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Ritter et al.

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(45) Date of Patent: Aug. 12, 2025

(54) **DRAIN SYSTEM FOR BATHTUB**

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(73) Assignee: **KOHLER CO.**, Kohler, WI (US)

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

(21) Appl. No.: **18/233,829**

(22) Filed: **Aug. 14, 2023**

(65) **Prior Publication Data**

US 2023/0383510 A1 Nov. 30, 2023

Related U.S. Application Data

(63) Continuation of application No. 17/117,325, filed on Dec. 10, 2020, now Pat. No. 11,725,373.

(60) Provisional application No. 62/948,233, filed on Dec. 14, 2019.

(51) **Int. Cl.**

E03C 1/242	(2006.01)
E03C 1/232	(2006.01)
E03C 1/24	(2006.01)

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

CPC ***E03C 1/242*** (2013.01); ***E03C 1/232*** (2013.01); *E03C 2001/2413* (2013.01)

(58) **Field of Classification Search**

CPC . E03C 1/232; E03C 1/22; E03C 1/242; E03C 2001/2413

See application file for complete search history.

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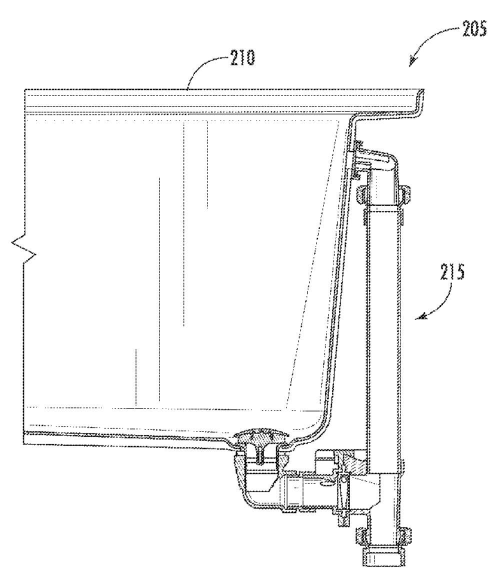
Primary Examiner — Janie M Loeppke

(74) *Attorney, Agent, or Firm* — FOLEY & LARDNER LLP

(57) **ABSTRACT**

A drain system for controlling a water level in a bathtub includes a drain exit assembly coupled to an exit drain of the bathtub and configured to receive water exiting the bathtub, a valve fluidly coupled to the drain exit assembly and operably coupled to a motor, and a pressure sensor communicatively coupled to the valve and in fluid communication with the drain exit assembly. The motor is configured to change the operational state of the valve based on a pressure sensed by the pressure sensor to control a water level within the bathtub.

13 Claims, 36 Drawing Sheets



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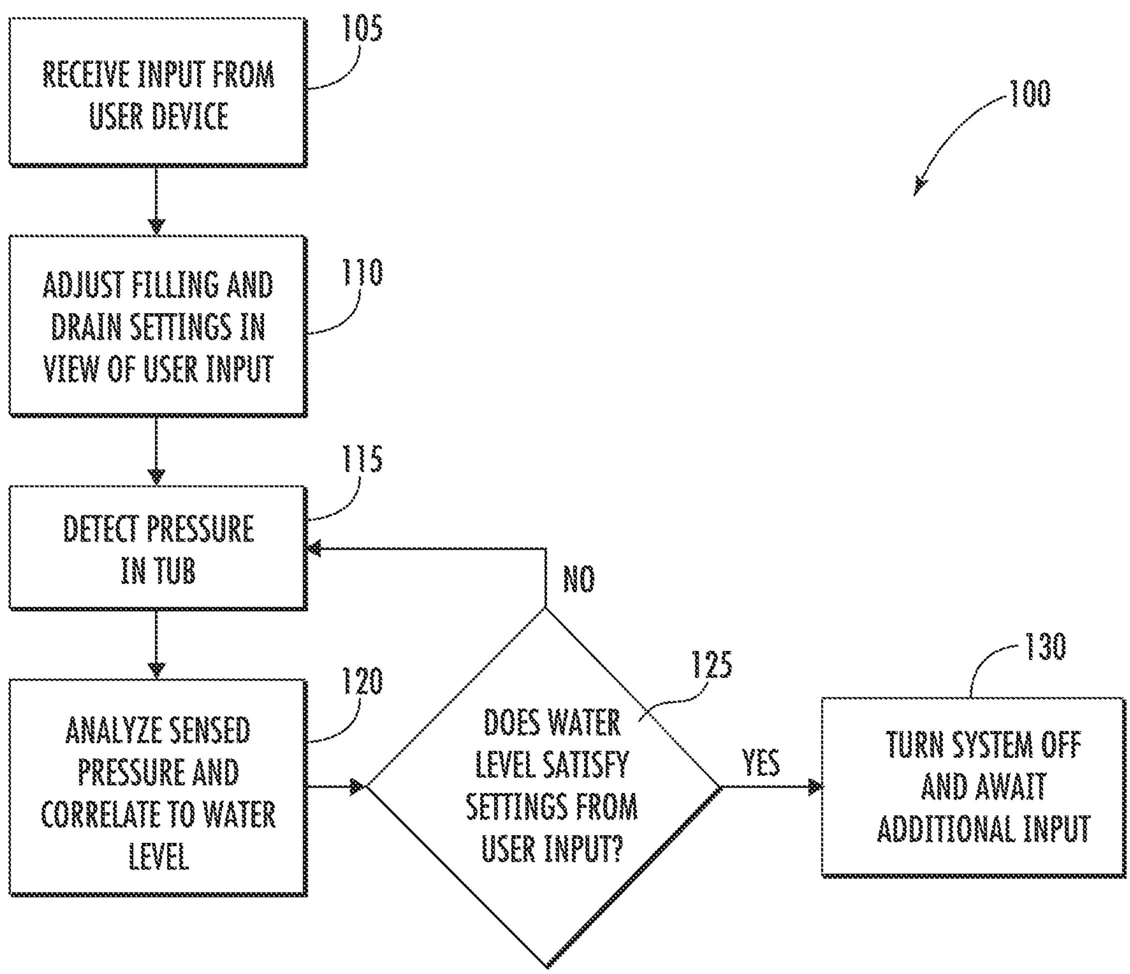

105
RECEIVE INPUT FROM USER DEVICE
100
110
ADJUST FILLING AND DRAIN SETTINGS IN VIEW OF USER INPUT
115
DETECT PRESSURE IN TUB
NO
120
ANALYZE SENSED PRESSURE AND CORRELATE TO WATER LEVEL
125
DOES WATER LEVEL SATISFY SETTINGS FROM USER INPUT?
YES
130
TURN SYSTEM OFF AND AWAIT ADDITIONAL INPUT

FIG. 1

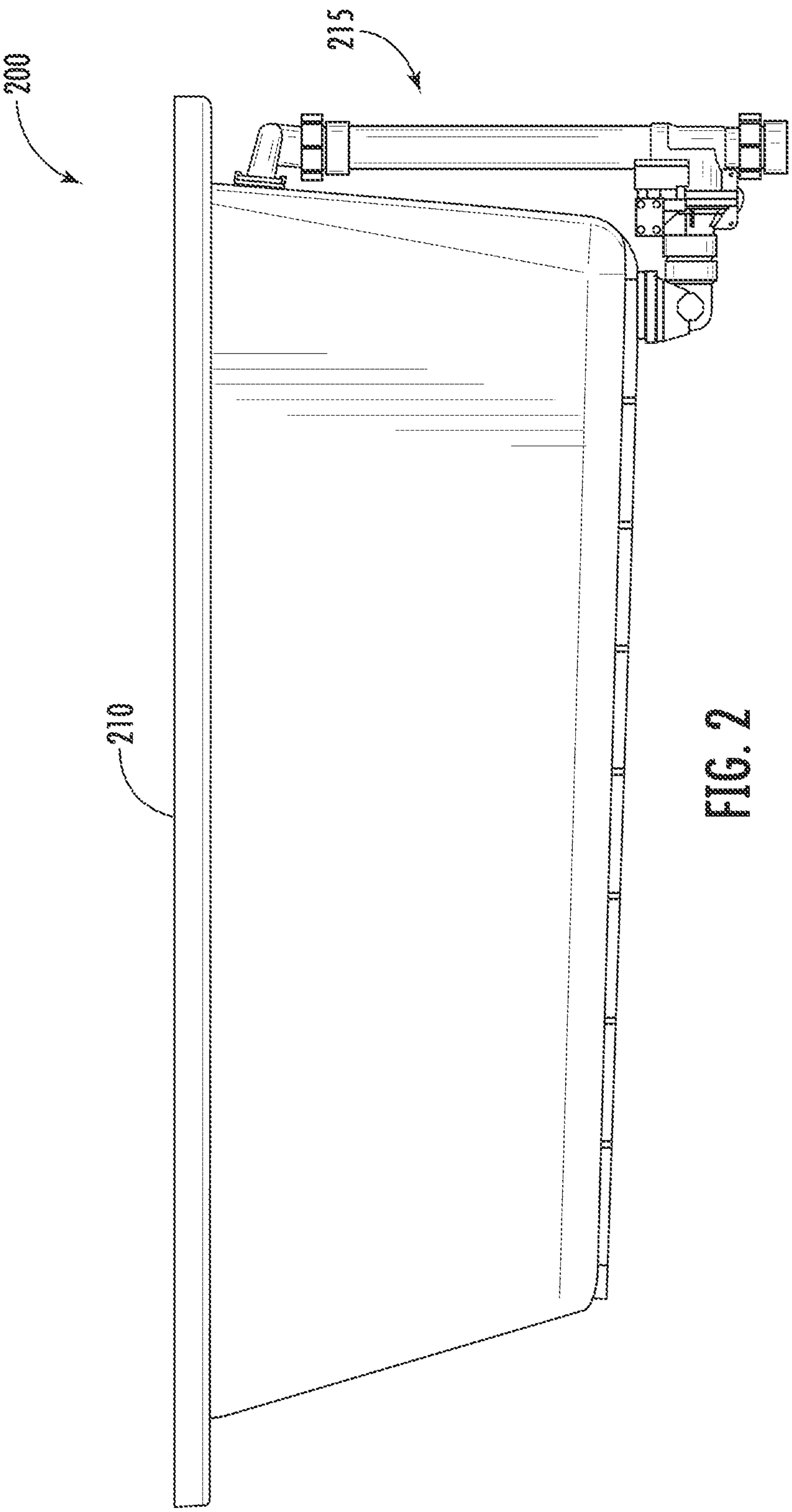


FIG. 2

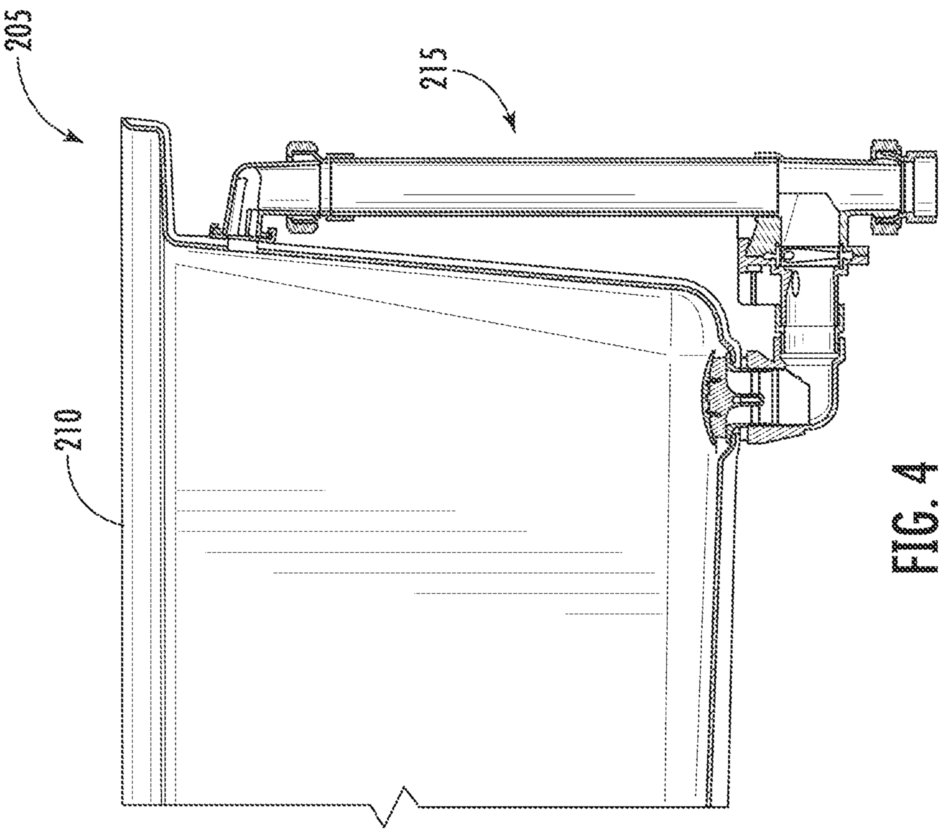
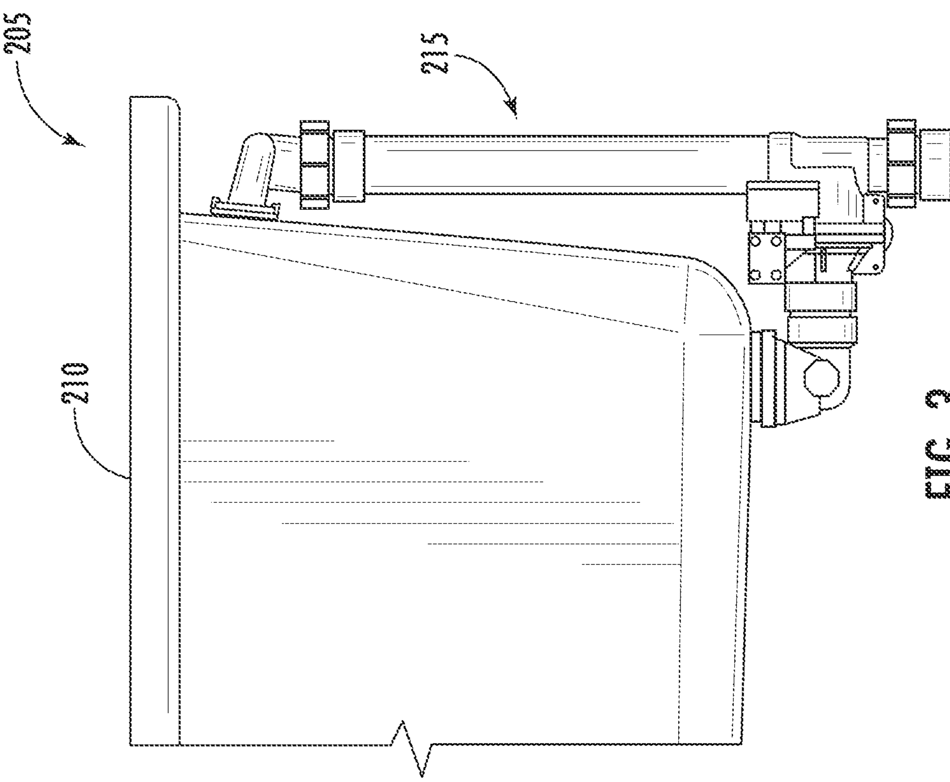


FIG. 4



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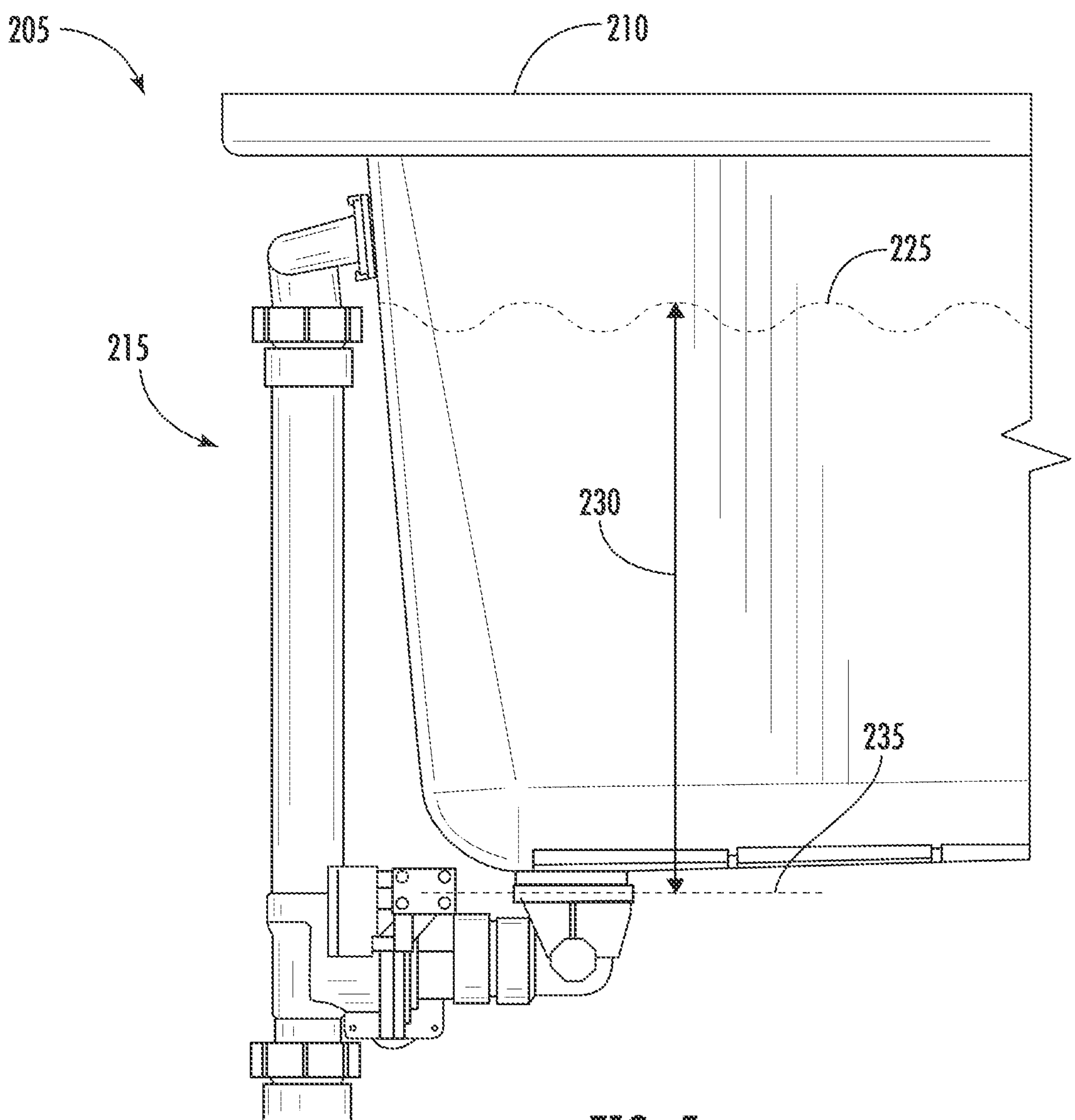

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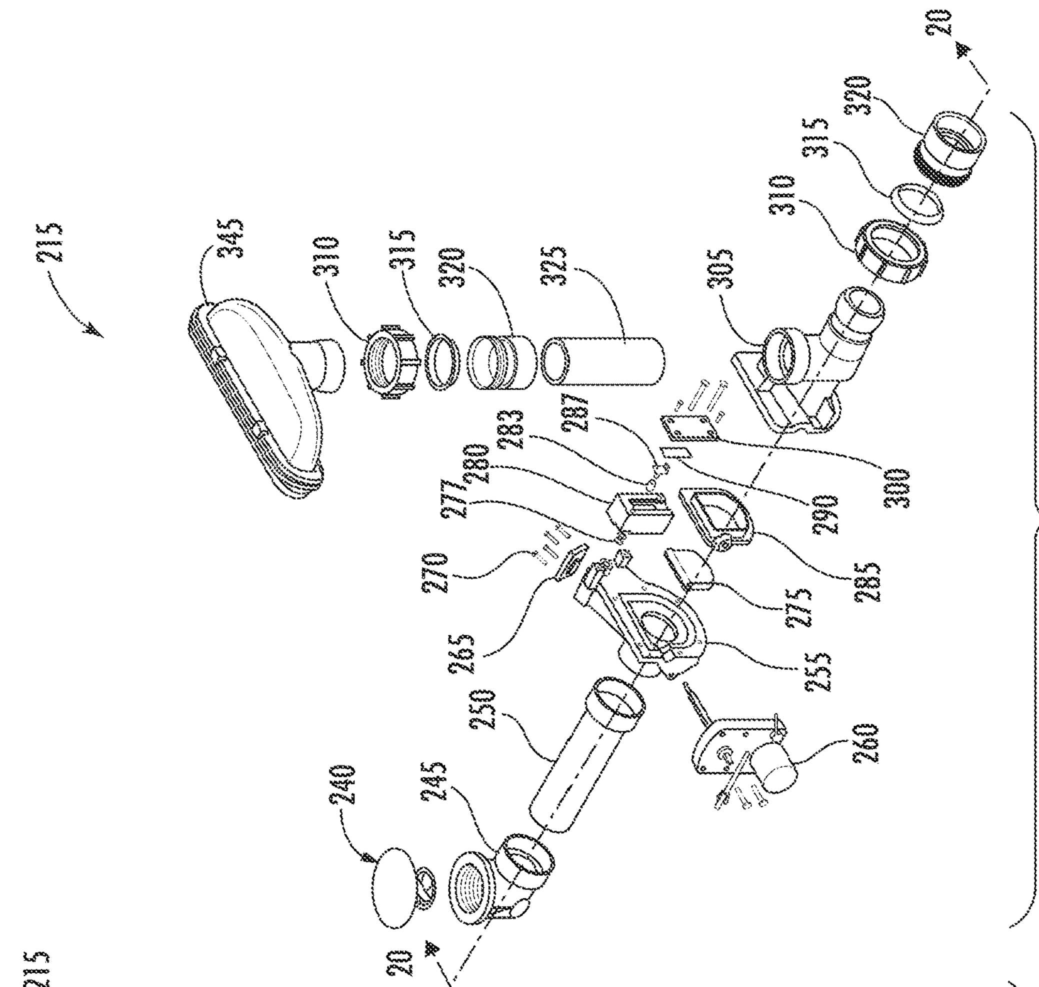
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FIG. 7

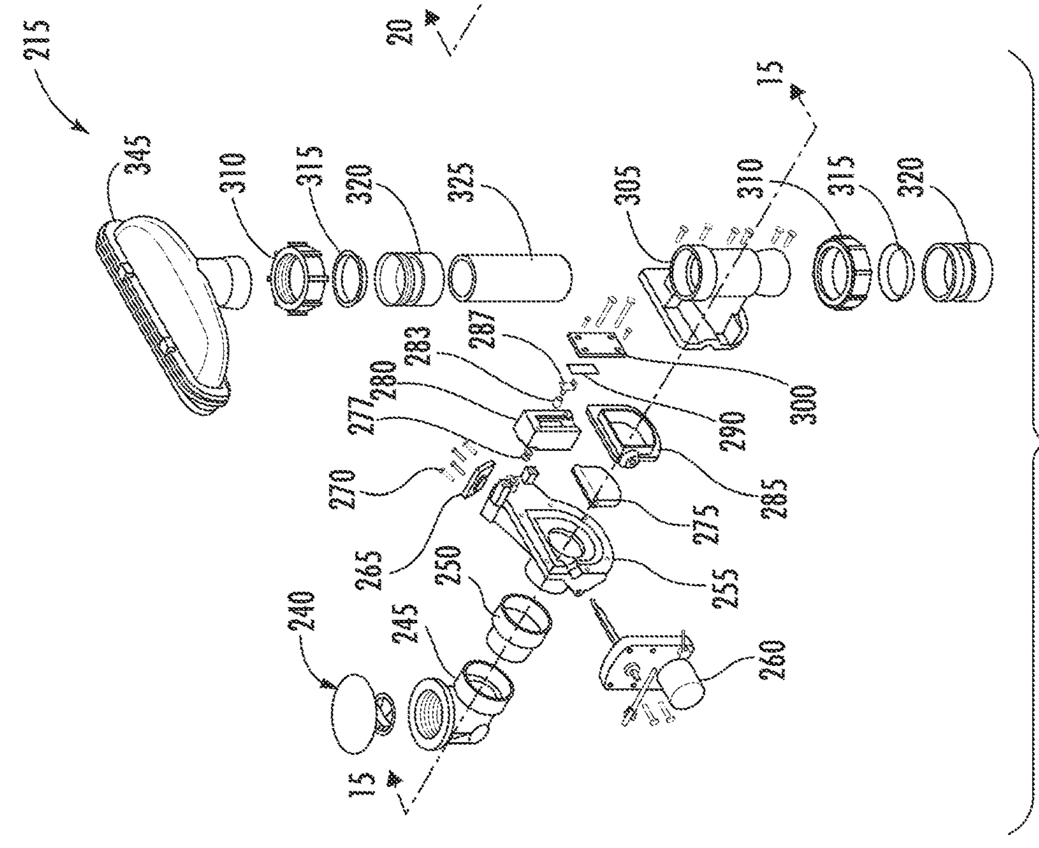
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FIG. 6

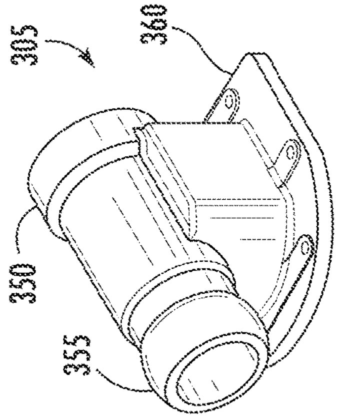


FIG. 8

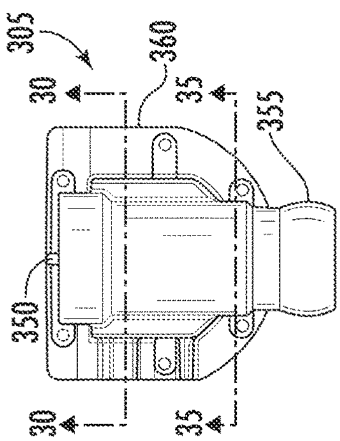
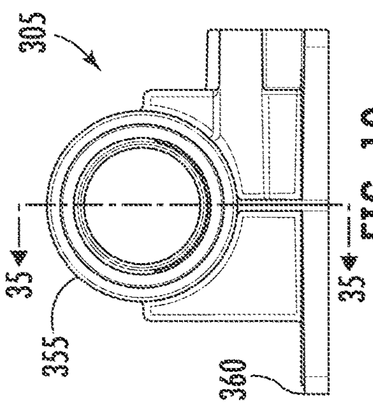


FIG. 9



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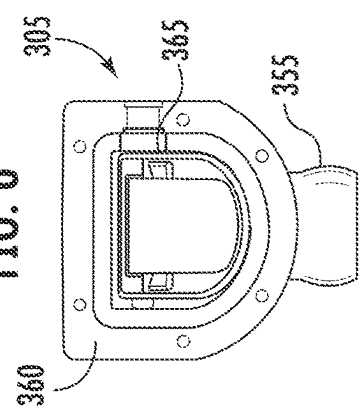

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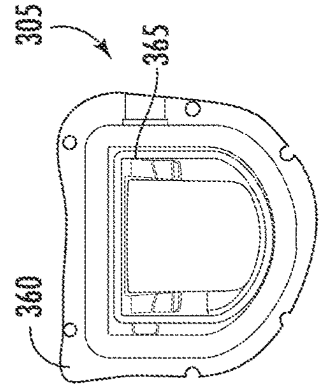

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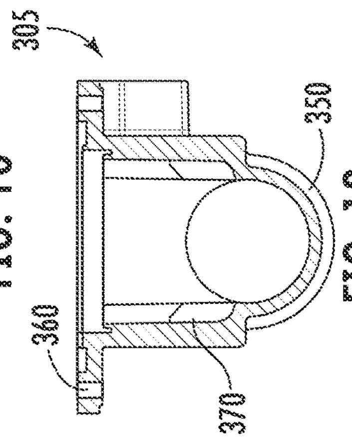
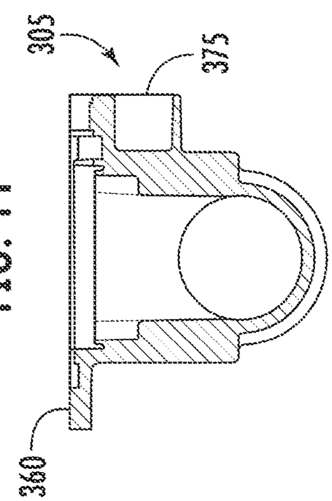


FIG. 13



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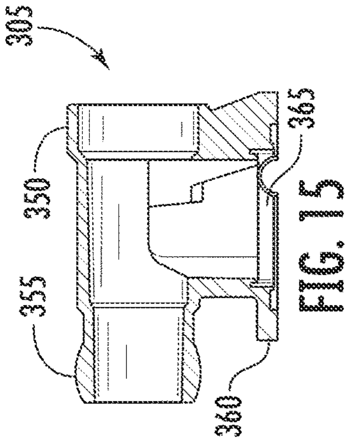

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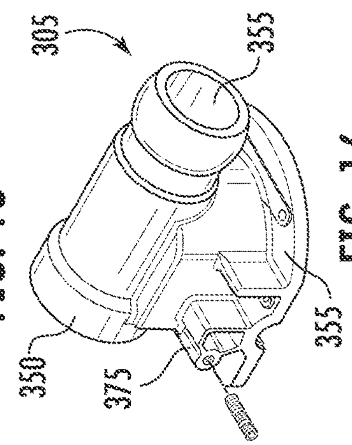

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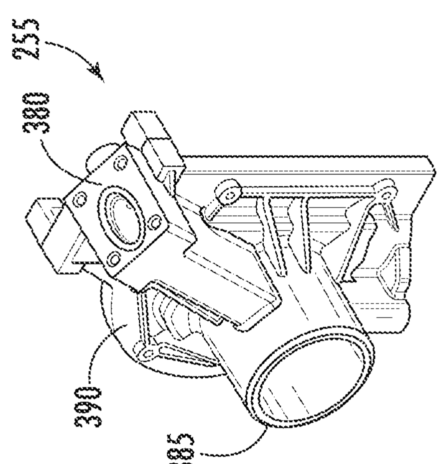

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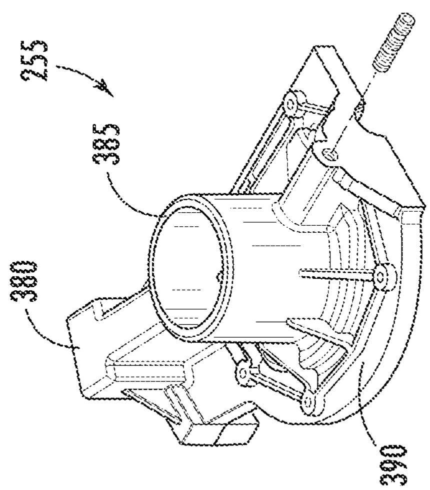


FIG. 18

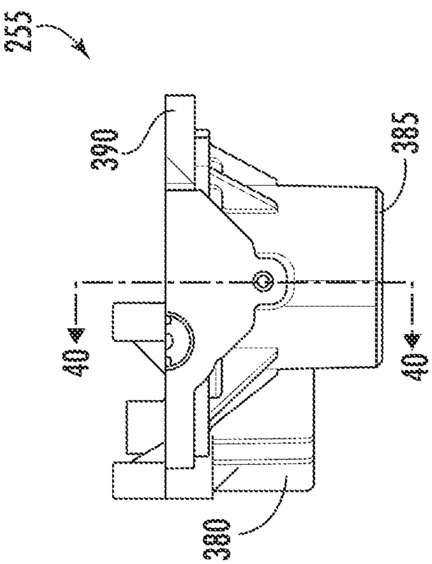


FIG. 19

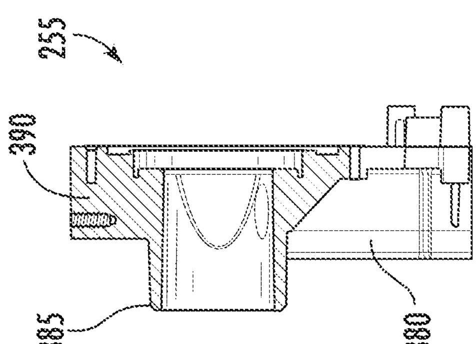
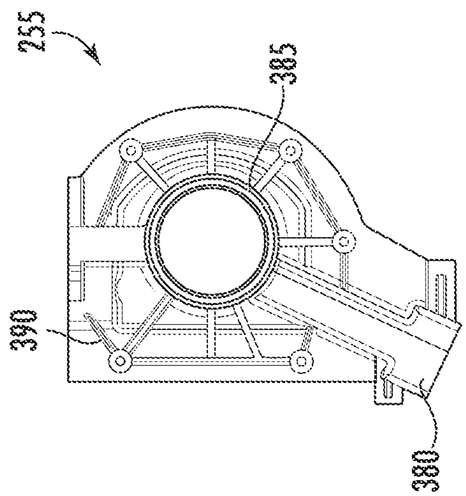


FIG. 20



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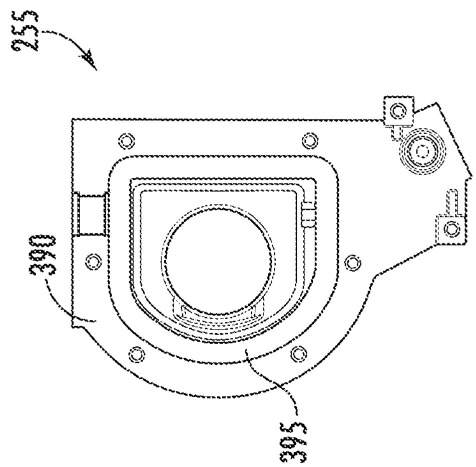


FIG. 22

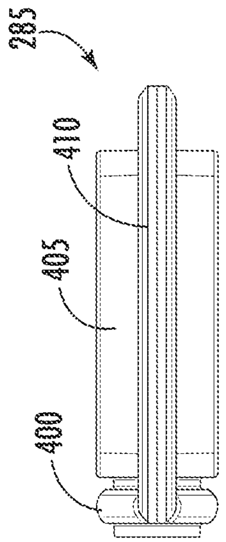


FIG. 25

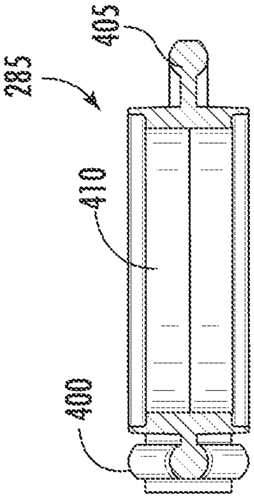


FIG. 28

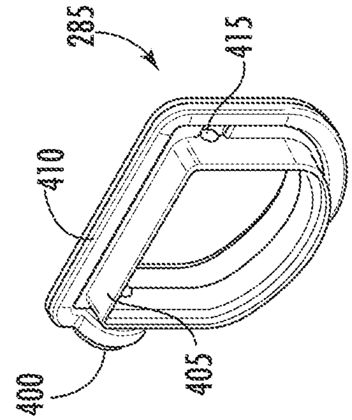


FIG. 29

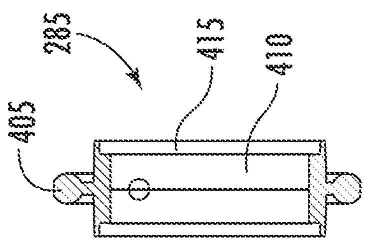
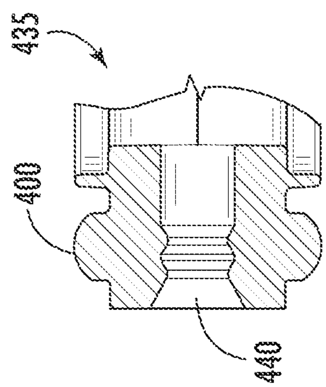


FIG. 24



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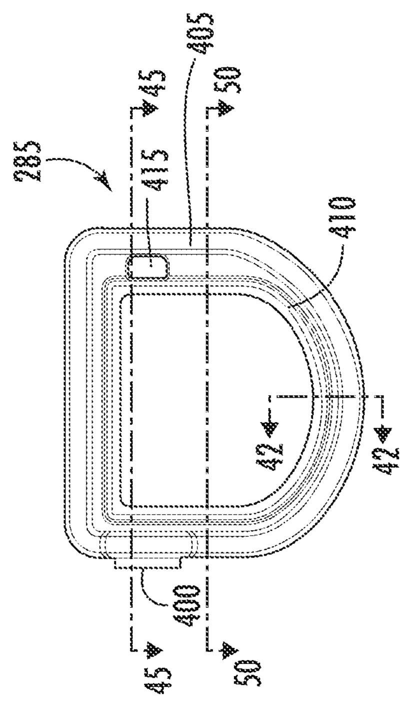


FIG. 23

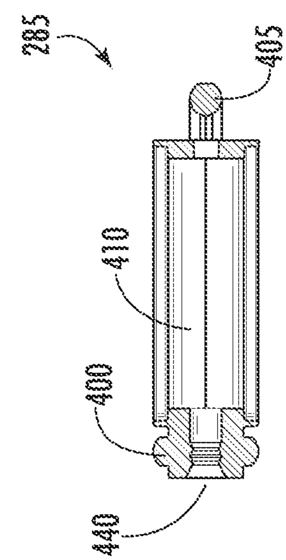
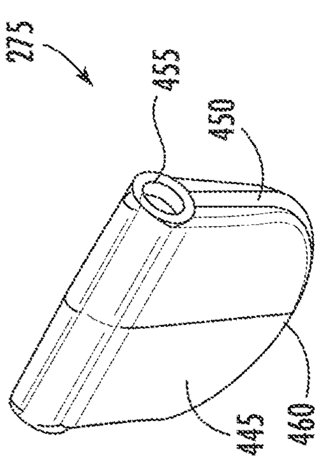


FIG. 26



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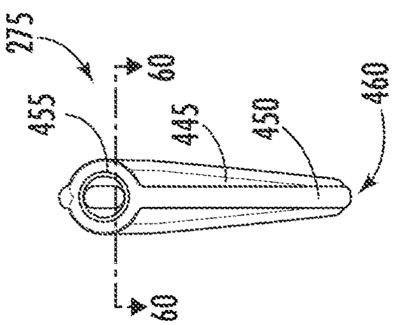

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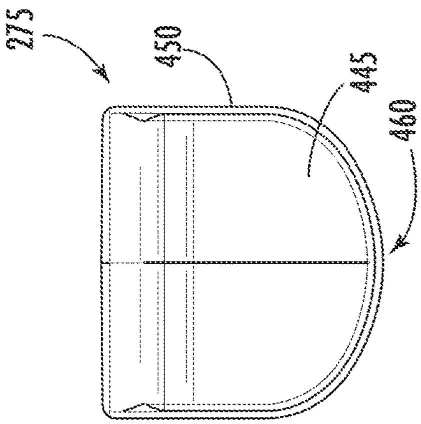

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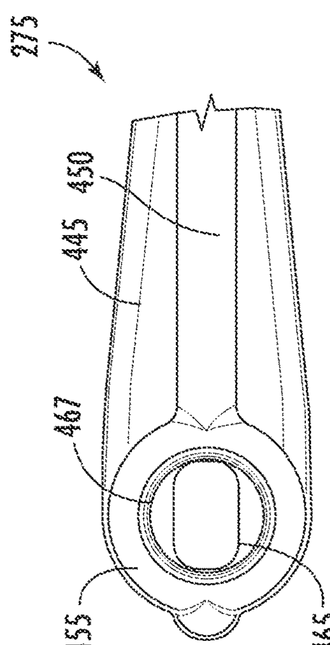


FIG. 33

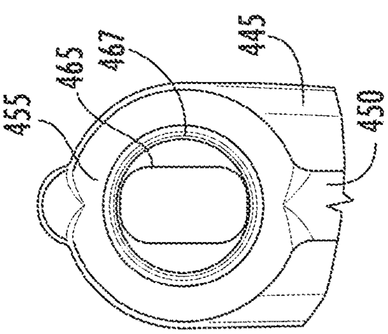
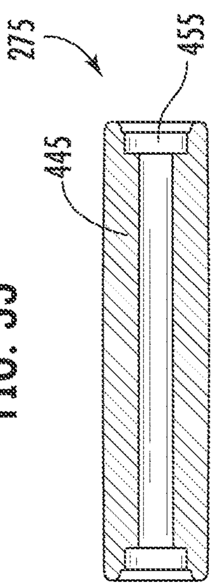


FIG. 34



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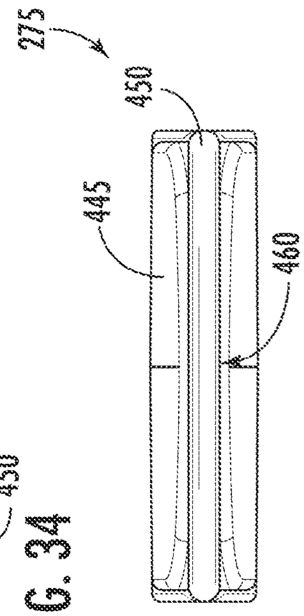

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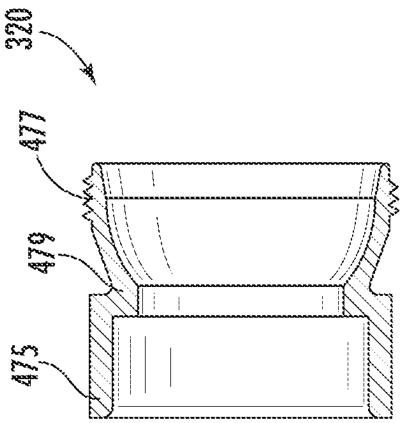

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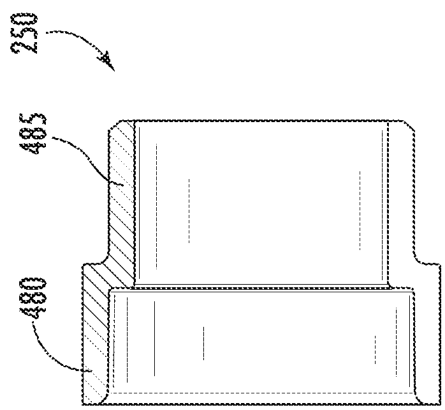


FIG. 42

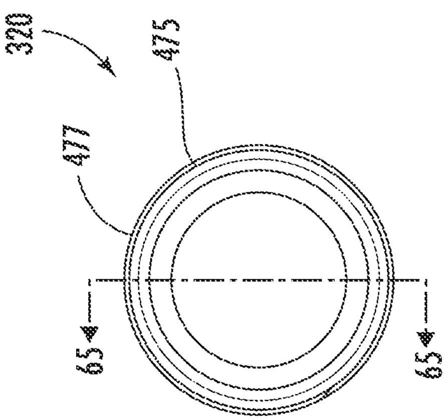
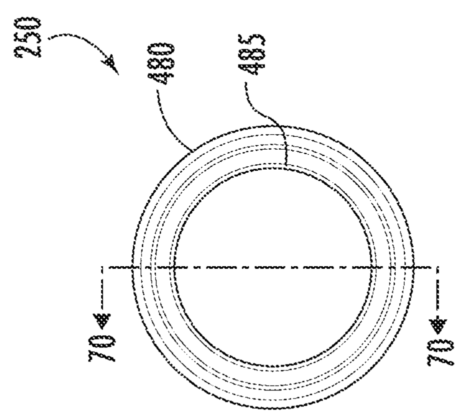


FIG. 38



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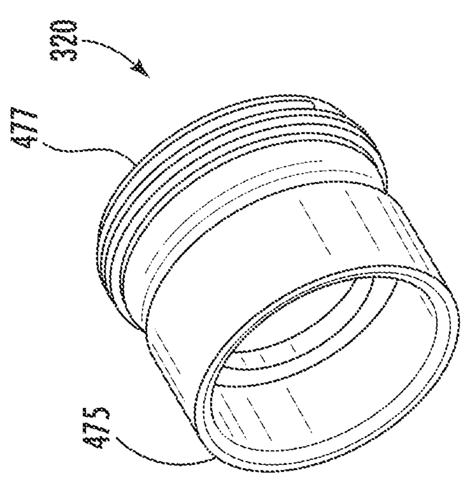

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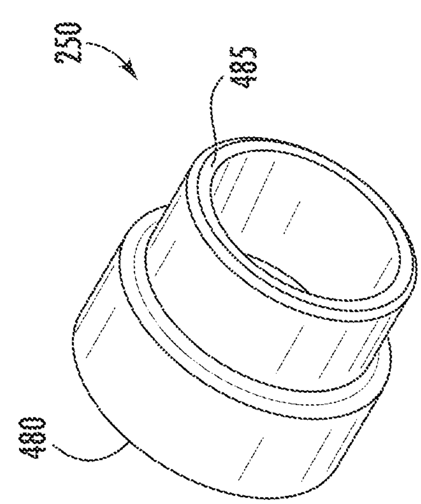

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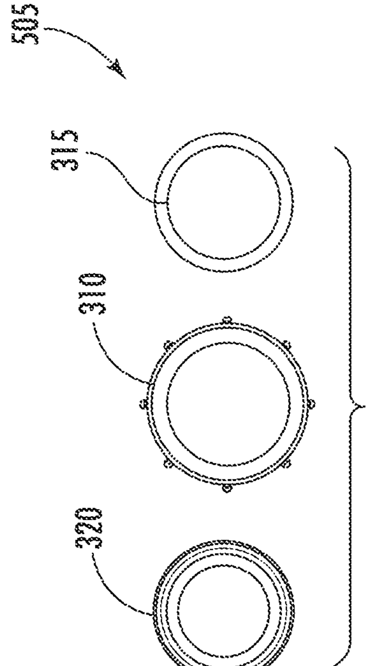


FIG. 44

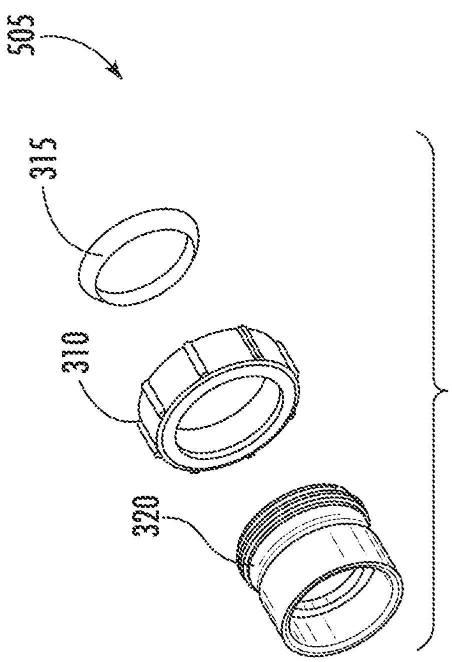
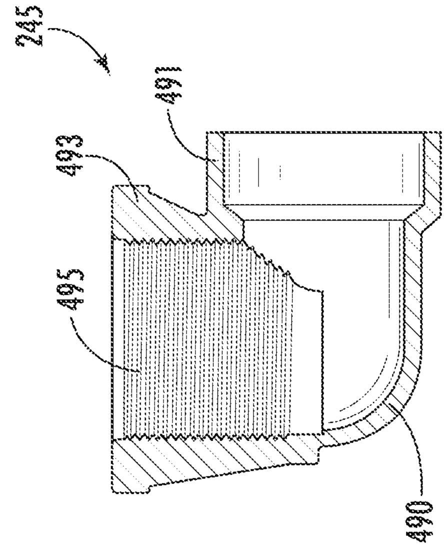


FIG. 43



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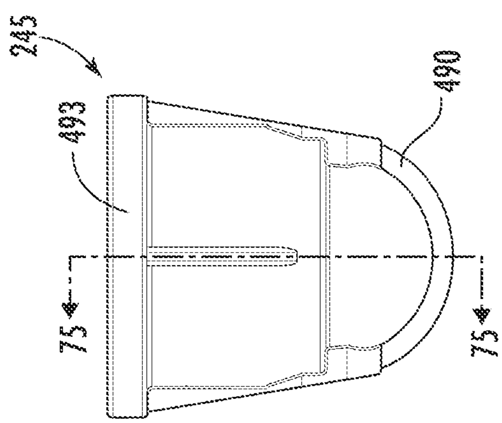


FIG. 46

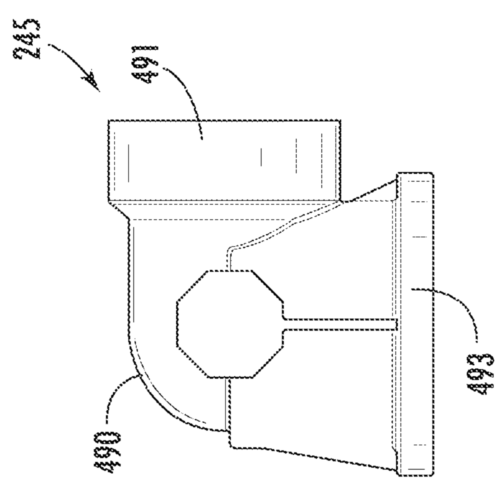


FIG. 45

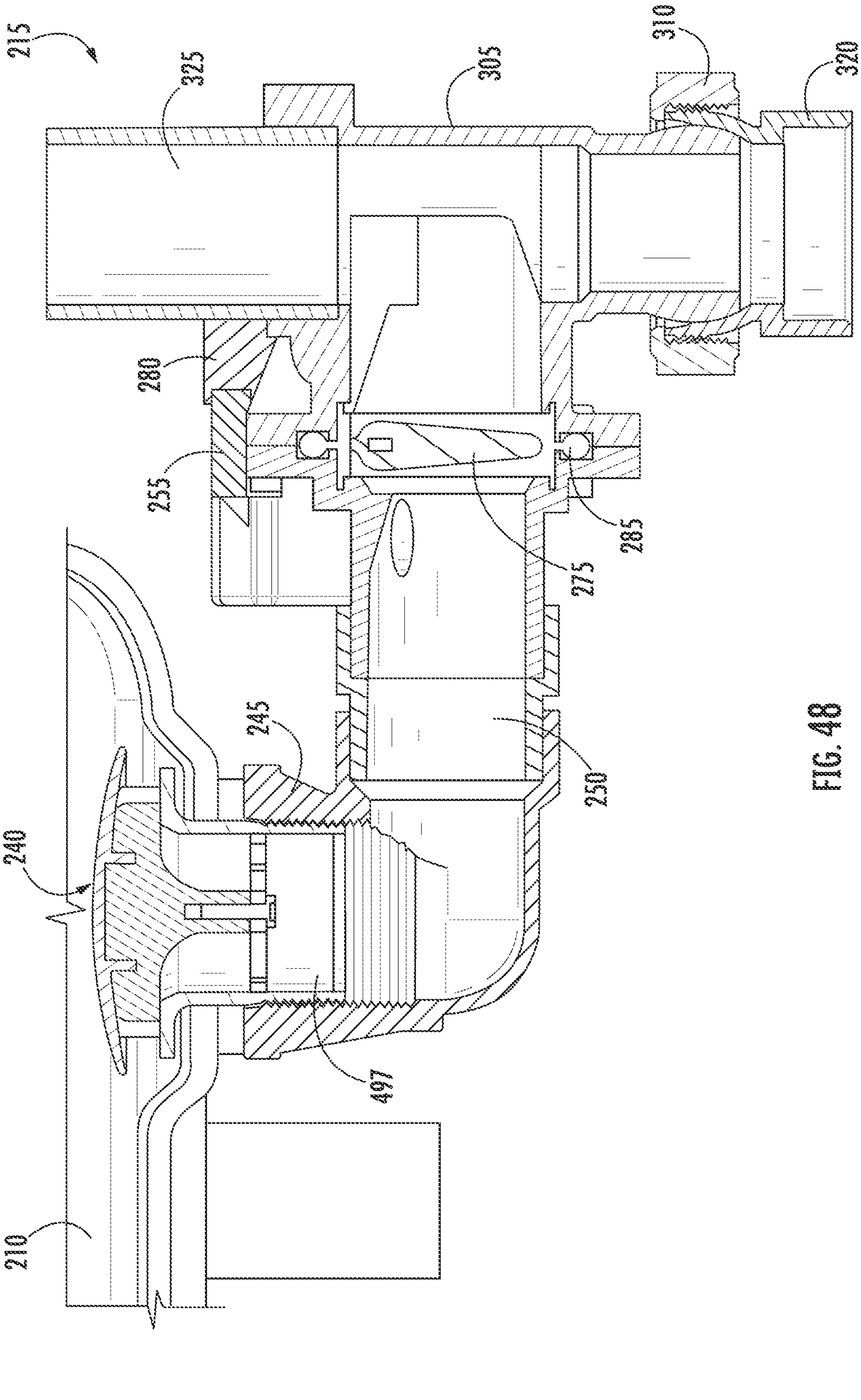


FIG. 48

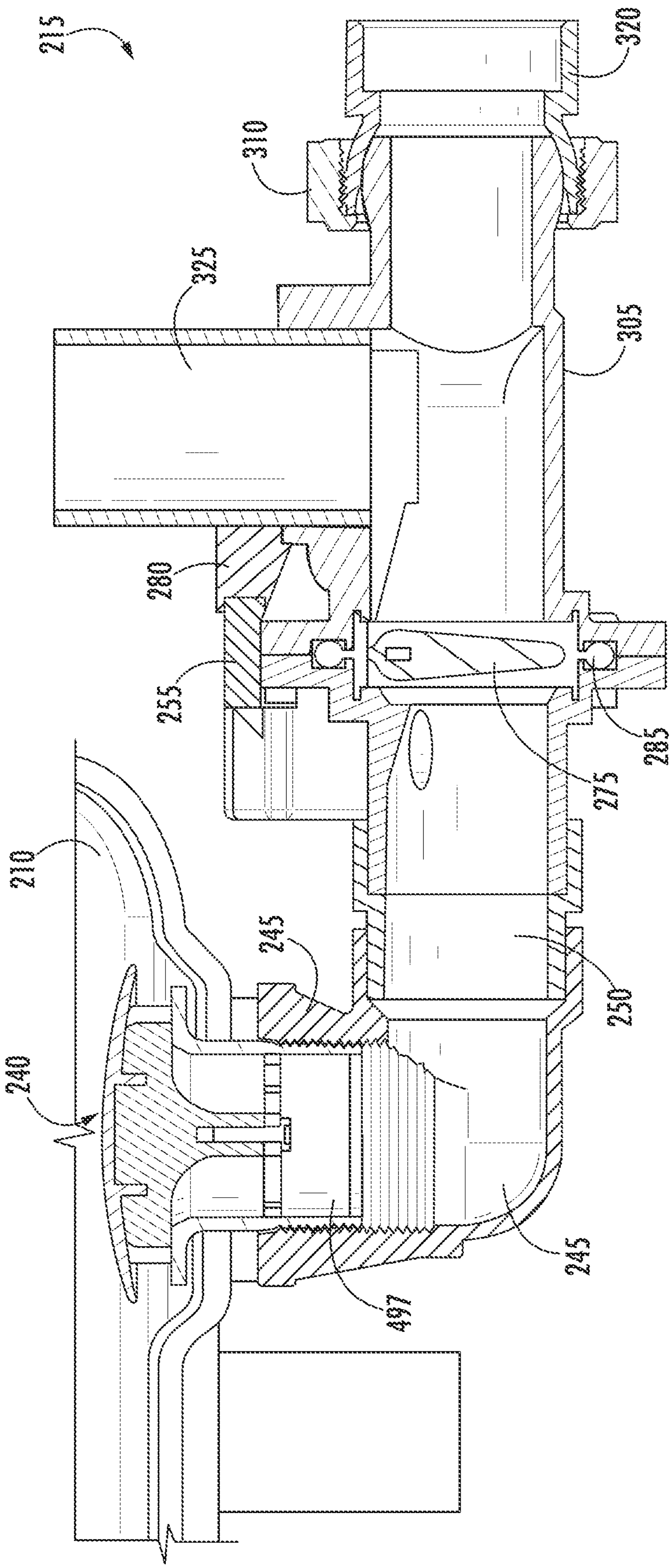


FIG. 49

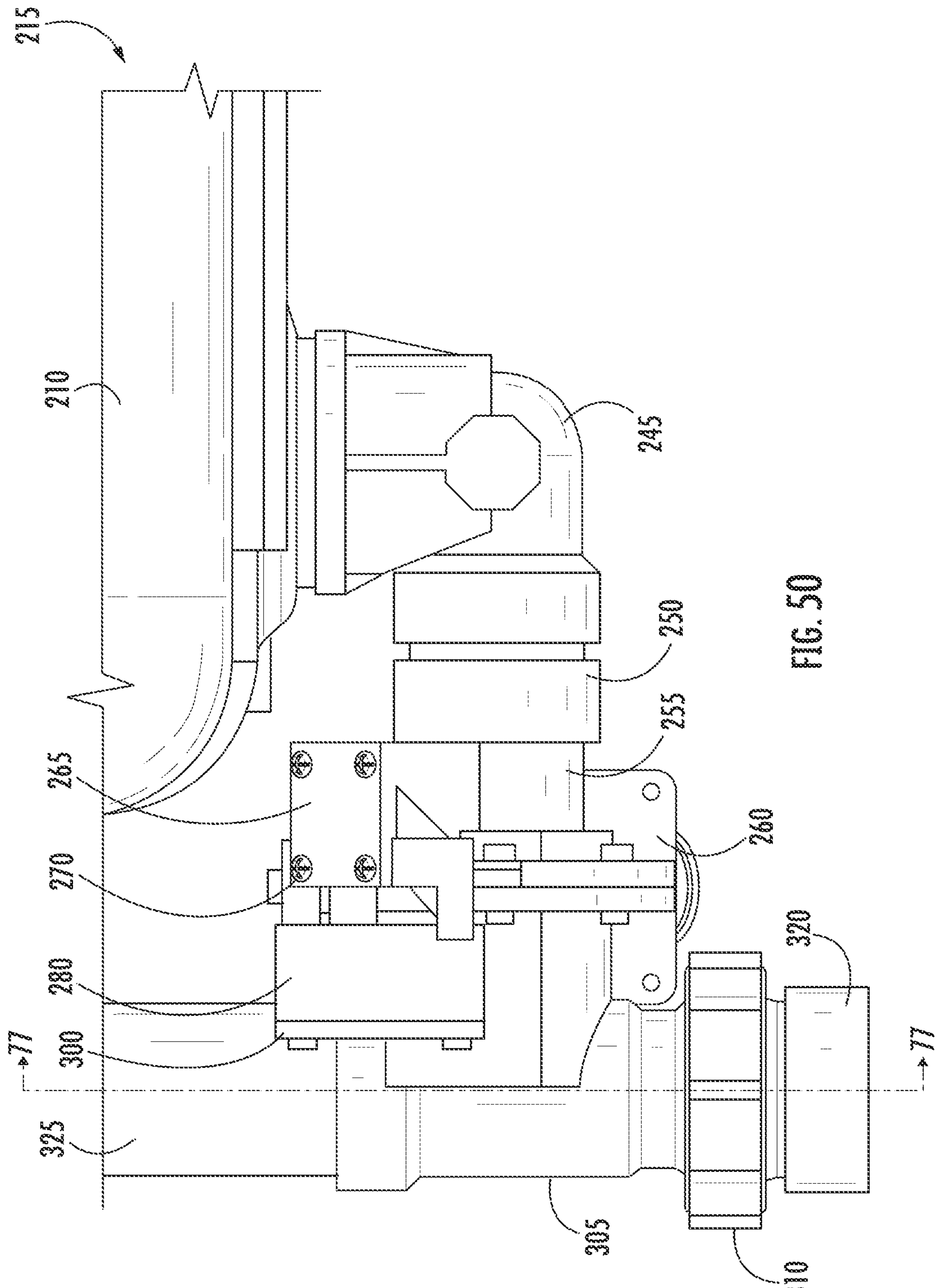


FIG. 50

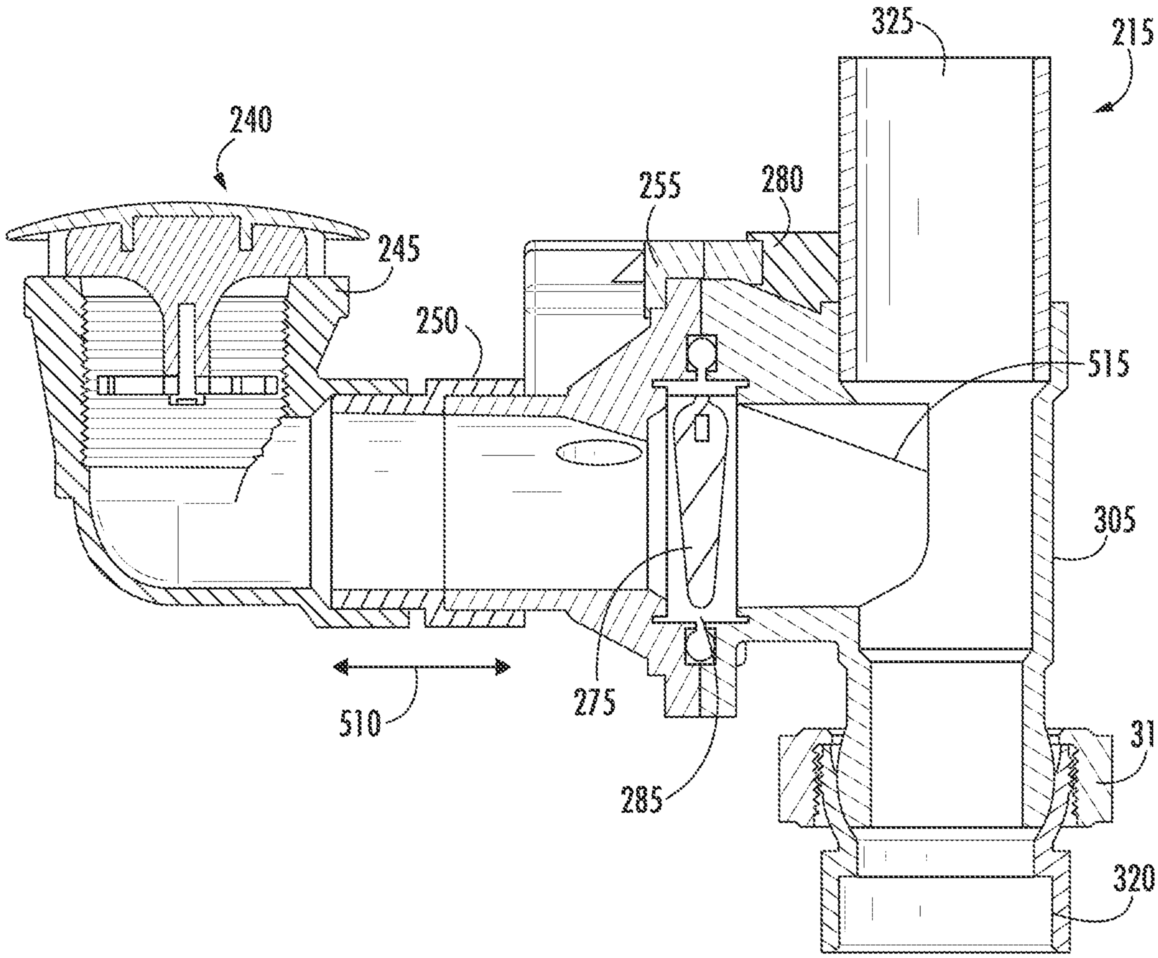


FIG. 51

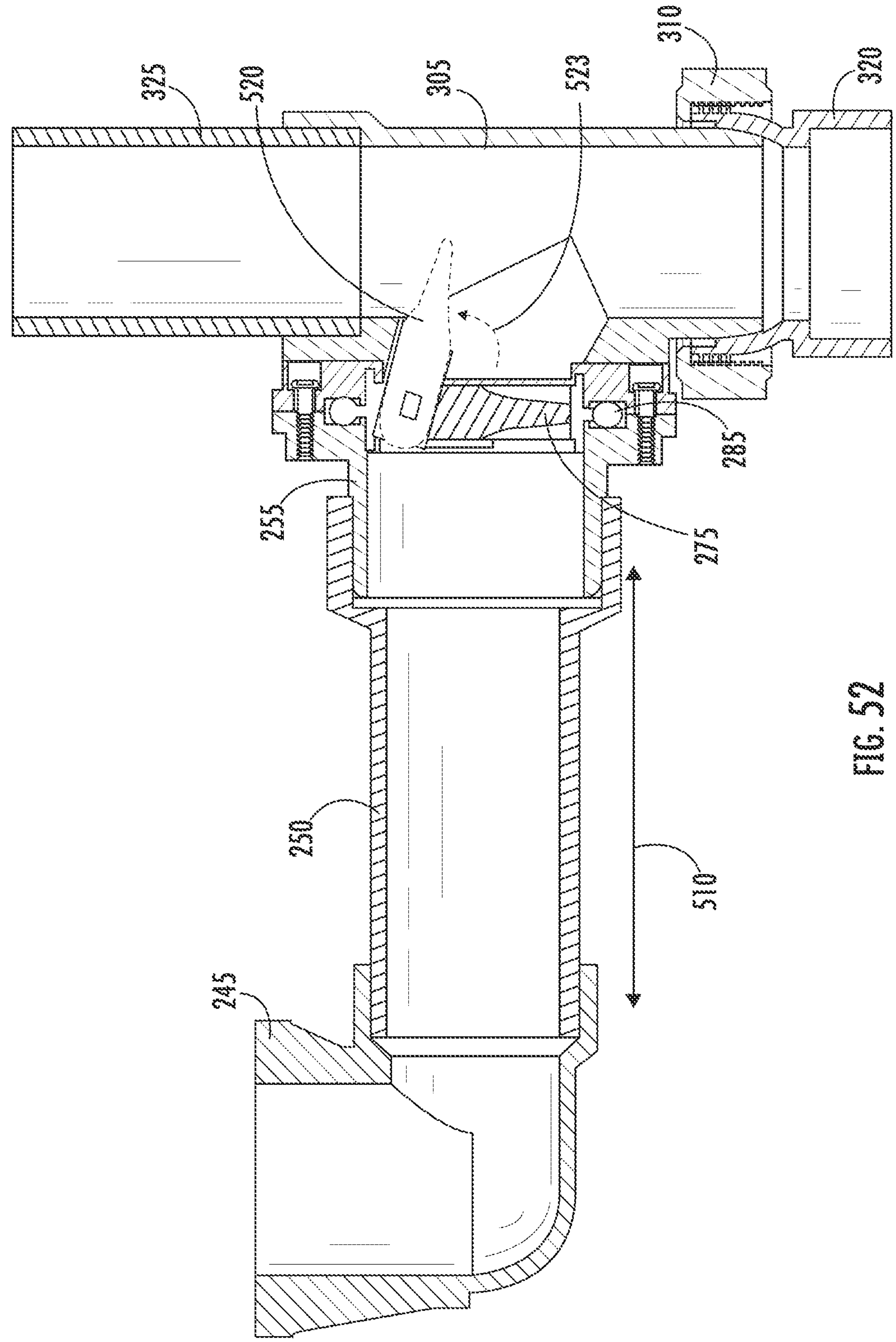


FIG. 52

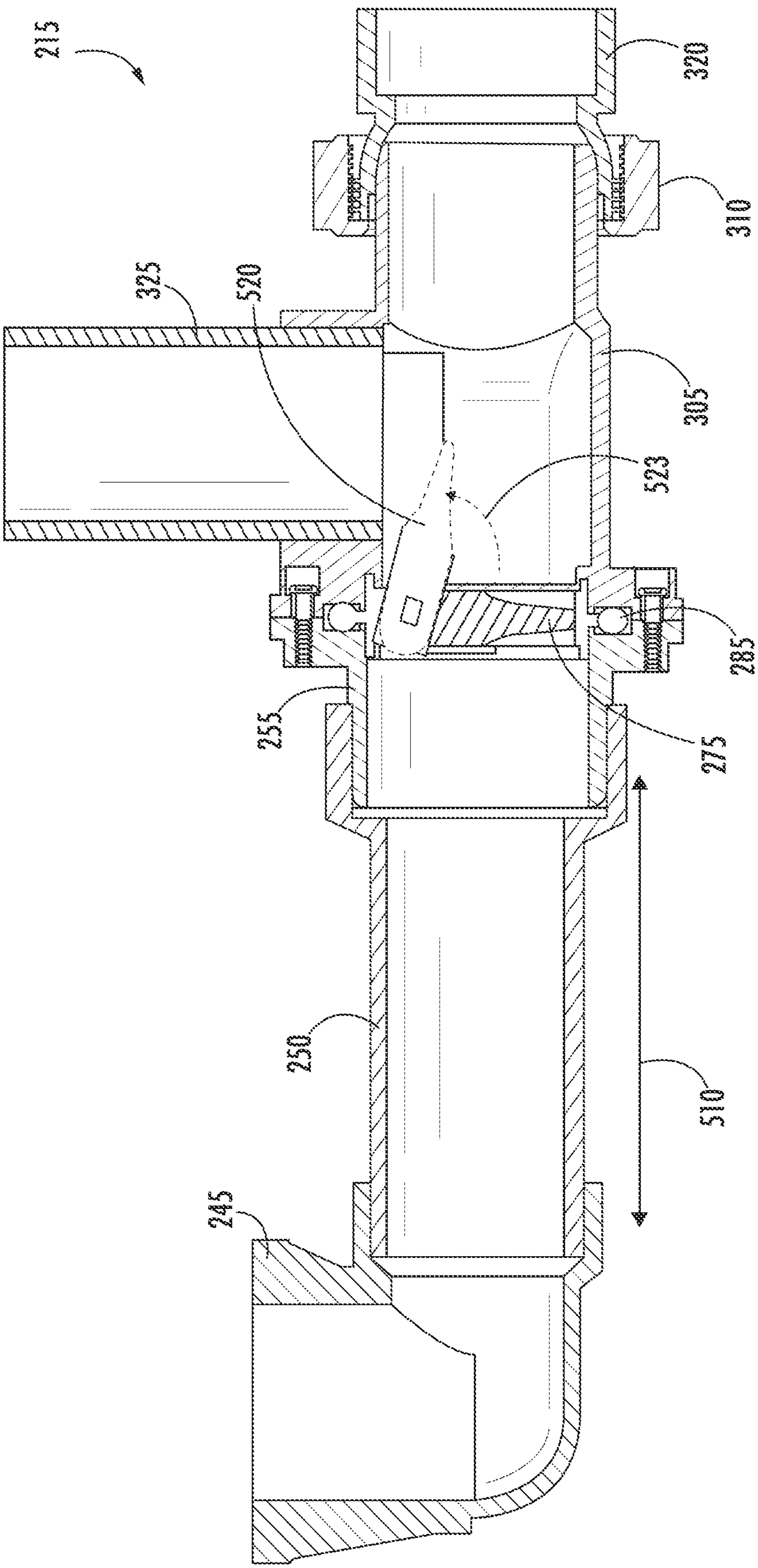


FIG. 53

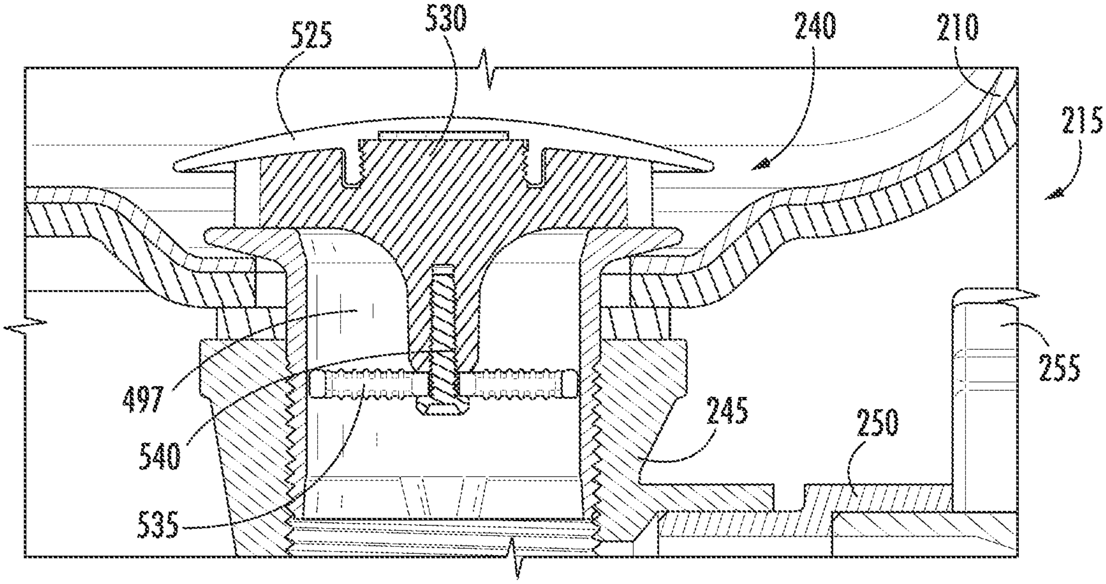


FIG. 54

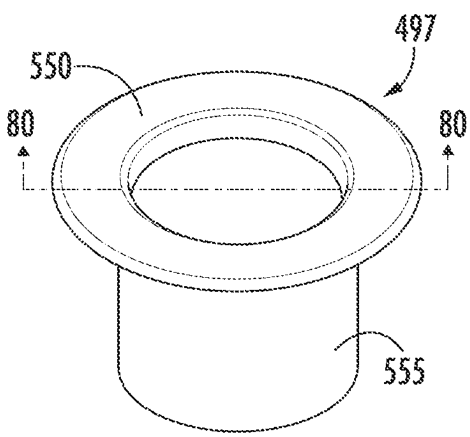


FIG. 55

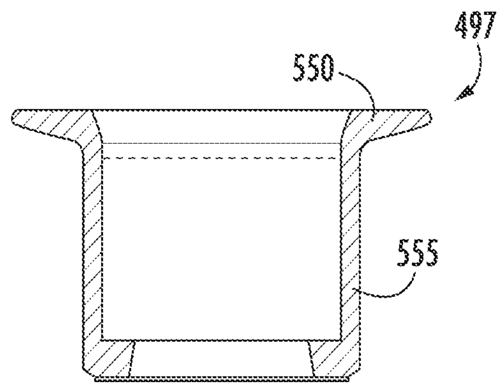


FIG. 56

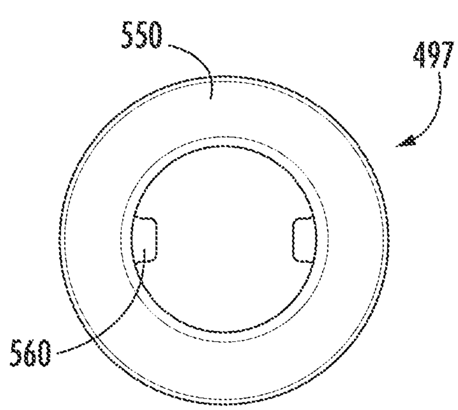


FIG. 57

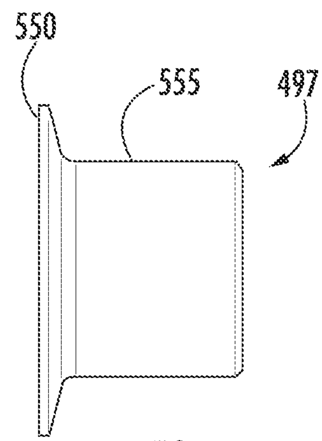


FIG. 58

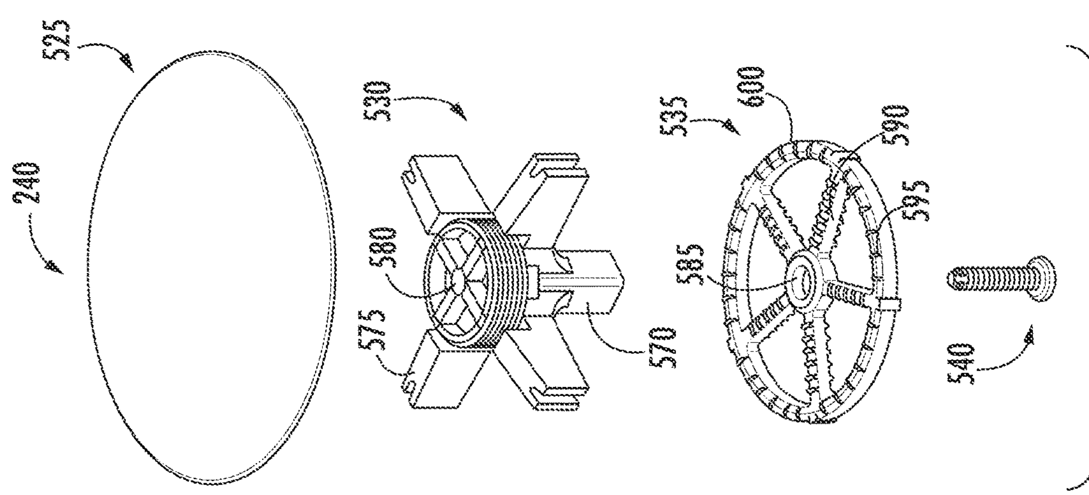


FIG. 59

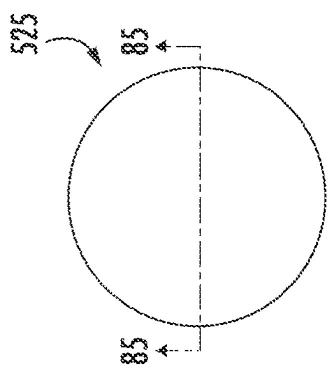


FIG. 60

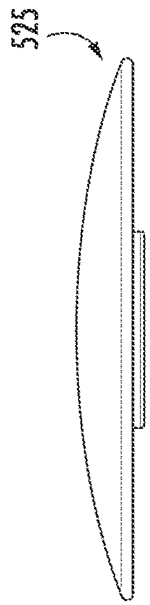


FIG. 61

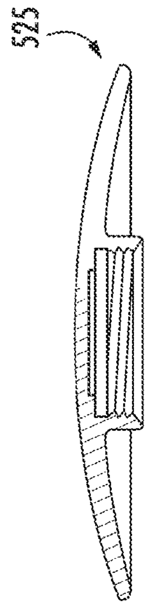


FIG. 62

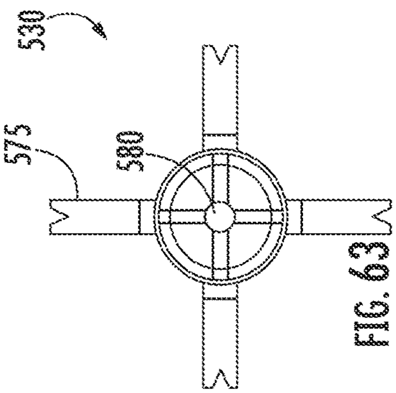


FIG. 63

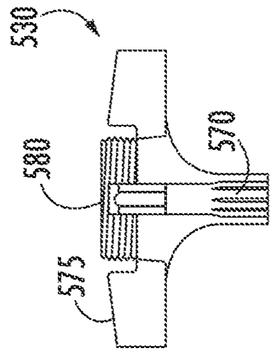


FIG. 64

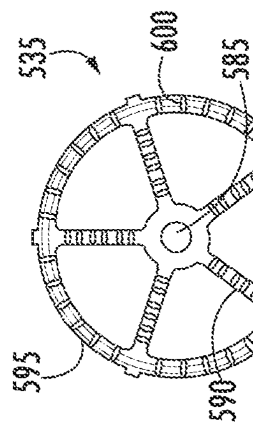


FIG. 65

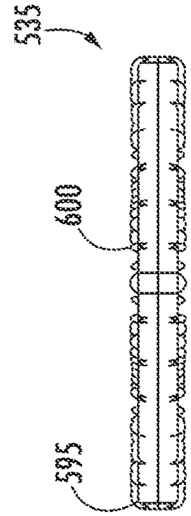


FIG. 66

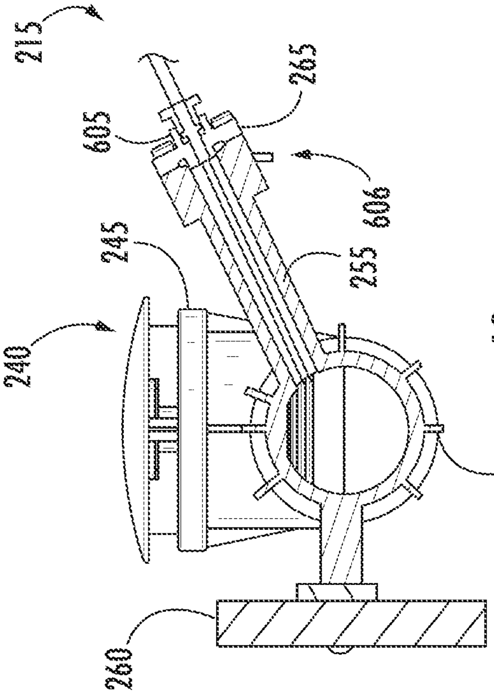


FIG. 68

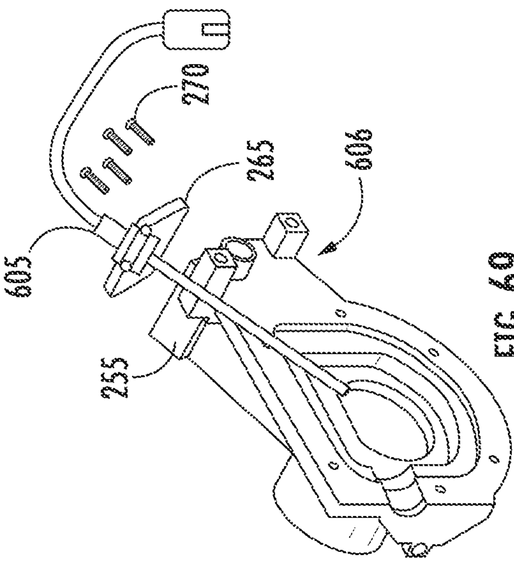


FIG. 69

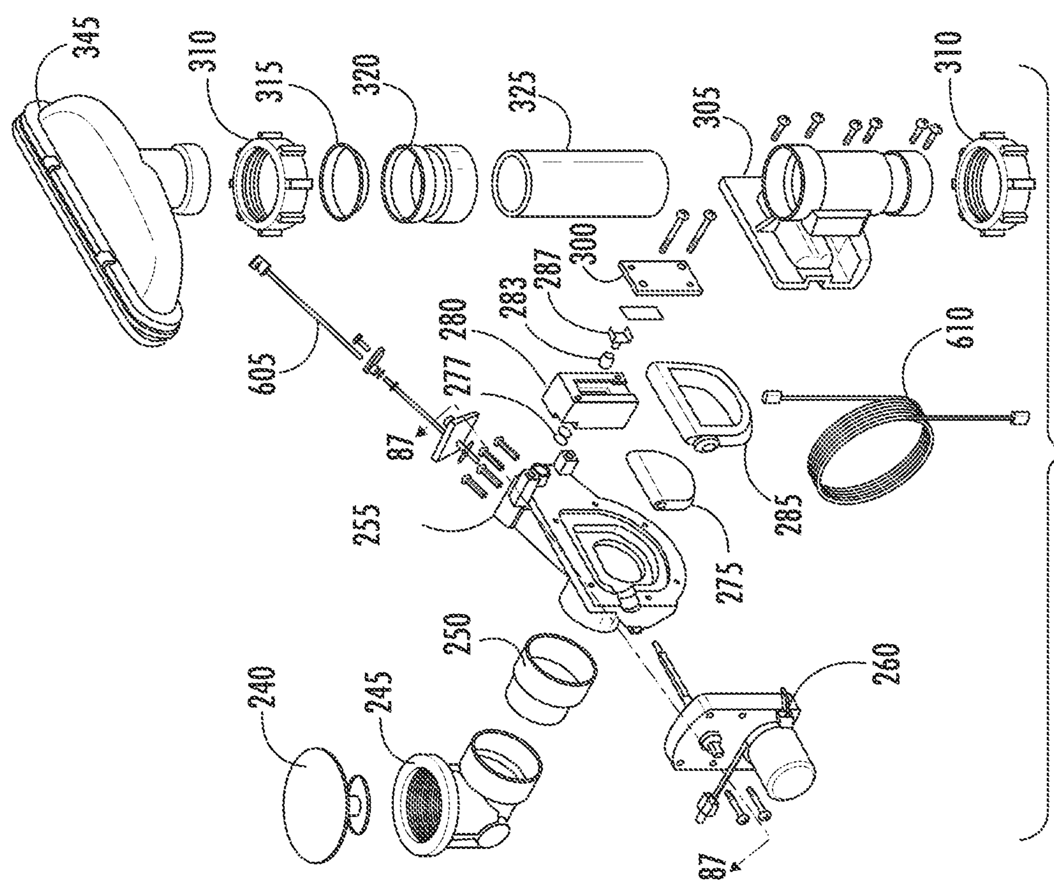


FIG. 67

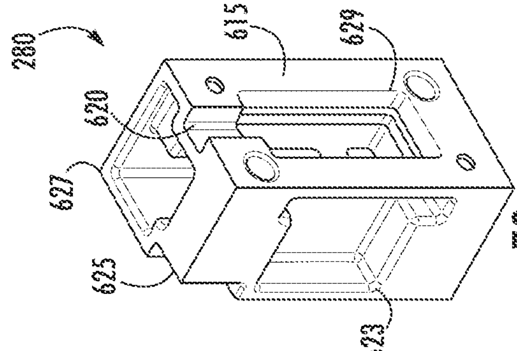


FIG. 70

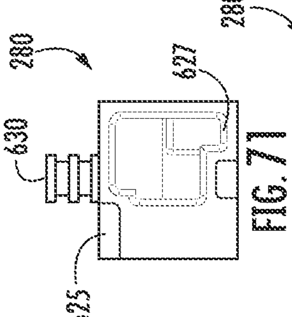


FIG. 71

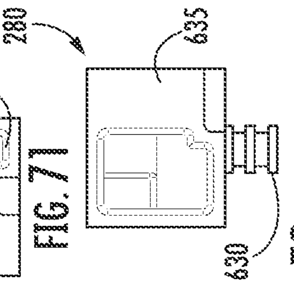


FIG. 72

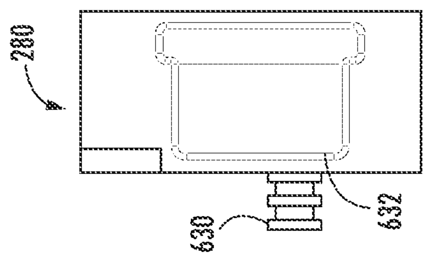


FIG. 73

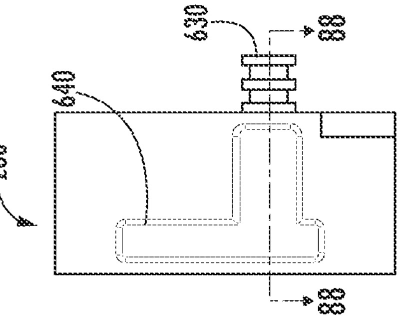


FIG. 74

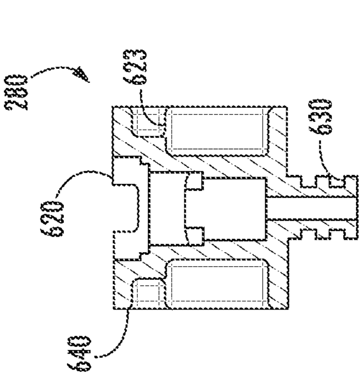


FIG. 75

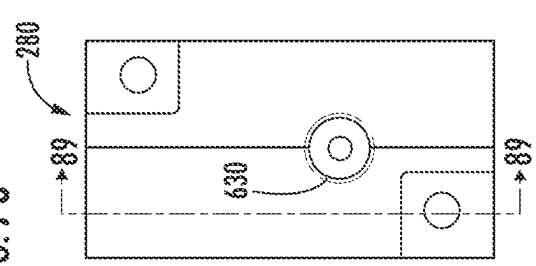


FIG. 76

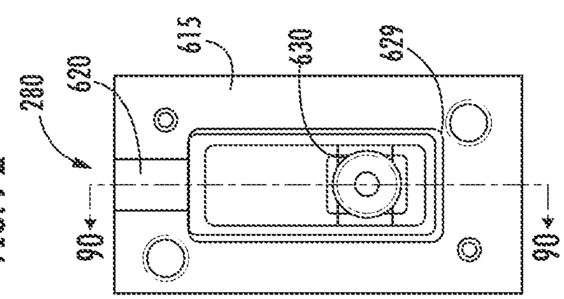


FIG. 77

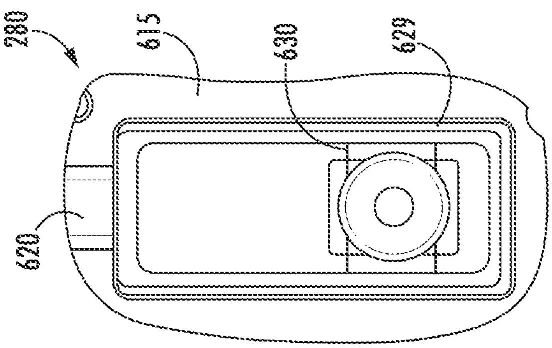


FIG. 78

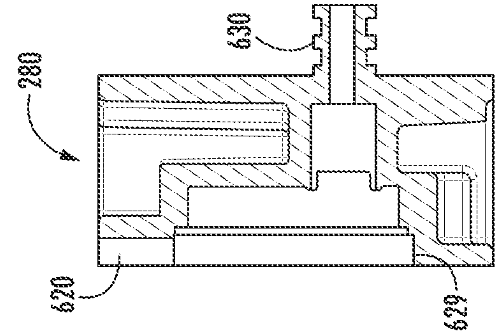


FIG. 79

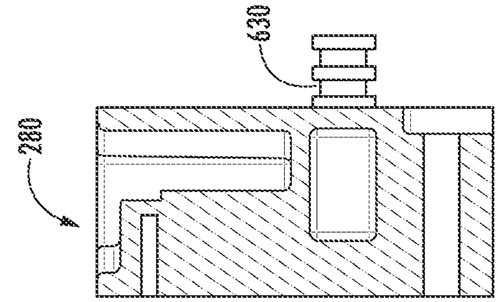


FIG. 80

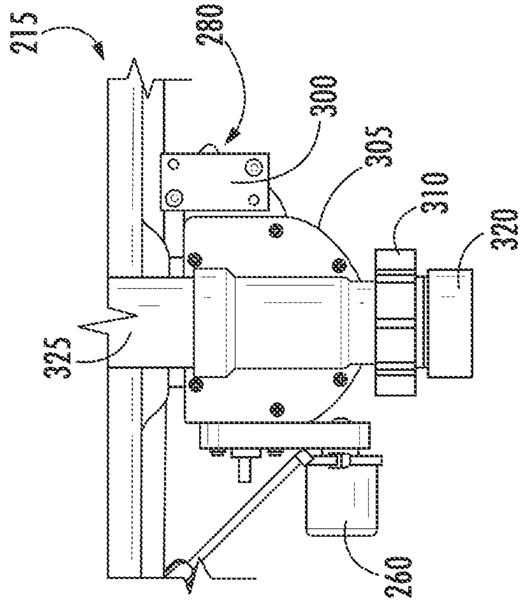


FIG. 82

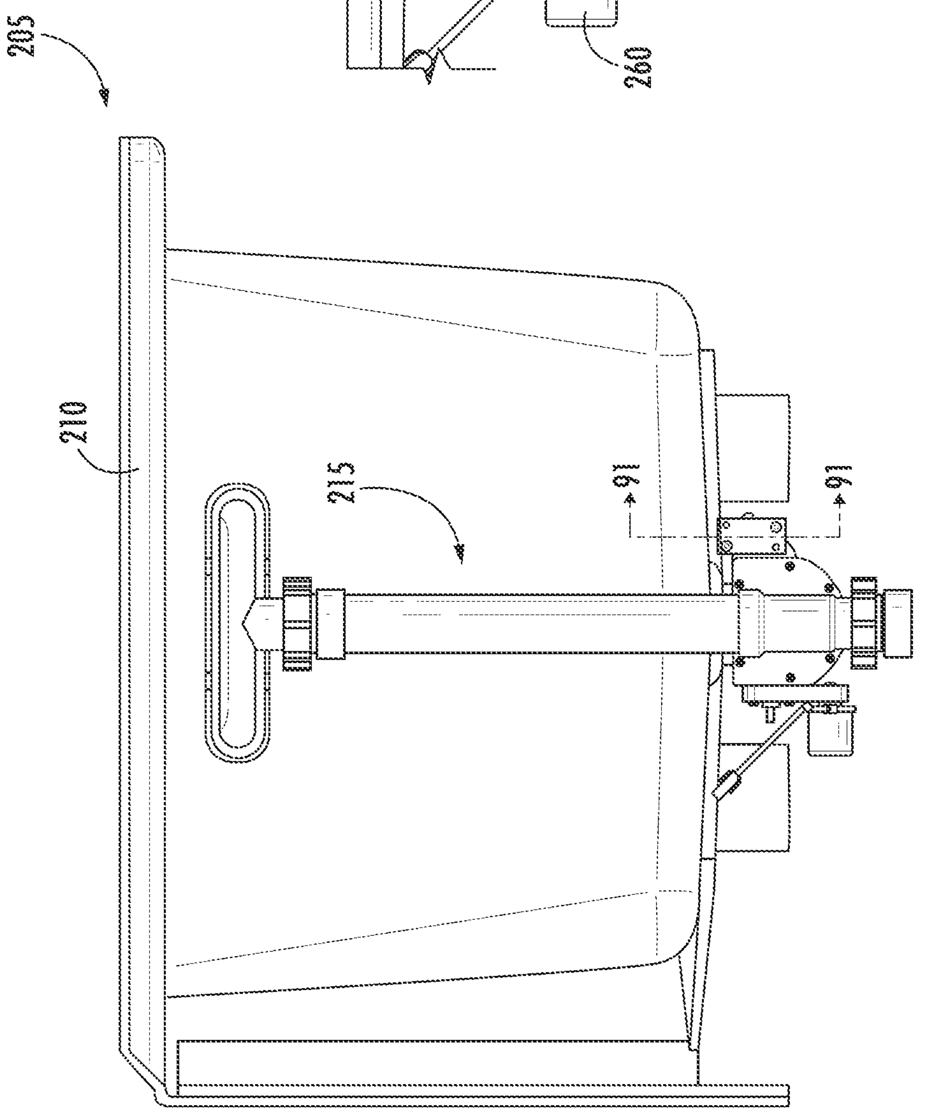


FIG. 81

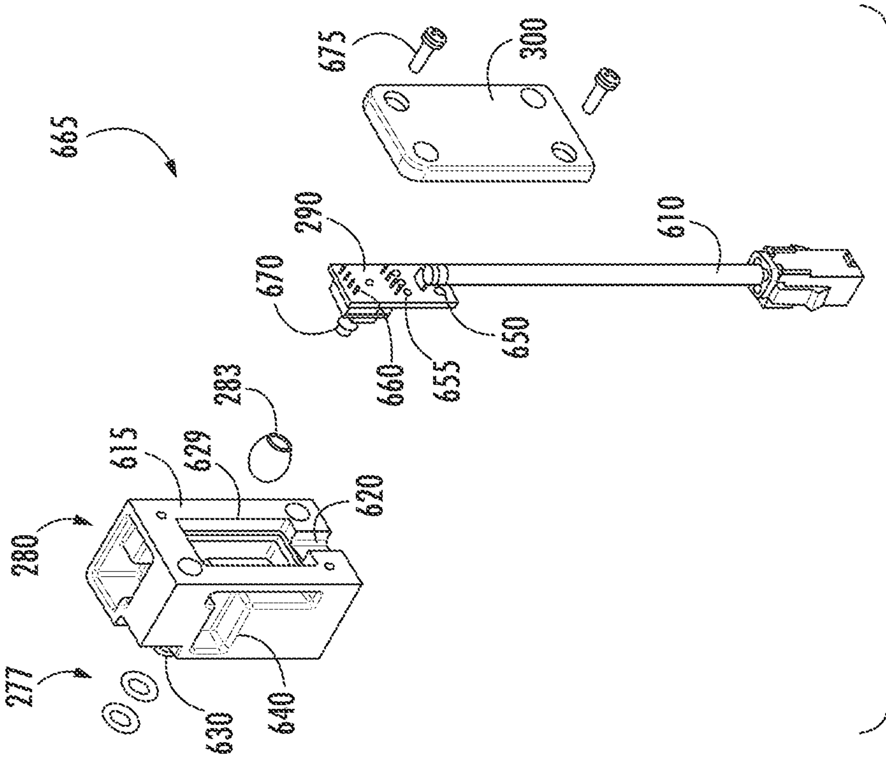


FIG. 85

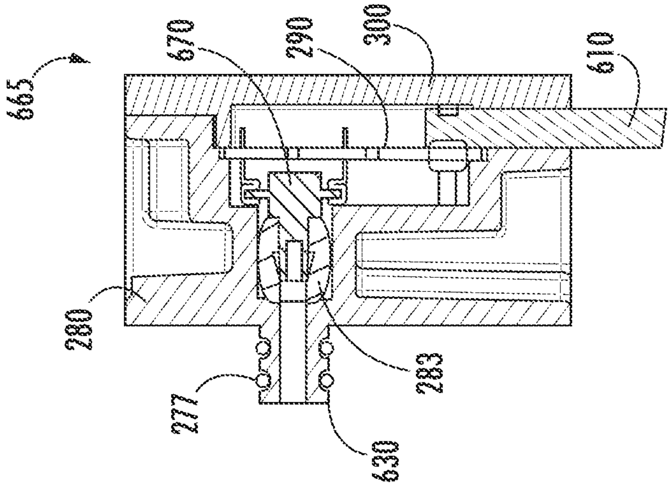


FIG. 84

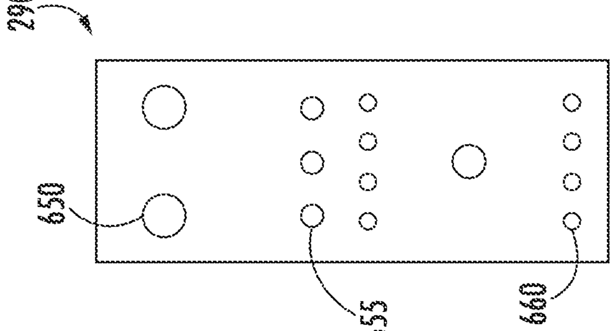


FIG. 83

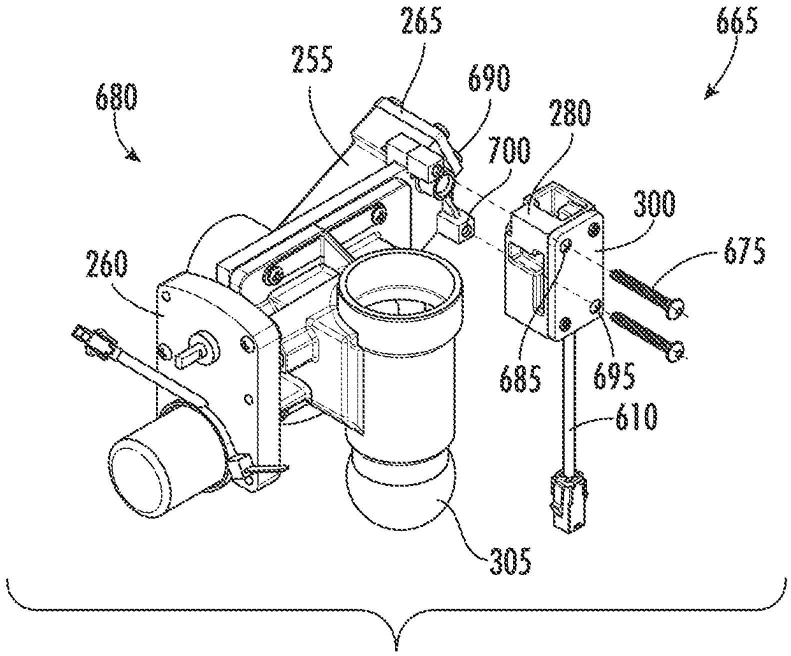


FIG. 86

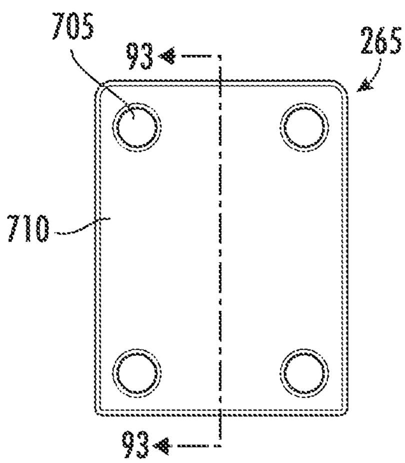


FIG. 87

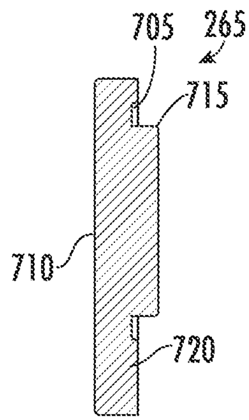


FIG. 88

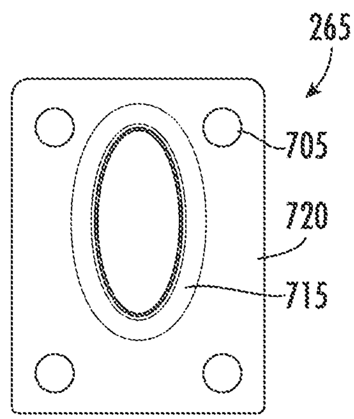


FIG. 89

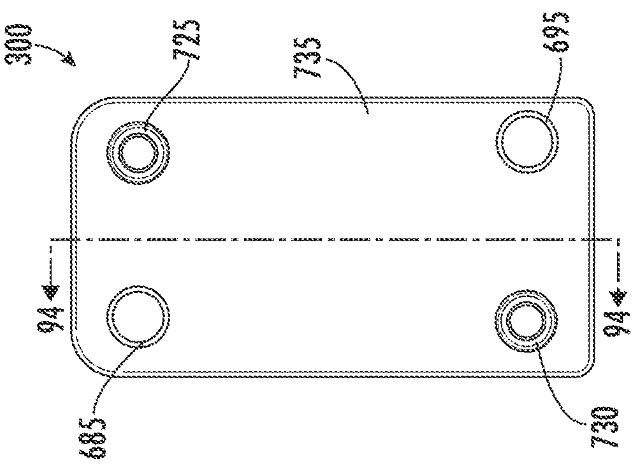


FIG. 90

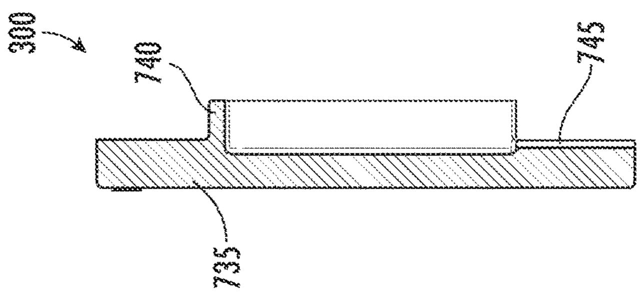


FIG. 91

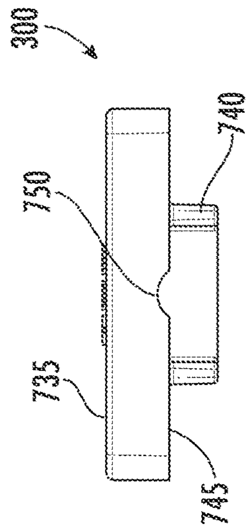


FIG. 92

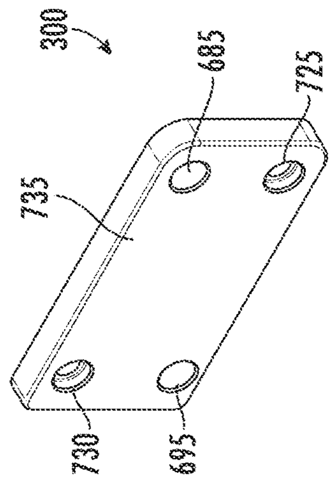


FIG. 93

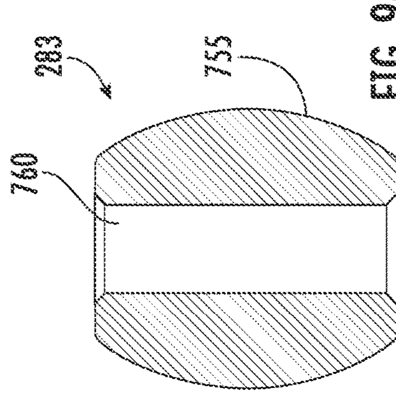


FIG. 94

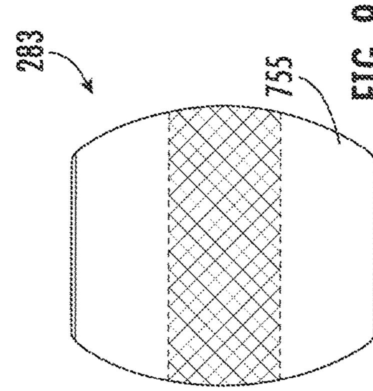
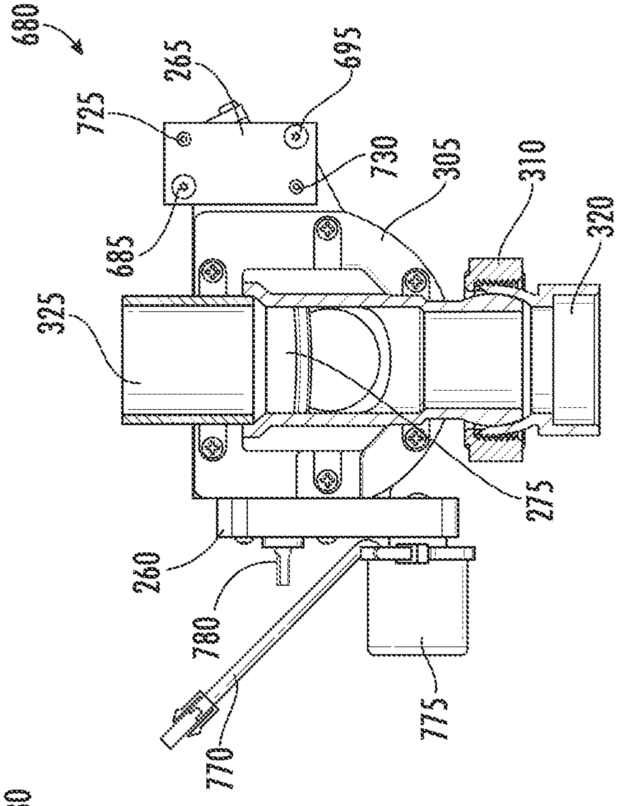


FIG. 95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695
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FIG. 97

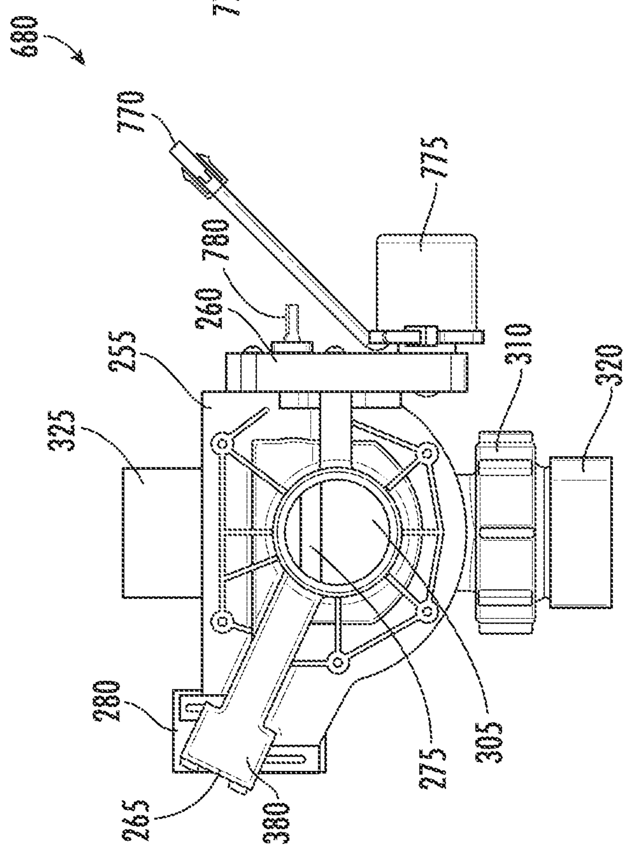
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FIG. 96

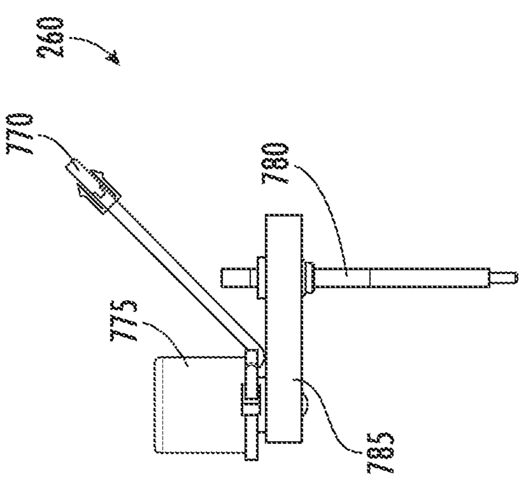

FIG. 98

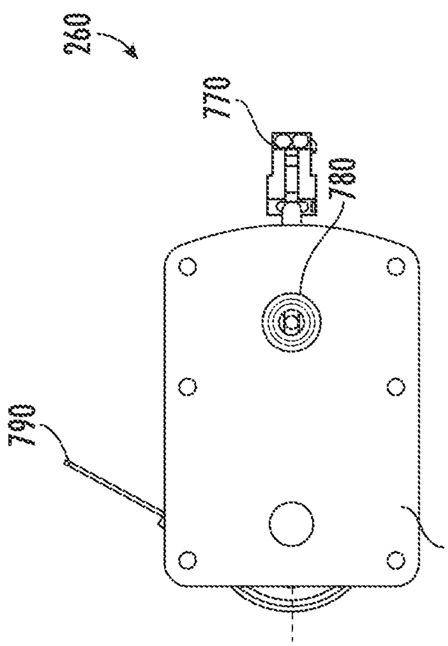

FIG. 99

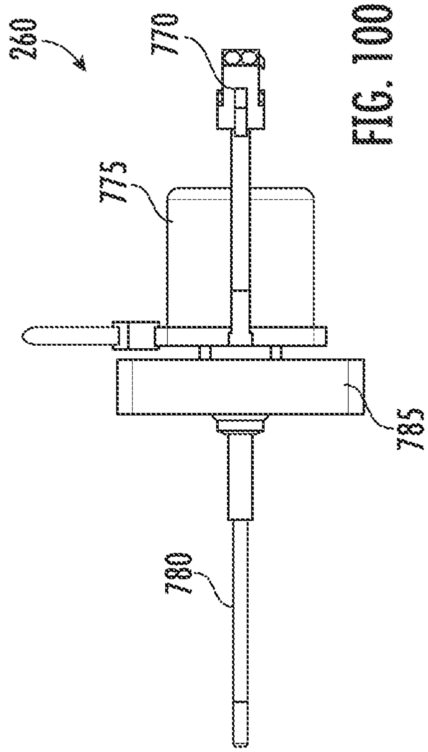

FIG. 100

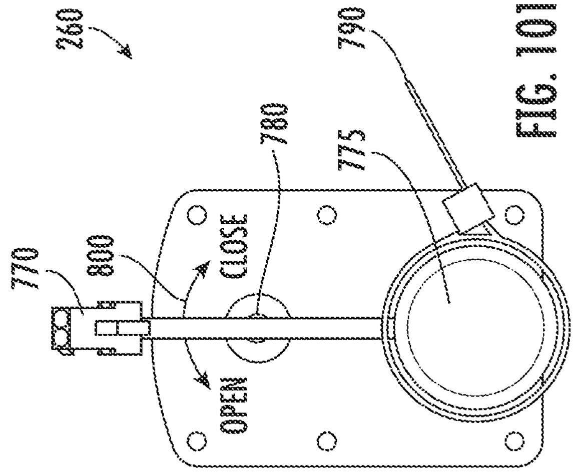

FIG. 101

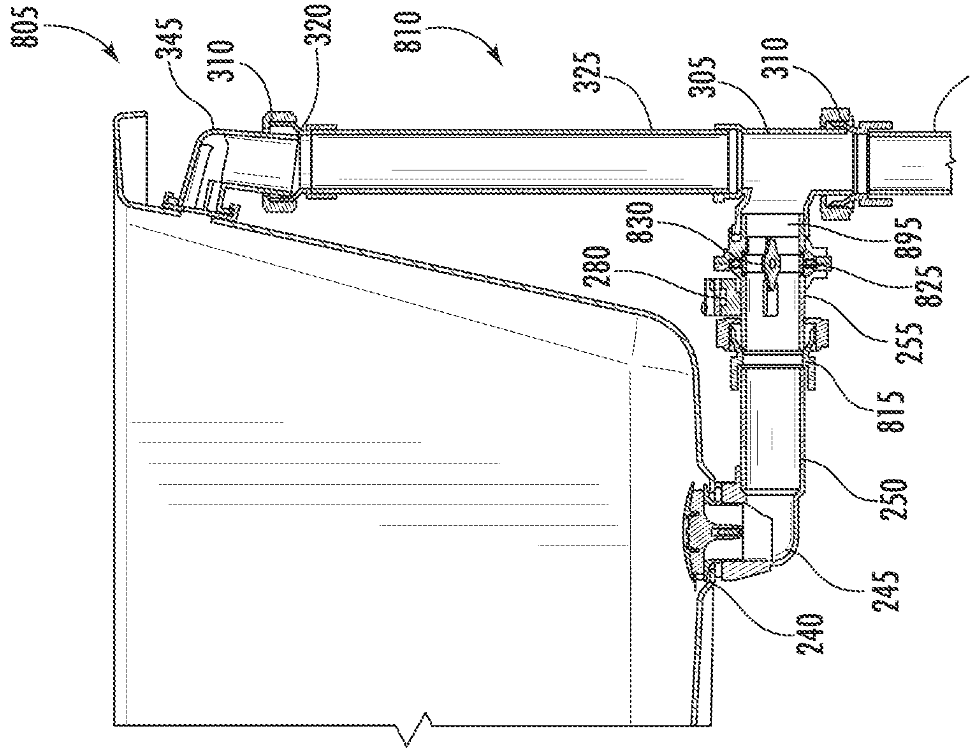

FIG. 103

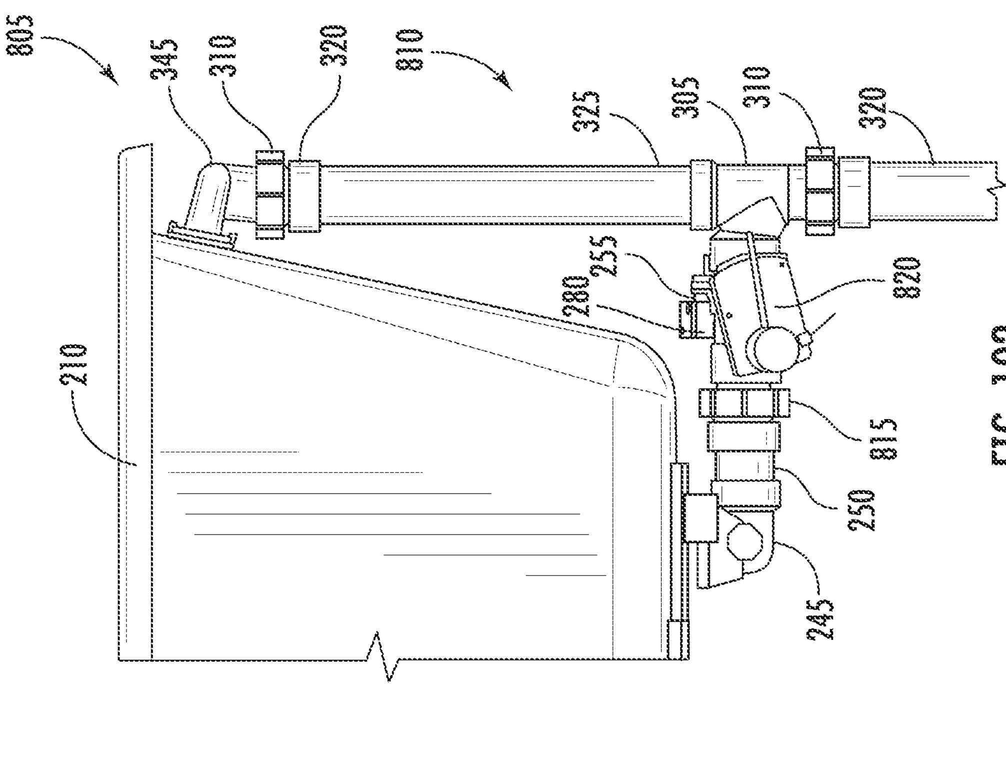

FIG. 102

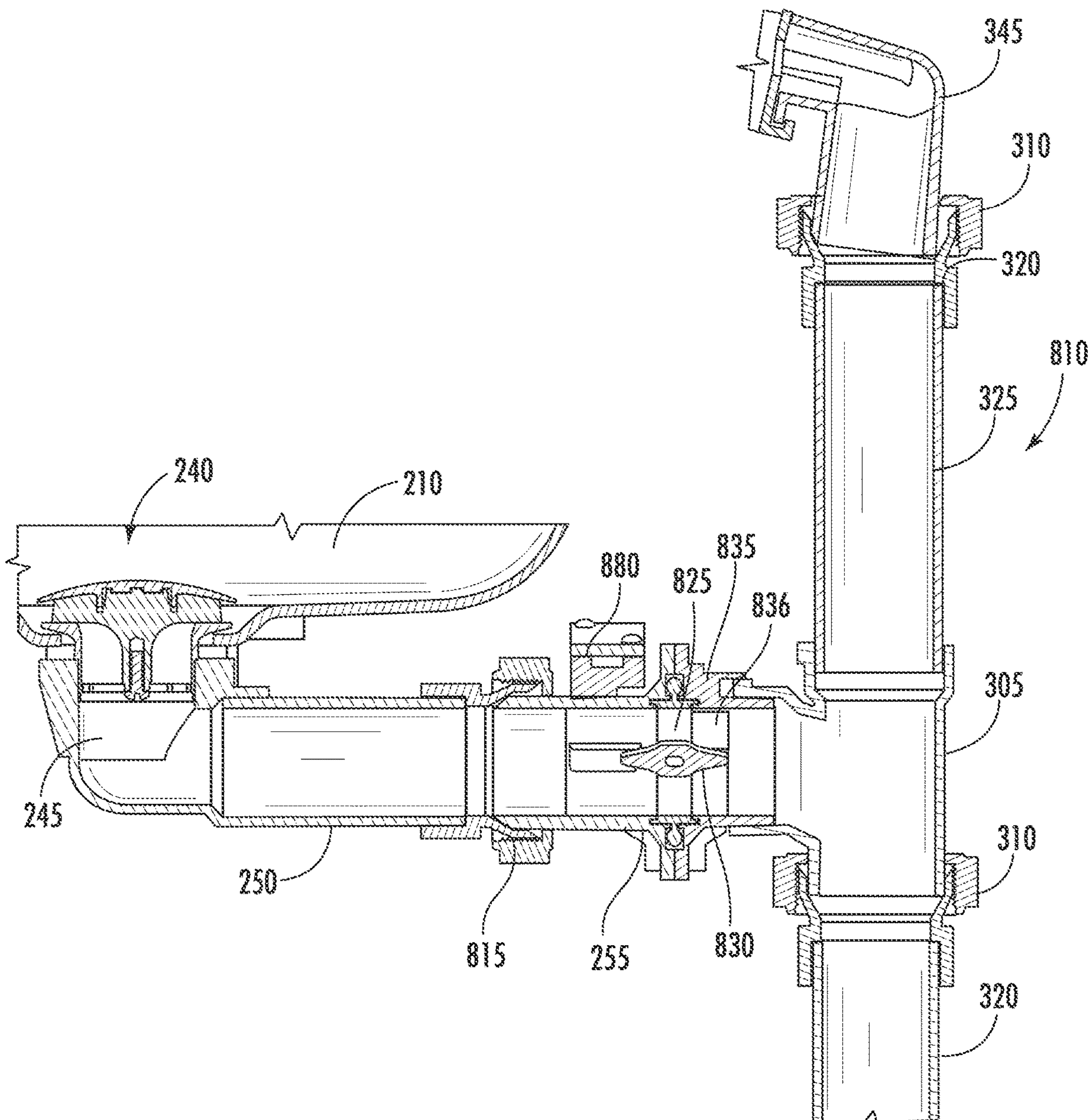
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FIG. 104

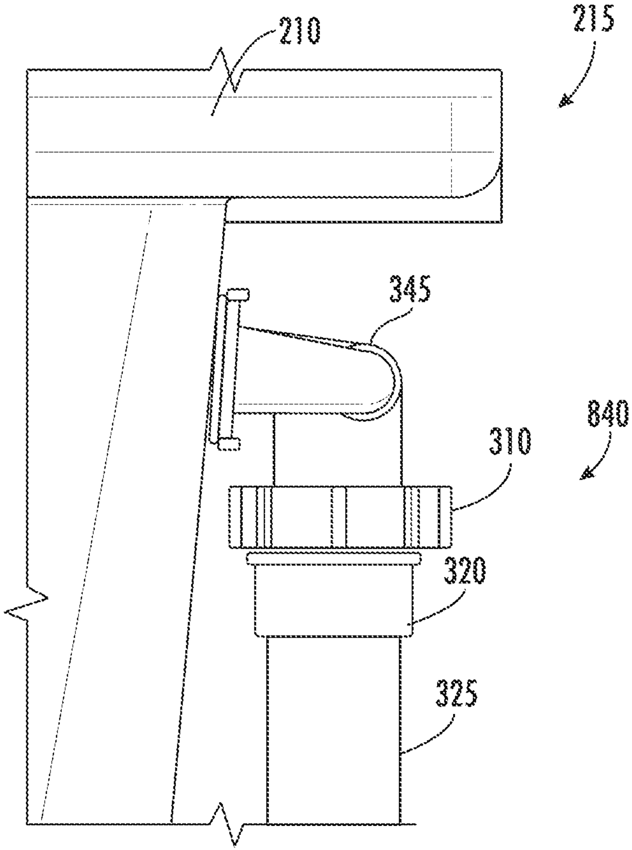

FIG. 105

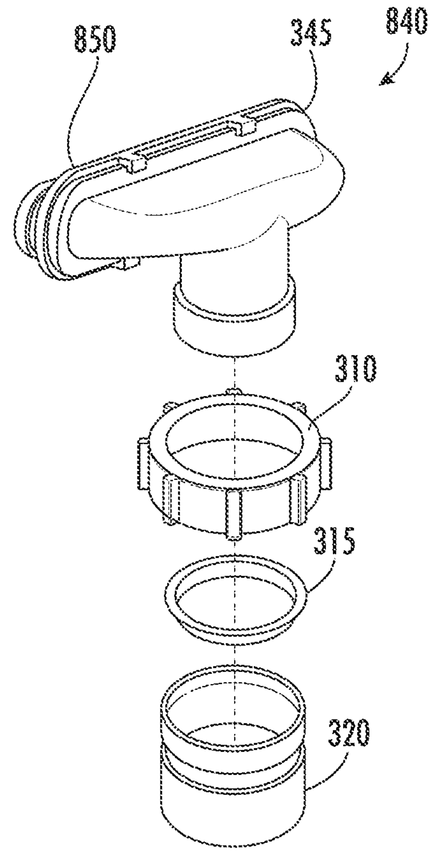

FIG. 106

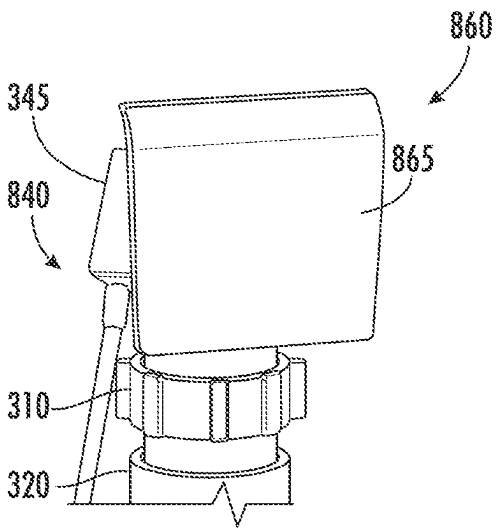

FIG. 107

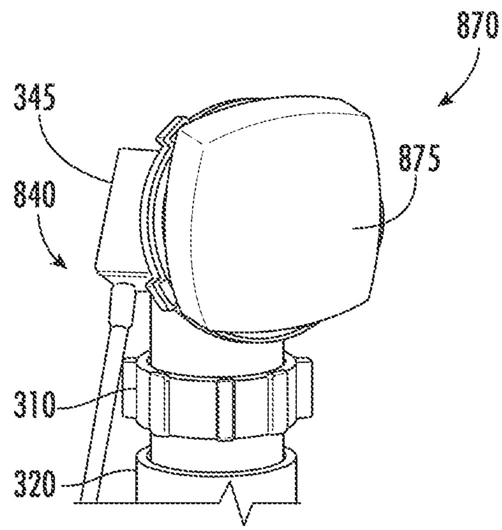

FIG. 108

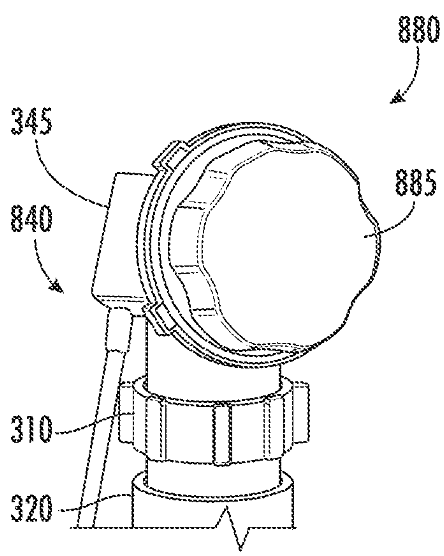

FIG. 109

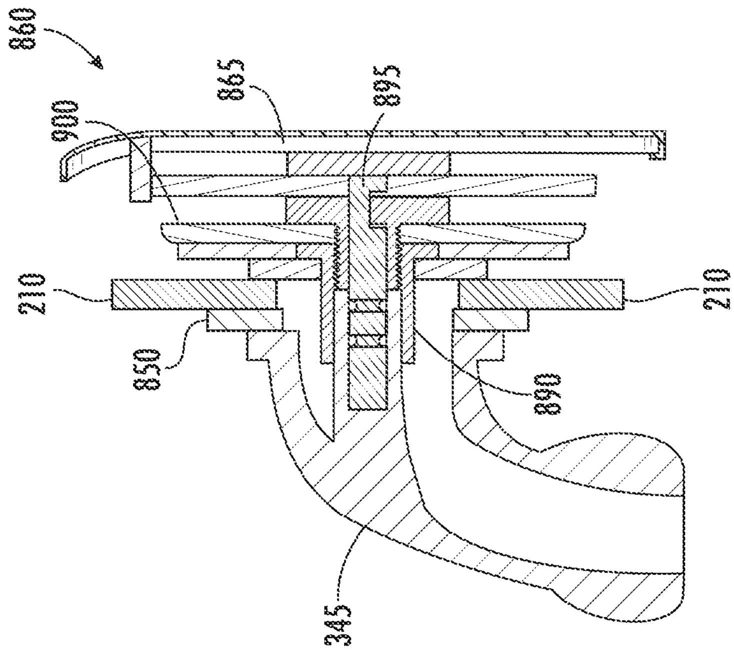

FIG. 111

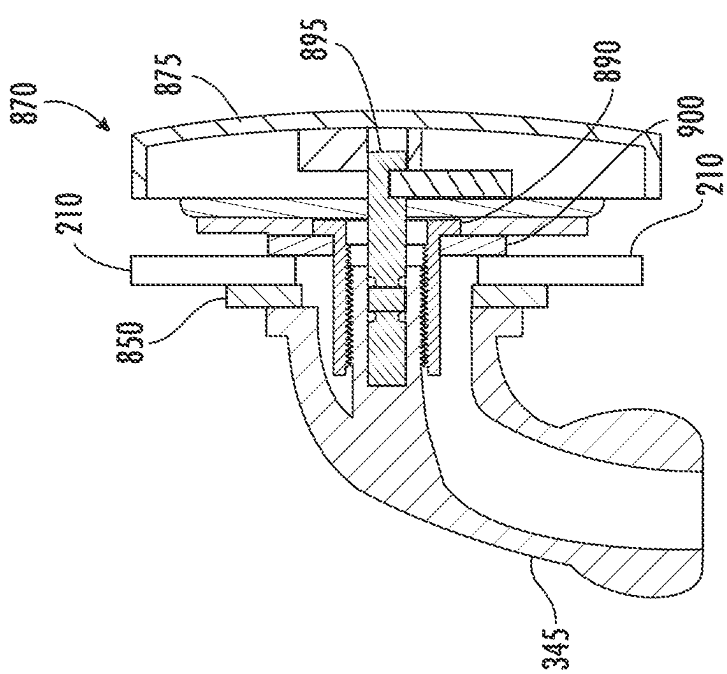

FIG. 110

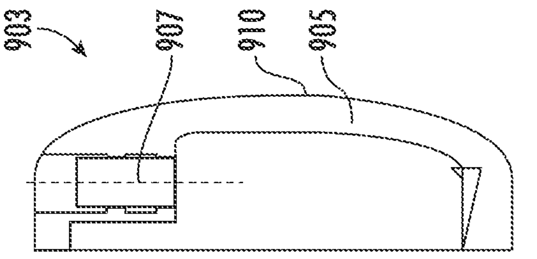

FIG. 116

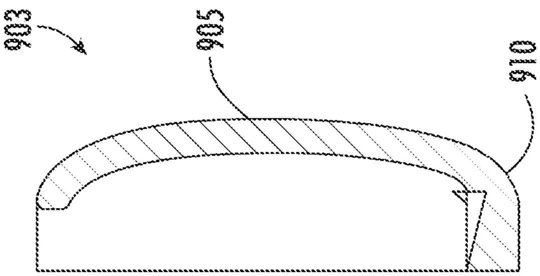

FIG. 115

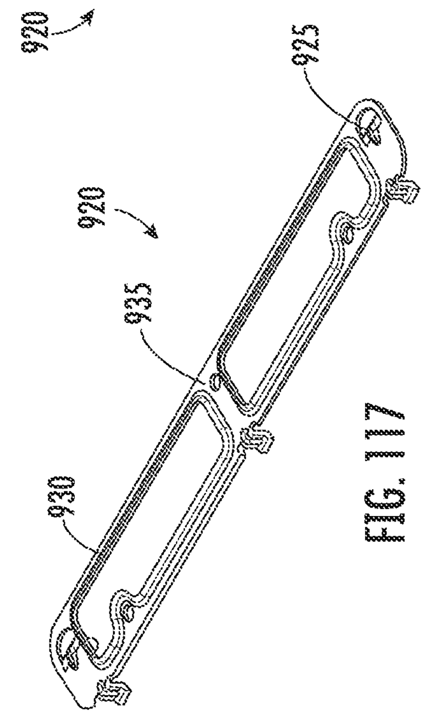

FIG. 117

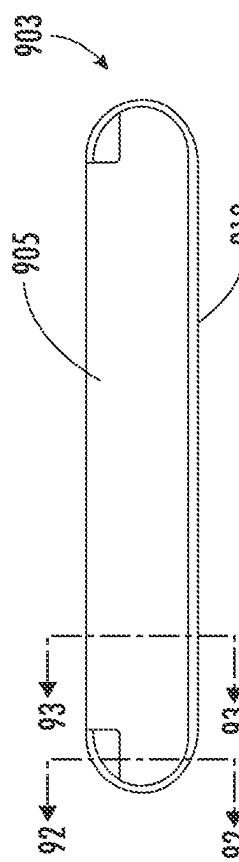

FIG. 112

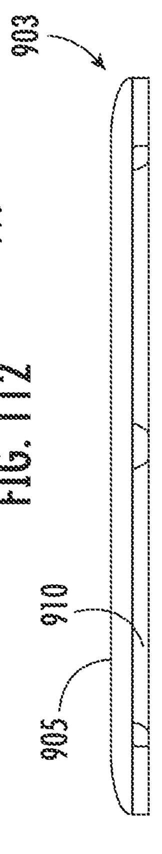

FIG. 113

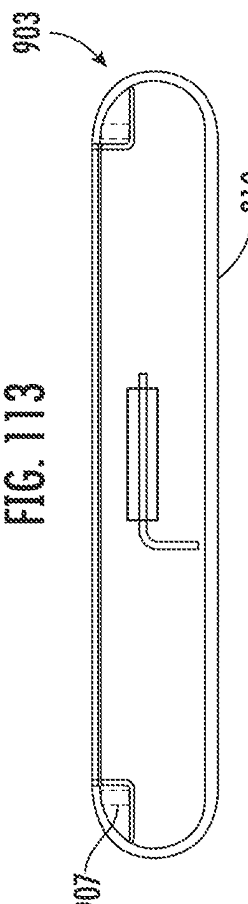

FIG. 114

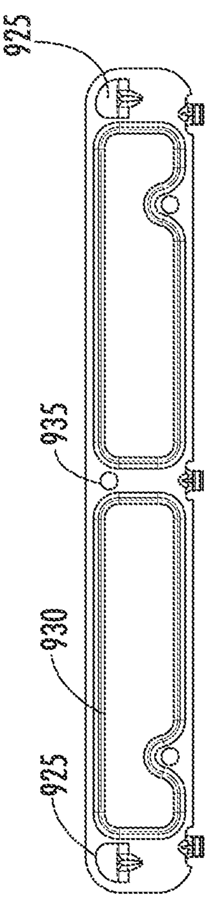

FIG. 118

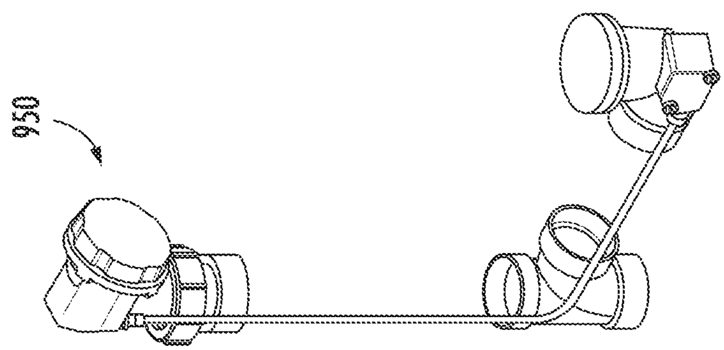

FIG. 121

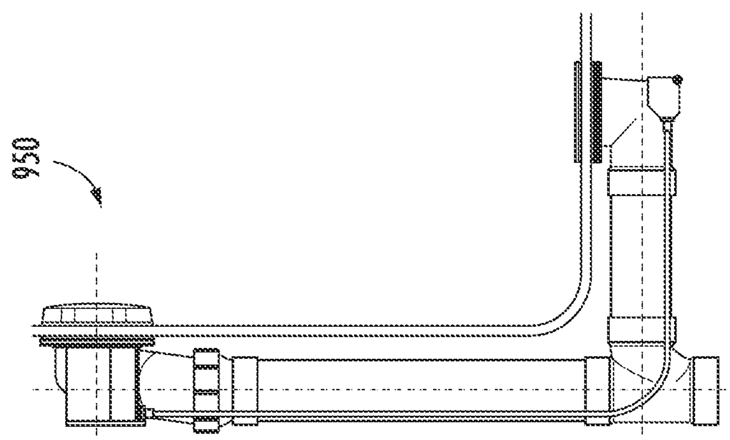

FIG. 120

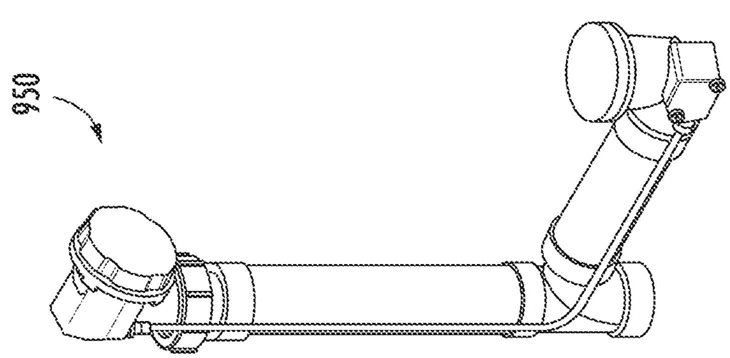

FIG. 119

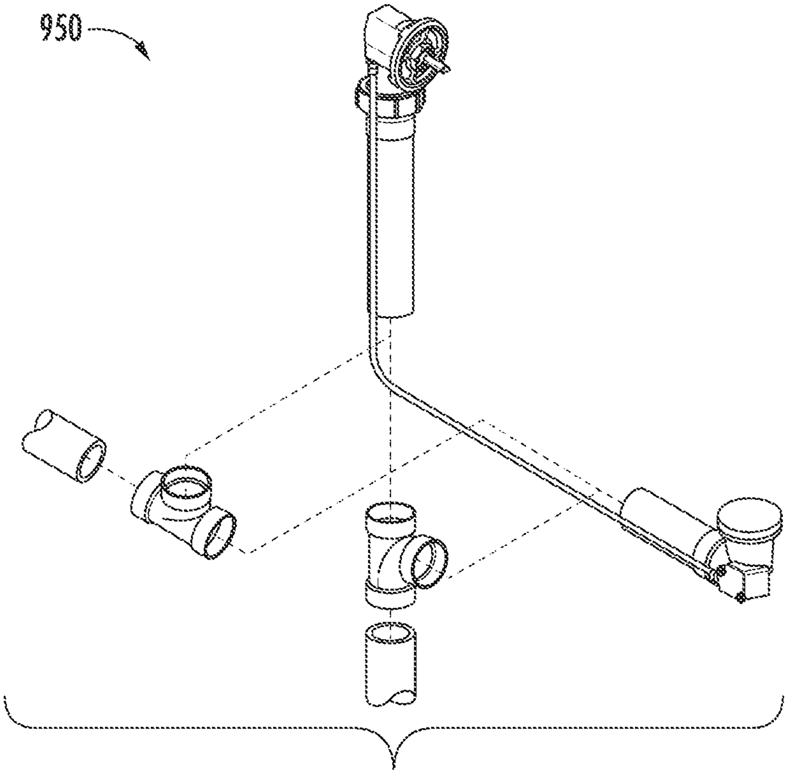

FIG. 122

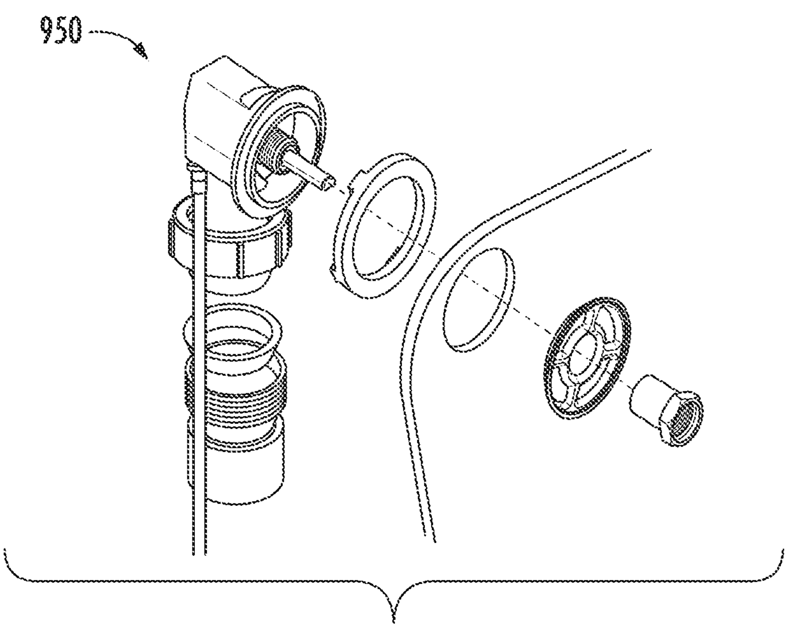

FIG. 123

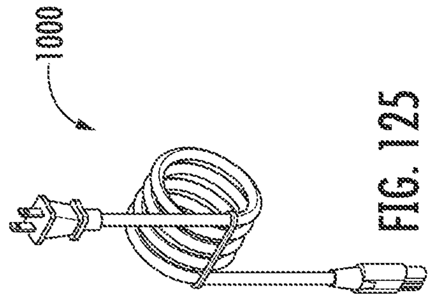

FIG. 125

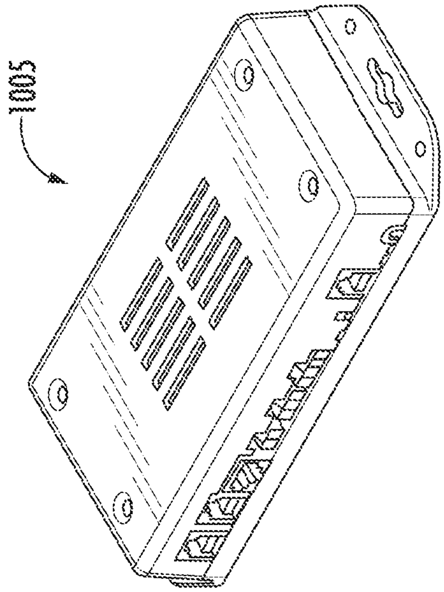

FIG. 127

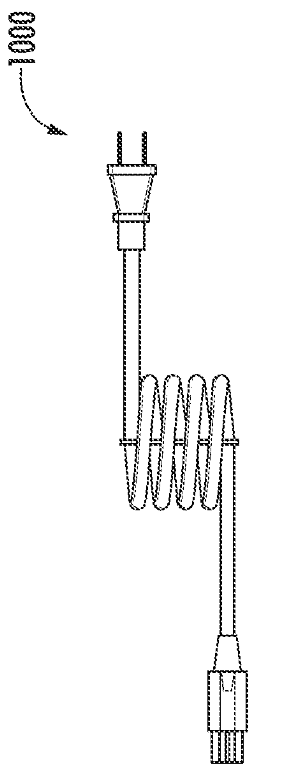

FIG. 124

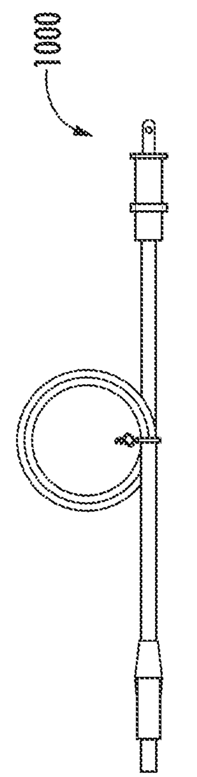

FIG. 126

DRAIN SYSTEM FOR BATHTUB

CROSS-REFERENCE TO RELATED PATENT APPLICATIONS

This application is a continuation of U.S. patent application Ser. No. 17/117,325, filed on Dec. 10, 2020, which claims the benefit and priority to U.S. Provisional Application No. 62/948,233, filed Dec. 14, 2019, the entire disclosure of which is hereby incorporated by reference herein.

BACKGROUND

The present disclosure relates generally to systems used in a bath or shower environment to improve a user's bathing experience. More specifically, the present disclosure relates to controlling water flow through bathtub exit and overflow drains.

Bathtub fill and drain features are often asynchronous, requiring separate operation of fill and drain features. In addition, bathtub fill and drainage systems are often specific to a particular bathtub design and have specific installation requirements.

It would be advantageous to provide a versatile fill and drainage system for a bathtub that can coordinate, control, and monitor bathtub filling and drainage to ensure a best possible experience by a user.

SUMMARY

At least one embodiment of this application relates to a system for controlling a water level in a bathtub, which includes a drain exit assembly coupled to an exit drain of the bathtub, a valve fluidly coupled to the drain exit assembly, the valve being operably coupled to a motor, wherein the motor is configured to change an operational state of the valve, a pressure sensor communicatively coupled to the valve and in fluid communication with the drain exit assembly. The drain exit assembly is configured to receive water exiting the bathtub and the motor is configured to change the operational state of the valve based on a pressure sensed by the pressure sensor to control a water level within the bathtub.

In various embodiments, the valve is a paddle valve. In other embodiments, the valve is a butterfly valve. In some embodiments, the valve is coupled to an inlet valve body, the inlet valve body coupled to a housing, wherein the pressure sensor is disposed within the housing. The inlet valve body may include an air pocket, wherein the pressure sensed by the pressure sensor associated with the air pocket. In some embodiments, the system further includes a thermistor communicatively coupled to the valve and in fluid communication with the drain exit assembly. In various embodiments, the motor is further configured to change the operational state of the valve based on a temperature measured by the thermistor.

In various embodiments, the system also includes an overflow drain assembly, the overflow drain assembly configured to receive water from an overflow drain of the bathtub. The overflow drain assembly may be configured for coupling to an overflow drain cover. In various embodiments, the overflow drain assembly is fluidly coupled to the drain exit assembly downstream of the valve. In some embodiments, the motor is configured change the operational state of the valve based on one or more routines, the one or more routines being set by a user device. In various embodiments, the system may include one or more fluid coupling components, wherein the one or more fluid coupling components are sizable to accommodate at least one of a bathtub size or type. The system may further include an outlet valve body fluidly coupled to the valve, wherein the outlet valve body is configured to receive water flowing from the valve and direct the water away from the bathtub. The outlet valve body may be configured to direct the water in a downward direction relative to the bathtub. In other embodiments, the outlet valve body may be configured to direct the water in a horizontal direction relative to the bathtub. The outlet valve body may include one or more contoured features to facilitate quiet water flow therethrough. In various embodiments, the pressure indicates at least one of the water level or an occupancy of the bathtub.

According to another aspect of this application relates to a method for controlling a water level in a bathtub, wherein the method includes receiving, by a drain exit assembly, water exiting the bathtub, wherein the drain exit assembly is coupled to an exit drain of the bathtub. The method further includes sensing, by a pressure sensor, a pressure associated with an inlet valve body coupled to a valve, wherein the valve is fluidly coupled to the drain exit assembly, and changing, by a motor, an operational state of the valve responsive to the pressure sensor sensing the pressure, wherein the pressure sensor is in fluid communication with the drain exit assembly and operatively coupled to the valve. In various embodiments, the method further includes receiving, by the motor, an input from a user device, wherein the input comprises instructions associated with at least one of setting the water level or a temperature of water within the bathtub.

Yet another aspect of this application relates to a bathtub drain system, wherein the system includes a bathtub configured to receive water and having a first drain and a second drain, and a drain exit assembly fluidly coupled to the first drain, an overflow drain assembly fluidly coupled to the second drain. The drain exit assembly may be to receive water flowing through the first drain and the overflow drain assembly may be configured to receive water flowing through the first drain. The overflow drain assembly is fluidly connected to the drain exit assembly downstream of a valve coupled to the drain exit assembly. The valve is controlled by a motor and fluidly coupled with a pressure sensor, wherein the pressure sensor is configured to sense a pressure associated with a water level in the bathtub. The motor may be configured to change an operational state of the valve responsive to the pressure sensed by the pressure sensor.

BRIEF DESCRIPTION OF THE FIGURES

FIG. **1** is a flow diagram illustrating operations performed by a drain system, according to an exemplary embodiment.

FIG. **2** is a side view of the drain system of FIG. **1** attached to a bathtub, according to an exemplary embodiment.

FIG. **3** is a reproduction of FIG. **2**, near an attachment site of the drain system, according to an exemplary embodiment.

FIG. **4** is a side cross-sectional view of the drain system of FIG. **1**, according to an exemplary embodiment.

FIG. **5** is a side view of the drain system of FIG. **1** and representation of a bathtub fill height, according to an exemplary embodiment.

FIG. **6** is an exploded view of the drain system of FIG. **1** implementing a paddle valve design, according to an exemplary embodiment.

FIG. **7** is an exploded view of the drain system of FIG. **1** implementing a paddle valve design, according to another exemplary embodiment.

FIG. **8** is a perspective view of an outlet valve body of the drain system of FIG. **6**, according to an exemplary embodiment.

FIG. **9** is a front view of the outlet valve body of FIG. **8**, according to an exemplary embodiment.

FIG. **10** is a top view of the outlet valve body of FIG. **8**, according to an exemplary embodiment.

FIG. **11** is an end view of the outlet valve body of FIG. **8**, according to an exemplary embodiment.

FIG. **12** is a reproduction of FIG. **11** near a valve paddle interface, according to an exemplary embodiment.

FIG. **13** is a cross-sectional view of the outlet valve body of FIG. **8** taken along line **25-25** of FIG. **9**, according to an exemplary embodiment.

FIG. **14** is a cross-sectional view of the outlet valve body of FIG. **8** taken along line **30**-of FIG. **9**, according to an exemplary embodiment.

FIG. **15** is a cross-sectional view of the outlet valve body of FIG. **8** taken along line **35**-of FIG. **10**, according to an exemplary embodiment.

FIG. **16** is a perspective view of the outlet valve body of FIG. **8**, according to an exemplary embodiment.

FIGS. **17-18** are perspective views of the inlet valve body of the drain system of FIGS. **6-7**, according to exemplary embodiments.

FIG. **19** is a side view of the inlet valve body of FIGS. **17-18**, according to exemplary embodiments.

FIG. **20** is a cross-sectional view of the inlet valve body of FIGS. **17-18** taken along line of FIG. **19**, according to exemplary embodiments.

FIG. **21** is a back end view of the inlet valve body of FIGS. **17-18**, according to an exemplary embodiment.

FIG. **22** is a front end view of the inlet valve body of FIGS. **17-18**, according to an exemplary embodiment.

FIG. **23** is a front view of the valve seal of the drain system of FIGS. **6-7**, according to an exemplary embodiment.

FIG. **24** is a side cross-sectional view of the valve seal of FIG. **23** taken along line **42-42** of FIG. **23**, according to an exemplary embodiment.

FIG. **25** is a top view of the valve seal of FIG. **23**, according to an exemplary embodiment.

FIG. **26** is top cross-sectional view of the valve seal of FIG. **23** taken along line **45-45** of FIG. **23**, according to an exemplary embodiment.

FIG. **27** is a reproduction of FIG. **26** near a valve seal connection to a valve body, according to an exemplary embodiment.

FIG. **28** is a top cross-sectional view of the valve seal of FIG. **23** taken along line **50-50** of FIG. **23**, at a position below a connection to the valve body, according to an exemplary embodiment.

FIG. **29** is a perspective view of the valve seal of FIG. **23**, according to an exemplary embodiment.

FIG. **30** is a perspective view of the paddle valve of the drain system of FIGS. **6-7**, according to an exemplary embodiment.

FIG. **31** is a front view of the paddle valve of FIG. **30**, according to an exemplary embodiment.

FIG. **32** is a side view of the paddle valve of FIG. **30**, according to an exemplary embodiment.

FIGS. **33-34** are reproductions of FIG. **32** near a connection point of the paddle valve to the valve seal, according to exemplary embodiments.

FIG. **35** is a top cross-sectional view of the paddle valve of FIG. **30** taken along line **60-60** of FIG. **31**, through a connection point of the paddle valve to the valve seal, according to an exemplary embodiment.

FIG. **36** is a bottom view of the paddle valve of FIG. **30**, according to an exemplary embodiment.

FIG. **37** is a perspective view of a swivel joint socket of the drain system of FIG. **6**, according to an exemplary embodiment.

FIG. **38** is an end view of the swivel joint socket of FIG. **37**, according to an exemplary embodiment.

FIG. **39** is a side cross-sectional view of the swivel joint socket of FIG. **37** taken along line **65-65** of FIG. **38**, according to an exemplary embodiment.

FIG. **40** is a perspective view of a reducing coupler of the drain system of FIGS. **6-7**, according to an exemplary embodiment.

FIG. **41** is an end view of the reducing coupler of FIG. **40**, according to an exemplary embodiment.

FIG. **42** is a cross-sectional view of the reducing coupler of FIG. **40** taken along line **70-70** of FIG. **41**, according to an exemplary embodiment.

FIG. **43** is a perspective view of a swivel ball fittings kit of the drain system of FIGS. **6-7**, according to an exemplary embodiment.

FIG. **44** shows end views of each component of the swivel ball fittings kit of FIG. **43**, according to an exemplary embodiment.

FIG. **45** is a side view of a drain elbow of the drain system of FIGS. **6-7**, according to an exemplary embodiment.

FIG. **46** is an end view of the drain elbow of FIG. **45**, according to an exemplary embodiment.

FIG. **47** is a side cross-sectional view of the drain elbow of FIG. **45** taken along line **75-75** of FIG. **46**, according to an exemplary embodiment.

FIG. **48** is a side cross-sectional view of the paddle valve design for a drain system near a bathtub exit drain with a vertically oriented swivel joint taken along line **15-15** of FIG. **6**, according to an exemplary embodiment.

FIG. **49** is a side cross-sectional view of a paddle valve design for a drain system near a bathtub exit drain with a horizontally oriented swivel joint taken along line **20-20** of FIG. **7**, according to an exemplary embodiment.

FIG. **50** is a side view of a paddle valve design for a drain system near a pressure sensor, according to an exemplary embodiment.

FIG. **51** shows a side cross-sectional view of a drain system near a reducing coupler and a valve input taken along line **15-15** of FIG. **6**, according to an exemplary embodiment.

FIG. **52** shows a side cross-sectional view of a drain system near a reducing coupler and valve input taken along line **15-15** of FIG. **6**, according to another exemplary embodiment.

FIG. **53** shows a side cross-sectional view of a drain system near a reducing coupler and valve input taken along line **20-20** of FIG. **7**, according to another exemplary embodiment.

FIG. **54** shows a side cross-sectional view of a drain system near a bathtub exit drain taken along line **15-15** of FIG. **6**, according to an exemplary embodiment.

FIG. **55** shows a perspective view of a bath drain strainer body of the drain system of FIG. **54**, according to an exemplary embodiment.

FIG. **56** shows a side cross-sectional view of the bath drain strainer body of FIG. **55** taken along line **80-80** of FIG. **55**, according to an exemplary embodiment.

FIG. **57** shows a top view of the bath drain strainer body of FIG. **55**, according to an exemplary embodiment.

FIG. **58** shows a side view of the bath drain strainer body of FIG. **55**, according to an exemplary embodiment.

FIG. **59** shows an exploded view of a drain cover assembly of the drain system of FIG. **54**, according to an exemplary embodiment.

FIG. **60** shows a top view of a drain stopper of the drain cover assembly of FIG. **59**, according to an exemplary embodiment.

FIG. **61** shows a side view of the drain stopper of FIG. **60**, according to an exemplary embodiment.

FIG. **62** shows a side cross-sectional view of the drain stopper of FIG. **60** taken along line of FIG. **60**, according to an exemplary embodiment.

FIG. **63** shows a top view of a drain post of the drain cover assembly of FIG. **59**, according to an exemplary embodiment.

FIG. **64** shows a side view of the drain post of FIG. **63**, according to an exemplary embodiment.

FIG. **65** shows a top view of a drain strainer of the drain cover assembly of FIG. **59**, according to an exemplary embodiment.

FIG. **66** shows a side view of the drain strainer of FIG. **65**, according to an exemplary embodiment.

FIG. **67** shows an exploded view of a drain system, according to an exemplary embodiment.

FIG. **68** shows a front view of a drain cover assembly, an inlet body valve, and connecting parts of the drain system of FIG. **67** near the bathtub exit drain, according to an exemplary embodiment.

FIG. **69** shows a perspective view of an inlet valve body and coupled thermistor of the drain system of FIG. **67**, according to an exemplary embodiment.

FIG. **70** shows a perspective view of a pressure sensor mounting block of the drain system of FIG. **67**, according to an exemplary embodiment.

FIG. **71** shows a bottom view of the pressure sensor mounting block of FIG. **70**, according to an exemplary embodiment.

FIG. **72** shows a top view of the pressure sensor mounting block of FIG. **70**, according to an exemplary embodiment.

FIGS. **73-74** show side views of the pressure sensor mounting block of FIG. **70**, according to exemplary embodiments.

FIG. **75** is a bottom cross-section of the pressure sensor mounting block of FIG. **70** taken along line **88-88** of FIG. **74**, according to an exemplary embodiment.

FIG. **76** shows a back view of the pressure sensor mounting block of FIG. **70**, according to an exemplary embodiment.

FIG. **77** shows a front view of the pressure sensor mounting block of FIG. **70**, according to an exemplary embodiment.

FIG. **78** is a reproduction of FIG. **77**, near cutout features, according to exemplary embodiments.

FIG. **79** shows a side cross-sectional view of the pressure sensor mounting block of FIG. taken along line **89-89** of FIG. **76**, according to an exemplary embodiment

FIG. **80** shows a side cross-sectional view of the pressure sensor mounting block of FIG. taken along line **90-90** of FIG. **77**, according to an exemplary embodiment.

FIG. **81** shows a front view of a drain system attached to a bathtub, according to an exemplary embodiment.

FIG. **82** is a reproduction of FIG. **81**, near an outlet valve body and pressure sensor mounting block, according to an exemplary embodiment.

FIG. **83** is a front view of a pressure sensor circuit board for a drain system, according to an exemplary embodiment.

FIG. **84** is a side cross-sectional view of a pressure sensor housing assembly for a drain system taken along line **91-91** of FIG. **81**, according to an exemplary embodiment.

FIG. **85** is an exploded view of a pressure sensor housing assembly for a drain system, according to an exemplary embodiment.

FIG. **86** is a partially exploded view of a pressure sensor and valve housing assembly for a drain system, according to an exemplary embodiment.

FIG. **87** is a front view of an air passage cover for the assembly of FIG. **86**, according to an exemplary embodiment.

FIG. **88** is a side cross-sectional view of the air passage cover of FIG. **87** taken along line **93-93** of FIG. **87**, according to an exemplary embodiment.

FIG. **89** is a back view of the air passage cover of FIG. **87**, according to an exemplary embodiment.

FIG. **90** is a front view of a pressure sensor housing cover for the assembly of FIG. **86**, according to an exemplary embodiment.

FIG. **91** is a side cross-sectional view of the pressure sensor housing cover of FIG. **90** taken along line **94-94** of FIG. **90**, according to an exemplary embodiment.

FIG. **92** is a bottom view of the pressure sensor housing cover of FIG. **90**, according to an exemplary embodiment.

FIG. **93** is a perspective view of the pressure sensor housing cover of FIG. **90**, according to an exemplary embodiment.

FIG. **94** is a side cross-sectional view of a pressure sensor seal for the assembly of FIG. **86** taken along line **91-91** of FIG. **81**, according to an exemplary embodiment.

FIG. **95** is a side view of the pressure sensor seal of FIG. **94**, according to an exemplary embodiment.

FIG. **96** is a back-end view of a valve motor assembly for a drain system, according to an exemplary embodiment.

FIG. **97** is a cross-sectional view of a valve motor assembly for a drain system taken along line **77-77** of FIG. **50**, according to an exemplary embodiment.

FIG. **98** is a front view of a valve motor for a drain system, according to an exemplary embodiment.

FIG. **99** is a side view of the valve motor of FIG. **98**, according to an exemplary embodiment.

FIG. **100** is a top view of the valve motor of FIG. **98**, according to an exemplary embodiment.

FIG. **101** is a side view of the valve motor of FIG. **98**, according to an exemplary embodiment.

FIG. **102** is a side view of a butterfly valve design for a drain system, according to an exemplary embodiment.

FIG. **103** is a side cross-sectional view of the drain system of FIG. **102**, according to an exemplary embodiment.

FIG. **104** is a reproduction of FIG. **103** near the butterfly valve, according to an exemplary embodiment.

FIG. **105** is a side view of an overflow drain assembly for a drain system, according to an exemplary embodiment.

FIG. **106** is an exploded view of the overflow drain assembly of FIG. **105**, according to an exemplary embodiment.

FIG. **107** is a perspective view of an overflow drain assembly with a tray-shaped cover, according to an exemplary embodiment.

FIG. **108** is a perspective view of an overflow drain assembly with a round cover, according to an exemplary embodiment.

FIG. **109** is a perspective view of an overflow drain assembly with a round cover, according to another exemplary embodiment.

FIG. **110** is a side cross-sectional view of an overflow drain assembly with a round cover, according to an exemplary embodiment.

FIG. **111** is a side cross-sectional view of an overflow drain assembly with a tray-shaped cover, according to an exemplary embodiment.

FIG. **112** is a back side view of the drain overflow cover, according to exemplary embodiments.

FIG. **113** is a bottom side view of the drain overflow cover of FIG. **112**, according to an exemplary embodiment.

FIG. **114** is a rear view of the drain overflow cover of FIG. **112**, according to an exemplary embodiment.

FIG. **115** is a side cross-sectional view of the drain overflow cover of FIG. **112** taken along line **92-92** of FIG. **112**, according to an exemplary embodiment.

FIG. **116** is a side cross-sectional view of the drain overflow cover of FIG. **112** taken along line **93-93** of FIG. **112**, according to exemplary embodiment.

FIG. **117** is a perspective view of a mounting plate for an overflow drain assembly, according to an exemplary embodiment.

FIG. **118** is a side view of the mounting plate of FIG. **117**, according to an exemplary embodiment.

FIG. **119** a perspective view of an existing overflow drain assembly, similar to exemplary embodiments of the herein disclosure.

FIG. **120** is a side view of the overflow drain assembly of FIG. **119**.

FIG. **121** is a perspective view of select components of the overflow drain assembly of FIG. **119**.

FIG. **122** is a partially exploded view of the overflow drain assembly of FIG. **119**.

FIG. **123** is a partially exploded view of the overflow drain assembly of FIG. **119**.

FIG. **124** is a top view representation of an existing power supply for a drain system, according to an exemplary embodiment.

FIG. **125** is a perspective view of the power supply of FIG. **124**.

FIG. **126** is a side view of the power supply of FIG. **124**.

FIG. **127** shows a controller for a drain system, according to an exemplary embodiment.

DETAILED DESCRIPTION

One embodiment of the present disclosure is a drain system that includes an overflow drain assembly coupled with a mechanical valve that is housed within a modular assembly to electronically control water flow through a bathtub exit drain. The system includes an exit drain assembly installed within the bathtub water outlet, which is coupled to a valve assembly to meter flow of the water exiting the bathtub. The valve assembly includes a valve that may be rotated about an axis at various angles to meter water flow exiting the bathtub. The valve assembly further includes a motor to actuate the valve. Operation of the valve is dependent on input received from sensors coupled to the valve assembly and input from one or more user devices. The one or more sensors are contained within a housing mechanically coupled to the valve assembly.

In some embodiments, the valve assembly of the drain system is fluidly coupled to the overflow drain assembly at the valve assembly outlet such that water outlets from the overflow assembly and the bath exit drain assembly are conjoined. The entire drain system is constructed via pipes, screws, swivel joints, adapters, and other common plumbing implementations that can be modified, interchanged, and/or customized to accommodate a wide variety of bathtub designs.

In other embodiments, the drain system includes one or more temperature sensors to enable temperature monitoring to inform fill and drain features. In some embodiments, the drain system includes one or more component options to adapt the system for installation in a wide variety of environments and/or to a wide variety of bathtub designs.

Referring generally to the figures, a drain system includes an overflow drain assembly coupled with a mechanical valve that is housed within a modular assembly to electronically control water flow through a bathtub exit drain. The system includes an exit drain assembly installed within the bathtub water outlet, which is coupled to a valve assembly to meter flow of the water exiting the bathtub. The valve assembly includes a valve that may be rotated about an axis at various angles to meter water flow exiting the bathtub. The valve assembly further includes a motor to actuate the valve. Operation of the valve is dependent on input received from sensors coupled to the valve assembly and input from one or more user devices. The one or more sensors are contained within a housing mechanically coupled to the valve assembly. The sensors may include pressure sensors and/or thermostatic sensors. The valve assembly is fluidly coupled to the overflow drain assembly at the valve assembly outlet such that water outlets from the overflow assembly and the bath exit drain assembly are conjoined. The entire drain system is constructed via pipes, screws, swivel joints, adapters, and other common plumbing implementations that can be modified, interchanged, and/or customized to accommodate a wide variety of bathtub designs. The drain system can facilitate controlled filling and draining of a bathtub, enable the control of water level and temperature maintenance, and adjust for occupancy.

In some implementations, the system is digitally controlled via one or more user interfaces, computer and/or smart device applications, cloud-based voice command systems, or any other suitable method for receiving input. In various implementations, the one or more user interfaces may be coupled to the system remotely or locally.

In some implementations, the system may be adapted to fit a multitude of bathtub designs that may or may not include an overflow exit drain in addition to a primary bathtub exit drain. For designs requiring an overflow exit drain, the system may be adapted to accommodate various overflow drain opening geometries.

In various implementations, the system can be configured for installation in various types of dwelling or framing conditions surrounding a bathtub. These conditions may include plumbing and drainage implementations above or below flooring, or in front of or behind adjacent structural framework (e.g. walls, studs, etc.).

In various implementations, the system includes adjustable components such as swivel joints, adapter/extension pipes, and outward-facing accessible screw fittings. These adjustable components may be included within the exit drain assembly, the valve assembly, the overflow drain assembly, or any fluidly or mechanically segments to the aforementioned assemblies.

In various implementations, the system includes components that can be interchanged for aesthetic purposes, such as an overflow cover assembly coupled to the overflow drain assembly. In various embodiments, overflow cover assemblies may be different shapes such as flat or tray-shaped, round, or a combination thereof. In various exemplary embodiments, the overflow cover assemblies may include components that facilitate ease of installation and adaptation to a multitude of bathtub designs.

In various exemplary embodiments, the system is configured to monitor the water level within a bathtub by measuring the pressure on an air pocket within an air passageway adjacent to a pressure sensor coupled to valve assembly. In various exemplary embodiments, the system is configured to determine the water level within a bathtub independent of the shape of the bathtub via a pressure measurement by the pressure sensor.

In various exemplary embodiments, the system is configured to provide a multitude of various functional capabilities beyond water level determination such as recognizing bathtub occupancy, operating based on preferences input by a user device, and providing digital information for data analytics that may be accessible by a user and/or user device (e.g. water usage, in-bath changes, trends, etc.).

In other exemplary embodiments, the system may have features that preserve the operation of the system over time, including moderating external pressure exposure (e.g. plunging) or pressure resulting from water drainage, to pressure-sensitive components (e.g. pressure sensor). In other exemplary embodiments, the system may include features that enable manual manipulation of components to allow operation without electronic control. In other exemplary embodiments, the system may include implementations for preventing debris within the bathtub from exiting into the system. Such implementations may include a debris strainer and drain exit cover over the bathtub water outlet.

In various exemplary embodiments, the system is configured to provide various safety or comfort features to a user of the bathtub attached system. In various embodiments, the valve may have limited runtime wherein the valve is only in an open or closed position for a preset period of time. The system may also be configured to adjust the valve opening such that water exiting the bathtub is not turbulent and produces minimal sound. In other embodiments, the system may be configured to have various calibration settings to ensure accurate filling, draining, and monitoring of a coupled bathtub. In yet other exemplary embodiments, the system may be configured to monitor the rate of change of sensed pressure to determine normal or abnormal filling, drainage, or bathtub occupancy. In various exemplary embodiments, a control of the drain system may enable the selective shut down or mode change of a system depending on predefined manufacturer error codes and/or user-device specified rules.

In various exemplary embodiments, the system may be configured to operate based on preset routines in response to input from a user device. Preset routines may be set by the user device and may include routines to sequentially or cyclically fill and/or drain water from a bathtub coupled to the system. Preset routines may operate based on a user device-determined point in time or according to a preset schedule defined by the user device. In various exemplary embodiments, such routines may include one or more purge cycle routines, whereby the system facilitates scheduled cleaning of the coupled bathtub.

In various exemplary embodiments, the system is configured to accommodate one or more predefined settings determined or set by a user device. The predefined settings may cause an increase or decrease in temperature of bath water, resulting from a system-initiated change in temperature and flow of water into and out of the bathtub. The settings may also cause the system alter the level of water within the bathtub, including filling or draining to preset amounts.

In various exemplary embodiments, the system may include an electronically coupled thermistor to measure and precisely control the temperature of water entering, exiting, or remaining within a bathtub. In various embodiments, the thermistor-containing system may facilitate the determination and setting of water temperature preferences within the bathtub, as defined or input by a user device. In various exemplary embodiments, the system may include a flow meter device coupled to water flow passageways located between the bathtub exit drain and the mechanical valve. In various embodiments, the device-containing system may monitor the amount and speed of water entering the system via the bathtub exit drain and, consequently, facilitate the determination and setting of desired water flow characteristics (e.g. drainage rates). The system may also be configured to provide digital information, such as to a user device, for the purposes of data analytics (e.g. temperature preferences, decay, trends, etc.). Digital information may be sourced from a thermistor, pressure sensor, flow meter device, or any other measuring implement mechanically or communicably coupled to the system.

In various implementations, the system may be configured to operate with various types of valve designs. In various exemplary embodiments, the system may include a gate or paddle-shaped valve which rotates about an attachment point located on one end of the valve. In alternative exemplary embodiments the system may include a butterfly valve with a central attachment point to facilitate equal pressure on valve surfaces and driving motor components. In various exemplary embodiments, the system may be configured to implement a particular valve design to accommodate requirements of a coupled motor (e.g. size, cost, etc.).

In various exemplary embodiments, components of the system may be configured to increase drain capacity and facilitate smooth and efficient water flow therein. Such configurations may include geometric features within the components to alter direction and velocity of water flow. In various exemplary embodiments, components included within the valve assembly may constructed to include features that reduces debris collection and promote a smooth flow geometry.

Turning now to the accompanying figures, and referring specifically to FIG. **1**, a method **100** for operation of a drain system is shown according to an exemplary embodiment. In operation **105**, the system receives input from a user device (local or remote) that pertains to the filling and/or draining of a bathtub coupled to the system (e.g. a desired water fill level), and subsequently adjusts filling and drain settings to accommodate the received input in operation **110**. The user device may communicate with the system via wired connections (e.g. Ethernet, USB, etc.) or wireless connections (e.g. Bluetooth, WiFi, NFC, etc.). According to one exemplary embodiment, input may be received from a user device (e.g. smart device, coupled user interface) at a controller or receiver.

The system detects and monitors pressure within the bathtub in operation **115**, which can be related to a water level and/or occupancy within the bathtub in operation **120**. The system can then determine if the water level satisfies the received user device input in operation **125**. If the determined water level is satisfies the conditions of the user device input received in operation **105**, the system can turn off or otherwise switch settings and/or modes and await further input from the user device (operation **130**). If the system determines that the water level does not satisfy the user device input that was received in operation **105**, the system can reiterate through operations **115**, **120**, and **125** until the user device input conditions are met.

FIG. **2** shows a side view of a drain system **215** adapted to fit a bathtub, according to an exemplary embodiment. The drain system **215** may be configured to operate according to method **100**. In FIG. **2**, the drain system **215** is mounted to bathtub **210** to facilitate water flow through a main water exit drain and an overflow drain. FIGS. **3** and **4** show side and side cross-sectional views of the system **215** adapted to fit a bathtub **210**, illustrating in greater detail the structure and connectivity of the system components. In FIG. **5**, system **215** is shown from an opposite side view (as compared to FIGS. **3** and **4**), illustrating a bathtub filled with water **225** and a corresponding water level determination **230** determined by a pressure sensor located within system **215** components beneath the bathtub **210** at a height **235** relative to the water **225**.

FIGS. **6** and **7** show exploded views of a drain system **215**, according to exemplary embodiments. System **215** receives water flowing out of a coupled bathtub (such as bathtub **210**) at drain exit assembly **240**. Drainage subsequently flows through elbow drain **245** and through reducing coupler **250**. Coupler **250** is fluidly connected to inlet and outlet valve bodies **255** and **305**, respectively. Inlet and outlet valve bodies **255** and **305** house a gate ("paddle") valve **275** and valve seal **285**. Valve **275** can be controlled to permit or prevent further water flow out of reducing coupler **250** depending on its position relative to seal **285** within valve bodies **255** and **305**. The paddle valve **275** is controlled by motor **260**, such that the motor **260** controls or changes an operational state of the valve **275** (e.g., changes the valve **275** position). Motor **260** can be electrically operated or manually overridden. Operation of motor **260** may be dependent on user-device input (e.g., via wired or wireless communication such as Bluetooth, WiFi, NFC, etc.) and/or sensed pressure information from a pressure sensor located in mounting block or housing **280**. Pressure sensor mounting block or housing **280** is further coupled to valve bodies **255** and **305**, in addition to pressure sensor circuit board **300**, seals **283**, sensor seals **283** and **287**, and O-rings **277**. The pressure sensor housing is coupled to the valve bodies **255** and **305** such that is located near an air passageway within inlet valve body **255**. The air passageway within inlet valve body **255** is covered by air passageway cover **265** and fasteners **270** such that it contains an air bubble that is pressurized (and measurable by a pressure sensor) depending on the water level within bathtub **210**. In various embodiments, the air bubble pressure may indicate occupancy of the bathtub **210**.

In various exemplary embodiments, the system **215** may be configured to provide various safety or comfort features to a user of the bathtub **210**. In various embodiments, the motor **260** may operate the valve **275** such that is in an open or closed position for a preset period of time. The system **215** may also be configured to adjust the valve **275** opening such that water exiting the bathtub **210** is not turbulent and produces minimal sound.

The outlet valve body **305** is fluidly coupled to receive water flow from pipe **325**, which directs water exiting bathtub **210** via an overflow drain elbow assembly **345** and a first set of connecting swivel ball fittings (including swivel joint socket **320**, joint gasket **315**, and swivel joint fitting **310**). Water exiting the bathtub via overflow elbow drain assembly **345** and paddle valve **275** assembly flow out through outlet valve body **305** and subsequently through a second set of connecting swivel ball fittings. Water flowing out of system **215** can then be connected to any additional downstream plumbing required to conclude water drainage.

In various exemplary embodiments, the system **215** may include a flow meter device fluidly coupled between the exit drain of the bathtub **210** and the valve **275** (e.g., to at least one of elbow drain **245**, coupler **250**, or inlet valve body **255**). In various embodiments, the system **215** may monitor an amount and/or speed of water entering the system **215** from the exit drain and, consequently, facilitate the determination and setting of desired water flow characteristics (e.g. drainage rates). The system **215** may also be configured to provide digital information (e.g., via NFC, Bluetooth, WiFi, direct connection), such as to a user device, for the purposes of data analytics (e.g. temperature preferences, decay, trends, etc.). Digital information may be sourced from the thermistor **605**, a pressure sensor in housing **280**, the flow meter device, or any other measuring implement mechanically or communicably coupled to the system **215**.

In various exemplary embodiments, the system **215** may be configured to operate based on one or more preset routines in response to input from a user device (e.g., received by the motor **260**). Preset routines may be set by the user device and may include routines to sequentially or cyclically fill and/or drain water from the bathtub **210**. Preset routines may operate based on a user device-determined point in time or according to a preset schedule defined by the user device. In various exemplary embodiments, such routines may include one or more purge cycle routines, whereby the system **215** facilitates scheduled cleaning of the coupled bathtub **210**.

The system **215** can be configured to accommodate various installation requirements, including facilitating drainage from a bathtub **210** above or below flooring on which bathtub **210** is located, or in front of or behind surrounding structures near which bathtub **210** is located. Adaptations of system **215** can be accomplished through adjusting swivel ball fittings (including swivel joint socket **320**, joint gasket **315**, and swivel joint fitting **310**) and/or using various configurations of outlet valve body **305**. FIG. **6** shows a vertical configuration for outlet valve body **305** and FIG. **7** shows a 90 degree ("horizontal") configuration for outlet valve body **305**.

FIGS. **8-16** show an outlet valve body **305** in a vertical configuration, in accordance with an exemplary embodiment. Locations **350** and **355** on outlet valve body **305** indicate locations of water inlet and outlet, respectively. Outlet valve body **305** is coupled to system **215**, such as to inlet valve body **255** via base plate **360**. FIG. **9** illustrates a front view of outlet valve body **305** wherein water enters at location **350** downward to location **355**. FIG. **10** shows a bottom, end view near location **355**, illustrating a substantially straight water flow path through outlet valve body **305**.

FIGS. **11-12** show end views of outlet valve body **305**, illustrating features **365** to facilitate coupling of a paddle valve **275** and seal **285**. FIGS. **13-14** show cross-sectional views of outlet valve body **305** taken along lines **25-25** and **30-30** of FIG. **9**, respectively, which illustrate features to facilitate smooth water flow (feature **370**) and enable connectivity to inlet valve body **255** and motor **260** (feature **375**). FIG. **15** shows a side cross-sectional view of outlet valve body **305** taken along line **35-35** of FIG. **10**, illustrating additional feature **365**, which encourages smooth water flow through outlet valve body **305**. FIG. **16** shows a perspective view of outlet valve body **305** opposite the view shown in FIG. **8**, illustrating feature **375** which enables connectivity to inlet body valve body **255** and motor **260**.

FIGS. **17-22** show an inlet valve body **255**, according to an exemplary embodiment. FIGS. **17-18** and FIGS. **19-20** show perspective and cross-sectional views, respectively, of an inlet valve body **255**, which includes base plate **390** for connectivity to outlet body valve **305**, air passage features **380** to facilitate pressure sensing, and inlet feature **385** through which water enters the inlet valve body **255**. FIGS. **21-22** show alternate cross-sectional views, respectively, of inlet valve body **255** to additionally illustrate feature **395**, which facilitates coupling of paddle valve **275** and seal **285** to inlet valve body **255**.

FIGS. **23-29** show a paddle valve seal **285**, according to an exemplary embodiment. FIG. **23** shows a front view of valve seal **285**, illustrating connectivity features **400** and **415** which facilitate connectivity to inlet and outlet valve bodies **255** and **305** (such as to features **375** and/or **390**). FIG. **23** also shows outer sealing features **405** and inner sealing features **410** which facilitate the generation of an effective seal between a paddle valve **275** and inlet and outlet valve bodies **255** and **305**. FIG. **24-25** show side cross-sectional (along line **42-42**) and outer top views of valve seal **285**, further illustrating features **400**, **405**, and **410**. FIGS. **26-27** show a top cross-sectional view (along line **45-45**) of seal **285**, illustrating connectivity feature **440** within feature **400** to enable coupling to and operation of paddle valve **275** relative to seal **285**. FIG. **28** shows a top cross-sectional view of seal **285** along line **50-50**. FIG. **29** shows a perspective view of seal **285**, illustrating sealing features **405** and **410** ad connectivity features **400** and **415**.

FIGS. **30-36** show a paddle valve **275**, according to an exemplary embodiment. FIG. **30** shows a perspective view of paddle valve **275** including a main valve surface **445** which provides a barrier for water flow from a bathtub exit drain through system **215**. When the paddle valve is closed, outer edge **450** on valve **275** engages with seal **285** to form a watertight seal, thereby preventing water flow. When the paddle valve **275** is opened, end **460** is rotated away from the direction of water flow about connectivity point **455** to permit water flow through system **215** from a bathtub exit drain. FIGS. **31-32** show side and front views, respectively, of paddle valve **275** to further illustrate features **450**, **455**, **445**, and **460**. FIGS. **33-34** show side views of paddle valve **275** to illustrate additional features **465** and **467**, which enable the paddle valve **275** to be coupled to seal **285**, inlet and outlet valve bodies **255** and **305**, and motor **260**. As illustrated in FIG. **35**, which shows a cross-sectional view of paddle valve **275** taken along line **60-60** of FIG. **31**, the connectivity point **455** may be configured to extend along a length of the paddle valve **275**. As shown in FIG. **36**, which is an end view of the paddle valve **275**, the main valve surface **445** may have a greater thickness as compared to that of the outer edge **450**.

FIGS. **37-39** show a swivel joint socket **320**, according to an exemplary embodiment. Swivel joint socket **320** may be used within system **215** to facilitate modular connectivity therein. FIG. **37** shows a perspective view of swivel joint socket **320**, illustrating a water flow inlet location **477** and a water flow outlet location **475**. FIG. **38** shows an end view of swivel joint **320**, further illustrating relative positions of features **475** and **477**. FIG. **39** shows a side cross sectional view of swivel joint socket **320** taken along line **65-65** of FIG. **38**, illustrating feature **479** positioned between locations **475** and **477** to facilitate smooth water flow.

FIGS. **40-42** show a reducing coupler **250**, according to an exemplary embodiment. FIG. shows a perspective view of reducing coupler **250**, illustrating water inlet location **480** and water outlet location **485**. FIGS. **41-42** show end and side cross-sectional views (taken along line of FIG. **41**), respectively, of reducing coupler **250** to illustrate the relative dimensions of reducing coupler **250** at locations **480** and **485**.

FIGS. **43-44** show exploded perspective and end views, respectively of a swivel ball fittings kit **505**, according to an exemplary embodiment. Swivel ball fittings kit **505** includes swivel joint socket **320**, swivel joint fitting **310**, and joint gasket **315**. Swivel ball fittings kit **505** may be implemented within system **215** to enable adaptation and/or customization of system **215** to a multitude of installation locations.

FIGS. **45-47** show an elbow drain **245**, according to an exemplary embodiment. FIGS. show side and end views, respectively of elbow drain **245** to illustrate water inlet location **493**, 90 degree bend **490**, and water outlet location **491**. FIG. **47** shows a side cross-sectional view of elbow drain **245** (taken along line **75-75** of FIG. **46**), further illustrating inner features **495** to facilitate the coupling of a drain cover assembly **240**.

FIGS. **48-53** show side views of system **215** near components that facilitate water flow out of a bathtub **210** exit drain, according to various exemplary embodiments. FIGS. **48-49** show a side cross-sectional view of system **215** (taken along line **15-15** of FIG. **6** and line **20-20** of FIG. **7**, respectively) installed above flooring near the bathtub **210** exit drain and paddle valve **285**, illustrating alternate configurations of outlet valve body **305**. FIG. **48** shows a vertical or linear configuration for outlet valve body **305**, enabling water to flow directly downward after passage through valve **275** and/or pipe **325**. FIG. **49** shows a 90 degree or horizontal configuration for outlet valve body **305**, enabling water to flow outward after passage through valve **275** and/or pipe **325**. As shown the outlet valve body **305** may include one or more contoured features **515** to facilitate quiet water flow through the system **215**. FIG. **50** shows a side view of system **215** installed below flooring near a bathtub **210** exit drain, illustrating an alternate configuration for system **215** installation. FIGS. **51-53** show side cross-sectional views of system **215** near the bathtub **210** exit drain, highlighting a distance **510** between elbow drain **245** and inlet valve body **255**. In various embodiments, system **215** may have a different distance **510** to accommodate installation requirements (e.g., size or type of the bathtub **210**, plumbing connecting to the bathtub **210**, etc.). FIGS. **52-53** also illustrate an alternate position **520** for paddle valve **275**, corresponding to an open valve configuration. Paddle valve **275** may be in position **520** after a rotation **523** caused by motor **260**.

Notably, the position of the paddle valve **275** as shown in FIG. **52** is angled downward in the fully open position. Advantageously, this positioning of the paddle valve **275** directs water to flow downward into the adjacent drain pipe structure, which the inventors have found significantly increases the speed at which water may drain from the bathtub **210**. According to one exemplary embodiment, water may drain from the tub **210** up to approximately 25% more quickly than if the pipes simply met at a 90 degree angle without the water being directed in manner that allows it to flow downward in the drain pipe. Without being limited to a particular theory, one potential reason for this increased drainage speed may be the reduction in cavitation in the water being drained as a result of controlling the fluid to flow in the desired direction.

FIG. **54** shows a side cross-sectional view of system **215** (taken along line **15-15** of FIG. **6**) near the bathtub **210** exit drain, illustrating the configuration of drain cover assembly **240** and comprising parts, including drain stopper **525**, drain post **530**, strainer **535**, and attaching screw **540**. FIGS. **55-58** show a bath drain strainer body **497**, according to exemplary embodiments. FIGS. **55-56** show perspective and side cross-sectional views, respectively, of drain strainer body **497**, illustrating upper surface **550** (to interface with drain post **530**) and round surface **555** (to interface with elbow drain **245**). FIG. **57** shows a top view of drain strainer body **497** additionally illustrating features **560** to interface with drain cover assembly **240**. FIG. **58** shows a side view of drain strainer body **497**.

FIG. **59** shows an exploded view of drain cover assembly **240** (including drain stopper **525**, drain post **530**, drain strainer **535**, and connecting screw **540**), according to an exemplary embodiment. FIGS. **60-61** show top and side views of drain stopper **525** which prevents large debris from entering system **215**. As illustrated in FIG. **62**, which is a cross-sectional view of the drain stopper **525** taken along line **85-85** of FIG. **60**, the drain stopper **525** may be dome shaped. FIGS. **63** and **64** show top and side views, respectively of drain post **530**, illustrating central post **580** which interfaces with drain stopper **525**, features **575** to catch unwanted debris from entering system **215**, and post **570** to couple with drain strainer **535**. FIGS. **65-66** show top and side views, respectively, of drain strainer **535**, to illustrate central aperture **585** which facilitates coupling to drain post **530**. In addition FIGS. **65-66** illustrate outer ring **595**, radial arms **590**, and texture features **600** to prevent any remaining debris from entering system **215**.

FIGS. **67-68** show system **215** including thermistor **605** coupled to inlet valve body **255**, according to an exemplary embodiment. Thermistor **605** enables temperature measurements and bath water monitoring to inform system **215** operation. As shown in FIG. **67**, which is an exploded view of the system **215**, the thermistor **605** may be coupled to the system **215** via the inlet valve body **255** disposed between the elbow drain **245** and the valve **275**. In various embodiments, the thermistor **605** may be communicably coupled to one or more controllers and/or one or more user devices such that the thermistor **605** may be used to monitor and/or control a temperature of water entering the bathtub **210**. In various embodiments, such temperature control may be based on one or more preset modes, conditions, settings (e.g., set by a controller and/or user device). As shown in FIGS. **68-69**, the thermistor **605** may be coupled to the inlet valve body **255** through an opening in the air passage cover **265** such that an end of the thermistor **605** extends through an elongated portion **606** of the inlet valve body **255**. In various embodiments, the thermistor **605** may facilitate the determination and setting of water temperature preferences within the bathtub **210**, as defined or input by a user device, which may be communicably coupled to the thermistor **605**.

FIGS. **70-80** show sensor housing **280**, which contains the pressure sensor for measuring pressure within the air passageway in inlet valve **255**, according to exemplary embodiments. Sensor housing **280** includes recessed features **620** and **625**, which are configured facilitate placement for coupling of the sensor housing **280** to the inlet and outlet valve bodies **255** and **305**, respectively. Cutout features **623**, **627**, **629**, and **640** facilitate engagement and coupling of the sensor housing **280** to inlet and outlet valve bodies **255** and **305** and containment of a pressure sensor (and associated connections). As shown in FIGS. **71-80**, the sensor housing **280** includes a protruding feature **630**, which is disposed on a side of the housing **280** opposite a side **615** in which the cutout **629** is disposed. In various embodiments, the protruding feature **630** engages with the O-rings **277** to enable fluid sealing of the coupling between the sensor **280** and the inlet valve body **255**.

FIGS. **81-82** show front views of system **215** as coupled to fit the bathtub **210**, according to exemplary embodiments. FIG. **82** illustrates the proximity of the motor **260** and outlet valve body **305**. As described, a water level within the tub **210** may be controlled based on a pressure associated with an air bubble within inlet valve body **255**, which may be measured by a pressure sensor **670**. FIG. **83** shows a front view of a pressure sensor circuit board **290**, which is coupled to sensor housing **280** to enable pressure measurement, in accordance with an exemplary embodiment. FIGS. **84** and **85-86** show side cross-sectional and exploded views, respectively, of pressure sensor housing assembly **665** containing pressure sensor **670**, circuit board **290**, and housing **280**, which couples to the inlet valve body **255** via extruded member **700**. As shown, the pressure sensor **670** is coupled to the pressure sensor circuit board **290** via apertures **650**, **655**, and **660**. Pressure measured by the pressure sensor **670** may be transmitted (e.g., to a controller, a user device, etc.) via a cable **610** coupled to the pressure sensor circuit board **290**. In various embodiments, the system **215** may be configured to monitor the rate of change of sensed pressure (e.g., sensed by the sensor **670**) to determine normal or abnormal filling, drainage, or bathtub **210** occupancy. In various embodiments, the system **215** may be configured to operate based on one or more preset thresholds or set points corresponding to a water level (e.g., determined based on the sensed pressure), a temperature, an occupancy, etc.

FIGS. **87**, **88**, and **89** show front, cross-sectional, and back views of the air passage cover **265** which couples to inlet valve body **255** (via features **705-720**), according to exemplary embodiments. As shown, the air passage cover **265** includes one or more apertures (e.g., through holes) **705** disposed within a first side **710** to facilitate coupling of the cover **265** to the inlet valve body **255**. Furthermore, the cover **265** may further include one or more protruding portions **715**, which may extend from a second side **720** to be received by one or more openings or recesses of the inlet valve body **255**.

FIGS. **90-93** show a pressure sensor housing cover **300** which couples to pressure sensor housing **280** (via features **685-735**), according to exemplary embodiments. As shown, the pressure sensor housing cover **300** includes apertures (e.g., through holes) **685**, **695**, **725**, and **730** disposed within the cover **300** (e.g., within a first side **735**) to facilitate coupling of the cover **300** to the pressure sensor housing **280**. Furthermore, the cover **300** may further include one or more protruding portions **740** and/or recessed features **750**, which may be disposed on a second side **745** of the cover **300** to be received by one or more features of the pressure sensor housing **280**.

FIGS. **94-95** show the pressure sensor seal **283** which interfaces with a pressure sensor via an inner surface **760** and with the pressure sensor housing **280** via an outer surface **755**, according to exemplary embodiments.

FIGS. **96-97** show back-end and cross-sectional views, respectively, of a valve motor assembly **680** for a drain system **215**, according to an exemplary embodiment. FIGS. **96-97** illustrate connectivity among motor **260**, inlet valve body **255**, and outlet valve body **305**. FIGS. **96-97** further illustrate a feature **770** attached to the motor **260** drive mechanism **775**, adjacent a motor shaft **780**, wherein the motor shaft **780** extends from the motor **260** body, which enables the motor **260** to be manually operated without electric control (e.g. "backdriven"). For example, in the event of a power failure or other situations in which the motor **260** ceases to function temporarily or permanently, a wrench may be used to move the motor shaft **780** so as to allow drainage to occur in the system. FIGS. **98-101** show side views of motor **260** to illustrate feature **770**, drive mechanism **775**, interfacing surface **785**, motor shaft **780**, portion **790** (e.g., lever, cable), and orientation direction **800**, according to exemplary embodiments. Motor shaft **780** may be rotated according to the orientation direction **800** to open or close the valve **275**.

FIGS. **102** and **103-104**, show side and side cross-sectional views of a drain system **810** (similar to system **215**) which includes a modified valve assembly **820**, according to exemplary embodiments. In contrast to the previously-discussed embodiments, FIGS. **103** and **104** shows a butterfly valve **830** design housed within inlet and outlet valve bodies **255** and **835**, respectively. Valve **830** interfaces with seal **825** as controlled by a motor (e.g. motor **260**) to meter water flow exiting coupler **815** through system **810**. According to an exemplary embodiment, valve **830** is configured as a substantially circular disk within the outlet valve body **835** and is configured to allow water to flow both over and under the valve **830** when it is in the open position as shown in FIG. **104**. A stop **836** (shown as a block member just above the right-most portion of the valve **830** in FIG. **104**) is provided to constrain rotation of the valve **830** further counterclockwise than shown in FIG. **104**. The stop **836** is integrally formed with and extends from a wall of outlet valve body **835** in FIG. **104**, but may have different sizes, shapes, or configurations according to other exemplary embodiments. As illustrated, the "fully open" position of the valve **830** is as shown in FIG. **104** such that the valve **830** is substantially parallel to the longitudinal axis of the outlet valve body **835**. The "fully closed" position would be 90 degrees from that position, such that the valve **830** blocks the flow of water through the outlet valve body **835**.

FIGS. **105** and **106** show side and exploded views, respectively, of an overflow drain assembly **840** of system **215** (or **810**), according to exemplary embodiments. Assembly **840** includes an overflow elbow section **345** (located on the exterior of bathtub **210**) through which water above a desired level in bathtub **210** may exit. Water flowing into section **345** subsequently flows through swivel ball fittings **310**, **315**, and **320** into pipe **325** to join the rest of water flow in system **215** (or **810**).

FIGS. **107-109** show perspective views of various overflow drain cover designs (located on interior of bathtub **210**) to be coupled with assembly **840**. FIGS. **107**, **108**, and **109** illustrate a tray-shaped cover design **860**, a contoured design **870**, and a round or scalloped design **880**, respectively. As illustrated, the overflow drain assembly **840** may be coupled to a tray-shaped drain cover **865**, a contoured cover **875**, or a round or scalloped cover **885**. In various embodiments, the drain covers **865**, **875**, **885** may be interchangeably coupled to the assembly **840**. FIGS. **110-111** illustrate side cross-sectional views of the contoured design **875** and the tray-shaped design **865**, respectively, according to exemplary embodiments. As shown, the elbow section **345** of the overflow drain assembly **840** may be coupled to either of covers **865**, **875** via one or more coupling components **890**, **895**, **900**. As shown, one or more sealing members **850** may be disposed between the bathtub **210** and the elbow section **345** to prevent water leakage therebetween.

In yet other embodiments, the overflow drain assembly **840** may be coupled to an elongated drain cover. FIGS. **112-113** show cross-sectional (taken along lines **92-92** and **93-93**, respectively) views and FIGS. **14-116** show side views of an elongated overflow drain cover **903**, according to exemplary embodiments. As shown in FIGS. **114** and **115**, the drain cover **903** may have a contoured body **905** with a curved outer edge **910**. As shown, the cover **903** may include one or more mounting portions **907**, which facilitate coupling to the overflow drain assembly **840**. According to an exemplary embodiment, the overflow drain covers (e.g., covers **865**, **875**, **885**) having different aesthetic designs may be coupled to the same "internal" portion of the overflow drain system **215** (or **810**). Stated another way, the overflow drain system (e.g., system **215** or **815** via the assembly **840**) may allow for the use of the same internal portion with multiple different user-facing overflow drain covers (e.g., covers **865**, **875**, **885**), which may advantageously allow users/installers to provide a desired aesthetic appearance for the drain cover without having to change or modify the internal portion of the overflow drain system **215** (or **810**).

FIGS. **117-118** show a mounting plate **920** to couple the overflow drain cover **903** to a bathtub **210** (e.g., via assembly **840**) As illustrated, the mounting plate **920** may include a contoured frame **935** having one or more mounting features or apertures **925**, **925** to facilitate coupling of the plate **920** to the assembly **840**. FIGS. **119-123** show various possible configurations for an overflow drain system **950** (similar or equivalent to system **215** and/or **810**), according to exemplary embodiments. As shown, the overflow drain system **950** may be configured as a modular system, wherein each component within the system may be removable and/or replaceable to accommodate various tub sizes (e.g., bathtub **210**), design preferences, and/or plumbing configurations. In various embodiments, the system **950** may be configured such that it may be retrofit to various tub (e.g., bathtub **210**) designs.

In various embodiments, the overflow drain system (e.g., system **215**, **810**, **950**) may be couplable to one or more power supply devices to enable automatic operation of the drain system. FIGS. **124-126** show various power supply devices **1000** to enable operation of a drain system **215** (and/or systems **810**, **950**), according to exemplary embodiments. In various embodiments, at least one of the motor **260**, pressure sensor **670**, thermistor **605**, or one or more controllers coupled to the system (e.g., system **215**, **810**, **950**) may draw power via devices **1000**.

In various embodiments, the overflow drain system (e.g., system **215**, **810**, **950**) may be couplable to a controller, such as controller **1005** as shown in FIG. **127**, to control one or more operations thereof (e.g., method **100**), wherein the controller may be a non-transitory computer readable medium or processor having computer-readable instructions stored thereon that when executed, cause the controller to carry out operations (e.g., operations **105-130** of method **100**) called for by the instructions. In various embodiments, the controller may be a thermostat or other computing device. In yet other embodiments, the controller may be configured as part of a data cloud configured to receive commands from a user control device and/or a remote computing device. The controller may include a power source (e.g., similar or equivalent to devices **1000**), a memory, a communications interface, and a processor. In other embodiments, the controller may include additional, fewer, and/or different components.

As utilized herein, the terms "approximately," "about," "substantially," and similar terms are intended to have a broad meaning in harmony with the common and accepted usage by those of ordinary skill in the art to which the subject matter of this disclosure pertains. It should be understood by those of skill in the art who review this disclosure that these terms are intended to allow a description of certain features described and claimed without restricting the scope of these features to the precise numerical ranges provided. Accordingly, these terms should be interpreted as indicating that insubstantial or inconsequential modifications or alterations of the subject matter described and claimed are considered to be within the scope of the application as recited in the appended claims.

It should be noted that the term "exemplary" as used herein to describe various embodiments is intended to indicate that such embodiments are possible examples, representations, and/or illustrations of possible embodiments (and such term is not intended to connote that such embodiments are necessarily extraordinary or superlative examples).

The terms "coupled," "connected," and the like, as used herein, mean the joining of two members directly or indirectly to one another. Such joining may be stationary (e.g., permanent) or moveable (e.g., removable or releasable). Such joining may be achieved with the two members or the two members and any additional intermediate members being integrally formed as a single unitary body with one another or with the two members or the two members and any additional intermediate members being attached to one another.

References herein to the positions of elements (e.g., "top," "bottom," "above," "below," etc.) are merely used to describe the orientation of various elements in the FIGURES. It should be noted that the orientation of various elements may differ according to other exemplary embodiments, and that such variations are intended to be encompassed by the present disclosure.

It is important to note that the construction and arrangement of the apparatus and control system as shown in the various exemplary embodiments is illustrative only. Although only a few embodiments have been described in detail in this disclosure, those skilled in the art who review this disclosure will readily appreciate that many modifications are possible (e.g., variations in sizes, dimensions, structures, shapes and proportions of the various elements, values of parameters, mounting arrangements, use of materials, colors, orientations, etc.) without materially departing from the novel teachings and advantages of the subject matter described herein. For example, elements shown as integrally formed may be constructed of multiple parts or elements, the position of elements may be reversed or otherwise varied, and the nature or number of discrete elements or positions may be altered or varied. The order or sequence of any process or method steps may be varied or re-sequenced according to alternative embodiments.

Other substitutions, modifications, changes and omissions may also be made in the design, operating conditions and arrangement of the various exemplary embodiments without departing from the scope of the present application. For example, any element disclosed in one embodiment may be incorporated or utilized with any other embodiment disclosed herein.

What is claimed is:

1. A drain system for a bathtub, the system comprising:

a drain exit assembly coupled to an exit drain of the bathtub, the drain exit assembly structured to receive water from the bathtub;

a valve fluidly coupled to and disposed downstream of the drain exit assembly, the valve structured to control water flow through the drain exit assembly, the valve including an air passageway configured to contain an air bubble pressurized by water in the bathtub; and

a housing positioned adjacent the air passageway of the valve the housing comprising at least one sensor operably coupled to the valve and in fluid communication with the drain exit assembly;

wherein the valve is structured to control water flow through the drain exit assembly based on an input from the at least one sensor satisfying a threshold, the threshold corresponding to at least one of a temperature setpoint or a level of water within the bathtub.

2. The drain system of claim **1**, wherein the at least one sensor is structured to sense at least one of a temperature or a pressure associated with the water from the bathtub.

3. The drain system of claim **2**, wherein a user device is configured to receive the input from the at least one sensor.

4. The drain system of claim **3**, wherein the user device is configured to determine an occupancy of the bathtub based on the rate of change.

5. The drain system of claim **3**, wherein the at least one sensor is structured to sense the pressure associated with the water from the bathtub, and wherein the user device is configured to determine a rate of change of the pressure.

6. The drain system of claim **2**, wherein the at least one sensor is structured to sense the pressure associated with the water from the bathtub by measuring a pressure within the air passageway.

7. The drain system of claim **1**, further comprising a motor operably coupled to the valve, the motor structured to control an operational state of the valve.

8. The drain system of claim **7**, further comprising a user device in communication with the motor, wherein the threshold is set by the user device.

9. The drain system of claim **1**, wherein the at least one sensor comprises a first sensor and a second sensor.

10. The drain system of claim **9**, wherein the first sensor is a thermistor and the second sensor is a pressure sensor.

11. The drain system of claim **1**, wherein the at least one sensor is configured to sense a pressure of the water from the bathtub, and wherein the valve is coupled to an inlet valve body, the inlet valve body configured to engage with one or more recesses of the housing.

12. The drain system of claim **11**, wherein the inlet valve body comprises an air pocket, and wherein the at least one sensor is further configured to sense a pressure within the air pocket.

13. The drain system of claim **1**, further comprising a flow meter device fluidly coupled between the exit drain and the valve.

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