United States Patent

[11] 3,614,457

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Schenectady, N.Y.
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[73] Assignee General Electric Company
Continuation-in-part of application Ser. No. 468,887, July 1, 1965, now abandoned.

[54] TURBINE OVERSPEED TRIP ANTICIPATOR
9 Claims, 7 Drawing Figs.

[52] U.S. Cl. 290/40, 60/73, 60/105, 317/19, 317/31, 415/10, 415/32
[51] Int. Cl. H02p 9/04
[50] Field of Search 137/21, 22, 24, 27, 26, 31, 35, 34, 36; 60/73, 105; 290/40; 415/10, 13, 16, 17, 30, 32; 317/19

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ABSTRACT: Turbine control system with conventional overspeed trip for stop valves and governor for control valves includes an additional trip device which temporarily closes stop valves to anticipate overspeed tripping, but reopens them to prevent permanent tripping if the governor functions to bring overspeed under control.

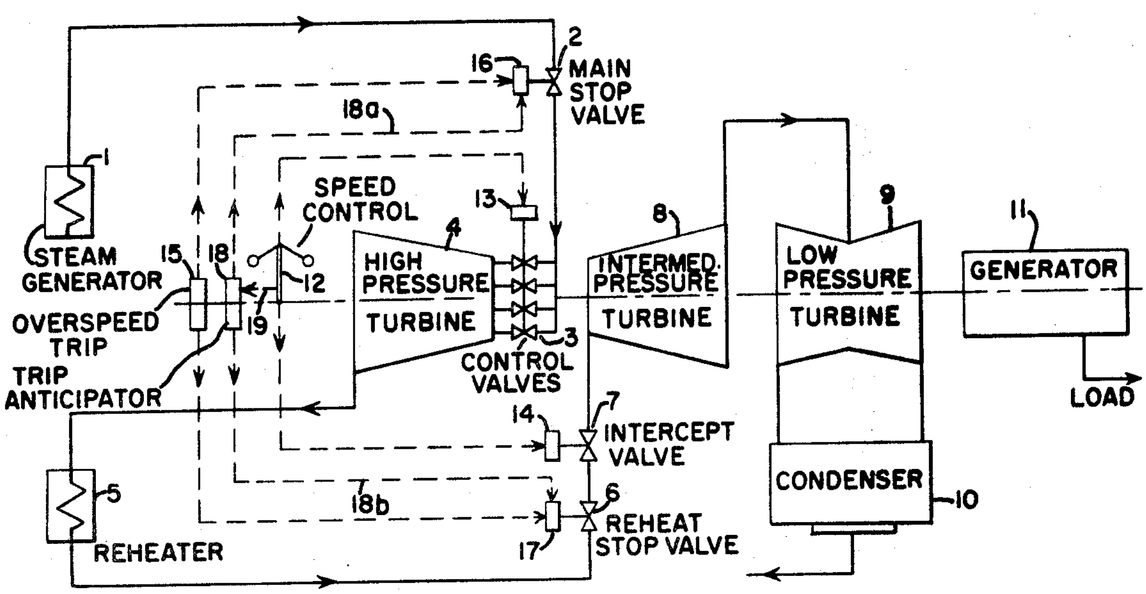

FIG. 1

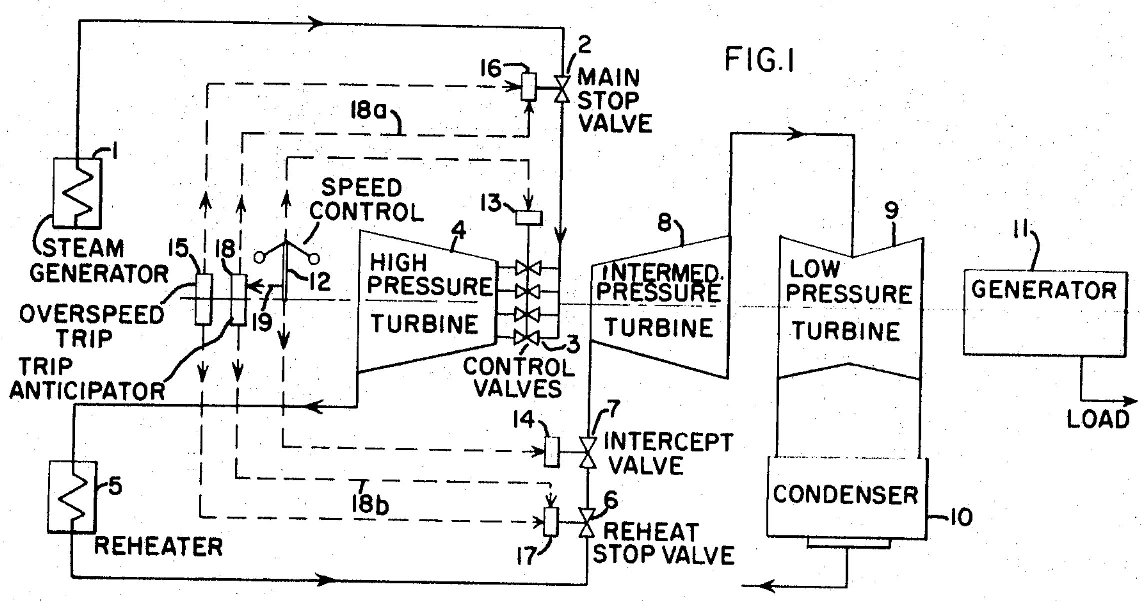

FIG. 2

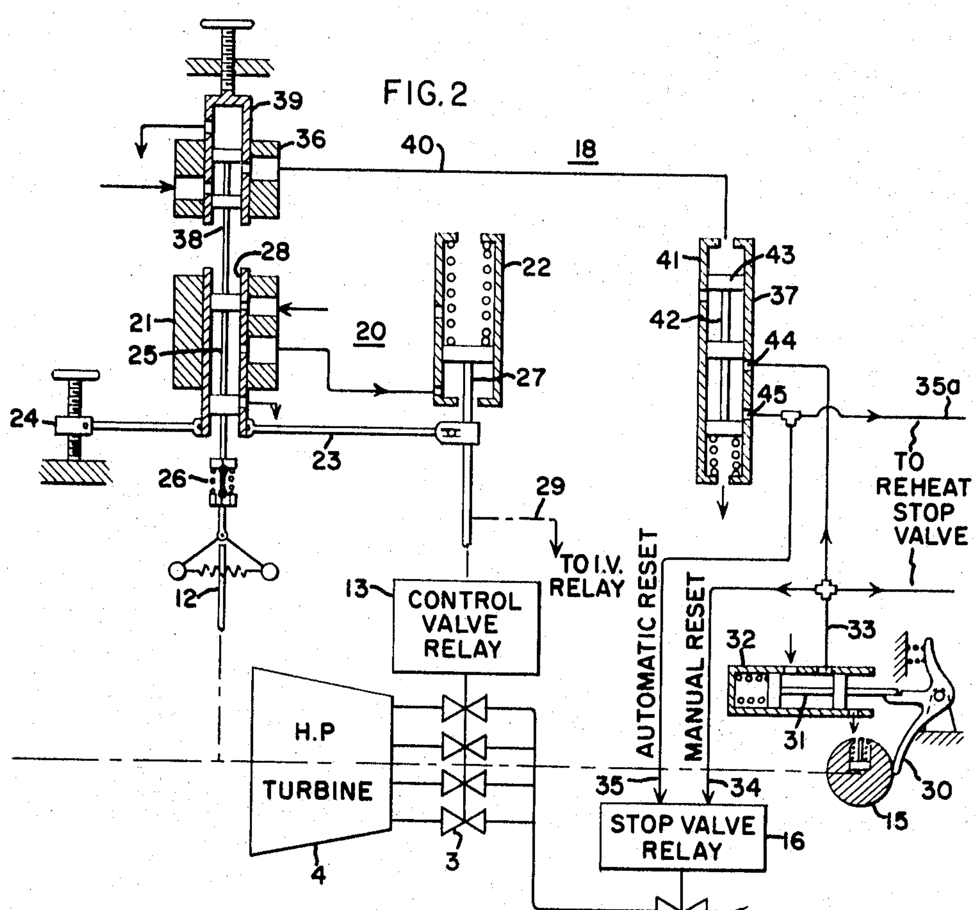

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FIG. 2a

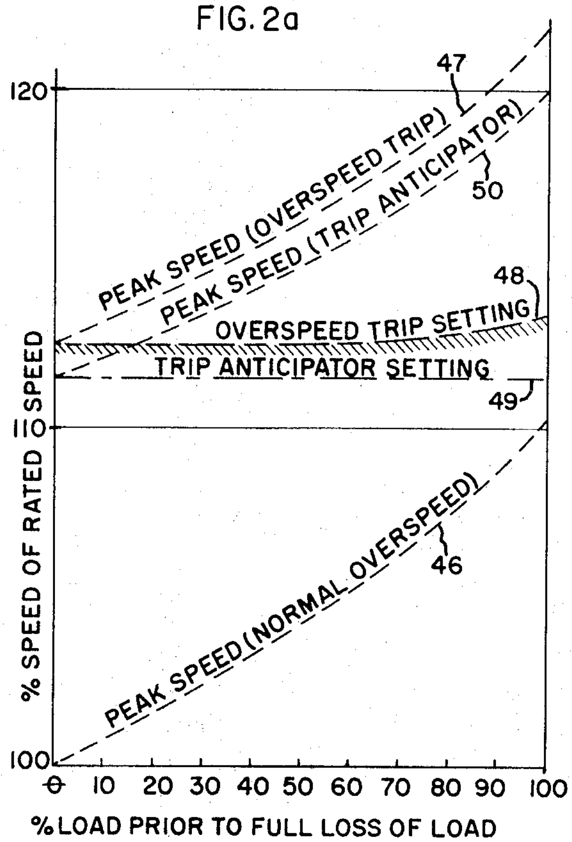

FIG. 3a

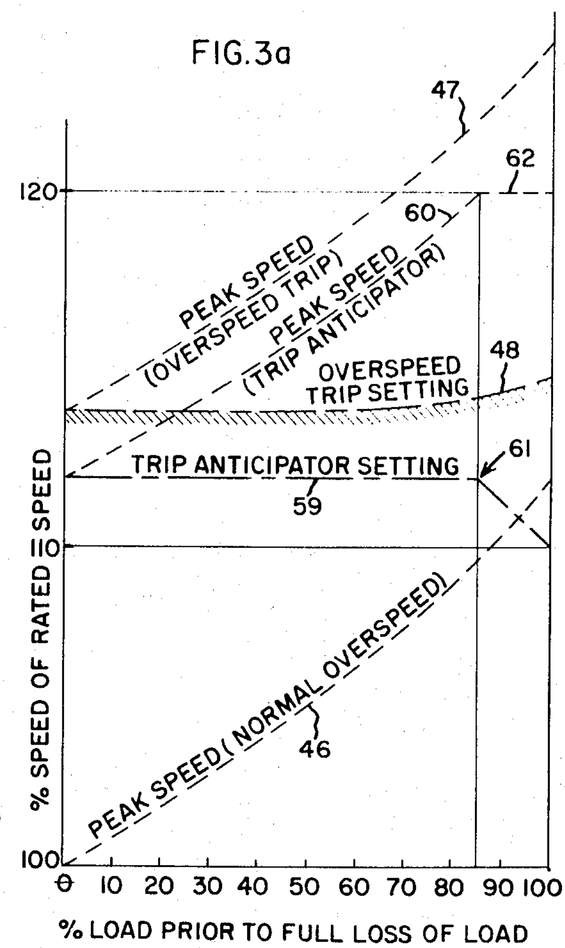

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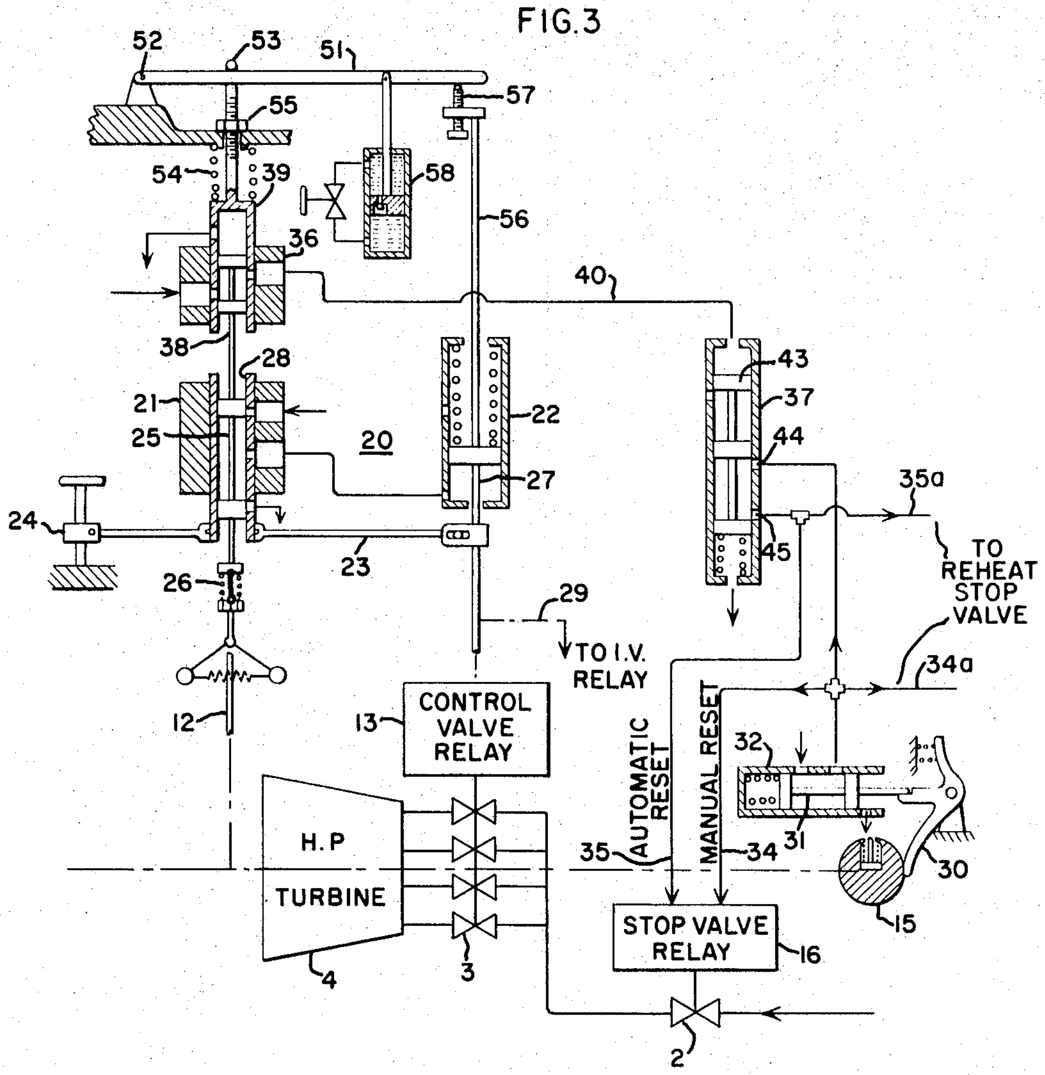
FIG. 3



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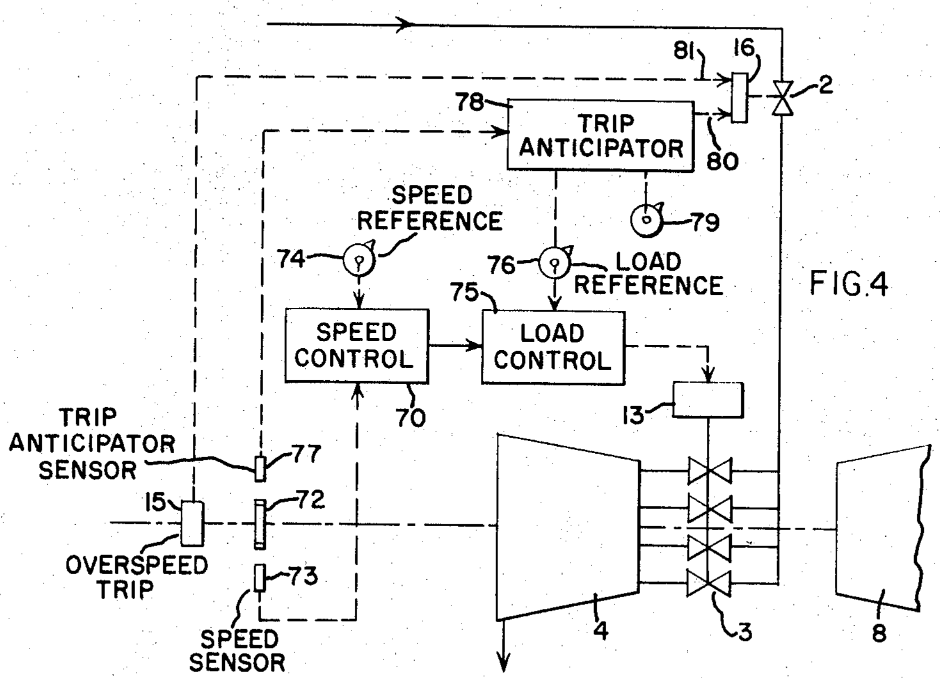

FIG.4

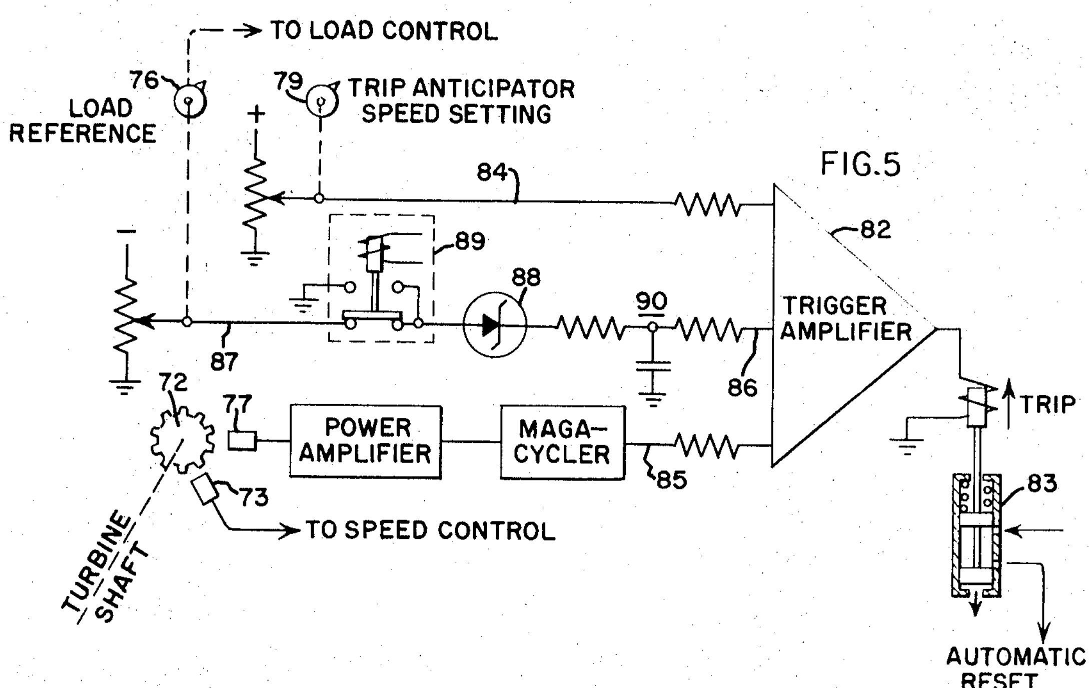

FIG.5

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TURBINE OVERSPEED TRIP ANTICIPATOR

CROSS REFERENCE

CROSS REFERENCE TO RELATED APPLICATIONS

This application is a continuation-in-part of my abandoned application Ser. No. 468,887 filed July 1, 1965 and assigned to the present assignee.

BACKGROUND OF THE INVENTION

This invention relates to an improved turbine control system for preventing dangerous overspeed of the turbine, and more particularly, the invention relates to a control system for anticipating and sometimes forestalling operation of the conventional overspeed emergency trip under conditions which would result in dangerous overspeed should the normal speed control system fail to control the turbine speed.

Improvements in large-capacity turbine-generators have resulted in greater difficulties in controlling speed upon loss of load, due to the greater entrained steam energy and higher power density relative to the inertia of the rotating parts. Faster-closing stop valves have contributed substantially to reducing the emergency speed rise during closing of these valves. However, improvements in stop-valve-closing speeds are being fully exploited and additional anticipatory measures are required to prevent overspeed.

Another approach has been to anticipate overspeed by closing the valves under condition of power-load unbalance. One such arrangement is disclosed in U.S. Pat. No. 3,198,954 granted Aug. 3, 1965 to M. A. Eggenberger and P. H. Troutman, and assigned to the assignee of the present application.

A conventional steam turbine-generator has two lines of defense against overspeed. There is normally a set of "control valves" operated by the speed governor. Ahead of the control valves in series is a "stop valve" actuated by a simple, very reliable emergency governor, preferably called an overspeed trip. In a reheat steam turbine, the same speed governor and emergency governor may also actuate respectively a set of "intercept valves" and "reheat stop valves" these having much the same control functions as the aforesaid control valves and stop valve.

The turbine is usually designed so that the overspeed trip must be manually reset by the operator and since this is undesirable for many reasons, including time required to put the turbine-generator back in service, the rules of design provide that the unit shall be capable of rejecting maximum guaranteed load without tripping the overspeed trip. Other design rules, which will be familiar to those skilled in the art, provide that the speed setting of the overspeed trip be a specified increment above the expected peak speed on loss of load. The above two rules necessarily mean that the turbine will be at a speed substantially above its normal operating speed at the time the overspeed trip is actuated should a need for it occur. Thereafter, the turbine reaches even greater overspeed before the closing of the stop and reheat stop valves reduce the steam flow to zero.

The greater the load which is being carried before load is lost, the more rapidly will the rotor accelerate because of the larger unbalance of torques on the rotors.

Accordingly, one object of the present invention is to provide a device which will anticipate imminent actuation of the overspeed trip and will act in its stead to prevent the turbine from exceeding a specified peak speed upon loss of load, should the control valves or intercept valves fail to control the speed.

Another object of the invention is to provide a device to close the stop valves at a speed lower than the overspeed trip setting, but to subsequently reopen the stop valves again should the normal speed-control system have functioned properly.

Still another object of the invention is to provide an improved overspeed trip anticipator which is adaptive in accordance with the conditions of load prevailing on the turbine-generator just prior to loss of load. Yet another object of the invention is to provide an improved device for limiting peak speed to a selected value without causing the overspeed trip to function while at the same time protecting the turbine against failure of the conventional overspeed system.

The subject matter of the invention is particularly pointed out and distinctly claimed in the concluding portion of the specification.

The invention, however, both as to organization and method of practice, together with further objects and advantages thereof, may best be understood by reference to the following description taken in connection with the accompanying drawing in which:

FIG. 1 is a simplified schematic diagram of a typical reheat turbine-generator powerplant and control system employing the invention,

FIG. 2 is a simplified diagram showing the trip anticipator in its simplest form added to a conventional control system,

FIG. 2*a* is a graph illustrating the operation of the device shown in FIG. 2,

FIG. 3 is a modified form of the invention illustrating an adaptive trip anticipator,

FIG. 3*a* is a graph illustrating the operation of the device shown in FIG. 3, and

FIGS. 4 and 5 illustrate a modified form of the invention for an electrohydraulic control system.

SUMMARY OF THE INVENTION

Briefly stated, the invention is practiced by providing speed responsive means to actuate the stop valves at a speed below the setting of the conventional overspeed trip, in such a manner that the stop valves may reopen should the normal speed-control system, using control valves and intercept valves, function properly. A modified form of the invention adapts the trip anticipator speed setting in accordance with the load on the turbine to positively limit peak speed below that which would occur upon actuation of the overspeed trip.

DESCRIPTION OF MECHANICAL-HYDRAULIC TRIP ANTICIPATOR

Referring now to FIG. 1 of the drawing, the steam flows from steam generator 1 through main stop valve 2, a set of control valves 3, high-pressure turbines 4, and is reheated in reheater 5. The steam then flows through reheat stop valve 6, intercept valve 7, intermediate-pressure turbine 8, low-pressure turbine 9 to condenser 10. Turbines 4, 8, 9 drive a load such as generator 11.

The normal speed-control system comprises a speed-responsive device 12, which can be either mechanical or electrical, connected to actuate conventional mechanical-hydraulic or electrohydraulic relays 13, 14 actuating control valves 3 and intercept valve 7 respectively.

An emergency governor or overspeed trip 15 is a simple speed-responsive device, such as an "offcenter bolt" or similar known device which trips main stop valve 2 and reheat stop valve 6 through relays 16, 17 respectively. This may be done by dumping oil pressure from a line by means of a pilot valve and is well known in the art.

The trip anticipator 18 which is the subject of the present invention is also connected to actuate relays 16, 17 in a manner to cause the stop valve 2 and reheat stop valve 6 to close. This is accomplished through a separate automatically resetting type of control to the stop valve relay 16, 17 as indicated by the dotted lines 18*a*, 18*b*. Trip anticipator 18 may employ a third speed-responsive device or it may be conveniently actuated by the main governor 12 as indicated by dotted line 19.

In order to simplify the description of the trip anticipator and its relation to the conventional turbine-generator control system, FIGS. 2 through 5 omit the reheat portion of the steam cycle and the portions of the control system which pertain to the reheat stop valve and intercept valve controlling the reheat steam. The trip anticipator is not necessarily restricted to use in a reheat turbine, but it is shown in that environment in FIG. 1 because it is most useful in large-capacity turbine-generator units which would normally employ reheat. However, an understanding of its operation is facilitated by examining the trip anticipator in its simplest form in FIG. 2, where the control elements have the same reference numbers as in FIG. 1, insofar as possible, although the figure is arranged in a slightly different manner.

Normal speed/load control is obtained by means of the speed governor 12 operating the control valves 3 through control valve relay 13. This is achieved through a speed-governing servomechanism shown generally as 20 comprising a pilot valve 21, a single acting servopiston 27 with cylinder 22, and a restoring lever 23 attached to an adjustable fulcrum 24. The stem 25 of pilot valve 21 is positioned up or down by the movements of speed governor 12 through a self-aligning link 26 to control the admission of hydraulic fluid from a pressure source to servomotor 22. The resulting movement of the servopiston 27 causes lever 23 to position slidable sleeve 28 of the pilot valve. Thus the movements of servopiston 27 correspond with the position of the speed governor, but the force and the stroke is greatly multiplied. Adjustment in accordance with desired load is accomplished by moving the adjustable fulcrum 24. The movements of servopiston 27 may also be communicated to the intercept valve relay (see FIG. 1) as indicated by the dot-dash line 29.

A simplified form of emergency overspeed trip is illustrated in FIG. 2 by means of a speed responsive offcenter bolt device 15 connected to rotate with the high-pressure turbine shaft. Device 15 is arranged to actuate a pivotable trip finger 30 so as to release stem 31 of a spring-loaded dump valve 32 in such a manner as to release oil pressure in conduit 33. Means (not shown) are provided to manually reset dump valve 31 after it has tripped, as will be understood by those skilled in the art.

Stop valve relay 16 which is a hydraulic servomechanism arranged to control stop valve 2 in an off-on manner, is provided with two incoming hydraulic lines shown as a "manual reset" line 34 and "automatic reset" line 35. Hydraulic pressure is required in both lines to hold stop valve 2 in an open position. Dumping of oil from line 34 necessitates manual resetting of stop valve relay 16. However, dumping of oil pressure from line 35 and subsequent restoration of hydraulic pressure will cause the stop valve 2 to first close and then reopen.

It will be understood that the foregoing description of the conventional speed-governing system through the control valves and the emergency overspeed trip system with the stop valve is described in very simple schematic form and that many other devices such as load limit, speed-regulation adjustment, and various other adjusting features would be necessary in an actual steam turbine control system.

The trip anticipator, shown generally as 18, consists of a trip anticipator pilot valve 36 and a trip-anticipator relay 37. Pilot valve 36 has a valve stem 38 which is positioned in accordance with turbine speed. This is conveniently accomplished by using the speed signal from the main governor 12 and arranging the pilot valve stem 38 so that it is an extension of pilot valve stem 25. However, it will be obvious that a supplementary speed-responsive means in addition to main governor 12 might be employed to position pilot valve stem 38.

Pilot valve sleeve 39 is adjustable and may be raised or lowered to determine the point at which hydraulic fluid in conduit 40 will be dumped to actuate the trip-anticipator relay 37, as should be apparent from the drawing. Downward movement of pilot valve stem 38 upon increase in speed causes fluid to be discharged from conduit 40 at the speed which is set using the adjustable sleeve 39.

Trip-anticipator relay 37 is in reality a pressure-actuated three-way valve and comprises a sleeve 41 and a spring-loaded stem 42. An upper land 43 acts as a piston to hold stem 42 downward against the spring pressure in the position shown so that ports 44 and 45 communicate when the turbine is at a speed below that at which the trip anticipator is actuated. On loss of pressure in conduit 40, stem 42 will rise and discharge fluid from the "automatic reset" line 35 through port 45 of the relay 37. On the other hand, fluid will not be discharged through port 44 of the relay 37, but hydraulic pressure will be maintained in the "manual reset" line 34 which is supplied by line 33 via the emergency dump valve 32.

Operation of FIG. 2 will be described by reference to the graph of FIG. 2*a*, on which the percent of rated load prior to full loss of load is plotted as the abscissa and on which the percent of rated speed is plotted as the ordinate. The dashed line 46 represents "normal overspeed" which is the peak speed which will result if load as indicated on the abscissa is lost and the main governor 12 acts in the expected manner through servomechanism 20 to close the control valves 3 so as to limit the overspeed. It will be observed that if 100 percent load is being carried and is suddenly lost, the normal overspeed curve 46 indicates that approximately 110 percent of rated speed will occur before the turbine speed levels off and starts decreasing.

Curve 47 illustrates the peak speed which will occur if the conventional overspeed trip is actuated at a speed setting indicated by dot-dash line 48 (assuming that the normal speed control through the control valves failed to function). Curve 48 is cross-hatched to indicate the margin of tripping which normally occurs with this type of governor, and it is also curved to illustrate the delay in tripping which takes place due to acceleration effects on the trip device at large load losses. Customary requirements applicable to large turbine-generators require that speed setting 48 of the overspeed trip be higher than the normal overspeed curve 46 by a specified increment so that loss of load will not result in actuating the overspeed trip. It will be observed that if full load is lost and if the control valves fail for some reason to control turbine overspeed in accordance with curve 46, then the overspeed trip will be actuated and the peak speed, as indicated by curve 47, will result in excessive speeds of the turbine.

Superimposed on the graph of FIG. 2*a* is a third set of curves in accordance with the present invention, designated as the trip-anticipator setting 49, shown in dot-dash lines, and the trip-anticipator peak-speed curve 50 shown in dashed lines. The trip-anticipator setting 49 is adjusted by means of the pilot valve sleeve 39 in such a manner that the peak-speed curve 50 resulting therefrom will terminate at a desired peak speed upon loss of full load, in this case 120 percent of rated speed. It will be observed that the trip-anticipator setting curve 49 lies below curve 48 and trip anticipation will occur before the conventional overspeed trip mechanism is put into play.

Referring back to FIG. 2, assume that full load is being carried and that full load is suddenly lost and that, for some reason, the control valves fail to control turbine overspeed in the expected manner shown by curve 46 on FIG. 2*a*. Lowering of pilot valve stem 38 will cause hydraulic fluid to be discharged from conduit 40, causing pilot valve stem 42 of the trip-anticipator relay 37 to rise. Fluid is dumped from the automatic reset line 35 which causes stop valve relay 16 to close stop valve 2. Similarly, fluid will also be dumped from the automatic reset line 35*a* leading to the reheat stop valve, causing it to close also.

Assume now that speed is brought under control before the turbine reaches the overspeed trip setting (curve 48 of FIG. 2*a*), decrease in speed will cause anticipator pilot valve stem 38 to rise and reestablish fluid pressure in conduit 40, causing the trip-anticipator relay stem 42 to resume its position shown in FIG. 2. This action reestablishes fluid pressure in line 35 and causes the stop valve relay 16 to reopen stop valves 2. The foregoing action has taken place without dumping of oil pressure from the manual reset lines 34 or tripping of the emergency governor pilot valve 32. The control over the turbine is reestablished in terms of the control valves 3, therefore, without actuating the overspeed trip.

If, on the other hand, the normal speed-governing system does not function, and the speed continues to rise, the overspeed trip will be actuated in the usual manner, causing the stop valve and reheat stop valve to remain closed. In this case, fluid will also be dumped from the manual reset lines 34, 34*a* by means of the overspeed trip pilot valve 32. However, it should be particularly noted that since the closing of the stop valves was anticipated and carried out at an earlier period in time, the peak turbine speed will not go any higher than curve **50**. Without a trip-ancitipator device, peak speed would reach the values indicated by curve **47**, which would result in an excessive overspeed for the turbine.

In the arrangement previously described in connection with FIGS. 2 and 2*a*, it was observed that the trip-anticipator setting 49 was fixed as determined by the setting of pilot valve sleeve 39 on the trip-anticipator pilot valve. FIG. 3 and the accompanying graph, FIG. 3*a*, illustrate a modification, wherein the trip-anticipator speed setting is caused to be adaptive to reflect the load being carried by the turbine. Here the setting of the trip-anticipator pilot valve sleeve is caused to reduce the trip-anticipator speed setting at high values of turbine load. In this manner, anticipated closing of the stop valves will take place even earlier and in some cases even before the turbine reaches its normal overspeed corresponding to this load level.

In FIG. 3, the same elements are indicated by the same reference numerals as in FIG. 2, with the following exceptions.

Pilot valve sleeve **39** of the trip-anticipator pilot valve **36** is positioned by means of a lever **51** fulcrumed at **52** when it moves upward sufficiently to hit an abutment **53** on the pilot valve sleeve stem. When lever **51** is below abutment **53**, the sleeve **39** is held in a fixed position by spring **54** in accordance with a speed adjustment depicted by nut **55**.

The right-hand end of lever **51** is raised by means of an extension **56** on the servomotor piston **27** at a point determined by the adjusting screw **57**.

A dash pot **58** serves as a "memory device" to hold the right-hand end of lever **51** in an elevated position for a few seconds in the event that extension **56** is suddenly withdrawn to a downward position, as would be the case in a sudden increase of speed upon loss of load.

As will be known to those skilled in the art, the position of servomotor piston **27** when the turbine-generator is synchronized and carrying load with other turbine-generators will be proportional to the load being carried at rated speed. On the other hand, when load is lost, the servomotor piston **27** will descend rapidly because of the increase in speed.

Reference to FIG. 3*a* of the graph will illustrate the operation of the modification shown in FIG. 3 with the adaptive trip-anticipator setting. The reference numbers correspond to those on the graph of FIG. 2*a* with the following exceptions.

Curve **59** illustrates the speed setting at which the trip-anticipator pilot valve is actuated to dump hydraulic fluid from line **40**. The corresponding peak speed which would be reached by the turbine is illustrated by curve **60**. It will be noticed that at point **61**, the trip-anticipator speed setting is gradually lowered as the load increases, at a rate which results in a flat peak-speed curve portion **62**. This results in limiting turbine overspeed to a selected valve. Point **61** on the graph is determined by the setting of adjustment screw **57** which, in turn, determines the point at which lever **51** commences to be raised. The slope of curve **59** beyond point **61** is, of course, determined by the mechanical advantage of lever **51**, and is predetermined so that a flat peak-speed curve at **62** results. The elements in FIG. 3 are shown as positioned at a load of approximately 85 percent when adjusting screw **57** just touches lever **51**. Subsequent increase in load will raise the pilot valve sleeve **39** to lower the setting at which subsequent increase in speed will cause the trip anticipator to function.

The operation of the modification shown in FIGS. 3 and 3*a* *is the same as previously described with respect to action of the trip anticipator at low values of load. Above the setting of* 85 percent load in the example shown, the turbine steam-control valves will be opened to such an extent that lever **51** will be raised by the extension **56** on the servomotor piston to lower the trip-anticipator speed setting. Upon loss of load, the extension **56** will be withdrawn, but dashpot **58** will hold lever **51** in an elevated position long enough for trip-anticipator pilot valve **36** to dump fluid from conduit **40**. This will evacuate the automatic reset lines **35**, **35*a*** as before and cause the stop valves to close. Restoration of fluid pressure in lines **35**, **35*a*** will reopen the stop valves should the control valves and intercept valves function in the expected manner. In any event, however, the turbine peak speed will not exceed that indicated as on curve portion **62** in FIG. 3*a*, because tripping of the conventional overspeed trip has been anticipated, and the stop valves have already been closed when overspeed tripping occurs. At very high values of load where the trip-anticipator setting crosses the normal overspeed curve, the stop valves will always close, but they will reopen if the normal speed-governing system functions properly without actuating the overspeed trip.

DESCRIPTION OF ELECTROHYDRAULIC TRIP ANTICIPATOR

As indicated previously, the trip anticipator is adaptable for use either with a mechanical or an electrical turbine control system and can receive its speed signal from an independent speed-responsive device. FIGS. 4 and 5 illustrate a modification of the invention, in simplified form, for use on an electrohydraulic control system of the type more fully described in U.S. Pat. No. 3,097,488 issued to M. A. Eggenberger et al. on July 16, 1963. The portions of the control for the reheat portion of the steam cycle are omitted for simplicity.

FIG. 4, in so far as it differs from the preceding figures, illustrates an electrohydraulic control for the steam control valves 3 comprising a speed control **70** and a load control **75**. The speed signal is obtained from a toothed wheel **72** on the turbine shaft which initiates pulses in a speed sensor **73** as before. The actual speed is compared with a desired or reference speed set with knob **74** and the resulting error signal, after suitable modification, is supplied to the load control unit **75**. There a desired load demand or load reference signal is superimposed on the speed signal so as to control the valves through relays **13**, in accordance with a conventional control system.

According to the present invention, an additional speed sensor **77** supplies a speed signal to the trip anticipator **78**. The trip-anticipator speed setting is adjusted as desired with knob **79**, this being analogous to the setting obtained with the pilot valve sleeve **39** in FIG. 2. Actuation of the trip anticipator dumps fluid from the automatic reset line **80** leading to the stop valve relay **16** as before. This is a different type of tripping action than is obtained by the overspeed trip **15** when dumping fluid from the manual reset line **81**. Reestablishment of pressure in line **80** will cause the stop valve **2** to automatically reopen, whereas manual resetting is necessary when fluid is dumped from line **81**.

Reference to FIG. 5 of the drawing shows a simplified form of electrical trip-anticipator actuator. A trigger amplifier **82** is arranged to actuate a solenoid dump valve **83** to dump fluid from the automatic reset line **80** when the summed voltage at the input to the trigger amplifier becomes negative. Dump valve **83** is analogous to valve **37** in FIG. 2.

An adjustable positive bias voltage is applied to line **84** by means of the trip-anticipator speed setting knob **79**. A counterbalancing, increasingly negative voltage is applied to line **85** as the turbine speed increases. At rated speed, the positive voltage on line **84** exceeds the negative voltage on line **85** by a selected amount, in accordance with the setting of knob **79**. To this extent, the trigger amplifier will be actuated if the turbine overspeeds to such an extent that the negative voltage exceeds the positive bias and trips the dump valve **83**. The action is thus the same as that of the mechanical-hydraulic system shown in FIG. 2 and its operation is as shown in FIG. 2*a*.

In order to provide the additional load adaptive feature described in the mechanical-hydraulic version of FIG. 3 and the operation of FIG. 3*a*, an additional input voltage to the trigger amplifier **82** is provided which, above a certain load, applies an increasingly negative voltage on line **86** as the load increases. This reduces the trip-anticipator setting above a selected load as indicated in FIG. 3[a].

Although the FIG. 3 mechanical-hydraulic arrangement reduced the trip-anticipator setting in accordance with actual load on the turbine (as imposed by the position of stop **57** in FIG. 3), the electrohydraulic version reduces the trip-anticipator setting in accordance with the load demand or load reference signal setting on the load control unit **75**. As the load reference is increased by turning knob **76**, an increasingly negative voltage is applied on line **87**. This voltage is blocked by Zener diode **88**, until the load setting exceeds a predetermined value, here about 70 percent load, after which the voltage on lead **86** becomes increasing negative and serves to lower the degree of overspeed at which the trip anticipator is actuated.

One of the accessory devices on the electrohydraulic control may include means to suddenly reduce the load reference signal, such as a relay **89**. To prevent the negative signal on line **86** from dropping suddenly to zero, an RC circuit **90** delays the sudden loss of the signal, acting in a similar manner to the dash pot **58** of FIG. 3.

Thus it will be seen that means have been provided which anticipate overspeed tripping by closing the stop valves in a time sufficient to prevent a peak speed exceeding a desired amount. If the normal speed-governing system functions as it should, then the stop valves will reopen. If the normal speed-governing system does not function, then the stop valves will already be closed when the conventional overspeed trip mechanism is actuated.

The additional modification of an adaptive trip-anticipator setting to lower the setting at high values of actual load or load demand is useful for very large capacity turbine-generator units in which the high-power density could result in excessive overspeeds if the conventional emergency overspeed trip were the only device used to control overspeed in the event of failure of the normal speed-governing system.

What is claimed as new and desired to secure by Letters Patent of the United States is:

1. In a turbine of the type having first and second valve means connected in series controlling the flow of motive fluid thereto and having normal speed-governing means actuating said first valve means and also having emergency speed-governing means arranged to close the second valve means at an overspeed trip setting, the improvement comprising:
   - overspeed trip-anticipator means arranged to close said second valve means at a selected trip-anticipator speed setting below the overspeed trip setting of the emergency speed-governing means and to reopen said second valve means if the turbine speed thereafter falls below said trip-anticipator speed setting without having first exceeded the overspeed trip setting of the emergency speed governing means, and
   - means arranged to reduce the trip-anticipator speed setting above a selected turbine load.

2. The combination according to claim **1** wherein said means arranged to reduce the trip-anticipator speed setting are load responsive.

3. The combination according to claim **1** wherein said means arranged to reduce the trip-anticipator speed setting are responsive to turbine load setting.

4. In a turbine of the type having first and second valve means connected in series to control the flow of motive fluid thereto, the combination of:
   - first governing means having first speed-responsive means and normally controlling said first valve means,
   - second governing means having second speed-responsive means and controlling said second valve means so as to close the second valves at an overspeed trip setting,
   - third governing means connected to temporarily close said second valve means in response to a trip-anticipator speed setting lower than the overspeed trip speed setting, whereby closing of the second valves by the second governing means is anticipated by the third governing means should the first governing means fail to control speed.
   - means arranged to reduce the trip-anticipator speed setting above a selected turbine load, and
   - means for temporarily retaining said trip-anticipator speed setting upon sudden loss of load.

5. The combination according to claim **4** wherein said second governing means dumps hydraulic fluid to cause the second valves to close and wherein said third governing means comprises relay means arranged to dump hydraulic fluid from a second line upon increase in speed and to reestablish hydraulic pressure in the second line upon decrease in speed, said second line being also connected to actuate the second valves.

6. The combination according to claim **4** wherein said third governing means employs a third independent speed-responsive means.

7. In a reheat steam turbine-generator powerplant having a high-pressure turbine and an intermediate-pressure turbine employing reheated steam, the combination of:
   - main stop valve and main control valves connected in series to control the flow of high-pressure steam to the high-pressure turbine,
   - reheat stop valve and intercept valves connected in series to control the flow of reheated steam to the intermediate pressure turbine,
   - main governing means connected to control admission of steam through said control valves and intercept valves in response to turbine speed,
   - emergency governor means connected to close said main stop valve and said reheat stop valve at an overspeed trip setting,
   - trip-anticipator means connected to temporarily close the main stop valve and the reheat stop valve upon reaching a selected trip-anticipator speed setting lower than the overspeed trip speed setting and to reopen said stop valves if the overspeed trip setting is not attained.
   - means arranged to reduce the trip-anticipator speed setting above a selected turbine load, and
   - means to retain the trip-anticipator speed setting temporarily upon sudden loss of load.

8. The combination according to claim **7** wherein said trip anticipator is actuated in response to a speed indication from said main governing means.

9. The combination according to claim **7** wherein said trip anticipator is actuated in response to a speed indication from an independent electrical speed responsive means.