

[54] **AUTOMATIC VALVE CHANGEOVER
APPARATUS FOR A TURBINE**

[75] Inventors: Yoshihiro Uchiyama; Yoshiyuki Nakano; Takashi Kishigami, all of Hitachi; Ryosuke Arie, Katsuta, all of Japan

[73] Assignee: Hitachi, Ltd., Tokyo, Japan

[22] Filed: Dec. 16, 1971

[21] Appl. No.: 208,796

[30] **Foreign Application Priority Data**

Dec. 16, 1970 Japan45/111750

[52] U.S. Cl.415/30, 415/1, 415/17,
415/38

[51] Int. Cl.F01b 25/06

[58] Field of Search.....415/1, 15, 17, 30

[56] **References Cited****UNITED STATES PATENTS**

3,340,883 9/1967 Peternel415/15

3,403,891	10/1968	Johnson et al.....	415/17
3,446,224	5/1969	Zwicky, Jr.....	415/1
3,552,872	1/1971	Giras et al.....	415/17
3,564,273	2/1971	Cockrell.....	415/17
1,000,783	8/1911	Cubelic.....	415/38

Primary Examiner—C. J. Husar

Attorney—Craig, Antonelli & Hill

[57] **ABSTRACT**

An automatic valve changeover apparatus for controlling the admission of steam to a turbine. During the starting-up operation of a turbine, the admission of steam is shifted from "full arc admission" to "partial arc admission" in accordance with electrical output signals from an output setter and a speed setter. The output signals of the output setter and the speed setter respectively control the opening of control valves and a steam stop valve in accordance with the detected open positions of these valves and the speed or output of the turbine.

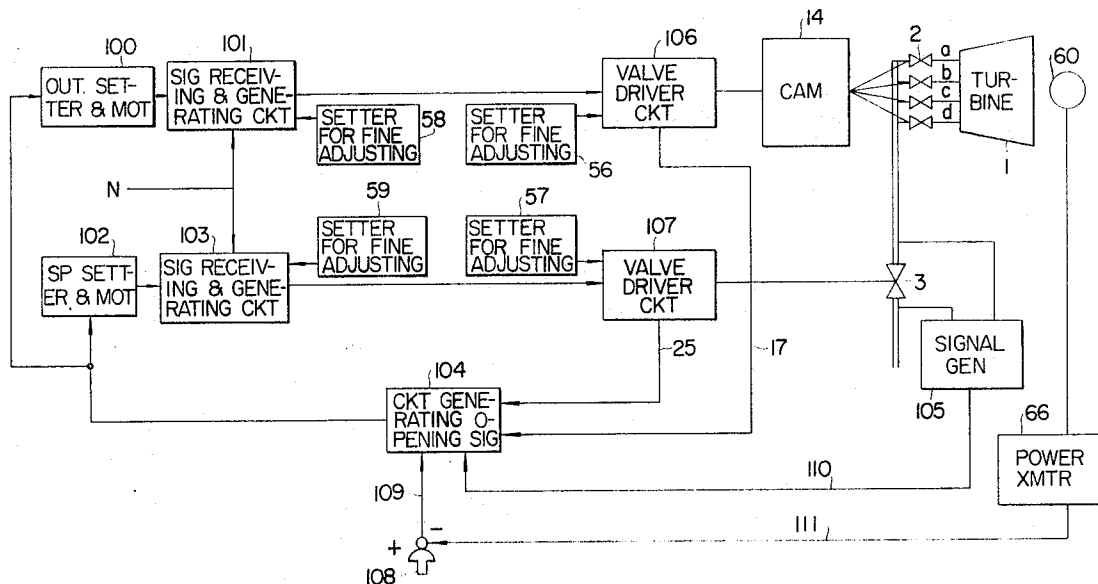
15 Claims, 6 Drawing Figures

FIG. 1A

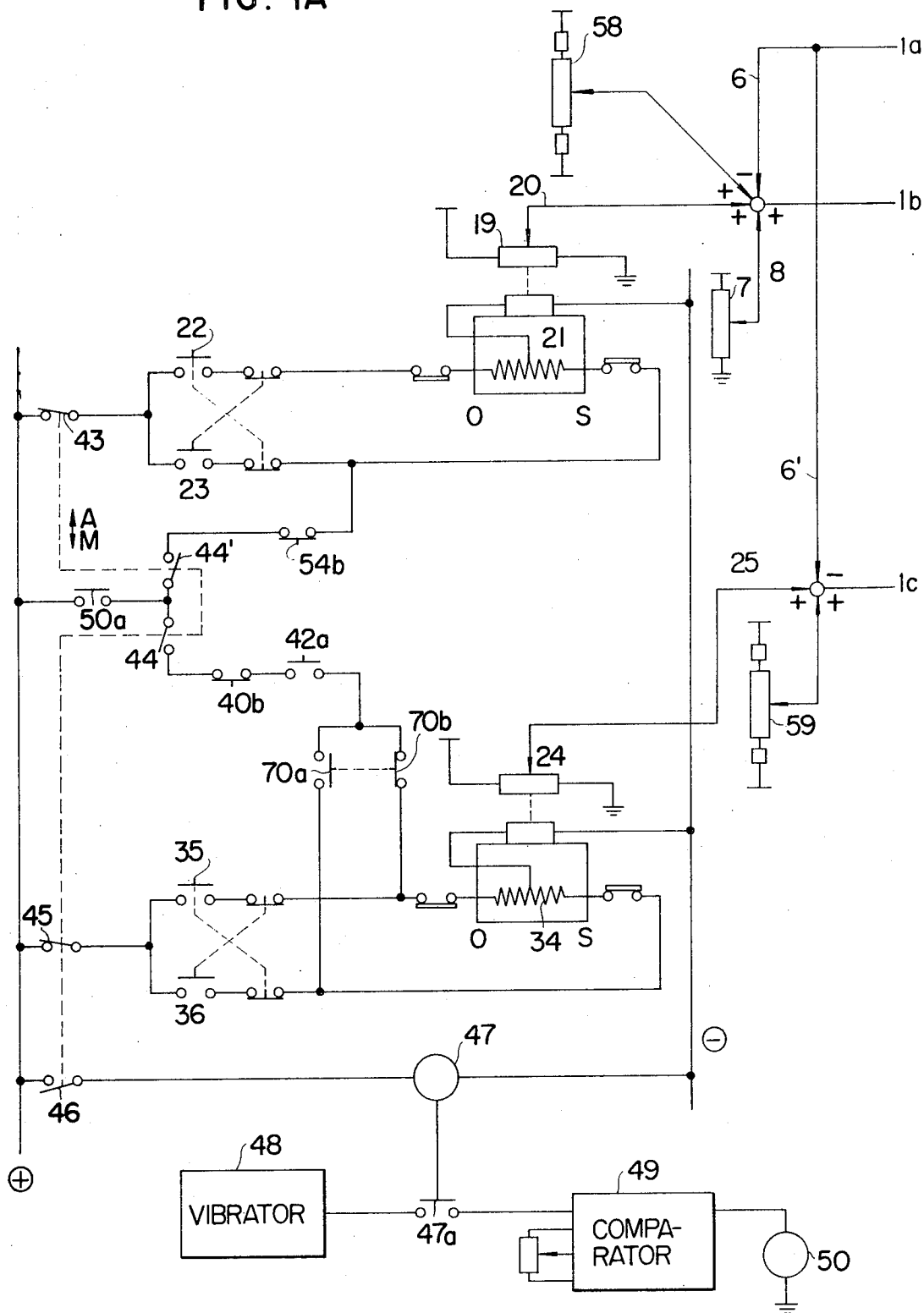


FIG. 1B

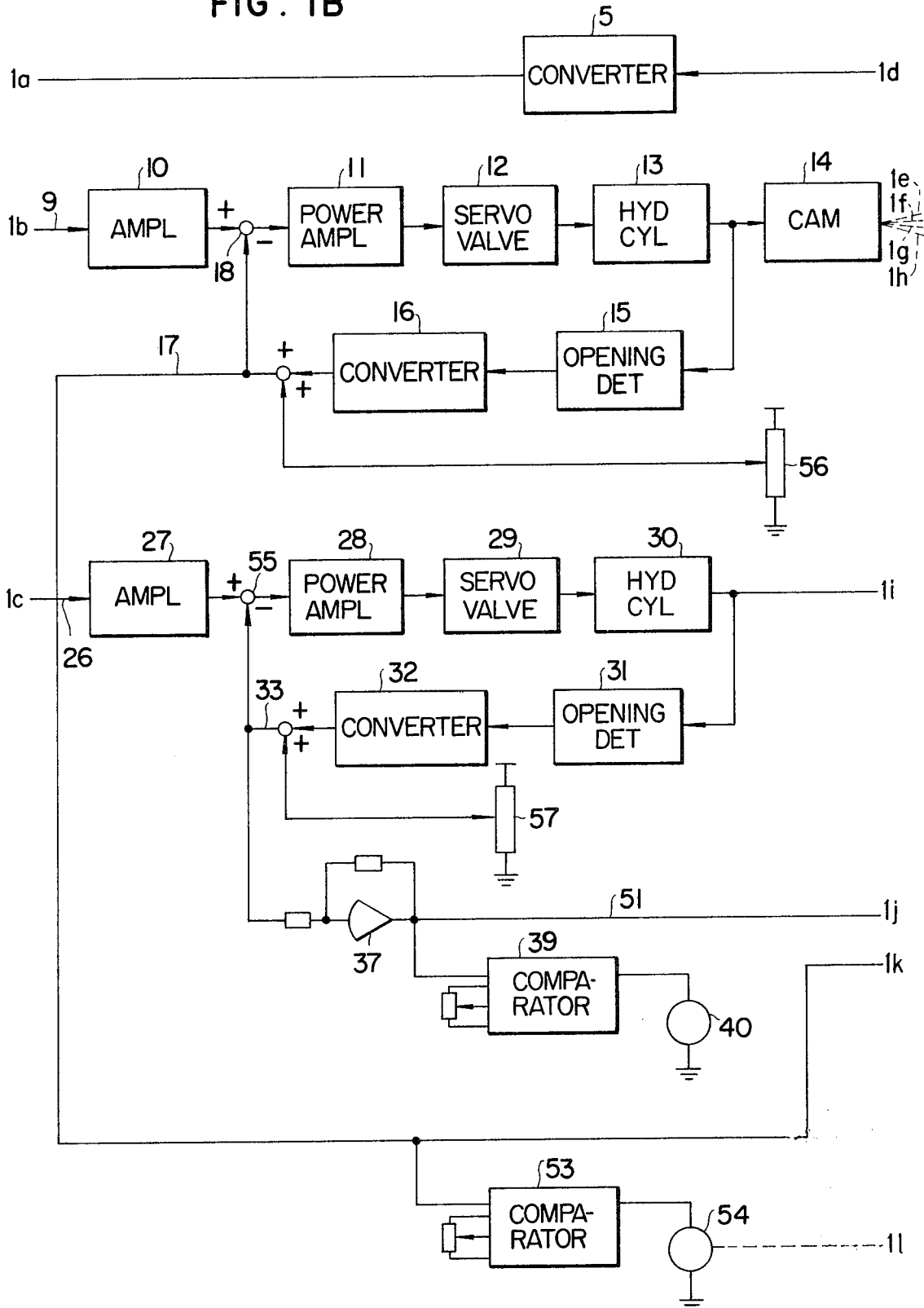


FIG. 2

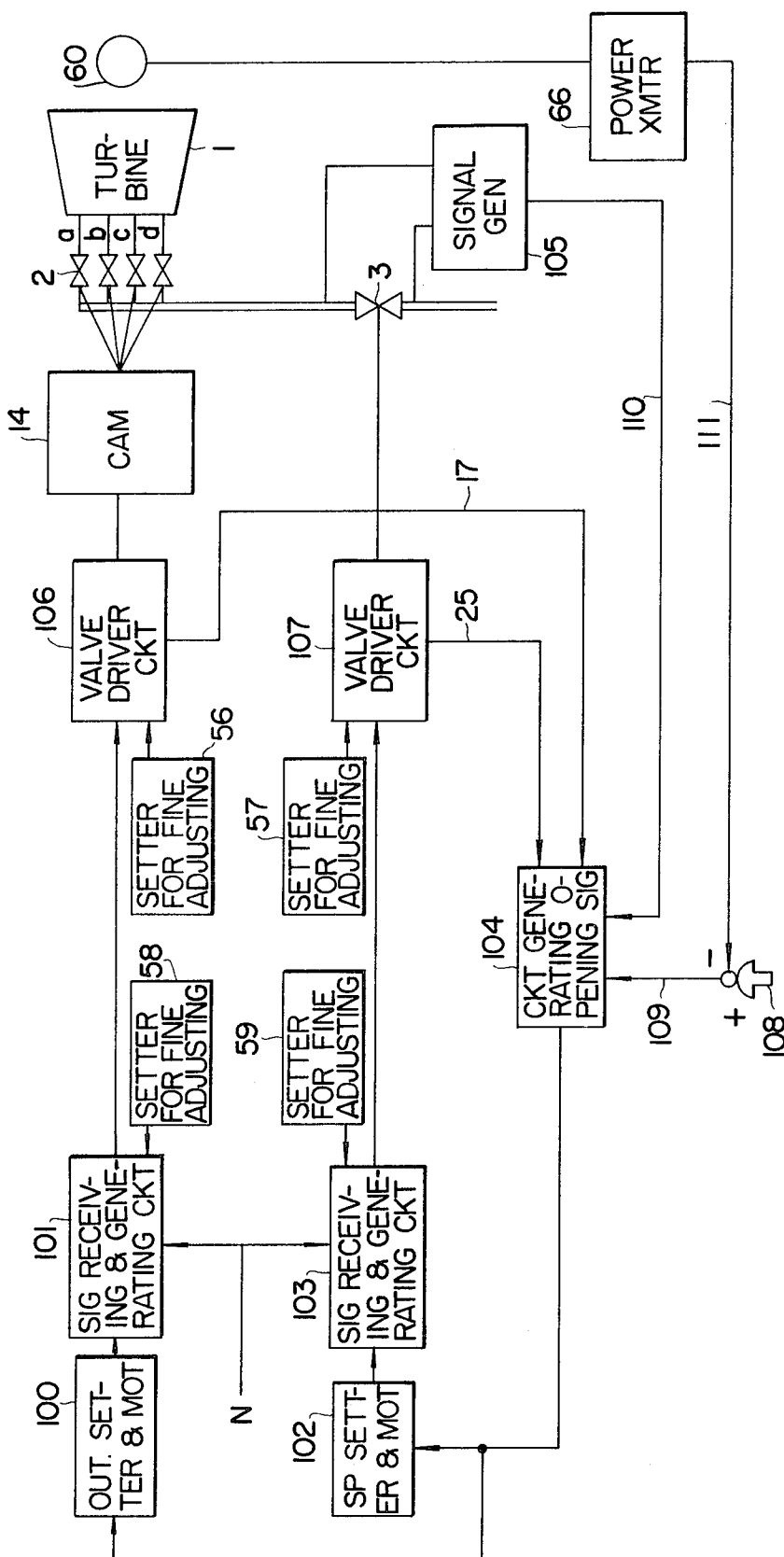


FIG. 3A

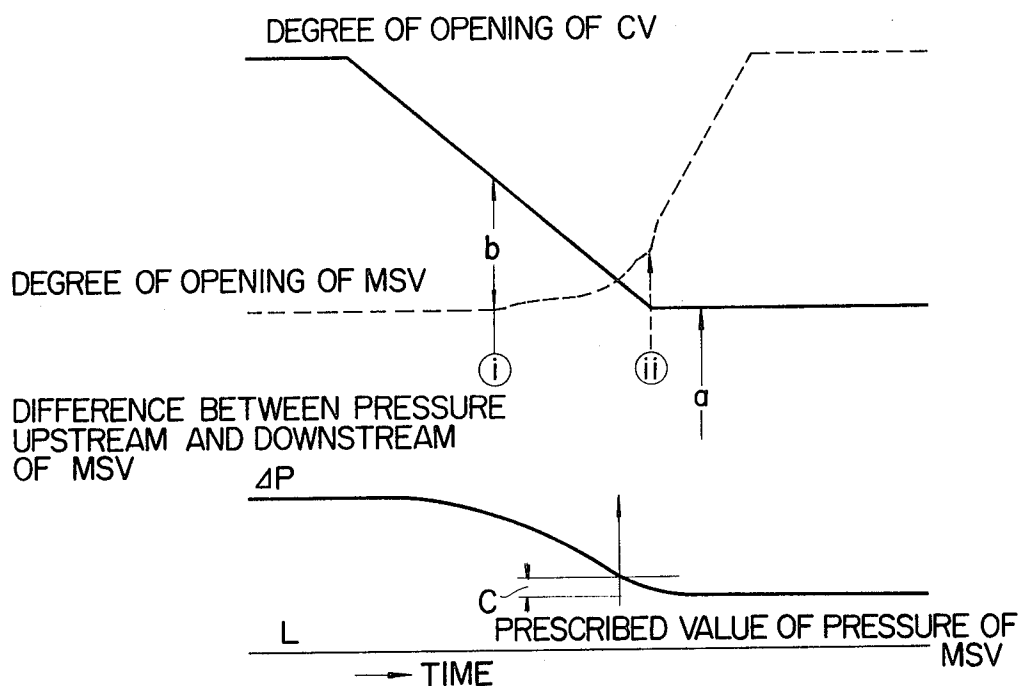
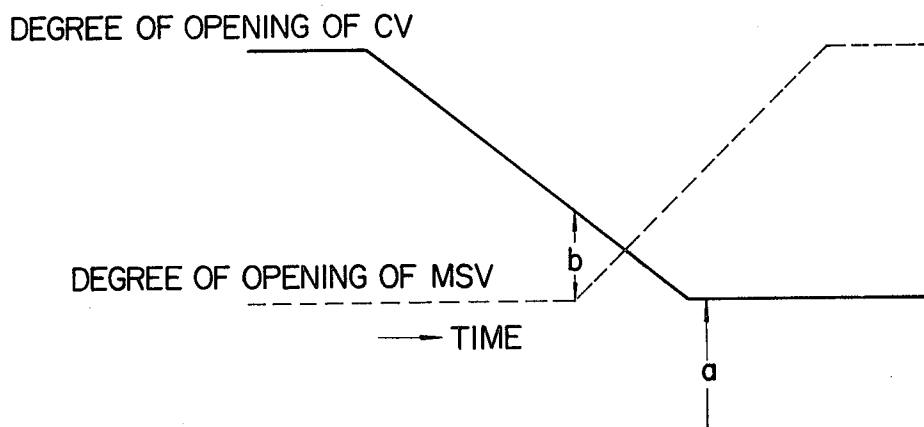


FIG. 3B



AUTOMATIC VALVE CHANGEOVER APPARATUS FOR A TURBINE

BACKGROUND OF THE INVENTION

This invention relates to an automatic valve changeover apparatus for a turbine which shifts automatically from "full arc admission" to "partial arc admission" during starting up of a turbine.

Generally, large-sized steam turbines are provided with several control valves which are arranged in parallel in inlets of a high pressure turbine section in order to control admission of the steam with each valve being connected to a group of nozzles arranged ahead of the first-stage turbine blade. These steam control valves open or close sequentially in accordance with the turning of a cam to control the admission of the steam. In operation, the first control valve which is fully closed opens and the turbine is driven by the admission of the steam from the first nozzle group. When the first control valve is substantially completely open, the second control valve starts to open and admits steam to the turbine blade from the second nozzle group. Each of the other control valves opens in turn as indicated above. After all of the control valves have opened, the steam is admitted to the turbine blade from the nozzles which are arranged in arc on the circumference of the inlet in the first stage turbine.

Each of the control valves is opened and closed in turn by the cam which is connected to a hydraulic cylinder with the control of the valves being arranged such that the flow rate of the steam through the control valves is proportional to the stroke of a piston of the hydraulic cylinder. The valve for controlling the flow rate of the steam and the nozzle group is divided into several valves and nozzle groups, respectively, in that the throttle loss of the valve at a low rate of flow is smaller than in case of a single valve and the provision of several valves and nozzle groups is thermodynamically advantageous. Admission from each of several nozzle groups sequentially is termed "partial arc admission."

On the other hand, as the pressure and temperature of the steam are raised, the thickness of the material for the nozzles at the first stage of the turbine and that of the casing become large. Accordingly, in view of the thermal stresses developed, it is preferable that when starting up a turbine that the cool casing or the cool nozzles not be partially heated with different temperatures present between the heated part and others. In order that, at the initial stage of starting up of the turbine, all the control valves are opened fully, the flow rate of the steam is controlled by means of a steam stop valve or main stop valve disposed in the upper reaches of the steam flow with respect to the control valves such that the steam is admitted from the nozzles of the full arc for the first stage of the turbine, and thereby the casing and the nozzles are evenly heated. The admission of the steam in this process of starting up of the turbine is termed "full arc admission." However, it is necessary to operate the turbine by partial arc admission, after the parts of the turbine which are under high pressure have been substantially heated.

Changeover between the partial arc admission and the full arc admission is achieved by changeover of the main stop valve and the control valves. In the case of manual changeover from the full arc admission to the

partial arc admission, at present, an operator continues to slowly close the control valves in small steps until the pressure difference between the upper and the lower extent of the steam flow with respect to the steam stop valve which is disposed in the upper extent of the steam flow with respect to the control valves falls within a prescribed value such that the steam stop valve may be opened against the pressure. The operator then starts to open the steam stop valve in small steps. While this operation appears to be simple and easily accomplished, it is not a simple operation, especially for a turbine utilized in a plant which is required to stop and start up occasionally.

A system is also known for changeover of the valves which utilizes an automatic changeover apparatus comprising a control means for the control valves constituted by an output setter, a signal generating means for operating the control valves and receiving feedback signals of the turbine speed to compare it with desired value, a valve driving means receiving signal for driving the control valves via a cam, and an analog signal generating means for operation of changeover by opening the steam stop valve after closing the control valves to the prescribed value of the degree of closure. A control means for the steam stop valve is constituted in the same manner as the control means for the control valves to change the output setter or a speed setter. The analog signal generating means is provided separately from the control means, the speed setter or the output setter, and is applied as a bias to addition points between the signal generating means and the valve driving means. With the method, the setting of a speed or an output and the bias are separately provided such that when a set speed value or a set output value is determined, a valve opening corresponding thereto is obtained.

The system, however, has the disadvantage that the relation varies dependent upon the magnitude of the value of the bias applied between the setting stage and the valve driving stage. Originally, this system was arranged for use only during a changeover of the valves, but when the system malfunctions, the system does not disturb the operation for the turbine because the bias signals from this apparatus cannot be simply cut off. If the control valves or the steam stop valve is not properly positioned as when the opening of the valves are greatly changed in a short period of time in this manner, the improper opening influences the other components throughout the automatic valve changeover apparatus. For example, for purposes of safety, an output of the turbine should not be hastily increased such that the steam stop valve starts to open before the control valves have been closed. As this apparatus only furnishes signals for the valve operations and does not ascertain the condition of the valves, this apparatus must furnish the succeeding signals in accordance with the instruction of the analog signal generating means for a changeover of the valves without ascertaining whether the valves are properly operating in accordance with the instruction. Furthermore, the changeover of the valves with a predetermined pattern of signals results in comparatively large fluctuation in the output attendant upon the changeover, and the fluctuation becomes larger in the case where the steam conditions differ from normal. Particularly, in a turbine hav-

ing a large single-cylinder output, the absolute value of the fluctuation in the load becomes large. Where this apparatus is utilized for applying an electric-hydraulic governing method, minute differences tend to occur in the valve opening for the command in dependence upon fluctuations in the supply voltage and the surrounding conditions. Also, when a differential transformer is exchanged after operation for a period of time, the apparatus may vary in its characteristic before and after the exchange so that readjustment of the characteristic is necessary.

SUMMARY OF THE INVENTION

In accordance with the present invention, there is provided an automatic valve changeover apparatus which overcomes the disadvantages and drawbacks of prior art arrangements and characterized in that changeover signals for valves are not supplied as the bias, but they are supplied by operating the speed setter of the output setter, and thereby are able to shift from full arc admission to partial arc admission with safety, with reliability, and with a little fluctuation of output of the turbine before and after the shifting operation.

According to another feature of the present invention, signal generating means for valve changeover may be cut off from the valve control means which control the control valves and the steam stop valve. The control means thereby can be free from being disturbed by malfunctions of the automatic valve changeover apparatus which is utilized only for a short period of time.

According to a further feature of the present invention, reliable operation is attained by confirming the degree of opening of the control valves and the steam stop valve and by detecting the pressure difference between the upper extent and the lower extent of a steam flow with respect to the steam stop valve.

It is therefore an object of the present invention to provide an automatic valve changeover apparatus for a turbine which overcomes the disadvantages and drawbacks of prior art arrangements.

It is another object of the present invention to provide an automatic valve changeover apparatus which is reliable and safe in operation.

It is a further object of the present invention to provide an automatic valve changeover apparatus which can be simply switched to manual control.

These and further objects, features, and advantages of the present invention will become more obvious from the following description when taken in connection with the accompanying drawings, which show, for purposes of illustration only, one embodiment in accordance with the present invention.

BRIEF DESCRIPTION OF THE DRAWINGS

FIGS. 1A, 1B and 1C are a schematic diagram showing an embodiment of the automatic valve changeover apparatus for a turbine;

FIG. 2 is a block diagram of FIGS. 1A, 1B and 1C; and

FIGS. 3A and 3B are graphs, respectively, illustrating variations in opening degree of the control valve (CV) and the steam stop valve (MSV), and the pressure difference between the upper reaches and the lower reaches of the steam flow with respect to the steam stop valve.

now to the drawings wherein like reference numerals designate like parts throughout the several views and more particularly to FIG. 1C, reference numeral 1 designates a steam turbine provided with a number of nozzles arranged in four groups (not shown). Each of the nozzle groups is disposed in a steam passage having a respective control valve 2a, 2b, 2c, 2d which controls the steam flow rate in each of the steam passages. Each of the steam passages is connected to a steam passage having a steam stop valve 3 which controls the steam flow rate therein. The steam turbine 1 is further provided with a turbogenerator 60 and a speed detector 4 which is connected with a rotor shaft (not shown) of the generator and detects the rotating speed of the rotor.

The control valves 2(a-b) are sequentially opened and closed by means of a cam 14 which is driven by a hydraulic cylinder 13 controlled by servo valve 12. The servo valve 12 is controlled by electric signals passed through a power amplifier 11. The reference numerals 6 and 6' designate signals of D.C. voltage supplied by a converter 5 in response to the output of the detector 4. The signal 6 is compared with and subtracted from a signal corresponding to a desired speed selected by a speed setter 7 to provide a signal 9 which represents the speed deviation and is amplified by a D.C. amplifier 10 having a gain conforming to the characteristic of the control means. The signal from the D.C. amplifier 10 is compared with a D.C. voltage signal provided by a converter 16. The converter receives signal from an opening detector 15 representative of the stroke of a piston of the cylinder corresponding to the area passing the steam within the control valves 2. The difference between signals from the D.C. amplifier 10 and the converter 16 is transmitted to the power amplifier 11.

When a turbo-generator 60 is driven and the rotor speed is kept substantially constant and in synchronism with the frequency of an electric power system, a signal 20 corresponding to a set output given by an output setter 19 is applied to the control means and performs the opening and closure of the control valves 2 to control the output of the steam turbine 1. The output setter 19 is a variable resistor which is rotatable and slideable.

The control means for the control valves 2 operates in response to the signal 9 of the difference between the signal 6 and 8 which is transmitted to the servo valve 12 through the D.C. amplifier 10 and the power amplifier 11 for actuating the hydraulic cylinder 13 to drive the cam 14 for sequentially operating the control valves 2. The movement of the cam 14 is detected by the opening detector 15 and the output signals representative of the movement are fed back to the addition point 18 for confirming whether the control valves 2 are properly and accurately responding to the applied signal. The signal 20 from the output setter 19 is superimposed upon the signal 9, such that the turbine 1 is controlled by the signals from the output setter 19 after revolution of the turbine rotor has synchronized the electric system with the generator.

On the other hand, the signal 6' is compared with a signal 25 from a speed setter 24, and provides a signal 26 of a speed deviation. In the same manner as in the operation of the control valves 2, the signal 26 opens and closes the steam stop valve 3 by means of a combination of amplifiers 27 and 28, a servo-valve 29, a hydraulic cylinder 30, an opening detector 31 and a

converter 32 providing an output signal to an addition point 55. The speed setter 24 is a resistor which is rotatable and slideable and is similar to the output setter 19. The operation of the control means for the steam stop valve 3 is similar to the operation of the control means for the control valves.

As shown in FIG. 1A, a D.C. motor 21 is connected to the output setter 19 which is a slidable resistor or the like for rotating the resistor. One of the lead wires of the D.C. motor 21 is connected to the negative side of a D.C. power source. The other lead is connected to the positive side of the D.C. power source through lead wire O or S, a manual spring-return switch 22, 23 which change the rotating direction of the D.C. motor 21, and a switch 43 which is interlocked with switches 44, 44', 45 and 46. When the lead wire O is connected electrically to the positive side of the D.C. power source, the D.C. motor rotates in one direction, whereas when the lead wire S is connected to the positive side the motor rotates in the other direction. As shown, the lead wire S is connected to the D.C. power source through the manual spring-return switches 22 and 23, and the switch 43 or through switches 54b, 44' and 50a, or moreover to a lead wire O or S of a D.C. motor 34 through the switches 54b, 44', 40b, 42a, 70a or 70b. The D.C. motor 34 is similar in construction and operation to the D.C. motor 21 and is connected to and rotates the speed setter 24 constituted by a slidable resistor or the like for changing the magnitude of the signals provided relating to the speed of the turbine 1. One of the lead wires of the D.C. motor 34 is connected with the negative D.C. power source and the other lead wire O or S is connected with the positive D.C. power source through a manual spring-return switch 35, 36 and the switch 45. Reference numeral 47 is a solenoid with a switch 47a which is closed when the solenoid 47 is electrically connected with the D.C. power source. The solenoid 47 may be electrically connected with the D.C. power source through a switch 46. A vibrator 48 produces signals which are applied to a comparator 49 through the switch 47a. The comparator 49 transmits to a solenoid 50 signals which are of higher level than a predetermined level of electrical potential and energizes the solenoid 50 for operating the switch 50a. The switches 43, 44', 44, 45 and 46 are arranged to be operated together.

As shown in FIGS. 1B and 1C, reference numerals 37, 38, 63 and 67 designate amplifiers, reference numerals 39, 41, 53, 64 and 69 designate comparators and reference numerals 40, 42, 54, 65 and 70 designate solenoids. The comparator 39 energizes the solenoid 40 for operating the switch 40b in response to signals 51 at a time when the main stop valve 3 is fully opened. The amplifier 38 amplifies the difference between signals 51 and 17, and an amplified signal 52 is transmitted to the comparator 41. The comparator 41 energizes the solenoid 42 when the signal 52 is of a higher level than a predetermined level. Thus, the difference in degree of opening between the control valves 2 and the steam stop valve 3 is evaluated. A comparator 53 is electrically connected with the opening detector 15 and a solenoid 54 operates a switch 54a and provides the signal 17 to the solenoid 54. Reference numerals 61 and 62 are pressure detectors which are disposed in the upper and lower extent of the steam passage with

respect to the main stop valve 3 and provide electrical output signals indicative of the detected pressure. The amplifier 63 amplifies the difference between signals from the pressure detector 61 and 62 and provides the amplified signal to the comparator 64 which provides an output signal corresponding to a difference of pressure below a predetermined pressure value for energizing the solenoid 65 and the associated switch 65a. The output of the turbo-generator 60 is detected and converted into a D.C. voltage signal by a power transmitter 66. A signal from an output setter 68 and the signals from the power transmitter 66 is supplied to the amplifier 67 which provides an output signal to comparator 69 which provides a signal for energizing the solenoid 70. Amplifier 67 and comparator 69 serve for comparing the signals applied thereto and calculating a deviation of the output. Reference numeral 71 is a setter providing a sufficiently large voltage having the same polarity as that of the voltage provided by the output setter 68. The setter 71 is connected electrically with the output setter 68 through the switch 54a and the switch 65a or switch 73, or through a switch 72. The switches 72 and 73 are for manual operation.

FIG. 2 illustrates in block diagram form the subject matter of the present invention. In this figure, reference numeral 100 indicates the output setter 19 and the motor 21. A circuit 101 is provided for receiving the feedback signal of the speed comparing it with a desired value and generating a signal for operating the control valves 2. This circuit includes the speed setter 7 and the amplifier 10. Reference numeral 106 represents a valve drive circuit for obtaining the operating signal to drive the control valves 2. The valve driver circuit includes the amplifier 11, the servo-valve 12, the hydraulic cylinder 13, the opening detector 15 and the converter 16 of the feedback circuit. Reference numerals 102, 103 and 107 respectively designate the similar circuits for the steam stop valve 3, wherein the circuit 102 includes the speed setter 24 and a motor 34, the circuit 103 includes the amplifier 28 and the circuit 107 includes the servo-valve 29, the hydraulic cylinder 30, the opening detector 31 and the converter 32.

A characteristic of the present invention is that the changeover signals for the valves 2 and 3 are not supplied as bias signals, but rather the signals are produced by operation of the speed setter 102 or the output setter 100. A signal for the valve operation is fed to the respective setters from a circuit 104 which generates the opening signal. The circuit 104 receives such signals as the signals 17 and 25 corresponding to the valve openings from the valve operating circuits, a pressure-difference signal 110 from a signal generator 105 of a difference in pressure ahead and behind the steam stop valve 3, and an output deviation signal 109 of the difference of a signal 111 from the output detector 66 of the turbo-generator 60 compared with a set load value 108. Thus, the circuit 104 confirms the opened and closed states of the valves 2 and 3 and judges the timing of the operations for generating the changeover signal.

Referring now to FIG. 3, FIG. 3A illustrates the states of the changeover. First, a signal for gradually closing the control valves 2(CV) is generated by the circuit 104 which produces the operating signal, and the control valves 2 are closed. The control valves 2

begin to close in a proper manner and a point of time *i* is confirmed at which the opening difference from that of the steam stop valve 3 (MSV) has become equal to or less than a certain value *b*, whereupon the operation of the steam stop valve 3 is started to thus attain safety of the operation. The steam stop valve 3 is operated by means of an automatic control means which reduces fluctuations in the electrical output which are caused by the fact that the control valves 2 are first closed gradually. At a point of time *ii* it is confirmed that the control valves 2 have been closed to a desired opening *a* and that the pressure difference between the upper extent and the lower extent of the steam passage with respect to the steam stop valve 3 has become small enough to fully open the steam stop valve 3, namely, smaller than a prescribed value *C*, the closing action of the control valves 2 is stopped and the control valves 2 are fully closed.

The operation of the apparatus of the present invention is such that the degree of opening of the steam stop valve 3 at the changeover is maintained by the signals from the speed setter 24 which fixes the rate of flow. The control valves 2 are fully opened by means of the signal of the output setter 19, and admits steam from the whole periphery of the first stage nozzles, that is full arc admission. Before the changeover, the interlocking switches 44, 44', 45 and 46 are on the "manual" side indicated by M in FIG. 1, and the switches 43 and 45 are closed while the switches 44, 44' and 46 are opened. In the state when the manual spring return switches 22, 23 or 35, 36 are operated, current flows on the O or S- sides of the D.C. motors 21 or 34 and rotate the motors in the forward and reverse direction. As a result, the resistors of the output setter 19 and the speed setter 24 connected with each of the D.C. motors are rotated to effect the opening-and-closure of the control valve 2 and the steam stop valve 3.

Prior to the valve changeover, the switches 43, 44, 44', 45 and 46 are thrown onto the "automatic" side indicated by A in FIG. 1, to close the switches 44, 44' and 46 and to open the switches 45 and 43. In this state, the motors 21 and 34 are no longer driven even by manipulating the manual spring return switches 22, 23, 35 and 36, so that any problem with the motors due to both "manual" and "automatic" operations may be prevented.

Upon the closure of the switch 46, the solenoid 47 is energized and its switch 47a is closed such that the solenoid 50 is energized periodically by the signals from the vibrator 48 and the comparator 49, and in conformity with the periodical energization, the switch 50a of the solenoid 50 closes and opens. Thus, current is supplied to the D.C. motor 21 from the S-side to gradually rotate the motor 21. The resistor 19 is therefore rotated, to generate the signal 20 for closing the control valves. The closing and stopping action appears as a result in the form of a change in the signal 17 relating to the opening degree of the control valves. A difference between the signal 17 and the signal 51 is fed into the amplifier 38, whereby the signal of a valve opening difference 52 is evaluated. When the opening difference between the control valves and the steam stop valve 3 is of a magnitude equivalent to *b* (FIG. 3A), the comparator 41 is actuated to energize the solenoid 42 and to close its switch 42a. This point of time is *i* in FIG. 3A.

Upon the closure of the switch 42a, current to the motor 34 flows via either closed switch 70a or 70b such that the motor 34 is driven to rotate the speed setter 24 whereby the opening setting voltage, that is the signal 25, of the steam stop valve 3 is changed and the steam stop is opened or closed. Accordingly, the opening-and-closure of the steam stop valve 3 is determined dependent upon which switch 70a or 70b is closed.

The value of the set output from the output setter 68 is a voltage corresponding to the generator output at the valve changeover. The deviation signal is adjusted so that it may actuate the comparator 69 to energize the solenoid 70, as the result, the switches 70a and 70b are operated "on" and "off." More specifically, when the output signal is negative, the switch 70b is closed while the switch 70a is opened, to rotate the motor 34 in the direction for opening the valve, whereby the actual output is increased by opening the steam stop valve 3. On the other hand, when the output deviation is positive, the switch 70a is closed while the switch 70b is opened in a similar manner to close the steam stop valve 3 thereby decreasing the actual output. The switches 70a, 70b are provided for operating the steam stop valve 3 to keep the output at a constant level, the output varying due to the gradual opening of the control valves 2.

Since the control valves 2 still continue to be closed thereafter, the steam pressure difference between the upper extent and the lower extent of the steam passage with respect to the steam stop valve 3 is gradually decreased and it becomes smaller than the pressure difference *C* capable of fully opening the steam stop valve 3 against the pressure difference. This state is detected by the pressure detectors 61 and 62 and the amplifier 63. The comparator 64 always compares the set pressure difference value *C* with the actual pressure difference which is detected by the pressure detectors 61 and 62 and calculated by the amplifier 63, and upon confirming that the pressure difference is smaller than the set value *C*, the comparator energizes the solenoid 65 for operating its switch 65a. When the control valves 2 continue to be closed and are closed to the predetermined value *a*, the comparator 53 is actuated to energize the solenoid 54, whereby its switch 54b is opened, the closing action of the control valves 2 is stopped, and the switch 54a is closed. This point of time is represented by *ii* in FIG. 3A. When, in this manner, the conditions imposed upon the pressure difference and the valve opening are established and the switches 54a and 65a are closed, a voltage of the setter 71 is applied to the amplifier 67. The voltage of the setter 71 is set at a value sufficient to open the switch 70a and to close the switch 70b through the comparator 69 and the solenoid 70 irrespective of the value of the load deviation, i.e., a sufficiently large voltage having the same periphery as that of the set output voltage from setter 68. Thereafter, the motor 34 rotates only in the direction of opening the steam stop valve 3, and fully opens the steam stop valve 3. When the steam stop valve 3 is fully opened, the comparator 39 is actuated to energize the solenoid 40, thereby opening its switch 40b to stop the rotation of the motor 34. In this manner, the changeover of the valves is carried out safely and reliably with little fluctuations in the load and with every step of the operation being detected and confirmed.

In the case where the output detector 66 does not function properly in this system or in the case where the output detector 66 is not provided on account of an economical limitation, it is possible to normally maintain the switch 70a open and the switch 70b closed by closing the switch 72 and always having the voltage of the setter 71 applied. As illustrated in FIG. 3B, the steam stop valve 3 starts opening at a fixed speed at the time when the difference of the opening degree between the steam stop valve 3 and the control valves 2 becomes b. Although no output control is performed in this process, the changeover of the valves 2 and 3 is possible with little fluctuations in the output if the difference of the opening degree b is appropriately selected. The stopping point of the respective valves 2 and 3 in this case is similar to that in the foregoing case.

In the case where the pressure-difference signal generator does not function properly, or where it is not provided for an economical reason, the confirmation of the allowable value of the pressure difference is omitted by closing the switch 73, but the changeover may be performed approximately in the same manner on the basis of the detection and confirmation of the opening position of the control valves 2.

As illustrated in the aforescribed embodiment, the present invention carries out the opening and closing of the valves 2 and 3 by operating at the desired set values of the respective valves, and rendering the setters for the valves therefor motor-driven. Therefore, the relation between the magnitude of each set value and the valve opening degree is unchanged and remains constant both during the changeover running and during the usual running, and hence, the operation is accomplished in an easy manner. When an abnormality occurs in the course of the changeover, the interlocking switches 43 to 46 are changed to the "manual" side at one touch, whereby the apparatus may be restored, in that condition, to the state of the normal running under the manual operation. Moreover, the changeover apparatus and the control means are completely separated during the normal running, so that the apparatus is advantageous in being capable of preventing the undesirable disturbance from being imparted to the main control loop due to an electrical trouble while the apparatus is not in use. Thus, the apparatus of the present invention may effect an easily usable and reliable automatic changeover.

The control means and the changeover apparatus utilize electronic components having characteristics which are easily varied by the exchange of a component and by the surrounding conditions such as temperature thereby causing an error to occur in the changeover position. Therefore, in order that the relation between the desired value voltage and the valve opening and the relation between the valve opening and the opening detecting voltage may be finely adjusted, the apparatus has the value setters 56, 57, 58 and 59.

Obviously, many modifications and variations of the present invention are possible in the light of the above teachings. It should therefore be understood that within the scope of the appended claims, the invention may be practiced otherwise than as specifically described.

We claim:

1. An automatic valve changeover apparatus for a turbine comprising steam passage means having a

steam stop valve and a plurality of control valves arranged therein, variable speed setter means for providing an output signal of a desired speed for the turbine, variable output setter means for providing an output signal of a desired output for the turbine, speed detector means for providing an output signal indicative of the rotor speed of the turbine, first means for controlling said control valves in accordance with the difference in signals from said speed detector means and one of said output setter means and said speed setter means, second means for controlling said steam stop valve in accordance with the difference of signals from said speed detector means and said speed setter means, and means for providing valve changeover output signals for varying at least one of said output setter means and said speed setter means when the steam admission to the turbine is shifted from full arc to partial arc admission.

2. An automatic valve changeover apparatus in accordance with claim 1, including means for disconnecting the output of said valve changeover means to said output setter means and to said speed setter means.

3. An automatic valve changeover apparatus in accordance with claim 1, wherein the turbine drives a generator and including load setting means for providing an output signal of a desired output for the generator, and means for providing output signals indicative of the opening position of said control valves and said steam stop valve, said valve changeover means being responsive to the signals of the opening position of said control valves and said steam stop valve and signals of the difference of signals from said load setting means and said speed detector means.

4. An automatic valve changeover apparatus in accordance with claim 1, wherein the turbine drives a generator and including load setting means for providing an output signal of a desired output for the generator, output detecting means for providing an output signal indicative of the generator output, and means for providing output signals indicative of the opening position of said control valves and said steam stop valve, said valve changeover means being responsive to the signals of the opening position of said control valves and said steam stop valve and signals of the difference of signals from said load setting means and said output detecting means.

5. An automatic valve changeover apparatus in accordance with claim 1, wherein said steam stop valve serves for controlling the output of the turbine when the admission of steam to the turbine is shifted from full arc to partial arc admission.

6. An automatic valve changeover apparatus in accordance with claim 1, wherein said variable output setter means includes means for providing a selected constant value output signal to provide fine adjustment of the output signal of said variable output setter means, and said variable speed setter means includes means for providing a selected constant value output signal to provide fine adjustment of the output signal of said variable speed setter means.

7. An automatic valve changeover apparatus in accordance with claim 1, including means for detecting the difference in steam pressure upstream and downstream of said steam stop valve and for providing an output signal indicative thereof, means responsive to

a predetermined pressure difference for providing an output signal to said valve changeover means, said valve changeover means being responsive thereto for varying said speed setter means to provide an output signal for fully opening said steam stop valve.

8. An automatic valve changeover apparatus in accordance with claim 1, wherein said first control means include valve driving means for rotating a cam, said cam being arranged for opening each of said control valves in a predetermined sequence.

9. An automatic valve changeover apparatus in accordance with claim 8, wherein said second control means includes valve driver means for opening and closing said steam stop valve.

10. An automatic valve changeover apparatus in accordance with claim 1, wherein said variable speed setter means includes a reversible motor for rotating a slideable resistor, said motor being operated in accordance with output signals from said valve changeover means.

11. An automatic valve changeover apparatus in accordance with claim 10, wherein said variable output setter means includes a reversible motor for rotating a slideable resistor, said motor being operated in accordance with the output signals of said valve changeover means.

12. An automatic valve changeover apparatus according to claim 4, wherein said steam stop valve serves for controlling the output of the turbine when the admission of steam to the turbine is shifted from full arc to partial arc admission and including means for

disconnecting the output of said valve changeover means to said output setter means and to said speed setter means.

13. An automatic valve changeover apparatus in accordance with claim 12, wherein said variable output setter means includes means for providing a selected constant value output signal to provide fine adjustment of the output signal of said variable output setter means, and said variable speed setter means includes means for providing a selected constant value output signal to provide fine adjustment of the output signal of said variable speed setter means.

14. An automatic valve changeover apparatus in accordance with claim 13, including means for detecting the difference in steam pressure upstream and downstream of said steam stop valve and for providing an output signal indicative thereof, means responsive to a predetermined pressure difference for providing an output signal to said valve changeover means, said valve changeover means being responsive thereto for varying said speed setter means to provide an output for fully opening said steam stop valve.

15. An automatic valve changeover apparatus in accordance with claim 14, wherein said first control means include valve driving means for rotating a cam, said cam being arranged for opening each of said control valves in a predetermined sequence, and said second control means includes valve driver means for opening and closing said steam stop valve.

* * * * *

35

40

45

50

55

60

65