March 16, 1965 W. H. SCHUTMAAT 3,173,245

CONTROL APPARATUS

Filed March 4, 1963

FIG-1

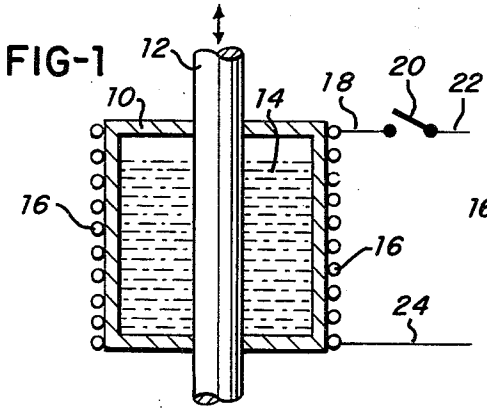


FIG-2

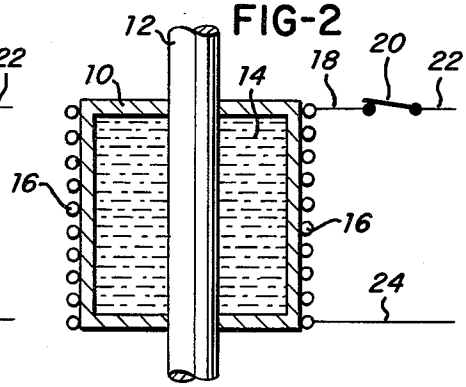


FIG-3

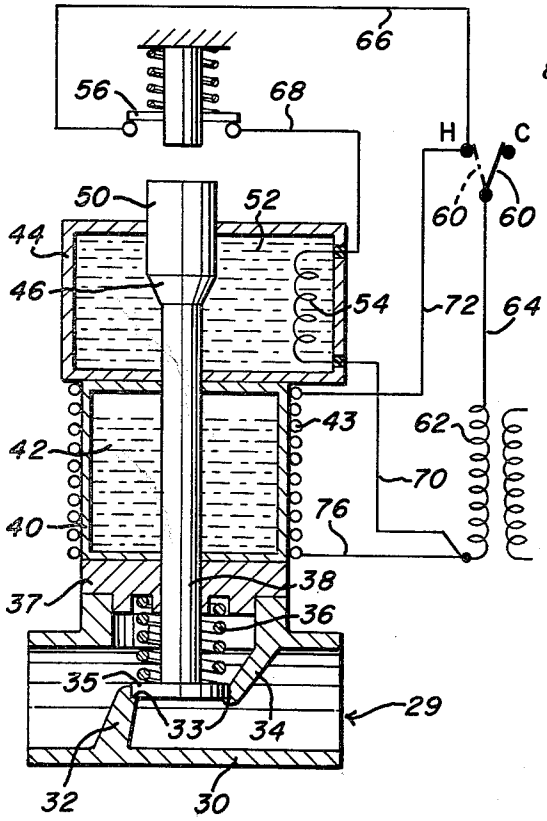


FIG-4

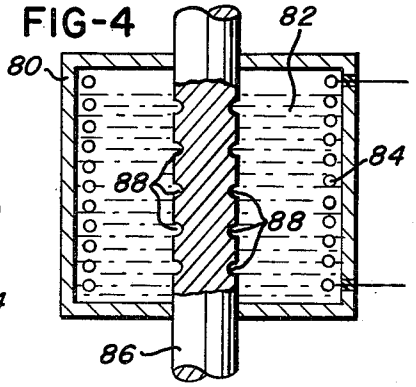
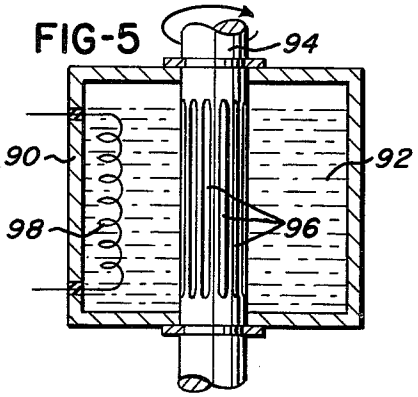


FIG-5



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CONTROL APPARATUS

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13 Claims. (Cl. 60—23)

This invention relates to control apparatus. The invention relates more particularly to control apparatus which is capable of locking or retaining a movable element in a given position.

An object of this invention is to provide apparatus which is capable of locking a movable element in a given position.

Another object of this invention is to provide such apparatus which is thermally operated.

Another object of this invention is to provide such apparatus in which electrical means may be employed to control the thermal energy.

Another object of this invention is to provide such apparatus which is capable of producing high values of force in consideration of the physical size thereof.

Another object of this invention is to provide such apparatus in which the rate of operation therof may be controlled.

Other objects and advantages reside in the construction of parts, the combination thereof, the method of manufacture, and the mode of operation, as will become more apparent from the following description.

In the drawings:

FIGURE 1 is a sectional diagrammatic view of apparatus of this invention showing elements of the apparatus in deactuated positions.

FIGURE 2 is a sectional diagrammatic view of the apparatus of FIGURE 1 showing elements of the apparatus in actuated positions.

FIGURE 3 is a diagrammatic view showing apparatus of this invention and control mechanism therefor in combination with a fluid valve.

FIGURE 4 is a diagrammatic sectional view of a modification of a portion of the apparatus of this invention.

FIGURE 5 is a diagrammatic sectional view of another modification of apparatus of this invention.

Referring to the drawings in detail, apparatus of this invention shown in FIGURES 1 and 2 comprises a rigid container **10**. A rod or shaft **12** extends through the container **10** and is normally reciprocally axially movable with respect to the container **10**.

Within the container **10** and encompassing the rod **12** is a quantity of thermally responsive expansible-contractible material **14**. The material **14** may be any material which has a suitable expansion characteristic over a desired temperature range. Hovever, preferably, the material **14** is a material which remains substantially solid at all operating temperatuures thereof so that sealing means between the rod **12** and the container **10** may not be required. For such use polyethylene, polypropylene, nylon or the like has been found to be satisfactory. In the use of some solid materials within this invention, container means therefor may not be required. However, the material **14** within the container **10** may be a material which becomes a liquid when heated within the operating range of the apparatus if proper sealing means are used between the container **10** and the rod **12**.

A heater element **16** is in thermal exchange relationship with the material **14**. Herein the heater element **16** is an electric heater coil which encompasses the container **10** and is adapted to heat the container **10**, which, in turn, heats the material **14**.

A connection lead **18** joins a portion of the heater element **16** to a switch **20**. A terminal lead **22** is also joined to the switch **20**. A conductor **24** is connected to an opposite portion of the heater element **16**. The conductors **22** and **24** connect to a source of electrical energy.

The material **14** under normal temperature conditions exerts no appreciable pressure upon the rod **12**. In fact, under normal temperature conditions the material **14** may not completely fill the container **10**, as shown in FIGURE 1. Therefore, as stated above, the rod **12** is normally freely axially movable with respect to the container **10**. However, when the switch **20** is closed, as shown in FIGURE 2, the heater element **16** is energized and the thermally responsive material **14** within the container **10** is heated and expands in volume. After a given period of time, the material **14** completely fills the container **10** and applies substantial pressure upon the rod **12**, as well as upon the walls of the container **10**. Such pressure of the material **14** locks or secures the rod **12** with respect to the container **10**.

Any suitable electrical control means for energization of the heater element **16** may be employed to prevent overheating of the material **14**, thus preventing the occurrence of excessive pressures of the material **14** within the container **10**. The rod **12** may be attached to any desired suitable element or mechanism for operation therewith.

Therefore, it is understood that control apparatus of this invention comprises means by which thermal energy may be used to control the operation of forces which lock an element or mechanism against operation. The thermal energy may be controlled and provided electrically or by any other suitable means.

When it is desired to release the rod **12**, the heater element **16** is deenergized, permitting the material **14** to cool so that the material **14** contracts in volume and releases the rod **12** for axial movement thereof with respect to the container **10**.

FIGURE 3

FIGURE 3 illustrates apparatus of this invention in combination with a fluid valve **29**. The valve **29** is provided with a housing **30** which has internal portions **32** and **34** forming a valve seat **33**. A closure member **35** is normally in engagement with the valve seat **33** to close the valve **29**. The closure member **35** is urged toward the valve seat **33** by a spring **36**. The spring **36** is compressed between the closure member **35** and a wall **37** of the housing **30**. A stem **38** is atttached to the closure member **35** and extends through the wall **37** of the housing **30**.

The stem **38** also extends through a container **40** which is disposed adjacent the housing **30** and has thermally responsive expansible-contractible material **42** therein. An electric heater element **43** is in thermal exchange relationship with the material **42** within the container **40**.

A container **44** is adjacent the container **40** and may be integral therewith or attached thereto, if desired. The stem **38** extends through the container **44**. However, within the container **44** the stem **38** has a tapered portion **46** which is joined to a larger diameter portion **50**. Within the container **44** and encompassing the stem **38** is a quantity of thermally responsive expansible-contractible material **52**. An electric heater element **54** is in thermal exchange relationship with the material **52**. The stem **38** terminates adjacent the container **44**.

A normally closed limit switch **56** is positioned adjacent the end of the stem **38** and is operable to open position by the stem **38** after a given amount of axial movement thereof.

The fluid valve **29** is shown herein as being a part

of an automatically controlled heating system. Fluid flowing through the valve **29** heats the space in which a thermostatic switch **60** is located. The thermostatic switch **60** is shown connected by means of a conductor **64** to one end of a transformer winding **62**. The thermostatic switch **60** has a heat position H and a cool position C.

The heat position H of the thermostatic switch **60** is joned to the limit switch **56** by means of a conductor **66**. A conductor **68** connects the switch **56** to one end of the heater element **54**. The other end of the heater element **54** is connected to the opposite end of the transformer winding **62** by means of a conductor **70**.

A conductor **72** joins the heat position H of the thermostatic switch **60** to one end of the heater element **43**. The other end of the heater element **43** is connected to the opposite end of the transformer winding **62** by means of a conductor **76**.

Normally the thermostatic switch **60** is in its cool position C, as illustrated by a solid line. However, if the temperature of the air in contact with the thermostatic switch **60** becomes lower than a given predetermined value, the thermostatic switch **60** moves to its heat position H, as shown by a broken line. When the thermostatic switch **60** is in its heat position H, the heater element **54** and the heater element **43** are energized.

Thus, the thermally responsive material **52** within the container **44** is heated and the thermally responsive material **42** within the container **40** is heated. Therefore, there is expansion of the material **42** within the container **40** and there is expansion of the material **52** within the container **44**. Expansion of the material **52** causes a pressure to be applied upon the tapered portion **46** of the stem **38**. This pressure causes axial movement of the stem **38** in a direction toward the limit switch **56**. Such movement of the stem **38** moves the closure member **35** from the valve seat **33** of the fluid valve **29**. Such movement of the stem **38** is against the forces of the spring **36** which engages the closure member **35**. When such movement of the closure member **35** occurs in a direction from the valve seat **33**, fluid is permitted to flow through the valve housing **30**.

When the stem **38** moves to such an extent that the stem **38** engages the limit switch **56** causing opening thereof, the circuit to the heater element **54** is opened. Thus, the thermally responsive material **52** within the container **44** is permitted to cool and to contract in volume.

However, due to the fact that the heater element **43** is energized simultaneously with energization of the heater element **54**, the thermally responsive material **42** within the container **40** is also heated and expands during expansion of the material **52** within the container **44**. The expansion characteristics and quantity of the material **42** within the container **40** are so determined and energization of the heater element **43** is so governed that expansion of the material **42** applies a locking force upon the stem **38** at substantially the same time that the stem **38** moves into engagement with the limit switch **56**, causing opening thereof.

Thus, as the stem **38** reaches the limit of its travel, the stem **38** is locked in position by the expanded condition of the material **42** within the container **40**. Therefore, the closure member **35** is retained in a maximum spaced position from the valve seat **33** and the fluid valve **29** is in its maximum open position for flow of fluid therethrough.

As stated above, flow of fluid through the fluid valve **29** causes heating of the air which contacts the thermostatic switch **60**. Therefore, after the valve **29** has been in an open condition for a period of time, the thermostatic switch **60** is heated to such a degree that the switch **60** operates to its cool position C. When such operation of the switch **60** occurs, the electrical circuit to the heater element **43** is opened.

Thus, the material **42** is permitted to cool and to contract in volume. Such contraction of the material **42** releases the stem **38** and permits the spring **36** to move the closure member **35** into engagement with the valve seat **33**. The fluid valve **29** is thus again closed so that no fluid flows therethrough.

Thus, it is understood that in the apparatus of FIGURE 3 electrical energy is applied for only a limited period of time for opening of the fluid valve **29** and a reduced amount of electrical energy is required to retain the fluid valve **29** in open position. Therefore, the apparatus as shown in FIGURE 3 provides means by which a fluid heating system is accurately electrically controlled.

FIGURE 4

FIGURE 4 shows a modification of apparatus of this invention. A container **80** has thermally responsive material **82** therein. A heater element **84** is also within the container **80** and is in heat exchange relationship with the material **82**. A rod or shaft **86** extends through the container **80** and is normally movable with respect to the container **80**, as discussed above with respect to the rod **12** of FIGURES 1 and 2. The rod **86** is provided with a plurality of grooves or notches **88**. Therefore, upon expansion of the material **82** within the container **80**, pressure of the material **82** within the grooves or notches **88** and within the container **80** provides a very high degree of locking force to retain the position of the rod **86** with respect to the container **80**.

FIGURE 5

In FIGURE 5 a container **90** has a quantity of thermally expansive material **82** therein. A rotatable shaft **94** has a plurality of elongate axially extending grooves **96** within the container **90**. A heater element **98** is in heat exchange relationship with the material **92**.

During normal conditions the shaft **94** is readily rotatable. However, when the material **92** is heated and a given amount of expansion occurs, pressure of the material **92** within the container **90** and within the grooves **96** locks the shaft **94** against rotation with respect to the container **90**. Such apparatus is employed in brake or clutch mechanism or is adapted for use in other types of mechanisms.

Although the preferred embodiment of the device has been described, it will be understood that within the purview of this invention various changes may be made in the form, details, proportion and arrangement of parts, the combination thereof and mode of operation, which generally stated consist in a device capable of carrying out the objects set forth, as disclosed and defined in the appended claims.

The invention having thus been described, the following is claimed:

1. Locking apparatus for a shaft comprising:
   a rigid container,
   the shaft extending into the container and normally movable with respect thereto,
   a quantity of thermally responsive expansible-contractible material within the container encompassing the shaft and operable by expansion to completely fill all available space within the container and to apply pressure upon the shaft to retain the position of the shaft against movement thereof with respect to the container,
   heater means in thermal exchange relationship with the thermally responsive material for causing heating and expansion thereof so that upon sufficient energization of the heater means the material expands and fills all available space within the container and the pressure of the thermally responsive material within the container and upon the shaft secures the shaft against movement with respect to the container.

2. The apparatus of claim 1 in which the heater means is electrical.

3. Locking apparatus comprising:
a container,
a shaft having a portion within the container and a portion extending from the container, the shaft being normally movable with respect to the container,
a quantity of thermally responsive expansible-contractible material within the container and operable by volumetric expansion to apply pressure upon the shaft,
heater means in thermal exchange relationship with the thermally responsive material for heating thereof,
the heater means causing heating of the thermally responsive material causing expansion thereof so that the thermally responsive material fills all available space within the container and applies pressure within the container and locks the shaft against movement with respect to the container.

4. The apparatus of claim 3 in which the heater means is electrical.

5. Locking apparatus comprising:
a container,
an axially movable shaft extending through the container,
a quantity of thermally responsive expansible-contractible material within the container and operable by expansion to fill all available space within the container and apply pressure within the container and upon the shaft, such pressure securing the shaft against movement with respect to the container.

6. Locking apparatus comprising:
a rigid container,
a rotary shaft having a portion within the container and a portion extending from the container,
a quantity of thermally responsive expansible-contractible material within the container and expansible in volume to apply greatly increased pressure within the container and upon the shaft so that the shaft is locked against rotary movement with respect to the container.

7. Control mechanism for valve apparatus having a reciprocally movable closure member and a stem attached to the closure member for movement thereof, comprising:
first stationary container means encompassing the stem and provided with thermally responsive expansible-contractible material therein engageable with the stem,
electric heater means in thermal exchange relationship with the thermally responsive material in the first stationary container means,
second stationary container means encompassing the stem and provided with thermally responsive expansible-contractible material therein engageable with the stem, the stem having a shoulder portion within the second container means,
electric heater means in thermal exchange relationship with the thermally responsive material in the second container means,
electrical control means connected to the electric heater means and to a source of electrical energy, the electrical control means including means energizing both of said electric heater means, means deenergizing the second said electric heater means while continuing energization of the first said electric heater means,
said second heater means causing expansion of the material within the second container means, thus causing pressure upon the shoulder portion of the stem so that there is movement of the stem, the first said heater means causing expansion of the material in the first container means, thus causing pressure upon the stem and securing the stem with respect to the first container means after the stem is moved.

8. Locking mechanism comprising:
a container,

a quantity of thermally responsive material within the container,
a rotary shaft having a portion within the container and engageable by the material, the portion of the shaft within the container having axial grooves, the shaft being normally rotatable with respect to the container,
and means for heating the thermally responsive material for expansion thereof, expansion of the material causing the material to fill all available space within the container so that the material applies pressure upon the portion of the shaft within the container, securing the shaft against rotation with respect to the container.

9. The mechanism of claim 8 in which the means for heating the thermally responsive material is electrical.

10. Apparatus of the of the type described comprising:
a container means,
a shaft having a portion within the container means, a portion of the shaft within the container means having a shoulder portion,
thermally responsive expansible-contractible material within the container means,
heater means in thermal exchange relationship with the thermally responsive material,
control means energizing the heater means, the control means including means energizing the heater means causing expansion of the material thus applying forces upon the shoulder portion of the stem causing movement thereof with respect to the container means, the control means also including means energizing the heater means causing expansion of the thermally responsive material thus applying pressure upon the shaft to prevent movement thereof with respect to the container means.

11. Apparatus of the type described comprising:
a rigid container,
a member having a portion within the container, the member and the container being normally freely relatively movable,
a quantity of thermally responsive expansible-contractible material within the container, the thermally responsive material normally having a contracted volumetic condition which permits free relative movement between the member and the container, the thermally responsive material being expansible in volume by heat applied thereto so that the thermally responsive material fills the available space within the container and applies pressure to all internal portions of the container and to the member, so that the member and the container are not freely relatively movable.

12. Apparatus of the type described comprising:
a rigid container,
a member having a portion within the container, the member and the container being normally freely relatively movable,
pressure material within the container, the pressure material normally having a contracted volumetric condition which permits free movement between the member and the container, the pressure material being expansible in volume so that the pressure material fills the available space within the container and applies pressure to all internal portions of the container and to the member so that the member and the container are restrained against relative movement.

13. Apparatus of the type described comprising:
a rigid container,
a rotary member having a portion within the container,
thermally responsive expansible-contractible material within the container, the thermally responsive expansible-contractible material being normally contracted in volume within the container so that a negligible pressure exists within the container and upon the shaft so that the member is normally freely

rotatable with respect to the container, the thermally responsive material being expansible in volume as heat is applied thereto to apply greatly increased pressure of the material within the container and upon the member so that the member is restrained against rotary movement with respect to the container.

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