Jan. 21, 1969 K. O. STRANEY ET AL 3,422,831

TURBINE CONTROL SYSTEM

Filed Feb. 20, 1967 Sheet 1 of 4

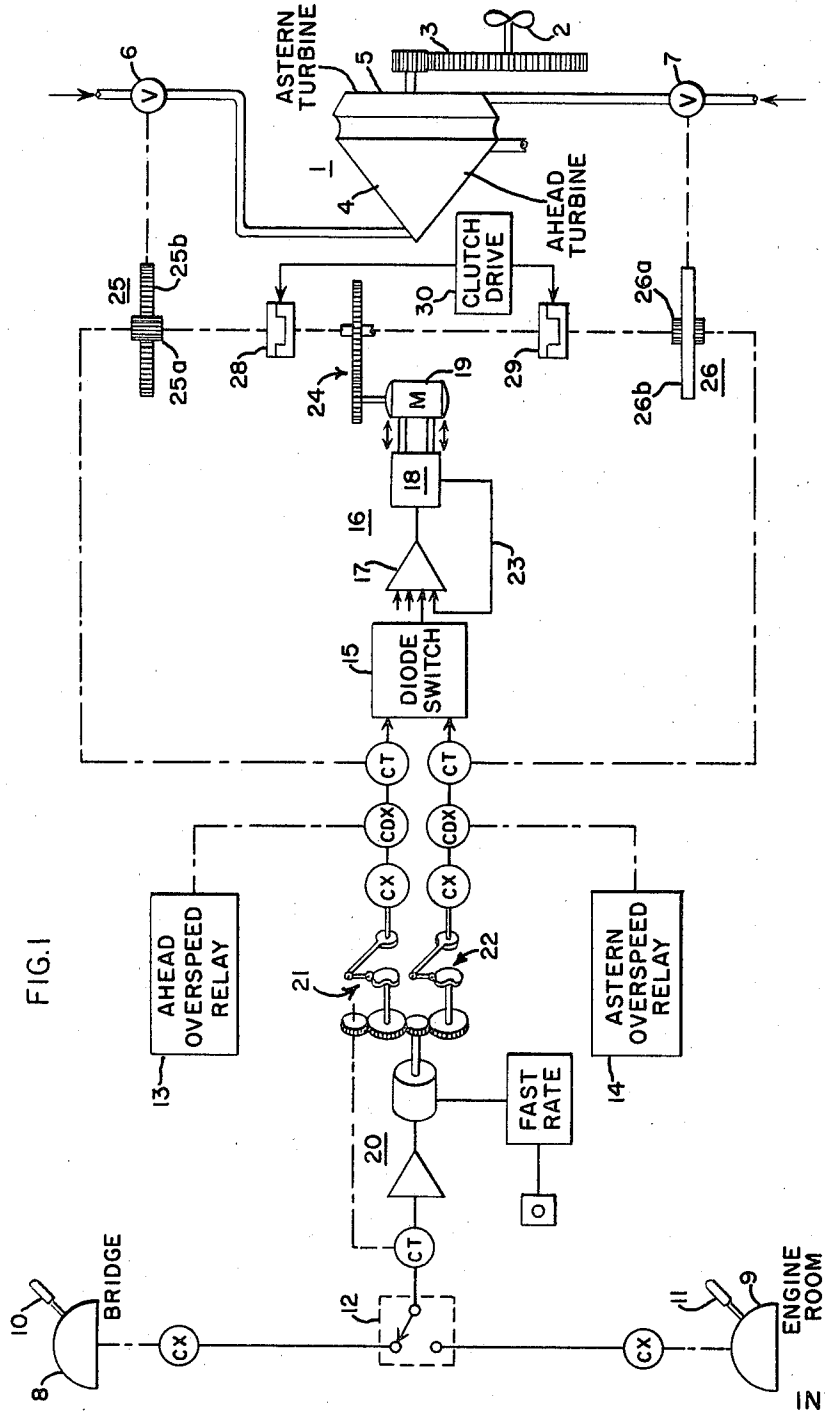


FIG. 1

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TURBINE CONTROL SYSTEM

FIG.2

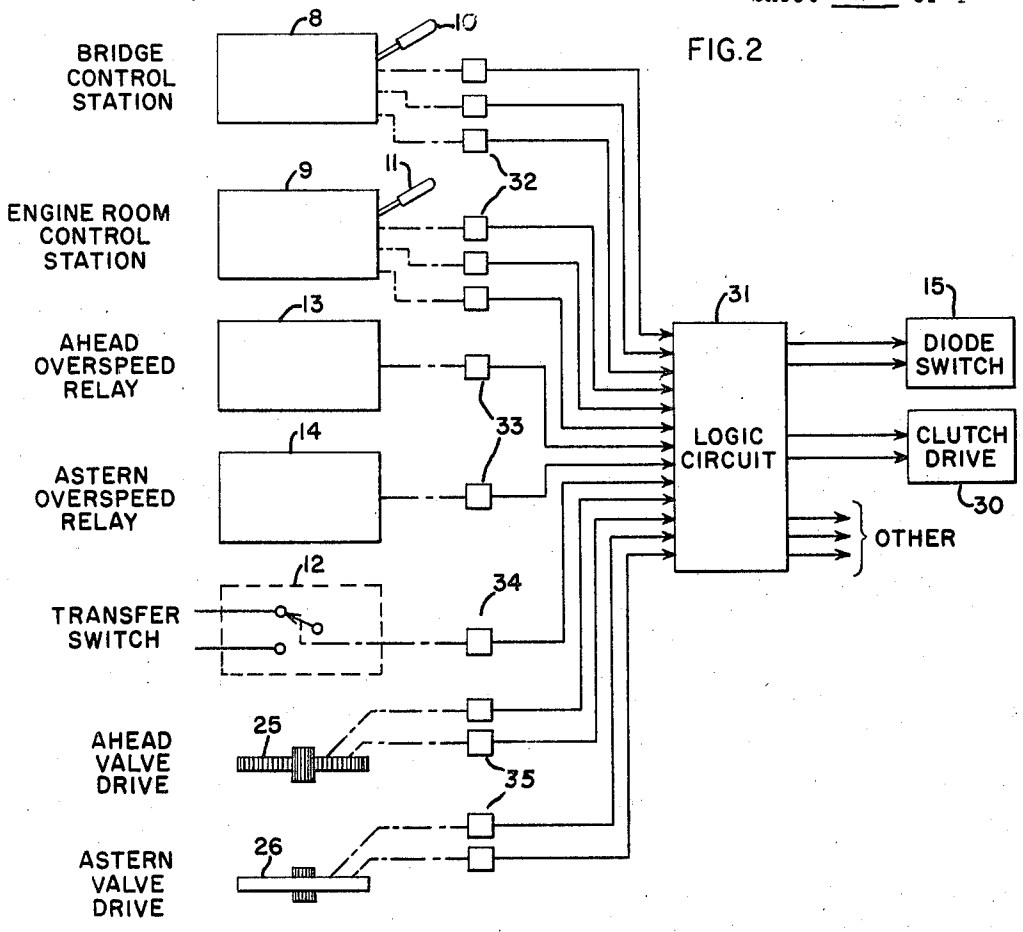
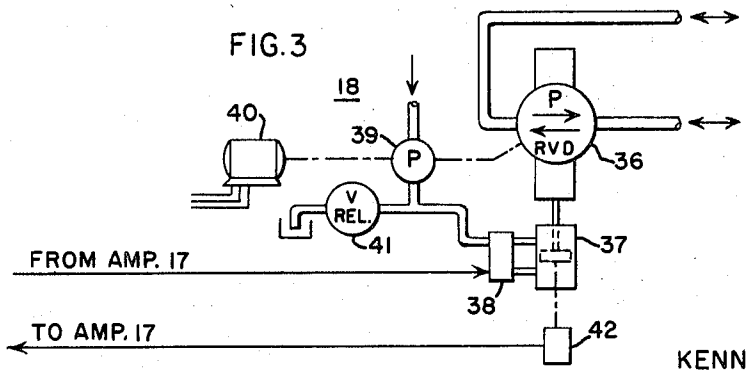


FIG.3



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TURBINE CONTROL SYSTEM
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FIG.4

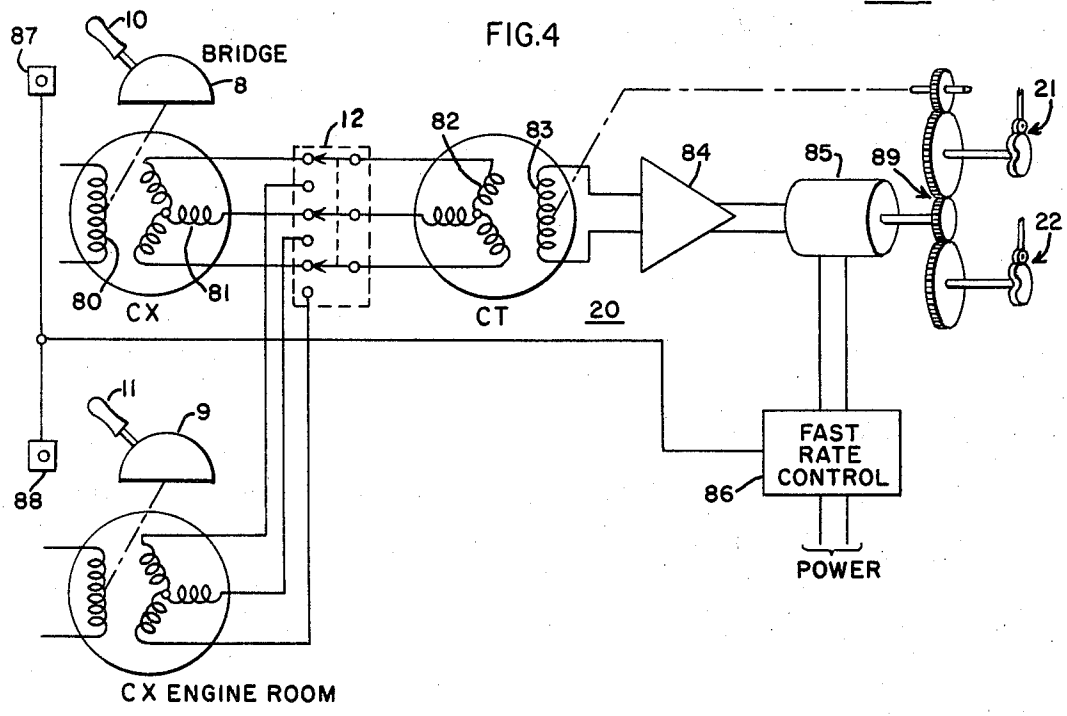
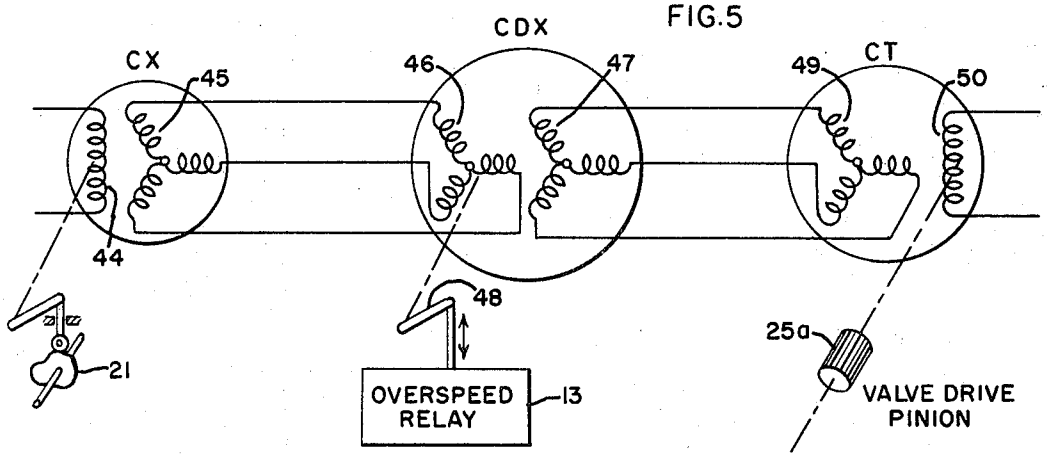


FIG.5



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Jan. 21, 1969 K. O. STRANEY ET AL 3,422,831

TURBINE CONTROL SYSTEM

Filed Feb. 20, 1967 Sheet 4 of 4

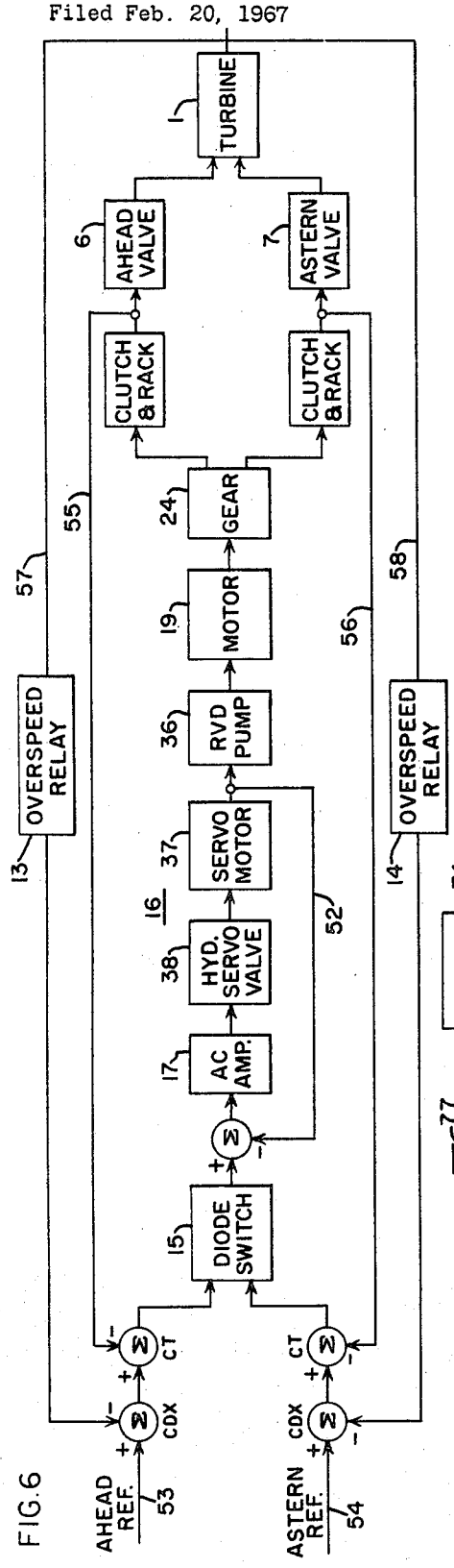


FIG. 6

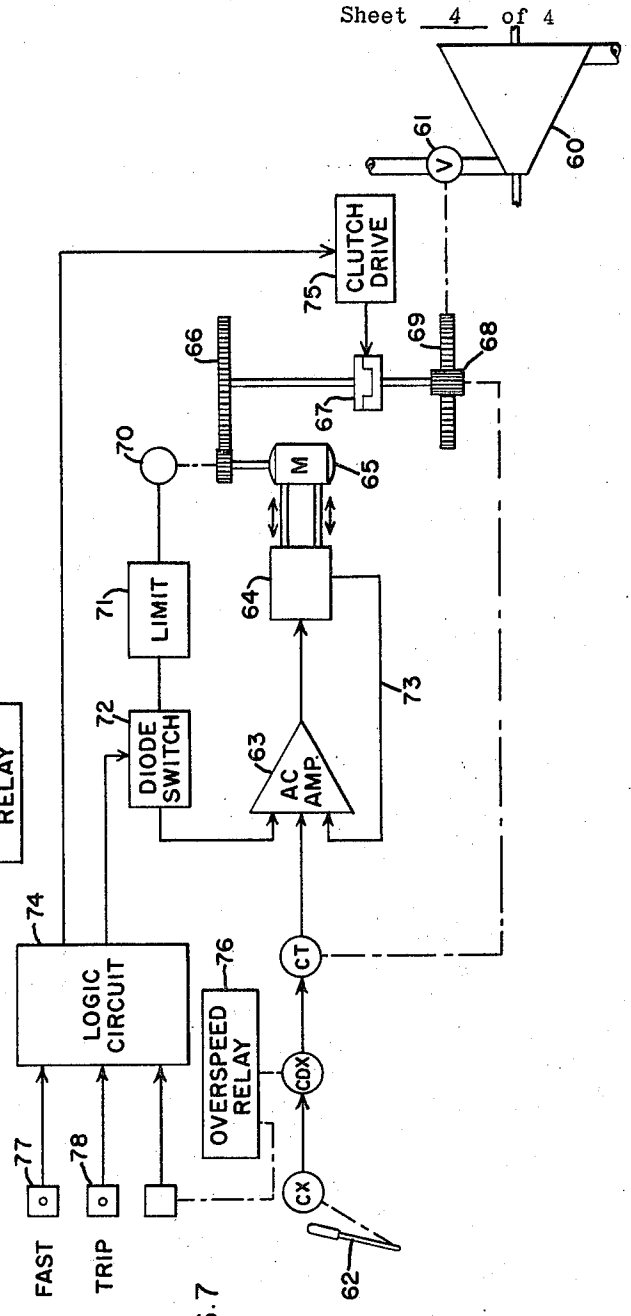


FIG. 7

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United States Patent Office 3,422,831 Patented Jan. 21, 1969

3,422,831

TURBINE CONTROL SYSTEM

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Filed Feb. 20, 1967, Ser. No. 617,320
U.S. Cl. 137—22 8 Claims
Int. Cl. F01k 7/16

ABSTRACT OF THE DISCLOSURE

Steam turbine has forward and reversing valves actuatable together in opposite directions by racks and pinions which can be selectively clutched or declutched to a common electrohydraulic power amplifier to enable independent or simultaneous movement of the valves. The power amplifier includes a combined AC synchro and hydraulic servo control responsive to AC valve positioning signals which are modified in the event of turbine overspeed.

BACKGROUND OF THE INVENTION

This invention relates to an improved electrohydraulic control system for a prime mover such as a steam turbine. More particularly, the invention relates to an improved AC electrohydraulic valve positioning servomechanism having capability for controlling forward and reversing steam turbine valves either independently or simultaneously, in response to independent or simultaneous AC valve positioning signals.

In a marine turbine control system, some of the requirements encountered are: the desire for alternate control capability from either the engineroom or the bridge; a need to operate one set of steam valves to obtain rotation of the turbine shaft for going ahead, and operation of another set of valves for going astern; capability to accomplish emergency speed change or rapid shaft reversal; controls which account for boiler limitations on available steam flow and pressure; and prevention of turbine overspeed. The foregoing requirements dictate a control system of extreme reliability and flexibility.

Turbine control systems are known wherein DC electrical signals in circuitry with operational amplifiers actuate high pressure hydraulic rams to control steam valve positions. Such systems have employed various known control techniques such as speed feedback signals from the turbine shaft as well as valve position and rate of change of valve position feedback signals. Such systems employ electrical summing of the DC feedback signals in DC operational amplifiers and result in relatively expensive control systems having accuracies which are often not warranted for some applications.

Marine turbine throttle control systems are known wherein the desired flexibility for operation of the ahead and astern valves either independently or simultaneously is obtained by two separate electrohydraulic control systems for the valves. Each control employs its own reversible variable delivery hydraulic pump driving a constant displacement hydraulic motor which in turn operates a set of valves. However, the previous provision of two separate valve control units of the foregoing type adds greatly to the cost of marine turbine control systems.

Accordingly, one object of the present invention is to provide an improved AC synchro control system employing a common power amplifier to actuate two control loops which would have conflicting effects on a prime mover.

Another object of the invention is to provide an improved and simplified marine turbine control system for obtaining independent or simultaneous operation of ahead and astern valves as desired.

Another object of the invention is to provide an improved AC synchro control system for a prime mover such as a steam turbine.

Still another object of the invention is to provide an improved elecrical AC synchro system combined with a power amplifying hydraulic system suitable for turbine valve positioning in marine turbines as well as in other types of prime mover applications.

Another object of the invention is to provide a turbine control system having various protective features and modes of operation which are initiated by simple on-off logic circuitry.

SUMMARY OF THE INVENTION

Briefly stated, the invention employs a single electrohydraulic power amplifier which moves forward and reversing valves in opposite directions at the same time or separately in response to separate or simultaneous valve positioning signals. The power amplifier utilizes AC input signals with summing of selected valve position feedback signals by orienting the windings of synchro control devices.

DESCRIPTION OF THE 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 an overall schematic view of the invention as applied to a marine turbine throttle control system,

FIG. 2 is a simplified schematic diagram of the inputs and outputs of the logic circuit which are used to obtain various modes of operation and protective features,

FIG. 3 is a schematic diagram of a suitable reversible variable delivery pump with associated equipment,

FIG. 4 is a simplified schematic diagram of an electromechanical rate control system,

FIG. 5 is a diagrammatic view of a suitable AC synchro control channel,

FIG. 6 is a block diagram of the marine turbine throttle control system shown in FIG. 1, and

FIG. 7 is a simplified schematic view of a modification showing a variable speed turbine control system for a mechanical drive.

DESCRIPTION OF THE PREFERRED EMBODIMENT

(*General arrangement—FIG. 1*)

Referring now to FIG. 1 of the drawing, a steam turbine shown generally at **1** rotates the ship's propeller **2** through a set of gears **3**. Steam turbine **1** includes a turbine section **4** comprising a number of steam stages for ahead operation and a turbine section **5** having one or two stages for astern operation as is known in the art. A set of ahead steam valves **6** having a suitable bar lift or cam arrangement serves to admit steam to the turbine section **4** for going ahead and a separate valve set **7** admits steam to turbine section **5** for going astern.

Referring to the lefthand side of FIG. 1, alternate control consoles **8**, **9** are provided on the bridge and in the engineroom respectively having hand levers **10**, **11**. Each console is arranged to remotely control the position of both the ahead and astern steam valves **6**, **7**. Transfer between bridge and engineroom control is accomplished by means of a transfer switch **12**, preferably located in the engineroom.

At the control station consoles **8**, **9**, the hand lever movements are used to position the rotors of synchro control transmitters (CX) at the consoles. The CX signal at the selected console is transmitted via transfer

switch **12** to a synchro control transformer (CT) to actuate an electromechanical rate control system **20**. The rate control system **20** drives two mechanical cam function generators **21** and **22**, which position the rotors of ahead and astern valve synchro control transmitters (CX).

The ahead and astern CX rotors are thus positioned by moving the hand levers at the consoles. However, they seek their new positions at a rate limited by the rate control system **20**. Moreover, the final ahead and astern CX rotor positions are not in direct correspondence with the hand lever positions, but are modified by the mechanical function generators **21**, **22** so as to provide the proper steam valve setting for a given hand lever setting with due regard to valve flow characteristics and the combined ship propeller and hull characteristics.

The AC voltage relationships corresponding to the ahead and astern CX rotor positions are reproduced electrically in ahead and astern synchro control differential transmitters (CDX) respectively. It will be observed that there are separate positioning signals for ahead and astern valves obtained from a single bridge (or engine room) console transmitter.

The AC signals entering the ahead and astern CDX are reference signals representing desired valve positions. The output from each of the CDX synchros may be modified by shaft rotations therein in accordance with mechanical movements in an ahead overspeed relay **13** and an astern overspeed relay **14**. The details of the overspeed relays are not shown since they are well known in the art, but they comprise oil-operated spring-loaded pistons which receive their actuating fluid from the turbine shaft-driven centrifugal pumps. The piston oil pressure increases with turbine speed and above a speed determined by the initial spring compression, the piston displacement is proportional to the turbine speed. The relay springs are set so that piston displacement does not take place until a turbine overspeed condition of operation is reached. Motion of the CDX shaft by the overspeed relay modifies the A-C signal output of the CDX in a manner such that said output provides a steam valve setting that is lower than that called for by the hand lever setting by an amount proportional to the degree of turbine overspeed.

From each CDX, the A-C signal enters a synchro control transformer (CT). In each CT, the input signal representing desired steam valve position is compared with the actual steam valve position determined by the rotor displacement of the CT device. The difference or error signal from each of the CT devices is simultaneously applied to diode switch **15**. Switch **15** is arranged so as to allow only one error signal to pass to a common electrohydraulic power amplifier shown generally as **16**.

It should be noted that there are separate ahead and astern control channels for input signals leading up to diode switch **15**, with additional provision for entering each of the control channels from either the bridge or engine room control consoles. However, the output from diode switch **15** controls only a single power amplifier **16**, which is used to position both sets of valves.

The power amplifier **16** includes an AC amplifier **17** with means to introduce appropriate reference and feedback signals, a reversible variable flow hydraulic pump **18**, a constant displacement hydraulic motor **19** and a set of reduction gears **24** driven by the hydraulic motor. AC amplifier **17** is a commercially obtainable high gain amplifier.

A position feedback circuit indicated at **23** measures the actual slide block position of the variable displacement hydraulic pump **18** for comparison with the desired slide block position from diode switch **15** in the AC amplifier **17** in a known manner.

When the hydraulic motor **19** turns, rotation of a gear set **24** moves ahead valve **6** in one direction and astern valve **7** in the opposite direction by means of two rack and pinion arrangements **25**, **26**. It is important to note that ahead pinion **25***a* is disposed on top of ahead rack **25***b*, while the astern pinion **26***a* is disposed below the astern rack **27***b*. Of course, other means of reversing the direction of motion of the two valves could be used in lieu of the rack and pinion arrangement, such as a reversing lever for one valve connection, or incorporating an additional gear mesh on one output side of gearbox **24**.

Although the mechanical arrangement is such that the valves would move in opposite directions upon rotation of gears **24**, actual movement does not occur unless the respective ahead and astern clutches **28**, **29** are engaged. The clutches are engaged or disengaged by separate electrical signals from the clutch drive **30**. When the clutches are disengaged the normal valve closing springs (not shown) will close the valves.

Logic circuit (FIG. 2)

The logic circuit designated as **31** accepts inputs from the control consoles in the engine room and bridge, the ahead and astern valve racks, the ahead and astern overspeed relays, and the transfer switch. These are indicated in the lefthand side of FIG. 2, having the same reference numerals as FIG. 1.

The outputs from the logic circuit **31** control the diode switch **15**, the clutch drive **30**, and various auxiliary functions (not shown) such as the condensate pump, steam drain valve, etc. which are not material to the present invention.

The logic circuit **31** itself consists of interconnected logical modules as, for example, known modules of the AND and OR type. Design of such circuits is conventional and well known to those skilled in the art from a consideration of the following functional description.

The logic circuit **31** derives its information from on-off limit switches on the input units and its output is predetermined in accordance with the arrangement of the AND and OR modules. Three limit switches **32** on each of the control stations **8**, **9**, indicate the position of the hand levers **10**, **11** to determine whether they indicate ahead or astern and the extent of their travel from the neutral position. Limit switches **33** on the overspeed relays serve to override the normal signal to the clutch actuator and disengage the clutches when a predetermined unsafe overspeed occurs. Limit switch **34** on the transfer switch indicates whether bridge or engine room has control. Two limit switches **35** on each of the valve gear racks **25**, **26** indicate the position of the ahead valves and astern valves as at their closed positions and at or above some selected steam flow position, i.e., 50% flow position.

As to the outputs from logic circuit **31**, there are two signals to diode switch **15** determining which error signal (ahead or astern) enters AC amplifier **17**. During valve overlap there will be two error signals, e.g., a valve closing signal in the astern control channel and a valve opening signal in the ahead control channel, but diode switch **15**, in accordance with the logic outputs, alows only a closing valve signal to pass through and blocks the signal which is not controlling the closing valves, whichever valve this may be at the time.

The clutch drive **30** is under control of the logic circuit **31** to allow overlap of valve movements. For example, when both clutches are engaged, the astern valve opens while the ahead valve is still closing and vice-versa. But if only one clutch is engaged, only the corresponding valve can open.

Hydraulic pump components (FIG. 3)

The hydraulic pump and associated equipment (**18** in FIG. 1) is conventional and a suitable arrangement may be seen in FIG. 3. A reversible flow variable delivery pump **36** is constructed in a known manner to effect pumping of relatively high pressure hydraulic fluid in either direction and at a rate of flow determined by the position

of a slide block therein (not shown). The slide block position is set by means of a hydraulic servomotor **37** controlled by a servovalve **38**. Servovalve **38** controls the admission of relatively low pressure hydraulic fluid from a pump **39** in accordance with the magnitude of an electrical signal from AC amplifier **17**. An electric motor **40** drives both low pressure pump **39** and the reversible variable delivery pump **36**. Pressure to servovalve **38** is maintained constant by means of a relief valve **41**. The slide block position is communicated to amplifier **17** as an AC signal by means of a transducer **42**. Transducer **42** may be a linear variable differential transformer with a movable core attached to the piston in servomotor **37**.

Rate control system (FIG. 4)

The rate control system **20** (see FIG. 1) is shown in greater detail in FIG. 4. The handle **10**, **11** at the consoles move the rotors of synchro control transmitters CX. Since the action of either is identical, depending upon the position of transfer switch **12**, only the bridge CX path will be described.

One half-sector of lever **10** rotation commands ahead valve position, and the other half controls astern valve motion. Lever movement reorients a CX rotor winding **80** and an appropriate signal is induced in CX stator winding **81**, which is reproduced in stator winding **82** of the CT. A signal is induced in the CT rotor winding **83** which acts as the input to a conventional AC amplifier **84**. Amplifier **84** operates a two phase motor **85** which, in turn, drives the cams of function generators **21**, **22**. A mechanical feedback path is provided from the motor output to actuate the rotor winding **83** of the CT so as to stop the motor when it has reached the desired position, as set by hand lever **10**.

A gearset **89** depicts a gear reducing mechanism, which, in combination with magnitude of the excitation voltage on motor **85**, provides a means of reducing and controlling the rate at which the cams reach their new positions. The excitation voltage for motor **85**, supplied through the fast rate controller **86**, is normally set at a reduced value to cause the rate system **20** to limit the speed of the steam valve movements, so as to correspond with changes in steam flow which are desirable for satisfactory performance. However, full excitation voltage may be applied by actuating pushbuttons **87** or **88** on the bridge or in the engine room, to permit fast response under emergency ship handling conditions. The fast rate controller **86** also incorporates a phase shifting means to satisfy the requirements of two-phase motor **85** from a single phase source.

Synchro-control channel (FIG. 5)

As mentioned previously, the control channel from either the bridge or engine room for both ahead and astern signals consists of a series of AC synchro-control devices arranged to effect summing of electrical and mechanical signals therein. Taking the synchro-control channel of FIG. 4 as typical, it is assumed that it represents the channel carrying the ahead valve positioning signal from the bridge, transfer switch **12** being properly oriented. A desired steam valve position has previously been indicated with hand lever **10** and the mechanical function generator **21** is effecting nonproportionate movement of the rotor winding **44** of the ahead synchro-control transmitter CX. A corresponding appropriate signal is induced in the stator winding **45** of the ahead CX, which is reproduced in the rotor winding **46** of a synchro-control differential transmitter CDX. A similar stator winding **47** in the CDX will reproduce this signal if relative orientations of winding **46** and **47** are the same. However, if the rotor winding **46** has been reoriented by the overspeed relay **13** upon occurrence of a predetermined overspeed, the CDX will reduce the magnitude of the reference signal induced in winding **47** by an amount proportional to the movement of an overspeed relay output member **48**.

The thus modified reference signal (or unmodified reference signal depending on the turbine speed) induced in winding **47** is reproduced in the stator winding **49** of a synchro-control transformer CT. As before, a voltage is induced in the rotor winding **50** of the CT which serves as one of the inputs to diode switch **15**.

Actual ahead valve position is sensed by orientation of rotor winding **50** through a mechanical connection to the ahead valve pinion **25***a*. The arrangement is such that actuation of the valve in a given direction by the signal induced in coil **50** will rotate valve pinion **25***a* in such a direction as to reduce the signal by reorienting rotor winding **50**. When the valve reaches the position called for by hand lever **10**, it will stop (provided that the valve position reference signal dictated by hand lever **10** has not been modified by action of the overspeed relay).

Block diagram (FIG. 6)

Reference to FIG. 6 shows a simplified block diagram employing conventional servomechanism symbology. It will be observed that there is a single group of power amplifying components extending from diode switch **15** to the gear set **24**, which provide the necessary amplification of power from the input electrical signals to the mechanical power needed to actually move the valves. Thus, all of the expense associated with these components is not duplicated for astern and ahead control as it is in known arrangements. The power amplifier **16** has an inner closed loop system including the A.C. amplification system and the hydraulic servo system. Slide block position feedback is indicated at **52**.

There are two means of entering the inner closed loop system, one being an appropriate ahead valve reference signal **53** and an astern valve reference signal **54** in accordance with the outputs of function generators **21**, **22** respectively. Feedback for two outer closed loop systems (both utilizing the common inner closed loop) is indicated at **55**, **56** in accordance with the position of the valve rack pinions. As explained previously, the logic circuit **31** can open either of these outer loops by causing either of the clutches **28**, **29** to disengage in order to interrupt the control signal to the respective valve as well as the corresponding feedback signal indicating valve position. However, even if both clutches are engaged, only one of the diode loops is actually in control. This is because the diode switch **15** allows only one valve position error signal to enter the common power amplifier **16**. The other valve will function under open loop control.

The overspeed relays **13**, **14** may modify the reference signals **43**, **54** in the event that overspeed takes place, as indicated by paths **57**, **58** for ahead and astern control channels respectively.

Operation (FIGS. 1–6)

The operation of the invention will be apparent from the following typical functions which may be required of the marine powerplant. For example, if the ship has been steaming at full ahead and the throttle is pulled to full astern, the logic circuit will allow the closing ahead valve to reach 50% flow (for example) before it actuates the astern clutch. At this point both valve sets operate simultaneously and the astern valve will open at the same rate as the closing ahead valve.

It is important to note that the logic circuit is so arranged as to keep the valve position feedback signal of the closing valve in the appropriate control loop until that valve is closed, after which it disengages the clutch for that valve and switches over to closed loop control for the opening valve, even though the valve has been already opening in open loop fashion (because the clutch was engaged). In the example given of moving the hand lever from full ahead to full astern, large error signals from both ahead and astern CT devices will appear at diode switch **15**. These two error signals dictate opening of the astern valve and closing of the ahead valve. Only the

signal indicating closing of the ahead valve will pass through the diode switch to actuate power amplifier **16**. Since the ahead clutch is engaged, the ahead valve will commence to close, but at the appropriate point (about 50% flow) the astern clutch will be engaged by the logic circuit and the astern valve will commence opening even though the ahead signal is doing the controlling. The astern valve is, therefore, opening in open loop fashion. As soon as the ahead valve becomes closed, however, the logic circuit will transfer control to the astern control channel by disengaging the ahead clutch and switching over to the astern feedback signal. Thereafter, the error signal gated by the diode switch **15** is the astern valve position error and the astern valve continues to open under closed loop control until it reaches the desired position.

The foregoing operation occurs under conditions of simultaneous ahead closing and astern opening signals on the function generators, derived from a single transmitter at the operator's console. Of course, if the indication from the bridge or engine room control console is simply to close the ahead valves with one movement and then at some later time to open the astern valves with a subsequent movement of the hand lever, two independently occurring error signals enter the diode switch **15** and the valve sets are controlled separately.

If the turbine starts to overspeed, the appropriate overspeed relay will effect a lower desired valve position signal than the input reference signal by modifying the electrical output of the CDX and hence the valve will start to move in a closing direction to match the modified reference signal. Exceeding a predetermined maximum overspeed, however, causes the limit switches on the overspeed relays to disengage the clutches and close the valves.

As mentioned previously, the rate of valve movement is limited by the rate control system **20**, unless the pushbuttons **87**, **88** are used to increase the rate under emergency conditions.

Modification (FIGURE 7)

Although the invention has been described with reference to a particular application in a marine turbine control system, features of the invention can also be used in other types of applications as typified by the variable speed turbine control system shown in FIGURE 7. There a turbine **60** has its inlet valves **61** set in accordance with the position of a hand lever **62** producing an appropriate electrical reference signal in the synchro transmitter CX. The signal is modified in accordance with the rotor positions in a CDX and CT arranged similar to those in FIGURE 4 and the valve position error signal enters AC amplifier **63**. A hydraulic pump **64** similar to the one in FIGURE 3 drives a constant displacement reversible hydraulic motor **65** and gear set **66** as before. An electrically actuated clutch **67**, when engaged, allows gear **66** to rotate pinion **68**, moving rack **69** and effecting changes in the position of valves **61**.

Rate of valve travel is accomplished in a slightly different manner than as described in FIGURE 4 of the previous arrangement. The electrohydraulic amplifier includes means to provide a rate feedback signal which is limited to a maximum value under normal conditions. An AC tachometer generator **70** is connected to hydraulic motor **65** to provide a voltage proportional to speed of the motor. This voltage is blocked by a threshold circuit **71** unless the voltage exceeds a value which is preselected in accordance with the desired maximum hydraulic motor speed. Should the voltage exceed this preselected value, then the voltage passes through a normally closed diode switch **72** to the input of amplifier **63**. Slide block position feedback **73** is provided as before.

A logic circuit **74** serves to effect opening and closing of diode switch **72** and actuation of the clutch drive **75**. Inputs to logic circuit **74** are from overspeed relay **76** and pushbuttons **77**, **78**.

The operation of the FIGURE 7 arrangement is as follows: If fast valve movement is desired, pushbutton **77** will open diode switch **72** so that rate of valve movement is not limited, but motor **65** moves at its maximum rate.

As before, if the turbine is beginning to overspeed, proportionate lowering of the reference signal supplied to AC amplifier **63** is effected by alteration of the rotor position in the CDX. If an even greater overspeed has occurred, in which it is desired ot absolutely close the valves, the overspeed relay through logic circuit **74** will de-energize the clutch **67** through the actuator **75**, allowing the valve springs to close the valve. This can also be accomplished through the logic circuit with pushbutton **78**.

Thus it will be observed that the invention provides a simplified control of valve movement through relatively inexpensive and reliable synchro control devices wherein closed loop control is accomplished by rotation of the relative winding positions in relatively inexpensive AC synchro control devices.

In the application of the invention to a marine turbine control sys.em, excellent flexibility of operation under the various requirements for such a system is achieved by employing a common power amplifier to operate both astern and ahead valves through appropriate selection of signals provided by the aforementioned synchro control devices. The logic circuit and the arrangement of valve control mechanisms so that they move in opposite directions under the control of the common power amplifier allows valve overlapping operation as dictated by the particular requirements of the ship and its boiler, as well as reducing the cost of the system.

While there is shown what is considered at present to be the preferred embodiment of the invention, it is of course understood that various other modifications may be made therein, 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 we claim as new and desire to secure by Letters Patent of the United States is:

1. A control system for a reversing turbine having first and second valves controlling the admission of motive fluid for forward and reverse rotation respectively, comprising:

first control means responsive to a first valve positioning signal for positioning the first valve,

second control means responsive to a second valve positioning signal for positioning the second valve,

power amplifier means common to portions of the first and second control means,

said first and second control means being arranged to cause the first and second valves to move in opposite senses with respect to control of steam flow therethrough in response to the output from the power amplifier means, and

logic means for selectively causing the first and second control means to operate either independently or simultaneously.

2. The combination according to claim **1**, wherein said first and second control means include first and second disengageable clutches respectively for disabling the action of the power amplifier means on either of the respective valves, and wherein said logic means is responsive to valve position and arranged to actuate said clutches at selected valve positions.

3. The combination according to claim **1**, including an AC synchro control mechanism to supply said first and second valve positioning signals as a function of a common AC input signal, and means to limit the rate of change of said power amplifier output to a selected value.

4. The combination according to claim **1**, including gating means enabling only one of said valve positioning

signals at a time to actuate said common power amplifier means.

5. The combination according to claim 1, wherein at least one of said first and second control means include an AC synchro control channel arranged to provide a valve positioning signal to said power amplifier, said synchro control channel having connected therein a synchro control differential transmitter arranged to modify the valve positioning signal so as to call for a reduced valve opening by changing the relative orientation of its stator and rotor windings in response to turbine overspeed.

6. A valve positioning control system for a turbine comprising:

a power amplifier connected to move said valve in response to an AC signal,

an AC synchro control input channel coupled to said power amplifier, and including:

a synchro control transmitter for providing an AC reference signal corresponding to a desired valve position,

a synchro differential transmitter for modifying the valve positioning signal by changing the relative orientation of its rotor and stator windings in response to turbine overspeed, and

a synchro control transformer having its rotor connected so as to be responsive to actual valve position and transmitting an AC valve position error signal to said power amplifier.

7. The combination according to claim 6 including means to limit the rate of change of output from the power amplifier to a selected value, with additional means to render the limiting means ineffectual so as to obtain fast valve movement under emergency conditions.

8. The combination according to claim 6, wherein the power amplifier output is clutched to a spring-biased valve moving mechanism and including speed responsive means to disengage said clutch upon the occurrence of a preselected turbine overspeed.

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NATHAN L. MINTZ, *Primary Examiner.*

U.S. Cl. X.R.

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