

Nov. 10, 1931.

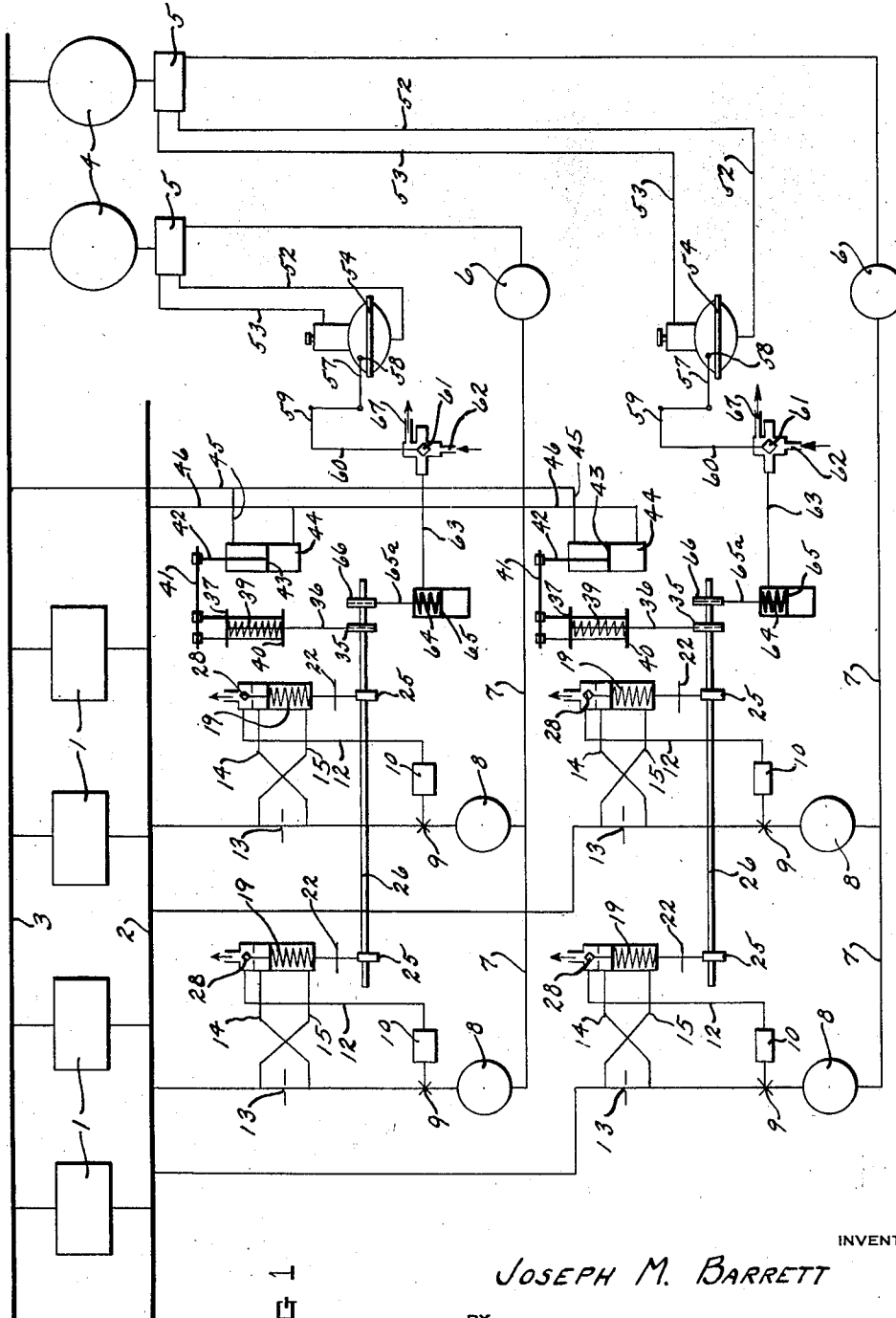
J. M. BARRETT

1,831,089

POWER PLANT REGULATOR

Filed Sept. 7, 1929

3 Sheets-Sheet 1



INVENTOR

JOSEPH M. BARRETT

.BY

Brockett, Hyde, Higley & Meyer
ATTORNEYS

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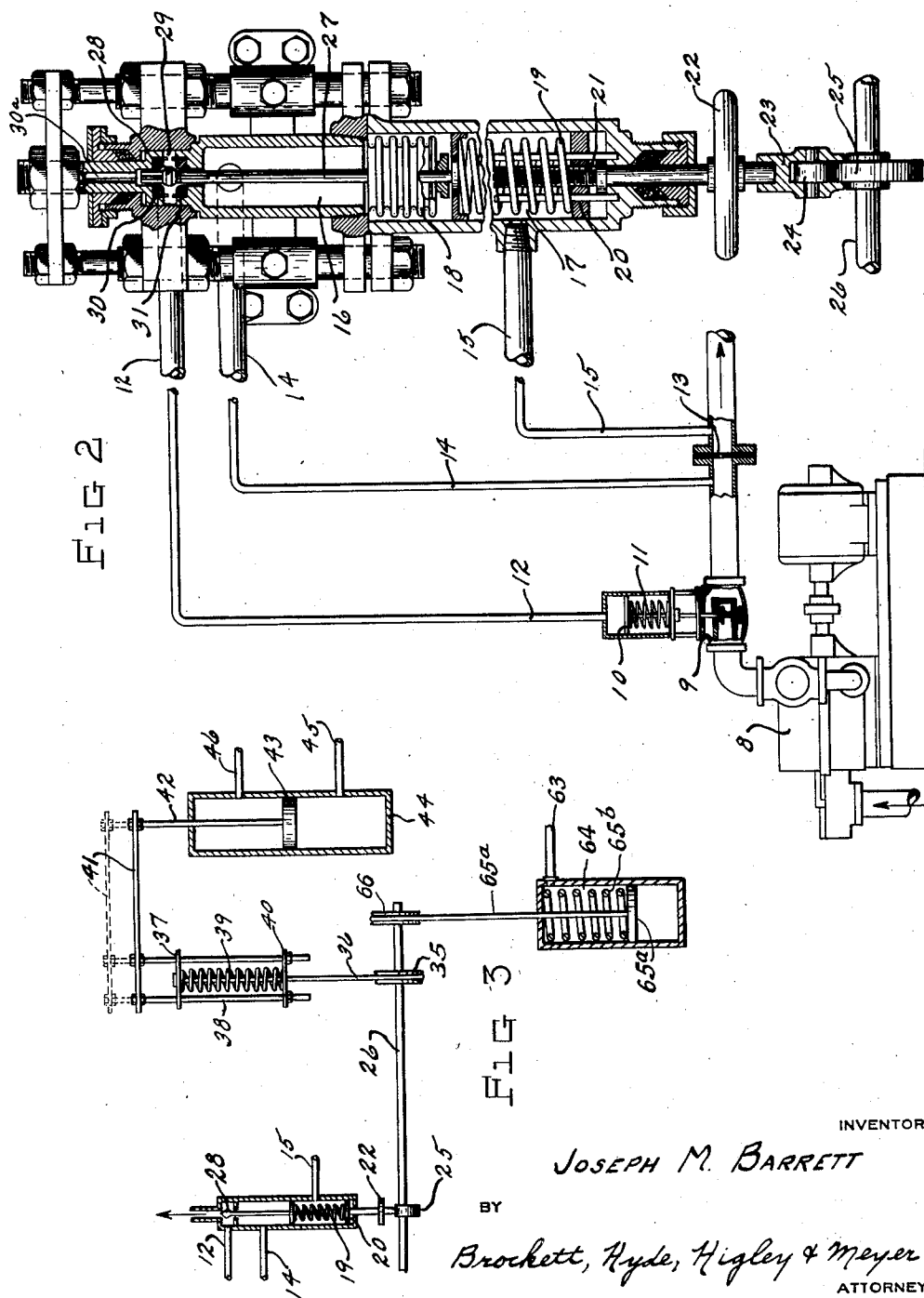
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INVENTOR

JOSEPH M. BARRETT

BY

Brockett, Hyde, Higley & Meyer
ATTORNEYS

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3 Sheets-Sheet 3

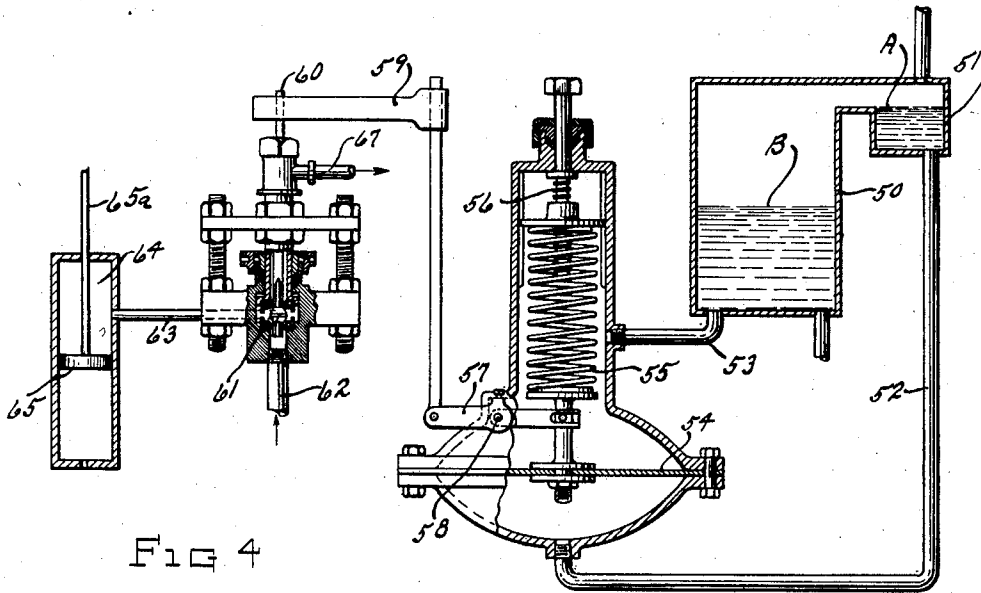


FIG 4

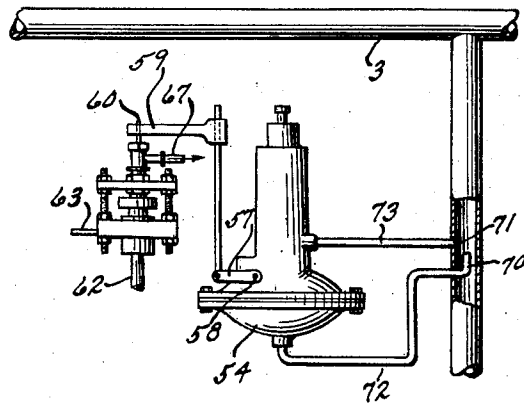


FIG 5

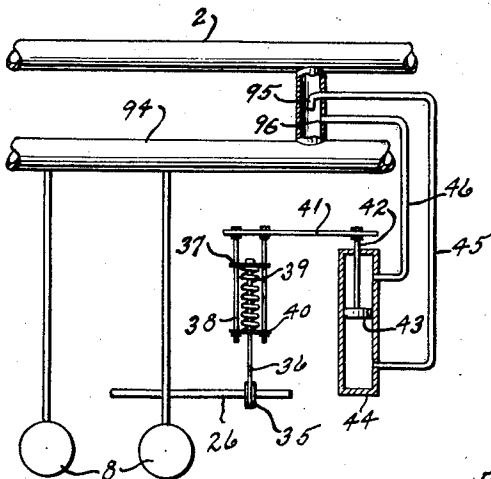


FIG 6

INVENTOR

JOSEPH M. BARRETT

BY

Brockett, Hyde, Higley & Meyer
ATTORNEYS

UNITED STATES PATENT OFFICE

JOSEPH M. BARRETT, OF CLEVELAND HEIGHTS, OHIO, ASSIGNOR TO BAILEY METER COMPANY, OF CLEVELAND, OHIO, A CORPORATION OF DELAWARE

POWER PLANT REGULATOR

Application filed September 7, 1929. Serial No. 391,065.

This invention relates to power plant regulators, and more particularly to pump control for boiler systems.

The invention has for its object to provide a method and apparatus for controlling pumps in several ways,—first, individually, so that each pump carries its proper share of the load; second, jointly so that all pumps are governed in accordance with the demand of the boiler system for water; and third, by groups, according to the apportioning of the pumps in groups to the several turbines or other devices, so that each group is controlled in accordance with the load of its particular turbine or other device.

Further objects of the invention are in part obvious and in part will appear more in detail hereinafter.

In the drawings, Fig. 1 represents a diagram of a typical power plant or system embodying the invention; Fig. 2 is a detail sectional elevation of the control mechanism for a single pump; Fig. 3 is a similar view, illustrating the joint control mechanism according to the demand of the boiler system for water; Fig. 4 is a sectional view illustrating group control according to the turbine load; Fig. 5 is a detail view, illustrating a modified form of group control; and Fig. 6 is a detail view, showing a modified form of water header joint control.

Fig. 1 of the drawings represents a typical power plant, including one or more boilers 1 taking water from a common water header 2 and supplying steam to a common steam header 3, which supplies steam to one or more devices 4 utilizing steam, which here, for convenience and not in any sense of limitation, may be denominated turbines. The boilers may be of various styles and sizes, each being equipped with any or all of the various appurtenances and accessories of modern boilers, requiring no description.

Each turbine delivers its steam to a condenser indicated conventionally at 5, which includes a well or sump shown in Fig. 4 in which the condensate is collected. According to the custom in the operation of modern power plants the condensate from one well is taken care of by a condensate pump 6 which

raises its pressure to say sixty pounds and delivers it to a condensate header 7 through which it is distributed to a group of one or more booster pumps 8, which jointly take the water load of one condenser and deliver it into the common boiler water supply header 2. The drawings show two groups, each including a turbine 4, a condenser 5, a condensate pump 6 and two booster pumps 8, although more groups may be employed and the number of booster pumps for each turbine may be varied according to size, capacity and other requirements in such systems.

Considering first a single group of booster pumps, the individual control of the pumps of this group, by which each takes its proportionate share of the group load, will first be described. This control is substantially identical with that described in my prior application for Liquid flow regulating apparatus, filed January 24, 1929, Serial No. 334,737, to which reference may be had for a more complete description, if desired. For the purposes of this application it is sufficient to say that the several pumps of a group may be of any kind or description, either rotary or reciprocating, constant speed or variable speed, and may be driven in any suitable manner by either constant speed or variable speed drivers, but in any event, each pump and driver, as a unit, will be equipped with some variable device, effective upon either the pump or its driver, adjustment of which will vary the output of the individual pump. Figs. 1 and 2 the drawings, merely for purposes of illustration, show the water outlet pipe of each pump provided with an adjustable balanced valve 9 actuated by a movable abutment 10, said abutment being subject on one face to the pressure of spring 11 and on the opposite face to the fluid pressure supplied by a pipe 12 from the controlling valve mechanism. The water outlet pipe is also provided with suitable differential pressure producing means, such as the orifice 13, pressures on opposite sides of which are led by the pipes 14, 15 to the chambers 16, 17 on opposite sides of a movable abutment, such as the flexible bellows 18, within the controlling valve mechanism. In the chamber 17

and also effective on the abutment is a compression spring 19, the compression of which may be varied by suitable adjustment of the spring perch 20, which may be moved longitudinally by manual rotation of hand wheel 22 on the threaded shaft 21 provided at its outer end with a head 23 carrying a roll 24 travelling on a cam 25 fast with the control shaft 26. Attached to the movable abutment 18 is the stem 27 of a relay control valve having a double conical valve member 28 lying within the chamber 29 to which the pipe 12 is connected. The opposite conical portions of the relay valve cooperate with opposed seats 30, 31, pressure being supplied through the seat 31 by passages around the valve stem from the chamber 16, while pressure is vented from the chamber 29 to exhaust by way of the passage 30a.

With this arrangement the abutment 18 is always subject on one face in chamber 16 to the high pressure side of the orifice 13 and on its opposite face in chamber 17 to the low pressure side of the orifice, as well as to the pressure of spring 19. The balance of the opposed pressures determines the position of the relay valve 28. The nearer valve 28 lies to the seat 31 the more throttled is the supply port for the flow of pressure to chamber 29 and to the movable abutment 18 and the greater is the opening of the vent to pipe 30a, whereas, the nearer the valve 28 is to the seat 30 the more throttled is the exhaust and the more open is the supply. The result is that the variations in the pressure drop across orifice 13 produce a relatively wide or amplified variation in pressure in the relay valve chamber 28, with amplified operation of the controlling valve 9 to maintain substantially uniform flow, except as hereinafter noted. By manual adjustment of the controlling valve mechanism for the individual pumps of the group, such as by actuation of their respective hand wheels 22, the several valve mechanisms may be set so that the pumps of a group individually take and maintain any proportionate share of the total load. For example, the load may be distributed between three pumps in proportion of 20%, 35% and 45%, or, if desired, $33\frac{1}{3}\%$ apiece, etc., and throughout all operations the pump control mechanism will maintain such proportionate relations between pumps.

In addition to the foregoing, all pumps of a group jointly, or, if desired, all pumps which supply the same boiler system, including the pumps of two or more groups, may also be jointly controlled according to a function of the boiler system. This master control may be according to any varying function of the boiler system, such as the flow of water through the common water header, the flow of steam through the common steam header, the excess pressure over the entire

boiler system, the flow of water through the header supplied by one group of pumps, or in proportion to any varying function of a single boiler in those cases where one boiler operates efficiently and is a desirable guide for operation of the boiler system as a whole.

In the arrangement shown in Fig. 1 the control according to variation in the boiler system follows variations in the excess pressure over the entire boiler system. For this purpose the excess pressure over the whole system is made to operate the cam shafts 26, one for each group of pumps, so as to turn said shafts and by rotation of the several cams 25 to readjust the several controlling valve mechanisms for the individual pumps according to variations in the demand of the boiler system for water. The cams, of course, may be fashioned or formed in any desirable shape, such as to take account of the law of squares, quadrupling the supply of water as the excess pressure doubles, etc., or in any other form. In the specific arrangement shown in Figs. 1 and 3, the cam shaft 26 is provided with a drum 35 around which is wound a tension member 36 connected to a head 37 sliding in a frame 38 carrying a compression spring 39, the opposite head 40 being connected to the frame, which has a lateral arm 41 attached to the rod 42 of a piston 43 working in a cylinder 44, the chambers on opposite sides of said piston being connected by the pipes 45, 46 to the steam and water supply headers 3, 2, respectively. Where there are several groups of pumps supplying the boiler system, as in Fig. 1, the excess pressure control pipes 45, 46 may be led in parallel to the several cylinders 44 which operate the group control shafts 26, as will be obvious.

As the excess pressure over the entire boiler system rises and falls, the piston 43 moves back and forth in its chamber. When said piston rises in Fig. 3 it exerts a pulling force and turns the cam shaft in one direction, and a biasing spring 65b tends to turn said shaft in the opposite direction, so that with variations in excess pressure the cam shaft is rotated in one direction or the other with a joint compensation in the valve control mechanisms of the several pumps in accordance with the boiler demand for water. The differential pressure effective on piston 43, of course, is effective upon the cam shaft through the spring 39, which forms a yielding connection and is more or less compressed with variations in excess pressure, as will be readily understood.

In those cases where it is desirable to control each group of pumps according to the flow of water from the pumps of the group, rather than by a function of the boiler as a whole, the control piston 43 for each group is actuated not by the excess pressure, as before described, but according to the arrangement shown in Fig. 6 and in my prior application

referred to, to wit, by providing the water header 94 for the particular group with pressure differential producing means, such as the impact and pressure nozzles 95, 96, connected by pipes to chambers on opposite sides of said piston.

The third method of control of this system is according to the turbine load, for which purpose the several cam shafts are controlled individually, each in accordance with the load of its particular turbine. This control may be according to variations in any function which varies according to the turbine load, such as the flow of steam to the turbine or the level of condensate in the condensate well of the condenser for the particular turbine. Fig. 4 shows the latter arrangement. The condensate well, indicated conventionally at 50, includes an over-flow chamber 51 in which liquid is always maintained at a constant level A, as well as the main chamber in which the level B of liquid rises and falls. Pipe connections 52 and 53 are led respectively from the over-flow chamber and the main chamber of the condensate well to the chambers on opposite sides of a movable abutment, such as a diaphragm 54, loaded on one side by a spring 55 adjustable by a screw 56, a stem attached to the abutment actuating a lever 57 pivoted at 58 and connected by the linkage 59 to the stem 60 of a relay control valve 61 of the same form and operating in the same manner as the relay valve 28, to wit, to control the flow of pressure from any suitable source, such as from the pipe 62, either to an exhaust pipe 67 or to a pipe 63 leading to a chamber 64 on one side of an abutment 65 attached to a tension member 65a fastened to the drum 66 on the cam shaft 26 and subject to the biasing spring 65b. With this arrangement, the differential in the pressures in the pipes 52 and 53 is inversely proportional to the level of liquid in the condensate well, because said pipes measure the difference in level between the over-flow well and the main chamber, and not the absolute level of water. Consequently, in the arrangement shown, as the level of liquid rises in the condensate well, the piston 65 moves over in the proper direction to rotate the cam shaft 26 and increase the duty of all pumps of this particular group.

This arrangement is useful in harnessing or associating the several groups of pumps so that each group properly takes care of the condensate produced by its own particular turbine. It avoids those situations in which one group of pumps attached to one turbine may lag behind, as it were, permitting the level of condensate in its well to unduly rise and even to overflow to storage, accompanying which is necessarily the fall of level of condensate in the condensate wells attached to other turbines and their necessary draft upon storage or make-up water to keep pace

with their supply. The result of the present arrangement, therefore, is to equalize the loads of the several groups of pumps in accordance with the operating characteristics of the turbines to which they are attached.

Fig. 5 shows another arrangement in which the group control is according to the flow of steam to each turbine, instead of according to the level of the condensate produced by the turbine. In this case the steam supply pipe to the turbine is provided with suitable pressure differential creating means, such as the impact and pressure nozzles 70, 71, connected by pipes 72, 73 to the chambers on opposite sides of the diaphragm 54, coupled to actuate the cam shaft 26, as before described.

As a result of all of the foregoing, each pump may be adjusted to take care of any proportionate share of load of a group of pumps of which it is a member; all of the pumps supplying a given boiler system may be jointly controlled in accordance with the demand of the boiler system for water, and finally, the several groups of pumps are controlled in a manner to balance group against group with due regard for varying turbine loads; all with marked increase in efficiency of the entire plant.

What I claim is:

1. A power plant of the character described, comprising a boiler system operating between a water header and a steam header, a plurality of turbines, a plurality of groups of pumps, one for delivering the condensate from each turbine to the water header, at least one of said groups including a plurality of pumps and means for controlling each group of pumps in accordance with the load of its particular turbine.

2. A power plant of the character described in claim 1, including also means for controlling all pumps of each group individually, whereby each one thereof maintains its proportionate share of the load of its group.

3. A power plant of the character described in claim 1, including also means whereby several groups of pumps are controlled in accordance with variations in the operation of the boiler system as a whole.

4. A power plant of the character described in claim 1, including also means whereby several groups of pumps are controlled in accordance with variations in the operation of the boiler system as a whole, and each pump is also individually controlled to maintain its proportionate share of the load of its group.

In testimony whereof I hereby affix my signature.

JOSEPH M. BARRETT.