

Jan. 15, 1935.

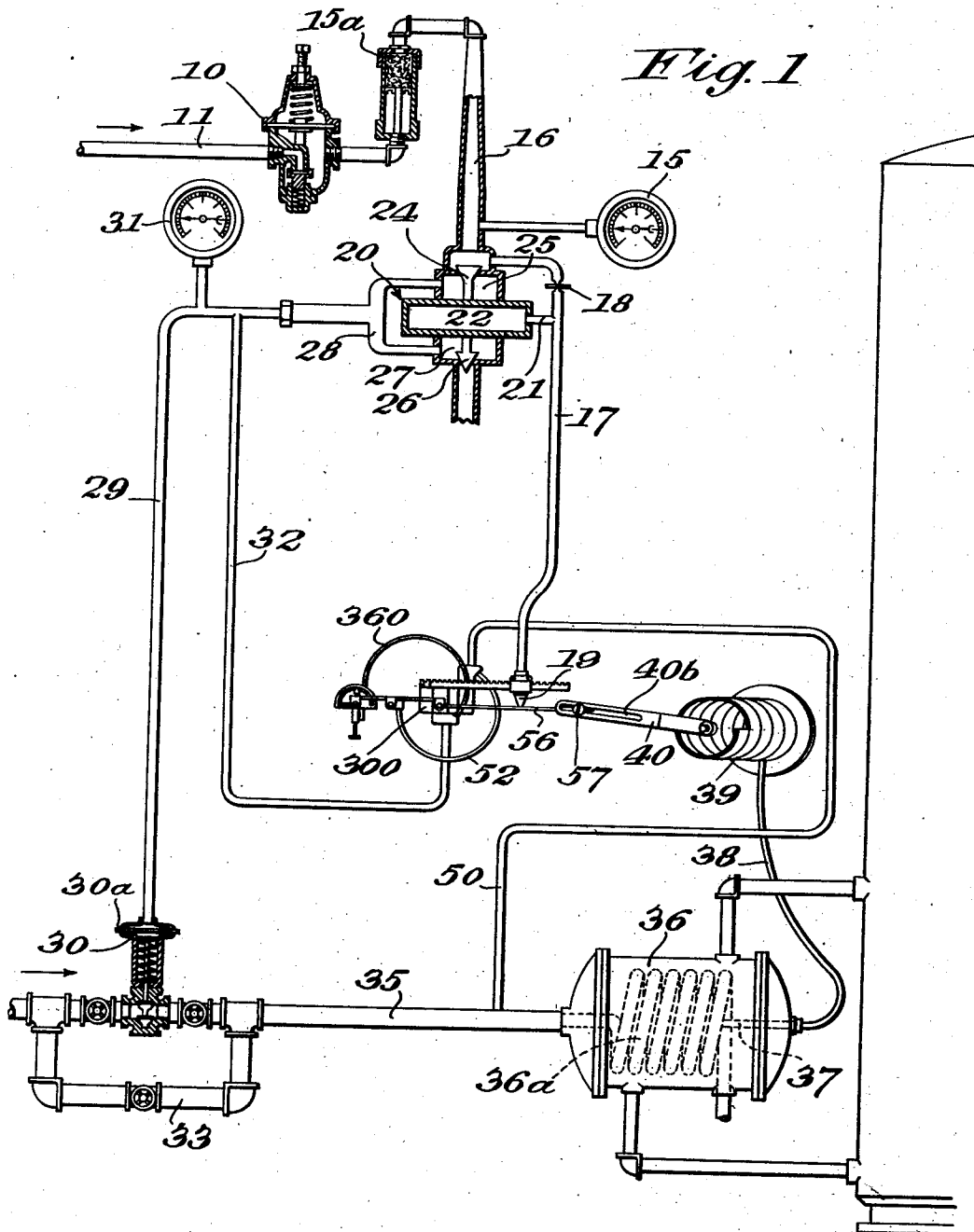
D. H. ANNIN

1,988,348

CONTROL INSTRUMENT

Filed Aug. 26, 1933

2 Sheets-Sheet 1



Inventor:
By *Douglas L. Annin*
Maxwell Cohn Copeland & Dike
Attorneys.

Jan. 15, 1935.

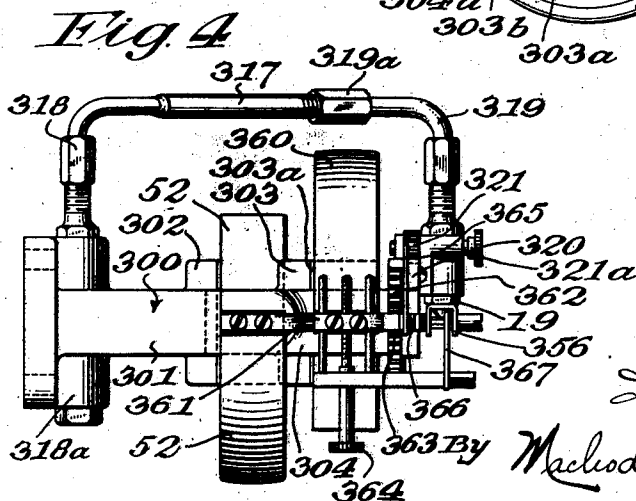
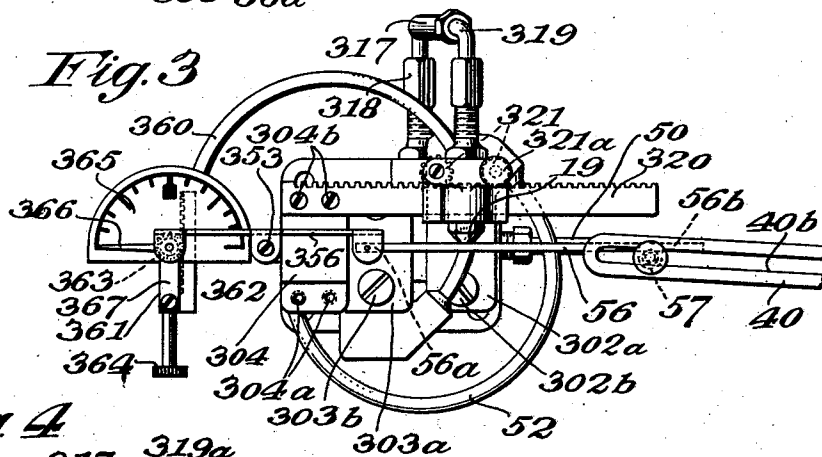
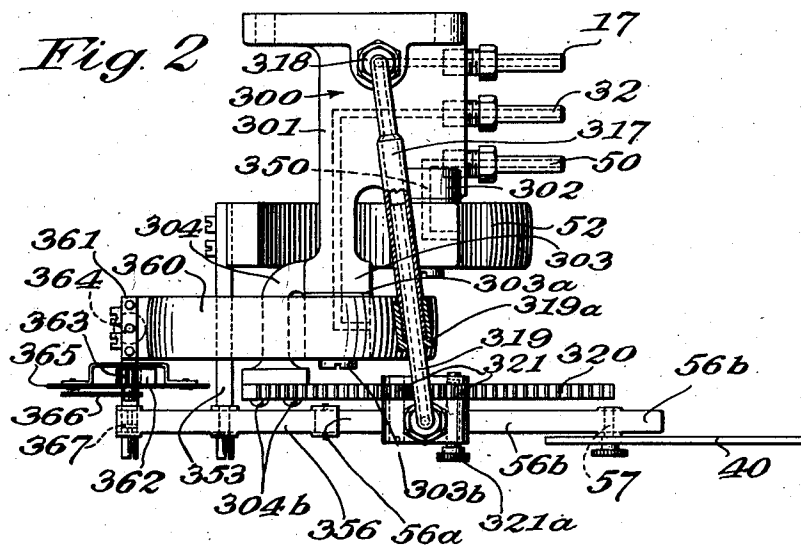
D. H. ANNIN

1,988,348

CONTROL INSTRUMENT

Filed Aug. 26, 1933

2 Sheets-Sheet 2



Inventor:

Douglas H. Annin
and Calvin Copeland & Dike
Attorneys.

Method, Calm, Copeland & Dike
Attorneys.

Attorneys.

UNITED STATES PATENT OFFICE

1,988,348

CONTROL INSTRUMENT

Douglas H. Annin, Brookline, Mass., assignor, by mesne assignments, to Eldon Macleod, Westwood, Mass., Frank A. Morrison, Newton, Mass., Cameron Macleod, Berwyn, Pa., Leslie Soule, Dedham, Mass., and Sullivan A. Sargent, Jr., Needham, Mass., trustees, doing business as Mason-Neilan Regulator Company, Boston, Mass.

Application August 26, 1933, Serial No. 686,949

23 Claims. (Cl. 236-18)

This invention relates to control instruments, and more particularly to a dual control instrument having compensation from the operating pressure.

A dual control instrument in the sense used herein, is one in which an operating pressure is used to operate a valve which controls the flow of a processing medium, such as steam or fuel, and the valve is controlled by the joint and resultant action of two instruments, one responsive to changes in the physical condition of the processing medium, and the other responsive to changes in the physical condition of the processed medium. Much of the fluctuation in the processed medium has been found to be due to previous fluctuations in the processing medium (the steam), and the purpose of the dual control is to anticipate and compensate for the fluctuations in the processing medium before they have resulted in fluctuations in the processed medium. Such an instrument is shown in Dahl application Serial No. 635,356, filed September 29, 1932. The invention herein includes a dual control instrument, which in addition is provided with compensation from the operating pressure which compensates or checks the action of the instrument responsive to changes in the physical condition of the processed medium. The purpose of the operating pressure compensation is to provide an immediate and effective check to the movement of the flapper in relation to the exhaust orifice of the pressure system operating the control valve, by movement in the opposite direction, thereby preventing "hunting" and achieving more accurate control over the controlled or processed medium. By looking at Fig. 1 for instance it will be obvious that considerable time may elapse before a change in control valve setting is reflected in a changed temperature of the processed medium and the thermostat, while the change in the pressure operating the control valve is immediately effective to change the flapper setting.

Another feature of the invention lies in the adjustable mounting which permits wide adjustments to be made in one instrument to meet all conditions in the field, and to provide varied control action in response to the changes in the physical conditions of the media being controlled.

Specifically, I have shown my invention adapted to temperature control in a steam heated installation, similar to that shown in Dahl application Serial No. 635,356, above, but it is to be understood that the invention is not so limited,

and in fact is readily adaptable to any dual control instrument wherein the compensation feature is desirable.

The steam heated installation comprises briefly a tank for containing raw gasoline or other substance to be thermally controlled and a pipe or steam coil in the tank for heating the gasoline. A control valve on the steam line controls the admission of steam to the coil in the tank. A temperature responsive instrument or thermostat in the gasoline tank is connected to a Bourdon tube which moves one end of the flapper lever with respect to an exhaust orifice, and a second Bourdon tube responsive to pressure is connected to the steam line below the control valve. A third Bourdon tube is connected to the operating pressure line leading to the control valve on the steam line. The two Bourdon tubes responsive to the pressure of the steam and to the operating pressure operate jointly by their resultant effect to move the fulcrum at the other end of the flapper lever. Thus the position of the flapper lever in relation to the exhaust orifice of the pilot valve mechanism operated by the independent pressure system is controlled by the joint and resultant effect of all three responsive instruments, which in turn controls the amount of operating pressure supplied to the control valve on the steam supply line and so the amount of steam supplied to the heating tank.

The position of the exhaust orifice of the pilot valve mechanism in a plane substantially parallel with the flapper lever is made adjustable by a rack and pinion arrangement which permits increased or decreased control action as desired in response to the changes in the physical conditions of the media being controlled, and the fulcrum position at one end of the flapper lever is likewise adjustable by another rack and pinion arrangement which permits relative adjustment between the operating positions of the two Bourdon tubes responsive respectively to the pressure in the steam line and to the pressure operating the control valve.

Before explaining in detail the present invention it is to be understood that the invention is not limited in its application to the details of construction and arrangement of parts illustrated in the accompanying drawings, since the invention is capable of other embodiments and of being practiced or carried out in various ways. Also it is to be understood that the phraseology or terminology employed herein is for the purpose of description and not of limitation.

tation, and it is not intended to limit the invention claimed herein beyond the requirements of the prior art.

In the drawings:

5 Fig. 1 is a diagrammatic view of my compensated dual control mechanism as adapted for temperature control in a steam heated installation.

10 Fig. 2 is a plan view of my adjustable mounting for the control mechanism.

Fig. 3 is a front elevation of the same adjustable mounting, and

Fig. 4 is a side elevational view from the left of Fig. 3 of the same mounting.

15 In Fig. 1, showing the invention diagrammatically, 10 represents a mechanism for maintaining an adequate and constant pressure of air or other gas for operating the independent pressure system, and as this mechanism forms no part of the invention claimed it need not be described in detail. The air or gas is supplied through pipe 11 and is suitably filtered as shown at 15a, the pressure gauge 15 indicating the operating pressure. The air passes down pipe 16 leading to a pilot valve mechanism 20. A branch pipe 17, which may be regarded as flexible and having a restricted orifice 18 by-passes the stream of air and ordinarily exhausts it to the atmosphere through exhaust orifice 19 at the lower end of branch pipe 17. A flapper lever 56, which is actuated by the three responsive instruments constitutes the adjustable mounting 300, to be later described in more detail, operates to close the exhaust orifice 19 and thereby build up pressure in branch pipe 17 below the restricted orifice 18.

Branch pipe 17 connects with a pilot valve mechanism 20 through the pipe 21 below the restricted orifice 18 which leads into a central diaphragm chamber 22. A stem 24 abutting the top side of the diaphragm chamber 22 forms a valve between pipe 16 and chamber 25. A similar stem 26 abutting the bottom side of the diaphragm chamber 22 forms an exhaust valve between the chamber 27 and the atmosphere. Both chambers are connected on the outside by pipe 28 which leads through pipe 29 to the control valve 30. A gauge 31 connected to pipe 29 records the pressure in said pipe. Pipe 32 connects the operating pressure in pipe 29 to the Bourdon tube 360 of the adjustable control mounting 300 to be later described. Control valve 30, which is preferably a diaphragm motor valve and is here shown as direct acting, but may be direct or reverse acting as desired, controls the admission of steam or other heating medium to the heating tank 36.

On the closing of exhaust orifice 19, pressure in diaphragm chamber 22 builds up, forcing valve 26 closed and valve 24 open, allowing pressure from pipe 16 to enter directly into chamber 25, flow through connecting pipe 28 into chamber 27 and equalize the pressures therein. When pressure in chamber 25 balances the force in central chamber 22, valve 24 closes to prevent pressure in 25 from increasing. Air pressure in pipes 28 and 29 as in a closed chamber immediately reacts on the diaphragm 30a to partially close control valve 30 permitting less steam to flow into the heating tank 36. At the same time air pressure reacts through pipe 32 on the Bourdon tube segment 360 to provide compensation, as later described.

75 Steam or other heating medium is supplied

to the heating vessel 36 through pipe 35, the steam flowing through coils 36a arranged therein. A by-pass 33 is provided on steam line 35 around control valve 30, to be used when desired. In the vessel 36 is the raw gasoline or other substance being thermally controlled. A thermostat 37 or other temperature responsive instrument containing an expansible fluid is provided in the vessel 36 and connects through pipe 38 to the coil 39 rigidly fixed at one end. The coil 39 may be helical, spiral, or a segment of a Bourdon tube or other device responsive to pressure (i. e. pressure responsive when thermostat 37 contains an expansible fluid). A pipe 50 connected to steam line 35 conveys the steam pressure to the second Bourdon tube 52, which in this instance is pictured as a segment.

The adjustable mounting 300 for the control mechanism is shown as actually used in Figs. 2, 3 and 4. It consists of a main frame member 301 preferably of cast aluminum for supporting the exhaust orifice 19 and flapper lever 56 and the two pressure responsive tubes which in part control their operation. The pipe 17 connects through the frame member 301 to a pipe connection 317 leading to exhaust nozzle 19. Pipe 317 is free to swivel in a socket 318 and the exhaust orifice 19 is made free to travel longitudinally along flapper lever 56 by a rack and pinion mounting comprising the rack 320 and pinions 321, and can be locked in position by screw 321a. To permit longitudinal extension of a pipe 317 as it travels on its rack and pinion mounting, the exhaust end 319 of pipe 317 is slidable in a sleeve 319a and in which the necessary stuffing is provided to prevent leakage of air. Rack 320 is detachably mounted as by screws 304b at one end to arm 304 of the main frame member 301. Pipe 317 can likewise be attached at bottom socket 318a and rack 320 is likewise reversible by using bottom threaded holes 304a. Pipe 50 connects the steam pressure in steam supply line 35 to the Bourdon tube segment 52 welded to a base member 302a which in turn is detachably mounted by suitable means as threaded screws 302b upon the arm 302 of the main frame member 301. A conduit 350 is provided through the member 301 for conducting the steam pressure to tube 52. The free end of tube segment 52 supports an arm 353 which constitutes a movable fulcrum for the arm 356 which is a longitudinal extension of flapper lever 56. Pipe 32 conveys the operating pressure which operates the control valve 30 to a third Bourdon tube segment 360 welded to a base member 303a which in turn is detachably mounted as by screws 303b to the arm 303 of main frame member 301. At its free end Bourdon tube 360 carries an arm 361 adjustably extensible in the same or tangential direction from the free end of Bourdon tube 360 by means of a rack and pinion arrangement comprising rack 362 and pinion 363 movable by means of a set screw 364. A dial 365 likewise attached to the free end of Bourdon tube 360 and a pointer 366 movable with pinion 363 indicates the amount of movement of arm 361 to and from the free end of Bourdon tube 360. An arm 367 rigidly supported at the front end of arm 361 extends upwardly to a distance about normally parallel with the arm 353 of Bourdon tube 352, and pivotally supports at its upward end one end of an arm 356. Arm 356 therefore is pivotally supported at one end by the arm 367, the position of which is vertically adjustable by

means of the rack and pinion arrangement 362 and 363, and is supported at the center by arm 353 of Bourdon tube 52. At its other end arm 356 pivotally supports flapper lever 56 at the latter's end 56a. The purpose of the rack and pinion arrangement attached to the free end of Bourdon tube 360 is to provide relative adjustment for the compensation to be provided by the operating pressure through Bourdon tube 360. At its other end 56b flapper lever 56 carries a pin 57 slidable in slot 40b provided longitudinally in the arm 40 rigidly attached to the free end of the temperature responsive tube 39. Thus it will be seen that the position of the end 56a of flapper lever 56 is determined by the joint or resultant effect of movement in the Bourdon tubes 52 and 360 once the adjustment of arm 361 has been fixed through the set screw 364, and the position of the end 56b of flapper lever 56 is determined by the movement in temperature responsive tube 39. Thus the position of flapper lever 56 with respect to exhaust orifice 19 is determined by the joint and resultant effect of the three instruments, responsive respectively to the temperature in the tank, the pressure of the steam supplying heat to the tank and of the pressure operating the control valve.

The operation of the device is as follows:

As the temperature in vessel 36 rises the expansive fluid in the thermostat 37 increases its pressure and unwinds Bourdon tube 39, which acting through arm 40 raises flapper lever 56 as to partially close orifice 19. Air pressure in pipe 17 below the restriction 18 then expands into diaphragm chamber 22 to divert the operating pressure through chamber 25 and pipe 29 to the diaphragm motor valve 30, shown here as a direct acting valve so that the air pressure partially closes it. This decreases the flow of heating medium through pipe 35 and further temperature rises at thermostat 37 is prevented. On a decrease in temperature, the action is opposite. Since fluctuations in the pressure in the heating medium likewise will cause a corresponding change in the temperature of the controlled medium, gasoline in the tank 36, these fluctuations are connected through pipe 50 to Bourdon tube 52 to change the position of the arm 353 and consequently the relative position of the flapper lever 56 with respect to the orifice valve 19. Here again an increase in the steam pressure through pipe 50 causes Bourdon tube segment 52 to unwind raising arm 53 and flapper lever 56, partially closing exhaust orifice 19, which in turn partially closes valve 30 and decreases the flow of heating medium. A decrease in the pressure of the steam works oppositely and valve 30 opens to supply more steam. Because in all installations, there will be a time lag in the response of the temperature conditions as indicated by thermostat 37 to a resetting of motor valve 30, resulting in a further lag before the flapper position relative to the exhaust orifice 19 is reset, I have placed an instrument responsive to the operating pressure, which works in an opposite direction from the instrument responsive to the pressure of the heating medium and to the temperature responsive device, and whose action is immediately effective on the flapper setting. The setting of the flapper valve as actuated by changes in temperature in the tank and changes in pressure in the heating medium is immediately compensated or counteracted by the operating pressure without waiting for the impulse to come through the

thermostat and coil 39, or coil 52. As temperature in the tank 36 rises and flapper 56 moves upwardly through the action of Bourdon tube 39 to partially close exhaust orifice 19, and the operating pressure builds up to operate control valve 30, the operating pressure is immediately conveyed to Bourdon tube segment 360 to lower flapper 56 and partially open exhaust orifice 19. On a decrease in temperature in tank 36, the action of Bourdon tube 360 is opposite. Likewise changes in the position of flapper lever 56 induced by changes in the pressure of the heating medium through pipe 50 and Bourdon tube 52 are likewise opposed by the action of Bourdon tube 360 acting in opposite direction thereto. Therefore any time-lag after the motor valve is operated and before the result is manifested in the changed physical condition of the controlling and controlled media, does not result in "hunting" or over-travel because the original impulse of the pilot control mechanism is off-set or compensated before the over-travel occurs. Thus the compensating action from the operating pressure stabilizes the control instrument and prevents the usual wide fluctuation, rendering this type of control extremely accurate.

The mounting 300 is completely adjustable for all types of installations met in the field, so that only one mounting is required to meet all conditions. Thus the positions of the pressure tubes and of the orifice and flapper are reversible by means of the detachable connections according to where a heating or cooling medium is being used, and where a direct acting or reverse acting control valve 30, which is closed or opened by the operating air pressure, is used. Four combinations are thus possible, both pressure tubes coiling over frame 301, both under, one under and the other over, as in Figs. 2, 3 and 4, and vice versa. At the same time, the range of control in one type of instrument is variable by means of the rack and pinion mountings for the exhaust orifice 19, and the effect produced by the operating pressure compensation is likewise adjustable by the rack and pinion mounting attached to the free end of Bourdon tube 360.

I claim:

1. A control mechanism of the class described, comprising a medium to be controlled, a second medium in controlling relationship thereto, a control valve governing the supply of said second medium, a pilot mechanism utilizing an independent source of pressure for operating said control valve and ordinarily exhausting to the atmosphere, an exhaust valve governing the exhaust from said mechanism, means responsive to the resultant effect of a variable characteristic of each medium for actuating said exhaust valve, and means for counteracting the movement of said exhaust valve.

2. A control mechanism of the class described, comprising a medium to be controlled, a second medium in controlling relationship thereto, a control valve governing the supply of said second medium, a pilot mechanism utilizing an independent pressure system for operating said control valve and ordinarily exhausting to the atmosphere, an exhaust valve governing the exhaust from said system, means for diverting said pressure to operate said control valve on the closing of said exhaust valve, joint means responsive to a variable characteristic in each medium for actuating said exhaust valve through the resultant action of said characteristics, and means in said pressure system for

counteracting the movement of said exhaust valve.

3. A control mechanism of the class described, comprising a medium to be controlled, a second medium in controlling relationship thereto, a control valve governing the supply of said second medium, a pilot mechanism utilizing an independent pressure system for operating said control valve and ordinarily exhausting to the atmosphere, an exhaust valve governing the exhaust from said system, a supply and waste valve in the pressure system, diaphragm mechanism acted on by said pressure and actuating said valve to divert said pressure to the control valve for operating the same on the closing of said exhaust valve, joint means responsive to changes in a variable characteristic in each medium for actuating said exhaust valve through the resultant action of said characteristics, and means responsive to the pressure in said pressure system for counteracting the movement of said exhaust valve.

4. A control mechanism of the class described, comprising a medium to be controlled, a second medium in controlling relationship thereto, a control valve governing the supply of said second medium, a pilot mechanism utilizing an independent pressure system for operating said control valve and ordinarily exhausting to the atmosphere, an exhaust valve governing the exhaust from said system, an instrument responsive to a variable characteristic in the controlling medium, another instrument responsive to a variable characteristic of the controlled medium, joint means operated by the resultant action of said instruments for actuating the exhaust valve of the independent pressure system, and means responsive to the pressure in said pressure system for counteracting the movement of said exhaust valve.

5. A control mechanism of the class described, comprising a medium to be controlled, a second medium in controlling relationship thereto, a control valve governing the supply of said second medium, a pilot mechanism utilizing an independent pressure system for operating said control valve and ordinarily exhausting to the atmosphere, an exhaust valve governing the exhaust from said system, means for diverting said pressure to operate said control valve on the closing of said exhaust valve, an instrument responsive to a variable characteristic of the controlling medium, another instrument responsive to a variable characteristic of the controlled medium, joint means operated by the resultant action of said instruments for actuating the exhaust valve of the independent pressure system, and means responsive to the pressure in said pressure system for counteracting the movement of said exhaust valve.

6. A control mechanism of the class described, comprising a medium to be controlled, a second medium in controlling relationship thereto, a control valve governing the supply of said second medium, a pilot mechanism utilizing an independent pressure system for operating said control valve and ordinarily exhausting to the atmosphere, an exhaust valve governing the exhaust from said system, a supply and waste valve in the pressure system, diaphragm mechanism acted on by said pressure and actuating said valve to divert said pressure to the control valve for operating the same on the closing of said exhaust valve, an instrument responsive to a variable characteristic of the con-

trolling medium, an instrument responsive to a variable characteristic of the controlled medium, joint means operated by the resultant action of said instruments for actuating the exhaust valve of the independent pressure system, and means responsive to the pressure in said pressure system for counteracting the movement of said exhaust valve.

7. A thermal control mechanism, comprising a medium being thermally controlled, a second medium in thermally controlling relationship thereto, a control valve governing the supply of said second medium, an independent pressure system for operating said control valve, an instrument responsive to temperature of the controlled medium, an instrument responsive to pressure of the controlling medium, means operated by the resultant action of the two instruments to control said independent pressure system, and means for counteracting the operation of said pressure system on the control valve.

8. A thermal control mechanism, comprising a medium to be thermally controlled, a second medium in thermally controlling relationship thereto, a control valve governing the supply of said second medium, a pilot mechanism utilizing an independent source of pressure for operating said control valve and ordinarily exhausting to the atmosphere, an exhaust valve governing the exhaust from said pilot mechanism, means responsive to the resultant effect of temperature of the controlled medium and of the pressure of the controlling medium for actuating said exhaust valve, and means responsive to the pressure in said pressure system for counteracting the movement of said exhaust valve.

9. A thermal control mechanism, comprising a medium to be thermally controlled, a second medium in thermally controlling relationship thereto, a control valve governing the supply of said second medium, a pilot mechanism utilizing the independent pressure system for operating said control valve and ordinarily exhausting to the atmosphere, an exhaust valve governing the exhaust from said system, means for diverting said pressure to operate said control valve on the closing of said exhaust valve, joint means responsive to the temperature of the controlled medium and the pressure of the controlling medium for actuating said exhaust valve through the resultant action of said temperature and pressure, and means responsive to the pressure in said pressure system for counteracting the movement of said exhaust valve.

10. A thermal control mechanism comprising a medium to be thermally controlled, a second medium in thermally controlling relationship thereto, a control valve governing the supply of said second medium, a pilot mechanism utilizing an independent source of pressure for operating said control valve and ordinarily exhausting to the atmosphere, an exhaust valve governing the exhaust from said mechanism, a supply and waste valve in the said mechanism, diaphragm mechanism acted on by said pressure and actuating said valve to divert said pressure to the control valve for operating the same on the closing of the exhaust valve, joint means responsive to the resultant effect of the temperature of the controlled medium and of the pressure of the controlling medium for actuating said exhaust valve, and means responsive to the pressure in said pressure system for counteracting the movement of said exhaust valve.

11. A thermal control mechanism comprising

a medium to be thermally controlled, a second medium in thermally controlling relationship thereto, a control valve governing the supply of said second medium, a pilot mechanism utilizing
 5 an independent source of pressure for operating said control valve and ordinarily exhausting to the atmosphere, an exhaust valve governing the exhaust from said pilot mechanism, an instrument responsive to the temperature of the controlled medium, another instrument responsive
 10 to the pressure of the controlling medium, joint means operated by the resultant action of said instruments for actuating the exhaust valve of the independent pressure system, and means responsive to the pressure in said pressure system for counteracting the movement of said exhaust valve.

12. A thermal control mechanism comprising a medium to be thermally controlled, a second medium in thermally controlling relationship thereto, a control valve governing the supply of said second medium, a pilot mechanism utilizing an independent source of pressure for operating said control valve and ordinarily exhausting
 25 to the atmosphere, an exhaust valve governing the exhaust from said mechanism, means for diverting said pressure for operating said control valve on the closing of said exhaust valve, an instrument responsive to the temperature of the controlled medium, another instrument responsive to the pressure of the controlling medium, joint means operated by the resultant action of said instruments for actuating the exhaust valve
 30 of the independent pressure system, and means responsive to the pressure in said pressure system for counteracting the movement of said exhaust valve.

13. A thermal control mechanism comprising a medium to be thermally controlled, a second medium in thermally controlling relationship thereto, a control valve governing the supply of said second medium, a pilot mechanism utilizing an independent source of pressure for operating said control valve and ordinarily exhausting
 45 to the atmosphere, an exhaust valve governing the exhaust from said mechanism, a supply and waste valve in the pressure mechanism, diaphragm mechanism acted on by said pressure and actuating said valve to divert said pressure to the control valve for operating the same on
 50 the closing of the exhaust valve, an instrument responsive to the temperature of the controlled medium, another instrument responsive to the pressure of the controlling medium, joint means operated by the resultant action of said instruments for actuating the exhaust valve in the pressure mechanism, and means responsive to the pressure in said pressure system for counteracting the movement of said exhaust valve.

14. A thermal control mechanism comprising a medium to be thermally controlled, a second medium in thermally controlling relationship thereto, a control valve governing the supply of said second medium, a pilot mechanism utilizing
 65 an independent source of pressure for operating said control valve and ordinarily exhausting to the atmosphere, an exhaust valve governing the exhaust from said mechanism, a movable flapper for supporting said exhaust valve, a lever supporting said flapper at one end, a second lever supporting said flapper at its other end, an instrument responsive to the temperature of the controlled medium, a coil actuated by the temperature responsive instrument for moving the
 70 first flapper supporting lever, a coil actuated by

the pressure of said second medium for moving said second flapper supporting lever, and so actuating the exhaust valve of the independent pressure system through the resultant action of said coils, a third coil responsive to the pressure
 5 of the independent pressure system for counteracting the movement of said exhaust valve as actuated by the first two coils.

15. In a control mechanism of the type described, a coil assembly comprising a main frame member, an exhaust valve, a flapper governing the exhaust from said valve, a lever supporting said flapper at one end, a second lever supporting said flapper at its other end, a pressure responsive coil mounted on said frame and forming
 15 at its free end a point of support for said second flapper lever, and a second pressure responsive coil mounted on said frame forming at its free end a second point of support for said second flapper lever.

16. In a control mechanism of the type described, a coil assembly comprising a main frame member, an exhaust valve, a flapper governing the exhaust from said valve, a lever supporting said flapper at one end, means for moving said
 25 exhaust valve longitudinally along said flapper, a second lever supporting said flapper at its other end, a pressure responsive coil mounted on said frame and forming at its free end a point of support for said second flapper lever, a second pressure responsive coil mounted on said frame forming at its free end a second point of support for said second flapper lever, and means for varying the setting of the second point of support as actuated by said second pressure coil.

17. In a control mechanism of the type described, a coil assembly comprising a main frame member, an exhaust valve, a flapper governing the exhaust from said valve, a lever supporting said flapper at one end, detachable rack and pinion means for moving said exhaust valve
 40 longitudinally along said flapper, a second lever supporting said flapper at its other end, a pressure responsive coil mounted on said frame and carrying an arm forming at its free end a point of support for said second flapper lever, a second pressure responsive coil detachably mounted on said frame and forming at its free end a second point of support for said second flapper lever, and means for varying the setting of said second point of support as actuated by said second pressure coil.

18. In a control mechanism of the type described, a coil assembly comprising a main frame member, an exhaust valve, a flapper governing the exhaust from said valve, a lever supporting said flapper at one end, detachable rack and pinion means for moving said exhaust valve
 55 longitudinally along said flapper, a second lever supporting said flapper at its other end, a pressure responsive coil mounted on said frame and carrying an arm forming at its free end a point of support for said second flapper lever, a second pressure responsive coil detachably mounted on said frame and forming at its free end a second point of support for said second flapper lever, an angle arm in tangential extension from the free end of said second coil forming a second point of support for said second flapper lever, a set screw and rack and pinion means for varying the setting of said second point of support of said second flapper lever.

19. A control mechanism of the class described, comprising a medium to be controlled, a second medium in controlling relationship
 75

thereto, a control valve governing the supply of said second medium, a pilot mechanism utilizing an independent pressure system for operating said control valve and ordinarily exhausting to the atmosphere, an exhaust valve governing the exhaust from said system, said pilot mechanism including a casing, a pair of diaphragms dividing said casing into two outer chambers and an inner chamber, a supply valve and a waste valve in said outer chambers governing the supply of waste and pressure in said system, said pressure expanding said inner chamber and actuating said supply and waste valves to divert said pressure to the control valve for operating the same on the closing of said exhaust valve, joint means responsive to a variable characteristic in each medium for actuating said exhaust valve through the resultant action of said characteristics, and means in said pressure system for counteracting the movement of said exhaust valve.

20. A control mechanism of the class described, comprising a medium to be controlled, a second medium in controlling relationship thereto, a control valve governing the supply of said second medium, a pilot mechanism utilizing an independent pressure system for operating said control valve and ordinarily exhausting to the atmosphere, an exhaust valve governing the exhaust from said system, said pilot mechanism including a casing, a pair of diaphragms dividing said casing into two outer chambers and an inner chamber, a supply valve and a waste valve in said outer chambers governing the supply of waste and pressure in said system, said pressure expanding said inner chamber and actuating said supply and waste valves to divert said pressure to the control valve for operating the same on the closing of said exhaust valve, an instrument responsive to a variable characteristic in the controlling medium, another instrument responsive to a variable characteristic of the controlled medium, joint means operated by the resultant action of said instruments for actuating the exhaust valve of the independent pressure system, and means responsive to the pressure in said pressure system for counteracting the movement of said exhaust valve.

21. A thermal control mechanism, comprising a medium to be thermally controlled, a second medium in thermally controlling relationship thereto, a control valve governing the supply of said second medium, a pilot mechanism utilizing the independent pressure system for operating said control valve and ordinarily exhausting to the atmosphere, an exhaust valve governing the exhaust from said system, said pilot mechanism including a casing, a pair of diaphragms dividing said casing into two outer chambers and an inner chamber, a supply valve and a waste valve in said outer chambers governing the supply of waste and pressure in said system, said pressure expanding said inner chamber and actuating

said supply and waste valves to divert said pressure to the control valve for operating the same on the closing of said exhaust valve, joint means responsive to the temperature of the controlled medium and the pressure of the controlling medium for actuating said exhaust valve through the resultant action of said temperature and pressure, and means responsive to the pressure in said pressure system for counteracting the movement of said exhaust valve.

22. A thermal control mechanism comprising a medium to be thermally controlled, a second medium in thermally controlling relationship thereto, a control valve governing the supply of said second medium, a pilot mechanism utilizing an independent source of pressure for operating said control valve and ordinarily exhausting to the atmosphere, an exhaust valve governing the exhaust from said mechanism, said pilot mechanism including a casing, a pair of diaphragms dividing said casing into two outer chambers and an inner chamber, a supply valve and a waste valve in said outer chambers governing the supply of waste and pressure in said system, said pressure expanding said inner chamber and actuating said supply and waste valves to divert said pressure to the control valve for operating the same on the closing of said exhaust valve, joint means responsive to the resultant effect of the temperature of the controlled medium and of the pressure of the controlling medium for actuating said exhaust valve, and means responsive to the pressure in said pressure system for counteracting the movement of said exhaust valve.

23. A thermal control mechanism comprising a medium to be thermally controlled, a second medium in thermally controlling relationship thereto, a control valve governing the supply of said second medium, a pilot mechanism utilizing an independent source of pressure for operating said control valve and ordinarily exhausting to the atmosphere, an exhaust valve governing the exhaust from said pilot mechanism, said pilot mechanism including a casing, a pair of diaphragms dividing said casing into two outer chambers and an inner chamber, a supply valve and a waste valve in said outer chambers governing the supply of waste and pressure in said system, said pressure expanding said inner chamber and actuating said supply and waste valves to divert said pressure to the control valve for operating the same on the closing of said exhaust valve, an instrument responsive to the temperature of the controlled medium, another instrument responsive to the pressure of the controlling medium, joint means operated by the resultant action of said instruments for actuating the exhaust valve of the independent pressure system, and means responsive to the pressure in said pressure system for counteracting the movement of said exhaust valve.

DOUGLAS H. ANNIN.