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REGULATING DEVICE FOR STEAM GENERATORS

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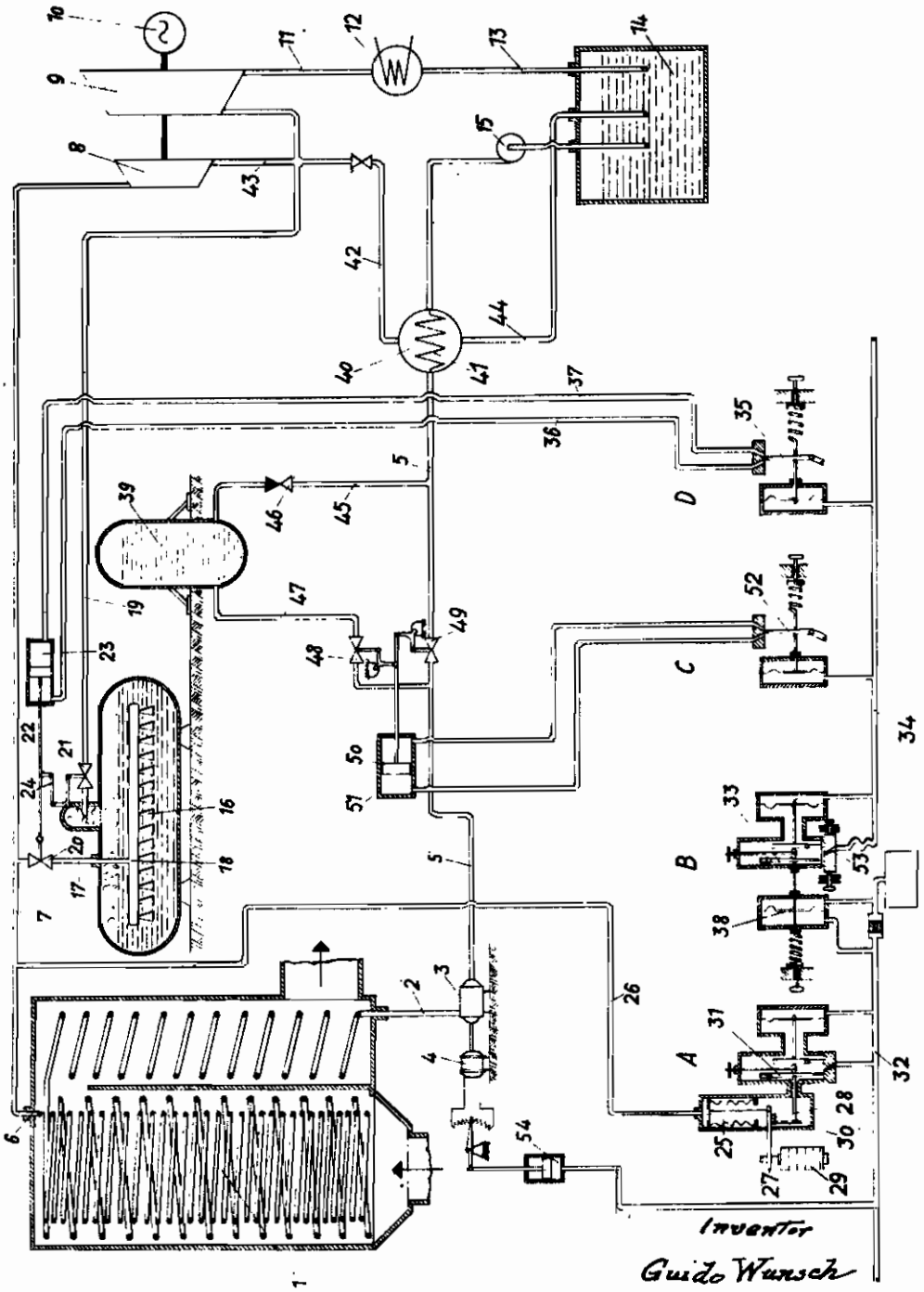

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REGULATING DEVICE FOR STEAM GENERATORS

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This invention relates to improvements in vapor power plants and more particularly to plants of the type comprising a vapor generator and means for storing energy to relieve said generator with respect to the generator load changes.

The main object of the present invention is to provide means for increasing the adaptability of the generator in regard to load changes.

A further object of the invention is to eliminate the disadvantages of the storing devices hitherto known.

Other aims, objects and advantages of the invention will appear from the following description in connection with the drawing showing by way of example only one embodiment of the present invention.

This drawing schematically represents a vapor power plant comprising a once-through vapor generator, a steam accumulator, a preheated liquid accumulator and controlling means for controlling the charging and discharging of said accumulators in response to the generator load changes.

The present invention deals with the following problem. Frequently a generator needs to possess great adaptability in order to follow load changes inasmuch as it would have to adjust itself instantaneously to the new value in the case of rapid load changes. Mostly this is not possible in practice. If the load were to increase rapidly from, say, 50% to 100%, the supply of heat—to take one of the essential factors in the operation of a generator—for instance, would immediately have to be doubled. Experience proves, however, that a certain minimum space of time has to be reckoned with for this increased supply to become effective and hence for the steam production likewise.

This difficulty in steam generator operation is more particularly noticeable in generators of small water content, for instance in once-through vapor generators. The adaptability of the latter is further limited inasmuch as the storing capacity on the one hand, on account of the inconsiderable water content in comparison with that of (drum) boilers, is considerably less and further by the fact that the delay in the water circulation in pipe generators impairs their adaptability to load fluctuations. When the load changes rapidly, the effective super-heater surface changes in an undesirable manner resulting in considerable temperature fluctuations in the super-heated steam even if the absolute change in the load is comparatively small.

In order to reduce the reaction of the load changes to the generator, it is known to provide a vapor accumulator for storing vapor upon any decrease in the generator load and for discharging the stored-up vapor upon an increase in the generator load with respect to a predetermined load value. The well known power plants of this type are provided with controlling means which operate in response to the load change, i. e. the deviation of the actual load from said predetermined load value. To this end the controlling means are made to be responsive to the absolute steam pressure variations or steam quantity variations in the main steam line caused by the load changes. With such control the vapor accumulator becomes effective only to a small extent if the absolute load variation is slight, and in this respect it is to be noted that the reaction of the load changes to the generator is not only dependent on the load variation per se, but also on the velocity at which the variation occurs, therefore, even if the load variation per se is slight, the reaction may be considerable if said variation occurs rapidly. It is to be borne in mind that a certain space of time is necessary for the generator to follow a load change. Thus, for instance as experience has taught, a once-through vapor generator must not be exposed to a greater load change than 10% per minute. Therefore due to its limited adaptability to load changes the generator requires a certain length of time for responding to these changes. In the event of the load variation per se being slight while the load variation velocity exceeds the value referred to above, the generator in following the load changes will lag more or less behind the actual rate of load change. On the other hand, the vapor accumulator controlled according to the pressure variations will relieve the generator to the same extent regardless of the velocity of the load variation. Obviously the relief action on the part of the accumulator, while sufficient at slight load variation velocities, in the case of great velocities of load changes must be inadequate for protecting the generator. For this reason adequate protection cannot be obtained either by means of an accumulator controlled merely in response to the load variation per se.

Now if the generator is not sufficiently relieved by the vapor accumulator, more time is required for the generator to attain the requisite new load condition. Accordingly the accumulator must be adapted to remain effective for a correspondingly longer period, i. e. the accumulator should possess a greater storing capacity.

The present invention is based on the con-

ception that these difficulties may be overcome by controlling the storing means in response to the load variation velocity. In this way the generator will be effectively relieved upon rapid load changes. Furthermore the time required for the generator to attain the requisite new load condition will be reduced.

Referring now to the drawing, 1 is a once-through vapor generator, the liquid receiving end of which communicates by means of a supply conduit 2 with a supply pump 3 driven by an electric motor 4. The pump 3 delivers the feed water from a conduit 5. The vapor produced by the generator 1 leaves the generator passage at 6 and enters a main steam conduit 7 leading to any steam consumption apparatus shown to be a steam turbine comprising a high pressure stage 8 and a low pressure stage 9, said turbine being provided in the embodiment shown for driving a dynamo 10. The waste steam from said low pressure stage 9 enters a conduit 11 and passes a condenser schematically shown at 12. The condensed steam flows through the conduit 13 into a reservoir 14. A pump 15 driven in any convenient manner is provided for delivering the liquid from said reservoir 14 into the feed water conduit 5 above referred to.

For relieving the generator 1 with respect to any load changes, a steam accumulator 16 of the well known type is provided, said accumulator containing liquid to be vaporized by means of the steam coming from the main conduit 7. To this end a steam charging conduit 17 branches off from the conduit 7 and leads to a steam deriver 18. A steam discharging conduit 19 communicates with the low pressure stage 9 of the steam consumption apparatus. In distinction from a communication of the conduit 19 with the high pressure stage 8 a greater pressure drop is available between the steam accumulator 16 and the consumption apparatus, so that the discharging capacity of the accumulator will be increased in comparison with the action of the discharging conduit 19 to the high pressure stage 8.

The charging conduit 17 and the discharging conduit 19 are each provided with a valve 20, 21, respectively. These valves are operatively connected—as shown in the drawing—so as to be inversely controlled. A piston rod 22 of a servo-motor 23 is linked to the connecting rods 24 for automatically controlling said two valves in response to the load variation velocity.

In the following the means for deriving a corresponding controlling impulse are dealt with singly.

In the embodiment shown, in the first instance a load impulse will be produced by means of a device shown in its entirety at A. This device comprises a bellows 25 acted upon by the same pressure as exists in the main conduit 7. For this purpose a pressure conduit 26 leads from the main conduit 7 to the bellows 25. The bellows 25 act upon one end of a lever 27 supported by an edge 28, at the other end of which a weight 29 is suspended for balancing the force exerted by the bellows. An arm 30 is secured to the lever 27 for transmitting the deflections of the lever 27 caused by the pressure variations in the conduit 26 on a well known jet pipe relay 31, so that the pressure produced in a controlling pressure conduit 32 varies in accordance with the pressure in the conduit 26 and hence with the load changes, it being understood that the pressure variations in the main conduit 7 are identical with the load changes.

For deriving a rate of change impulse from the load change impulse in the conduit 32 an additional device is provided shown as a whole at A. This device is fully explained in my previous patent 1,920,827 (reissued under 19,276) so that a further description does not seem necessary. According to this patent it follows that the pressure produced by the jet pipe 33 in the conduit 34 varies in accordance with the load variation velocity so that the pressure in the conduit last referred to represents a rate of change impulse.

A jet pipe relay D is operatively connected to the conduit 34 and provided for controlling the servo-motor 23. A jet pipe 35 of the relay D cooperates with two receiving nozzles, each of which communicates with a conduit 36, 37, respectively, leading to the servo-motor 23, as may be seen from the drawing.

The operation of the device described is as follows: Be it assumed that the load increases; the pressure in the main conduit 7 will then decrease so that the lever 27 of the device A will be rocked in an anticlockwise manner. Accordingly the jet pipe 31 will be likewise deflected in an anticlockwise manner thereby increasing the pressure in the conduit 32 in accordance with the load increase. The increased pressure in 32 thus produced acts upon the left side of the diaphragm 38 of the device B, whilst the pressure on its right side is a function of the velocity of the load change as more fully explained in my patent above referred to. Therefore, the jet pipe 33 varies the pressure in the conduit 34 in accordance with the increase in the rate of load change, so that by means of the relay D the servo-motor 23 closes the charging valve 20 and simultaneously opens the discharging valve 21 in dependence on the rate of load charge. Accordingly in case of a great rate of load change the two valves 20 and 21 will be more strongly influenced than in the case of a slight rate of load change.

In addition to the steam accumulator 16 a preheated liquid accumulator 39 is provided according to the embodiment shown in the drawing. This liquid accumulator is arranged to likewise relieve the generator in such a manner that upon a load increase the accumulated preheated liquid in 39 will be additionally supplied to the generator whilst upon a load decrease the surplus of preheated feed liquid will be stored in 39.

For preheating the feed liquid delivered by the pump 15 into the feed conduit 5, a preheater 40 is provided comprising a heat exchanging element 41 arranged in a casing or housing through which passes the steam coming from the medium pressure stage of the steam consumption apparatus. Accordingly the steam conduit 42 leading to the preheater 40 branches off from a conduit 43 leading from the high pressure stage 8 to the low pressure stage 9. The steam condensed in 40 flows through conduit 44 to the reservoir 14 above referred to. The preheated liquid leaving the preheater 40 flows through conduit 6 to the generator as long as the accumulator 39 remains inoperative. For accumulating the preheated liquid in 39 upon a load decrease, a conduit 45 branches off from the conduit 5 and communicates with 39. The conduit 45 'comprises a check valve 46 for preventing a return flow from 39 through 45. A discharge conduit 47 communicates with conduit 5 via a valve 48 behind a valve 49 inserted in the conduit 5 between the conduit 45 and the discharge conduit 47. The two valves 48 and 48 are operatively connected to the piston 50 of a servo-motor 51 so as to be inversely con-

trolled in a similar manner as the valves 20 and 21 of the steam accumulator 16. For controlling the servo-motor 51 another relay device C is provided and—similar to the device D—connected to the controlling pressure conduit 34 so that the servo-motor 51 controls valves 46 and 46 in dependence on the rate of load change in a manner similar to that according to which the servomotor 23 controls the valves 20 and 21.

The preheated liquid accumulator 39 operates as follows: Upon a load increase the pressure in the main conduit 7 decreases so that, as described above, the controlling pressure in 34 varies in accordance with the rate of load increase. Therefore the jet pipe 52 of the relay device C deflects (like the jet pipe 35 of the relay device D) in a clockwise manner so that the piston 50 of the servo-motor 51 will be displaced to the left, thus closing the valve 49 and simultaneously opening the valve 46. In this way the preheated liquid in 39 flows through the discharge conduit 47 into the feed conduit 5 to the pump 3 delivering the liquid into the generator. At the same time the closing of the valve 49 results in a reduction of the liquid supply through the preheater 40 so that the amount of preheating steam is correspondingly reduced and a greater amount of steam enters the low pressure stage 9. If, however, the generator load decreases, the piston 50 of the servo-motor 51 will be displaced to the right thus causing the opening of the valve 49 and simultaneously the closing of valve 46. In this case the liquid delivered by the pump 15 flows through the valve 49 as well as into the accumulator 39. Due to the reduced load the generator receives only a reduced amount of feed liquid so that a considerable part of the liquid delivered by the pump 15 enters the accumulator 39, the discharge of which is reduced or stopped. Under these circumstances the preheater 40 receives a greater amount of preheating steam coming from the steam consumption apparatus, i. e. the surplus not consumed by said apparatus due to the load decrease.

It is to be noted that, in distinction from the embodiment shown, only one of the two accumulators 16 and 39 may be provided. Furthermore it should be possible to modify the embodiment shown in such a manner that the two accumulators do not operate simultaneously but in series.

In some cases it may be desirable to control the accumulators in response to the rate of load change in such a manner that the generator will only be relieved when the rate of load change exceeds a predetermined value. This value depends on the generator characteristic determining the range of the rate of load change within which the generator does not require any relief by means of any accumulator. As mentioned above, a once-through vapor generator as shown in the drawing may follow a rate of load change of within 10% per minute. With this in view, the invention aims at providing auxiliary means for rendering inoperative the controlling system within said predetermined value whereby said accumulators merely relieve the generator upon a load change exceeding said value.

In the embodiment shown, a receiving nozzle 53 may for this purpose be transversely displaced in any suitable manner in order to vary the controlling pressure in the conduit 34 in response to the position of the jet pipe 33. In this manner it may be achieved that the pressure in 34 does not vary upon slight deflections of the jet pipe 33 corresponding to slight rate of load changes. In this way the accumulators do not become effective in response to all load changes and thus comparatively slight stored up energies suffice for the desired relief of the generator.

As may be seen from the drawing, the position of the receiving nozzle 53 may be adjusted at will so that the controlling system may be easily adapted to the working condition of the entire plant.

The accumulators may be controlled in response to the rate of load change as well as to the load change per se. The inventive principle consists merely therein that the accumulators in all events operate in response to the rate of load change. The manner in which the rate of load change impulse is derived is immaterial. Therefore the device B may be replaced by any other convenient means. Thus for instance a gyroscope might be used whose axis of rotation would be displaced in accordance with the load change impulse per se in such a manner that the rate of load change impulse could be obtained from the gyroscope precession moment.

For the sake of completeness it may be further submitted that any load change impulse for controlling the plant may be derived from the controlling pressure conduit 32. For instance a servo-motor 54 for controlling the electric motor 4 driving the pump 3 in response to the load change may be connected to the conduit 32.

While I have described and illustrated my invention by a special embodiment shown in the drawing, it will be readily understood by those skilled in the art that the description is not to be taken in a limiting sense, many modifications of the embodiment shown—apart from those mentioned above—being possible within the scope of my invention. Moreover it is not indispensable that all the features of my invention be used jointly since they may be employed advantageously in various combinations and subcombinations.

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