Dec. 30, 1947. J. L. TURNER 2,433,493

ELECTRICALLY HEATED BELLOWS MOTOR

Filed Oct. 15, 1943 2 Sheets-Sheet 1

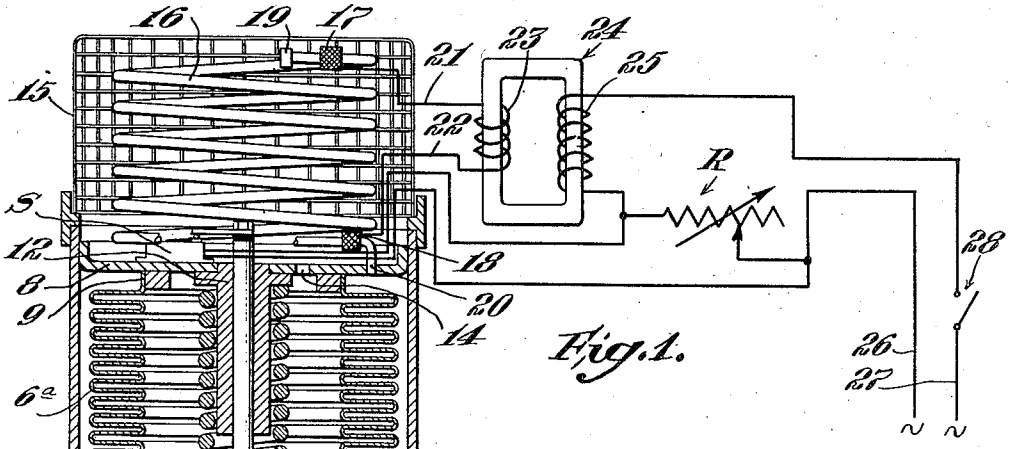


Fig. 1.

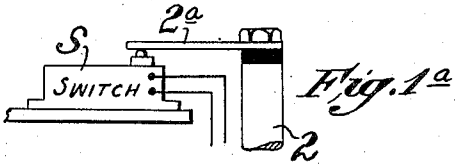


Fig. 1a

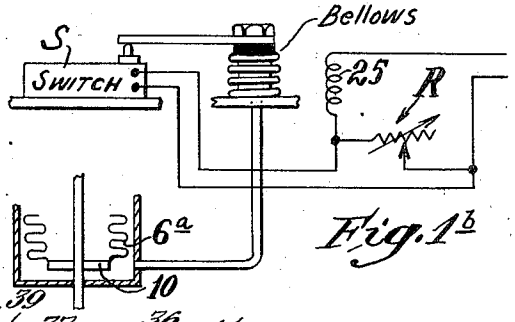


Fig. 1b

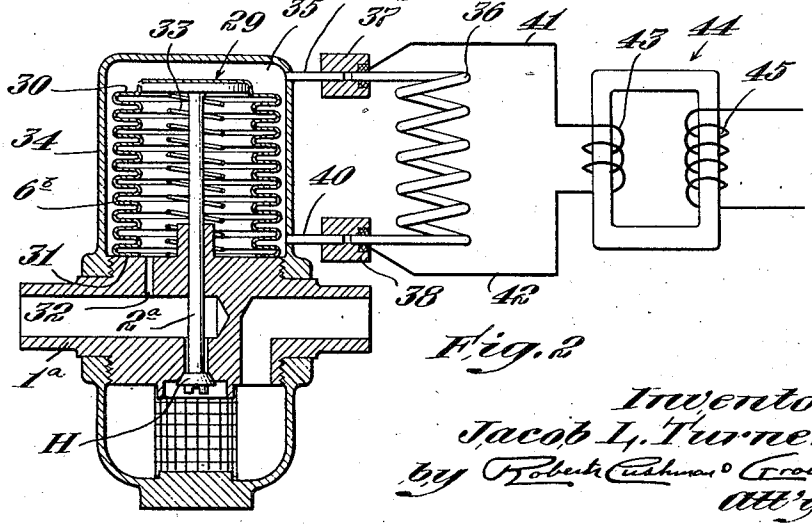


Fig. 2

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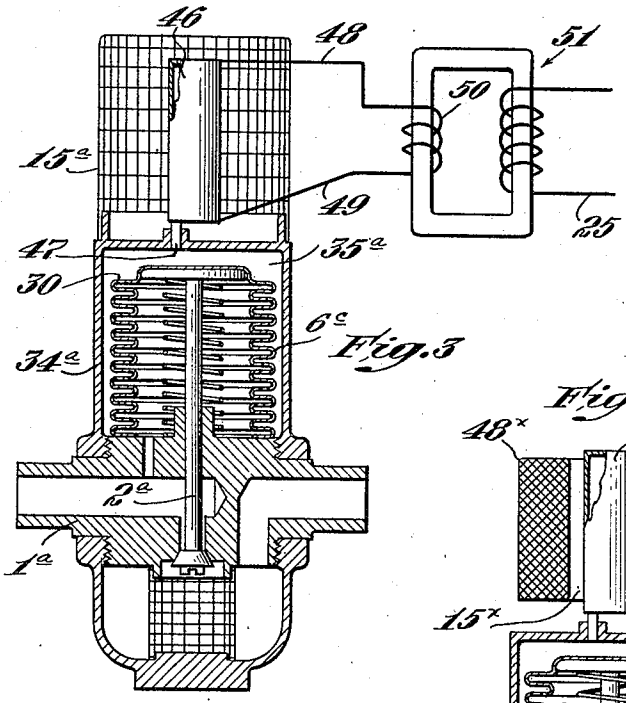
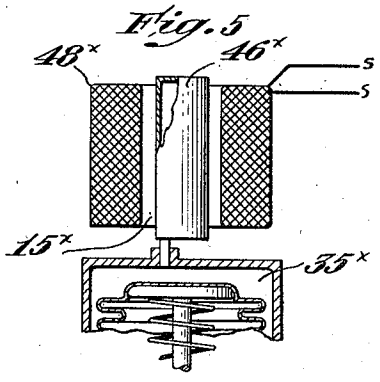


Fig. 3

Fig. 5



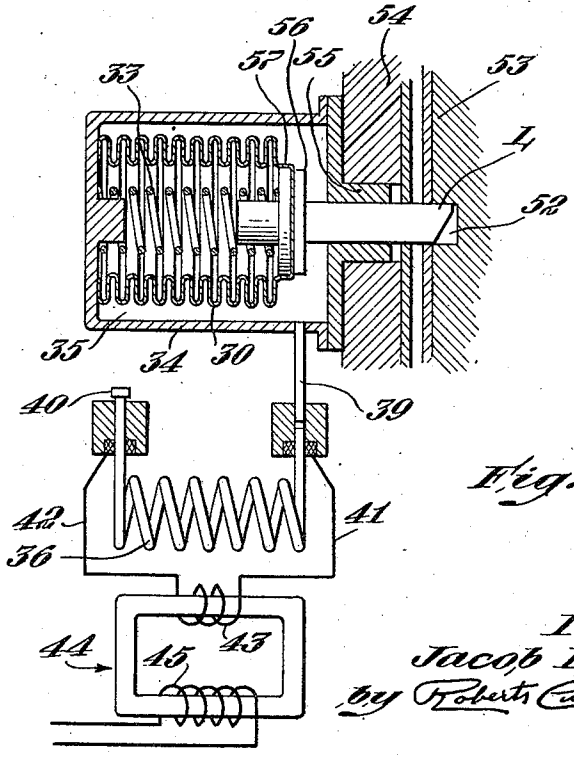


Fig. 4

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Patented Dec. 30, 1947 2,433,493

UNITED STATES PATENT OFFICE

2,433,493

ELECTRICALLY HEATED BELLOWS MOTOR

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Application October 15, 1943, Serial No. 506,439

2 Claims. (Cl. 60—25)

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This invention relates to electrically actuated control apparatus designed to operate a movable part located remotely from a control station. While of general utility, specific examples, herein chosen for illustration, but without limitation, show it as embodied in apparatus for operating a valve and a latch, respectively.

The present invention has for its principal object the provision of a remote control apparatus for valves or other devices, which may be depended upon to exert the requisite force for initiating movement of such part; which will move the part through the desired distance; and which will actuate the valve or other controlled part without substantial lag. A further object is to provide remote control apparatus including an electrically energized thermal motor which will operate with a minimum lag and in fact substantially instantaneously. Other and further objects and advantages of the invention will be pointed out in the following more detailed description and by reference to the accompanying drawings wherein

Fig. 1 is a diagrammatic elevation partly in vertical section illustrating one desirable embodiment of the invention as applied to the remote control of a valve;

Fig. 1[a] is a fragmentary diagrammatic view to larger scale illustrating the automatic switch of Fig. 1;

Fig. 1[b] is a view similar to Fig. 1[a] but illustrating a pressure-actuated automatic switch;

Fig. 2 is a view similar to Fig. 1 but illustrating a further embodiment;

Fig. 3 is a view similar to Fig. 1 but showing a still further embodiment;

Fig. 4 is a view similar to Fig. 2 but showing the invention as applied to the actuation of a latch instead of a valve; and

Fig. 5 is a fragmentary diagrammatic section illustrating an alternative way of heating the boiler shell.

Referring to the drawings the numeral 1 designates the body of a valve which may be of conventional type comprising a valve seat and valve head cooperating therewith (the seat and head not being shown) the head being secured to the lower end of a reciprocal valve stem 2 which passes through a stuffing box 3 in the valve bonnet 4 which is secured to the valve body by means of a nut 5[a]. The valve stem is reciprocated by means of a pressure motor comprising a fluid-tight casing 5 mounted on the valve bonnet 4 and comprising the bottom wall 7 and the top wall 8. Within the casing there is mounted a bellows diaphragm 6[a] whose upper end 9 is fixed to the upper wall 8 of the casing and whose lower end is secured to a head 10 which is fixed, as by welding, at 11 to the valve stem 2. A rigid sleeve device 12 is secured at its upper end to the upper wall 8 of the casing and constitutes a guide for the upper portion of

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the valve stem. A coil spring 13 embraces the sleeve 12 and engages the movable head 10 of the bellows-diaphragm, thereby tending to move the valve stem 2 downwardly. The space within the casing and exterior to the bellows diaphragm constitutes the motor chamber. The movement of the head 10 of the bellows device up or down corresponds to an increase or decrease respectively in the effective size of the motor chamber 6.

The interior of the bellows-diaphragm communicates, by means of a passage 14 in the wall 8, with the atmosphere. A protective cage 15, for example of woven wire or perforated metal, is mounted upon the upper end of the casing 5, and houses a boiler 16, here shown as consisting of a helical coil of tubing of small diameter, for example of the order of ⅛ inch in external diameter. This tubing is of a material which is resistant to the passage of electrical current and which becomes highly heated by the passage of such current. For example, the coil 16 may be a tube (of a wall thickness of for example 0.004") of iron, Nichrome, stainless steel or other alloy which is resistant to electrical current. The end portions of the coil 16 are mounted in insulating supports 17 and 18, the upper end of the coil being closed by a cap 19, while its lower end is placed in communication with the motor chamber 6 by means of a short rigid tube 20 passing through the upper wall 8 of the casing 5. The coil 16 and chamber 6 are first evacuated and then filled with a substance which expands very rapidly when heated. For example, this substance may normally be a liquid but it is a liquid which is very volatile and which assumes the gaseous condition or becomes a vapor when warmed. For example, the coil and chamber may contain methyl chloride, alcohol or ether. The opposite ends of the coil 16 are connected to the terminals 21 and 22 of the secondary 23 of a step-down transformer 24. The primary 25 of this transformer is connected to a source of electrical energy indicated by the conductors 26 and 27, the supply of current to the primary being determined by a switch 28. If desired a variable resistor R may be placed in series with the primary or secondary thereby to determine the amount of current supplied to the boiler coil 16. This variable resistor R may be arranged for manual adjustment or for automatic adjustment, as desired, or may be replaced by a fixed resistor if preferred, initially set to provide the proper amount of current, or the resistor may be dispensed with entirely under some circumstances. If a variable resistor (R—1) is placed in series with the primary of the transformer and if no switch is placed on the valve (unless the switch is a safety limit switch) and if the value of the resistance is made to change in cooperation with an automatic control system, the period of time required to heat the coil to operative temperature thus being variable so that the

valve can (within given limits) be made to modulate.

Preferably an automatic switch S, designed to respond to some desired condition, is arranged in association with the motor device and in circuit with the primary 25. For instance, such switch S may be a pressure-responsive switch Fig. 1[b] designed to cut off or reduce the current if the pressure in the boiler become excessive; or it may be a switch as here illustrated (Fig. 1[a]) comprising a commercial snap switch for example of the type known as a mu switch whose actuator pin is engageable by an arm 2[a] fixed to the upper end of the valve stem 2, thereby to prevent overtravel of the valve. Since the switch S may be of conventional type for instance, one such as is disclosed in the patent to Leupold, No. 1,780,758, November 4, 1930, it is unnecessary to describe it in further detail.

The operation of the apparatus as above described is substantially as follows:

When the switch 28 (which may be located at any desired distance from the valve 1) is closed, current is supplied to the primary 25 of the transformer thereby energizing the secondary 23 and supplying current at substantial amperage to the boiler coil 16. Since the mass of the coil is very small, the coil is thus heated substantially instantaneously and the fluid is heated very quickly and, expanding, and/or vaporizing, produces pressure in the chamber 6, thus tending to collapse the bellows-diaphragm and thus lifting the valve stem 2. When it is desired to move the valve stem in the opposite direction the switch 28 is opened thus cutting off the heating current and since the boiler coil 16 is a very open coil of large external area and small mass, it very quickly cools so that the fluid contained within it contracts thus permitting the spring 13 to move the valve stem 2 in the direction opposite to that which it was moved upon closing the switch 28.

Since the bellows-diaphragm may be made of such area as to provide almost any desired force, the arrangement may be used for the control of valves of substantial capacity and with the certainty that the valve will be actuated properly since a maximum force is available as soon as the boiler 16 has become heated.

In Fig. 2 a modified construction is illustrated wherein the valve body 1[a] is provided with a valve seat which cooperates with the valve head H carried by the valve stem 2[a]. In this instance the delivery passage of the valve communicates by a passage 32 with the interior of a bellows-diaphragm 6[b] whose lower end 31 is fixed to the valve body and whose upper end 30 is fixed to a head 29 secured to the upper end of the valve stem 2[a]. A coil spring 33 tends to move the valve head H toward its seat, while the downward movement of the head 29 opens the valve. The bellows-diaphragm is arranged within a fluid-tight case 34 mounted on the valve body and defining the expansible contractible motor chamber 35. In this instance the boiler consists of a helical coil 36 of small diameter or capillary tubing which is located entirely outside of the casing 34. The opposite ends of this boiler coil are mounted in insulating supports 37 and 38, respectively, said ends of the coil communicating with the chamber 35 by means of short tubes 39 and 40 respectively. The coil 36 is of highly resistant metal and contains a volatile fluid or gas as above described. The opposite ends of the coil 36 are connected to the terminals 41 and 42 of the secondary 43 of a transformer 44, whose primary 45 is connected to a source of electrical energy in the same way as the transformer previously described.

Referring to Fig. 3, a further arrangement is illustrated, generally similar to that of Fig. 2, for example, except as to the type of boiler employed. Thus in Fig. 3 the motor casing 34[a] houses a bellows-diaphragm 6[c] whose upper end 30 is connected to the upper end of the valve stem 2[a]. In this instance there is mounted on the upper end of the casing 34[a] a cage 15[a] similar to the cage 15 above described, within which is located a cylindrical boiler 46 whose shell consists of thin material which is highly resistant to electrical current and which becomes heated by the passage of the current. This boiler 46 is closed except for a short length of tube 47 providing communication between the interior of the boiler shell and the motor chamber 35[a] in the casing 34[a]. The opposite ends of the boiler shell 46 are connected to the terminals 48 and 49 of the secondary 50 of a transformer 51, the primary 25 of the transformer being connected to a suitable source of electrical energy as in Fig. 1, for example. The boiler 46, like the boilers 16 and 36, previously described, contains a highly volatile liquid or a gas, and when the shell is heated by the passage of electrical current the rapid expansion of the fluid produces a pressure in the chamber 35[a] thus moving the valve stem 2[a] downwardly.

In Fig. 4 a motor arrangement very similar to that of Fig. 2 is illustrated but in this instance the motor device is arranged to actuate a latch L. This latch is a reciprocal bar whose free end is designed at times to enter a socket 52 in a part 53 which is relatively movable as respects another part 54 in which is mounted a guide 55 for the shank portion of the latch L. The shank portion of the latch is secured to a part 56 which is rigidly secured to the movable head 57 of a bellows-diaphragm 30 whose other end is fixed to the end wall of a moter casing 34. A spring 33 tends to advance the latch L into the socket 52 while the movement of the bellows-diaphragm in response to pressure within the chamber 35 retracts the latch from the socket. The chamber 35 of the motor device communicates by means of a short tube 39 with one end of a tubular boiler coil 36, the other end of the coil being closed by a cap 40. This boiler coil is connected to the terminals 41 and 42 of the secondary 43 of a transformer 44. When the circuit through the primary 45 of this transformer is closed, current is supplied to the boiler coil 36, thus heating the latter very quickly and vaporizing the liquid within the boiler coil and producing a high pressure in the liquid filling chamber 35 thereby causing diaphragm 30 to retract the latch L. When the current is cut off, the boiler coil quickly cools and the spring 33 again advances the latch L into operative position.

In Fig. 5 there is shown an alternative arrangement for heating the boiler. The boiler 46[x] is connected to the valve-actuating motor substantially as in Fig. 3. However, in this instance the boiler is placed in the field of a coil 48[x]. Changing magnetic flux generated by the coil causes a potential difference between the particles of the shell of the boiler. Thus if the coil be energized by an alternating current of proper frequency and potential, a current will be induced in the boiler shell, heating it and causing the fluid therein to vaporize in a few seconds. The expanding fluid produces pressure in the motor chamber 35[x],

thus tending to collapse the bellows or diaphragm and actuate the valve. If the shell of the boiler be made of magnetic material which is highly resistant to current flow, then the heating of the boiler will be caused partly by the flow of induced current in the shell, and partly through the effect of hysteresis resultant from the rapid change in magnetic polarity of the shell. An air space 15x between the boiler shell and magnet permits rapid cooling of the boiler when current flow ceases.

It is obvious that any of the boilers herein described, as well as the means for heating them, may be employed to supply pressure fluid to the actuating motor of any desired type of remote control equipment, assuming that such equipment need not be operated absolutely instantaneously and does not require too great a force.

While the movable wall of the motor chamber has herein been illustrated as the head of a bellows-diaphragm, it is obvious that it might be constituted by a diaphragm of other type, or under some circumstances by a piston.

While certain desirable embodiments of the invention have been illustrated and described by way of example, it is to be understood that the invention is not necessarily limited to these precise embodiments, but is to be regarded as broadly inclusive of all equivalent constructions and applications of the basic principle which fall within the terms of the appended claims.

I claim:

1. In combination with a reciprocal controlled part, a pressure motor comprising a fluid-tight casing having spaced top and bottom walls, the reciprocal part passing through aligned apertures in the top and bottom walls, packing means operative to prevent leakage through the aperture in the bottom wall, the top wall being fixed and a rigid elongate guide sleeve secured at its upper end to the top wall and having a bore which constitutes a guideway for the reciprocal part, a helical coiled spring embracing the guide sleeve, a bellows-diaphragm within the casing, one end of the bellows-diaphragm being secured leak-tight to the fixed top wall of the casing, a rigid head secured leak-tight to the other end of the bellows-diaphragm, the head being movable toward and from the top wall of the casing, the space within the casing external to the diaphragm constituting a motor chamber, the top wall of the casing having an aperture providing communication between the interior of the bellows-diaphragm and the atmosphere, the aforesaid spring being arranged to urge the head away from the top wall of the casing, means connecting the head to the reciprocal controlled part, a cylindrical coil of tubing of lesser external diameter than that of the casing, coaxial with the guide sleeve and located above the fixed top wall of the casing, said coil being of a material of high electrical resistance, one end of the bore of said tubing communicating with the motor chamber, means closing the other end of the coil of tubing, the coil and motor chamber being filled with a normally liquid, volatile material, insulating means supporting the coil, a rigid protective cage mounted upon the top wall of the casing and which houses the coil, a step-down transformer whose secondary is in series with a part at least of the coil, means for varying the current supplied to the primary of the transformer, and a switch for controlling the flow of current through the primary of the transformer.

2. Apparatus of the class described comprising in combination with an elongate reciprocal controlled part, a fixed support having therein a guide bore for said reciprocal part, a fluid-tight casing having spaced top and bottom walls, the bottom wall being provided with an aperture for the passage of the reciprocal part and being welded leak-tight to the support, a rigid guide sleeve fixed at its upper end to the top wall of the casing and depending into the casing, the bore of said sleeve being coaxial with the bore in the support, a bellows-diaphragm within the casing, said diaphragm having a rigid head secured leak-tight to its lower end, said head being spaced from the bottom of the casing and movable toward and from the bottom of the casing, the upper end of the bellows-diaphragm being secured leak-tight to the underside of the top wall of the casing, the latter having an orifice providing for free access of atmospheric air to the interior of the bellows diaphragm, the reciprocal part passing through the bore in the support and through the casing and into the bore in the tubular guide sleeve, means fixing the lower head of the bellows-diaphragm to the reciprocal part whereby movement of the lower head of the bellows-diaphragm reciprocates said part, a coil spring embracing the tubular guide sleeve and having its lower end abuttting the lower head of the bellows-diaphragm thereby tending to expand the diaphragm, an open coil of tubing of a high electrical resisting material mounted upon the top wall of the casing, the coil being electrically insulated from the casing, the tube forming the coil having a thin wall and the coil being of small mass whereby it heats quickly when traversed by current and cools quickly when the current is cut off, the lower end of the bore of said tube communicating with the space within the casing exterior to the bellows-diaphragm, the bore of the coil and said space being filled with a volatile liquid, means for protecting the coil from mechanical injury while admitting free circulation of air about the coil, means closing the upper end of the coil, a step-down transformer whose secondary is in series with a portion at least of said coil of tubing, a variable resistor for controlling the current supplied to the primary of the coil, a switch for controlling the flow of current through the coil of tubing, and means operative, when the movable head of the bellows-diaphragm reaches a predetermined point in its travel away from the bottom wall of the casing, to actuate the switch, thereby to break the circuit through the coil of tubing.

JACOB L. TURNER.

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