Feb. 14, 1933. N. HILGERS 1,897,845

CONTROL SYSTEM

Filed Sept. 16, 1930

Fig. 1.

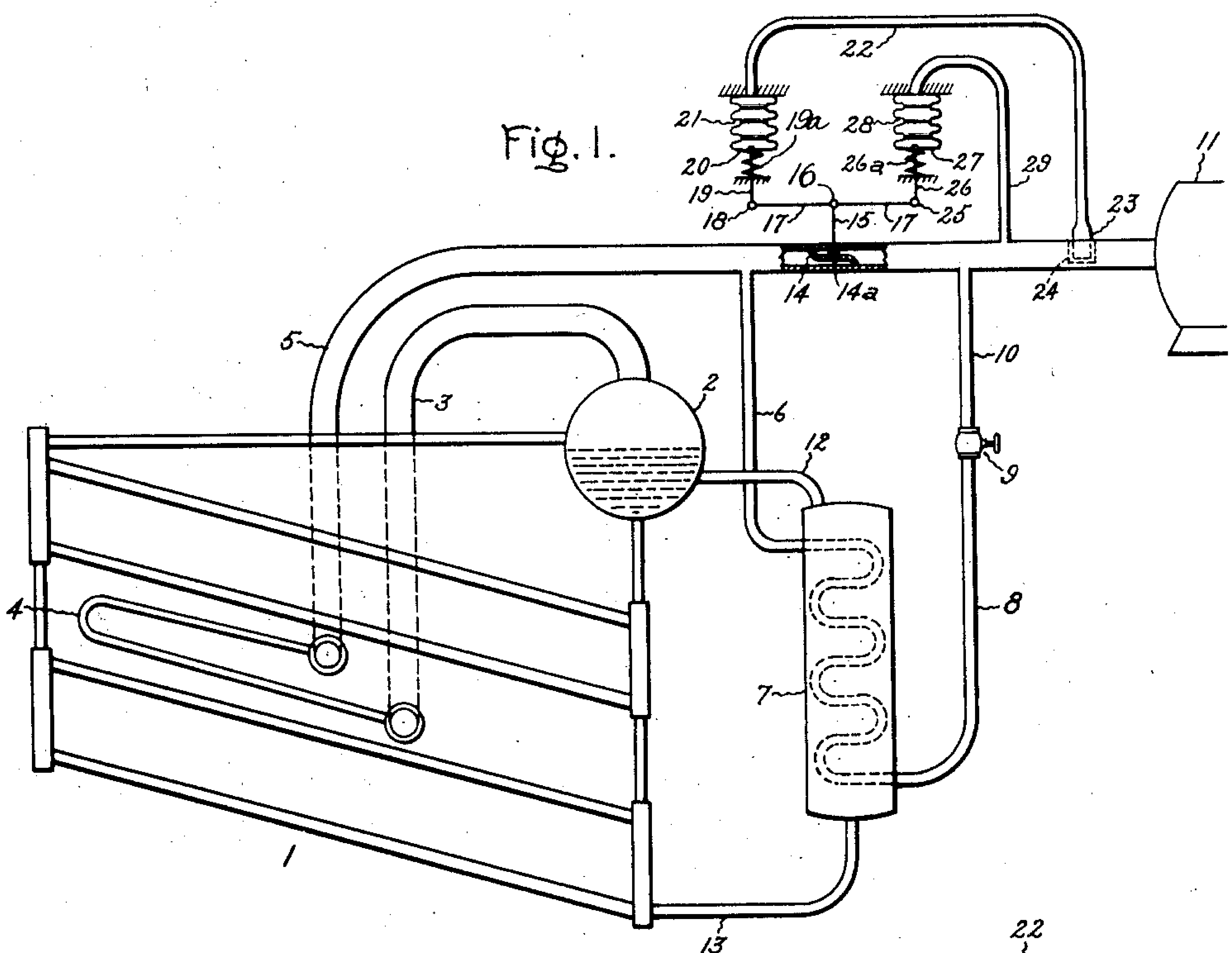
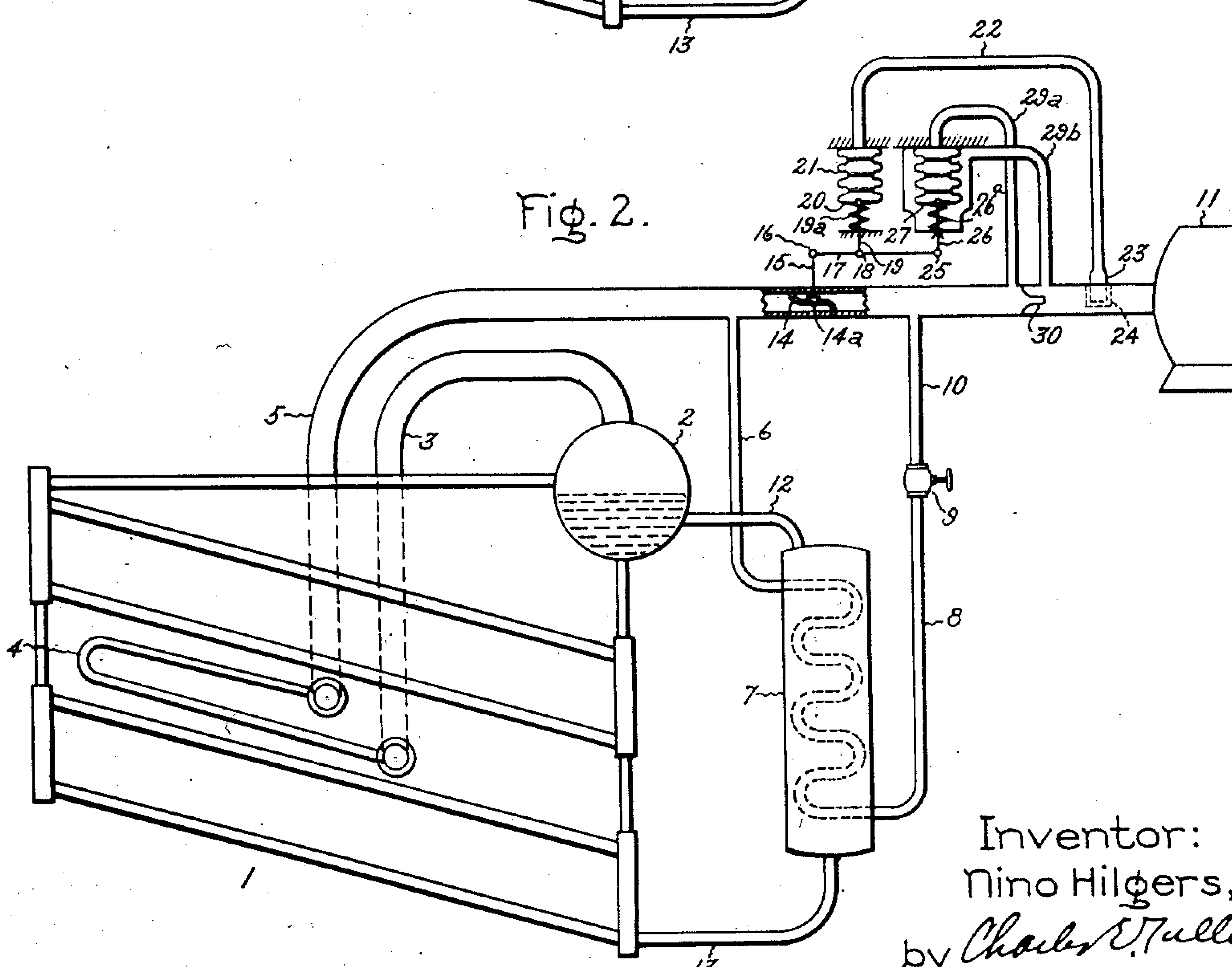


Fig. 2.



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UNITED STATES PATENT OFFICE

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CONTROL SYSTEM

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In the regulation or control of factors of a flowing fluid which vary as the result of variations in the rate of flow or independently through some external cause, it is often true that a factor other than the one which it is desirable to control is the first to vary, and variations in the factor to be controlled may be anticipated or checked sooner if the actual regulation of the factor which is to be controlled is accomplished by means sensitive to variations in another factor.

My invention relates to an improved control system wherein this fact is made use of to accomplish regulation of a factor varying with operation of an apparatus.

As an example, but in no wise a limitation, I have chosen to illustrate and describe the control of the temperature of steam to a turbine.

In modern steam power stations it is advisable to use as high steam temperatures as possible for the thermal advantage to be gained and to keep down the moisture content of the steam in the low pressure stages of the turbine without the necessity of expensive and complicated intermediate reheating. The allowable temperature may be limited, however, by the strength and temperature-resisting properties of the materials of construction. Thus it is desirable to have the steam temperature lie between certain limits and serious damage might result if the temperature of the steam were allowed to exceed the predetermined maximum or minimum limits. These limits may be different for different installations.

If the load on the turbine were to decrease, the flow of steam would decrease, the pressure would rise and the temperature would rise due to the decreased velocity through the boiler superheater, and assuming a certain time lag before any change could be made in the rate of fuel supplied to the furnace. The temperature rise, however, will not occur or be felt at the turbine until a relative time interval has elapsed between the decrease in steam demand, the decrease in velocity through the superheater and the effect of this decrease in velocity resulting in an increased temperature having been transmitted to the turbine.

Temperature of steam to a turbine may vary from other causes, however, than change in demand; for instance, changes in the rate of supply of fuel or air to the furnace. Also certain designs of superheaters have other than a straight line characteristic with rating; i. e., the total temperature of the steam in what is commonly called the "convection" type superheater, increases as the rate of steam generation increases and in what is commonly called the "radiant" type of superheater the total temperature of the steam decreases as the rate of steam generation increases.

One object of my invention is to provide a control of temperature of the steam to a turbine, wherein the controller is positioned or actuated by variations in a factor or factors whose variations precede or tend to cause variations in the temperature.

A further object is to have the control action checked or modified by variations in the temperature.

Still another object is to provide a control which may be actuated by either pressure variations or steam temperature variations, or both simultaneously, to the end that steam temperature is maintained at the desired value.

Other objects of the invention are in part obvious and in part will appear more in detail from the description hereinafter.

In the drawing, wherein like numerals of reference represent like objects, Fig. 1 is a diagrammatic view of a system embodying my invention, and,

Fig. 2 is a similar view of a modification.

1 represents conventionally any suitable boiler having a drum 2 from the steam space of which a conduit 3 leads to superheater 4. 5 is a conduit through which the superheated steam passes from superheater 4 to turbine 11 of conventional design and shown only in part.

A heat exchanger 7 is connected by means of conduits 12 and 13 with the water system of boiler 1 in a manner such that due to temperature differences relatively hotter water will rise in heat exchanger 7 and pass through conduit 12 to drum 2 of boiler 1, being replaced in heat exchanger 7 by relatively cooler water passing from the boiler through conduit 13.

A by-pass to conduit 5 comprises conduit 6, any suitable coils or passages in heat exchanger 7 and in suitable heat-conducting relation with the water contained in heat exchanger 7, conduit 8, stop valve 9 and conduit 10.

In conduit 5, intermediate the points of connection of conduits 6 and 10 is a regulating valve 14 positioned relative to its seat 14*a* by movement of the stem 15. The position of valve 14 relative to its seat 14*a* determines the percentage of the steam leaving superheater 4 through conduit 5, which will be by-passed through heat exchanger 7.

Beyond the by-pass there is connected to conduit 5, a pipe 29 leading to an expansible metal bellows 28 having a movable abutment 27 to which is rigidly connected rod 26 articulated to a floating lever 17 at pivot point 25.

Beyond the by-pass in conduit 5 is a thermometer well 24 containing a bulb 23, part of the thermostatic system comprising the bulb 23, the connecting capillary 22 and the expansible metal bellows 21, of a common type wherein changes in temperature at bulb 23 result in changes in pressure in the expansible metal bellows 21 through the medium of an expansible gas or by vapor tension principles. A movable abutment 20 of bellows 21 carries rigidly a rod 19 articulated to floating lever 17 at pivot point 18.

Intermediate pivot points 18 and 25 the lever 17 is connected at pivot point 16 with the movable stem 15 of valve 14.

In Fig. 2, a nozzle 30 is inserted in conduit 5, creating from flow a pressure differential in conduits 29*a* and 29*b*, applied internally and externally to expansible metal bellows 28 to cause motion of the rod 26.

The rod 19 of the temperature responsive device is articulated to lever 17 intermediate the pivot points 16 and 25.

Springs 19*a* and 26*a* form the calibrating media of the expansible metal bellows 21 and 28, bearing against the movable abutments 20 and 27.

In operation, assume that the load on turbine 11 has decreased, then the flow of steam through conduit 5 decreases, and assuming a time lag before any change in the rate of heat supply to the boiler occurs, the pressure in conduit 5 increases. This pressure increase transmitted through pipe 29 to expansible bellows 28 moves the abutment 27 downwardly against spring 26*a*, carrying rigidly connected rod 26 downwardly. Lever 17 pivots about point 18 causing a downward movement of rod 15 tending to bring valve 14 closer to its seat 14*a*, resulting in a throttling of the flow through conduit 5 past valve 14 and a by-passing of some of the steam of conduit 5 through by-pass 6, heat exchanger 7, and back to conduit 5 through conduit 10. The steam so by-passed gives up some of its heat to the water in heat exchanger 7 and the temperature of the admixture of steam beyond the re-entrant point of the by-pass will be lower than if no part of the steam flowing through conduit 5 had been so by-passed.

The slowing down of the velocity of the steam through the superheater will tend toward a higher steam temperature in conduit 5 approaching the by-pass, but with a certain portion of this higher temperature steam by-passed through the heat exchanger where its temperature will be lowered, the resultant temperature at the admission to the turbine will tend to remain constant. Actual temperature variations, however, to which bulb 23 is sensitive, will result in a change in pressure within the bellows 21, acting on the movable abutment 20 to move rod 19 upwardly or downwardly and causing lever 17 to pivot around point 25 and reposition stem 15 and valve 14 relative to the valve seat 14*a* to modify or check the action of control from pressure.

Thus a change in temperature caused by a change in rate of flow will be anticipated, and the micrometer adjustment or checking action will be accomplished from any changes in temperature which may occur.

In Fig. 2 I have shown the arrangement of linkage and control means whereby the initial regulation or by-passing effect is accomplished from a change in the rate of flow rather than from a change in the steam pressure. Here again, the modifying or checking action is accomplished from a temperature-responsive control.

Assuming the same condition, namely that the load on the turbine decreases, then the rate of flow of steam to the turbine decreases, causing a decrease in the differential pressure existing between connections 29*a* and 29*b* to the end that movable abutment 27 will move upwardly, carrying with it rigidly connected rod 26 and lever 17 pivoted at 18 causing valve stem 15 to move downwardly so that valve 14 approaches its seat 14*a* and causes a by-pass of part of the steam flowing through conduit 5.

If insufficient correction has been accomplished then temperature-responsive device consisting of bulb 23, connecting capillary 22 and expansible sylphon 21 functions to move abutment 20 downwardly, carrying with it rigidly connected rod 19 in a manner such that lever 17 pivoting at 25 will move valve stem 15 downwardly, carrying valve 14 still closer to its seat 14*a* and causing a greater percentage of the total flow of steam to go through the by-pass.

If conversely the correction has been of too great an amount, then the opposite temperature effect is felt upon expansible bellows 21, to the end that movable abutment 20 moves upwardly, carrying with it rod 19 to the end that lever 17 pivoted at 25 causes valve stem 15 to move upwardly and valve 14 to move away from its seat 14*a*, thus decreasing the percentage of the total flow of steam which passes through the by-pass.

It is of course understood that the resistance to flow through the by-pass is greater than it would be through conduit 5 past valve 14, so that normally with valve 14 wide open practically all of the flow of steam would be through valve 14. The flow through the by-pass is accomplished only by throttling down valve 14 and thus introducing a restriction to flow.

Assuming no change in steam demand of turbine 11, and correspondingly no change in flow through nozzle 30 or past pressure connection 29, but a change in B. t. u. input at the boiler or some other reason for change in temperature of the steam flowing through conduit 5. Temperature-responsive system bulb 23, capillary 22 and bellows 21 of each of Figures 1 and 2 immediately act to position lever 17 around pivot 25 to the end that valve stem 15 is moved to so position valve 14 relative to valve seat 14*a* that a change will be made in the amount of steam by-passed through the heat exchanger 7.

It will be apparent that I have a control of the temperature of steam to a turbine, wherein a corrective measure is introduced from a factor, for example steam pressure or steam flow, which would tend to cause a variation in the temperature after a certain time interval. I have a control sensitive to a variation in either of two factors or to variations in both of them simultaneously in the same or opposite directions, to the end that one of the factors may be maintained at a desired value.

Obviously in illustrating and describing this one preferred embodiment of my invention, wherein the temperature of steam to a turbine is controlled, I am not limiting myself other than is disclosed in the claims in view of prior art.

It is apparent that in the operation of any apparatus having factors which vary in value with the operation, there will be possibly certain factors by whose variations other factors will be affected, and that by a control from variations in the first factor a change or variation in the second or depending factors can be anticipated or obviated.

What I claim as new and desire to secure by Letters Patent of the United States, is:—

1. In combination, a vapor generator having a superheater, a conduit for the passage of superheated vapor therefrom, a by-pass to a portion of the conduit, fluid surrounding the by-pass in heat conducting relation with the vapor flowing therethrough, the fluid in thermal circulation with the vapor generator, a valve in the conduit between the exit and re-entrant points of the by-pass thereto, a pressure responsive device sensitive to vapor pressure beyond the by-pass and adapted to position the valve in a closing direction when the vapor pressure increases and in an opening direction when the vapor pressure decreases, and a temperature responsive device sensitive to vapor temperature beyond the by-pass and adapted to position the valve independently of the pressure responsive device.

2. In combination, a vapor generator, vapor utilizing apparatus, a conduit connecting the two for vapor flow therethrough, a heat exchanger connected in the liquid circuit of said generator, a by-pass connection to the conduit in heat conducting relation to the heat exchanger, a control valve in the conduit intermediate the exit and re-entrant points of connection of said by-pass, and a regulator for the valve sensitive to variations in a factor of the vapor which is a function of the rate of operation of the vapor utilizing apparatus adapted on an increase in the rate of operation of said apparatus to operate said valve to decrease the amount of vapor and upon a decrease in the rate of operation of the apparatus to operate the valve to increase the amount of vapor by-passed through the heat exchanger and further responsive to variations in a factor of the vapor which is a function of the operation of the vapor generator.

3. In combination, a vapor generator, vapor utilizing apparatus, a conduit connecting the two for vapor flow therethrough, a heat exchanger connected in the liquid circuit of said generator, a by-pass connection to the conduit in heat conducting relation to the heat exchanger, a control valve in the conduit intermediate the exit and re-entrant points of connection of said by-pass, and a regulator for the valve sensitive to variations in temperature of the vapor entering the apparatus and further sensitive to variations in a factor of the operation of the apparatus which factor upon change in the rate of operation of the apparatus will vary earlier than the vapor temperature and adapted upon an increase in the rate of operation of said apparatus to operate said valve to decrease the amount of vapor and upon a decrease in the rate of operation of the apparatus to operate said valve to increase the amount of vapor by-passed through the heat exchanger.

4. In combination, vapor generating apparatus, vapor utilizing apparatus, a conduit connecting the two for vapor flow therethrough, a heat exchanger connected in the

liquid circuit of said generating apparatus, a by-pass connection to the conduit in heat conducting relation to the heat exchanger, a control valve in the conduit intermediate the exit and re-entrant points of connection of said by-pass, and a regulator for the valve sensitive to two factors conjointly effective for positioning the valve, each of said factors varying with the operation of both the vapor generating apparatus and the vapor utilizing apparatus, said regulator adapted upon an increase in the rate of operation of said utilizing apparatus to decrease the amount of vapor by-passed and upon a decrease in the rate of operation of the utilizing apparatus to increase the amount of vapor by-passed through said heat exchanger.

In witness whereof, I have hereunto set my hand this 29th day of August, 1930.

NINO HILGERS.