April 12, 1955 W. D. HUGHES 2,706,136

AUTOMATICALLY CONTROLLED SYSTEM FOR ASH DISPOSAL

Filed June 21, 1950 5 Sheets-Sheet 1

Fig. 1.

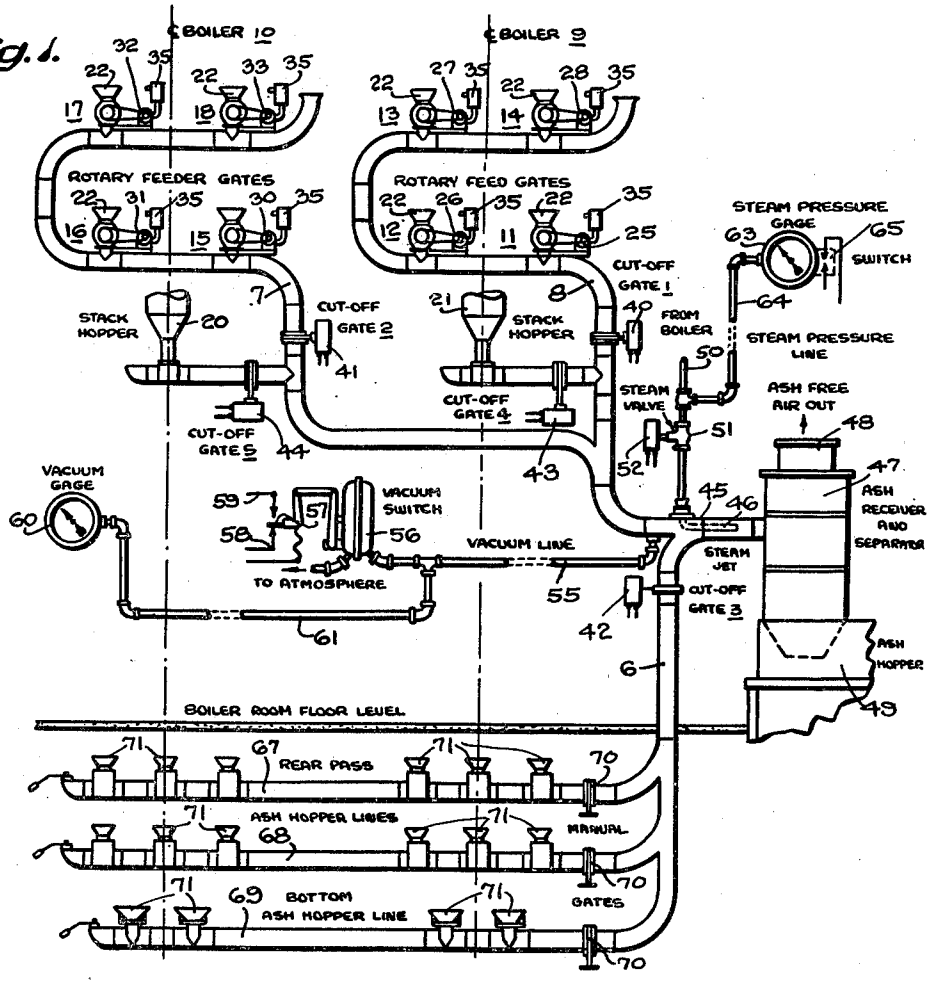
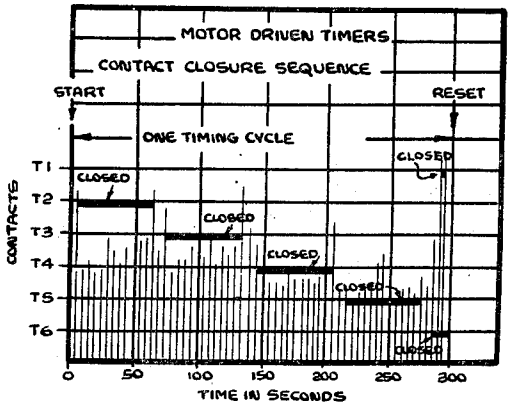


Fig. 4.



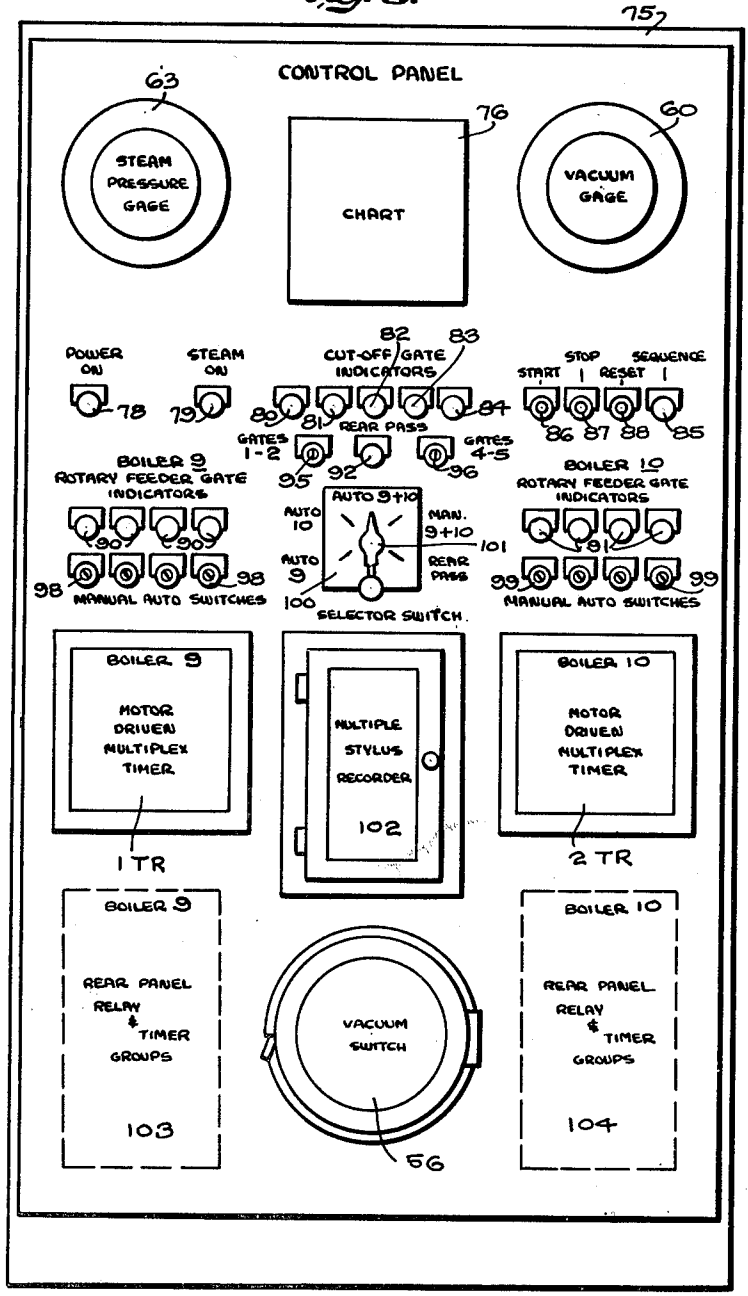
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AUTOMATICALLY CONTROLLED SYSTEM FOR ASH DISPOSAL

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Fig. 2.



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AUTOMATICALLY CONTROLLED SYSTEM FOR ASH DISPOSAL

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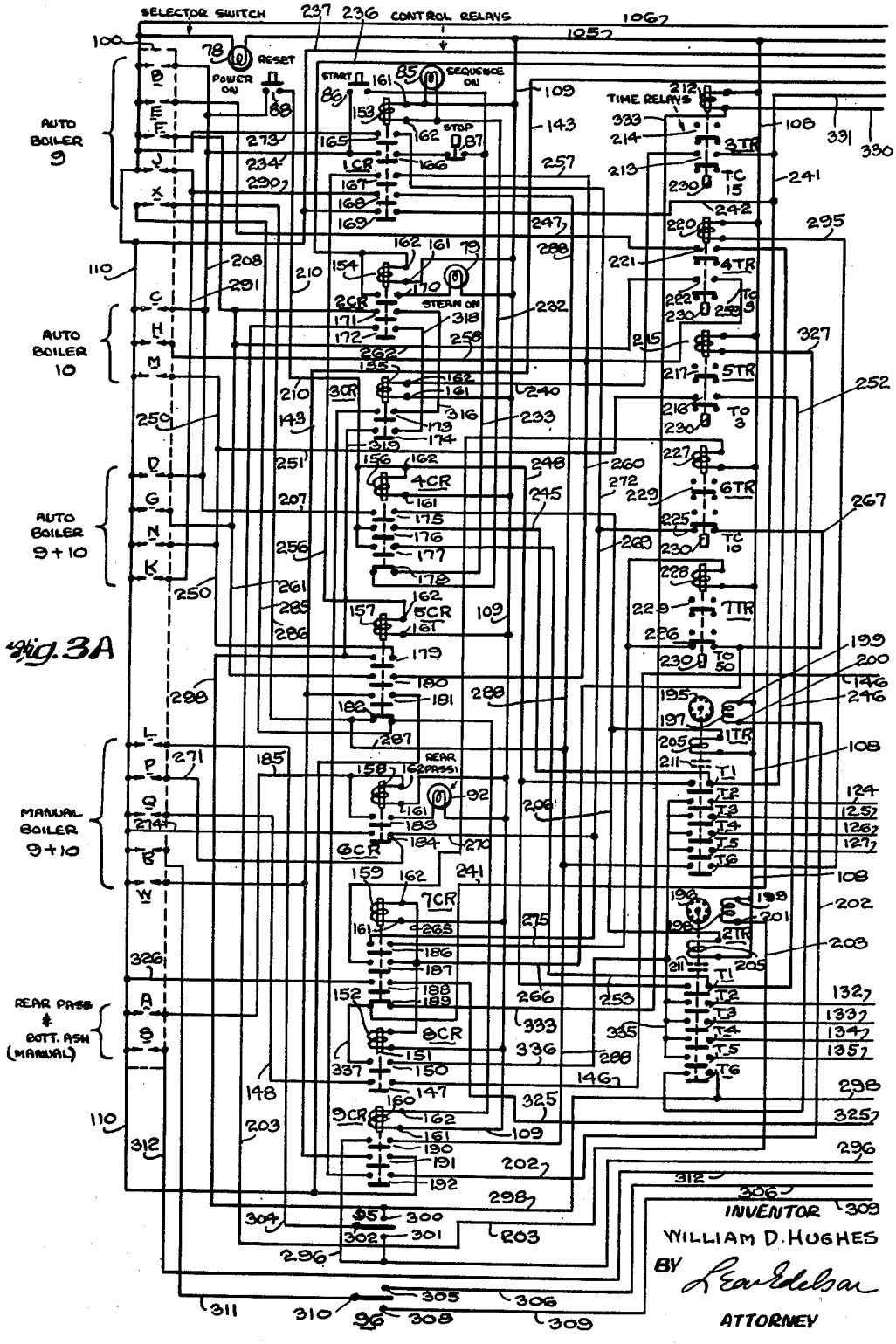


Fig. 3A

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AUTOMATICALLY CONTROLLED SYSTEM FOR ASH DISPOSAL

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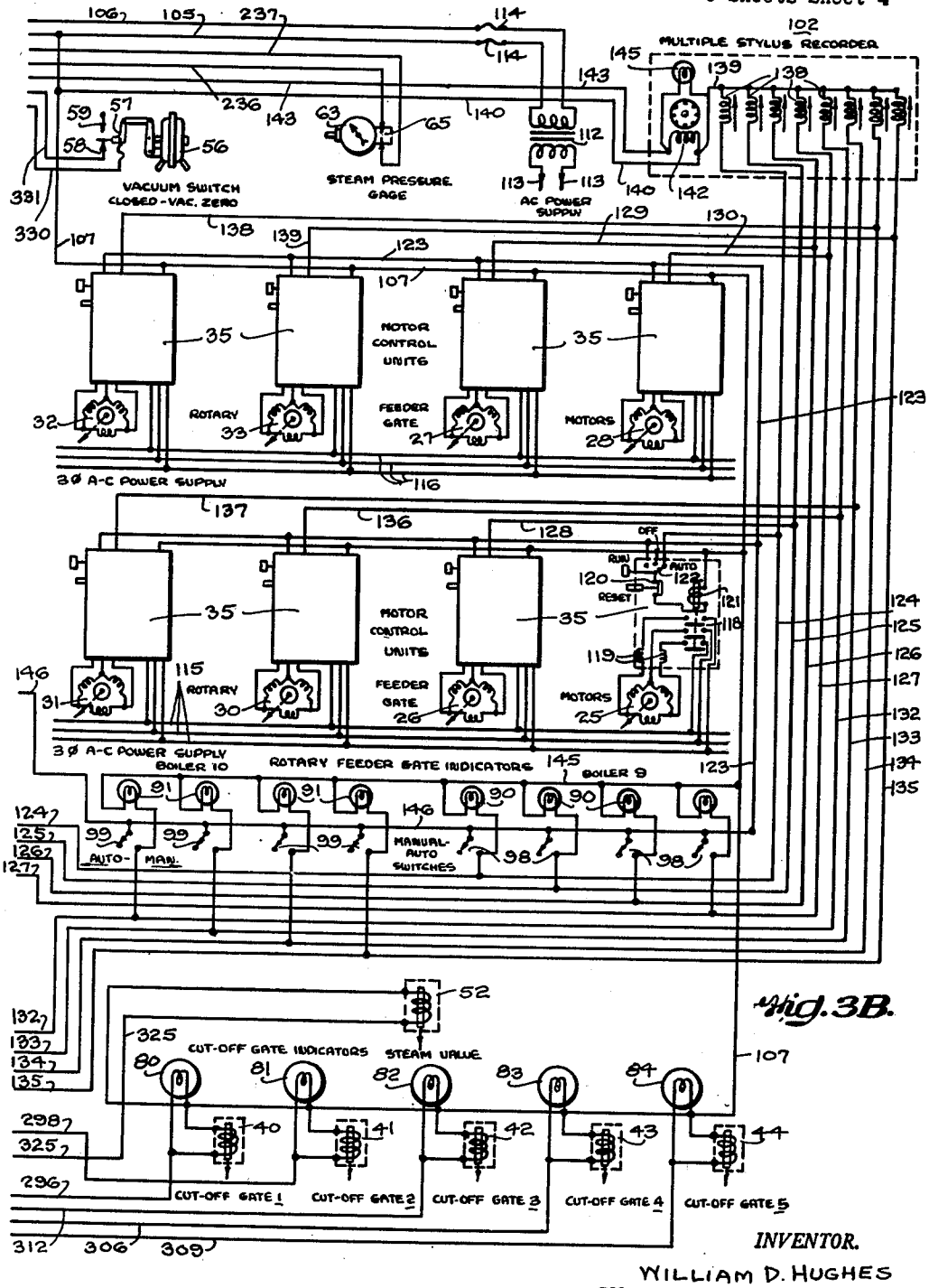


Fig. 3B.

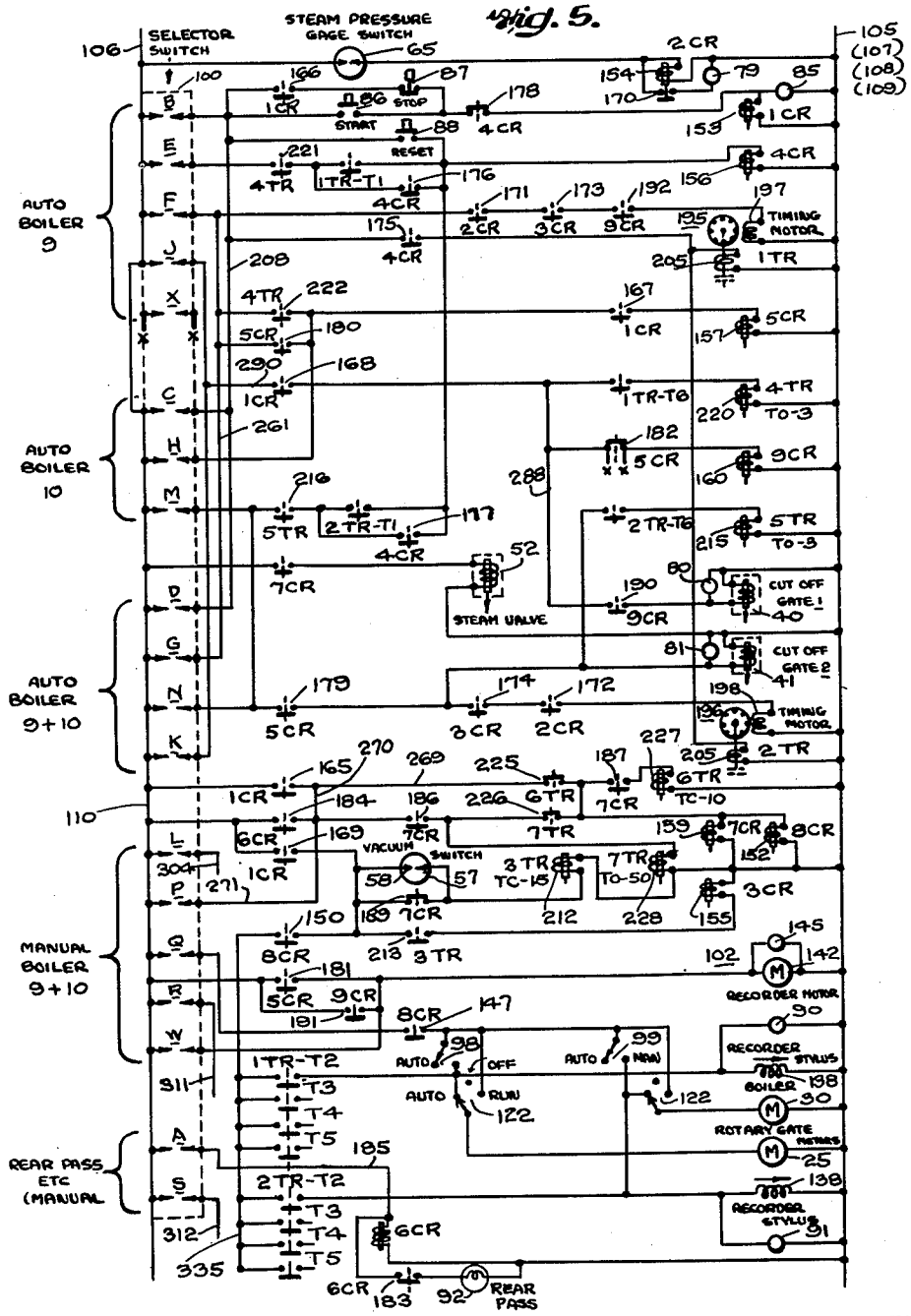
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Fig. 5.



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2,706,136

AUTOMATICALLY CONTROLLED SYSTEM FOR ASH DISPOSAL

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Application June 21, 1950, Serial No. 169,492

22 Claims. (Cl. 302—27)

The present invention relates to ash handling systems, and particularly to ash handling systems for power plants and other large boiler installations, where the problem of ash removal and disposal in large quantities, continuously from a plurality of ash producing units, is an important one.

In power plants of the coal burning type, and likewise in heating plants which utilize coal or other combustible material as fuel, the production of ash from the various units is substantially continuous and varies in quantity depending upon the load imposed upon the power or heating plant, as the case may be.

In such plants, it is customary to have a plurality of boiler or other ash producing units, which may be operated or shut down in varying numbers, as required to meet the varying load conditions. By utilizing a number of smaller units, rather than one large unit, greater flexibility may be obtained in carrying the load most economically. However, with an increasing number of boiler or other combustion and ash producing units, the problem of ash removal becomes greater in proportion. The greater the number of units, the greater the problem, both as to quantity of ash removed and attendance required to effect removal of the ash in such a manner as not to interfere with proper combustion.

With modern power plants, and to a certain extent with heating plants, automatic operation is desirable for the reason that varying load conditions may be met best by means responsive to variations in load conditions, and also for economy in operation and certainty of control beyond anything possible with direct control by operators. Likewise, it is desirable to provide ash handling equipment for removing the ash accumulation substantially continuously and in accordance with the production of the ash, which in turn, as hereinbefore indicated, depends upon the varying load conditions imposed upon the plant.

It is, therefore, a primary object of this invention to provide an improved ash handling system for power plants and the like, which is adapted for operation with one or a plurality of ash producing units such as boilers, and which is also adapted to be operated either automatically or manually, as desired, by electrical control means.

It is a further object of this invention to provide an improved ash handling system for a plurality of boiler or other ash producing combustion units, which may selectively operate to withdraw ashes automatically from each unit under electrical control, through the medium of timing relays and simplified circuit means interconnecting such relays, together with an improved ash handling apparatus adapted for remote control electrical operation.

A further and important object of the invention is to provide an ash handling system for boiler plants and the like which provides for the removal of ash progressively from each unit of the boiler plant through a simplified conduit system provided with vacuum jet control and rotary feeder means wholly electrical-relay controlled from a centralized location.

It is desirable, in large boiler plant installations, to provide for the control of all units from a centralized location, such as a panel conveniently located within the plant, not only to indicate the condition of operation of the system, but also to provide a record of any irregularity in the operation. A system embodying the present invention is particularly adapted for this arrangement, in that the electronic control circuits are arranged for centralized switching and indicating control. Furthermore, in accordance with the invention, a plurality of control and timing relays are so interconnected with the apparatus to be controlled that both sequential operation of the various ash handling elements for each boiler unit, and manual operation thereof, may be provided through a minimum of switches and other control elements adapted for panel board mounting.

It is, therefore, a still further object of this invention to provide an ash handling system which is adapted for sequential control of a plurality of ash producing units, such as coal burning boilers or the like, through the medium of a minimum number of electrical control and timing relays, wholly automatically or manually, as desired.

It is a further and important object of the invention to provide an improved ash handling system providing sequential control of a plurality of ash producing units, which operates to remove ashes and other solid combustion products wholly through conduit means under vacuum, with improved feeder means therefor at each unit wholly under control the vacuum through electrical relay-controlled gates and electric motor drive means.

A closed conduit system for ash removal with vacuum involves the problem of maintaining the vacuum in the system while feeding material therethrough, and the sequential control of a system involving a plurality of feeding units for each boiler. The system of the present invention involves improved and simplified means for effecting sequential control in dependence upon the vacuum in the ash removal conduit system.

In one form of the invention, the vacuum is created in the conduit system by a steam jet under electrical control, and the electrical system is furthermore controlled by a vacuum switch also connected with the vacuum system, together with rotary electric motor driven feeder gates which serve to maintain the conduit closed while at the same time feeding the ash directly into the conduit from each boiler or other ash producing unit. Between the vacuum switch and the rotary feeder gates is a simplified electrical control system embodying a minimum number of electrical control and timing relays, together with electrical circuits providing for both individual and joint control of all boiler units both automatically and manually, as well as indicating and recording elements as required for continuous operation of the plant.

It is, therefore, a further object of the invention to provide an improved sequential control system for multiple-unit ash handling and the like, which operates to control the ash removal not only from one unit in predetermined sequence from various points, but sequentially from unit to unit, wholly automatically, with a minimum of simplified and reliable operational and control elements, and which at the same time is adapted for manual operation as desired, selectively or in any sequence.

The invention will further be understood from the following description when considered in connection with the accompanying drawings, in which a present preferred ash handling system and sequential control therefor are shown for a multiple unit boiler plant of the type used for steam driven power plants and the like, and its scope is defined by the appended claims.

In the drawings:

Figure 1 is a schematic diagram showing an ash handling conduit system and feeder and control means connected therewith, in accordance with the invention;

Figure 2 is a front view of an electrical control panel or unit for operation of the ash handling system shown in Figure 1, also arranged in accordance with the invention;

Figures 3A and 3B, taken together, is a schematic circuit diagram of an ash handling system provided with sequential and manual control, also in accordance with the invention;

Figure 4 is a graph showing certain features of the

operation of the system shown in Figures 3A and 3B; and

Figure 5 is a simplified schematic circuit diagram of the electrical system shown in Figures 3A and 3B, further illustrating the invention.

Referring to Figure 1, a branched, closed conduit system is shown for ash removal from two boiler units of a power plant. Three main branches **6**, **7** and **8** are included in the present system. The branches **7** and **8** serve boilers **10** and **9**, respectively, indicated generally by the center lines shown in the figure with respect to the diagrammatic representation of the boiler room floor level. Each of the branches **7** and **8** is supplied with ash through rotary feeder gates. Conduit **8**, for boiler **9**, is provided with four rotary feeder gates **11**, **12**, **13** and **14**, while the branched conduit **7**, for boiler **10**, is provided with rotary feeder gates **15**, **16**, **17** and **18**. In accordance with the invention, the rotary feeder gates are operated in the same sequence as their numbered designations for clearing the boilers of ash from a plurality of points on each boiler.

It will be noted that the branched conduit **8** is provided with a cut-off gate **1**, whereas the conduit **7** is provided with a cut-off gate **2**, both arranged to be electrically operated. In addition, conduit **6** is provided with a similar cut-off gate **3**. Stack hoppers **20** and **21** are connected with the conduit branches **7** and **8**, respectively, through cut-off gates **5** and **4**, which are similar to the other cut-off gates and are arranged to be electrically operated remotely.

The rotary feeder gates are each provided with a hopper **22**, through which the ashes pass from the boiler into the ash handling conduit and are driven by electric motors, rotary gates **11—14** being driven by motors **25—28**, while rotary gates **15—18** are driven by motors **30—33**, all through suitable belt drives as indicated. While any suitable rotary gate feeder may be used, it may be considered that each rotary gate is of the rotary-vane type for carrying the ash from the hoppers into the conduit when operated by the motor means. Each motor is provided with a control unit connected therewith, as indicated at **35**, and arranged to be connected electrically with the remainder of the system, as will be hereinafter described.

The cut-off gates **1—5** are likewise arranged to be electrically operated through solenoid control elements **40—44**, also arranged to be connected electrically with the remainder of the system.

It will be noted that the ash conveying conduit branches **6**, **7** and **8** are joined with a common conduit **45**, in which is located a steam jet **46** directed to produce a vacuum on the system when supplied with steam. This conduit is connected with a relatively large ash receiver and separator unit **47**, into which it discharges the ashes and other products of combustion drawn from the three branches **6**, **7** and **8**. Such ash receiving separators are old and well known, and further description is believed to be unnecessary, except to point out that the ash-free air is discharged through the open top outlet conduit **48**, while the ashes are removed from a suitable ash hopper indicated at **49** at the bottom of the separator unit. The handling of the ashes beyond this point does not concern the invention, although it may be pointed out that the usual conveyor belt system may be used.

The steam jet **46** is supplied with operating steam from a supply pipe **50**, with which it is connected to the boiler or other supply source (not shown), and the supply of steam to the jet is controlled by a steam valve **51** having an electrical solenoid control unit **52** connected therewith and adapted for remote electrical control, as will hereinafter be described.

Also connected with the conduit section **45**, common to all of the three branches **6**, **7** and **8**, is a vacuum line **55** connected with a vacuum switch **56** which is responsive to the vacuum conditions in the conduit for operating a switch comprising a movable contact **57** and fixed contacts **58** and **59**, which may be connected to the system for control purposes, as will be hereinafter described. As indicated in the drawing, the vacuum switch contacts **57** and **58** are closed when the vacuum in the vacuum line **55** and in the conduit system is substantially zero or at a minimum. This condition obtains when the ash from the rotary feeder gates falls to substantially zero and the vacuum system draws air only through the conduit branches.

A vacuum gauge **60** may also be connected with the vacuum line through suitable piping **61**, for reading the vacuum condition in the ash conveying conduit system. Likewise, a steam pressure gauge **63** is connected through a steam pressure line **64** with the steam pressure supply pipe **50** on the supply side of the valve **51**, as indicated, to operate when the steam is on, in operation. When the pressure is of sufficient value for proper operation, the steam gauge is arranged to operate a control switch **65** which is connected into the system for control purposes as will hereinafter appear.

The conduit branch **6**, controlled by cut-off gate **3**, serves to convey ashes from the rear pass portion of both boilers, and is provided with suitable branches **67**, **68** and **69**, controlled by manual gates **70** through which the various branches may be selected in clearing the rear pass lines of ashes, as well as the bottom hopper of the boiler system.

The branch **6** and its connecting lines represent any additional ash removal conduit connections which may be provided for the system to be manually controlled at any time as desired, although, as will hereinafter appear, such branch conduit may be controlled automatically, if desired, as may the other branches. Accordingly, further description is believed to be unnecessary, except to point out that the branch lines **67—69** are provided with suitable ash hoppers **71** through which ashes are collected for application to the branch lines, and thence through branch **6** to the ash receiver and separator **47** during certain portions of the operation of the plant. Normally, however, the cut-off gate **3** is closed, cutting off all three branches, except when required to clear the rear pass and bottom hopper lines.

Referring now to Figure 2, in which like parts are designated by the same reference characters as in Figure 1, a control unit for the system may be provided, and arranged with a control panel **75** on the front thereof, which is adapted to contain the control and indicating elements of the system, whereby electrical remote control is provided. The control unit, furthermore, serves to house all of the electrical relays and other apparatus conveniently and effectively, while the front of the panel contains a grouping of instruments and controls adapted to facilitate operation of the system by an attendant.

In the present example, the control unit panel is provided with the steam pressure gauge **63** and the vacuum gauge **60** in the upper portion of the panel on opposite sides of an operating chart indicated at **76**. A series of indicating lamps, and push button control elements form the next lowermost line of equipment on the panel, elements **78** and **79** being indicator lamps for indicating that the power and steam are on when illuminated. Operation of the cut-off gates **1—5** is indicated through indicator lamps **80–84**, inclusive, and the fact that the sequence of operations for sequential control is on, is indicated by a lamp **85**.

Start, stop and reset control switches for the system, of the push-button type, are indicated respectively on the panel board in the same row with the indicator lamp **85**, at **86**, **87** and **88**, respectively.

Operation of the rotary feeder gates for each boiler is indicated by indicator lamps **90** and **91**, indicator lamps **90** being for boiler **9** and indicator lamps **91** being for boiler **10**, as shown.

Operations of the rear pass conduit by opening of gate **3** under certain conditions of operation, as hereinafter described, is indicated by an indicator lamp **92**. On either side of the indicator lamp **92** are selector switches **95** and **96**, arranged for selective manual operation of gates **1** or **2**, or **4** or **5**, as indicated.

Likewise, manual operation switches for the rotary feeder gates of boiler **9** are indicated at **98**, while similar switches for the manual operation of the rotary gates of boiler **10** are indicated at **99**, one for each gate.

The system is adjusted for manual or automatic operation in connection with one or both boilers by means of a rotary selector switch **100**, which is provided with a control lever **101** by which the various contacts (not shown) are adjusted for various conditions of operation. In the present example, six different conditions of operation are provided for, these being off, automatic operation of boiler **9**, automatic operation of boiler **10**, automatic operation of boilers **9** and **10**, sequentially manual operation of boilers **9** and **10**, and operation of the rear pass and bottom ash portions of the system, also manually.

The control panel contains, in addition to the control

and indicating elements hereinbefore referred to, two motor driven multiplex or multiple circuit timers 1TR and 2TR. These control the major operations of the ash handling system in connection with boilers 9 and 10, respectively, when under automatic operation.

The condition of the ash discharge system at each boiler outlet is recorded automatically during the operation by a multiple stylus recorder 102, also located on the panel. In the present example, this is provided with a plurality of recording styli corresponding in number to the number of automatically operated rotary feeder gates, being eight in number. It will be appreciated, however, that in the present example, the operation of two boiler units with four rotary gates each is only by way of example, as a greater or lesser number of rotary gates and a single boiler may be controlled in accordance with the invention, for the sequential and automatic handling of the ash disposal.

The vacuum switch 56 is mounted on the lower portion of the panel, between two relay panels 103 and 104 which are located on the rear of the panel and contain the various control and timer relays which are incorporated in the system, the group 103 being directed more to the control of the boiler 9, both automatically and manually, while the group 104 contains relays for the control of the boiler 10. These relays and their contacts in operation will further be understood from a consideration of Figures 3A and 3B, taken together along with the preceding figures.

Referring now to Figures 3A and 3B, jointly, as a single schematic circuit diagram of a system embodying the invention, in which the same reference characters are used for like parts as in the preceding and subsequent figures, the entire control system is energized and operates in response to current supplied through two supply leads 105 and 106. Lead 105 has three main branch leads 107, 108 and 109 for energizing the various pieces of apparatus and control circuits in the system, whereas the supply lead 106 is connected mainly to the various pairs of switch contacts of the selector switch 100, through a branch conductor 110 connected with one of each pair of switch contacts as indicated, in addition to certain of the control circuits and elements directly, as will hereinafter be described.

The pairs of selector switch contacts are designated by the letters A, B, C, D, E, F, G, H, J, K, L, M, N, P, Q, R, S, W and X. For convenience in considering the operation of the system, the pairs of contacts which are closed in response to each adjustment of the selector switch are grouped within the dotted outline of the switch 100, as shown, the group B, E, F, J and X being closed when the selector switch is set for automatic operation of boiler 9; the group C, H, and M being closed for automatic operation of boiler 10; the group D, G, N, K being closed for automatic operation of boilers 9 and 10; the group L, P, Q, R, W being closed for manual operation of boilers 9 and 10; and the group A, S being closed for manual operation of the rear pass and bottom ash portion of the system.

It will thus be seen that, as the selector switches are adjusted to any one of the five operating positions indicated in Figures 2 and 3A, certain selected ones of the control circuits are energized from the power supply leads 106—110, and the operation of the system is such that the circuit is then completed through various control elements and circuits to the opposite power supply lead 105, through one of the branch leads 107, 108 or 109.

The operating current provided by the power supply leads 105—106 may be derived from any suitable alternating current source in the system shown. In the present example, the supply leads are connected through a step-down transformer 112 to higher voltage alternating current power supply mains 113, which may be assumed to supply current at 440 volts alternating current. Suitable fuses 114 are provided in each supply lead connection with the transformer on the low voltage side. It will also be noted that the indicator lamp 78 is connected directly across the leads 105—106 to indicate when the power is on.

While the rotary feeder gate motors may, in some installations, be operated also directly from the power supply leads 105—106, in the present example, for a large power plant installation, the rotary feeder gate motors require a considerable amount of power and, accordingly, are shown as being of the three-phase type supplied from three-phase alternating current power supply circuits 115 and 116. The motors are connected with the three-phase power supply circuits through the motor controller units 35, as shown more particularly in Figure 3B, and a preferred form of the controller unit is shown by the interior circuit arrangement of one unit for the motor 25. Each of the other motor controllers is the same and connected in the same manner.

As will be seen, alternating current power is taken from the three-phase supply circuit, through the contacts 118 of a three-phase switch, to the motor, the motor connection including overload relay coils 119, which operate on overload to release a reset switch 120. The reset switch is in circuit with the operating coil 121 for the controller which, when energized, closes the contacts 118. One terminal of the coil 121 is connected to supply branch 107 and the opposite side is connected through the reset switch 120 and a selector switch 122 with a control circuit lead 123 or a control circuit lead 124. The switch has three positions as indicated, and is shown in the position in which it provides connection with the control circuit lead 124 for automatic operation of the system, whereas when it is moved to provide a connection with the control circuit lead 123, it is arranged to cause the motor to operate under manual control. A third, or intermediate, position is provided for turning off the motor.

In a similar manner, the motor controller units for the motors 26, 27 and 28 are each connected with the control circuit lead 123 in parallel relation to each other, and individually to the remaining control circuit leads 125, 126 and 127 of the group of four control leads, of which lead 124 is the first, the connections with the latter leads being respectively through leads 128, 129 and 130 for the motors concerned with the operation of the boiler 9.

For the motors 30, 31, 32 and 33 for the rotary feeder gates of boiler 10, the motor controller units are connected in parallel to the control circuit lead 123, and individually to a second group of four control leads 132, 133, 134 and 135, the latter connections being made, as shown, through their respective circuit connections leads 136, 137, 138 and 139.

With this arrangement, the various motor controllers may be set to the off position, whereby the operating windings of the control switches may be disconnected from circuit to maintain the motor in a shut-down condition when repairing or otherwise working on the individual rotary gates, and may selectively be connected for automatic or manual operation, the manual operation connection being that provided through the common control circuit lead 123. For automatic operation the individual control units are connected with the individual control circuit leads 124—127 for boiler 9, and 132—135 for boiler 10. Thus, when so connected, energizing each of the individual leads provides a circuit through the motor controller switch operating coil back to lead 107 and the power supply lead 105. Energy is supplied from the lead 106 to the leads 124—127 and leads 132—135 sequentially and in timed relation through the operation of the contacts T2—T5 of the motor driven timing relay 1TR and the contacts T2—T5 of the motor driven timing relay 2TR, to which the leads referred to are shown as directly connected. It will thus be seen that automatic operation of the rotary gates is controlled by the timing relays 1TR and 2TR. Tracing of the circuits from the contacts referred to will hereinafter be given.

It will be noted that, in addition to the operating coils of the motor controllers, there is connected with each of the selective control circuit leads 124–127 and 132–135 a stylus operating coil of the multiple stylus recorder 102, so that the multiple stylus recorder may operate in response to operation of each rotary feeder gate. In the present example, the stylus operating coils 138 are individually connected each with one of the leads referred to, and in common with a lead 139, which in turn is connected through a lead 140 with the branch supply lead 107 in common with the operating coils of the motor controllers 35, whereby when the individual motor controllers are energized selectively to operate each of the rotary feeder gates in turn, the corresponding individual stylus of the multiple stylus recorder is operated simultaneously.

It will be noted that the multiple stylus recorder is of the motor driven type, having a motor operating winding 142, which is likewise connected with the supply lead 140, above referred to, and is provided with a control

lead **143** which is connected to the various contacts of relays hereinbefore referred to, and to one of the pair of contacts W of the switch **100**. Thus, when the switch is closed for manual operation, the timing motor stylus is energized, and is likewise energized under certain other operating conditions, as will hereinafter appear. The recorder is provided with a pilot light **145**, which is connected directly across or in parallel with the motor winding **142** and is, therefore, energized when the motor operates, that is, when the recorder is in operation, and serves to indicate to an attendant that the recorder is operating at the proper times.

It will also be noted that the rotary feeder gate indicator lamps **90** and **91** are connected in parallel with supply branch **107** through a supply lead **145**, and individually to the rotary feeder gate motor and recorder control leads **124–127** and **132–135**, so that there is in parallel with each motor and recorder stylus, one of the rotary feeder gate indicator pilot lamps. These lamps, therefore, indicate to an attendant at the control panel the individual rotary feeder gate motor which is operating when each lamp is energized. The manual-automatic switches **98** and **99**, associated with each rotary feeder gate indicator on the control panel, and illustrated in the circuit diagram of Figure 3B, are of the two-point type, shown in the open position, and operative when closed to provide a circuit connection from the control circuit lead **123** to the control circuit lead to which the associated lamp indicator is connected.

In this manner, for manual operation the individual switches **98** and **99** may be closed to energize any one of the leads **124–127** and **132–135** from the control lead **123**, so that the individual feeder gate motor and recording stylus corresponding thereto may be operated without automatic control. This connection for manual operation, may be seen by tracing the supply lead **123** through a common connection lead **146** and the contacts **147** of a control relay 8CR, thence through a connection lead **148** to the contacts Q of the selector switch **100**.

It will thus be seen that when the selector switch is set for manual control of the boilers **9** and **10**, and the contacts Q are used, operating current will be supplied from the supply lead **106** through the lead **148**, the contacts **147**, the lead **146** to each of the motor controllers **35**, and to the switches **98** and **99**, and if any of these switches is closed, operating current will then flow from the lead **146** through the respective recorder stylus operating coil to the lead **139**, the lead **140** and the lead **107**, back to the supply lead **105**. Likewise, if any one of the motor controllers **35** is set for manual or Run operation, the corresponding operating coil will be energized in a similar manner, from the lead **123**, and the return circuit will be provided directly with the lead **107** as hereinbefore described. This phase of the operation will hereinafter be considered more fully.

In addition to the control relay 8CR, there are eight other similar control relays, 1CR–7CR and 9CR. All of these relays have a plurality of contacts which are operated simultaneously when the relay is energized, and while they may be of any suitable type, for clearer illustration and understanding of the invention they are shown herein as being of the solenoid coil operating type, and the contacts are arranged in pairs to be closed by the movement of the individually insulated shorting bars between pairs of contacts. The connection with the solenoid operating core is indicated in dotted lines. Thus. in the case of the first relay 8CR, above referred to, an additional pair of contacts **150** are provided for simultaneous closure by operation of a solenoid core **151** when the relay operating coil **152** is energized.

The remainder of the control relays are similarly arranged for operation, being provided with operating coils **153–160** for relays 1CR–7CR and 9CR, respectively. It will be noted that one terminal **161** of each control relay coil is connected with the operating current supply branch lead **109**, so that all of the relay coils are connected in parallel with one supply lead **105**. The opposite terminals **162** are connected through the various control circuits and switch connections to the branch **110**, and thence to the opposite operating current supply lead **106**, as will hereinafter appear.

The control relay 1CR is provided with five pairs of contacts **165–169**, inclusive, all of which are normally open, but are simultaneously closed when the relay is energized. The relay 2CR has only three pairs of contacts **170–172**, inclusive, which likewise are normally open but are simultaneously closed when the relay is energized. This same arrangement is also true of control relay 3CR, except that this relay has only two pairs of contacts **173** and **174**.

The control relay 4CR is provided with three normally open pairs of contacts **175**, **176** and **177**, and one pair of normally closed contacts **178**. When energized, the relay contacts **175–177** are closed, while the contacts **178** are opened. This same arrangement is provided for relay 5CR, which has three normally open pairs of contacts **179**, **180** and **181**, and one pair of normally closed contacts **182**. The control relay 6CR is provided with two normally open pairs of contacts **183** and **184**. It may be noted in passing that this control relay is concerned only with the rear pass and bottom ash disposal under manual operation, and is in no way concerned with the automatic operation of the system, as will be seen from the fact that the operating connection for the terminal **162** of the relay coil **158** is connected through a lead **185** only with the pair of contacts A of the selector switch **100**, and, therefore, the relay winding **158** and the rear pass indicator lamp **92** (which is connected in parallel with the relay winding **158** through the contacts **183**) are energized only when the contacts A are closed for rear pass and bottom ash manual operation.

The control relay 7CR, like the control relays 4CR and 5CR, is provided with three normally open pairs of contacts **186**, **187** and **188**, and also one pair of normally closed contacts **189**. When the relay is energized, the contacts **186—188** are closed and the contacts **189** are opened. The control relay 8CR is provided with only two pairs of contacts **147** and **150**, both of which are normally open, as hereinbefore described, while the control relay 9CR is provided with three normally open pairs of contacts **190**, **191** and **192**, all of which are closed when the relay is energized.

It will be noted that the control relays 1CR–9CR are arranged in a group, one above the other, in the circuit diagram of Figure 3A, for a more ready understanding of the operation of the system, in that all of the relays of this group are instantaneous opening and instantaneous closing relays, having no time control feature, and function substantially wholly as relays or electrically operable multiple contact switches of the two-point or two position type. Accordingly, any suitable relays for the purpose may be provided in lieu of those shown.

In a similar manner, the timing relays for the system, which are seven in number, have been arranged as a group, one above the other, and include the two motor operated timing relays 1TR and 2TR, hereinbefore referred to, these being on the panel front and being effectively motor driven timers.

Referring to Figure 4, along with Figures 3A and 3B, the timing or contact closure sequence of the timing relays or motor driven timers 1TR and 2TR is shown for a further understanding of their operation. In the particular system in which the relays are provided, the contacts T1 of both relays close for five seconds only, during a timing cycle of 300 seconds. After a pause of ten seconds, the contacts T2, T3, T4 and T5 of both timing relays 1TR and 2TR close consecutively for 60 seconds, with a ten-second interval between, and this is followed by a ten-second interval, after which the contacts T6 close and remain closed for fifteen seconds. During this time the contacts T1 are closed for the interval of five seconds, as hereinbefore mentioned.

The motor driven timers 1TR and 2TR are provided with operating motors **195** and **196**, respectively, having motor operating windings **197** and **198**. One terminal **199** of each motor operating winding is connected with the branch supply circuit lead **108**, which in turn is connected with the supply lead **105**. The opposite terminals **200** and **201**, respectively, of the timing motors **195** and **196** are connected with respective control leads **202** and **203**, the former being connected with one of the pair of contacts **192** of the control relay 9CR, while the latter is connected with one of the pair of contacts **172** of the control relay 2CR. In addition, each motor driven timer is provided with a reset coil **205**. These are each connected with the common supply lead **108**, and in parallel with a control lead **206** through which they are simultaneously energized in connection with the contacts **175** of the control relay 4CR. The tracing of this circuit may be completed through a lead **207** and thence through a

bus connection 208 with the contacts B, C and D of the selector switch 100.

Thus it will be seen that the reset coils 205 of the motor driven timers 1TR and 2TR are simultaneously energized whenever the selector switch is set for automatic operation for boiler 9, boiler 10, or both boilers, and the control relay 4CR is energized to close the contacts 175. It will likewise be seen that the operating winding 156 of the relay 4CR is connected through a control lead 210 with the reset control switch 88, and thence to the supply bus 208 which, as hereinbefore pointed out, is energized from the lead 110 whenever the selector switch is adjusted for automatic operation in any one of the three positions. Therefore, when the reset button or switch is operated, the control relay 4CR is energized, and under such conditions the reset coils 205 of the timing relays 1TR and 2TR are energized to reset the timers to zero, for starting the timing sequence shown in Figure 4. The fact that the relay contacts may be reset is schematically illustrated in the diagram by the dotted clutch connections 211 interposed between the reset coils 205 and the contacts of the relays 1TR and 2TR.

The remainder of the timing relays are arranged for timed closing or timed opening with operation otherwise instantaneous. For example, the timing relay 3TR is instantaneous opening and time closing, requiring a fifteen-second interval to close. The relays 4TR and 5TR are instantaneous closing and time opening, requiring a three-second interval to open. The timing relay 6TR is instantaneous opening and time closing, requiring a ten-second interval to close, and the timing relay 7TR is instantaneous closing and time opening, requiring a 50-second interval to open.

While any suitable multiple contact timing release may be provided for use in the system with the timing arrangement above indicated, for purpose of illustration, the same solenoid coil operating type has been shown in the drawing as for the control relays, comprising a solenoid operating coil and pairs of contacts arranged to be opened or closed by shorting bars operated in unison and insulated one from the other. In the present example, the relay 3TR is provided with an operating coil or winding 212, and operates to close a pair of contacts 213 when energized. The relay is provided with additional contacts 214, which are not used. This is likewise true of the timing relay 5TR, the operating winding 215 of which, when energized, serves to close a pair of contacts 216, other pairs of contacts 217 not being used.

The relay 4TR is provided with an operating winding 220, which operates when energized to close two pairs of contacts 221 and 222 simultaneously. The timing relays 6TR and 7TR are each provided with a pair of normally closed contacts 225 and 226, which are opened when the relay coils or windings 227 and 228 are energized. Since these relays are of a commercial type, additional unused contacts 229 are provided therein as indicated.

It will be noted that each of the relays is shown with a rectangular element 230, connected at the opposite end of the contact operating system from the solenoid operating coil, and this may be taken to represent a dash pot or other timing means by which the desired timing operation is attained. As such relays are commercially available and well known, no further description is believed to be necessary.

The main operating relay of the system is control relay 1CR, the operating winding 153 of which is connected in parallel with the sequence On, indicating lamp 85, and is further connected through a control lead 232 with the contacts 178 of control relay 4CR, thence through a control lead 233 with the stop switch 87 and start switch 86. The stop switch 87 is connected through relay contacts 166 of the control relay 1CR in parallel with the start switch 86, with a lead 234, and thence to the bus connection 208 for the selector switch contacts for automatic operation in any one of the three positions hereinbefore referred to. Therefore, upon setting the selector switch to any one of the automatic operation positions, operation of the start switch 86 energizes the operating winding 153 of the relay 1CR, which then remains energized through the contacts 166 and the stop switch 87. All of the contacts remain closed until the stop button or switch 87 is operated to open the circuit.

The operating coil 154 of the relay 2CR and the Steam On indicating lamp 79, in parallel therewith through the contacts 170, is energized through a control lead 236, thence through the switch contact 65 of the steam pressure gauge 63, returning through a return lead 237 to the main supply bus 110 as shown. Therefore, as soon as the steam is applied for the steam jet for producing a vacuum on the conduit system, with a pressure sufficient to close the switch 65, the relay 2CR is energized, together with the indicating lamp 79, and the contacts of the relay 2CR remain closed as long as the steam is on. Since the system cannot operate without the application of steam to the jet, this operates as a safety or control relay for preventing operation of the system in the absence of steam pressure on the jet.

The operating winding of the relay 3CR is energized through a control lead 240, which is connected through the normally open contacts 213 of the timing relay 3TR, thence through a bus connection 241 and a lead 242 with the contacts 169 of the control relay 1CR, and is, therefore, energized upon closure of the contacts 213 of the timing relay 3TR when control relay 1CR is energized.

The circuit connections for the control relay operating windings, as above described for the control relays 1CR, 2CR and 3CR, may further be seen and more readily understood by reference to the simplified schematic circuit diagram of the system shown in Figure 5, to which, along with Figures 3A and 3B, attention is now directed, and in which, as hereinbefore pointed out, like reference characters throughout refer to like parts, circuits and circuit elements. It is obvious that, in the simplified circuit diagram of Figure 5, only the fundamental circuit connections are shown, and one each of the rotary gate motors for boilers 9 and 10, and one each of the recording styli for the recorder in connection with each boiler are shown, as illustrating the connections for the other rotary gate motors and recording styli which are shown completely in the circuit diagram of Figures 3A and 3B. However, the selector switch 100 is shown in the same position and with the contacts arranged in the same sequence in Figure 5 as in Figure 3A, for ready reference to the five selective positions of operation for the switch.

From a consideration of Figures 3A, 3B and 5, it will be seen that the operating winding 156 for the control relay 4CR is not only energized through the lead 210 and the reset button or switch 88 from the bus connection 208 and any one of the selector switch contacts B, C or D, but is also energized through other circuit connections provided by various relays, as more clearly shown in Figure 5 in connection with selector switch contacts E, M and N.

The contacts 176 and 177 of the control relay 4CR are hold-in contacts which serve to hold the operating winding 156 energized whenever the relay is first initially energized, for example, by closing of the reset switch 88. For boiler 9, it will be seen that when the relay contacts 176 are closed, the operating winding 156 of relay 4CR receives energy for operation through the contacts 221 of the timing relay 4TR and the selector switch contacts E. This circuit may be traced in Figure 3A from the contacts 176 through a connection lead 245 to one of the terminals T1 of timing relay 1TR, and thence through a lead 246 to the contacts 221 of timing relay 4TR. From the contacts 221 the circuit is completed through a lead 247 connected to the contacts of the selector switch, and thence to the power supply bus 110. The relay, therefore, remains energized after the initial energization through the circuit connection provided by way of holding or hold-in contacts 176 and the contacts 221 of the timing relay 4TR. It will be noted that the contacts T1 of the timing relay 1TR are connected in parallel with the hold-in contacts 176 of the control relay 4CR, whereby the relay 4CR may momentarily be operated to close when the timing relay 1TR reaches a position for closing the contacts T1.

Referring to the diagram of Figure 4, it will be seen that these contacts T1 are closed in the system of the present example, substantially momentarily for a period of five seconds, and at a time when the contacts T6 are likewise closed, the latter contacts being closed for five seconds preceding and following the closing of the contacts T1. The remaining contact of the contacts T1 of timing relay 1TR is connected through a lead 248 to the lead 210 and the terminal 162 of the operating winding 156 of the control relay 4CR.

A similar circuit connection for energizing the operating winding 156 of the control relay 4CR is provided

when the selector switch 100 is set to close in the automatic operating position for boiler 10 and in the position for automatic operation of boilers 9 and 10. In either of the latter positions, the contacts M or N are closed and this serves to complete an operating circuit connection with the contacts 216 of the timing relay 5TR. This connection, in Figure 3A, may be traced through a bus connection 250 and a lead 251. From the contacts 216 of the timing relay 5TR the circuit further may be traced through a lead 252 to the contacts T1 of the timing relay 2TR and through a lead 253 continuing therefrom to the contacts 177 of the control relay 4CR. From this point the connection ties in with the contacts 176, the operating winding 156 and the reset button or switch 88 and the circuitry hereinbefore described. It will be noted that the contacts T1 of the timing relay 2TR are effectively connected in parallel with the contacts 177 by reason of the connection lead 253 and an extension of the lead 248 to provide a connection 254 with the remaining contact of the contacts T1 of the timing relay 2TR.

Therefore, it will be seen that, for operation of boiler 9, the control relay 4CR is energized through the timing relay 4TR contacts 221, whereas for boiler 10 the relay is energized through the timing relay 5TR contacts 216 and that, in addition to the hold-in contacts 176 and 177, the relay may likewise be energized through the contacts T1 of timing relay 1TR, for the operation of boiler 9, and through the contacts T1 of timing relay 2TR for operation of boiler 10 or boilers 9 and 10.

The control relay 5CR is likewise an important control element of the system and is energized only when the control relay 1CR is energized through three circuit connections provided by the relays 4TR, 5CR and the selector switch contacts F, H and G. The connection with the contacts H of the selector switch is direct from the control relay contacts 167 of the control relay 1CR, the circuit being traced from the terminal 162 of the relay operating coil 167 through a lead 256 to the contacts 167 and thence through a connection lead 257 with a lead 258, which is connected with the contacts H of the selector switch 100.

Branch connection leads 259 and 260 from the lead 258 provide connections, respectively, with the contacts 222 of the timing relay 4TR and the contacts 180 of the control relay 5CR. The remaining terminals of the contacts 222 and 180 are connected in parallel through a lead 261 and a lead 262.

The control relay 6CR is concerned only with the operation of the rear pass and bottom ash removal under manual operating conditions, which has hereinbefore been described in connection with the circuitry of Figure 3A. Accordingly, the circuit for the control relay 6CR, with the selector switch contacts A, does not appear in the simplified circuit diagram of Figure 5, although the control contacts 184 appear therein, as will be understood hereinafter in connection with the description of operation.

The relays 7CR and 8CR are arranged to be operated simultaneously, and for that purpose the operating windings 152 and 159 are connected in parallel through a connection lead 265 with a control lead 266—267, which in turn is connected with the contacts 226 of timing relay 7TR and the contacts 225 of the timing relay 6TR, as well as the contacts 187 of the control relay 7CR itself.

From the contacts 225 and 226, parallel circuit connections may be traced to the contacts 165 and 184 of control relays 1CR and 6CR, respectively, in parallel, and to the contacts P of the selector switch 100. In the circuit of Figure 5, this is easily traceable and it will be noted that, in the connection from the contacts 226 of the timing relay 7TR, the contacts 186 of the control relay 7CR are interposed in series. In the circuit of Figure 3A, these connections may be traced from the contacts 225 of the timing relay 6TR through a lead 269 to the contacts 186, with a branch lead connection 270 with the contacts 184 and a continuing branch connection 271 with the contacts P of the selector switch. The connection further may be traced through a lead 272 from the lead 269 and the contacts 225 to the contacts 165 of the control relay 1CR. From the contacts 165 and 184, connections are made through leads 273 and 274, respectively, with the main supply lead 110 of the system.

The lead 266—267 is likewise tied in with the contacts 226 of the timing relays 7TR. From the contacts 226, a circuit connection through a lead 275 and the contacts 186 is provided with the circuit lead 269, with which the contacts 165 of the control relay 1CR and the contacts 184 of the control relay 6CR are connected. With this arrangement, it will be seen that the control relays 7CR and 8CR are energized when either of the timing relays 6TR or 7TR is energized simultaneously with the energization of either of the control relays 1CR or 6CR or when the selector switch is set for manual operation and the contacts P are closed. The control through the timing relay 7TR is further made subject to the operation of the control relay 7CR and closure of the contacts 186.

This control network for the relays 7CR and 8CR further controls the timing relay 6TR through the contacts 187 of the control relay 7CR, as will be seen from an inspection of the circuitry of Figure 5. In other words, the operating winding 227 of the timing relay 6TR is connected in parallel with the operating windings 152 and 159, respectively, of the control relays 8CR and 7CR through the contacts 187 of the control relay 7CR. This circuit is shown in detail in Figure 3A and may be traced from the windings 159 and 152 through the lead 266, thence through the contacts 187 and a connection lead 280 to the operating winding 227, and through the winding 227 to the supply lead 108 .

The operating winding 228 of the timing relay 7TR is likewise connected into the presently considered control network associated with the control relays 7CR and 8CR, being connected with the network between the contacts 186 of control relay 7CR and the contacts 226 of the timing relay 7TR to receive operating current through either the contacts 165 of control relay 1CR or the contacts 184 of control relay 6CR whenever the contacts 186 of control relay 7CR are closed. Likewise, the same operation occurs when the contacts P of the selector switch are closed and the relay contacts 186 are closed at the same time. This circuit may be traced in Figure 3A from the operating winding 228 of the timing relay 7TR to the supply lead 108 and an extension circuit connection from the lead 275 and the contacts 226.

The operating winding 160 of the control relay 9CR is connected through a terminal 161 with the power supply lead 109, while the terminal 162 is connected through a lead 284 with the normally closed contacts 182 of the control relay 5CR and through a further extension lead 285 with the contacts X of the selector switch 100, being in the group which are closed when the normally open switch is set for automatic operation of boiler 9. A return lead 286 from the contacts X, which are the only contacts not connected with the supply bus 110, is connected also with the opposite one of the normally closed contacts 182 of the control relay 5CR, so that the contacts 182 and the contacts X are in parallel.

A further connection from the lead 286 is provided through a circuit lead 287 with a bus connection 288 which is connected with one of the contacts T6 of the timing relay 1TR contacts 190 of the control relay 9CR and the contacts 168 of the control relay 1CR. The contacts 168 are in turn connected through a lead 290 with a bus connection 291 and the contacts J and K of the selector switch in parallel. The control relay 9CR is operated, therefore, when the operating winding 160 is energized through closure of the contacts X, or of the contacts 182 of the control relay 5CR, which are in parallel, together with closure of the contacts 168 of the control relay 1CR and either of the contacts J or K of the selector switch 100.

These same contacts J and K of the selector switch 100 and the contacts 168 of the control relay 1CR serve simultaneously to control the energization of the operating window 220 of timing relay 4TR or the operating solenoid 40 and the indicator lamp 80 of the cut-off gate 1. The latter connection is provided through the contacts 190 of the control relay 9CR, while the former connection is made through the contacts T6 of the timing relay 1TR, as is clear from the simplified diagram of Figure 5. In Figures 3A and 3B, these connections are provided in the case of the operating winding 220 for the timing relay 4TR on one side of the winding 220, directly with the supply lead 108, whereas the opposite winding is connected through a lead 295 with the contacts T6 of the timing

relay 1TR, and thence through the contacts to the lead 288.

The connection for the operating solenoid 40 of cut-off gate 1 is provided directly with the supply lead 107 on one side, and through a supply lead 296 with the contacts 190 of the control relay 9CR, and thence through the contacts 190 to the lead 288. It will thus be seen that the cut-off gate 1 is under the control of contact 168 of relay 1CR and is operated whenever the contacts 190 of the relays 9CR are closed. Likewise, the timing relay 4TR is operated under the control of the contacts 168 of the control relay 1CR, and momentarily whenever the contacts T6 of the timing relay 1TR are closed. As appears in the diagram of Figure 4, the contacts T6 are closed over a period of fifteen seconds, being open during the remainder of the timing cycle of the relay 1TR.

Cut-off gate 2 is operated by the solenoid 41, and is provided with the indicator lamp 81 in parallel therewith. This is controlled by the contacts 179 of the control relay 5CR, together with the contacts M or N of the selector switch 100. The operating circuit may be traced in Figures 3A and 3B from the contacts M and N in parallel, as provided by the circuit lead 250, thence through the contacts 179 of the control relay 5CR to a circuit connection lead 298, which in turn is connected with the operating solenoid 41 and the indicator lamp 81. The circuit is completed through connection of the operating solenoid 41 and the indicator lamp 81 with the supply branch lead 107. As pointed out hereinbefore, this is connected with the power supply lead 105.

It will be noted that the manual operation switch 95 for gates 1 and 2 is provided with a contact 300, connected with the supply lead 298 for the cut-off gate 2 operating solenoid 41 and a contact 301, connected with the supply lead 296 for the cut-off gate 1 operating solenoid 40. A selector contact 302, shown in the normally open position, is arranged to connect with either of the contacts 300 or 301 selectively, to close the switch in one direction or the other for manual operation of the cut-off gates 1 and 2. For this purpose, the selector contact 302 is connected through supply lead 304 with the contacts L of the selector switch, which are closed for manual operation of the boilers 9 and 10.

In this manner, when the selector switch is closed for manual operation of boilers 9 and 10, the cut-off gates 1 and 2 may be operated by manual operation of the selector switch 95. In a similar manner, the wholly manual cut-off gates 4 and 5 (Figure 3B) are controlled by the manual control switch 96. This switch, like the selector switch 95, is provided with a contact 305, connected through a control lead 306 with the operating solenoid 43 and the indicator lamp 83 for the cut-off gate 4, while a second contact 308 is connected through the control lead 309 with the operating solenoid 44 and indicator lamp 84 for the cut-off gate 5.

Return connection to the power supply is provided by connection for the solenoids 43 and 44 and the indicator lamps 83 and 84 with the branch supply lead 107. The operating contact 310 for the selector switch 95 may be moved from a normally open position, as shown, into connection with either of the contacts 305 or 308 to manually operate the cut-off gates 4 and 5, respectively, the power supply connection from the contact 310 being indicated by the circuit lead 311 with the contacts R of the selector switch 100, this being in the group for manual operation of boilers 9 and 10 as shown in Figures 3A and 3B. These connections are omitted in Figure 5, as the manual operating connections are clear in the circuit of Figures 3A and 3B.

While cut-off gates 4 and 5 are manually operable by selector switch 96 when the contacts are closed, the cut-off gate 3 is wholly operated by the selector switch 100 through closure of the contacts S for the rear pass and bottom ash manual position of the selector switch. For this purpose, the contacts S provide a supply connection from the supply lead or bus 110 and a connection lead 312 to the operating solenoid 42 and indicator lamp 82 for the cut-off gate 3. The circuit is completed through connection of the indicator lamp and operating solenoid with the branch supply lead 107, as shown in Figure 3B. The circuit connections for the cut-off gate 3, like those for the cut-off gates 4 and 5, are omitted in Figure 5 for the purpose of simplifying the drawing and for the reason that the connections are clear in the main diagram of Figures 3A and 3B.

The motor driven timing relays 1TR and 2TR are operated through control relays 2CR and 3CR, both of these relays being energized whenever the timing motors are operated. In addition, the timing motor for the relay 1TR is under control of the relay 9CR, while the timing motor for the timing relay 2TR is under control of the relay 5CR. The timing motor for the relay 1TR is, furthermore, under control of the contacts F or G of the selector switch, whereas the timing motor for the relay 2TR is under control of the contacts M or N of the selector switch. These connections are clear from the schematic circuit of Figure 5, and may be traced in the complete circuit diagram of the system shown in Figures 3A and 3B.

From the terminal 200 of the timing relay motor operating winding 197 for the timing relay 1TR, a circuit may be traced through the lead 202 and the contacts 192 of the control relay 9CR, and thence through a connection lead 315 to the contacts 173 of the control relay 3CR, and thence through a connection lead 316 and the contacts 171 of the control relay 2CR to the bus connection 261 for the contacts F and G of the selector switch, and thence to the supply lead or bus 110.

Tracing, now, the corresponding circuit for the timing relay 2TR, the terminal 201 of the motor operating winding 198 is connected through a lead 203 with the contacts 172 of the control relay 2CR, and thence through a connection lead 318 to the contacts 174 of the control relay 3CR. The circuit is completed from the contacts 174 through a connection lead 319 to the contacts 179 of the control relay 5CR, and thence to the bus connection 250 and the contacts M and N of the selector switch.

From a study of the circuit diagram, particularly as shown in Figure 5, it will be seen that the timing motor for the relay 2TR and the cut-off gate 2 are controlled through the contacts 179 of the control relay 5CR. In a similar manner, the cut-off gate 1 and the timing motor for the relay 1TR are both controlled by the relay 9CR through the operation of contacts 190 and 192. This is for the reason that, as appears in Figure 1, the cut-off gate 1 is provided for boiler 9 and cut-off gate 2 is provided for boiler 10. Likewise, timing relay 1TR serves to operate the rotary feeder gates for boiler 9, whereas timing relay 2TR serves to operate the rotary feeder gates for boiler 10. Therefore, the respective cut-off gates must be operated with the rotary feeder gates for the respective boilers. Further description of the operation of the rotary feeder gate motors and of the recorder will be given hereinafter.

The electrical operating element or solenoid 52 for the steam valve is connected with the branch supply lead 107 at one terminal and at the other terminal is connected through a control lead 325 with the contacts 188, the control relay 7CR and, through the contacts 188, with a supply lead 326 which is connected with the branch supply bus or lead 110 for the opposite side of the power supply circuit. The steam valve is operated, that is, opened, whenever the solenoid 52 is energized by closure of the contacts 188 of the control relay 7CR.

The timing relay 7CR is controlled in unison with the timing motor of the timing relay 2TR and with the cut-off gate 2 through operation of the contacts 179 of control relay 5CR. For this purpose, the operating winding 215 of the timing relay 5TR is connected at one terminal with the branch supply lead 108. The opposite terminal is connected through a control lead 327 with the contacts T6 of timing relay 2TR, and from the contacts T6 the connection is continued to the lead 298, which in turn is connected with the operating solenoid 41 for cut-off gate 2, as shown more clearly in Figure 5, and at the same time is connected at a point between the contacts 179 of control relay 5CR and the contacts 174 of control relay 3CR. This connection is shown in Figure 3A by the connection for the lead 298 from the contacts T6 of the timing relay 2TR to the contacts 179 of control relay 5CR, and thence to the contacts 174 of control relay 3CR. The operating winding 215 of timing relay 5TR is, therefore, operated whenever the contacts T6 of the timing relay 2TR close for the 15-second interval, as indicated in Figure 4, and the contacts 179 of control re'ay 5CR are closed. This is assuming that the selector switch is set for automatic operation of either boiler 10 or boilers 9 and 10, in which case the contacts M or N of the selector switch are closed.

The remaining relay operating winding is that of the

timing relay 3TR, and its operating connection will now be described. The operating winding 212 is connected on one side with the branch power supply lead 108, while the other terminal of the coil is connected to the contact 57 of the vacuum switch 56 through an extended circuit connection lead 330. The return connection from the vacuum switch 56 is provided in connection with the contact 58 and is provided by a return conductor 331 which is connected with the lead 241 in the circuitry previously described and leads, as shown in the circuit diagram of Figure 5, back through the contacts 169 of control relay 1CR to the power supply branch 110. Therefore, the timing relay 3TR is energized whenever the vacuum switch contacts 57 and 58 are closed and the control relay 1CR is energized.

The timing relay 3TR may also be energized whenever the control relay 1CR is energized, and the contacts 169 are closed, at the same time the control relay 7CR is deenergized so that its normally closed contacts 189 are the closed position as shown in Figures 3A and 5. These contacts provide a shunt connection across the contacts of the vacuum switch 56, as is more clearly seen in Figure 5 and as may be traced in the circuit diagram of Figure 3A from one terminal of the control relay operating winding 212 through a control lead 333 to the contacts 189 of the control relay 7CR, and thence to the lead 241 hereinbefore mentioned, thereby placing the contacts 189 in parallel with the contacts 57 and 58 of the vacuum switch 56.

Referring again to the motor driven timing relays 1TR and 2TR, the circuit connections and control effect of the timing contacts T1 and T6 of these relays have hereinbefore been described and the circuits controlled thereby have been traced. The remaining contacts T2–T5, inclusive, for each of these timing relays are utilized for the remote control of the corresponding number of rotary feeder gate motors, timing relay 1TR serving to control the motors for boiler 9 and timing relay 2TR serving to control the motors for boiler 10.

One of each pair of the contacts referred to for both timing relays is connected in parallel through a circuit connection 335, shown in Figure 3A, and the branch connection 336 therefrom to the contacts 150 of the control relay 8CR. The operating circuit may then be traced from the contacts 150 through a connection lead 337 with one of the contacts 189, control relay 7CR, and thence to the circuit connection lead 241 hereinbefore referred to. This connection is easily traceable in Figure 5 from the lead 335 to the contacts 150, and thence to the contacts 169 of control relay 1CR and one side of the power supply circuit 106 or 110, the latter being the branch provided for connection with the selector switch.

The timing contacts T2 to T5, inclusive, of the timing relay 1TR are connected to provide, selectively, circuit connections between the lead 335 and each of the leads 124–127, respectively, which are connected, as shown in Figure 3B, each with one of the stylus operating windings 138 of the multiple stylus recorder 102 and with motor control units 135 for the feeder gate motors 25, 26, 27 and 28, respectively.

As described previously, application of operating voltage to the leads 124–127 serves to operate the respective recorder styli and the respective motors through the motor control units. For example, assuming the contacts T2 of the timing relay 1TR to be closed, current flows from the lead 335 through the contacts and the lead 124 to the first or left-hand (in the drawing) stylus operating winding 138 of the multiple stylus recorder, and thence through the lead 139, the supply lead 107 and the connection therewith to the main supply lead 105, thereby energizing the stylus operating winding.

Simultaneously, current flows from the lead 124 through selector switch 122 of the motor control unit for the rotary feeder gate motor 25, thence through the reset contacts 120 and the operating switch winding 121 back to the branch supply lead 107 and the main supply lead 105, as above described, thereby energizing the winding 121, causing the three-phase contactor switch 118 to close and to supply the motor 25 with energy from the power supply leads 115. The motor then operates to drive the rotary feeder gate 11 for boiler 9.

In a similar manner, the remaining motors 26, 27 and 28 and the corresponding stylus operating winding 138 for the multiple stylus recorder 102 are energized successively as the contacts T3, T4 and T5 close to energize the power supply leads 125, 126 and 127. Referring to Figure 4, it will be seen in what order the contacts T2–T5 will close and for what duration of time in the present example. As set up for the particular operation here provided, the contacts remain closed for a period of 60 seconds and remain open throughout the remainder of the timing cycle, with a 10-second interval between the closing of the contacts T2—T3, the contacts T3—T4, and the contacts T4—T5, as appears more clearly in the diagram of Figure 5.

It will be noted that the rotary feeder gate indicators 90 for boiler 9 are connected each with one of the leads 124–127, to be energized simultaneously with energization of the corresponding feeder gate motor and recorder stylus, the indicator lamps being connected through a return circuit lead at 45 with the branch supply lead 107, in common with the feeder gate motors and recorder.

It will also be seen that when the manual-auto switches 98 are moved from the normally open position shown to the closed position, connection is made by each switch between its respective control leads 124–127 and the control lead 146, which in turn is connected through the contacts 147 and a lead 148 with the contacts Q of the selector switch, and thence to the supply circuit lead 106–110. Therefore, when the selector switch is set for manual operation of boilers 9 and 10, thereby closing contacts Q, any one of the feeder gate motors and the corresponding stylus of the recorder may be operated by closing any of the manual-auto switches 98 for the boiler 9. As will hereinafter be seen, this provides for the manual operation and clearing of the feeder gates directly from the panel board shown in Figure 2, or other suitable control point at which the switches 98 may be located. As shown in Figure 2, and also as represented in Figure 3B, the rotary feeder gate indicators and the manual auto switches are located in close association on the panel board.

The operation of the multiple stylus recorder and the rotary feeder gate motors 30, 31, 32 and 33 for boiler 10 is carried out in a similar manner by the successive closure of the contacts T2–T5 of the timing relay 2TR, whereby the control leads 133–135 (Figure 3B) are energized in the same manner as the corresponding control leads 124–127 for boiler 9. In this manner the motors 30–33 may be operated in succession with the rotary feeder gate indicators 91 and the recording styli corresponding thereto. The manual-auto switches 98 serve to energize the control leads 132–135 selectively for the individual manual operation of the rotary feeder gate motors for boiler 10, whenever the lead 146 is energized by the closure of the contacts Q of the selector switch as above described.

In the simplified circuit diagram of Figure 5, a single circuit connection is shown for the contacts T2 of the timing relays 1TR and 2TR in connection with the corresponding recorder stylus operating windings 138 and the rotary gate motors 25 and 30, for example. In this circuit diagram also, the manual control switches for the motor control units are indicated to show the full operation of the system and the rotary gate motors are indicated as being operated directly by energization from the supply leads 105—106, as would be the case where sufficient power might be supplied thereby. It should be understood, of course, that the motor designations M in the schematic diagram of Figure 5 may be either the motor or the operating solenoid for the contactor switch as above described.

Automatic operation of the system may now be considered, with particular reference to Figure 5. For automatic operation of boiler 9 alone, the selector switch 100 is turned to the boiler 9 position, thereby closing contacts B, E, F, J and X only, and the reset button 88 is pressed if necessary. The pilot or indicator lamps for power and steam are lighted, when power is on and the steam is at a pressure sufficient to close the switch 65. The start button 86 is then pressed, and this brings in the relay 1CR, which maintains the closed position, that is, is energized, through the relay 4CR normally closed contacts 178 from the contact B of selector switch 100 and the contacts 166 through stop switch 87.

The relay 1CR contacts 165 energize the coils of relays 7CR and 8CR, through timing relay 6TR normally closed contacts 225. Relay 7CR picks up relays 6TR and 7TR, opening 6TR normally closed contacts, hold-

ing in relays 7CR and 8CR through timing relay 7TR normally closed contacts 226. At the end of 50 seconds, the timing relay 7TR contacts 226 (normally closed) open, deenergizing relays 7CR and 8CR and timing relay 6TR and 7TR coils. Timing relay 6TR normally closed contacts 225 remain open for 10 seconds after the relay 6TR coil is deenergized, then reclose, allowing repetition of the 50 seconds-10 seconds action above. Thus the relays 7CR and 8CR will close for 50 seconds and open for 10 seconds, as long as this group circuit for boiler 9 is energized. The relay 7CR contacts 187 energize four-way solenoid 52 for the steam valve, which produces vacuum for the system.

The relay 1CR contacts 168 from auto 9 (J) selector contact, energize the relay 9CR. Through auto 9 (X) contacts, the relay 9CR remains energized and contacts 190 are then closed to energize the solenoid 40 of the cut-off gate 1 and associated pilot or indicator lamp 80.

The relay 9CR contacts 191 energize the recorder motor 142 and indicator lamp 145. Also the relay 1CR contacts 169 will energize the pneumatic timer relay 3TR if the gate 1 ash pipe is clear, so that no vacuum is applied on vacuum switch 56 for a period of 15 seconds, and the contacts close. The relay 3TR normally open contacts 213 close, thereby energizing the relay 3CR.

The relay 3CR contacts 173 complete the operating circuit to the 1TR timer motor 195 from lead 110 through auto 9 (F) contacts, thence through relay 9CR (normally open) contacts 192 and contacts 171 of relay 2CR (normally open), thence through contacts 173 and the timing motor winding 197 to the supply lead 108. The timing relay 1TR motor begins timing in accordance with contact schedule as shown in Figure 4, and contacts 1TR—T2 close, moving recorder pen 1 and starting rotary gate 11. This lights the pilot for the rotary gate 11. Rotary gate 11 remains in operation for 35 seconds, then is deenergized by release of timing relay 7TR. In ten seconds, rotary gate 11 restores, then operates 50 seconds on and 10 seconds off until ash is completely drawn out of gate 11. At this time, the vacuum switch 56 will remain closed for 15 seconds or more, allowing the timing relay 3TR to bring in the control relay 3CR. This allows the timing relay 1TR motor to advance, thereby opening contacts 1TR—T2 and closing contacts 1TR—T3. This transfers operation and recording from rotary gate 11 to rotary gate 12, on which the above operation repeats. However, the initial "on" time of rotary gate 12 will be different from that of rotary gate 11, since the clearing of rotary gate 11 of ash may occur at any time during the 50 second-10 second cycling of timing relays 6TR—7TR.

Operation of rotary gates 12, 13 and 14 occurs in sequence with transfer being effected by the timing relay contacts 1TR—T3, T4 and T5 as each hopper is cleared of ash. Timing of the relay 1TR advances only as the control relay 3CR is energized (due to lack of vacuum in the ash pipe for more than 15 seconds). Running time of each rotary gate is recorded, in 50 seconds "on," 10 seconds "off" intervals, on respective pens of the recorder 102. Completion of the cycle and resetting of auto 9 control takes place after rotary gate 14 has been cleared. The timing relay 3TR, after a 15-second interval, energizes control relay 3CR which allows timing relay 1TR to close T6 contacts, whereupon the timing relay 4TR is energized. The relay 4TR normally open contacts 222 energize the control relay 5CR, which operates but has no function in auto 9 position.

Five seconds after the contacts 1TR—6 close, the contacts 1TR—T1 close, allowing timing relay 4TR normally open contacts 221 to pick up 4CR, which then maintain a circuit around 1TR—T1. The relay 4CR operates, energizing reset clutches 205 of both timing relays 1TR and 2TR and the relay 1TR resets, opening all contacts. The timing relay 5TR coil 215 is deenergized. The relay 4CR releases control the relay 1CR by opening 4CR normally closed contacts 178. The relay 1CR releases relays 5CR and 9CR. The pilot 145 is extinguished and the motor 142 recorder is turned off. The relay 4CR remains in operation for a total of three seconds, until 4TR-normally open contacts 221 have timed out, releasing the relay 4CR and the timing relay 1TR and 2TR clutch coils. At this point the operating cycle is completed and the system is at rest.

Considering now operation of the auto-boiler 10 alone, the selector switch 100 is set to boiler 10 position, thereby closing contacts C, H and M only, and the start button or switch 86 is operated. The relay 1CR picks up and remains energized through selector switch contacts (C). The relay 1CR energizes the relay 5CR, and the relay 5CR (normally closed) contacts 182 prevent relay 9CR from operating. Also the relay 5CR, normally open contacts 179 energize the operating solenoid 41 of cut-off gate 2 and the associated pilot indicator 81. The relay 5CR normally open contacts 181 energize the recorder motor 142 and indicator lamp 145.

The relay 1CR normally open contacts energize the relay 6TR—7CR—8CR circuit which initiates a cycle of 50 seconds on and 10 seconds off for the vacuum supply on the conduit system. The relay 1CR energizes the timing relay 3TR through the normally closed contacts 57—58 of the vacuum switch 56. If ash pipe from the boiler 10 to the cut-off gate 2 is clear, preventing vacuum from being established, the timing relay 3TR (after 15 seconds) will operate the relay 3CR. The latter relay closes the operating circuit to the timing relay 2TR motor timer 196 which advances the timing according to the graph shown in Figure 4. The contacts 2TR—T2, T3, T4 and T5 close in turn, in the same manner as the corresponding contacts of 1TR controlling boiler 9, effecting the drawing of ash from rotary gates, 15, 16, 17 and 18 in turn, until ash is exhausted from the four hoppers of boiler 10.

The completion of the cycle and reset operation of boiler 10 is as follows: After the ash is exhausted from rotary gate 18, the vacuum can no longer be established, and in fifteen seconds the timing relay 3TR operates the relay 3CR. The contacts 2TR—T6, energizing the timing relay 5TR which operates fully. The timing relay 5TR normally open contacts 216 close, making ready the operating circuit to the relay 4CR through contacts 2TR—T1. Five seconds after the contacts 2TR—T6 close, the 2TR—T1 contacts close, operating the relay 4CR, and maintaining a circuit around contacts 2TR—T1, through 5TR contacts 176. This holds the relay 4CR in operation for three seconds until the relay 5TR times out.

The relay 4CR, in operating, releases the relay 1CR, which in turn releases the relays 5CR and 3CR. The relay 3CR stops the timing relay 2TR timer motor 196–198. At this time, the relay 4CR energizes the reset clutches 205 of both times 1TR and 2TR, holding these in operation for three seconds while the timing relay 5TR times out. The reset action of the timing relay 2TR opens the circuit through contacts 2TR—T6, which deenergizes the relay 5TR coil 215. The timing relay 5TR, in opening its contacts 216, releases relay 4CR, which releases the reset clutches 205 of both timers 1TR and 2TR. The system is completely restored at this point of operation.

For operation of both boilers 9 and 10 automatically, the selector switch 100 is turned to boiler 9 and 10 position, thereby closing contacts D, G, N and K, and the start button or switch 86 is operated as before. The relay 1CR picks up and provides a circuit connection to selector switch contact (D). The sequence of operation includes operation of control relays, pneumatic timers and motor driven timer 1TR the same as in boiler 9 operation, until the rotary gate 14 has been cleared. Then the operation transfers from boiler 9 to boiler 10.

The timing relays 4TR and 1TR—T1 contacts cannot energize relay 4CR, since selector switch contact (E) is open. The relay 5CR is operated by the timing relay 4TR, and releases the relay 9CR, stopping the timing relay 1TR motor but not resetting it. 1TR—T6 and T1 remain closed (see Figure 4). The relay 9CR, in releasing, deenergizes the cut-off gate 1, and the relay 5CR, in operating, energizes the cut-off gate 2, allowing air to be drawn into the ash pipe serving boiler 10. When air has been drawn for 15 seconds, the timing relay 3TR operates the relay 3CR, energizing the timer motor of timing relay 2TR. The timing relay 2TR in turn closes its contacts T2, T3, T4 and T5 by which rotary gates 15, 16, 17 and 18 are cleared of ash.

After all gates are cleared, the contacts 2TR—T6 close, energizing the timing relay 5TR, which prepares the circuit for operating relay 4CR through selector switch contact N. Reset operation of both motor timer clutches 205 proceeds when timing relay 2TR contact (T1) closes five seconds later, as in boiler 10 operation. The system is then completely restored to normal and rest condition.

In the present system, all control operations and signals are at 110 volts, 60 cycles, obtained through 30A fuses **114** in each side of the control line. The capacity of the control transformer may be of the order of 1.5 kva. continuously. The large fuses are used to permit frequent operation of cut-off gate solenoids momentary heavy current which draw at 110 volts.

Opening of any one of the five solenoid-operated cut-off gates is indicated by an associated pilot or indicator lamp. Rotation of any of the eight motor driven rotary gates is also indicated by an associated pilot lamp, when the gate is operated from the controller. The various indicator lamps may have various colors for ready identification.

Travel of the chart of the operation recorder **102** is indicated by the chart lamp being on inside the recorder. Fully reset condition of the motor driven timers **1TR** and **2TR** is indicated by the respective reset clutch solenoids being energized for three seconds continuously. This allows the timing means to be restored to their normal positions. In a preferred type of timer, known commercially as the Eagle multiplex motor driven synchronous timer, the timing means will restore only on the first reset position of clutch solenoids, being held thereafter in the normal position until operated by the timer motors.

It will be seen that the timing relays **6TR** and **7TR** control the periodic application of the vacuum to the conduit system and the operation of the rotary feeder gates through control relays **7CR** and **8CR**, respectively. The timing relay **6TR** is arranged for instant opening and time closing (10 seconds), while the timing relay **7TR** is arranged for instant closing and time opening (50 seconds). Therefore, the system operates for 50 second intervals to remove ash and pauses for 10 seconds, and repeats until the ash is fully removed from each rotary gate position. The vacuum falls and the closing of the vacuum switch contacts for 15 seconds allows 15-second time closing of relay **3TR**, which in turn operates relay **3CR** and causes the particular motor operated timing relay **1TR** or **2TR** to advance to the next contact for energizing the next rotary gate motor in the sequence.

For manual operation, referring generally to the circuit of Figure 5, the selector switch **100** is set to the manual 9 and 10 position, which closes contacts L, P, Q, R and W. The switch **95** is operated to open either of the gates **1** or **2**, being moved right or left from the off or center position as viewed in Figure 2.

The two-position switches **98** or **99** are then operated to put any one of the rotary feeder gates in motion, being moved from auto to manual position. The recorder motor is then energized through contacts (W) and the relay circuit **6TR—7TR—7CR—8CR** is in operation through the circuits connected with contact P. When **8CR** closes contacts **147**, in the sequence, the rotary gate motor selected will operate through current from contact Q of the selector switch and the associated recorder stylus will record the operation in 50 and 10 second on and off intervals until the selectors **98** or **99** are turned back to auto operation. Complete clearance of the ash from each point in the system is indicated by the falling of the vacuum at the gauge to or toward zero. The stack may be cleared likewise by opening gates **4** and **5** by operation of switch **96**, while the selector switch **100** is in the manual position, since the vacuum controlling relays **6TR** and **7TR** are in operation to pulse the steam valve on for 50 seconds while relay **7TR** is opening (T. O. 50 sec.) and off for the 10-second interval that relay **6TR** is closing.

Manual operation may be obtained in the same manner while operating automatically to assist in clearing any sluggish ash condition at any rotary gate. To return to automatic operation, the operation selector switch **100** is turned back to the previous position at which automatic operation was progressing and the start switch is operated. Operation then continues from the point at which it was interrupted.

However, it will be seen that if the reset switch is operated, the timing relays **1TR** and **2TR** will be reset and cause the automatic cycle to start with the first rotary gate feeder again.

For rear pass and bottom ash clearance, the operation selector switch **100** is moved to the rear pass position shown in Figure 2, which causes contacts A and S only to be closed, and the operation may be seen readily from an inspection of Figures 3A and 3B. This energizes cut-off gate **2** and relay **6CR** is energized. This causes relays **6TR**, **7TR**, **7CR** and **8CR** to be energized. The steam jet is turned on, thereby putting vacuum on the system in the 50-second and 10-second cycle without operating the recorder. The falling of the vacuum on the gauge indicates clearance of the ash.

From the foregoing description of a present preferred system, it will be seen that, in accordance with the invention, an improved ash handling system includes means for periodically applying vacuum to a conduit system and operating a plurality of ash feeding units in sequence under control of timing relays which advance the cycle of operation in accordance with the ash condition at each point. This provides for handling the ash from a plurality of ash producing units by electrical control from a centralized unit having instruments for recording the duration of each operational step as a measure of the ash discharge from each point.

The system provides sequential control of the various rotary feeder means in dependence upon the vacuum condition in the conveyor conduit and operates to advance the timing of the operation in steps which are initiated as soon as each unit is cleared.

Sequential control of a plurality of feeders for each ash producing unit is provided, in accordance with the invention, by a minimum of timing and control relays in a simplified electrical system having a single selector switch and a relatively small number of controls, making for easy operation and minimum attendance.

It will be understood, of course, that the present invention is susceptible of various changes and modifications which may be made from time to time without departing from the general principles or real spirit of the invention and it is accordingly intended to claim the same broadly, as well as specifically, as indicated in the appended claims.

What is claimed as new and useful is:

1. An improved ash handling system for power plants and the like having a plurality of ash producing units, comprising a closed ash conveying conduit connected with said ash producing units, a plurality of electric motor operated rotary gate ash feeder means connected with said conduit at each of said ash producing units for feeding ash thereto from each of said units in sequence, means for maintaining a vacuum on said conduit, and vacuum operated switch means responsive to the vacuum in said conduit for effecting sequential operation of said feeder means.

2. An improved ash handling system as defined in claim 1, wherein the electric motor operated feeder means are further sequentially controlled by electrical timing relay means providing a predetermined time of operation for each of the feeder means.

3. An improved ash handling system as defined in claim 1, wherein the electric motor operated feeder means are further sequentially controlled by electrical timing relay means providing a predetermined time of operation for each of the feeder means, and wherein said timing relay means is controlled by additional relay means responsive to operation of the vacuum operated switch means, whereby reduction of vacuum in said conduit in response to reduction of the ash content operates to advance the operation of the system.

4. An improved ash handling system for power plants and the like having a plurality of ash producing units, comprising a closed ash conveying conduit connected with said ash producing units, a plurality of electric motor operated rotary gate ash feeder means connected with said conduit at each of said ash producing units for feeding ash thereto from each of said units in sequence, means for maintaining a vacuum on said conduit, vacuum operated switch means responsive to the vacuum in said conduit for effecting sequential operation of said feeder means, and means for recording the time duration of the operation of each ash feeder means as a measure of the ash content derived from each unit.

5. An improved ash handling system for fuel burning power plants and the like comprising in combination, closed ash conveying conduit means having a branched conduit connection for each ash producing unit of the plant, a plurality of rotary ash feeder gates connected with each conduit branch in connection with each ash producing unit for feeding ash to the conduit means, individual electric motor means for operating said feeder gates, relay controlled electric circuit means for operat-

ing said rotary feeder gates in predetermined sequence, means for applying a vacuum to said conduit system for withdrawing ash therefrom, and vacuum switch means connected with said conduit for controlling the sequence of operation of said rotary feeder gates.

6. An improved ash handling system as defined in claim 5, wherein a multiple stylus recorder is provided for indicating the duration of operation of each rotary feeder gate and is provided with individual electrically operated styli connected for operation each with one of said rotary feeder gate motors, whereby the operation of each feeder gate may be compared with that of the others for duration of operation as an indication of the condition of operation of the ash disposal system.

7. An improved ash handling system as defined in claim 5, wherein the rotary feeder gates are sequentially responsive through electrically operated timing relays one for each ash producing unit, and wherein the timing relays are selectively controlled by said vacuum switch means.

8. An improved ash handling system as defined in claim 6, wherein electrical control relays are selectively operable for automatic and manual operation of the system through a single selector switch providing selectable sequential operating connections therefor.

9. An ash handling system adapted for sequential control of a plurality of ash producing units comprising in combination, ash conveying conduit means having a branch for each ash producing unit, means for creating a vacuum on said conduit means for ash withdrawal, a vacuum controlled switch connected with said conduit means for controlling said system in response to the vacuum condition therein, a plurality of electric motor operated rotary feeder gates for feeding ash from each unit to said conduit means at a plurality of different ash collecting locations, an electrical control system connected between said vacuum switch and said rotary feeder gates including electric motor drive means for said gates and electrical control and timing relay means therefor, a selector switch and electrical circuits in said control system for selective individual and joint control of said units, and indicating and recording elements connected with said system for effecting continuous ash withdrawal sequentially from said units in predetermined order.

10. In an ash disposal system for power plants and the like, the combination with a plurality of ash producing units, of conduit means for withdrawing ash therefrom, and including vacuum producing means adapted for periodic operation, a vacuum operated switch connected with said conduit means and operable in response to change in vacuum, electric motor driven rotary gate means for feeding ash to said conduit means from a plurality of points in connection with each of said ash producing units, electric relay controlled means for actuating said rotary gate means sequentially in response to changes in vacuum in said conduit means, selector switch means for adjusting said system for manual and automatic operation sequentially from unit to unit and sequentially through each unit to effect ash removal from point to point throughout the system, and means for indicating the time duration of ash removal from each point in each unit and including a multiple stylus recorder having recording styli connected for response to operation of each ash feeder means.

11. A system for continuously removing ash from a plurality of ash producing units comprising in combination, an ash conveying conduit having a branch conduit for each unit, a plurality of electric motor driven rotary gate ash feeding devices for each unit connected with a branch of said conduit, gate means for selectively placing each conduit branch in operation, said gate means being electrically operable, an electric motor for each of said ash feeding devices, means for applying a vacuum to said conduit to effect ash withdrawal thereto, the degree of vacuum being determined by the ash delivered by said devices, vacuum switching means responsive to the vacuum condition in said conduit, a motor driven timing relay for each of said units providing sequential control of the motors for each unit, and an electrical control system connected with said vacuum switching means and including control relays for operating said timing relays in response to changes in the vacuum condition in said conduit, whereby said motors are sequentially operated in predetermined order cyclically to withdraw ash from said units, and control means for initiating each cycle of operation.

12. A system as defined in claim 11, wherein means are provided for indicating the duration of operation of each feeder device to provide an indication of the quantity of ash removed through each device during a cycle of operation of the system.

13. A system as defined in claim 11, wherein means are provided for indicating the duration of operation of each feeder device to provide an indication of the quantity of ash removed through each device during a cycle of operation of the system, and wherein a single multiple-contact selector switch is provided having a plurality of operating positions providing selectively for operation of each unit individually and collectively and for manual operation of the system.

14. A system as defined in claim 13, wherein a plurality of timing relays are provided for introducing in the cycle of operation of the system a predetermined operating time and a predetermined pause between ash withdrawal operations.

15. A system as defined in claim 14, wherein one of the control relays provides for starting and stopping the operation of said system, and wherein individual start and stop switches are provided for operating said relay.

16. A system for continuously removing ash from a plurality of ash producing units comprising in combination, an ash conveying conduit having a branch for each of said units, a plurality of rotary gate ash feeding devices for each unit individually connected with a branch of said conduit, individual electric motor drive means for each of said ash feeding devices, means for applying vacuum to said conduit to effect ash withdrawal through a selected branch, the degree of vacuum being determined by the ash delivered by said devices, vacuum switch means operably responsive to the vacuum condition in said conduit, electric motor driven timing relay means providing sequential operation of the electric motor drive means for each unit, selector switch means for selectively connecting the timing relay means for each of said units for operation of said ash feeding devices in predetermined sequence, a control relay connected with each of said timing relay means for applying current therethrough for operating the electric motor drive means for said ash feeding devices under sequential control of said timing relays, a pair of timing relays for controlling the operation of said last-named control relay and said electric motor drive means, one of said pair of timing relays being adjusted to operate over a predetermined period of time and the other of said pair of timing relays being adjusted to operate over a shorter time interval for initiating successive cycles of operation for each of said electric motor drive means, and a relay responsive to operation of said vacuum switch means for applying operating current to said motor driven timing relay means dependent upon a low vacuum condition in said conduit to advance the sequential operation of the electric motor drive means and the ash feeding devices.

17. A system for continuously removing ash from a plurality of ash producing units, comprising in combination, an ash conveying conduit having a branch for each of said units, a plurality of rotary ash feeding devices for each unit connected with a branch of said conduit, individual electric motor drive means for each of said ash feeding devices, means for applying a vacuum to said conduit to effect ash withdrawal therethrough, vacuum switch means connected with said conduit and operably responsive to a low vacuum condition therein, electric motor driven timing relay means providing sequential operation of the motor drive means for each unit, a control relay connected with and operable by said vacuum switch means to apply operating current to said motor driven timing relay means selectively to advance the operating cycle to the next successive motor driven ash feeding device in the sequence, control relays for simultaneously energizing the vacuum applying means for the conduit and the selected electric motor drive means for the ash feeding devices through said motor driven timing relay means, and a pair of timing relays connected with and controlling said last-named relays simultaneously and including a timing relay which operates with a predetermined long time delay and a second timing relay which operates with a relatively short time delay to effect periodic operation of each sequentially selected motor driven ash feeding device and

periodic stopping of said device under control of said vacuum switch means, whereby the ash feeding devices are sequentially operated in predetermined order cyclically to withdraw ash from said units.

18. An improved ash handling system for power plants and the like having a plurality of ash producing units, comprising a closed ash conveying conduit connected with said ash producing units, a plurality of electric motor operated rotary ash feeder gates connected with said conduit at each of said ash producing units, electric motor driven timing means for sequentially selecting each of said ash feeder gates for operation, control relay means including two interconnected time delay relays for operating each selected ash feeder gate over a predetermined longer time interval and for stopping the operation thereof over a shorter time interval in successive cycles, relay-controlled steam jet means simultaneously operable with said last-named means for applying a vacuum to said conduit to effect ash withdrawal therethrough during said predetermined longer time interval, vacuum switch means connected with said conduit and responsive to a low vacuum condition therein for operation of said first-named electric motor driven timing means, said control relay means being adapted for periodically energizing each selected motor operated rotary feeder gate and said steam jet means to create a vacuum in said system over said predetermined longer time interval and for stopping said gate and cutting off said steam jet means over said relatively shorter time interval, whereby the ash withdrawal at each selected gate is alternately stopped and started, and relay controlled means responsive to the operation of the vacuum switch for advancing the operation of said motor driven timing relays to energize a succeeding gate in the sequence, said relays operating to advance the operational sequence when the vacuum is substantially zero.

19. An ash handling system for a plurality of ash producing units comprising in combination, conduit means connected with said ash producing units for conveying ash therefrom, means for applying periodically a vacuum to said conduit means, a plurality of electric motor operated rotary ash feeder means for each unit connected with said conduit means, and electrical control means for actuating said feeder means in sequence and responsive to the vacuum in said conduit means, said electrical control means including a motor driven timing relay for each unit for energizing the ash feeder means therefor individually and sequentially in predetermined order, motor driven timing relays for effecting an advance in the sequence of operations from one feeder means to the next in predetermined order, a control switch responsive to the vacuum in said conduit means for controlling said last-named relays in response to a reduction in the vacuum to substantially zero, and additional timing relays for operating each of said ash feeder means for a predetermined time interval and for stopping the operation thereof over a shorter time interval periodically.

20. A system as defined in claim 19, in which a multiple unit recorder is provided in connection with each ash feeder means for recording the time of operation as an indication of a condition of operation of said feeder means.

21. A system as defined in claim 20, in which all operations are controlled from a central control unit and wherein a selector switch is provided for presetting all operations of the system.

22. An improved ash handling system for a multiple unit fuel burning power plant comprising in combination, means including a plurality of electric motor driven rotary feeder gates and a common conduit connected therewith for selectively withdrawing ash from each unit at a plurality of different points, an electronic control circuit network including a plurality of timing and control relay means, and selector means for the circuits of said network effective to connect said relay means for effecting ash withdrawal under predetermined vacuum condition in said conduit sequentially from each withdrawal point of a unit, said timing and control relay means including a main control relay responsive to start and stop operations for the system, a vacuum control relay for said conduit, an ash feeder control relay, a pair of timing relays for controlling said last-named relays simultaneously periodically for a predetermined time interval with delay intervals therebetween in successive cycles, two motor driven sequential timing relays for each unit for effecting operation of the feeder gates and withdrawal of ash sequentially from each point in predetermined order, an automatic reset relay for said last-named timing relays, and a relay responsive to the vacuum in said conduit for effecting operation of said sequential timing relays in response to a reduction of the vacuum in the conduit, whereby said units are cleared of ash in predetermined order sequentially in response to changes in the vacuum in said conduit.

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