Sept. 1, 1942. W. A. RAY 2,294,694

CONTROL SYSTEM

Filed June 7, 1940

Fig. 1

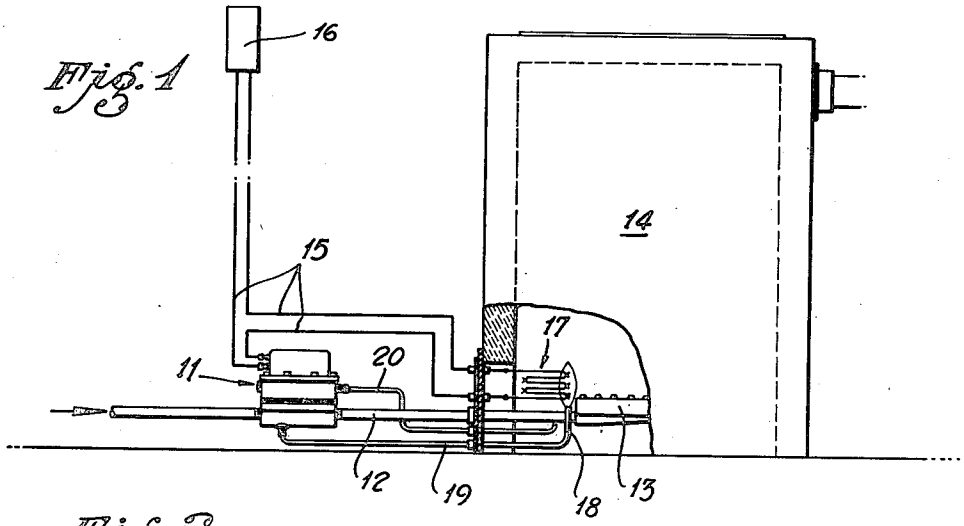
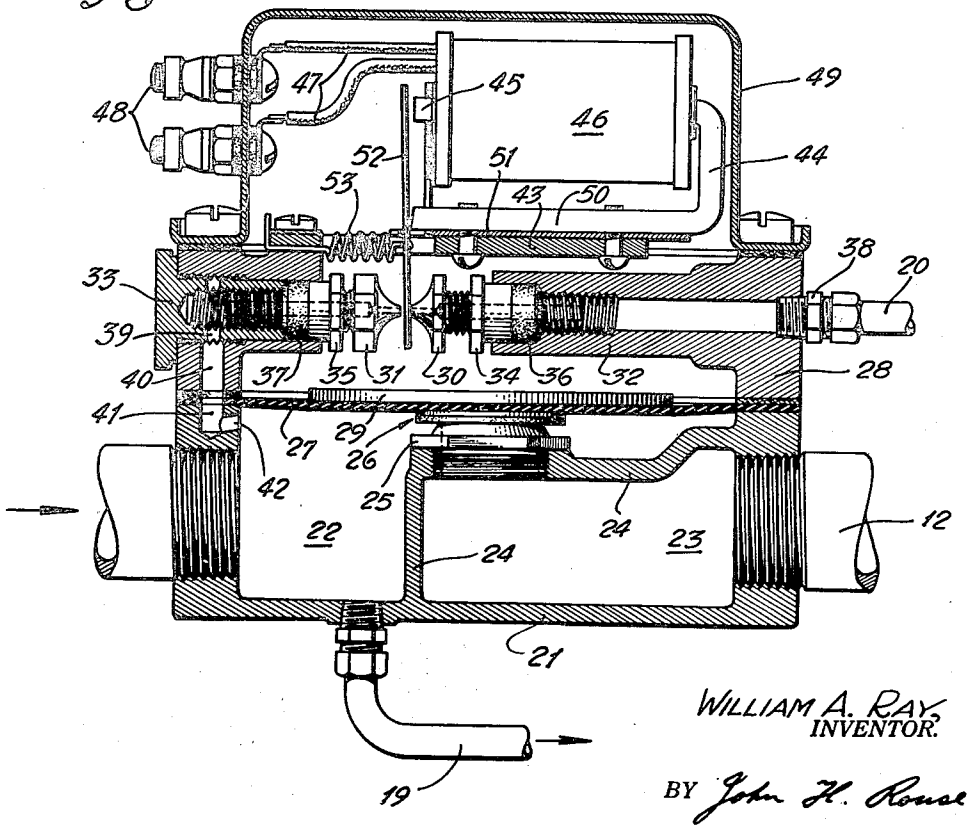


Fig. 2



WILLIAM A. RAY,
INVENTOR.

BY John H. Rouse,
ATTORNEY

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CONTROL SYSTEM

William A. Ray, Glendale, Calif.

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5 Claims. (Cl. 158—117.1)

My present invention relates to control systems and particularly to a system for controlling, from a remote position, the operation of a gas burner valve which is energized by thermoelectric power.

In the prior art, it is known that a fuel control valve may be operated by thermoelectric power. However, such operation is limited to a system in which the thermoelectric device, the valve, and its controlling switch are electrically interconnected by relatively short copper wire of large diameter. The employment of such connecting wire, in the systems disclosed, is essential, as in most instances only a single thermoelectric couple is provided, the voltage normally produced by which is very low—of the order of 10 to 20 millivolts when the thermocouple is constructed of preferred dissimilar materials which are adapted to be subjected to an ordinary gas flame, such as: Copper-"Constantan," "Chromel"-"Constantan," or "Chromel"-"Copel." The voltage being low, the current must necessarily be relatively high when there is sufficient power generated by the thermocouple to operate the electromagnet of the system. It is desirable that the thermoelectric device be such as can be operated by very small fuel consumption, as by the flame of an ordinary pilot burner. Accordingly, the resultant power generated is of the minutest quantity—of the order of 5 to 20 milliwatts. This maximum power can be attained by matching the resistance of the load, i. e., the control electromagnet, to the resistance of the source. This requires, when the thermoelectric device has a voltage of the order of 10 to 20 millivolts, as in the above example, that the current flow be 0.25 to 2 amperes for maximum power drawn from the source. A large proportion of the power is lost in the connecting wires if their resistance is other than very low. As will be pointed out hereinafter, extending the length of the system to 50 or 100 feet has a tremendous effect upon the efficiency of the system. This is primarily due to the very minute available power (at best, at very minute potential). For this reason, the prior art systems described hereinabove have been adapted only for local control, for example: the control of a boiler burner by a switching device responsive to the temperature of the boiler water, as is shown in the British patent to Askania-Werke, No. 441,686. In that patent, a plurality of thermocouples are disclosed, but they are arranged in parallel and therefore the total voltage produced by them is equal to that of a single thermocouple. As early as the year 1897, automatic operation of a thermoelectrically energized fuel control valve was proposed by Franke in his United States Patent No. 581,707. However, in his system which relates to the control of incandescent illuminating burners, the parts are only separated by a few inches and so no problem of transmission of power is there involved.

In the British patent to Lenning, No. 351,712, and in the Austrian patent to Kleidorfer, No. 124,350, a plurality (4 and 6, respectively) of series-interconnected thermocouples are shown. However, in both of these patents, only a local "manual reset" system is taught, wherein a thermoelectrically energized electromagnet is employed for maintaining a gas valve in open condition when it is first so conditioned by manual means, no switching means being included. The system of Lenning is intended for use in gas-heated refrigerating apparatus or water heaters, and that of Kleidorfer in a cookstove.

The main feature of the systems described above is that of safety—the valves of these systems being arranged to close upon the cessation of thermoelectric power which results when the flame, to which the thermoelectric device is subjected, is extinguished. Another feature, when the system is designed for automatic control of a gas valve, is the elimination of the requirement for an external source of electrical power, the connection of which usually requires the services of a licensed electrician in addition to those of the gas appliance installer.

Heretofore, however, it has not been taught how a thermoelectrically energized gas burner valve could be controlled from a point remote from the valve and the thermoelectric device—as, for example, in a system for heating a space which is at a substantial distance from the heating unit or furnace, and the temperature of which space it is desirable to automatically control by a thermostat.

The main obstacle to the extension of the controlling switch or thermostat of the prior art systems to a distance of, say, 100 feet, has been the excessive electrical loss in the line connecting the thermostat with the valve and the thermoelectric device. As has been stated hereinabove, the reason for this excessive loss, when ordinary wiring is employed, is the relatively high current which this wiring must carry when the voltage of the electrical source is very low. As has been stated, the voltage of a thermocouple, composed of materials adapted to be heated by an ordinary gas flame, is approximately 10 to 20 millivolts,

and the power required for the operation of a sensitive electromagnetic valve operator is 5 to 20 milliwatts. Taking, for example, the values of 20 millivolts and 10 milliwatts, and setting the permissible I^2R loss in the line at 2.5 milliwatts (25 per cent of the power), it is found that for a two-conductor line 100 feet in length, copper wire slightly larger than No. 0000 A. W. G. (0.460" diam.) would be required. This is calculated on the basis of 200 feet of wire, having a total resistance at 20° C. of 0.0098 ohm, through which 0.5 ampere is flowing. Obviously, it would be entirely impracticable to employ such wire. In low-voltage high-current circuits, losses due to the contact-resistance of switching devices are also very high.

In view of the hereinabove described deficiencies of the prior art thermoelectric control systems, it is a main object of my present invention to provide an improved system wherein a thermoelectrically energized gas burner valve is efficiently controllable from a point remote from the valve and the thermoelectric device, when the devices are connected with the remote point by ordinary electrical wiring.

I primarily accomplish this object by increasing the voltage of the thermoelectric device; without, however, increasing its power, so that the amount of fuel required for its generation remains the same. The advantage of such a change is not obvious until consideration is taken of the fact that the loss in a given line or resistance is not in direct proportion to the amount of current flowing therein, but to the square of the current, as is represented by the electrical power equivalent I^2R. As an example: in a given circuit, if the voltage is increased 12 times, and the amperage correspondingly reduced 12 times, the resistance of the line, or the cross-sectional area of the conductor, can be reduced 144 times with the same loss therein resulting.

Referring back to the power loss example given above, by increasing the voltage 12 times as the only change, the following values are obtained: voltage, 0.240; wattage, 0.010; permissible line loss, 0.0025 watt. From these values, the required size of copper wire is found to be slightly smaller than No. 18 A. W. G. (0.040" diam.); the 200 feet of such wire having a resistance of 1.227 ohms and the current flowing through it now being only 0.042 ampere. Such wire is of a preferred size for low voltage wiring, the size of ordinary "bell" wire being No. 16 to No. 19 A. W. G. In the examples given above, the "hot" resistance of a thermoelectric generator composed of a single pair of relatively massive short elements, plus the resistance of the length of large-diameter copper wire necessary for connecting the generator with a valve two or three feet distant, is approximately 0.015 ohm. The hot resistance of a 12-couple thermopile may be of the order of 2 ohms, as its elements must be of smaller mass so as to be effectively heated by a similar small flame. The respective electromagnet loads may be arranged to have resistances approximately equivalent to those of their sources.

Another object of my invention is the provision of simple, dependable and effective means for accomplishing the above-stated object.

Other objects and advantages of the invention will be found in the description, the drawing, and the appended claims.

This application is a continuation-in-part of my copending applications: Serial No. 222,673, filed August 2, 1938; and Serial No. 279,220, filed June 14, 1939.

For complete understanding of the invention, reference may be had to the following detailed description and accompanying drawing, wherein:

Figure 1 is a mainly diagrammatic view of a gas burner control system embodying my invention; and

Figure 2 is an enlarged sectional view of the electrically operated valve shown in Fig. 1.

Referring first to Fig. 1 of the drawing, the numeral 11 indicates an electrically operated valve adapted to control gas flow through a conduit 12 to a main burner 13 located in a furnace 14. Electrically connected in circuit with the valve, by wires 15, is a thermostat 16 and a thermoelectric device 17 comprising a plurality of series-interconnected thermocouples, the hot junctions of which are arranged to be heated by the flame of a constantly burning pilot burner 18, which is connected by a pipe 19 with the inlet of the valve 11; a vent pipe for this valve, extending within the furnace chamber, being indicated at 20.

In the constructional view of the valve 11, shown in Fig. 2, the numeral 21 indicates a valve casing having an inlet 22 and an outlet 23 separated by a partition 24. Threaded in an opening formed in this partition is a hollow valve seat member 25, cooperable with which is a valve member 26 carried by a flexible diaphragm 27 which is secured at its margin between the connecting side walls of the casing 21 and an upper valve casing section 28. A plate 29, secured to the valve member, serves to stiffen the center portion of the diaphragm and to gravity-bias the valve member.

Provided in the upper casing section 28 are pilot valve jet members 30 and 31, the member 30 being threaded in a hollow inner extending portion 32 of the section, and the member 31 being carried by a capped sleeve 33 threaded in a thickened portion of an end wall of the section. The jets 30 and 31 are sealingly locked in adjusted position by nuts 34 and 35, and packing members 36 and 37, respectively. Threaded in the open outer end of the hollow portion 32 is a fitting 38 for the connection of the vent pipe 20. The sleeve 33 is provided with lateral openings 39 communicating with aligned passages 40 and 41 formed in the connecting side walls of the casing section and the casing, a branch passage 42 connecting these passages with the valve inlet 22.

Mounted on an apertured plate 43, secured to the section 28, is an electromagnet comprising a U-shaped core 44 which carries on its free upper arm 45 an energizing coil 46, the leads 47 of which are connected to terminals 48, insulatingly mounted in a side wall of a housing 49, covering the open upper end of the casing section. Fulcrumed on the lower arm 50 of the core, and guided in the apertured end portion of a metal strip 51 interposed between the arm 50 and the plate 43, is an armature 52, the lower end portion of which is normally held in engagement with the jet 30 by the force of a compression spring 53 and is movable therefrom into engagement with the other jet 31 when the upper end portion of the armature is attracted toward the end of core arm 45 upon passage of current in coil 46.

The valve shown in Fig. 2 is adapted to be operated by the pressure of the fluid controlled by it. Assuming that the valve is connected to supply fuel to a burner, as shown in Fig. 1, when

the armature is in its unattracted position as shown, fluid can flow from the inlet **22**, through passages **42**, **41** and **40**, opening **39**, and the open jet member **31**, to the space above the diaphragm **27**; which space is now otherwise sealed, the outlet jet **30** being closed by the armature. The fluid pressure on either side of the diaphragm thus being the same, the main valve member **26** is held in engagement with its seat by its own weight and that of plate **29**. If the electromagnet core is energized, the armature is attracted, closing jet **31** and opening jet **30**. The fluid compressed above the diaphragm can now escape through the vent pipe **20** to the atmosphere, permitting the fluid pressure below the diaphragm to open the main valve.

The valve shown in Fig. 2 (and claimed in my copending application, Serial No. 279,220, referred to above) is particularly adapted for use in the system of my present invention on account of its sensitivity, electrical power of less than 10 milliwatts being required for the control of a ½" I. P. S. valve. The main reason for such sensitivity is the small surface area, surrounding the opening in the jet member, with which the armature engages. The diameter of the tip of the jet member may be as small as 0.035 inch, and that of the outer end of its opening 0.028 inch or less. Thus, sufficient armature pressure to tightly close the jet can be produced with minimum expenditure of power. The quantity of gas passing through the vent **20** when the valve is operated to open, is very small due to the small displacement of the valve diaphragm **27**. Accordingly, the accumulation of foreign matter, carried by the gas, in harmful amounts in the various passages of the valve structure is greatly retarded.

While, on account of its sensitivity, a pilot-controlled pressure-operated valve is preferred, sensitive direct operated valves, such as, for example, the valve disclosed in my copending application, Serial No. 326,022, filed March 26, 1940, can also be employed when the burner gas consumption is not very great.

The general operation of the heating control system shown in Fig. 1 should be apparent to those skilled in the art: the burner being automatically turned on and off, upon energization of the valve, according to the demand of the thermostat **16**. As is indicated by the break in the thermostat line, the thermostat is intended, if desired, to be located at some point distant from the furnace, as in a separate space or room heated thereby. As has been pointed out in the preamble, the distance from the valve (or furnace), at which this point may be, is dependent mainly on the voltage produced by the thermoelectric device **17**. When this device is arranged to generate power at a relatively elevated voltage, due to the series connection of the thermocouple, the controlling thermostat **16** or the valve **11** may be placed at the most desirable location, remote from the burner **13**. Thus there is no material restrictive limit to the use of the system for controlling temperatures at a distance from the source of heat; by the aid of this invention, it is entirely practicable to utilize a thermoelectric generator of minute power (such as can be obtained from the small flame of an ordinary pilot burner) and to fulfill the requirements of ordinary room heating systems.

As diagrammatically shown, the device **17** is composed of but three series-interconnected thermocouples. However, in practice, I have found that at least eight thermocouples, of the most efficient stable materials at present available (such as, "Copel" and "Chromel") are required when the thermostat is to be at a point 50 feet distant from the valve and connected therewith by ordinary wiring. Obviously, when it is desired to increase that distance, still higher voltage (or number of thermocouples) is called for.

Particularly adapted to the practice of my invention, is the "Pilot generator" disclosed in the copending application of William R. Ray, Serial No. 225,075, filed August 15, 1938. This device is a combination pilot burner and thermoelectric device, comprising twelve series-connected thermocouples arranged around a central burner tube, The voltage output of the device is approximately 0.240.

Even when a thermoelectrically energized device is to be locally controlled by switching means, there is advantage in the use of a plurality of series-connected thermocouples on account of the relatively high contact resistance of the average control device. Even a mercury tube switch of standard manufacture, rated at 5 amps. capacity, may have a "contact" resistance as high as 0.03 ohm, which would introduce a substantial loss when the current carried by it is relatively high and the available power low.

By my present invention, I have taught that, under normal conditions, it is not (as it might seem) necessary to increase the power output of a thermoelectric device (with corresponding increase in the consumption of fuel) when it is desired to extend its circuit controlling device to a distance—but merely to increase the voltage output, and correspondingly decrease the current.

I claim as my invention:

1. In a heating control system for a room: a furnace for heating said room and remote therefrom; a burner for said furnace; a valve for controlling the supply of fluid fuel to said burner and located in the vicinity of said furnace; sensitive electrically operated means associated with said valve for controlling the operation thereof; a thermoelectric generating device for energizing said electrically operated means and subjected to the heat of combustion of fuel adjacent said burner; a thermostat in said room; and a circuit composed of ordinary electric house wiring and interconnecting the electrically operated means, the thermoelectric device and said thermostat; said thermoelectric device being of such size and capacity that it can be properly heated by a small flame such as that of an ordinary pilot burner, and comprising a plurality of thermocouples interconnected in electrical series to produce a voltage that is relatively high so that the current required for the operation of said means is low and the power loss in said wiring is correspondingly low.

2. In a heating control system for a room: a furnace for heating said room and remote therefrom; a burner for said furnace; a valve for controlling the supply of fluid fuel to said burner and located in the vicinity of said furnace; sensitive electrically operated means associated with said valve for controlling the operation thereof; a thermoelectric generating device for energizing said electrically operated means and subjected to the heat of combustion of fuel adjacent said burner; a thermostat in said room; and a circuit composed of ordinary electric house wiring and interconnecting the electrically operated means, the thermoelectric device and said thermostat; said thermoelectric device being formed of not

less than six thermocouples arranged in series-aiding relation, and being of such size that it can be properly heated by a small flame such as that of an ordinary pilot burner.

3. In a heating control system for a room: a furnace for heating said room and remote therefrom; a burner for said furnace; a valve for controlling the supply of fluid fuel to said burner and located in the vicinity of said furnace; sensitive electrically operated means associated with said valve for controlling the operation thereof; a thermoelectric generating device for energizing said electrically operated means and subjected to the heat of combustion of fuel adjacent said burner; a thermostat in said room; and a circuit composed of ordinary electric house wiring and interconnecting the electrically operated means, the thermoelectric device and said thermostat; said thermoelectric device being of such size and capacity that it can be properly heated by a small flame such as that of an ordinary pilot burner, and comprising a plurality of thermocouples arranged in series-aiding relation to generate at least 120 millivolts, the power capacity of the thermoelectric device being of the order of ten milliwatts.

4. In a heating control system for a room: a furnace for heating said room and remote therefrom; a burner for said furnace; a valve for controlling the supply of fluid fuel to said burner and located in the vicinity of said furnace; sensitive electrically operated means associated with said valve for controlling the operation thereof; a thermoelectric generating device for energizing said electrically operated means and subjected to the heat of combustion of fuel adjacent said burner; a thermostat in said room; and a circuit composed of ordinary electric house wiring and interconnecting the electrically operated means, the thermoelectric device and said thermostat; said thermoelectric device being of such size and capacity that it can be properly heated by a small flame such as that of an ordinary pilot burner, and comprising a plurality of thermocouples arranged in series-aiding relation to generate voltage so high that the current required for the operation of said means is low and the power loss in said wiring, when said thermostat is located at a point as remote as 50 feet from the thermoelectric device, does not exceed 25 per cent of the power consumed by said means.

5. In a heating control system for a room: a furnace for heating said room and remote therefrom; a main burner for said furnace; a pilot burner for said main burner; a valve for controlling the supply of fluid fuel to said main burner and located in the vicinity of said furnace; sensitive electrically operated means associated with said valve for controlling the operation thereof; a thermoelectric generating device for energizing said electrically operated means and heated by the flame of said pilot burner; a thermostat in said room; and a circuit composed of ordinary electric house wiring and interconnecting the electrically operated means, the thermoelectric device and said thermostat; said thermoelectric device comprising a plurality of thermocouples interconnected in electrical series to produce a voltage that is relatively high so that the current required for the operation of said means is low and the power loss in said wiring is correspondingly low.

WILLIAM A. RAY.