United States Patent

[11] 3,601,617

[72] Inventors Francisco P. De Mello
Burnt Hills;
Markus A. Eggenberger, Schenectady;
Richard J. Mills, Scotia, all of, N.Y.

[21] Appl. No. 41,271
[22] Filed May 28, 1970
[45] Patented Aug. 24, 1971
[73] Assignee General Electric Company

[54] **TURBINE CONTROL SYSTEM WITH EARLY VALVE ACTUATION UNDER UNBALANCED CONDITIONS**
10 Claims, 8 Drawing Figs.

[52] U.S. Cl. .... 290/40 C
[51] Int. Cl. F01d 21/00
[50] Field of Search 290/1, 40, 51, 52

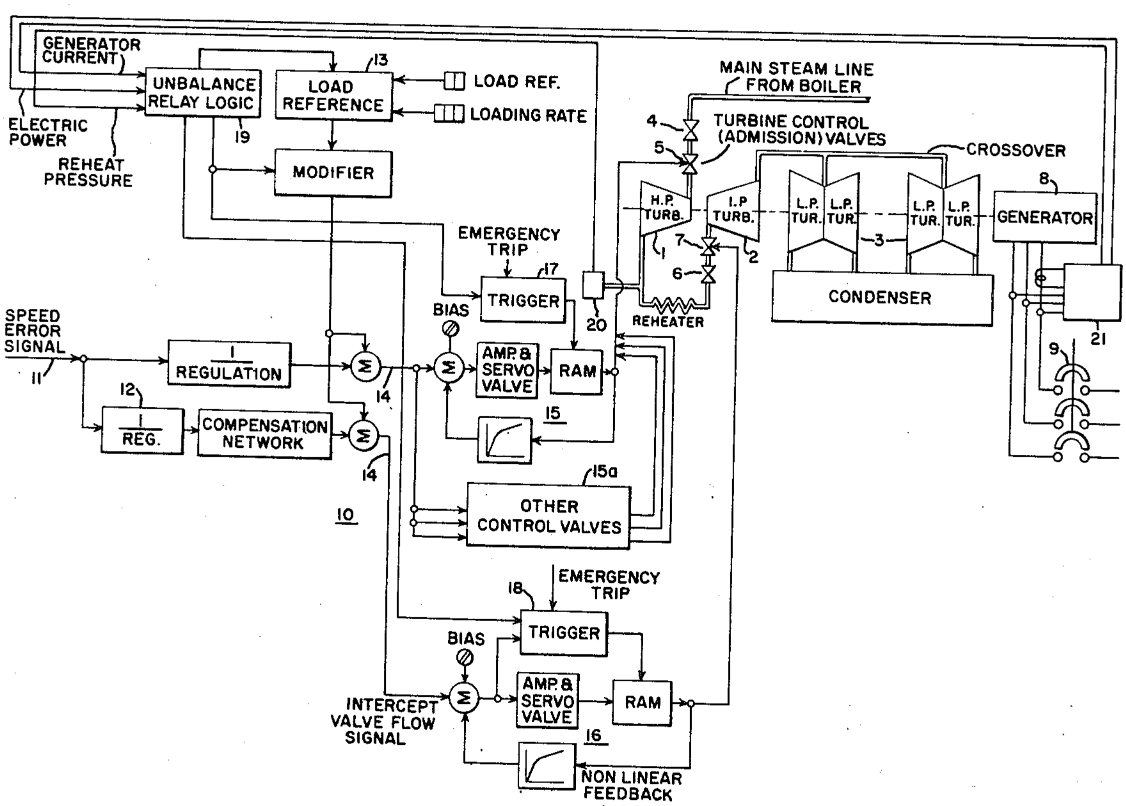
[56] References Cited

UNITED STATES PATENTS

1,792,241	2/1931	Ray	290/40
2,803,785	8/1957	Desch	290/40 X
3,274,443	9/1966	Eggenberger et al.	290/40 X
3,421,014	1/1969	Moorganov	290/40

Primary Examiner—Oris L. Rader
Assistant Examiner—W. E. Duncanson, Jr.
Attorneys—William C. Crutcher, Bryan C. Ogden, Frank L. Neuhauser, Oscar B. Waddell and Joseph B. Forman

ABSTRACT: A large steam turbine-generator control system with normal valve positioning systems for speed and load control and fast valve closure systems for turbine overspeed control, wherein the system also includes early valve actuation relay logic designed to function upon logical combinations of unbalance and time-rate-of-change of unbalance of selected turbine-generator measured operating conditions such as mechanical input power, electrical load and generator terminal current.



PATENTED AUG 24 1971 | 3,601,617

SHEET 1 OF 4

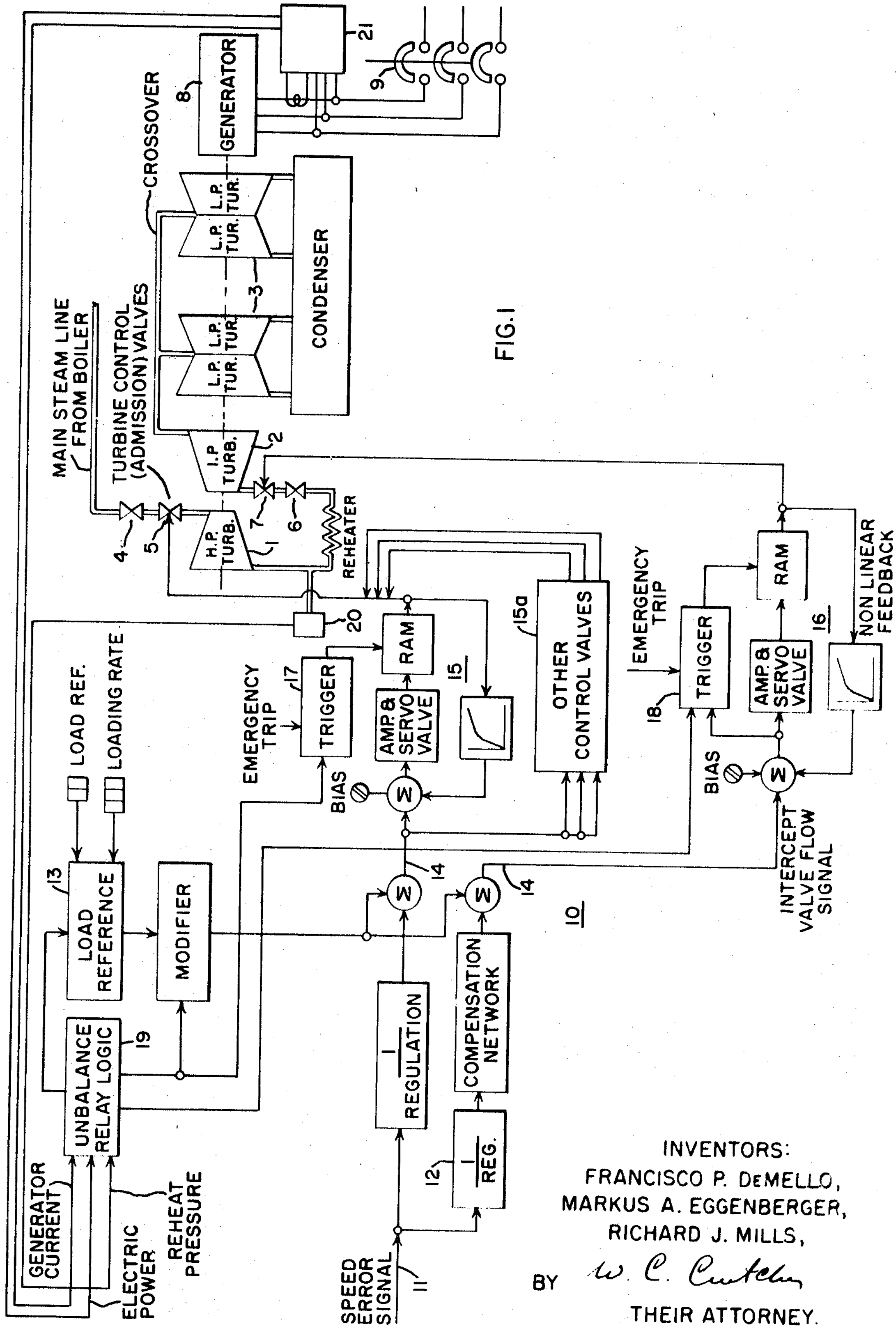


FIG. 1

INVENTORS:
FRANCISCO P. DeMELLO,
MARKUS A. EGGENBERGER,
RICHARD J. MILLS,

BY W. C. Cutler

THEIR ATTORNEY.

FIG.2

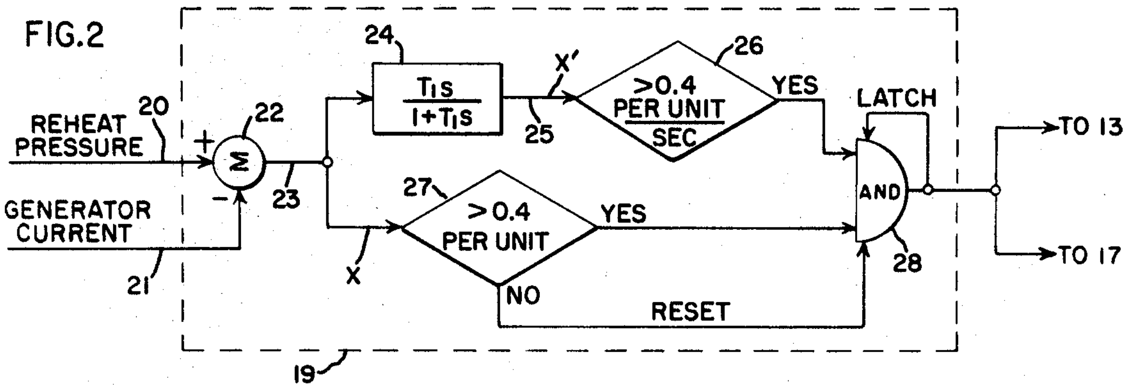


FIG.3

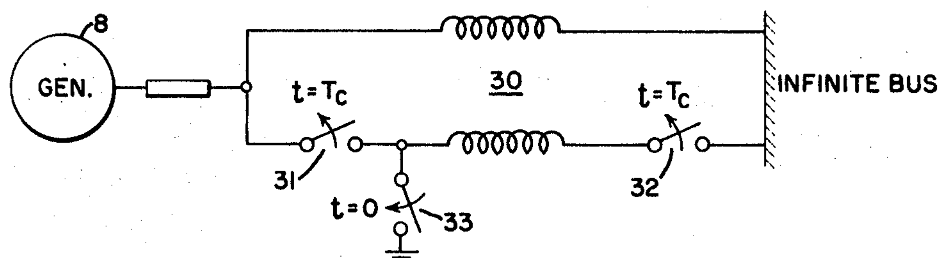
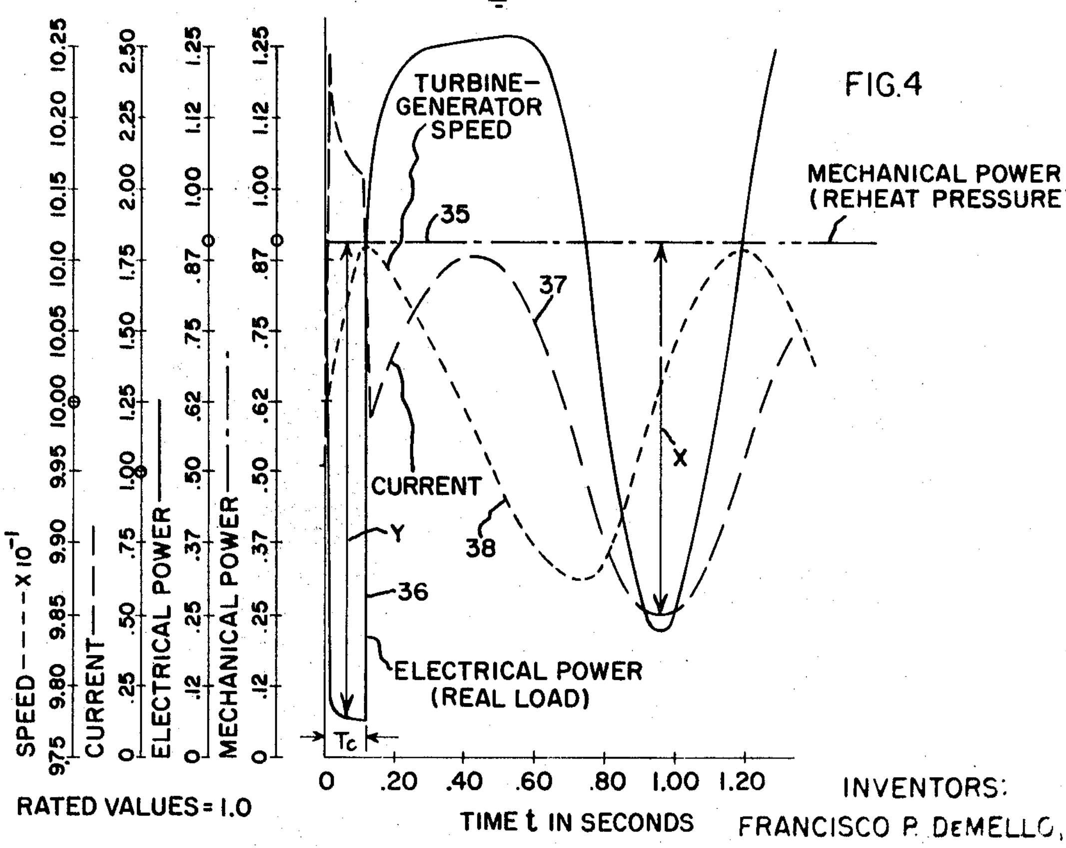
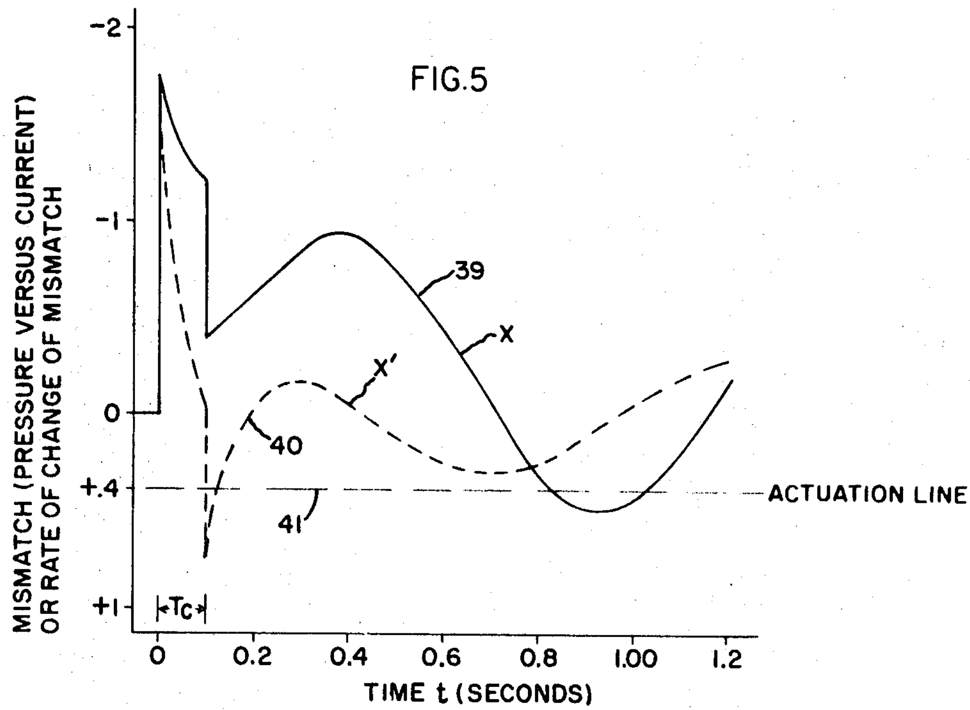


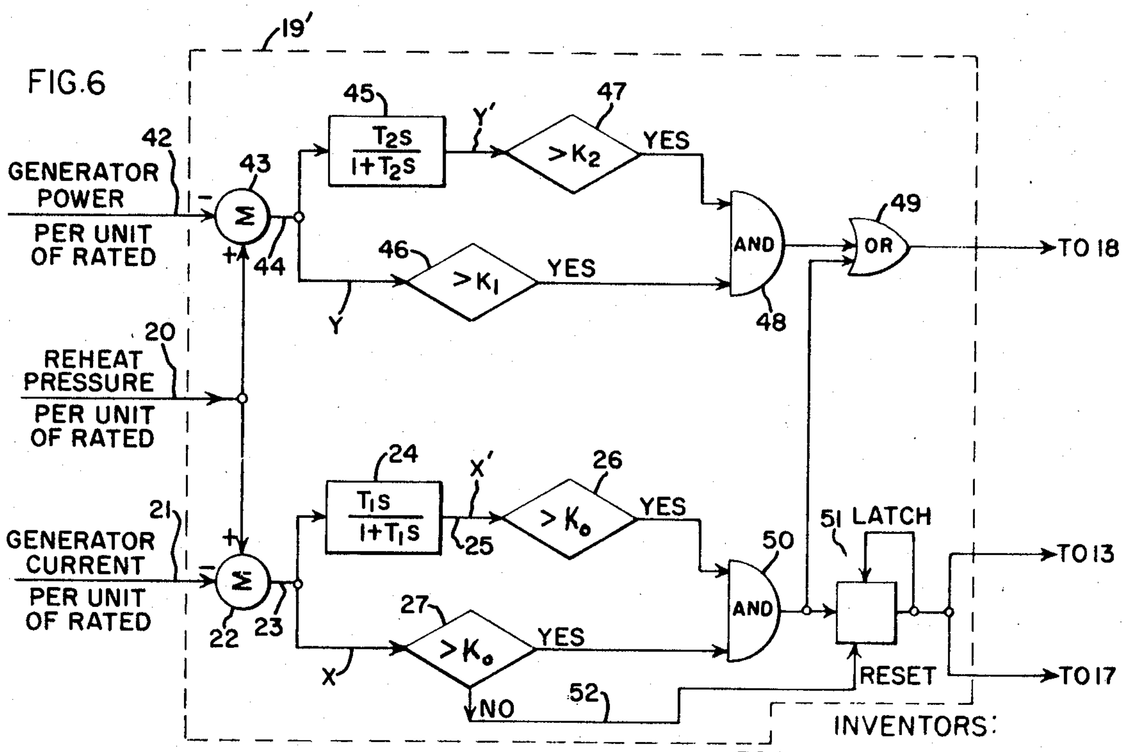
FIG.4



RATED VALUES = 1.0

INVENTORS:
FRANCISCO P. DEMELLO,
MARKUS A. EGGENBERGER,
RICHARD J. MILLS,
BY W. C. Crutcher
THEIR ATTORNEY.





INVENTORS:
FRANCISCO P. DEMELLO,
MARKUS A. EGGENBERGER,
RICHARD J. MILLS,

BY W. C. Crutcher
THEIR ATTORNEY.

FIG.7

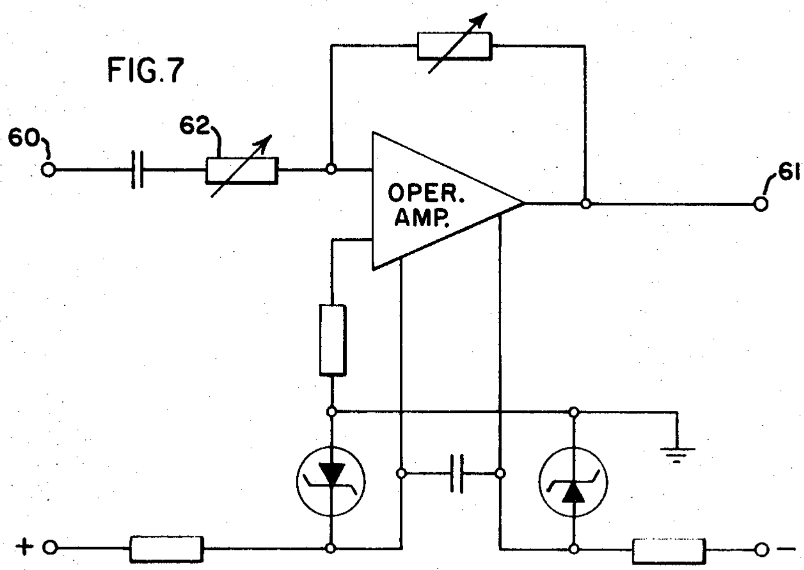
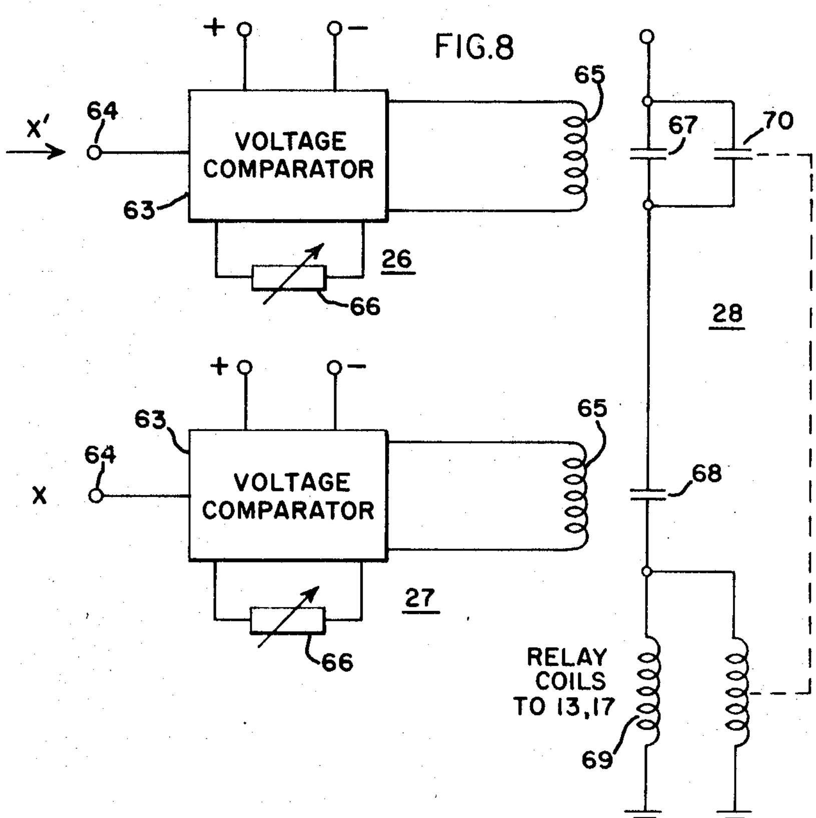


FIG.8



INVENTORS:
FRANCISCO P. DeMELLO,
MARKUS A. EGGENBERGER,
RICHARD J. MILLS,

BY W. C. Crutcher
THEIR ATTORNEY.

TURBINE CONTROL SYSTEM WITH EARLY VALVE ACTUATION UNDER UNBALANCED CONDITIONS

Background of the Invention

This invention relates to turbine valve control systems for protection of the turbine and associated equipment under unbalanced conditions. More particularly, the invention relates to early valve actuation under the control of a logic system which provides overspeed protection and aid to system stability without producing undesirable valve actions during temporary power system transient swings.

Modern designs of large steam turbine-generators with low inertia-to-power ratios and more stringent reliability requirements have moved toward more sophisticated turbine control systems. Also there has been considerable interest in the utility industry concerning coordination of turbine controls with electrical power system requirements as an aid to electrical system stability.

In the past, turbine manufacturers have been primarily concerned with overspeed protection, and the controls have henceforth been designed to protect the turbine in the event of a "load rejection." A load rejection is defined here as the sudden and "permanent" loss of all or part of the electrical load on the generator as occurs, for example, when opening the main generator circuit breaker. Following a load rejection, the electrical load on the generator (output) will be very low (essentially zero), while the mechanical turbine power (input), roughly proportional to steam pressure, will be substantially the same. until the valves reduce the steam flow. The resulting unbalance will accelerate the rotor and cause overspeed.

It has been suggested in U.S. Pat. No. 3,198,954 to M. A. Eggenberger et al. that a predetermined condition of unbalance can anticipate and reduce potential rotor overspeed by initiating a reduction in the valve opening before overspeed takes place.

Another type of major system upset is a fault (short circuit) on some portion of the transmission system. In the short time period immediately following a fault, the load on the generator will drop, similar to the case of a load rejection, but contrary to a load rejection situation, the generator terminal current will rise suddenly due to the fault. After the fault has been cleared, the attendant change in network conditions can cause oscillations in the terminal current (and electrical load) as the system attempts to return to normal operation. If the system is inherently stable, it is not necessarily desirable to actuate closing of the turbine valves during the fault or after the fault has been cleared.

It has been suggested that schemes using time delays can be employed to eliminate undesired tripping of the valves on short duration of mechanical/electrical power mismatches, but there schemes may act to deteriorate turbine overspeed protection. Other more elaborate schemes have been suggested in the prior art, using circuit breaker positions and/or distance relay interfaces, but these will create controls which varied in each system application, and are not considered practical for general application.

A turbine control system which is actuated by unbalance between mechanical power and electrical load is normally unable to distinguish between the case of a "load rejection" and a "fault," whereas different types of valve actions might be desired for these two situations, Another known system has suggested use of unbalance between mechanical power and current at the generator terminals to rapidly close the valves. This arrangement does distinguish between a load rejection and a fault, but may be apt to close the valves unnecessarily during "swings" of the electrical current following clearing to the fault when transiently unbalanced conditions exist.

Accordingly, one object of the present invention is to provide an improved turbine control system with provision for different types of early valve actuation to best suit the type of system unbalance which has occurred.

Another object of the invention is to provide an improved turbine valve control system which provides overspeed protection and capability to aid system stability, without being susceptible to undesired actuation during nonharmful transient conditions.

DRAWING

The subject matter which is regarded as 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 drawings, in which:

FIG. **1** is a simplified schematic view of a reheat steam turbine-generator and its load control system,

FIG. **2** is a functional logic diagram of one type of unbalance relay in the present invention,

FIG. **3** is a simplified representation of a power system under fault conditions,

FIG. **4** is a graph showing time variation of various operating variables of a conventional turbine-generator following the occurrence and clearing of a fault,

FIG. **5** is a graph showing the response of variables used in the relay logic of FIG. **2** as they behave during the fault and following its clearing,

FIG. **6** is a functional logic diagram of a modified type of relay, and

FIGS. **7** and **8** examples of suitable devices for use in the logic systems.

Summary of the Invention

Briefly stated, the invention employs a control system responsive to logical combinations of unbalance and time rate of change of unbalance between various pairs of normally balanced variables to effect early turbine valve actuation for overspeed protection or as an aid to electrical system stability.

Description of the Preferred Embodiment

FIG. **1** of the drawing shows a typical reheat turbine-generator and its associated control system suitable for use with the subject invention. Steam for the boiler passes through high pressure, reheat (intermediate pressure) and low pressure turbines **1**, **2** and **3** respectively. Means for controlling the steam flow include main stop valves **4**, control (admission) valves **5**, reheat stop valves **6**, and intercept valves **7**. The turbines drive generator **8** which supplied the transmission line via a circuit breaker **9**.

The load control system for the turbine-generator is shown generally at **10**, on the left. A controlling signal is introduced at **11** representing the speed error, or difference between generator shaft frequency and speed reference. After modification of the speed error signal by a factor representing the setting for speed regulation in devices **12**, a load reference signal from a source **13** representing a desired load on the turbine-generator is summed with the modified speed error signal and a resulting valve position signal representing desired valve position appears on lines **14**. Electrohydraulic servo mechanisms, such as indicated generally at **15** for typical control valve (others indicated at **15***a*) and at **16** for the intercept valves, place the valves in the proper position for the desired load. Additional details of the foregoing type of control system may be seen in U.S. Pat. No. 3,097,488 issued to M. A. Eggenberger et al. on July 16, 1963, incorporated herein by reference.

The valve positioning servo mechanisms **15**, **16** include trigger and dump valve actuators **17**, **18** respectively which, upon introduction of appropriate electrical signals, actuate solenoid-operated dump valves to release hydraulic oil from the bottom of the valve positioning rams, allowing the valves to close. See U.S. Pat. No. 3,495,501 issued Feb. **15**, **1970** to Jens Kure-jensen for details of a suitable fast-closing valve actuator. Fast closure times for a typical valve are on the order of 0.1 seconds.

Control over the load reference source **13** and the dump valve triggers **17**, **18** comes about through actuation of the desired logic by the "unbalance relay logic" device **19** which is the subject of the present invention. The unbalance relay logic **19** has provision for introducing input variables representative of turbine-generator-operating conditions. One such input is provided by a pressure transducer **20** measuring reheat steam pressure, which is proportional to mechanical input power to the turbine-generator shaft under steady state conditions. A wattmeter device **21** connected to the generator output terminals provides a signal proportional to electrical power output of the generator (kw. load), as well as a signal proportional to the generator terminal current.

As will become apparent during the following description, one embodiment of the present invention employs only reheat pressure and generator current to actuate the unbalance relay, while a modification employs three input quantities, reheat pressure, generator current and electrical power (kw.).

Referring now to FIG. **2** of the drawing, a functional logic diagram is illustrated for the unbalance relay system **19**. A first input signal **20** proportional to reheat steam pressure and the second input signal **21** proportional to generator terminal current are compared at **22**. This pair of signals is normally matched under normally steady-state turbine-generator-operating conditions. A signal representative of the difference or unbalance between the two input quantities appears at **23**. This difference signal is designated herein as X.

The signal X on **23**, representing a steam pressure and generator current mismatch (under unbalanced conditions), is fed to two logic channels. In the upper branch, the signal is differentiated with respect to the time at **24** to provide a signal X′ representative of time rate of change of unbalance at **25**.

The differentiation device **24** is preferably implemented by a discriminator network in a manner that passes instantaneous changes in signal **23** with a unity gain, while at the same time attenuating slower changes as indicated by the transfer function. This device allows discrimination between step changes (as in load rejections) and slower changes caused by system swings. This type of differentiator also prevents the undesirable amplification of high frequency noise. The differentiated quantity X′ is subjected to a comparator device **26**, here preferably a voltage comparator, which provides an output in the event that the time rate of change of mismatch is greater than a selected quantity, here 0.4 per unit per second (or 40 percent per second). This selected quantity is adjustable so hat the threshold value may be set, at which an output will be obtained.

In the lower channel, the undifferentiated value X of the mismatch is also introduced to a similar comparator device **27**, which provides an output in the event that the mismatch X is greater than a selected threshold quantity, here also selected as 0.4 per unit (or 40 percent.)

The two outputs from comparator devices **26**, **27** are both inputs to a logical AND **28**, which in turn provides an output signal to load reference source **13** and to control valve trigger **17** only in the event that both of the aforesaid logical conditions are met. The output signal acts to reduce the load reference and to close the control valves by setting the load reference signal to zero and actuating the control valve trigger **17**.

The logical AND device **28** is provided with latch and reset inputs to keep device **28** actuated (after its initial actuation until the input to comparator device **27** falls below its threshold value, at which time logical AND device **28** is reset.

It will be understood to those skilled in the control art that the actual implementation of the unbalance relay system **19** shown in the logic diagram of FIG. **2** may take many forms in actual practice.

For example, the relay system **19** can be analog in nature, in which case the inputs are DC voltages summed at a summing junction, the differentiator **24** can be a passive RC network, the comparator devices **26**, **27** can be biased diodes, and the AND device can be comprised of simple electromechanical contacts in series.

It will also be understood to those skilled in the art that the functional diagram shown in FIG. **2** can be completely accomplished with special digital circuits or completely in terms of computer programming instructions for a general purpose digital computer. In the latter case, samplings are taken of reheat pressure and generator current, converted to digital quantities, and subjected to the various logical decision processes set forth in the diagram. The differentiation process represented at **24** is accomplished with a difference equation algorithm operating on successive samples of the periodically measured quantities. The comparator and AND functions **26**, **27**, **28** are accomplished by means of simple quantitative comparisons and conditional branch statements in the particular computer language used.

By way of specific example, although in no way intended to limit the scope of the present invention, FIGS. **7** and **8** show one preferred manner of implementing the logic diagram of FIG. **2**.

FIG. **7** shows a discriminator circuit which may be employed as the differentiator **24** of FIG. **2**. Unbalance signal X introduced at input terminal **60** will provide a rate of change of unbalance signal X′ at the output terminal **61**. The transfer function of the circuit is as indicated inside box **24** in FIG. **2** with a time constant T_l. Variation of time constant T_l is accomplished in the circuit of FIG. **7** by adjusting resistance **62**.

FIG. **8** shows a logic circuit suitable for devices **26**, **27** and **28** of FIG. **2** employing relay closures actuated by two voltage comparators **63**. Signals X and X′ applied at input terminals **64** will provide output currents through relay actuating coils **65** when the inputs exceed threshold values set by means of variable resistors **66**. As previously mentioned, each adjustable threshold is preferably set at 0.4 per unit of rated values.

The arrangement of relay closures serves to implement the logic. Actuation of both output coils **65** provides closure of series-connected relay contacts **67**, **68** to actuate output coil **69**. The "latch and reset" is provided by relay closure **70** as should be apparent from the drawing.

Operation of FIG. 2 Embodiment

For an understanding of the operation of the present invention, it is first necessary to consider the operation of a conventional turbine-generator under system disturbances. The problem of a load rejection has been previously explained wherein the power and terminal current both collapse together. The situation in the case of a fault on the transmission line is more complicated, and a better understanding is facilitated by reference to the simplified drawing of FIG. **3**. There the generator **8** is shown connected to a simplified transmission system **30**. Remote tie line breakers are indicated at **31** and **32**. Representation of a fault or grounding of one line of the transmission system **30** at time $t = 0$ is represented by a switch **33**. Thereafter, the normal fault clearing relays cause opening of the breakers **31**, **32** at a small but finite time interval T_C also indicated. The ordinate is provided with various scales quantifying the particular parameter identified at the initial balanced state at time $t = 0$. Mechanical power (or input power) represented by reheat pressure, is shown as line **35** and is relatively constant. The electrical load (or generator output power) indicated as line **36** which drops rapidly until the time of fault clearing, and thereafter oscillates after the fault is cleared. Generator terminal current is indicated by line **37** which rises rapidly at first during a surge of current toward the fault and then decays due to generator demagnetization, until the fault is cleared. Thereafter, it drops in value and oscillates as indicated by curve.

Turbine-generator rotor speed is indicated by line **38**. Due to the initial unbalance of mechanical input power and electrical output power caused by the fault, the rotor suffers an increase in speed until clearing of the fault. Thereafter, the speed will oscillate as it seeks a steady value.

As mentioned previously, the degree of unbalance between reheat pressure and generator current is indicated as a quantity X. This is a positive quantity for the instant shown on the graph. Similarly, the degree of unbalance or mismatch between mechanical power and generator electrical power (load) is indicated by quantity Y and is positive for the instant indicated. This second pair of turbine-generator-operating conditions is also normally matched, but become mismatched during unbalanced conditions.

Reference to FIG. 5 of the drawing illustrates the relative values of the unbalance X and time rate of change of unbalance X' under the situation of a fault such as that indicated in FIG. 4. The time *t* in seconds is the abscissa, while the mismatch (or rate of change of mismatch) between reheat pressure and the generator current in terms of per unit (or per unit per second) values is represented on the ordinate. The value of the mismatch X is shown by the solid line **39**, while the rate of the change of mismatch X' is shown by dotted line **40**. As will be apparent from the logic of FIG. 2, these quantities must be greater than 0.4 per unit and 0.4 per unit per second respectively (below the actuation line **41**) before the logical AND device **28** is actuated and there is a corresponding output from unbalance relay **19**. As indicated in FIG. 5, the rate of change of mismatch signal X' is below the actuation line **41** immediately following clearing of the fault. Subsequently, at a time approaching one second, the absolute value of mismatch of X, represented by line **39**, is below the actuation line, but at this later time, the rate of change of mismatch of X' is not severe enough to cause the unbalance relay to fulfill both logical conditions. Therefore, the unbalance relay **19** of the present invention is not actuated, whereas it might have become undesirably actuated during a transient back swing of the current with prior art devices if the rate factor X' were not present in the disclosed logic system.

The action of the unbalance relay shown in FIG. 2 is such that the unbalance relay is actuated during a load rejection when both the values of mismatch and the rate of change of mismatch are greater than specified threshold values. These specified threshold values may be altered individually for particular control conditions.

The action of the aforedescribed unbalance relay **19** is to trip the control valves by actuating trigger **17** and to also set the load reference to zero for both the control valves and intercept valves by altering the outputs from load reference device **13**, so that both of the control valves and intercept values will close. This type of valve actuation is primarily to control overspeed. However, the unbalance relay logic **19** is not actuated either during a fault or during a transient backswing of current following a fault which might otherwise resemble a load rejection under previous systems.

Following a load rejection which actuates the unbalance relay **19**, thus closing the turbine control and intercept valves, it would not be desirable to reopen the control valves until the mismatch X is reduced to less than the selected quantity (here 0.4 per unit or 40 percent). The mismatch X may be reduced either by restoring the electrical load or by reducing the reheat pressure. The purpose of the latch and reset inputs to the AND device **28** is to keep this device actuated (after its initial actuation) until the absolute mismatch X is reduced to less than the selected value, regardless of the rate of change signal X'. Table I sets forth the conditions and type of action taken by the unbalance relay **19**.

TABLE I

Event	X>0.4	X'>0.4	Action
During Load Rejection	Yes	Yes	Trip control valves; set load reference to zero for control and intercept valves; "AND" device 28 latches
During Fault Clearing	No	Yes	None

TABLE I—Continued

Event	X>0.4	X'>0.4	Action
During Transient Backswing following fault	Yes	No	None
Following Load Rejection	Yes	Any*	None: control valves remain in tripped position and load ref. remains zero
Following Load Rejection	No	Any	Allow control valves to reopen; restore load ref. to control and intercept valves

* "AND" device 28 latched.

MODIFICATION

Reference to FIG. 6 of the drawing illustrates a modification of the unbalance relay logic, designated **19'**, which can be substituted for relay logic **19** in FIG. **1**. Inputs are signals at **20** representative of reheat pressure at **21** representative of generator current, and an additional input at **42** representative of generator electrical power. A first comparison is made of normally balanced conditions of generator electrical power and reheat pressure at **43**, and a signal representing the difference or mismatch therebetween, hereinafter designated as Y, appears at **44**. This mismatch is also indicated as Y in FIG. 4. Signal Y passes to two channels as before, and is differentiated in the upper channel by a differentiator **45** to provide a time rate of change of mismatch Y'. Both the mismatch Y and the time rate of change of mismatch Y' are introduced to comparator devices **46, 47** respectively as before. Devices **46, 47** provide outputs to a logical AND device **48** if both of the values Y and Y' exceed selectable threshold values, here shown as K_1 and K_2 respectively. The values of K_1 and K_2 are selected in a manner similar to the use of settings **66** in FIG. **8**. The output from AND device **48** provides one input to an OR device **49**.

Referring back to the input end of unbalance relay **19'**, reheat pressure and generator current are compared as before at **22**, and the difference signal X is acted on by devices **24, 26** and **27** in a manner identical to the corresponding devices in relay logic **19**. The selectable threshold values for devices **26** and **27** are indicated as K_0, which can be chosen as 0.4 per unit in a typical system. The output of comparator devices **26** and **27** are introduced into an AND device **50**. The output of AND device **50** is introduced into a latching relay **51** and also as a second input to the OR device **49**. The relay **51** latches itself such that it will remain set until reset by the signal **52** from device **27**. The purpose of the latching relay **51** is the same as for the corresponding AND device **28** of relay logic **19**.

It will be seen that the modified unbalance relay logic provides basis for two entirely different types of valve actions according to the fulfillment of the conditions as indicated.

First, it will be observed that upon fulfillment of both the mismatch and the rate of change of mismatch of generator power and reheat pressure exceeding the threshold values K_1, K_2 respectively, there will be an output from AND **48** to intercept valve trigger **18** (see FIG. 1). This will provide a signal to close the intercept valves in the event of a fault and under selected circumstances will aid in system stability.

Under the more severe case of a load rejection, there is additionally an output from AND device **50** to latching relay **51** and to OR device **49**, which results in signals to also actuate the control valve fast closure trigger **17**, to alter the load reference source **13**, and to actuate the intercept trigger **18** (see FIG. 1), thus controlling turbine overspeed.

Under a third condition of system disturbance, where it is not desired to actuate the unbalance relay **19'**, i.e., during temporary transient swings of current and load, it should be apparent that there will be no output from comparator device

... or from comparator device **26**, since the rates of change of mismatch (Y' and X' respectively) are not sufficient to exceed the specified values. Therefore, there is no output at all from the unbalance relay, because the logical AND requirements are not met in either of the and devices **48**, **50**.

It should be further recognized that the minimum settings K_1 and K_2 required to actuate comparator devices **46** and **47** respectively, may be set independently of the K_0 settings of devices **26** and **27**. Thus the severity of a transient fault required to actuate relay **19'** may be set independently of the severity of a load rejection required for actuation of the relay. Note also that the time constant T_2 of differentiator **45** may be set independently of T_1 in differentiator **24**. The effect of these independent adjustments is to allow the setting of relay **19'** to be tailored for the specific needs of each application.

Reference to Table II shows that one type of more drastic early valve actuation is taken in the case of load rejection, with a less drastic (but nevertheless desirable) early valve action for severe temporary faults, and no action at all during transient backswing following a fault.

TABLE II

Event	$X>K_0$	$X'>K_0$	$Y>K_1$	$Y'>K_2$	Action
During load rejection	Yes	Yes	Yes	Yes	Trip control valves, intercept valves, set load reference to control and intercept valves; relay 51 latches.
During fault	No	No	Yes	Yes	Actuate fast closure of intercept valves only.
During fault clearing	No	Yes	Any	No	Allows I.V. to reopen.
During transient backswing following fault	Yes	No	Yes	No	None.
Following load rejection	Yes	Any*	Any*	No	Allows I.V. to reopen. C.V. remain closed. Load reference remains at zero.
Do	No	Any	Any	No	Allow control valves to reopen; restore load reference to control and intercept valves.

*Relay 51 latched.

Thus it will be seen that an early valve actuation control system has been disclosed which will distinguish between the more severe case of load rejection and a fault, as well as one which will not be undesirably actuated upon transient swings following a fault. Moreover, the modified system provides additional flexibility in providing discrimination between load rejection and fault conditions with a different type of valve action in each circumstance.

While there has been described herein what is considered to be the preferred embodiment and one alternate form of the invention, other modifications will occur to those skilled in the art, and it is intended to cover in the appended claims all such modifications as fall within the true spirit and scope of the invention.

What is claimed is:

1. In a turbine-generator control system having a plurality of steam valves with means to position said valves to control the turbine, and further having fast closing triggers arranged to reduce steam flow through selected valves rapidly in response to actuating signals, the combination of:

first control means providing a first signal responsive to a first value of mismatch between a first pair of normally matched signals representing turbine-generator-operating conditions, when said first value exceeds a first selected threshold value,

second control means providing a second signal responsive to a time rate of change of said first value of mismatch which exceeds a second selected threshold value, and

first logical AND means providing an actuating signal to a first one of said fast closing triggers when both of said first and second signals are applied to said AND means.

2. The combination according to claim **1**, wherein said first pair of turbine-generator-operating conditions are steam pressure and generator terminal current.

3. The combination according to claim **1**, wherein said first pair of turbine-generator-operating conditions are steam pressure and generator real load.

4. The combination according to claim **1**, wherein said second control means includes a discriminator circuit having a transfer function $Ts/1+Ts$ with means for adjusting the time constant T.

5. The combination according to claim **1**, wherein said first and second control means each including a voltage comparator arranged to compare said mismatch signal with said threshold value and having additional means to adjust said threshold value to determine the degree of mismatch at which said first or second signal is supplied from the first or second control means respectively.

6. The combination according to claim **1** further including latching means operated by said first AND means to maintain said actuating signal, and also including reset means operated by said first control means when said first value falls below said threshold value and arranged to unlatch the latching means and thereby terminate the actuating signal.

7. The combination according to claim **1** and further including:

third control means providing a third signal responsive to a second value of mismatch between a second pair of normally matched signals representing turbine-generator-operating conditions when said second value exceeds a third selected threshold value,

fourth control means providing a forth signal responsive to a time rate of change of said second value of mismatch which exceeds a forth selected threshold value, and

second logical AND means providing an output to a second one of said fast closing triggers when both of said third and forth signals are applied thereto.

8. The combination according to claim **7**, wherein said first pair of turbine-generator-operating conditions are steam pressure and generator terminal current and wherein said second pair of operating conditions are steam pressure and generator real load.

9. The combination according to claim **7**, further including means connected to provide an additional output from said second logical AND means to said first fast closing trigger, whereby said first trigger is actuated by an output from either the first or the second logical AND means while said second trigger is actuated by an output from said second logical AND means.

10. In a turbine-generator control system having a plurality of steam turbine valves with means to position said valves to control the turbine and further having fast closing triggers arranged to reduce steam flow through selected valves rapidly in response to actuating signals, the combination of:

a first relay logic circuit responsive to a pair of normally matched signals representative of steam pressure and generator current and providing a first output signal when the mismatch and time rate of change of mismatch both exceed selected threshold values,

a second relay logic circuit responsive to a pair of normally matched signals representative of steam pressure and generator real load and providing a second output signal when the mismatch and time rate of change of mismatch both exceed selected threshold values,

a first trigger logic circuit responsive to said first relay logic circuit and arranged to effect one type of turbine valve actuation to control overspeed, and

a second trigger logic circuit responsive to either or both of said first and second relay logic circuits and arranged to effect another type of turbine valve actuation to aid system stability.