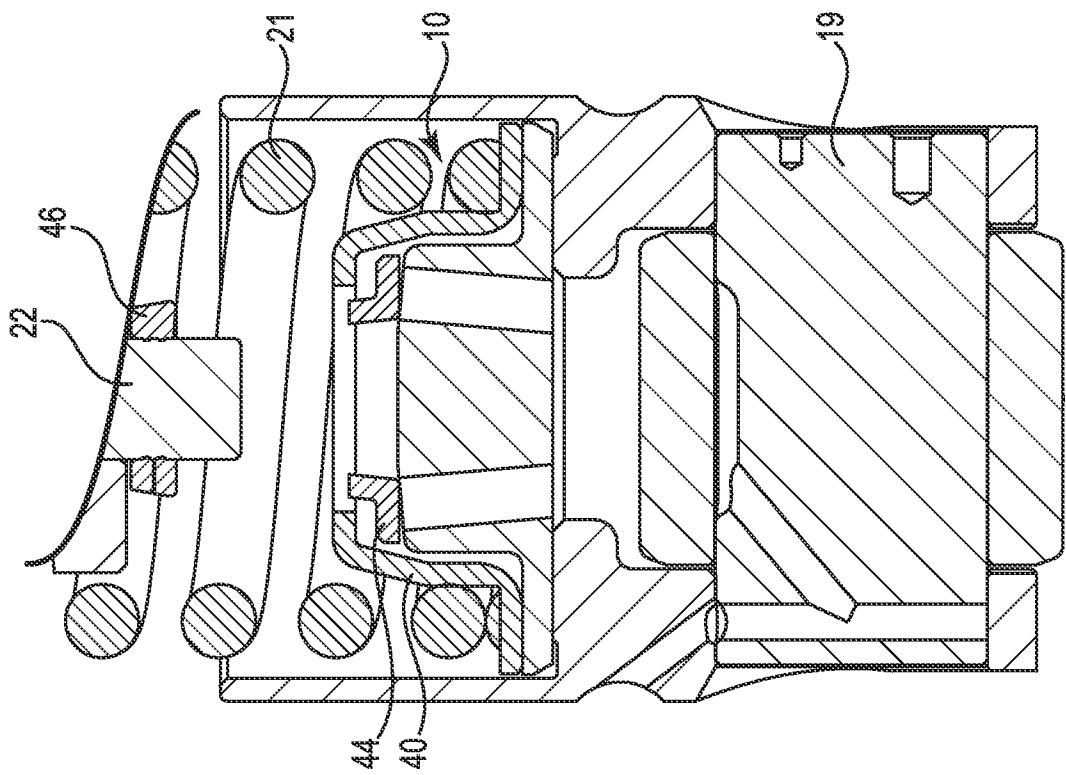
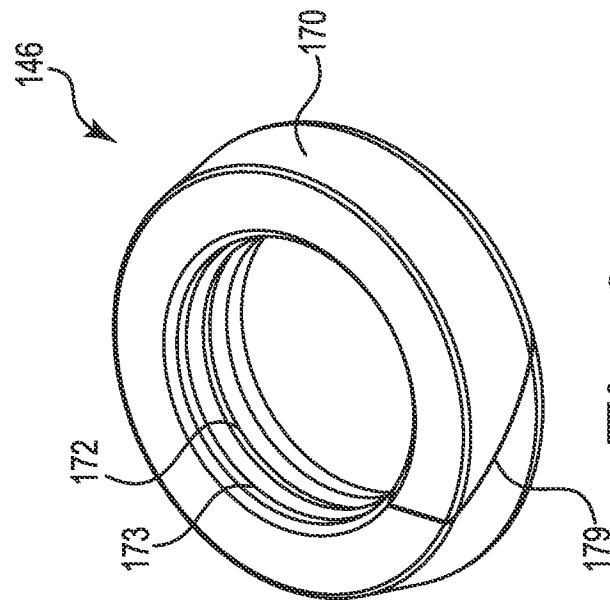


Fig. 6



800

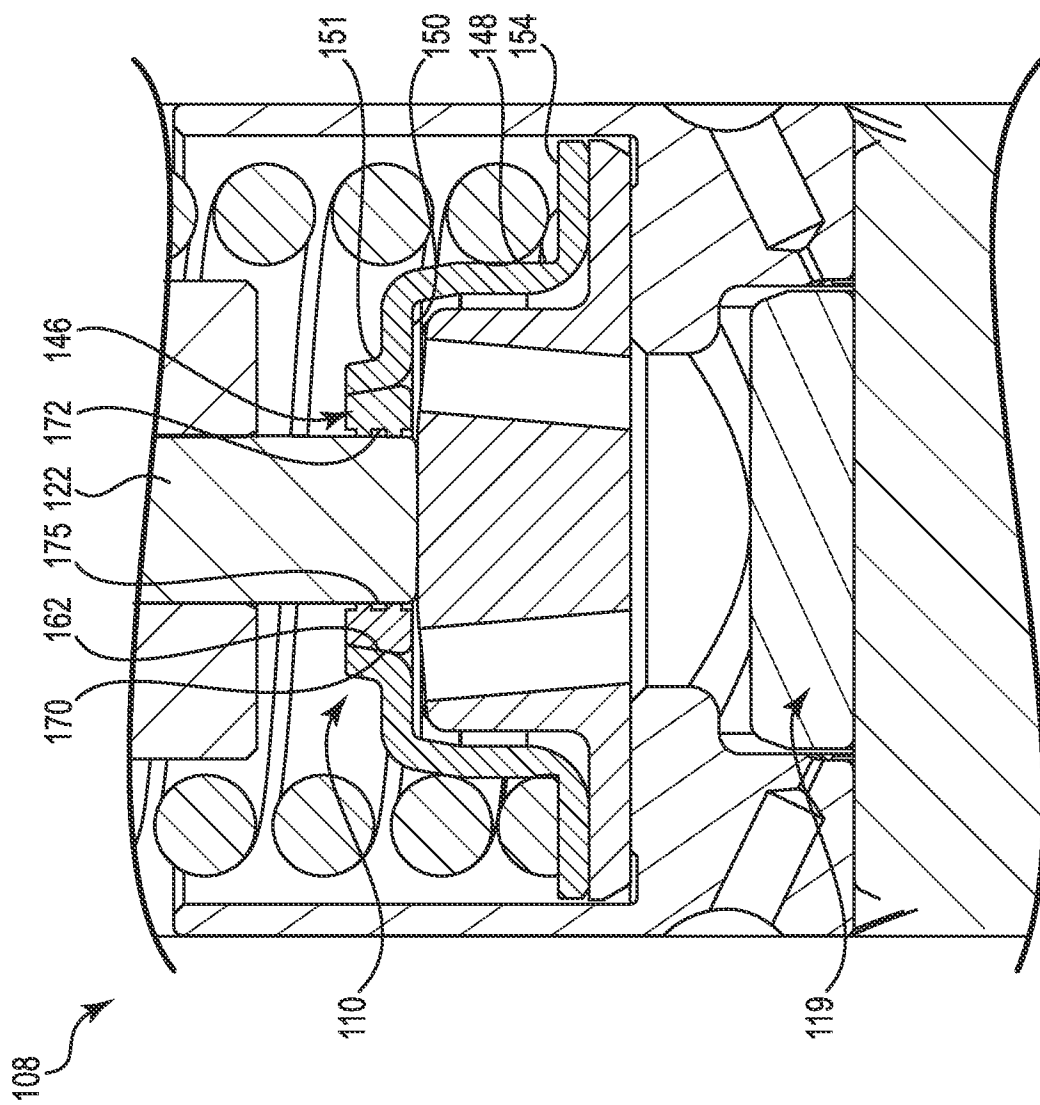


Fig. 7

INTERNATIONAL SEARCH REPORT

International application No.

PCT/US2014/072761

A. CLASSIFICATION OF SUBJECT MATTER IPC(8) - F02M 59/44 (2015.01) CPC - F02M 2200/26 (2015.01) 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) IPC(8) - F01L 1/32, 3/10; F02M 37/04, 59/10, 59/44 (2015.01) CPC - F01L 1/32, 3/10; F02M 59/102, 59/44, 2200/26 (2015.01) (keyword delimited) Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched USPC - 92/129; 123/90.3, 90.67, 495; 251/337; 417/471 Electronic data base consulted during the international search (name of data base and, where practicable, search terms used) Orbit, Google Patents, Google Scholar, Google, YouTube search terms used: collar, collet, deform, seizure, stick, fail, retainer, injector		
C. DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US 3,938,484 (MÜELLER) 17 February 1976 (17.02.1976) entire document	1-5, 9
Y	US 5,520,155 A (HEFLER) 28 May 1996 (28.05.1996) entire document	1-5, 9
A	GB 761,405 A (VALVES LIMITED) 14 November 1956 (14.11.1956) entire document	1-22
A	US 5,775,203 A (OSBORN et al) 07 July 1998 (07.07.1998) entire document	1-22
A	US 8,070,464 B2 (GRANT et al) 06 December 2011 (06.12.2011) entire document	1-22
☐ Further documents are listed in the continuation of Box C.		
* 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 09 March 2015		Date of mailing of the international search report 24 APR 2015
Name and mailing address of the ISA/US Mail Stop PCT, Attn: ISA/US, Commissioner for Patents P.O. Box 1450, Alexandria, Virginia 22313-1450 Facsimile No. 571-273-3201		Authorized officer: Blaine R. Copenheaver PCT Helpdesk: 571-272-4300 PCT OSP: 571-272-7774