Jan. 23, 1962 P. PROFOS 3,017,869

CONTROL SYSTEM

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Fig. 1.

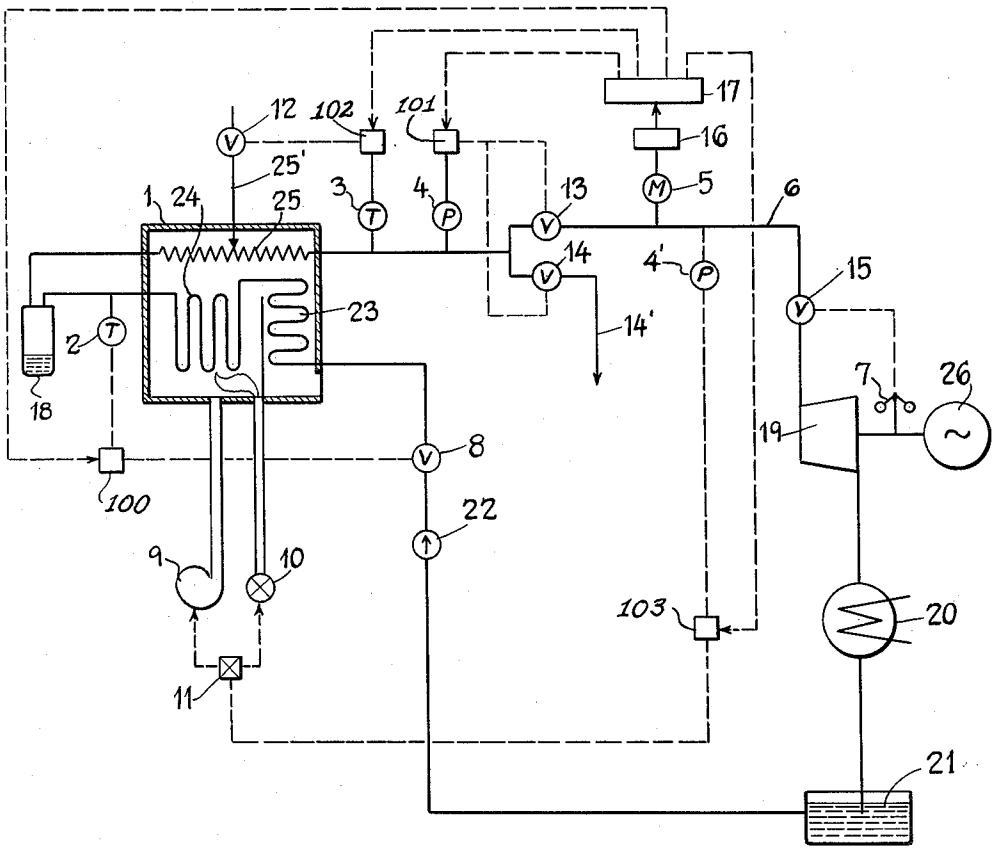
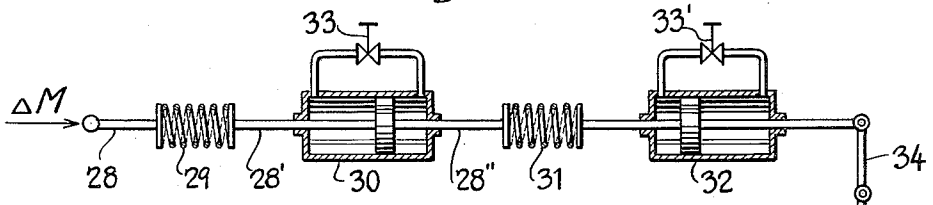


Fig. 2



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Fig. 3a.

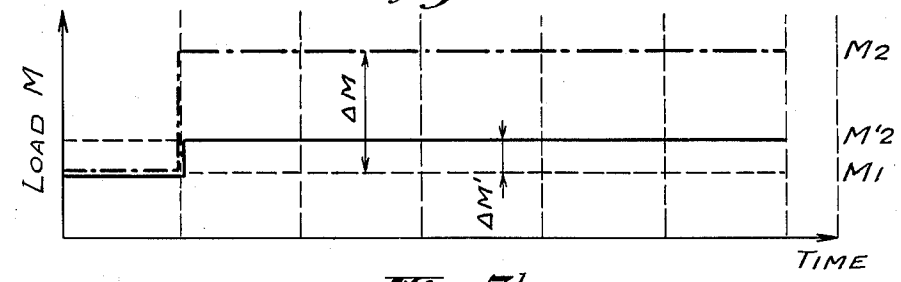


Fig. 3b.

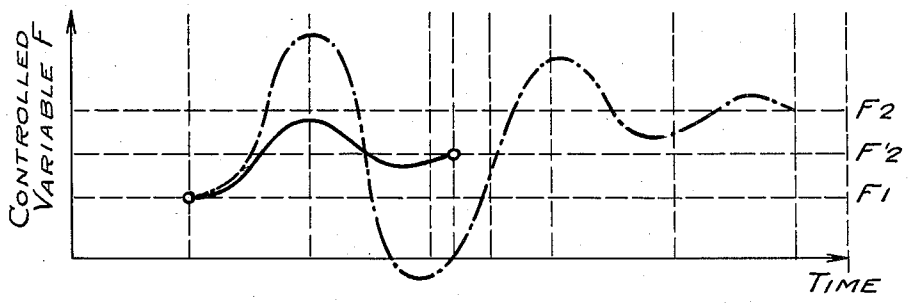
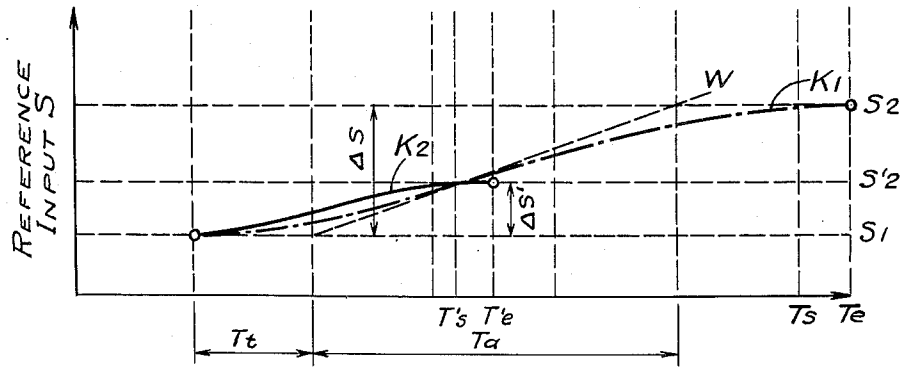


Fig. 3c.



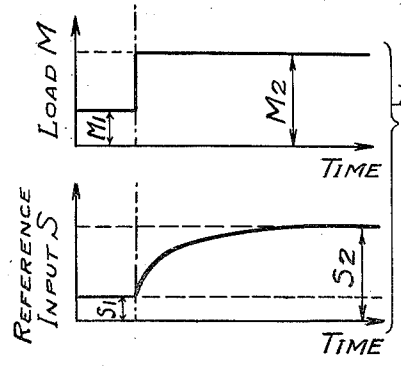


Fig. 3d.

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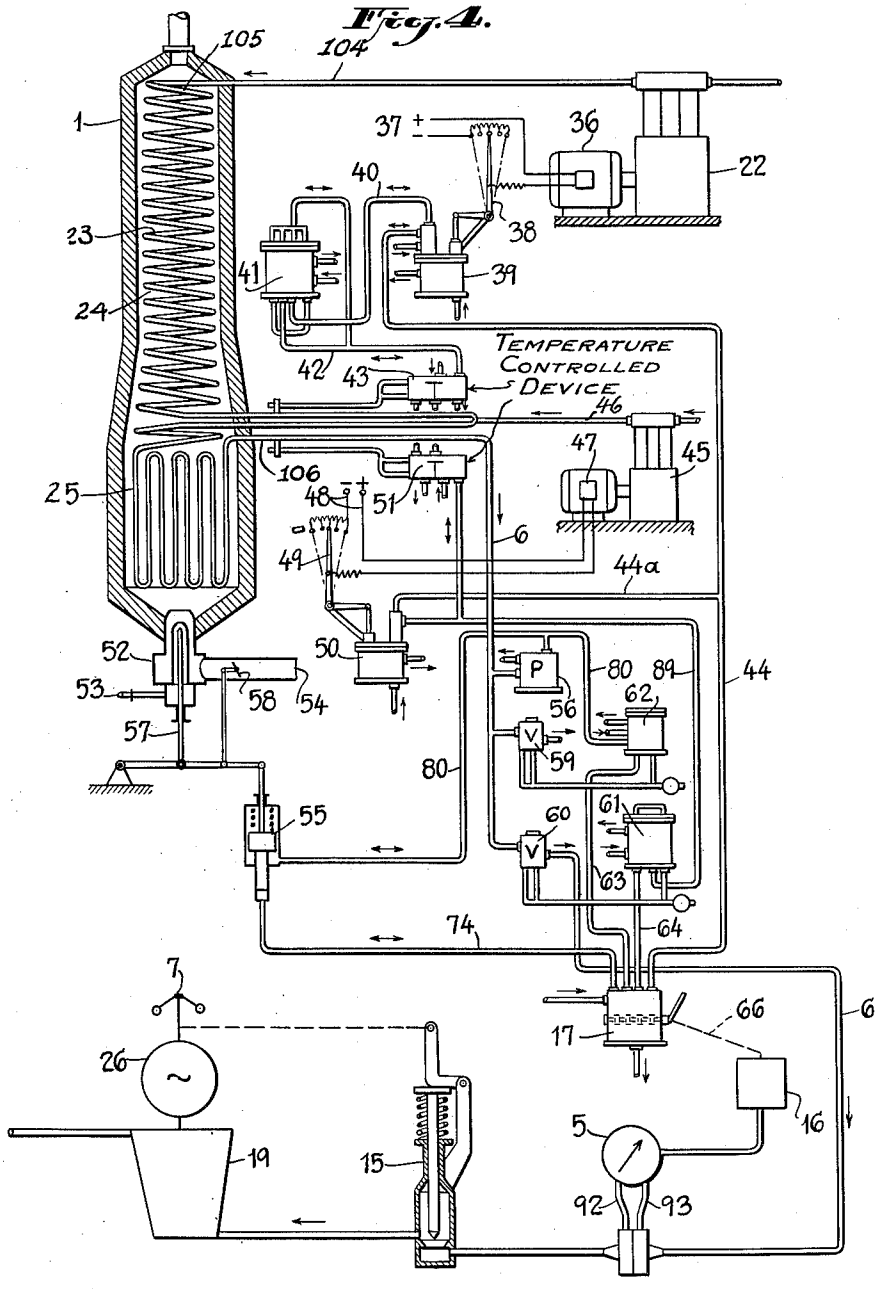
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Fig. 4.



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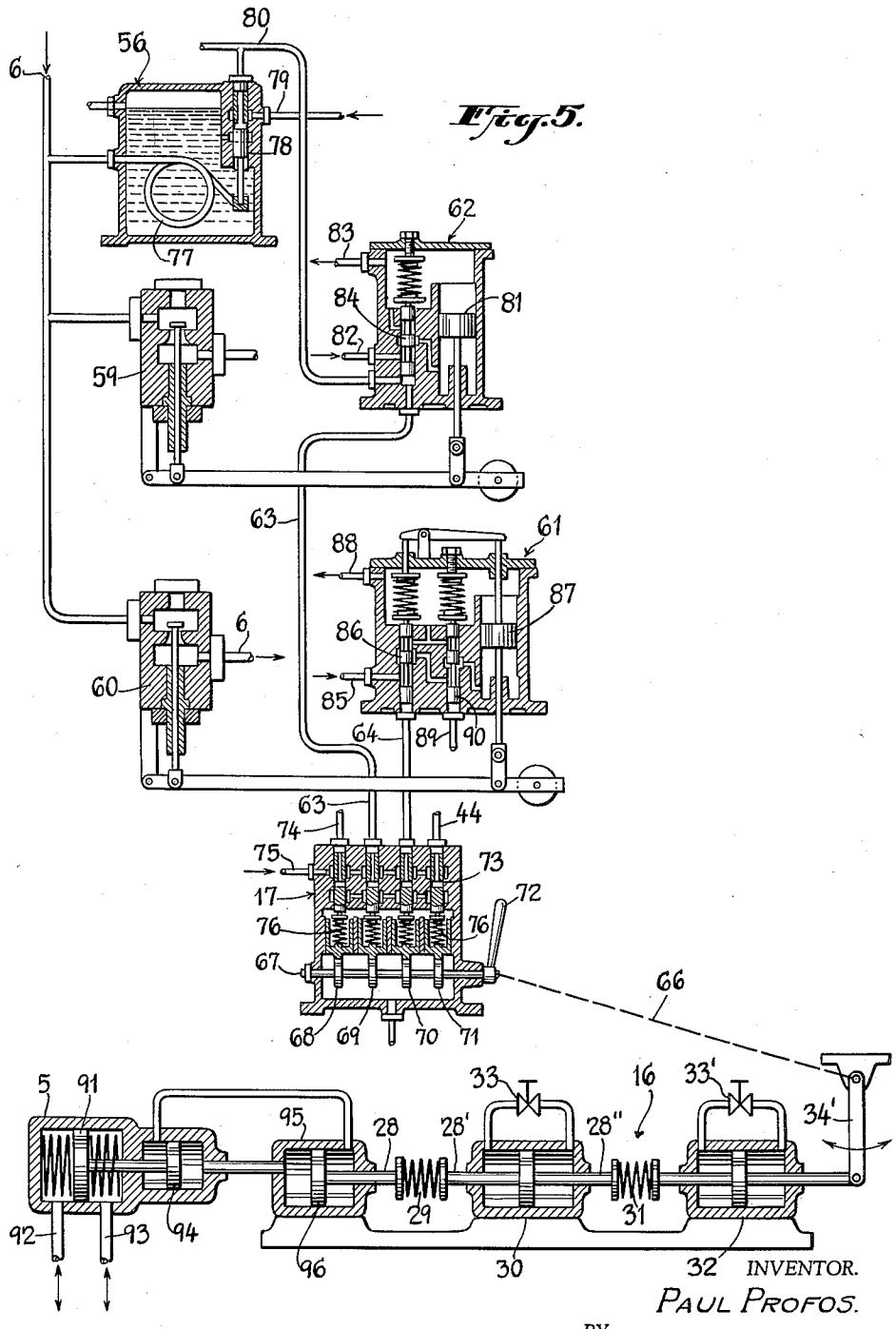
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Fig. 5.



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3,017,869

CONTROL SYSTEM

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Filed Feb. 14, 1957, Ser. No. 640,196
Claims priority, application Switzerland Feb. 15, 1956
7 Claims. (Cl. 122—479)

The present invention relates to a method and means for changing the values or reference inputs to be maintained by regulators of an energy producer, more particularly of a steam generating apparatus, so that different values are maintained by the regulators at different outputs, the change of the adjustment of the value to be maintained by the regulators being effected a period of time after the regulators have responded to a new load condition.

When operating a producer of energy, for example, a forced flow steam generator there is, when the load is constant, a thermodynamic equilibrium between the supply of operating media, namely fuel, combustion air, water, and the characteristics of the output, namely amount, pressure, and temperature of the produced steam. This equilibrium is disturbed when the load is changed and is not restored until all operating factors are balanced relatively to one another and are in agreement with the new load and the control oscillations of the individual regulators have subsided.

There are several possibilities of adjustment of the regulators to comply with the new load. It may be desirable to change the pressure of the live steam according to the load, particularly in forced flow steam generators operating at very high pressures and at great load variations. If the steam pressure is so changed that the inlet flow area of a turbine receiving steam from the steam generator is the same at all loads, the control method is known as the sliding pressure method. The advantage of this method resides in the fact that the turbine is operated at optimum efficiency at all loads. This method ensures best overall operating efficiency of the plant, particularly at frequent partial load conditions.

The sliding pressure method, however, is objectionable because the operating conditions of the steam generator must be built up until the new load is obtained. There is a time lag or delay between the changes effected at the inlet of the tube system of a forced flow steam generator and the changes produced thereby at the outlet of the tube system. These changes are amplified by the natural inertia of any steam generator due to its accumulating capacity. Therefore, quick changes of load cannot be effected by the sliding pressure method. If quick changes of load are forced on the steam generator with a deviation from the sliding pressure operation, considerable operating difficulties are encountered, particularly because of disturbances of the temperature regulation and maintenance of the steam pressure.

Because of the shortcomings of the true sliding pressure method, the so-called step pressure method has been suggested in which load variations are met at first by maintenance of the steam pressure and by subsequently gradually and manually adjusting the live steam pressure to the new load. This method is desirable from the standpoint of the steam generator operation but has the disadvantage that the turbine operates a considerable length of time below optimum efficiency so that the overall efficiency of the plant is at least temporarily reduced. The method is, therefore, applicable only to plants in which load variations occur relatively seldom.

It is desired to automatically change the individual operating characteristics of an energy producer, for

example, a steam generator, i.e., to adjust the steam pressure, the steam temperature, the temperature of the feed water, the supply of feed water, of fuel, of air, etc., in accordance with the load and to a predetermined degree so that these characteristics are different at different loads. The manner in which these changes are produced is of utmost importance.

If the value to be maintained by a regulator is too quickly changed to meet the new load the control operation taking place during the change of load is disturbed, causing prolonged and increased control oscillations until equilibrium is obtained after the change of load.

If the value to be maintained by a regulator is changed too slowly at a change of load, energy losses are produced because the energy producer operates too long at unfavorable efficiency conditions.

It is known to delay control effects in steam power plants by interposing an integrating system in the control mechanism. Such a system, which may be called a transmission system of the first order, consists of a resistance and of an accumulating element, for example, a throttling device through which a regulating medium flows into an accumulator, or an electric resistance through which an electric condenser is charged.

If an energy carrier is supplied through a throttle device to an accumulator, the energy condition of the latter is changed, the change being produced the quicker, the smaller the throttle effect and the smaller the capacity of the accumulator. This arrangement is not suitable for solving the problem of changing the value to be maintained by a regulator, because at momentary load changes, the change of the value to be maintained by the regulator is initiated instantaneously according to a linear time function. The control operation of a control circuit, for example, of a temperature regulation, receives not only a control pulse caused by the change of the load, but also a disturbing pulse because of the quick change of the adjustment of the value to be maintained by a regulator at the critical moment of the control operation. Experience has shown that the control operation with an instantaneous change of the value to be maintained by the regulator is worse than a control operation with no change of the reference input of the regulator.

It is an object of the present invention to provide a method and means for controlling the retarding characteristic of the adjustment of the value to be maintained by a regulator so that the resetting of the apparatus for adjusing the value to be maintained by the regulator is completed not sooner than the regulating oscillations have abated in the control circuit of the regulator and so that a graph showing the adjustment as a function of time begins with a horizontal tangent and thereupon gradually approaches the new value to be maintained by the regulator. With this method the control operation of the control circuit is not adversely affected by the resetting of the reference input of the regulator.

It is desirable that the adjustment of the value to be maintained by the regulator is effected in such manner that the new value is approached asymptotically. According to the invention the adjustment of the value to be maintained by the regulator is so performed that there is at first an idle period after which the new value is gradually attained. It is important that the idle period T_t amounts to at least 5% of the starting period T_a of the adjustment. Because of the different lengths of time elapsing between the initiation and the effect of a control pulse for different regulating circuits, as, for example, for combustion materials, feed water supply, water injection, and the like, it is necessary that different lengths of time are provided for the change of the value to be maintained by regulators for different operating media. These lengths of time must be so that the adjustment of

the new value maintained by each regulator is completed not sooner than the regulating oscillations caused by a change of load in the respective regulating circuit have subsided.

The oscillation period of a control circuit after receiving a control pulse of a certain magnitude can be calculated or found by tests on the energy producer. The oscillating period of a control circuit is the time within which the oscillating amplitude caused by a control or a disturbing pulse abates below a predetermined permissible minimum value. After determination of the oscillating period of a control circuit the time is determined which is needed for resetting the apparatus for adjusting the value to be maintained by the respective regulator to conform with the new load.

The method of adjusting the value to be maintained by a regulator according to the invention can be performed by hand; it is, however, preferred to use an automatic control apparatus. Such an apparatus includes a load measuring device interposed in the conduit connecting the energy producer with an energy consumer and responding to the load on the energy producer, the load measuring device being connected with devices for adjusting the values to be maintained by individual regulators which are needed for controlling the energy producer. The apparatus according to the invention includes a modifying or retarding device interposed between the load measuring device and the device for adjusting the value to be maintained by a regulator, the retarding device including at least two pulse delaying or damping and accumulating units arranged in series relation, each of the units including a resistance element and an accumulating element for the control pulse energy emitted by the load measuring device.

The novel features which are considered characteristic of the invention are set forth with particularity in the appended claims. The invention itself, however, and additional objects and advantages thereof will best be understood from the following description of embodiments thereof when read in connection with the accompanying drawing in which:

FIG. 1 is a diagrammatic illustration of a steam power plant equipped with control apparatus according to the invention;

FIG. 2 is a diagrammatic illustration of a sender or retarding device according to the invention;

FIGS. 3*a* to 3*d* are diagrams relating to the operation of the control system according to the invention;

FIG. 4 is a more detailed diagrammatic illustration of a steam power plant equipped with control apparatus according to the invention;

FIG. 5 is a diagrammatic illustration of a control system according to the invention.

Like parts are designated by like numerals in several figures of the drawing.

Referring more particularly to FIG. 2 of the drawing, numeral **28** designates a rod connected with and receiving pulses from a conventional load measuring device. The rod **28** is connected with a first accumulating element **29** which is in the form of a coil spring. The far end of the coil spring is connected by means of a rod **28'** with a dash pot or throttling element **30**. The piston of the latter is connected by a rod **28''** with a second accumulating element **31**, which is also in the form of a coil spring whose far end is connected with a second dash pot or throttling element **32**. The piston of the dash pot **32** is connected with a lever **34** which transmits the accumulated pulse to the adjusting apparatus for setting the value to be maintained by a regulator. The dash pots **30** and **32** include conventional throttle valves **33** and **33'**, respectively, by means of which the time values T_t and T_a can be increased or decreased, as desired, for tuning the transmission device shown in FIG. 2 to the duration of the control oscillations of its respective control circuit.

According to the invention an individual retarding unit or sender may be provided for each adjusting device for setting the value to be maintained by the regulator. This, however, would require complicated mechanisms.

It is usually sufficient to provide only two retarding units or senders which are directly or indirectly connected with groups of devices for adjusting the settings of several regulators, one group consisting of regulators in which the adjustment must be performed very slowly and the other group including the regulators in which the adjustment can be performed relatively quickly.

FIG. 3*c* is a diagram in which the movement produced by the lever **34** is plotted relatively to the time. The dash-dot curve K_1 represents the function of the adjustment of the value to be maintained by a regulator in dependence on the time.

Letter W designates a line which is tangent to the point of inflection of the dash-dot curve K_1. The intersections of the line W with the horizontal lines S_1 and S_2, which show the positions of the device for adjusting the values to be maintained by a regulator before and after a change of load, determine the time period T_t during which the adjusting device is inactive and the time period T_a during which the adjustment is started.

FIG. 3*d* shows the adjustment function curve obtained with a transmission or retarding device of the first order, i.e., with a single integrating element. This curve begins with a steep, substantially vertical tangent and gradually approaches the new value to be maintained by the regulator whereby the speed of adjustment diminishes. With a retarding device of this type the value maintained by the regulator is changed very quickly at the moment of a change of the load, the speed of change diminishing thereafter, i.e., the change is effected at greatest speed at the beginning of the control operation, at a time when the disturbances of the equilibrium of the system caused by the control pulse are greatest. For this reason a single integrating element is unsuitable for the solution of the problem which is the object of the present invention.

FIGS. 3*a*, 3*b*, and 3*c* show diagrams illustrating the adjustment of the value to be maintained by a regulator according to the invention, employing a transmission device of the second order. These figures show the time T as abscissae. FIG. 3*a* shows the load M of the energy producer as ordinates. The ordinates in FIG. 3*b* designate the item F to be controlled, for example, fuel supply, air supply, water supply, pressure, temperature, water injection, and the like. The ordinates S in FIG. 3*c* indicate the positions of the device for adjusting the values to be maintained by a regulator.

In case of a sudden load change the load M_1 in FIG. 3*a* is instantaneously changed to the load M_2. The disturbing pulse produced by the change of the load causes a change of the value F. Because of the inertia of the system the change of the value F begins very slowly and increases at a gradually increasing rate. Thereupon the control mechanism reverses the regulating effect so that the value F_1 is changed to a new value F_2 within a certain period of time in gradually diminishing waves.

In the meantime the load measuring device has emitted a pulse ΔS corresponding to the new value to be maintained by the regulator to the sender for readjusting the setting device of the regulator. The sender retards the transmission of the pulse. The curve K_1 in FIG. 3*c* shows that the speed with which the readjustment of the setting device for changing the value to be maintained by the regulator is smallest at the beginning of the adjustment and during the time when the amplitude of the regulating oscillation (FIG. 3*b*) is greatest. The speed is greatest at the point of inflection of the curve K_1 whereafter the adjustment approaches the new value S_2 at gradually decreasing speed.

With the method according to the invention the total time T_e needed for the adjustment is greater than the oscillation period T_s (FIG. 3*b*) of the control circuit.

The retarding characteristic of the sender must be so

adjusted relatively to the regulating oscillation characteristic of the regulating circuit that the rule $T_e > T_s$ is followed for the smallest load change as well as for the greatest load change of the system.

The dash-dot lines in FIGS. 3*a*, 3*b*, and 3*c* refer to maximal load changes ΔM and the solid lines to minimal load changes ΔM'. To comply with a minimal load change the value F_1 is increased to F'_2 and the value S_1 is changed to S'_2. As seen in FIG. 3*c* the time T'_e for minimal load changes is greater than the time T'_s. Experiments have shown that these conditions are obtained with the retarding device according to the invention. If this device is once adjusted so that it agrees with the duration of the control operation in the circuit in which it is used, it operates satisfactorily at relatively great as well as at relatively small regulating amplitudes.

FIG. 1 illustrates the application of the invention to a steam power plant. Feed water is pumped into a steam generator **1** by means of a feed pump **22** through a feed water regulator **8**. The feed water passes through an economizer **23** and therefrom through an evaporating tube system **24** at the outlet of which a thermostat **2** is arranged for controlling the feed water supply. The effluent of the tube system **24** is conducted through a water separator **18** and therefrom through a superheater **25**. At the outlet of the latter a temperature sensitive device **3**, for example, a thermostat and a pressure sensitive device **4** are arranged. For producing the desired steam temperature at the outlet of the superheater **25** a pipe **25'** is arranged for injecting water into the superheater, the amount of water injected being controlled by a regulator **12** which is responsive to the thermostat **3**. Numeral **10** designates a device for controlling the amount of fuel supplied to the steam generator, the amount of combustion air supplied to the steam generator being controlled by a device **9**. The devices **9** and **10** are actuated by a regulator **11** which is controlled according to the pressure in the steam main which acts on a pressure sensitive device **4'**.

The steam main **6** connecting the outlet of the superheater **25** with a steam turbine **19** is provided with a steam pressure regulating apparatus including a pressure maintaining valve **13** interposed in the steam main and a relieve valve **14** interposed in a relieve or by-pass pipe **14'**. A load measuring apparatus **5** is also connected with the steam main and a turbine inlet valve **15** is interposed in the steam main, the valve **15** being responsive to a speed governor **7**. The turbine **19** drives an electric generator **26**. The operating medium discharged by the turbine is condensed in a condenser **20**, the condensate being collected in a tank **21** from which it is returned to the steam generator by the feed pump **22**.

The load measuring device **5** is directly or indirectly operatively connected with a sender **16** according to the invention for actuating an apparatus for adjusting the setting of the values to be maintained by the individual regulators. The pulse emitted by the load measuring and pulse producing device **5** is modified in the sender **16** and transmitted to an apparatus **17** distributing the modified pulses to the individual regulators for adjusting the setting of the values to be maintained by the individual regulators. The device **17** is illustrated in FIG. **5** and will be described later. Because of the provision of the load measuring device and the sender **16** the individual items for operating the steam generator as, for example, the combustion regulator **11**, the pressure maintaining apparatus **13**, **14**, or the temperature regulation which is effected by the injection regulator **12**, **25'** and the feed water regulator **8**, are controlled not only in dependence on the steam pressure but also in dependence on the greatness of the load M, i.e., the regulators must respond to two superimposed control pulses.

Let us assume first that the plant shown in FIG. 1 is in normal operation and operates at 100% load.

The load measuring device and pulse generator **5** indicates full load and the modifying device **16** is in its extreme position. The settings of the distributing device **17** and of adjusting devices connected with regulators **100**, **101**, **102** and **103** for actuating the feed valve **8**, the pressure maintaining valves **13** and **14**, the water injection valve **12**, and the heating control device **11**, respectively, are at their end positions corresponding to 100% load and the regulators for the combustion **11**, the feed water supply **8**, etc., maintain an energy condition in the steam generating system corresponding to 100% load.

It is now assumed that the load demanded by the consumer **26** is reduced by 50%. In this case, the speed governor **7** closes the inlet valve **15** to maintain a constant speed of the turbine shaft. This causes an immediate increase of the pressure in the pressure sensitive devices **4** and **4'**. The pressure sensitive device **4'** causes a reduction of the fuel and air supply by way of the regulator **11** while the pressure sensitive device **4** prevents an excessive increase of the pressure in the steam main by temporarily opening the relieve valve **14**. The load measuring device **5** indicates 50% load and sets the sender **16** to correspond to this load and the sender begins to transmit the control pulse with retardation to apparatus **17** and therefrom to the devices **100**, **101**, **102** and **103** for changing the setting of the values to be maintained by the individual regulators.

Changes of the pressure and of the amounts of operating media flowing through the system make themselves felt at the temperature sensitive devices. The thermostat **3** prevents an excessive temperature increase in the superheater by opening the water injection regulator **12** and the thermostat **2** increases the feed water supply upon an increase of the temperature of the operating medium leaving the evaporator **24**. During the control period in which a new output condition is produced the values to be maintained by the individual regulators are also changed so that these values correspond to the new load.

The new condition is, therefore, not only obtained by controlling the individual regulating circuits according to the disturbing pulse caused by the change of load, but also by a new setting of the values maintained by the individual regulators which values now correspond to 50% load.

If, after a stable period at 50% load the load is suddenly increased to 100%, the control operation is performed as at the previously described load reduction but in the opposite sense.

FIG. 4 is a more substantial illustration of the regulation of a steam power plant. The operating medium in liquid form is supplied to the steam generator **1** by means of a feed pump **22** which is connected by means of a feed pipe **104** with the inlet **105** of a tube system **23**, **24** in which the liquid is evaporated, the vapor being superheated in a superheater **25**. The superheated steam emerging from the outlet **106** of the superheater **25**, is conducted through a steam main **6** to steam consumers. The feed pump **22** is driven by an electric motor **36** receiving power through conduits **37**. The speed of the motor **36** is controlled by means of a regulator **38**. The regulator **38** is actuated by a conventional hydraulic servomotor **39**. Operating fluid is supplied to the servomotor **39** through a pipe **40**, the supply of fluid through this pipe being controlled by a device **41** receiving operating fluid from a temperature sensitive device **43** which is connected to and actuated according to the temperature of the medium at the connection of the tube system **23**, **24** of the steam generator with the superheating tube system **25** of the steam generator. The servomotor **39** is not only actuated by fluid coming from or escaping through the conduit **40**, but also by fluid which is supplied or withdrawn through a conduit **44** which is controlled by the device **17** for adjusting the setting of the value to be maintained by the regulator **38**.

An injection pump 45 pumps liquid operating medium through a conduit 46 into a part of the tube system 23, 24 which is downstream of the point which is connected with the temperature controlled device 43. The injection pump 45 is driven by an electric motor 47 which receives current from a supply system through conduits 48. The speed of the motor 47 is controlled by a regulator 49 which is actuated by a servomotor 50. The latter is controlled by a device 51 which responds to the temperature of the steam leaving the superheater 25 and also by the apparatus 17 to which the servomotor 50 is connected by a conduit 44*a* and which adjusts the setting of the value to be maintained by the regulator 49.

A combustion device 52 which receives fuel through a conduit 53 and combustion air through a conduit 54 is actuated by a servomotor 55 which responds to a pressure sensitive device 56 to which it is connected by a conduit 80 and to the apparatus 17 with which it is connected by the conduit 74. Actuation of the combustion control is effected by moving a fuel valve spindle 57 and an air damper 58 which are linked to the piston of the servomotor 55.

The steam in the steam main 6 is conducted either through a pressure maintaining valve 60 to the inlet valve 15 of a steam engine 19 or through a relieve valve 59 and a by-pass conduit, if desired, into a condenser, not shown. The pressure regulating valve 60 is actuated by a servomotor or motor-operator 61. The relieve or by-pass valve 59 is actuated by a servomotor or motor-operator 62. The servomotors or motor-operators 61 and 62 are connected by conduits 64 and 63, respectively, with the device 17 for adjusting the set points of the motor-operators and thereby the reference input of the valves according to the load. The servomotor 62 responds also to the pressure sensitive device or element 56 to which it is connected by a pulse conduit 80 for opening the valve 59 at excessive pressures in the steam main 6. The servomotor 61 is connected with the temperature sensitive device or element 51 by a conduit 89 for closing the valve 60 at an undesired temperature reduction in the steam main 6. The reference inputs of the valves 59 and 60 are so adjusted by the device 17 that the valve 59 is fully closed and the valve 60 is fully open during normal full load operation of the plant.

The steam passing through the valve 60 is conducted through the load measuring device 5 before it passes through the inlet valve 15 into the turbine 19. The inlet valve 15 is actuated by a speed governor 7 in the conventional manner. The pulses generated by the load measuring device 5 are modified in the pulse modifying device 16 and transmitted to the device 17 by a pulse conduit 66.

FIG. 5 shows the apparatus 17 for distributing the modified pulses received from the device 16 according to a predetermined key to the individual regulators 101, 102, 100 and 103 in FIG. 1 or to the regulators 55, 62, 61, 39 and 50 in FIG. 4 for changing the setting of the value to be maintained by the regulators.

The device 17 includes a shaft 67 carrying cams 68 to 71 which are so formed as to produce the desired reference inputs by the regulators which are individually associated with the cams. The shaft 67 can be rotated by manipulation of a lever 72. The latter may be connected by suitable conventional means 66, not shown in detail, with the sender 16 for automatic actuation by the latter so that each load measured by the device 5 produces a predetermined setting of the reference inputs of the individual regulators. Each of the cams 68 to 71 actuates a control piston 73 which are all alike. The chambers in which the pistons 73 are reciprocally movable are individually connected with the servomotors 39, 50, 61, 62, and 55 by conduits 44, 44*a*, 64, 63, and 74, respectively. A pipe 75 supplies an operating fluid at constant pressure to the apparatus 17. This fluid is distributed into the conduits 44, 64, 63, and 74 at pressures depending on the pressures of springs 76. The latter sit individually in axially movable cups which rest individually on the cams 68 to 71. The ends of the springs protruding from the cups individually abut against the control pistons 73. The pressures produced by the springs 76 depend on the angular position of the cams 68 to 71.

The pressure sensitive device 56 comprises a tubular coil spring 77 the interior of which is connected with the steam main 6. The free end of the spring 77 is connected with a slide valve 78 whose position is changed according to the changes of the steam pressure in the pipe 6. The valve 78 controls the flow of a constant pressure fluid from a supply conduit 79 into a pulse conduit 80 in which the pressure of the fluid corresponds to the position of the valve 78, i.e., to the pressure in the conduit 6.

The servomotor 62 includes a slide valve 84 controlling the flow of a constant pressure operating fluid from an inlet pipe 82 to an outlet pipe 83 and to the sides of a piston 81. The position of the slide valve 84 is controlled by the pulse pressures in the conduits 80 and 63 which act on one end of the valve 84 against the pressure of a spring provided at the other end of the valve. The pulses coming from the conduit 80 are produced by the pressure sensitive device 56 and tend to actuate the valve 84 so that the piston 81 which is connected with the relieve valve 59 causes opening of the latter when the pressure in the pipe 6 exceeds the normal operating pressure. The moment at which the valve 59 is actually opened by the piston 81 depends on the position of the cam 69 which depends, in a retarded manner, on the amount of steam measured by the device 5. The mechanism is preferably so set that the relieve valve 59 is opened when the pressure maintaining valve 60 is almost closed at which time very little or no steam flow is measured by the device 5.

The servomotor 61 for the valve 60 includes two piston valves 86 and 90 arranged in series with respect to the flow of a constant pressure fluid which enters the device 61 at 85 and whose flow to the sides of a working piston 87 and to an outlet 88 is controlled by the valves 86 and 90. The valve 86 is controlled by the pressure of the pulses in the conduit 64 which pressure depends on the angular position of the cam 70 in the device 17, the pulse pressures acting on one end of the valve 86 against the pressure of a spring provided at the other end of the valve. The valve 90 is controlled by the pulse pressure in the conduit 89 which is produced by the device 51 (FIG. 4) which reacts to the steam temperature at the outlet of the steam generator 1. The piston 87 is mechanically connected with the valve 60 and, because of the valve 86, actuates the valve 60 to maintain the steam pressure in the steam main 6 at every load condition at a value at which the turbine 19 operates at optimum efficiency at that load. Because of the valve 90 the piston 87 actuates the valve 60 so that, if the temperature of the steam at the outlet of the superheater 25 is too low, the valve 60 is closed to avoid passage of water through the pipe 6 into the turbine 19.

The sender or retarding device transmitting control pulses from the load measuring device 5 is substantially like the one shown in FIG. 2. The rod 28 is not directly connected with the conventional device 5 whose piston 91 is moved according to the pressures in conduits 92 and 93 which are connected with the steam main 6 downstream and upstream of a conventional orifice interposed in the steam main, an auxiliary piston 94 being connected with the piston 91 for controlling flow of an operating fluid to and from a cylinder 95 and moving a piston 96 in the cylinder 95 in synchronism with the movements of the pistons 91 and 94. The rod 28 is connected with the piston 96.

The servomotors 39 and 50 of FIG. 4 are similarly constructed as the servomotors 61 and 62.

I claim:

1. In a steam generating plant comprising a steam generator having a tube system for evaporating water

and superheating the evaporated water, a live steam conduit connected to the outlet of said tube system, a device connected to the inlet of said tube system for controlling the feedwater supply thereto, and a device for supplying fuel and air for combustion to the steam generator; a control system including a pressure responsive control pulse generator connected to said live steam conduit and producing control pulses corresponding to the pressure of the live steam produced by the steam generator, a temperature responsive control pulse generator connected to said tube system and producing control pulses corresponding to the temperature of the produced steam, regulators individually connected to said devices for controlling the operation thereof and individually connected to said pulse generators for receiving control pulses therefrom to be actuated thereby for increasing the water supply to said tube system upon an increase of the temperature of the steam in said tube system and for increasing the fuel and air supply upon a decrease of the live steam pressure, and vice versa, said regulators individually including adjusting means for changing the control pulses received from said pulse generators and thereby altering the effect of the control pulses on said regulators, a steam flow responsive control pulse producing means connected to said live steam conduit and producing pulses corresponding to the amount of live steam flowing through said conduit, and a pulse delaying means connected to said steam flow responsive control pulse producing means for delaying the control pulses produced by said steam flow responsive control pulse producing means relatively to the control pulses produced by said pulse generators, said pulse delaying means being connected to all of said adjusting means for transmitting the delayed pulses to said adjusting means for actuating the latter after elapse of a period of time after the pulses produced by said pulse generators have actuated the respective regulators for increasing the pressure and temperature affecting said regulators after an increase of steam flow and vice versa.

2. In a steam generating plant as defined in claim 1 a pipe branching off from said live steam conduit upstream of the connection of said pressure responsive pulse generator, a valve in said pipe, a pressure responsive element connected to said live steam conduit upstream of the connection of said branch pipe and said live steam conduit for producing control pulses corresponding to the live steam pressure, and a motor operator operatively connected to said valve and to said element to open said valve when the live steam pressure upstream of the valve exceeds a predetermined set point and to close said valve upon decrease of the pressure below the set point, said motor operator including set point adjusting means operatively connected to said pulse delaying means for changing the set point of said motor operator after elapse of a period of time after a change of the steam flow for increasing said set point after an increase of steam flow and vice versa.

3. In a steam generating plant as defined in claim 1 a pipe branching off from said steam conduit down stream of the connection of said pressure responsive pulse generator, a valve in said pipe corresponding to the live steam, a motor operator operatively connected to said valve and to said pressure responsive pulse generator to open said valve when the live steam pressure exceeds a predetermined set point and to close said valve upon decrease of the pressure below the set point, said motor operator including adjusting means for adjusting the set point, said adjusting means being operatively connected to said pulse delaying means for increasing the set point of said motor operator after elapse of a period of time after the steam flow has increased and vice versa, a valve in said live steam conduit downstream of the connection of said branch pipe, a second motor operator operatively connected to said valve in said live steam conduit, and a temperature responsive element connected to said live steam conduit upstream of said branch pipe and producing control pulses corresponding to the live steam temperature, said temperature responsive element being operatively connected to said second motor operator to open said valve in said steam conduit upon increase of the live steam temperature above a predetermined set point and to close said valve in said conduit upon decrease of the live steam temperature below the set point, said second motor operator including adjusting means for adjusting the set point, said adjusting means being operatively connected to said pulse delaying means for increasing the set point of said second motor operator after elapse of a period of time after the steam flow has increased, and vice versa.

4. In a steam generating plant according to claim 1 a temperature responsive element connected to said live steam conduit and producing control pulses corresponding to the temperature of the live steam, a valve interposed in said live steam conduit, and a motor operator operatively connected to said valve and to said temperature responsive element for actuation of said motor operator in response to the control pulses produced by said element to close said valve upon decrease of the live steam temperature below a predetermined temperature, and vice versa, said motor operator including adjusting means for changing the control pulses in response to which said motor operator is actuated, said adjusting means being operatively connected to said pulse delaying means for changing the control pulses in response to which said motor operator is actuated after elapse of a period of time after a change of the steam flow for reducing the temperature upon which said valve is closed, after the steam flow has decreased, and vice versa.

5. The method of controlling the operation of a forced flow steam generator at variable rates of steam flow from the generator comprising the steps of increasing the rate of heat supply to the steam generator in immediate response to a decrease of the pressure of the produced steam below a predetermined pressure forming the set point of the rate of heat supply control, of decreasing the rate of heat supply in immediate response to an increase of the pressure of the produced steam above a predetermined pressure, of increasing the rate of feedwater supply to the generator in immediate response to an increase of the steam temperature above a predetermined temperature forming the set point of the rate of feedwater supply control, of decreasing the rate of feedwater supply to the generator in immediate response to a decrease of the steam temperature below a predetermined temperature, and of delayedly increasing said predetermined pressure and temperature which form the set points of the control of the rates of heat and feedwater supply, upon an increase of the rate of steam flow from the generator and after effecting said increase of the rate of heat supply and said decrease of the rate of feedwater supply, and of delayedly decreasing said predetermined pressure and temperature upon a decrease of the rate of steam flow and after effecting said decrease of the rate of heat supply and said increase of the rate of feedwater supply.

6. The method according to claim 5 wherein completion of the steps of increasing or decreasing said predetermined pressure and temperature is delayed until the regulating oscillations caused by said increase of the rate of heat supply and said decrease of the rate of feedwater supply or caused by said decrease of the rate of heat supply and said increase of the rate of feedwater supply have subsided.

7. In a steam power plant comprising a forced flow steam generator having a tube system, means for passing an operating medium through said tube system, the medium entering the tube system in liquid state and leaving the tube system as superheated steam, and a steam consumer connected to said generator for receiving steam therefrom, the combination of means for controlling the

rate of heat supply to said generator, means responsive to the pressure of the produced steam and connected to said heat supply control means for increasing the rate of heat supply upon a decrease of the pressure of the produced steam below a predetermined pressure, forming the set point of said rate of heat supply control means, and for decreasing the rate of heat supply to the generator upon an increase of the pressure of the produced steam above a predetermined pressure, means for controlling the rate of feedwater supply to the generator, means responsive to the temperature of the operating medium of the steam generator and connected to said feedwater supply control means for decreasing the rate of feedwater supply upon a decrease of the temperature of the operating medium below a predetermined temperature, forming the set point of said feedwater supply control means, and for increasing the rate of feedwater supply upon an increase of the temperature of the operating medium, means responsive to the rate of steam flow from said generator to said consumer and connected to said means for controlling the rate of heat supply and

of feedwater supply to said generator for increasing the predetermined pressure and temperature forming the set points of said control means, upon an increase of the rate of steam flow and for decreasing the predetermined pressure and temperature of said control means, upon a decrease of the rate of steam flow, and delaying means interposed between said rate of steam flow responsive means and said control means for delaying increase and decrease of said predetermined pressure and temperature until after said control means have effected a change of the rates of heat and of feedwater supply.

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