ABSTRACT: An apparatus for controlling the steam production of preferably ship steam boilers comprising transmitters for providing signals corresponding to air pressure, fuel oil pressure and steam pressure and controlling the operation of the burners of the boilers via a time integrating circuit, an adding circuit, comparators and drive circuits controlling servomotors for dampers and fuel oil valves and for igniting and extinguishing at least most of said burners.
FIG. 2

FIG. 5

INVENTORS:

JERK G. OLDENBURG
STEN B.O. WILHELMSSON
KRISTER K.O. LEHMENVAD
BRENNER, TILGNER, RASMUSSEN

ATTORNEYS
This invention relates to an apparatus for controlling burners preferably for ship steam boilers, in which apparatus the burners for each steam boiler have associated with them a servomotor for setting their dampers and a servomotor for setting their fuel oil valves, the damper servomotor being connected to a first drive circuit and the fuel oil valve servomotor being connected to a second drive circuit, at least most of the burners being associated with a third drive circuit for igniting and extinguishing said burners with a certain time lag successively one after the other.

For instance, the previously known apparatus of the above-described type are extremely bulky and very expensive in manufacture. The bulky construction of these previously known apparatuses as is largely due to the necessity of making use of per se spaceous components in the various circuits. The operating reliability of the previously known apparatus is also less than satisfactory.

The object of the present invention is to overcome the drawbacks of these prior art apparatuses and to make it possible to use integrated circuit components for controlling boiler operation.

This object is attained by the present invention in the apparatus outlined in the foregoing by the fact that the drive circuits have two inputs each connected to one comparator, one of said comparators serving to set the drive circuit into a first condition while the other comparator serves to set the drive circuit into another condition, and two outputs each associated with one of the conditions into which the drive circuit can be set, and that the comparators provided for the first drive circuit are adapted to receive a signal from an air pressure transmitter and a signal from a fuel oil pressure transmitter, the comparators provided for the second drive circuit are adapted to receive a signal from the fuel oil pressure transmitter and a signal from a steam pressure transmitter which is coupled to the comparators via a time integrating circuit and an adding circuit and which is fed via a frequency compensating circuit, and the comparators provided for the third drive circuit are coupled to the output of the integrating circuit.

For greater clarity, the invention will be more fully described in the following with reference to the accompanying drawings in which:

FIG. 1 is a block diagram for a control apparatus intended for two ship steam boilers;

FIG. 2 is a wiring diagram for the blocks 3, 4, and 15 in FIG. 1;

FIG. 3 is a wiring diagram for the blocks 5—8 in FIG. 1;

FIG. 4 is a wiring diagram for the blocks 9—11 in FIG. 1;

FIG. 5 is a wiring diagram for the blocks 14 in FIG. 1;

FIG. 6 is a wiring diagram for the blocks 12 and 13 in FIG. 1; and

FIG. 7 is a wiring diagram for a net assembly suitable for the control apparatus.

The control apparatus illustrated in FIG. 1 is intended for two ship steam boilers, and the burners of one boiler are associated with the blocks 1—8 shown at the bottom of FIG. 1, while the burners of the other boiler are associated with the blocks 1—8 shown at the top of FIG. 1. In the following specification the control apparatus will be described merely with regard to one boiler.

The burners have associated with them a servomotor for a damper which is intended for instance for three burners, and a servomotor for a fuel oil valve which is also intended for the three burners. The damper servomotor is illustrated in FIG. 1 by block 1 while the fuel oil valve servomotor is illustrated by block 2. The servomotor 1 is associated with a drive circuit 3 the output of which is coupled to the servomotor 1 which will be supplied with current for setting the damper in one direction from one output and for setting the damper in the other direction from the other output. The drive circuit 3 further has two inputs 20 and 23 as in FIG. 3 and via one of said inputs the drive circuit can be set into a condition for supplying servo operating current over one output while the drive circuit can be set via the other input into a second condition for supplying opposite servo operating current over the second output. Setting of the drive circuit from one to the other condition e.g. damper opening to damper closing is realized by means of a pair of comparators within a comparator assembly 5, in which a comparator F7 is connected to one input 20 and the other comparator F8 to the other input 23. Further, the pair of comparators is connected to an air pressure transmitter 7 and a fuel oil pressure transmitter 8. The latter is also connected to a pair of comparators within a comparator assembly 6 for a drive circuit 4 which is operatively connected to servomotor 2. It should be observed that the drive circuits 3, 4, and 15 are identical. Further, the pair of comparators in the block 6 is connected to an adding circuit 9 which in turn is connected to a time integrating circuit 10 and to an input amplifier 11. The time integrating circuit 10 is also connected to the input amplifier 11. The input of the amplifier 11 is coupled to a steam pressure transmitter 12 which is fed by a frequency compensating circuit 13. Also connected to the output of the integrating circuit 10 is a pair of comparators as illustrated in FIG. 5 comprising comparator assembly 14 which controls the drive circuit 15 which is for igniting and extinguishing two of the burners. Whenever the burners need be extinguished, first one burner is extinguished and with a certain time lag the other burner. Ignition takes place in the same manner.

The air pressure transmitter 7 can be of practically any conventional construction whatever. The oil and steam pressure transmitters 8, 12 can also be of any conventional construction whatever.

It should be pointed out that the connecting points bearing the same reference numerals in the various circuits shown in Figs. 2, and 7 are interconnected, and that the connecting points bearing voltage indication are to be connected to the respective connecting terminals in the net assembly shown in FIG. 7.

Each drive circuit 3, 4, and 15 is of the construction shown in FIG. 2. One input 20 of the drive circuit is connected to a comparator F7 in the pair of comparators comprising assembly 5 and via a resistor R57 to a transistor T1 which is also connected to a voltage input of OV and via a signal lamp L1 to a voltage input of +45V. The connection between transistor T1 and signal lamp L1 is coupled via a diode D10 to a moving contact member K1 of a relay Re1. The relay Re1 has further moving contact member K2 which is connected to one output 21 of the drive unit. The operating coil of the relay Re1 is connected in parallel to a diode D11 and one end is connected to a voltage input of +45V, and the other end is connected to the fixed contact member for a moving contact member K1 corresponding to the first-mentioned moving contact member of relay Re1 and associated with a relay R2 which is identical with relay Re1. The corresponding fixed contact member of relay Re1 is coupled to one end of the operating coil in the relay Re2, the other end of the coil being also connected to the voltage input of +45V(a).

The other moving contact member K2 of relay Re2 is coupled to the other output 22 of the drive unit. The first moving contact member of relay R2 is coupled via a diode D10 to the connection between a signal lamp L2 and a transistor T2, the signal lamp L2 being coupled to the voltage input of +45V. Transistor T2 furthermore is connected via a resistor R157 to the other input 23 of the drive unit and to a voltage input of OV. This input is connected to the connection between transistor T2 and resistor R157 via a resistor R159. Thus each drive circuit comprises two transistors which are interconnected via diodes D10 and the operating coals of relays Re1 and Re2.

The pair of comparators of comparator assembly 5 is shown in FIG. 3 and includes two comparators F7 and F8 and an operation amplifier F5. The minus input of the comparator F7 is coupled via a resistor R23 to the sliding contact of a potentiometer P3 whose terminals are connected to a voltage input
of -6V and a voltage input of +12V. Potentiometer P3 serves to set the operating voltage of comparator F7. The plus input of comparator F7 is connected via a resistor R25 to the comparator output and via a resistor R24 to the output of operational amplifier F5, which output is connected to the minus input of comparator F8 via a resistor R26. The plus input of comparator F8 is connected via a resistor R28 to the comparator output and via a resistor R27 to the sliding contact of a potentiometer F4 whose terminals are connected to a voltage input of -6V and a voltage input of +12V. Potentiometer P4 also serves to set the operating voltage of comparator F8. Operational amplifier F5 is connected via a condenser C19 to a voltage input of -6V and its output is connected via a resistor R20 coupled in parallel with a condenser C9 to the minus input which is connected via a diode D6 to a voltage input of OV and via a resistor R19 to the sliding contact of a potentiometer P2. The latter is inserted between a voltage input of OV and air pressure transmitter 7 which is also connected to a voltage input OV. Further, a resistor R18 is connected over potentiometer P2 which serves to set the excess air supplied to the boiler. The plus input of operational amplifier F5 is connected via a resistor R22 to a voltage input of OV and via a resistor R21 to fuel oil pressure transmitter 8 which is also connected to a voltage input of OV.

The pair of comparators of comparator assembly 6 includes two comparators F9 and F10 whose outputs are connected to the inputs of drive circuit 4 in the same manner as outputs F7 and F8 are connected to 20 and 23 to drive circuit 3. The minus input of comparator F9 is connected via a resistor R30 to a voltage input of OV via a resistor R29 to fuel oil pressure transmitter 8 and to a voltage input of OV via a condenser C10. The side of resistor R29 facing away from the minus input is connected to a voltage input of OV via a RC network comprising a condenser C20 coupled in parallel with a resistor R17. The plus input of comparator F9 is connected via a resistor R32 to the output and via a resistor R31 to adding circuit 9. Further, the plus input is connected via a resistor R30 to the sliding contact of a potentiometer P5 which is inserted between a voltage input of -6V and a potentiometer P6 whose other terminal is applied to the voltage input of -6V. The connection between potentiometer P5 and potentiometer P6 is connected to a voltage input of +12V via a resistor R49 which is shunted by means of a potentiometer P7 which in turn is partially shunted via its sliding contact to the connection between potentiometers P5 and P6. Potentiometer P5 serves to set the operating voltage of comparator F9, and potentiometer P6 serves to set the operating voltage of comparator F10 while potentiometer P7 serves to balance comparators F9 and F10 relative to the corresponding comparators for the second boiler. The sliding contact of potentiometer P6 is connected via a resistor R34 to the minus input of comparator F10, said minus input being connected to adding circuit 9 via a resistor R33. The plus input of comparator F10 is coupled via a condenser C11 to a voltage input of OV, via a resistor R36 to the output and via a resistor R35 to fuel oil pressure transmitter 8.

The wiring diagram for blocks 9, 10 and 11 is shown in FIG. 4. Adding circuit 9 includes an operational amplifier F4 whose output at 24 is connected to a voltage input of -6V via a resistor R16 and to the minus input via a condenser C7 coupled in parallel with a resistor R14. Amplifier F4 proper is coupled to the voltage input of -6V via a condenser C8. The plus input of the amplifier is coupled to a voltage input of OV via a resistor R15. Moreover, the minus input is coupled to a voltage input of OV via a diode D5 and connected to the output of F1 via an amplifier F11 via a resistor R13 and to the output of amplifier F2 in integrating circuit 10 via a resistor R12. Integrating circuit 10 includes that the output of amplifier F2 is also the output of the circuit and is coupled to a voltage input of OV via a condenser C6 and to the minus input of amplifier F3 via a condenser C4. Amplifier F3 is connected to a voltage input of -6V via a condenser C3 and its plus input is connected to the voltage input of OV via a resistor R11. The minus input of amplifier F3 is further coupled to the output of the amplifier via a resistor R10 and to the sliding contact of a potentiometer F8 via a resistor R52. Coupled to the connection between resistor R52 and the minus input is a diode D3 and a condenser C5 whose other terminals are connected to the voltage input of OV. The terminals of potentiometer F8 are connected over two resistors R54 and R55, the connection between said resistors being applied to a voltage input of OV. One terminal of the potentiometer is coupled to a voltage input of +12V via a resistor R53 and the other terminal of the potentiometer is connected to a voltage input of -6V via a resistor R56. The output of amplifier F3 is coupled via a resistor R9 to the plus input of amplifier F2, said plus input being coupled via a resistor R4 to the output of input amplifier 1. Amplifier F2 is connected to a voltage input of +12V via a condenser C2.

The output of amplifier F2 is connected to the minus input of the amplifier via a Zener diode D9 and a diode D2. The minus input of amplifier F2 is connected to a voltage input of OV via a resistor R6 coupled in parallel with a diode D4. Inserted between said voltage input and the plus input of the amplifier is a diode D24. Moreover, the plus input of amplifier F2 is connectable to the output of comparator F9 via a resistor R7, a pushbutton K and a diode D8, and its minus input is connectable to the output of comparator F10 via a resistor R8, pushbutton K and a diode D7. This feedback to amplifier F2 from the outputs of comparators F9 and F10 serves to tune in the control apparatus.

Input amplifier 11 is an operational amplifier F1 which is coupled to a voltage input of OV via a condenser C1 and the output of which is connected to a voltage input of -6V via a resistor R5, to the minus input via a resistor R1, and to the plus input via a diode D1. Besides the output is coupled to the amplifier proper via connection 25. The plus input of amplifier F1 is besides connected to steam pressure transmitter 12 at terminal 26.

FIG. 6 shows a wiring diagram for the frequency compensating circuit 13. The primary winding of a transformer TR2 is connected to a net assembly as shown in FIG. 7 for receiving a voltage of 220V, and the secondary winding of transformer TR2 is connected to the minus input and plus input of a comparator F11 via a resistor R60 and two resistors R59, R61, respectively. The connection between the secondary winding and resistor R60 is connected to a voltage input of OV and to the connection between resistors R59 and R61 via a Zener diode D23. The plus input of comparator F11 is connected to the output of the comparator via a resistor R62. Moreover, the output is coupled to the minus input of operational amplifier F12 via a condenser C21 and a resistor R63. The connection between condenser C21 and resistor R63 is coupled to a voltage input of OV via a resistor R67 and a diode D22 connected in parallel therewith. The connection between diode D22 and the voltage input is coupled to the plus input of amplifier F12 via a resistor R64. The voltage input of OV is further coupled to the minus input of amplifier F12 via a diode D25. The minus input is further connected to the output of amplifier F12 via a condenser C22 connected in parallel with resistor R65 and a potentiometer P9. The sliding contact of potentiometer P9 is connected to the output of amplifier F12, said output being coupled to a voltage input of OV via a condenser C24 and to the steam pressure transmitter 12 at 26. Further, amplifier F12 is coupled to the voltage input of OV via a condenser C23, and the plus input of amplifier F12 is coupled via a resistor R66 to the sliding contact of a potentiometer P1 whose one terminal is coupled to a voltage input of OV via a resistor R3 while the other terminal of potentiometer P1 is coupled to a voltage input of -6V via a resistor R2. It should be noted that potentiometer P1 serves to set the required value of the steam pressure.

FIG. 5 shows the pair of comparators in comparator assembly 14 which includes a comparator F6 and a comparator F106 each connected to one input of the drive unit 15 as at 20 and 23. The output of comparator F6 is connected to the plus input of the comparator via a resistor R39. Further, the
The net assembly shown in FIG. 7 is of conventional construction and fed by an alternating current of 220V, and a frequency of 60Hz. via input 30, 31. This is coupled to the primary winding of a transformer TR1 via a switch S10 and two fuses S1 and S2 and to output 27, 28 via fuses S3 and S4. Via fuses S1 and S2 input 30, 31 is coupled to two means 32, 33 for stabilized direct voltage. The means connected to input 30, 31 lie in parallel. Transformer TR1 has a secondary windings. A rectifier bridge D14—D17 and D18—D21, respectively, and a resistor R50 and R51, respectively, are connected over said secondary windings. Connected to the connection between diodes D14 and D15 is a switch S11 leading to a voltage tap of +45V (a), and a voltage tap of +45V. The connection between diodes D17 and D20 leads to a tap of OV and the connection between diodes D18 and D19 leads via a fuse S5 to a voltage tap of −50V. Inserted between the taps of +45V and OV are a resistor R63 connected in series with a lamp L3, and in parallel with said circuit a condenser C18. Inserted between the taps OV and −50V are a resistor R68 and in parallel therewith a condenser C18. Means 32 and 33 are interconnected and said connection leads to a tap of OV and to the connection between diodes D17 and D20. Further, there leads from means 32 a voltage tap of +12V and from means 33 a voltage tap of −6V. Inserted between the taps of OV and +12V is a condenser C15, and between the taps of OV and −6V a condenser C16.

The mode of operation of the apparatus will be briefly described in the following.

The voltage received from a steam pressure transmitter 12 is fed into input amplifier F1. The signal received from F1 is proportional to the input signal and is the deviation of the steam pressure from the required value. The proportional error signal is integrated in integrating circuit 10 which delivers a signal which is the integral of the error signal. The integrated error signal and the proportional error signal are added in adding circuit 9. This circuit will thus produce a signal which is proportional to the need of fuel oil and is applied to the pair of comparators in comparator assembly 6. To this pair there is also applied the signal from the fuel oil pressure transmitter, for said adding circuit signal from said adding circuit is compared with the signal from the fuel oil pressure transmitter. In conformity with the signal obtained at the comparison, either comparator F9 or comparator F10 will thus be engaged so as to set the drive circuit into one of its conditions.

The voltage from fuel oil pressure transmitter 8 and the signal from air pressure transmitter 7 will be compared in the pair of comparators in comparator assembly 5. The resulting comparison signal will set drive circuit 3 into one of its conditions. Moreover, the integrated error signal is supplied to the pair of comparators in comparator assembly 14, and when it has attained a certain predetermined value it engages comparator F6 whereby drive circuit 15 will be set into one of its conditions. As a result burner 2 is ignited. Drive circuit 15 is set into its opposite condition when the integrated error signal sinks below the predetermined value via comparator F106. If the drive circuit remains in this condition for a certain predetermined period the burner 3 also will be extinguished.

The above-described control apparatus suggested by the present invention satisfies the requirements outlined in the introduction inasmuch as the operational amplifiers F1—F2 and F12 can be integrated circuit components and comparators F6—F10 and F11 can be integrated circuit components. This will permit building up of a very compact apparatus which is also extremely reliable.

We claim:

1. An apparatus for controlling burners preferably for ship steam boilers, comprising a servomotor for setting dampers for said burners for each steam boiler, a servomotor for setting fuel oil valves of said burners, a first drive circuit for driving said damper servomotor, a second drive circuit for driving said fuel oil valve servomotor, a third drive circuit for igniting and extinguishing at least most of said burners with a certain time lag successively one after the other, comparators for controlling said drive circuits, said drive circuits having two inputs each connected to one of said comparators, one of these comparators serving to set the drive circuit into one condition while the other comparator serves to set the drive circuit into another condition, and two outputs each associated with one of said conditions, a first transmitter for providing a signal corresponding to the air pressure for the steam boiler which is connected to the comparators for the first drive circuit, a second transmitter for providing a signal corresponding to the fuel pressure for the burners which is connected to the comparators for the second drive circuit, a third transmitter for providing a signal corresponding to the produced steam pressure, a time integrating circuit coupled to said steam pressure transmitter, an adding circuit coupled to said time integrating circuit and the comparators, and a frequency compensating circuit for feeding said time integrating circuit, said comparators for the third drive circuit being coupled to the output of said time integrating circuit.

2. An apparatus as claimed in claim 1, wherein said comparators have two inputs, one being a minus input and the other a plus input, and one output which is connected to one input of the respective drive circuit for setting said drive circuit into one of its conditions.

3. An apparatus as claimed in claim 2, wherein the minus input of one comparator for the first drive circuit is a reference input, while the plus input is connected on one hand to the minus input of the other comparator for the same drive circuit, the plus input of said other comparator being a reference input, and on the other hand to the output of an operation amplifier, the minus input of said operation amplifier being coupled to said air pressure transmitter while the plus input of said operation amplifier is coupled to said fuel oil pressure transmitter.

4. An apparatus as claimed in claim 2, wherein the minus input of said one comparator for the second drive circuit and plus input of said other comparator for the same drive circuit are coupled to said fuel oil pressure transmitter, and the plus input of said one comparator and the minus input of said other comparator are reference inputs and coupled on one hand to the minus input of the second comparator for the same drive circuit, whose plus input is a reference input and whose minus input is coupled to the output of said time integrating circuit, and on the other hand to said steam pressure transmitter via an input amplifier in the form of an operation amplifier whose output is connected to the input of said time integrating circuit and that of said adding circuit and whose plus input is coupled to said steam pressure transmitter.

5. An apparatus as claimed in claim 2, wherein the minus input of said one comparator for the third drive circuit and the plus input of said other comparator for the same drive circuit are reference inputs, and the plus input of said one comparator and the minus input of said other comparator are coupled to the output of said integrating circuit.

6. An apparatus as claimed in claim 4, wherein said time integrating circuit includes two operation amplifiers, the plus input of one operation amplifier being connected via a first resistor to the output of the input amplifier and via a second resistor to the output of the other operation amplifier, while the plus input of said said one comparator is coupled to the minus input of the adding circuit and via a condenser to the minus input of said other operation amplifier.

7. An apparatus as claimed in claim 6, wherein the integrating time of said time integrating circuit can be determined by means of the relation between said first resistor and said other resistor.
8. An apparatus as claimed in claim 1, wherein said frequency compensating circuit includes a comparator and an operation amplifier, the minus input of the comparator is coupled to a connection for the secondary winding of a transformer and the plus input of said comparator is coupled to the second connection of the secondary winding, and the output of said comparator is coupled to the minus input of the operation amplifier, the output of said operation amplifier being coupled to said steam pressure transmitter and the minus input of said operation amplifier being a reference input by which the required value of said steam pressure transmitter is adjustable.