

Sept. 10, 1963

D. W. FATH ETAL

3,103,347

GRAPHIC SIGNALING AND INDICATING SYSTEM

Filed March 15, 1961

8 Sheets-Sheet 1

Fig. 1

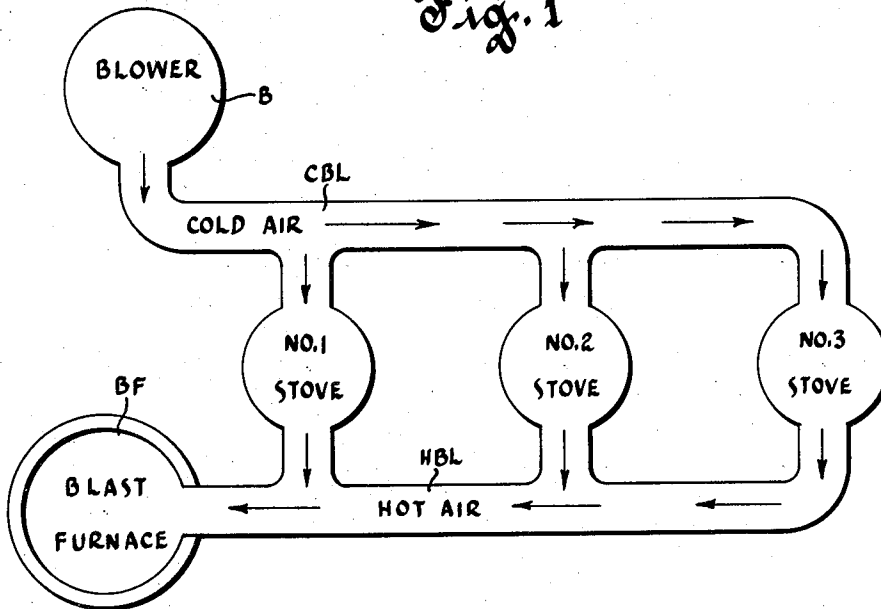
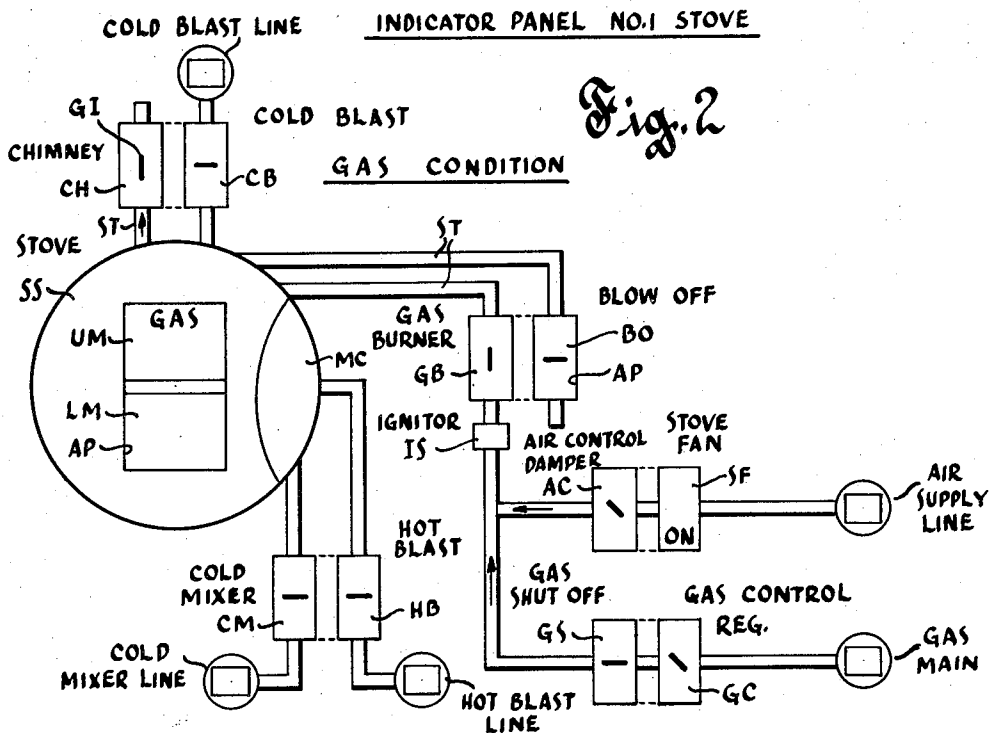


Fig. 2



Sept. 10, 1963

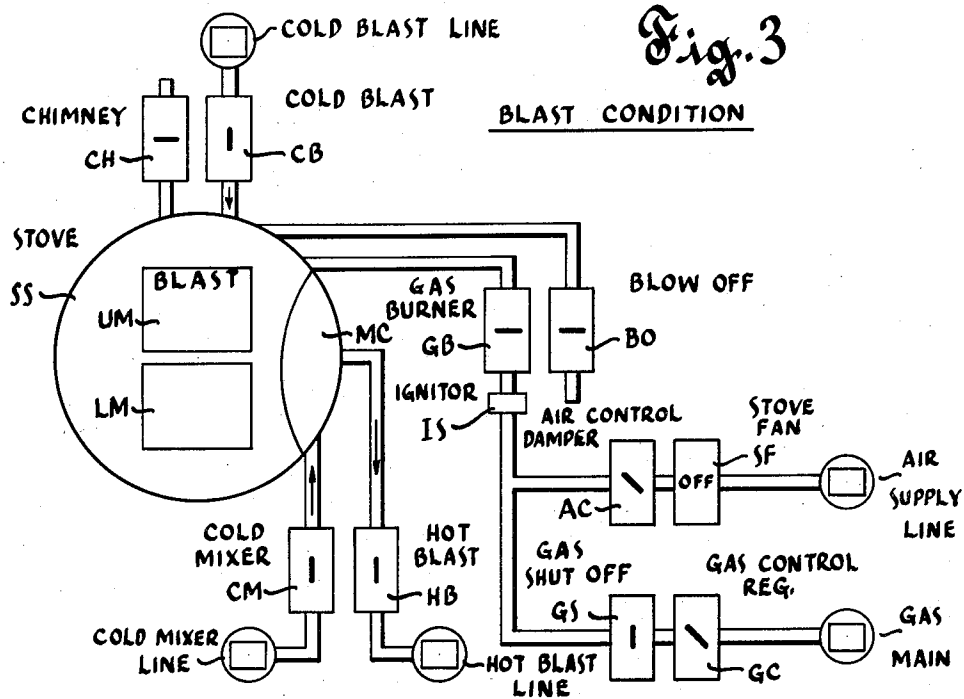
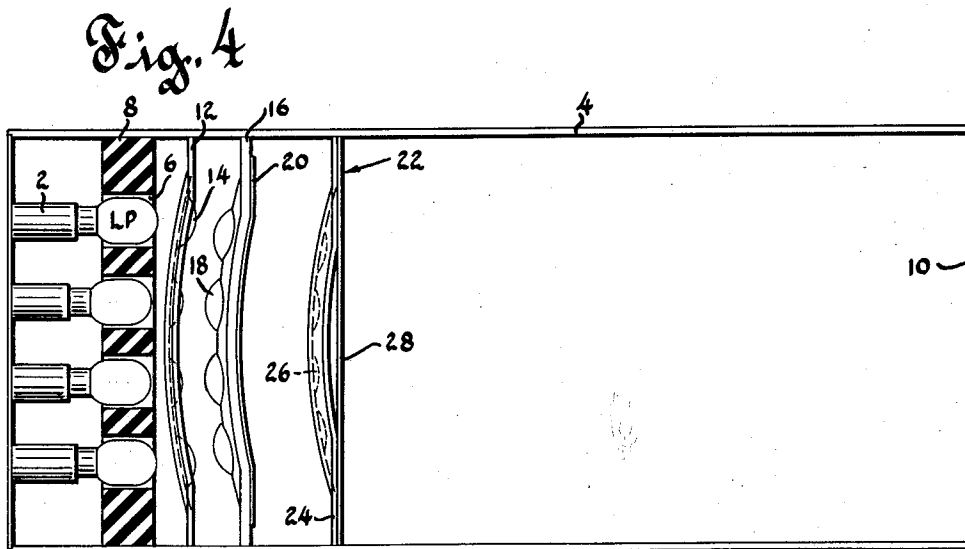
D. W. FATH ETAL

3,103,347

GRAPHIC SIGNALING AND INDICATING SYSTEM

Filed March 15, 1961

8 Sheets-Sheet 2



Sept. 10, 1963

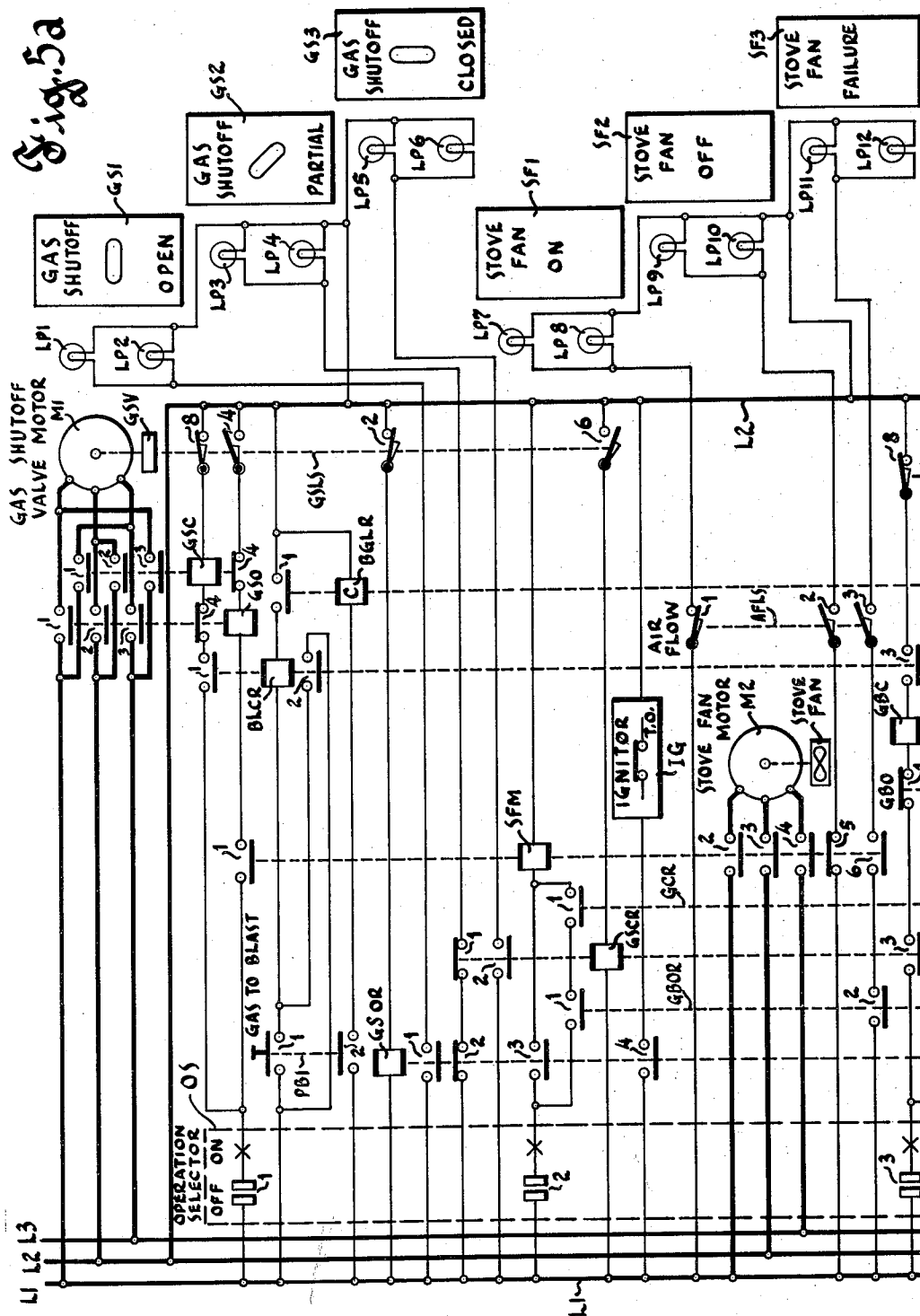
D. W. FATH ETAL

3,103,347

GRAPHIC SIGNALING AND INDICATING SYSTEM

Filed March 15, 1961

8 Sheets-Sheet 3



Sept. 10, 1963

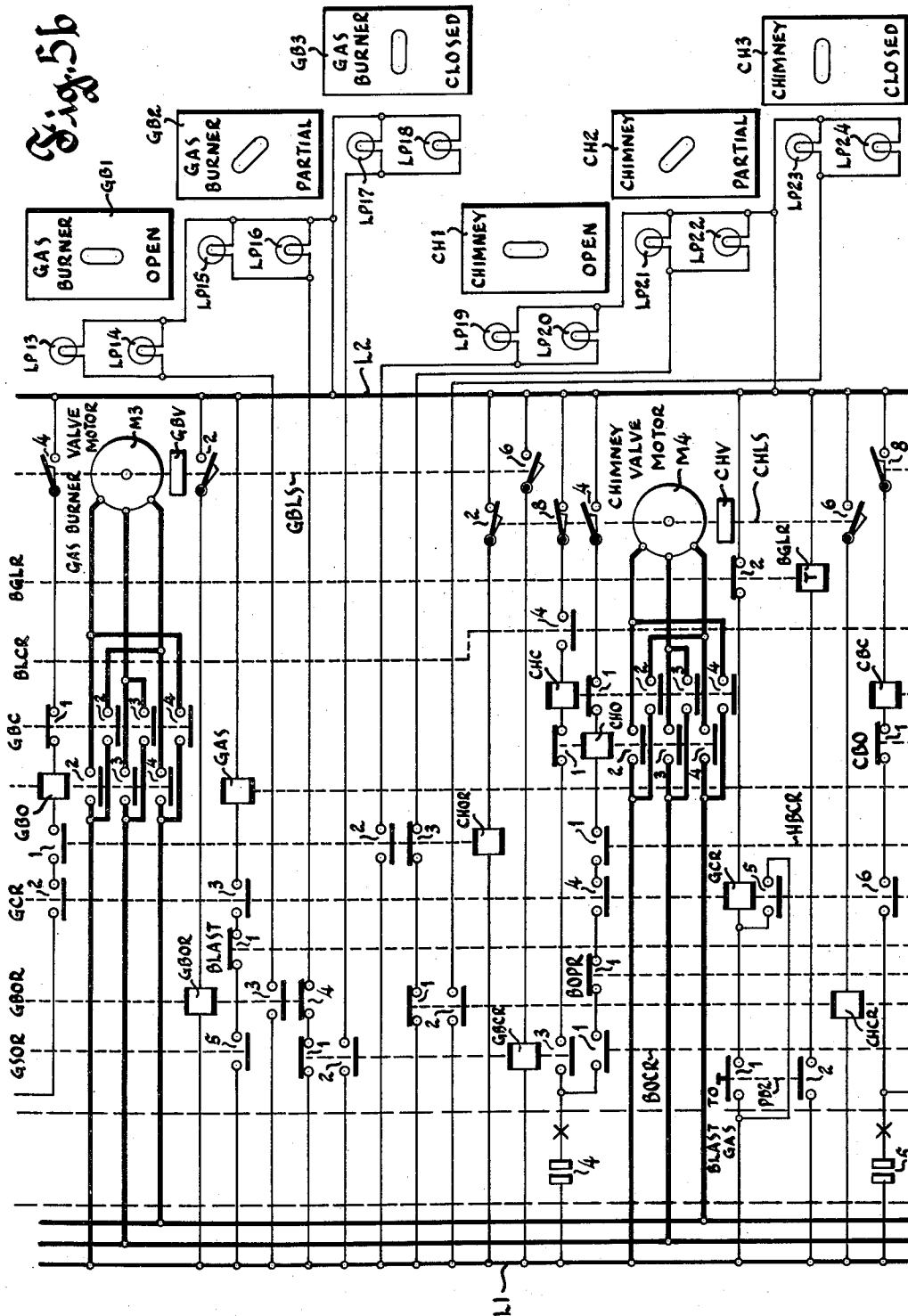
D. W. FATH ETAL

3,103,347

GRAPHIC SIGNALING AND INDICATING SYSTEM

Filed March 15, 1961

8 Sheets-Sheet 4



Sept. 10, 1963

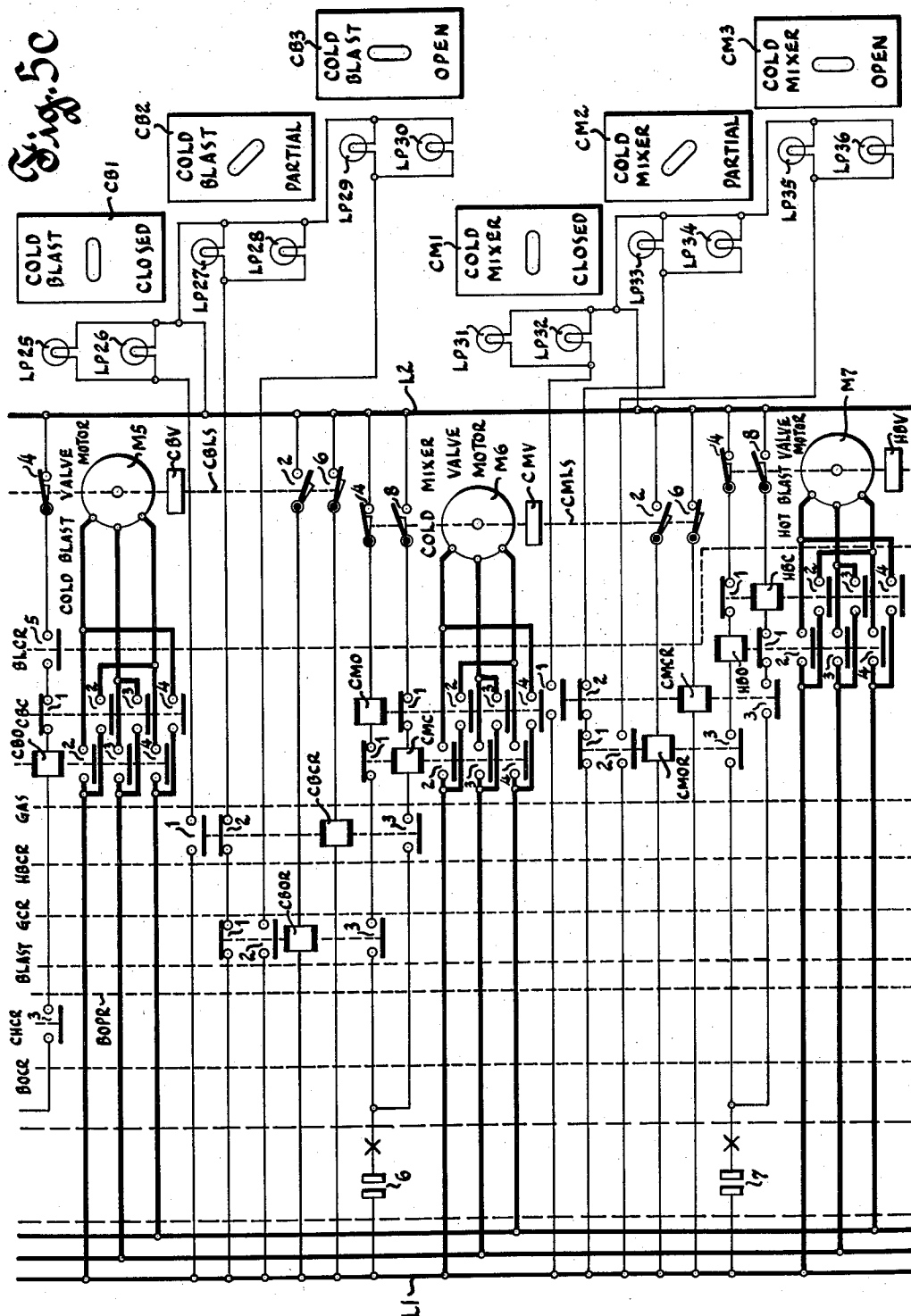
D. W. FATH ETAL

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GRAPHIC SIGNALING AND INDICATING SYSTEM

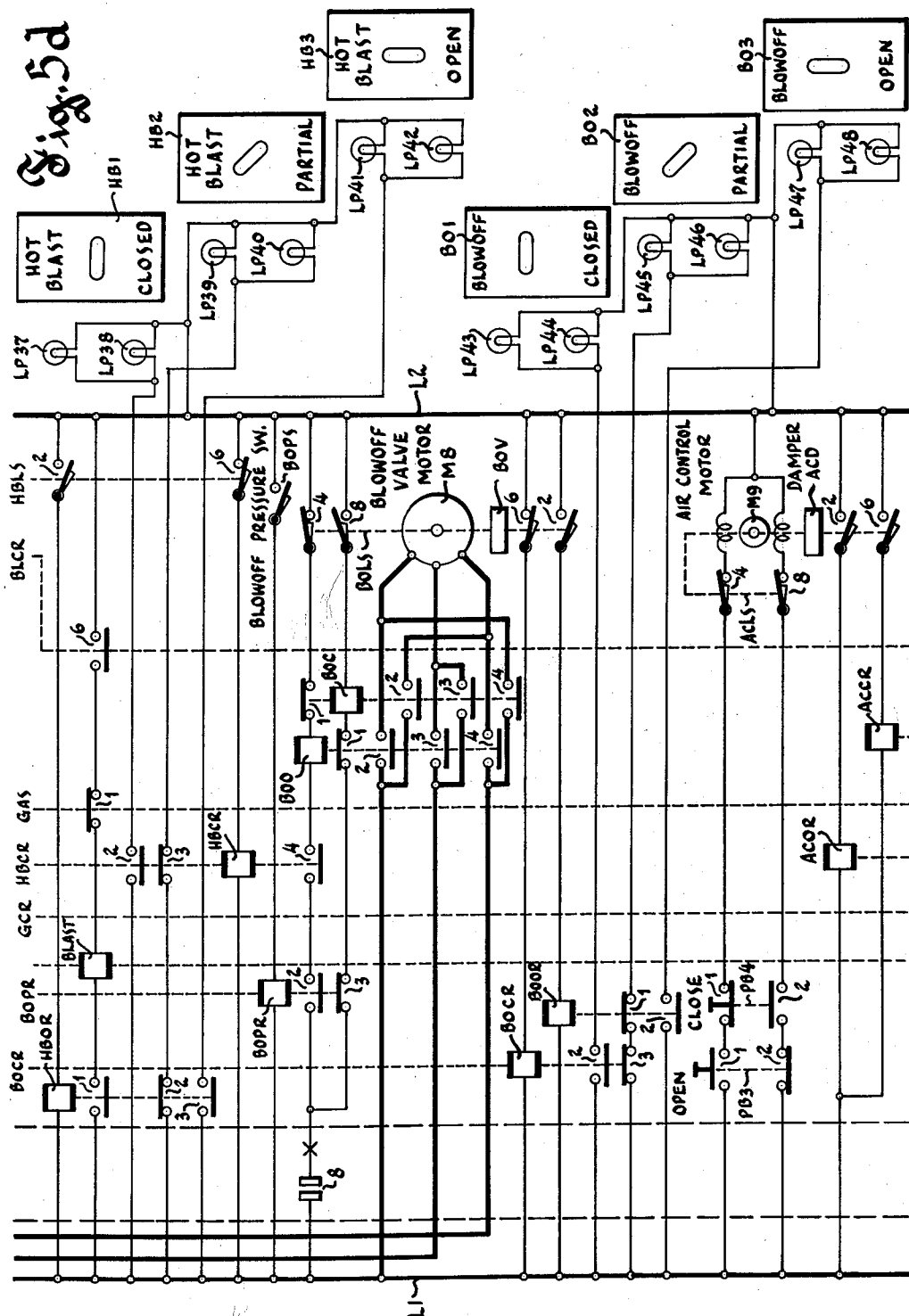
Filed March 15, 1961

8 Sheets-Sheet 5



3,103,347

8 Sheets-Sheet 6



Sept. 10, 1963

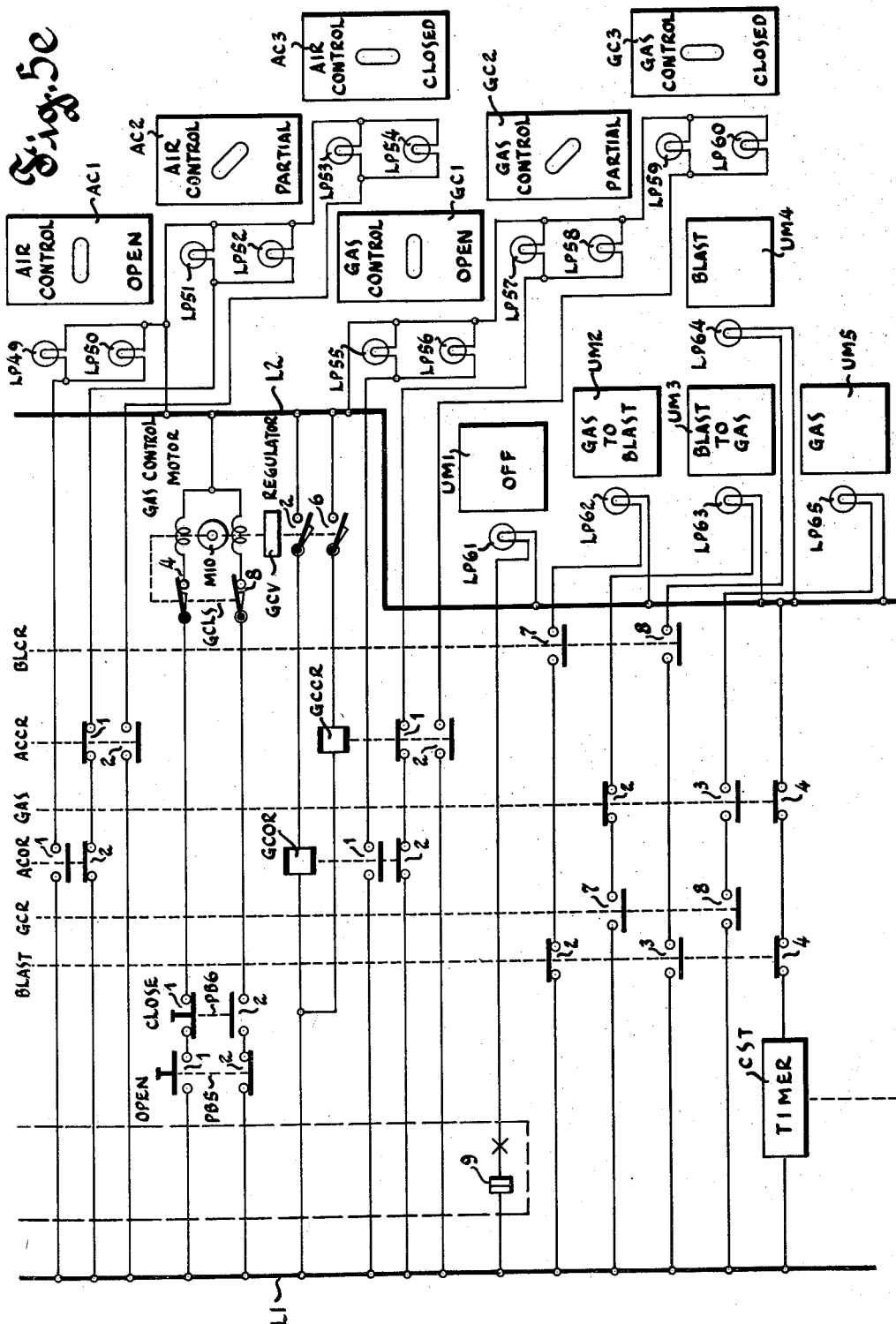
D. W. FATH ETAL

3,103,347

GRAPHIC SIGNALING AND INDICATING SYSTEM

Filed March 15, 1961

8 Sheets-Sheet 7



Sept. 10, 1963

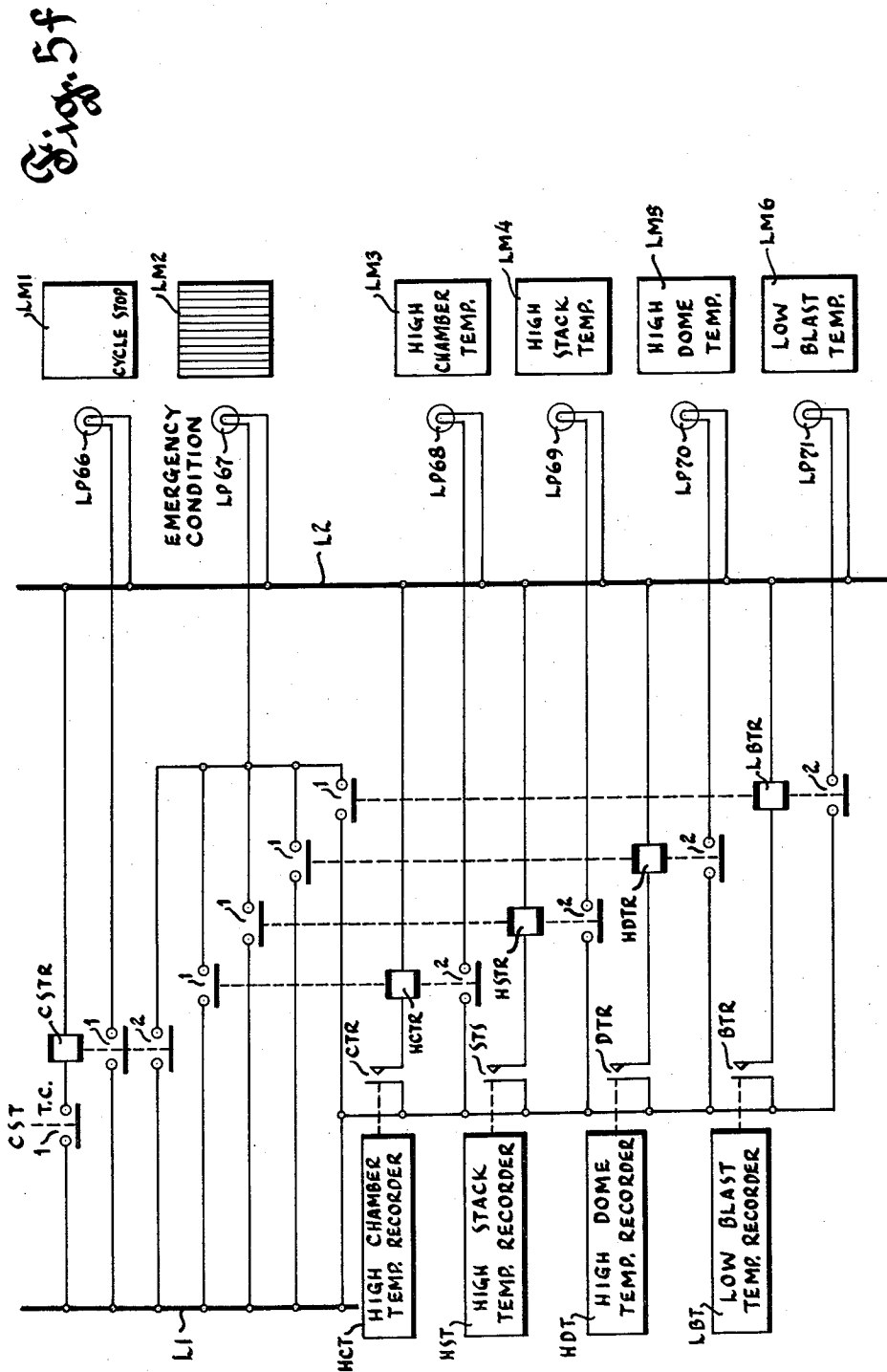
D. W. FATH ETAL

3,103,347

GRAPHIC SIGNALING AND INDICATING SYSTEM

Filed March 15, 1961

8 Sheets-Sheet 8



1

3,103,347

GRAPHIC SIGNALING AND INDICATING SYSTEM

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Filed Mar. 15, 1961, Ser. No. 95,964

7 Claims. (Cl. 263—19)

This invention relates to graphic signaling and indicating systems and to control systems therefor.

While not limited thereto, the invention is especially applicable to heating stove changing and control systems for blast furnaces and the like for graphic diagram representation of a plurality of stove operations and conditions and for indication of a variable plurality of stove changing operations the sequence of which may be selectively controlled.

In the operation of a blast furnace for converting iron ore into pig iron, the furnace is charged with certain materials, the principal ones of which are iron ore, coke and limestone. The coke is burned as a fuel to heat the iron ore and to melt the latter into liquid iron. The limestone is used as a purifying or purging material. It takes up impurities from the iron ore and forms liquid slag which is lighter than and floats on top of the liquid iron.

In order to cause the coke to burn at a sufficiently high temperature and to produce sufficient heat to cause the iron ore to melt into liquid iron, it is necessary to blow air into the furnace at the lower portion thereof. For best results, this air must be preheated before it is blown into the furnace. This is known as the hot air blast. For this purpose and because a blast furnace operates continuously, the furnace is provided with a plurality of stoves so that while one stove is being used to produce the hot air blast, the other stoves can be heated. Each stove is provided with an open brickwork called checkers and a gas burner. When the stove is in its gas condition, gas is burned therein to heat the checkers. When the stove is changed to its blast condition, cold air is forced into the stove and through the hot checkers thereof to preheat the air and is then driven into the furnace.

The gas which is burned to heat the stoves is obtained from the blast furnace. A large portion of the gas produced in the furnace is hot carbon monoxide gas which is released by the burning coke and is an excellent fuel. Some of this hot gas is mixed with air and is then fed to the gas burner at the bottom of the stove and is burned in the stove to heat the checkers. The stove gas burner is connected to a gas main or conduit and also to an air main, that is, a source of combustion air. The stove is also connected with a chimney and a blow-off device, the latter being used for equalizing the pressure inside and outside the stove.

Each stove is connected to a cold blast line or conduit and the latter is connected to a blower whereby cold air is forced into the stove. The stove is provided with a mixing chamber which is connected to a hot blast line or conduit and therethrough to the furnace. The mixing chamber is also connected to a cold mixer line for mixing cold air with the hot air to maintain the hot air blast at the proper temperature.

Each of the aforementioned connections is provided with a valve for closing and opening the same. The gas connection is also provided with a gas control regulator such as a butterfly valve for regulating the flow of gas. The air connection to the gas burner is provided with a stove fan for forcibly mixing combustion air with the gas and is provided with an air control damper for controlling the flow of combustion air. The aforementioned valves

2

must be operated in one sequence to change the stove from its gas condition to its blast condition and must be operated in another sequence to change the stove from its blast condition to its gas condition.

As the aforementioned stoves are provided with automatic control means for operating the valves in the proper sequences to change each stove from one condition to another and are also normally provided with individual manual control means disclosed in T. Kraschinsky and G. C. Lutsch copending application Serial No. 96,027, filed March 15, 1961, now Patent No. 3,062,521, issued November 11, 1962, for operating each valve, it has been found desirable to provide graphic signaling and indicating means to afford the viewer a diagram representation of the operating condition of each stove. This is particularly desirable so that the operator can see at a glance the condition of each stove and the condition of each valve on each stove before initiating a change in the condition thereof.

An object of the invention is to provide improved graphic signaling and indicating means.

Another object of the invention is to provide improved graphic indicating means affording diagram representations of diverse operating conditions of a plurality of parts of a selectively operable system.

A further object of the invention is to provide the aforementioned graphic indicating and signaling means with improved control means.

A more specific object of the invention is to provide improved graphic indicating means for exhibiting selected operating conditions of a heating stove and control means therefor.

Another specific object of the invention is to provide improved means for graphically indicating in a plurality of steps operation of a heating stove through its operating cycles.

Another specific object of the invention is to provide improved signaling and graphic indicating means having exhibiting elements arranged according to and likened to the operating elements of a heating stove system.

Another specific object of the invention is to provide, in a plural-stove stove-changing system, improved signaling and graphic indicating means for indicating the operating steps of a plurality of stove-changing control devices in accordance with their sequence of operation and arranged so as to readily indicate the operating condition of each stove in the system.

According to the invention, there is provided for a plural-stove stove-changing system operating in conjunction with a blast furnace, an indicator panel for each stove. Each such panel is provided with a diagram representation of a stove and a plurality of conduit connections to the stove. These conduit connections are provided with stove indicator devices for exhibiting signals and graphic valve and regulating element indications of the closed and the open and the transition conditions of the valves and regulating elements. There is also provided on each such panel a main indicator device for exhibiting a summary indication of the operating condition of the respective stove. Each such main indicator device further includes means for exhibiting emergency conditions of the respective stove. There is also provided a control system for operating the stove control valves, regulators and devices and concurrently for operating the aforementioned indicator devices therefor.

The above mentioned and other objects and advantages of the invention and the manner of obtaining them will become more apparent and the invention itself will be best understood by reference to the following description of an embodiment thereof taken in conjunction with the accompanying drawings, wherein:

FIGURE 1 is a schematic illustration of a plural-stove heating stove system for a blast furnace;

FIG. 2 shows a front view of an indicator panel having a graphic representation of a heating stove and connections thereto and signaling and graphic indicating devices representing stove control elements showing the stove in its gas condition;

FIG. 3 is a front view of an indicator panel similar to that of FIG. 2 except showing the stove in its blast condition;

FIG. 4 is a top sectional view of a graphic signaling and indicating device used on the indicator panel in FIGS. 2 and 3; and

FIGS. 5a through 5f, when arranged in alphabetical sequence from top to bottom, show an automatic control system for one stove for operating the stove control and indicator devices.

Referring to FIG. 1, there is shown schematically a plural-stove system for a blast furnace. A blower B is connected through a cold blast conduit or line CBL to stoves Nos. 1, 2 and 3 in parallel. Stoves Nos. 1, 2 and 3 are connected through a hot blast conduit or line HBL to a blast furnace BF. It will be apparent that with this arrangement any one of the stoves may be utilized to supply hot air to the blast furnace while the remaining stoves are being heated.

FIG. 2 shows an indicator panel for stove No. 1, the indicator panels for the other stoves being similar. The indicator panel is preferably constructed of metallic material or insulating material such as formica or the like. The stove graphic symbol or figure SS and the igniter symbol IS and the symbols representing connections to the cold blast line, the hot blast line, the cold mixer line, the air supply line and the gas main are preferably formed of plastic or metallic sheet material secured to the front face of the indicator panel. The indicator panel is provided with a plurality of rectangular apertures AP so that the indicators which are mounted on the back of the panel can be seen from the front thereof. The stove indicators include a chimney valve indicator CH, a cold blast valve indicator CB, a cold mixer valve indicator CM, a hot blast valve indicator HB, a gas burner valve indicator GB, a blowoff valve indicator BO, an air control valve or damper indicator AC, a stove fan indicator SF, a gas shutoff valve indicator GS and a gas control regulator or butterfly valve indicator GC. In addition, stove symbol SS includes a symbolic mixing chamber MC and there are superimposed at the center of the stove symbol an upper main indicator UM for indicating the operating conditions of the stove and a lower main indicator LM for indicating emergency conditions of the stove. The strips ST on the indicator panel connecting the stove indicators and devices to one another and to the stove are preferably formed of plastic or metallic strip material secured to the face of the indicator panel.

The line GI in the center of each valve indicator represents a graphic indication of the valve position. For example, with respect to chimney valve indicator CH which is located on a vertical stripe or strip ST representing a conduit, the vertical line GI shown in FIG. 2 graphically shows that the valve is open as it is in line with the associated strip ST. When such line GI on chimney valve indicator CH is transverse to its associated strip ST, it graphically depicts a closed valve as shown in FIG. 3. When line GI is at a 45 degree angle with its associated strip ST, it graphically depicts a transition condition, that is, either an opening or a closing valve. In FIGS. 2 and 3, the air control damper and the gas control regulator graphic indicators are shown at a 45 degree angle to indicate that such damper and regulator are partially open. As will be apparent from the indicators, in FIG. 2 the stove is shown in its gas condition whereas in FIG. 3 the stove is shown in its blast condition.

Referring to FIG. 4, there is shown a top sectional view

of an indicator or projector such as for example, the upper main indicator UM or the lower main indicator LM in FIGS. 2 and 3. The indicator is provided with four vertical columns of lamps there being three lamps LP in each column. The lamps LP are removably mounted in sockets 2 at the left-hand end of an elongated enclosure 4 which is rectangular in cross-section. The transparent envelope portions of lamps LP extend into holes 6 in an opaque and relatively thick light shielding plate 8 mounted transversely within enclosure 4. Immediately on the right-hand side of lamps LP there is provided a lens network including a member carrying graphic symbols and indicia through which the light beams of lamps LP pass to project images on the screen 10 at the right-hand end of enclosure 4. This lens network comprises a first plate 12 curved into the form of a partial sphere and having mounted on the right-hand concave surface thereof a plurality of convex lenses 14 one for each lamp LP. A second plate 16 is mounted to the right of and in spaced relation to plate 12 transversely of enclosure 4. Plate 16 is also curved into the form of a partial sphere and has mounted on the left-hand convex surface thereof a like plurality of convex lenses 18. The right-hand surface of plate 16 has secured thereto a graphic symbol and indicia sheet 20. Sheet 20 is a photo negative or the like which is opaque except for the graphic symbols and indicia which are transparent. A third plate 22 is mounted to the right of and in properly spaced relation to plate 16 transversely of the enclosure. Plate 22 is formed of two laminations. The left-hand lamination 24 is curved into the form of a partial sphere and in the same direction as plates 12 and 16 are curved and has secured to the right-hand concave surface a like plurality of convex lenses 26, portions of which can be seen through such laminations in FIG. 4. The right-hand lamination 28 is an opaque plate having a like plurality of holes therein. This system of lenses is arranged so that the graphic valve symbols and indicia are projected on particular parts of the screen 10 and to prevent superimposing thereof on one another.

One indicator such as shown in FIG. 4 is used for each of upper main indicator UM and lower main indicator LM in FIGS. 2 and 3. One such indicator is also used for indicator pairs CH—CB, CM—HB, GB—BO, AC—SF and GS—GC. However, as will be apparent, stove fan indicator SF does not require any graphic symbol. Lower main indicator LM also differs in its construction to provide for the red background emergency condition indication LM2 shown in FIG. 5f and hereinafter described in connection therewith. To provide for this indication, sheet 20 in indicator LM is provided with a transparent or cut-off portion for its associated lamp LP67 shown in FIG. 5f and being rectangular to correspond to the shape of screen 10. Also, the associated hole in lamination 28 of plate 22 is covered with red colored glass or the like. All of the details of the indicator of FIG. 4 have not been shown to avoid complicating the drawings. This indicator is of a well known rear-projection type in-line digital display device manufactured by Industrial Electronics Engineers, Inc. and identified as Model No. 80,000.

Referring to FIGS. 5a through 5f, there is shown a control system for operating stove No. 1. The control systems for operating stoves Nos. 2 and 3 or as many stoves as may be desired are similar and therefore have not been shown to avoid duplication. The manner in which FIGS. 5a through 5f connect to one another will be apparent when they are arranged in order from top to bottom.

The control system is energized from a three-phase alternating current power supply source represented by power supply lines L1, L2 and L3 extending down the left-hand sides of FIGS. 5a through 5d. The system is provided with an operation selector switch OS shown in its off condition and which must be turned on before the

5

system can be operated to control the stove. Selector switch OS is provided with normally open contacts 1, 2 and 4 through 8 in the circuits of the reversing contactors of the valve motors, a normally open contact 3 in the circuit of the stove fan main contactor and a normally closed contact 9 for signaling purposes.

Means are provided in the control system which respond to pressing of one pushbutton switch to automatically change the stove from its gas condition to its blast condition in the proper sequence of operation. Means are also provided which respond to pressing another pushbutton switch to automatically change the stove from its blast condition to its gas condition. For these purposes, the system is provided with a gas to blast pushbutton switch PB1 in FIG. 5a and a blast to gas pushbutton switch PB2 in FIG. 5b.

The system is provided with eight three-phase alternating current motors for operating the respective valves and the stove fan and two single-phase alternating current motors for operating the air control damper and the gas control regulator.

Gas shutoff valve GSV shown in FIG. 5a is provided with an operating motor M1 having reversing contactors including a gas shutoff opening contactor GSO provided with contacts 1 through 4 and a gas shutoff closing contactor GSC provided with contacts 1 through 4 for controlling opening and closing of the gas shutoff valve. Gas shutoff valve GSV is also provided with a graphic signaling and indicating devices GS shown in FIGS. 2 and 3 and control means for exhibiting indications GS1, GS2 or GS3 shown in FIG. 5a. These control means include a gas shutoff valve limit switch GSLS, a gas shutoff open relay GSOR and a gas shutoff closed relay GSCR. Graphic signaling and indicating devices GS is provided with gas shutoff valve indicator lamps LP1 through LP6. Limit switch GSLS is provided with contacts 2, 4, 6 and 8 for controlling contactors GSO and GSC and relays GSOR and GSCR. Relay GSOR is provided with contacts 1 through 5 for controlling gas shutoff valve indicator lamps LP1 through LP4 and for controlling a stove fan, as gas igniter IG and a gas condition indication control relay GAS hereinafter described. Relay GSCR is provided with contacts 1, 2 and 3 for controlling gas shutoff valve indicator lamps LP3 through LP6 and for controlling closure of a gas burner valve.

The stove fan, shown schematically in FIG. 5a, is provided with an operating motor M2 which in turn is controlled by a stove fan main contactor SFM. The stove fan is also provided with a signaling and indicating device SF shown in FIGS. 2 and 3 and control means for exhibiting indications SF1, SF2 and SF3 shown in FIG. 5a. These control means include an air flow limit switch AFLS and main contactor SFM. Indicator SF is provided with stove fan indicator lamps LP7 through LP12. Main contactor SFM is provided with contacts 1 through 6 for controlling gas shutoff opening contactor GSO, for controlling motor M2 and for controlling stove fan indicator lamps LP9 through LP12. Limit switch AFLS is provided with contacts 1, 2 and 3 for controlling stove fan indicator lamps LP7 through LP12 and these contacts are shown in the positions they assume when the stove fan is running, that is, contact 1 closed and contacts 2 and 3 open, this being apparent because application of power to lines L1 and L2 will energize lamps LP7 and LP8 to exhibit stove fan On indication SF1.

Gas burner valve GBV shown in FIG. 5b is provided with an operating motor M3 having reversing contactors including a gas burner opening contactor GBO provided with contacts 1 through 4 and a gas burner closing contactor GBC provided with contacts 1 through 4 for controlling opening and closing of the gas burner valve. Gas burner valve GBV is also provided with a graphic signaling and indicating device GB shown in FIGS. 2 and 3 and control means for exhibiting indications GB1, GB2 and GB3 shown in FIG. 5b. These control means in-

6

clude a gas burner valve limit switch GBLS, a gas burner open relay GBOR and a gas burner closed relay GBCR. Graphic signaling and indicating device GB is provided with gas burner valve indicator lamps LP13 through LP18. Limit switch GBLS is provided with contacts 2, 4, 6 and 8 for controlling contactors GBO and GBC and relays GBOR and GBCR. Relay GBOR is provided with contacts 1 through 4 for controlling stove fan main contactor SFM, stove fan failure indicator lamps LP11 and LP12 and gas burner valve indicator lamps LP13 through LP16. Relay GBCR is provided with contacts 1, 2 and 3 for controlling gas burner valve indicator lamps LP15 through LP18 and for controlling closure of a chimney valve. An igniter IG is provided for igniting the gas.

Chimney valve CHV shown in FIG. 5b is provided with an operating motor M4 having reversing contactors including a chimney opening contactor CHO provided with contacts 1 through 4 and a chimney closing contactor CHC provided with contacts 1 through 4 for controlling opening and closing of the chimney valve. Chimney valve CHV is also provided with a graphic signaling and indicating device CH shown in FIGS. 2 and 3 and control means for exhibiting indications CH1, CH2 and CH3 shown in FIG. 5b. These control means include a chimney valve limit switch CHLS, a chimney open relay CHOR and a chimney closed relay CHCR. Graphic signaling and indicating devices CH is provided with chimney valve indicator lamps LP19 through LP24. Limit switch CHLS is provided with contacts 2, 4, 6 and 8 for controlling contactors CHO and CHC and relays CHOR and CHCR. Relay CHOR is provided with contacts 1, 2 and 3 for controlling gas burner valve opening contactor GBO and chimney valve indicator lamps LP19 through LP22. Relay CHCR is provided with contacts 1, 2 and 3 for controlling chimney valve indicator lamps LP21 through LP24 and for controlling opening of a cold blast valve.

Cold blast valve CBV shown in FIG. 5c is provided with an operating motor M5 having reversing contactors including a cold blast opening contactor CBO provided with contacts 1 through 4 and a cold blast closing contactor CBC, shown in FIG. 5b, provided with contacts 1 through 4 for controlling opening and closing of the cold blast valve. Cold blast valve CBV is also provided with a graphic signaling and indicating device CB shown in FIGS. 2 and 3 and control means for exhibiting indications CB1, CB2 and CB3 shown in FIG. 5c. These control means include a cold blast valve limit switch CBLS, a cold blast open relay CBOR and a cold blast closed relay CBCR. Graphic signaling and indicating device CB is provided with cold blast valve indicator lamps LP25 through LP30. Limit switch CBLS is provided with contacts 2, 4, 6 and 8, shown in FIGS. 5b and 5c, for controlling contactors CBO and CBC and relays CBOR and CBCR. Relay CBOR is provided with contacts 1, 2 and 3 for controlling cold blast valve indicator lamps LP27 through LP30 and for controlling opening of a cold mixer valve. Relay CBCR is provided with contacts 1, 2 and 3 for controlling cold blast valve indicator lamps LP25 through LP28 and for controlling closure of the cold mixer valve.

Cold mixer valve CMV shown in FIG. 5c is provided with an operating motor M6 having reversing contactors including a cold mixer opening contactor CMO provided with contacts 1 through 4 and a cold mixer closing contactor CMC provided with contacts 1 through 4 for controlling opening and closing of the cold mixer valve. Cold mixer valve CMV is also provided with a graphic signaling and indicating device CM shown in FIGS. 2 and 3 and control means for exhibiting indications CM1, CM2 and CM3 shown in FIG. 5c. These control means include a cold mixer valve limit switch CMLS, a cold mixer open relay CMOR and a cold mixer closed relay CMCR. Graphic signaling and indicating device CM is provided with cold mixer valve indicator lamps LP31

through LP36. Limit switch CMLS is provided with contacts 2, 4, 6 and 8 for controlling contactors CMO and CMC and relays CMOR and CMCR. Relay CMOR is provided with contacts 1, 2 and 3 for controlling cold mixer valve indicator lamps LP33 through LP36 and for controlling opening of a hot blast valve. Relay CMCR is provided with contacts 1, 2 and 3 for controlling cold mixer valve indicator lamps LP31 through LP34 and for controlling closure of the hot blast valve.

Hot blast valve HBV shown in FIG. 5c is provided with an operating motor M7 having reversing contactors including a hot blast opening contactor HBO provided with contacts 1 through 4 and a hot blast closing contactor HBC provided with contacts 1 through 4 for controlling opening and closing of the hot blast valve. Hot blast valve HBV is also provided with a graphic signaling and indicating device HB shown in FIGS. 2 and 3 and control means for exhibiting indications HB1, HB2 and HB3 shown in FIG. 5d. These control means include a hot blast valve limit switch HBLS shown in FIGS. 5c and 5d, a hot blast open relay HBOR and a hot blast closed relay HBCR shown in FIG. 5d. Graphic signaling and indicating device HB is provided with hot blast valve indicator lamps LP37 through LP42. Limit switch HBLS is provided with contacts 2, 4, 6 and 8 shown in FIGS. 5c and 5d for controlling contactors HBO and HBC and relays HBOR and HBCR. Relay HBOR is provided with contacts 1, 2 and 3 for controlling a main blast indication control relay hereinafter described and for controlling hot blast valve indicator lamps LP39 through LP42. Relay HBCR is provided with contacts 1 through 4 for controlling chimney valve opening contactor CHO, for controlling hot blast valve indicator lamps LP37 through LP40 and for controlling a blowoff valve opening contactor hereinafter described.

Each stove is provided with a blowoff pressure switch BOPS shown in FIG. 5d which closes when the pressure within the stove chamber reaches a predetermined high value and which reopens when such high pressure is relieved. Switch BOPS controls a blowoff pressure relay BOPR having contacts 1, 2 and 3 for controlling chimney valve opening contactor CHO and the opening and reclosure of a blowoff valve.

Blowoff valve BOV shown in FIG. 5d is provided with an operating motor M8 having reversing contactors including a blowoff valve opening contactor BOO provided with contacts 1 through 4 and a blowoff valve closing contactor BOC provided with contacts 1 through 4 for controlling opening and closing of the blowoff valve. Blowoff valve BOV is also provided with a graphic signaling and indicating device BO shown in FIGS. 2 and 3 and control means for exhibiting indications BO1, BO2 and BO3 shown in FIG. 5d. These control means include a blowoff valve limit switch BOLS, a blowoff open relay BOOR and a blowoff closed relay BOCR. Graphic signaling and indicating device BO is provided with blowoff valve indicator lamps LP43 through LP48. Limit switch BOLS is provided with contacts 2, 4, 6 and 8 for controlling contactors BOO and BOC and relays BOOR and BOCR. Relay BOOR is provided with contacts 1 and 2 for controlling blowoff valve indicator lamps LP45 through LP48. Relay BOCR is provided with contacts 1, 2 and 3 for controlling chimney valve opening contactor CHO and for controlling blowoff valve indicator lamps LP43 through LP46.

Air control damper ACD shown in FIG. 5d is provided with an operating motor M9 of the single-phase reversing type. The motor is provided with an Open pushbutton switch PB3 having contacts 1 and 2 for controlling the motor in a first direction to operate the air control damper in the opening direction and a Close pushbutton switch PB4 having contacts 1 and 2 for controlling the motor in a reverse direction to operate the air control damper in the closing direction. Air control damper

ACD is also provided with a graphic signaling and indicating device AC shown in FIGS. 2 and 3 and control means for exhibiting indications AC1, AC2 and AC3 shown in FIG. 5e. These control means include an air control damper limit switch ACLS, an air control open relay ACOR and an air control closed relay ACCR. Graphic signaling and indicating device ACP is provided with air control damper indicator lamps LP49 through LP54. Limit switch ACLS is provided with contacts 2, 4, 6 and 8 for controlling reversing of motor M9 and for controlling relays ACOR and ACCR. Relay ACOR is provided with contacts 1 and 2 for controlling air control damper indicator lamps LP49 through LP52. Relay ACCR is provided with contacts 1 and 2 for controlling air control damper indicator lamps LP51 through LP54.

Gas control regulator GCR shown in FIG. 5e is provided with an operating motor M10 of the single-phase reversing type. The motor is provided with an Open pushbutton switch PB5 having contacts 1 and 2 for controlling the motor in a first direction to operate the gas control regulator in the opening direction and a Close pushbutton switch PB5 having contacts 1 and 2 for controlling the motor in the reverse direction to operate the gas control regulator in the closing direction. Gas control regulator GCR is also provided with a graphic signaling and indicating device GC shown in FIGS. 2 and 3 and control means for exhibiting indications GC1, GC2 and GC3 shown in FIG. 5e. These control means include a gas control regulator limit switch GCLS, a gas control open relay GCOR and a gas control closed relay GCCR. Graphic signaling and indicating device GC is provided with gas control regulator indicator lamps LP55 through LP60. Limit switch GCLS is provided with contacts 2, 4, 6 and 8 for controlling reversing of motor M10 and for controlling relay GCOR and GCCR. Relay GCOR is provided with contacts 1 and 2 for controlling gas control regulator indicator lamps LP55 through LP58. Relay GCCR is provided with contacts 1 and 2 for controlling gas control regulator indicator lamps LP57 through LP60.

Upper main indicator UM shown in FIGS. 2 and 3 is provided with lamps LP61 through LP65 for exhibiting indications UM1 through UM5 shown in FIG. 5e. Lower main indicator LM shown in FIGS. 2 and 3 is provided with lamps LP66 through LP71 for exhibiting indications LM1 through LM6 in FIG. 5f. Control means are provided for controlling lamps LP61 through LP65 to operate upper main indicator UM. These control means include contact 9 of operation selector switch OS and contacts of certain relays common to the system hereinafter described. Control means are also provided for controlling lamps LP66 through LP71 to operate lower main indicator LM. These control means include a cycle stopped timer CST and a cycle stopped timer relay CSTR, a high chamber temperature recorder HCT and a high chamber temperature relay HCTR, a high stack temperature recorder HST and a high stack temperature relay HSTR, a high dome temperature recorder HDT and a high dome temperature relay HDTR, and a low blast temperature recorder LBT and a low blast temperature relay LBTR.

Cycle stopped timer CST is provided with a timed closing contact 1 for controlling relay CSTR. Relay CSTR is provided with contacts 1 and 2 for controlling lower main indicator lamps LP66 and LP67, respectively. Recorder HCT is provided with a switch CTR for controlling relay HCTR and the latter is provided with contacts 1 and 2 for controlling lower main indicator lamps LP67 and LP68, respectively. Recorder HST is provided with a switch STR for controlling relay HSTR and the latter is provided with contacts 1 and 2 for controlling lower main indicator lamps LP67 and LP69, respectively. Recorder HDT is provided with a switch DTR for controlling relay HDTR and the latter is provided with contacts 1 and 2 for controlling lower main indicator lamps LP67 and LP70, respectively. Recorder LBT is pro-

vided with a switch BTR for controlling relay LBTR and the latter is provided with contacts 1 and 2 for controlling lower main indicator lamps LP67 and LP71, respectively.

Each stove control system is also provided with control devices common to each such control system for controlling operation of the aforementioned stove elements in the proper sequences to change the stove from gas to blast and to change the stove from blast to gas. These control devices include a main (blast) indication control relay BLAST shown in FIG. 5d, a main (gas) indication control relay GAS shown in FIG. 5b, a blast control relay BLCR shown in FIG. 5a, a gas control relay GCR shown in FIG. 5b and a blast and gas latching relay BGLR shown in FIG. 5a. Relay BLAST is provided with contacts 1 through 4 for controlling main (gas) indication control relay GAS, upper main indicator lamps LP62 and LP64 and cycle stopped timer CTS. Relay GAS is provided with contacts 1 through 4 for controlling main (blast) indication control relay BLAST, upper main indicator lamps LP63 and LP65 and cycle stopped timer CST. Relay BLCR is provided with contacts 1 through 8 for controlling gas shutoff closing contactor GSC, a maintaining circuit for its own operating coil, gas burner closing contactor GBC, chimney closing contactor CHC, cold blast opening contactor, main (blast) indication control relay BLAST and upper main indicator lamps LP62 and LP64. Relay GCR is provided with contacts 1 through 8 for controlling stove fan main contactor SFM, gas burner opening contactor GBO, main (gas) indication control relay GAS, chimney opening contactor CHO, a maintaining circuit for its own operating coil, cold blast closing contactor CBC and upper main indicator lamps LP63 and LP65. Latching relay BGLR is provided with contacts 1 and 2 for controlling relays BLCR and GCR, respectively. Latching relay BGLR is of the well known type having a closing coil C and a tripping coil T. Latching relay BGLR is shown in its tripped condition wherein contact 1 is open and contact 2 is closed. Contact 1 will close and contact 2 will open when closing coil C is energized and the relay will latch in this position. When tripping coil T is energized, contact 1 will reopen and contact 2 will reclose and the relay will latch in this position until the closing coil is again energized.

All the contactors and relays in the system of FIGS. 5a through 5f are shown in their deenergized condition. Also, the contacts thereof are shown in the positions that they assume when the corresponding contactors and relays are deenergized.

The conditions of the stove control valves, the igniter, the stove fan, the air control damper and the gas control regulator when the stove is in its gas condition and also when the stove is in its blast condition are as follows:

	Gas Condition	Blast Condition
Gas shutoff valve GSV.....	open.....	closed.
Igniter IG.....	on-off.....	off.
Stove fan SF.....	on.....	Do.
Gas burner valve GBV.....	open.....	closed.
Chimney valve CHV.....	do.....	Do.
Cold blast valve CBV.....	closed.....	open.
Cold mixer valve CMV.....	do.....	Do.
Hot blast valve HBV.....	do.....	Do.
Blowoff valve BOV.....	do.....	closed.
Air control damper ACD.....	partial or open.....	
Gas control regulator GCV.....	do.....	

The valve operated limit switches in FIGS. 5a through 5d, the air flow limit switch in FIG. 5a, the air control damper limit switch in FIG. 5d, and the gas control regulator limit switch in FIG. 5e are shown in the positions they assume when the stove is in its gas condition for convenience of description of operation. That is, the contacts of gas shutoff valve limit switch GSVLS, gas burner valve limit switch GBLS and chimney valve limit switch CHLS are shown in the positions they assume when these valves are fully open; the contacts of cold blast valve

limit switch CBLS, cold mixer valve limit switch CMLS, hot blast valve limit switch HBLS and blowoff valve limit switch BOLS are shown in the positions they assume when these valves are fully closed; the contacts of air flow limit switch AFLS are shown in the positions they assume when the stove fan is on; the contacts of air control damper limit switch ACLS are shown in the positions they assume when the air control damper is partially open; and the contacts of gas control regulator limit switch GCLS are shown in the positions they assume when the gas control regulator is partially open.

The operation of the system will now be described.

Let it be assumed that three-phase electrical power is connected to power supply lines L1, L2 and L3 in the upper left-hand portion of FIG. 5a. Let it also be assumed that operation selector switch OS is turned to its On position so that contacts 1 through 8 thereof are closed and contact 9 thereof is open. Let it further be assumed that stove No. 1 in FIG. 1 is in its gas condition as schematically indicated in FIG. 2 and that it is desired to change such stove to its blast condition as schematically indicated in FIG. 3.

In the gas condition of stove No. 1, its gas shutoff valve is open, its igniter has ignited the gas burner and has returned to its off condition, its gas burner valve is open, its chimney valve is open, its cold blast valve and cold mixer valve and hot blast valve are closed, its stove fan is on, its blowoff valve is closed, its air control damper is partially open and is capable of being regulated and its gas control regulator or butterfly valve is partially open and is capable of being regulated.

Referring to the circuit diagram in FIGS. 5a through 5f, in this gas condition, gas shutoff open relay GSOR, stove fan main contactor SFM, gas burner open relay GBOR, gas relay GAS, chimney open relay CHOR, gas control relay GCR, cold blast closed relay CBOR, cold mixer closed relay CMCR, hot blast closed relay HBCR and blowoff closed relay BOCR are energized. Consequently, the normally open contacts of each such relay and contactor are closed and the normally closed contacts thereof are open. Blast and gas latching relay BGLR is in its tripped condition wherein contact 1 is open and contact 2 thereof is closed. The manner in which the aforementioned relays are energized and their sequence of energization will become apparent from the following description entitled "Blast to Gas."

Gas to Blast

To change the stove from gas to blast, the stove must be pressurized before the hot blast valve is opened to prevent reverse flow into the stove from the hot blast line. To this end, first the gas shutoff valve is closed, the stove fan is stopped, the gas burner valve is closed and the chimney valve is closed. Next the cold blast valve and the cold mixer valve are opened in that order to pressurize the stove in response to the blower forcing cold air therein. Finally, the hot blast valve is opened to permit the hot blast air to be driven into the blast furnace.

To change the stove from its gas condition, wherein the stove is being heated, to its blast condition wherein air is passed through the hot stove to the hot blast line to preheat the air before it is introduced into the blast furnace, pushbutton switch PB1 in FIG. 5a is momentarily pressed. Normally open contacts 1 and 2 of pushbutton switch PB1 close. Contact 2 of switch PB1 energizes closing coil C of blast and gas latched relay BGLR to close contact 1 and to open contact 2 of the latter. Closure of contact 1 of relay BGLR causes energization of blast control relay BLCR through contact 1 of pushbutton switch PB1. Opening of contact 2 of relay BGLR deenergizes gas control relay GCR.

Deenergization of relay GCR opens its normally open contacts 1 through 8. Contact 1 of relay GCR opens a point in a parallel energizing circuit for contactor SFM

11

and contact 2 thereof opens a point in the circuit of contactor GBO. Contact 3 of relay GCR interrupts energization of relay GAS and contact 4 thereof opens a point in the circuit of contactor CHO. Contact 5 of relay GCR interrupts its self-maintaining circuit and contact 6 thereof opens a point in the circuit of contactor CBC. Contact 7 of relay GCR opens a point in the circuit of lamp LP63 and contact 8 thereof interrupts energization of lamp LP65 to extinguish upper main graphic indication UM5 (GAS).

Deenergization of relay GAS closes its normally closed contact 1 in the circuit of relay BLAST, closes its normally closed contact 2 in the circuit of lamp LP63 and opens its normally open contact 3 in the circuit of lamp LP65. Relay GAS also closes its normally closed contact 4 to complete a circuit through contact 4 of relay BLAST for cycle stopped timer CST to start the latter timing. However, as hereinafter described, relay BLAST energizes to interrupt timer CST before it has timed out.

Relay BLCR closes normally open contacts 1 through 8 thereof. Contact 2 of relay BLCR completes a self-maintaining circuit in shunt of contact 1 of pushbutton switch PB1 whereafter the latter may be released to allow it to reopen. Contact 1 of relay BLCR closes an energizing circuit for gas shutoff closing contactor GSC through contact 1 of operation selector switch OS, normally closed interlocking contact 4 of contactor GSO and contact 8 of gas shutoff valve limit switch GSLS. Contacts 3, 4 and 5 of relay BLCR close points in the circuits of contactors GBC, CHC and CBO, respectively. Contact 6 of relay BLCR closes a point in the circuit of main indication control relay BLAST. Contact 7 of relay BLCR completes an energizing circuit through normally closed contact 2 of relay BLAST for lamp LP62 of the upper main graphic indicator UM to exhibit indication UM2 (Gas to Blast), thereby to indicate that the stove is in the transition period wherein it is being changed from gas to blast. Contact 8 of relay BLCR completes a point in the circuit of lamp LP64.

The aforementioned energization of contactor GSC in the upper right-hand portion of FIG. 5a causes closure of contacts 1, 2 and 3 thereof to connect power supply lines L1, L2 and L3 to motor M1. As a result, gas shutoff valve motor M1 operates in a first direction to close gas shutoff valve GSV. Contactor GSC also opens its interlocking contact 4 to prevent concurrent energization of contactor GSO.

As the gas shutoff valve starts to close, contact 4 of limit switch GSLS closes in the circuit of contactor GSO and contact 2 of limit switch GSLS opens to deenergize gas shutoff open relay GSOR. As a result, contact 1 of the latter opens to deenergize lamps LP1 and LP2 to extinguish graphic indication GS1. Contact 2 thereof closes to complete an energizing circuit through contact 1 of relay GSCR to energize lamps LP3 and LP4 thereby to light gas shutoff graphic indicator GS shown in FIGS. 2 and 3 to exhibit graphic indication GS2 shown in FIG. 5a to indicate that the gas shutoff valve is partially open, that is, closing. Relay GSOR opens contact 3 to interrupt energization of stove fan motor main contactor SFM. Relay GSOR also opens contact 4 to interrupt the starting circuit of igniter IG and opens contact 5 in the circuit of relay GAS.

Contactor SFM opens contact 1 in the circuit of contactor GSO and opens contacts 2, 3 and 4 to disconnect motor M2 from power supply lines L1, L2 and L3 and thereby to stop the stove fan. Contactor SFM also closes contact 5 and opens contact 6. When the stove fan stops and the air flow decreases, air flow limit switch AFLS opens contact 1 and closes contacts 2 and 3 thereof. Contact 1 of limit switch AFLS interrupts energization of lamps LP7 and LP8 to extinguish indication SF1 and contact 2 thereof closes to energize lamps LP9 and LP10 through contact 5 of contactor SFM. This causes stove fan indicator SF to be lighted to exhibit indication SF2

12

to show that the stove fan is off. Contact 3 of limit switch AFLS closes without effect as contact 6 of contactor SFM is open.

When the gas shutoff valve reaches its fully closed position, contact 8 of limit switch GSLS opens to interrupt energization of contactor GSC and contact 6 of limit switch GSLS closes to energize relay GSCR. Contactor GSC opens contacts 1, 2 and 3 to deenergize and stop gas shutoff valve motor M1 and recloses contact 4 thereof in the circuit of contactor GSO.

Relay GSCR opens contact 1 to deenergize lamps LP3 and LP4 to extinguish indication GS2 and closes contact 2 to energize lamps LP5 and LP6 thereby to light graphic indicator GS to exhibit indication GS3, shown in FIG. 5a, to show that the gas shutoff valve is closed. Relay GSCR also closes contact 3 to energize contactor GBC in a circuit extending from line L1 through contact 3 of operation selector switch OS, contact 1 of contactor GBO, contact 3 of relay BLCR and contact 8 of limit switch GBLS to line L2. Contactor GBC opens contact 1 to prevent concurrent energization of contactor GBO and closes contacts 2, 3 and 4 to connect power supply lines L1, L2 and L3 to gas burner valve motor M3. As a result motor M3 closes gas burner valve GBV.

When the gas burner valve starts to close, contact 4 of limit switch GBLS closes in the circuit of contactor GBO and contact 2 of limit switch GBLS opens to interrupt energization of relay GBOR. Contacts 1, 2 and 3 of relay GBOR open and contact 4 thereof closes. Contact 3 of relay GBOR interrupts energization of lamps LP13 and LP14 to extinguish indication GB1 and contact 4 thereof completes an energizing circuit through contact 1 of relay GBCR to energize lamps LP15 and LP16. As a result, gas burner graphic indicator GB is lighted to exhibit indication GB2 to show that the gas burner valve is partially open or rather that the gas burner valve is in its transition period, that is, closing. Contact 1 of relay GBOR opens a point in the parallel circuit of stove fan motor main contactor SFM. Contact 2 of relay GBOR opens a point in the circuit of stove fan failure indication lamps LP11 and LP12.

When the gas burner valve reaches its fully closed position, contact 8 of limit switch GBLS opens and contact 6 of limit switch GBLS closes. Contact 8 of limit switch GBLS interrupts energization of contactor GBC whereupon the latter recloses contact 1 and reopens contacts 2, 3 and 4 to stop motor M3. Contact 6 of limit switch GBLS energizes relay GBCR across lines L1 and L2. Relay GBCR opens contact 1 to interrupt energization of lamps LP15 and LP16 to extinguish graphic indication GB2 and closes contact 2 to energize lamps LP17 and LP18. This causes gas burner valve indicator GB to be lighted to exhibit indication GB3 to show that the gas burner valve is closed. Relay GBCR also closes contact 3 to energize contactor CHC through contact 4 of operation selector switch OS, contact 1 of contactor CHO, contact 4 of relay BLCR and contact 8 of limit switch CHLS across lines L1 and L2.

Contactor CHC opens interlocking contact 1 to prevent concurrent energization of contactor CHO and closes contacts 2, 3 and 4 to connect power supply lines L1, L2 and L3 to chimney valve motor M4. As a result, motor M4 closes chimney valve CHV. When the chimney valve starts to close, contact 2 of limit switch CHLS opens and contact 4 thereof closes. Contact 2 of limit switch CHLS interrupts energization of relay CHOR whereupon the latter opens contacts 1 and 2 and closes contact 3. Contact 1 of relay CHOR opens a point in the circuit of contactor GBO. Contact 2 of relay CHOR interrupts energization of lamps LP19 and LP20 to extinguish graphic indication CH1 and contact 3 thereof energizes lamps LP21 and LP22 through contact 1 of relay CHCR. This causes chimney valve graphic indicator CH to be lighted to exhibit indication CH2 thereby

to indicate that the chimney valve is partially open or closing.

When the chimney valve is fully closed, contact 8 of limit switch CHLS is opened and contact 6 thereof is closed. Contact 8 of limit switch CHLS interrupts energization of contactor CHC whereupon the latter closes contact 1 and opens contacts 2, 3 and 4 to deenergize and stop motor M4. Contact 6 of limit switch CHLS energizes relay CHCR to open contact 1 and to close contacts 2 and 3 thereof. Contact 1 of relay CHCR interrupts energization of lamps LP21 and LP22 to extinguish indication CH2 and contact 2 thereof energizes lamps LP23 and LP24. As a result, chimney valve graphic indicator CH is lighted to exhibit indication CH3 to show that the chimney valve is fully closed. Contact 3 of relay CHCR completes an energizing circuit for contactor CBO through contact 5 of operation selector switch OS, contact 1 of contactor CBC, contact 5 of relay BLCR and contact 4 of limit switch CBLS across lines L1 and L2.

Contact 1 of relay CHCR opens interlocking contact 1 to prevent concurrent energization of contactor CBC and closes contacts 2, 3 and 4 to connect power supply lines L1, L2 and L3 to cold blast valve motor M5. As a result, motor M5 is energized in the proper direction to cause cold blast valve CBV to be opened. When the cold blast valve starts to open, contact 8 of limit switch CBLS closes in the circuit of contactor CHC and contact 6 thereof opens, the latter interrupting energization of relay CBCR. Contact 1 of relay CBCR opens to interrupt energization of lamps LP25 and LP26 to extinguish graphic indication CB1 and contact 2 thereof closes to energize lamps LP27 and LP28 through contact 1 of relay CBOR. As a result, cold blast valve graphic indicator CB is lighted to exhibit indication CB2 to show that the cold blast valve is partially open or is opening. Contact 3 of relay CBCR opens a point in the circuit of contactor CMC.

When the cold blast valve is fully opened, contact 4 of limit switch CBLS opens and contact 2 thereof closes. Contact 4 of limit switch CBLS interrupts energization of contactor CBO whereupon the latter recloses contact 1 and reopens contacts 2, 3 and 4 to stop motor M5. Contact 2 of limit switch CBLS energizes relay CBOR across lines L1 and L2. Relay CBOR opens contact 1 to deenergize lamps LP27 and LP28 to extinguish graphic indication CB2 and closes contact 2 to energize lamps LP29 and LP30. This causes cold blast valve graphic indicator CB to be lighted to exhibit indication CB3 to show that the cold blast valve is fully open. Relay CBOR also closes contact 3 to energize contactor CMO through contact 6 of operation selector switch OS, contact 1 of contactor CMC and contact 4 of limit switch CMLS across lines L1 and L2.

Contact 1 of relay CBOR opens interlocking contact 1 to prevent concurrent energization of contactor CMC and closes contacts 2, 3 and 4 to connect power supply lines L1, L2 and L3 to cold mixer valve motor M6 whereupon the latter opens cold mixer valve CMV. When the cold mixer valve starts to open, contact 8 of limit switch CMLS closes in the circuit of contactor CMC and contact 6 thereof opens, the latter interrupting energization of relay CMCR. Relay CMCR opens contact 1 to deenergize lamps LP31 and LP32 to extinguish graphic indication CM1 and closes contact 2 to energize lamps LP33 and LP34 through contact 1 of relay CMOR. As a result, cold mixer valve graphic indicator CM is lighted to exhibit indication CM2 to show that the cold mixer valve is partially open or opening. Relay CMCR also opens contact 3 thereof in the circuit of contactor HBC.

When the cold mixer valve is fully open, contact 4 of limit switch CMLS opens and contact 2 thereof closes. Contact 4 of limit switch CMLS interrupts energization of contactor CMO whereupon the latter recloses contact 1 and reopens contacts 2, 3 and 4 to stop cold mixer valve motor M6. Contact 2 of limit switch CMLS energizes relay CMOR across lines L1 and L2. Relay CMOR

opens contact 1 to interrupt energization of lamps LP33 and LP34 to extinguish graphic indication CM2 and closes contact 2 to energize lamps LP35 and LP36. As a result, cold mixer valve graphic indicator CM is lighted to exhibit indication CM3 to show that the cold mixer valve is fully open. Relay CMOR also closes contact 3 to energize contactor HBO through contact 7 of operation selector switch OS, contact 1 of contactor HBC and contact 4 of limit switch HBLS across lines L1 and L2.

Contact 1 of relay CMOR opens interlocking contact 1 to prevent concurrent energization of contactor HBC and closes contacts 2, 3 and 4 to connect power supply lines L1, L2 and L3 to hot blast valve motor M7, whereupon the latter opens hot blast valve HBV. When the hot blast valve starts to open, contact 8 of limit switch HBLS closes in the circuit of contactor HBC and contact 6 thereof opens. Contact 6 of limit switch HBLS interrupts energization of relay HBCR. Relay HBCR opens contact 1 in the circuit of contactor CHO, opens contact 2 to deenergize lamps LP37 and LP38 to extinguish graphic indicator HB1 and closes contact 3 to energize lamps LP39 and LP40 through contact 2 of relay HBOR across lines L1 and L2. This causes hot blast valve graphic indicator HB to be lighted to exhibit indication HB2 to show that the hot blast valve is partially open or opening. Relay HBCR also opens its contact 4 in the circuit of contactor BOO.

When the hot blast valve is fully open, contact 4 of limit switch HBLS opens and contact 2 thereof closes. Contact 4 of limit switch HBLS interrupts energization of contactor HBO whereupon the latter recloses contact 1 and reopens contacts 2, 3 and 4 to stop motor M7. Contact 2 of limit switch HBLS energizes relay HBOR across lines L1 and L2. Contact 1 of relay HBOR closes a circuit through contact 1 of relay GAS and contact 6 of relay BLCR to energize relay BLAST. Contact 2 of relay HBOR interrupts energization of lamps LP39 and LP40 to extinguish graphic indication HB2 and contact 3 thereof energizes lamps LP41 and LP42 across lines L1 and L2. As a result hot blast valve graphic indicator HB is lighted to exhibit indication HB3 to show that the hot blast valve is fully opened.

The aforementioned energization of main indication control relay BLAST causes opening of its interlocking contact 1 to prevent concurrent energization of main indication control relay GAS. Relay BLAST also opens contact 2 to interrupt energization of lamp LP62 and to extinguish indication UM2 and closes contact 3 to energize lamp LP64. As a result, upper main graphic indicator UM is lighted to exhibit indication UM4 to show that the stove is in its blast condition. Relay BLAST also opens contact 4 to interrupt energization of cycle stopped timer CST thereby to cause the timer to reset to its normal position.

In the event the system stops due to an abnormal condition and contact 4 of relay BLAST does not open within a predetermined time interval following closure of contact 4 of relay GAS, timer CST times out at the end of such time interval and closes timed-closing 1 thereof to energize cycle stopped timer relay CSTR. Relay CSTR closes contact 1 to energize lamp LP66 and closes contact 2 to energize lamp LP67. As a result, lamp LP66 lights lower main indicator LM to exhibit indication LM1 to show that the cycle has stopped and lamp LP67 lights lower main indicator LM to exhibit a red background indication LM2 to show that there is an emergency condition.

When the abnormal condition has been corrected and contact 4 of relay BLAST opened, timer CST resets and reopens its contact 1 to deenergize relay CSTR. Relay CSTR opens its contacts 1 and 2 to deenergize lamps LP66 and LP67 and to extinguish the cycle stopped and emergency condition indications LM1 and LM2.

The stove is now in its blast condition. In this condition, the gas shutoff valve, the gas burner valve, the chim-

ney valve and the blowoff valve are closed; the cold blast valve, the cold mixer valve and the hot blast valve are open; and the stove fan is off.

This blast condition of the stove is indicated on the stove No. 1 graphic signaling and indicating devices exhibiting indications CS3, GB3, CH3, BO1, CB3, CM3, HB3 and SF2 as shown in FIGS. 3 and 5a through 5d. A summary of this blast condition of the stove is indicated on the stove No. 1 upper main indicator UM by exhibiting indication UM4 (Blast) as shown in FIGS. 3 and 5e.

Blast to Gas

To change from blast to gas, the pressure inside the stove must be relieved before reheating of the stove can be initiated to prevent the high pressure within the stove from causing damage. To this end, first the cold blast valve, the cold mixer valve and the hot blast valve are closed in that order so that the stove is completely closed. Next, the blowoff valve is opened and, when the pressure inside the stove has been relieved, the blowoff valve is reclosed. Then, the chimney valve and the gas burner valve are opened in that order and the stove fan is started to prepare the stove for heating. Finally, the gas shutoff valve is opened and the igniter is operated to ignite the gas at the burner.

To change the stove back to its gas condition, that is, to change the stove from its blast condition, wherein air is passed through the hot stove to the hot blast line to preheat the air before it is introduced into the blast furnace, to its gas condition, wherein the stove is being heated, pushbutton switch PB2 in FIG. 5b is momentarily pressed to close contacts 1 and 2 thereof. Contact 2 of switch PB2 completes an energizing circuit for tripping coil T of latching relay BGLR across lines L1 and L2. As a result, contact 1 of relay BGLR opens and contact 2 thereof closes and relay BGLR is latched in this condition until such time as closing coil C thereof is again energized. Contact 1 of relay BGLR interrupts energization of blast control relay BLCR whereupon the latter opens contacts 1 through 8 thereof. Contact 1 of relay BLCR opens a point in the circuit of contactor GSC. Contact 2 of relay BLCR interrupts its self-maintaining circuit. Contacts 3, 4 and 5 of relay BLCR open points in the circuits of contactors GBC, CHC and CBO, respectively. Contact 6 of relay BLCR interrupts energization of relay BLAST. Contact 7 of relay BLCR opens a point in the circuit of lamp LP62 and contact 8 thereof interrupts energization of lamp LP64 to extinguish the upper main indicator indication UM4 (Blast).

The aforementioned deenergization of relay BLAST causes closure of its interlocking contact 1 in the circuit of relay GAS and causes closure of contact 2 in the circuit of lamp LP62. Relay BLAST also opens contact 3 in the circuit of lamp LP64 and closes contact 4 to complete an energizing circuit for cycle stop timer CST through contact 4 of relay GAS across lines L1 and L2. Such energization causes timer CST to start timing a predetermined time interval. Normally, contact 4 of relay GAS opens to reset timer CST before such time interval has expired as hereinbefore described. In the event the system does not operate in its normal manner and timer CST times out, it will close its timed closing contact 1 to energize cycle stop timer relay CSTR to give an emergency indication as hereinafter described.

The aforementioned closure of contact 2 of blast and gas latching relay BGLR causes energization of gas control relay GCR through contact 1 of pushbutton switch PB2 across lines L1 and L2. As a result, relay GCR closes its self-maintaining contact 5 in shunt of contact 1 of pushbutton switch PB2 to maintain the same energized whereafter pushbutton switch PB2 may be released to allow it to open. Relay GCR also closes contact 1 in the circuit of contactor SFM, closes contact 2 in the circuit of contactor GBO, closes its contact 3 in the cir-

cuit of relay GAS and closes contact 4 in the circuit of contactor CHO. Relay GCR further closes its contact 6 to complete an energizing circuit for contactor CBC through contact 5 of operation selector switch OS, contact 1 of contactor CBO and contact 8 of limit switch CBLS across lines L1 and L2. In addition, relay GCR closes its contact 8 in the circuit of lamp LP65 to prepare this lamp for energization and closes its contact 7 to complete an energizing circuit for lamp LP63 through contact 2 of relay GAS across lines L1 and L2. This causes upper main indicator UM to be lighted to exhibit indication UM3 to show that the system is in its transitory condition from blast to gas.

The aforementioned organization of contactor CBC causes the cold blast valve CBV to be closed; that is, contactor CBC opens its interlocking contact 1 to prevent concurrent energization of contactor CBO and closes its contacts 2, 3 and 4 to connect power supply lines L1, L2 and L3 to cold blast valve motor M5. As a result, motor M5 closes the cold blast valve. As the cold blast valve starts to close, contact 4 of limit switch CBLS closes in the circuit of contactor CBO and contact 2 of limit switch CBLS opens to interrupt energization of relay CBOR. Relay CBOR opens its contact 3 in the circuit of contactor CMO and opens its contact 2 to interrupt energization of lamps LP29 and LP30 to extinguish indication CB 3. Relay CBOR also closes its contact 1 to complete an energizing circuit for lamps LP27 and LP28 through contact 2 of relay CBCR across lines L1 and L2. As a result, cold blast valve graphic indicator CB is lighted to exhibit indication CB2 to show that the cold blast valve is partially open or closing.

When the cold blast valve is fully closed, contact 8 of limit switch CBLS opens to interrupt energization of contactor CBC and contact 6 of limit switch CBLS closes to energize relay CBCR. Contactor CBC recloses contact 1 in the circuit of contactor CBO and reopens its contacts 2, 3 and 4 to stop cold blast valve motor M5. Relay CBCR opens its contact 2 to deenergize lamps LP27 and LP28 to extinguish graphic indication CB2 and closes its contact 1 to energize lamps LP25 and LP26. As a result, cold blast valve graphic indicator CB is lighted to exhibit indication CB1 to show that the cold blast valve is fully closed. Relay CBCR also closes its contact 3 to complete an energizing circuit for contactor CMC through contact 6 of operation selector switch OS, contact 1 of contactor CMO and contact 8 of limit switch CMLS across lines L1 and L2.

The aforementioned energization of contactor CMC causes cold mixer valve CMV to be closed. To this end, contactor CMC opens its interlocking contact 1 to prevent concurrent energization of contactor CMO and closes its contact 2, 3 and 4 to connect power supply lines L1, L2 and L3 to cold mixer valve motor M6, whereupon motor M6 closes the cold mixer valve. When the cold mixer valve starts to close, contact 4 of limit switch CMLS closes in the circuit of contactor CMO and contact 2 thereof opens, the latter interrupting energization of relay CMOR. Relay CMOR opens its contact 2 to deenergize lamps LP35 and LP36 to extinguish cold mixer valve graphic indication CM3 and closes its contact 1 to energize lamps LP33 and LP34 through contact 2 of relay CMCR across lines L1 and L2. As a result, cold mixer valve graphic indicator CM is lighted to exhibit indication CM2 to show that the cold mixer valve is partially open or closing. Relay CMOR also opens its contact 3 in the circuit of contactor HBO.

When the cold mixer valve is fully closed, contact 8 of limit switch CMLS opens to interrupt energization of contactor CMC and contact 6 of limit switch CMLS closes to energize relay CMCR across lines L1 and L2. Contactor CMC recloses its contact 1 in the circuit of contactor CMO and reopens its contacts 2, 3 and 4 to stop cold mixer valve motor M6. Relay CMCR opens its contact 2 to interrupt energization of lamps LP33 and

LP34 to extinguish cold mixer valve graphic indication CM2. Relay CMCR closes its contact 1 to energize lamps LP31 and LP32 across lines L1 and L2. As a result, cold mixer valve graphic indicator CM is lighted to exhibit indication CM1 to show that the cold mixer valve is fully closed. Relay CMCR also closes its contact 3 to energize contactor HBC through contact 7 of operation selector switch OS, contact 1 of contactor HBO and contact 8 of limit switch HBLS across lines L1 and L2.

The aforementioned energization of contactor HBC causes the hot blast valve to be closed. To this end, contactor HBC opens its interlocking contact 1 to prevent concurrent energization of contactor HBO and closes its contacts 2, 3 and 4 to connect power supply lines L1, L2 and L3 to hot blast valve motor M7, whereupon the latter closes the hot blast valve HBV. When the hot blast valve starts to close, contact 4 of limit switch HBLS closes in the circuit of contactor HBO and contact 2 of limit switch HBLS opens to interrupt energization of relay HBOR. Relay HBOR opens its contact 1 in the circuit of relay BLAST and opens its contact 3 to deenergize lamps LP41 and LP42 to extinguish hot blast valve graphic indication HB3. Relay HBOR also closes its contact 2 to energize lamps LP39 and LP40 through contact 3 of relay HBCR across lines L1 and L2. This causes hot blast valve graphic indicator HB to be lighted to exhibit indication HB2 to show that the hot blast valve is partially open or closing.

When the hot blast valve is fully closed, contact 8 of limit switch HBLS opens to interrupt energization of contactor HBC and contact 6 of limit switch HBLS closes to energize relay HBCR across lines L1 and L2. Contactor HBC recloses its contact 1 in the circuit of contactor HBO and reopens its contacts 2, 3 and 4 to disconnect the power supply and to stop the hot blast valve motor M7. Relay HBCR closes its contact 1 in the circuit of contactor CHO and opens its contact 3 to deenergize lamps LP39 and LP40 to extinguish hot blast valve graphic indication HB2. Relay HBCR also closes its contact 2 to energize lamps LP37 and LP38 across lines L1 and L2. This causes hot blast valve graphic indicator HB to be lighted to exhibit indication HB1 to show that the hot blast valve is fully closed. Relay HBCR also closes its contact 4 in the circuit of contactor BOO.

First, assuming that there is high pressure within the stove due to heat from the blast furnace or for other reasons, it is necessary for safety reasons to reduce this pressure, that is, to equalize the pressure inside and outside the stove. This pressure must be equalized before the stove can be changed to gas, that is, before the chimney valve is opened and the gas is turned on and ignited. Such pressure equalization is accomplished by opening the blowoff valve until the pressure is equalized and then reclosing the blowoff valve.

If the pressure within the stove is not excessive, then the opening and closing of the blowoff valve is automatically omitted in the blast to gas sequence of operation.

First, assuming that the pressure within the stove is high, such pressure causes closure of blowoff pressure switch BOPS when the stove is in its blast condition. Switch BOPS energizes blowoff pressure relay BOPR whereby the latter opens contacts 1 and 3 and closes contact 2. Contact 1 of relay BOPR opens a point in the circuit of chimney valve opening contactor CHO to prevent the chimney valve from being opened. In this manner, relay BOPR prevents the blast to gas cycle of operation from advancing until the pressure inside and outside the stove has been equalized. Contact 3 of relay BOPR opens a point in the circuit of contactor BOC and contact 2 of relay BOPR closes a point in the circuit of contactor BOO. As a result, when contact 4 of relay HBCR closes as aforementioned, contactor BOO is energized in a circuit extending through contact 8 of operation selector switch OS, contact 2 of relay BOPR, contact 1 of contactor BOC and contact 4 of limit switch BOLS across lines L1 and L2.

The aforementioned energization of contactor BOO causes the blowoff valve BOV to be opened. To this end, contactor BOO opens its interlocking contact 1 to prevent concurrent energization of contactor BOC and closes its contacts 2, 3 and 4 to connect power supply lines L1, L2 and L3 to blowoff valve motor M8, whereupon the latter opens the blowoff valve. When the blowoff valve starts to open, contact 8 of limit switch BOLS closes in the circuit of contactor BOC and contact 6 of limit switch BOLS opens to interrupt energization of relay BOCR. Relay BOCR opens its contact 1 to prevent opening of the chimney valve until the blowoff valve has been reclosed. Relay BOCR opens its contact 2 to deenergize lamps LP43 and LP44 to extinguish blowoff valve graphic indication BO1. Relay BOCR closes its contact 3 to energize lamps LP45 and LP46 through contact 1 of relay BOOR across lines L1 and L2. This causes blowoff valve graphic indicator BO to be lighted to exhibit indication BO2 to show that the blowoff valve is partially open or opening.

When the blowoff valve is fully open, contact 4 of limit switch BOLS opens to interrupt energization of contactor BOO and contact 2 of limit switch BOLS closes to energize relay BOOR across lines L1 and L2. Contactor BOO recloses its interlocking contact 1 in the circuit of contactor BOC and reopens its contacts 2, 3 and 4 to stop blowoff valve motor M8. Relay BOOR opens its contact 1 to interrupt energization of lamps LP45 and LP46 to extinguish blowoff valve graphic indication BO2 and closes its contact 2 to energize lamps LP47 and LP48 across lines L1 and L2. This causes blowoff valve graphic indicator BO to be lighted to exhibit indication BO3 to show that the blowoff valve is fully open.

The stove now remains in this condition with the blowoff valve open until the pressure inside and outside the stove has been equalized. When the pressure has been equalized, blowoff pressure switch BOPS opens to cause the blowoff valve to be reclosed. To this end, switch BOPS interrupts energization of relay BOPR. Relay BOPR closes its contact 1 in the circuit of contactor CHO to prepare the chimney valve for opening. Relay BOPR opens its contact 2 in the circuit of contactor BOO and closes its contact 3 to energize contactor BOC through contact 8 of operation selector switch OS, contact 1 of contactor BOO and contact 8 of limit switch BOLS across lines L1 and L2.

The aforementioned energization of contactor BOC causes the blowoff valve to be reclosed. To this end, contactor BOC opens its interlocking contact 1 to prevent concurrent energization of contactor BOO and closes its contacts 2, 3 and 4 to connect power supply lines L1, L2 and L3 to blowoff valve motor M8 to operate the latter in the reverse direction and to close the blowoff valve. When the blowoff valve starts to close, contact 4 of limit switch BOLS closes in the circuit of contactor BOO and contact 2 of limit switch BOLS opens to interrupt energization of relay BOOR. Relay BOOR opens its contact 2 to deenergize lamps LP47 and LP48 to extinguish blowoff valve graphic indication BO3 and closes its contact 1 to energize lamps LP45 and LP46 through contact 3 of relay BOCR across lines L1 and L2. This causes blowoff valve graphic indicator BOO to be lighted to exhibit indication BO2 to show that the blowoff valve is closing.

When the blowoff valve is fully closed, contact 8 of limit switch BOLS opens to interrupt energization of contactor BOC and contact 6 of limit switch BOLS closes to energize relay BOCR across lines L1 and L2. Contactor BOC recloses its contact 1 in the circuit of contactor BOO and reopens its contacts 2, 3 and 4 to stop blowoff valve motor M8. Relay BOCR opens its contact 3 to deenergize lamps LP45 and LP46 to extinguish blowoff valve graphic indication BO2 and closes its contact 2 to energize lamps LP43 and LP44 across lines L1 and L2. This causes blowoff valve graphic indicator BO to be lighted to exhibit indication BO1 to show that the blowoff valve is fully closed. Relay BOCR also closes

its contact 1 to initiate opening of the chimney valve CHV. To this end, contact 1 of relay BOCR completes an energizing circuit to contactor CHO through contact 4 of operation selector switch OS, contact 1 of relay BOPR, contact 4 of relay GCR, contact 1 of relay HBCR, contact 1 of contactor CHC and contact 4 of limit switch CHLS across lines L1 and L2.

Secondly, let it be assumed that the pressure inside the stove is not high enough such as requires equalization. Under this condition, the hereinbefore described opening and closure of the blowoff valve is automatically omitted from the blast to gas sequence of operation. Under this condition, blowoff pressure switch BOPS will remain open and relay BOPR will be deenergized. As a result, contact 2 of relay BOPR will remain open to prevent energization of blowoff valve opening contactor BOO thereby to prevent opening of the blowoff valve when contact 4 of relay HBCR closes as hereinbefore described.

Also, contact 1 of relay BOPR will remain closed in the circuit of contactor CHO. Furthermore, the blowoff valve will remain closed thereby maintaining relay BOCR energized through contact 6 of limit switch BOLS across lines L1 and L2. Consequently, when relay HBCR closes its contact 1 as hereinbefore described, contactor CHO is energized in a circuit extending through contact 4 of operation selector switch OS, contact 1 of relay BOCR, contact 1 of relay BOPR, contact 4 of relay GCR, contact 1 of contactor CHC and contact 4 of limit switch CHLS across lines L1 and L2.

The remainder of the blast to gas sequence of operation is the same regardless of whether the blowoff valve was operated or not.

Contact 1 of relay BOPR will remain closed in the circuit of contactor CHO. Furthermore, the blowoff valve will remain closed thereby maintaining relay BOCR energized through contact 6 of limit switch BOLS across lines L1 and L2. Consequently, when relay HBCR closes its contact 1 as hereinbefore described, contactor CHO is energized in a circuit extending through contact 4 of operation selector switch OS, contact 1 of relay BOCR, contact 1 of relay BOPR, contact 4 of relay GCR, contact 1 of contactor CHC and contact 4 of limit switch CHLS across lines L1 and L2.

When the chimney valve is fully opened, contact 4 of limit switch CHLS opens to interrupt energization of contactor CHO and contact 2 of limit switch CHLS closes to energize relay CHOR across lines L1 and L2. Contactor CHO recloses its contact 1 in the circuit of contactor CHC and reopens its contacts 2, 3 and 4 to stop chimney valve motor M4. Energization of relay CHOR gives an indication that the chimney valve is fully open and also initiates opening of the gas burner valve. To this end, relay CHOR opens contact 3 to deenergize lamps LP21 and LP22 to extinguish chimney valve graphic indication CH2 and closes contact 2 to energize lamps LP19 and LP20 across lines L1 and L2. This causes chimney valve graphic indicator CH to be lighted to exhibit indication CH1 to show that the chimney valve is fully open. Relay CHOR also closes contact 1 to energize contactor GBO through contact 3 of operating selector switch OS, contact 2 of relay GCR, contact 1 of contactor GBC and contact 4 of limit switch GBLS across lines L1 and L2.

The aforementioned energization of contactor GBO causes gas burner valve GBV to be opened. To this end, contactor GBO opens interlocking contact 1 to prevent concurrent energization of contactor GBC and closes contacts 2, 3 and 4 to connect power supply lines L1, L2 and L3 to gas burner valve motor M3 whereby the latter

opens the gas burner valve. When the gas burner valve starts to open, contact 8 of limit switch GBLS closes in the circuit of contactor GBC and contact 6 of limit switch GBLS opens to deenergize relay GBCR. Relay GBCR opens contact 3 to prevent closure of the chimney valve, opens contact 2 to deenergize lamps LP17 and LP18 to extinguish gas burner valve graphic indication GB3 and closes contact 1 to energize lamps LP15 and LP16 through contact 4 of relay GBOR across lines L1 and L2. This causes gas burner valve graphic indicator GB to be lighted to exhibit indication GB2 to show that the gas burner valve is partially open or opening.

When the gas burner valve is fully open, contact 4 of limit switch GBLS opens to interrupt energization of contactor GBO and contact 2 of limit switch GBLS closes to energize relay GBOR across lines L1 and L2. Contactor GBO recloses its contact 1 in the circuit of contactor GBC and reopens its contacts 2, 3 and 4 to disconnect power from gas burner valve motor M3 to stop the latter. Relay GBOR establishes an indication that the gas burner valve is fully open and starts the stove fan. To this end, relay GBOR opens contact 4 to deenergize lamps LP15 and LP16 thereby to extinguish gas burner valve graphic indication GB2 and closes contact 3 to energize lamps LP13 and LP14 across lines L1 and L2. This causes gas burner valve graphic indicator GB to be lighted to exhibit indication GB1 to show that the gas burner valve is fully open. Relay GBOR also closes contact 2 for purposes hereinafter described and closes contact 1 to energize contactor SFM through contact 2 of operation selector switch OS and contact 1 of relay GCR across lines L1 and L2.

Contact 1 of relay BOPR will remain closed in the circuit of contactor CHO. Furthermore, the blowoff valve will remain closed thereby maintaining relay BOCR energized through contact 6 of limit switch BOLS across lines L1 and L2. Consequently, when relay HBCR closes its contact 1 as hereinbefore described, contactor CHO is energized in a circuit extending through contact 4 of operation selector switch OS, contact 1 of relay BOCR, contact 1 of relay BOPR, contact 4 of relay GCR, contact 1 of contactor CHC and contact 4 of limit switch CHLS across lines L1 and L2.

When the chimney valve is fully opened, contact 4 of limit switch CHLS opens to interrupt energization of contactor CHO and contact 2 of limit switch CHLS closes to energize relay CHOR across lines L1 and L2. Contactor CHO recloses its contact 1 in the circuit of contactor CHC and reopens its contacts 2, 3 and 4 to stop chimney valve motor M4. Energization of relay CHOR gives an indication that the chimney valve is fully open and also initiates opening of the gas burner valve. To this end, relay CHOR opens contact 3 to deenergize lamps LP21 and LP22 to extinguish chimney valve graphic indication CH2 and closes contact 2 to energize lamps LP19 and LP20 across lines L1 and L2. This causes chimney valve graphic indicator CH to be lighted to exhibit indication CH1 to show that the chimney valve is fully open. Relay CHOR also closes contact 1 to energize contactor GBO through contact 3 of operating selector switch OS, contact 2 of relay GCR, contact 1 of contactor GBC and contact 4 of limit switch GBLS across lines L1 and L2.

The aforementioned energization of contactor GBO causes gas burner valve GBV to be opened. To this end, contactor GBO opens interlocking contact 1 to prevent concurrent energization of contactor GBC and closes contacts 2, 3 and 4 to connect power supply lines L1, L2 and L3 to gas burner valve motor M3 whereby the latter

opens the gas burner valve. When the gas burner valve starts to open, contact 8 of limit switch GBLS closes in the circuit of contactor GBC and contact 6 of limit switch GBLS opens to deenergize relay GBCR. Relay GBCR opens contact 3 to prevent closure of the chimney valve, opens contact 2 to deenergize lamps LP17 and LP18 to extinguish gas burner valve graphic indication GB3 and closes contact 1 to energize lamps LP15 and LP16 through contact 4 of relay GBOR across lines L1 and L2. This causes gas burner valve graphic indicator GB to be lighted to exhibit indication GB2 to show that the gas burner valve is partially open or opening.

When the gas burner valve is fully open, contact 4 of limit switch GBLS opens to interrupt energization of contactor GBO and contact 2 of limit switch GBLS closes to energize relay GBOR across lines L1 and L2. Contactor GBO recloses its contact 1 in the circuit of contactor GBC and reopens its contacts 2, 3 and 4 to disconnect power from gas burner valve motor M3 to stop the latter. Relay GBOR establishes an indication that the gas burner valve is fully open and starts the stove fan. To this end, relay GBOR opens contact 4 to deenergize lamps LP15 and LP16 thereby to extinguish gas burner valve graphic indication GB2 and closes contact 3 to energize lamps LP13 and LP14 across lines L1 and L2. This causes gas burner valve graphic indicator GB to be lighted to exhibit indication GB1 to show that the gas burner valve is fully open. Relay GBOR also closes contact 2 for purposes hereinafter described and closes contact 1 to energize contactor SFM through contact 2 of operation selector switch OS and contact 1 of relay GCR across lines L1 and L2.

Contact 1 of relay BOPR will remain closed in the circuit of contactor CHO. Furthermore, the blowoff valve will remain closed thereby maintaining relay BOCR energized through contact 6 of limit switch BOLS across lines L1 and L2. Consequently, when relay HBCR closes its contact 1 as hereinbefore described, contactor CHO is energized in a circuit extending through contact 4 of operation selector switch OS, contact 1 of relay BOCR, contact 1 of relay BOPR, contact 4 of relay GCR, contact 1 of contactor CHC and contact 4 of limit switch CHLS across lines L1 and L2.

opens its contact 3 to prevent closure of the gas burner valve and opens its contact 2 to deenergize lamps LP5 and LP6 to extinguish gas shutoff valve graphic indication GS3. Relay GSCR also closes its contact 1 to energize lamps LP3 and LP4 through contact 2 of relay GSOR across lines L1 and L2. This causes gas shutoff valve graphic indicator GS to exhibit indication GS2 to show that the gas shutoff valve is partially open or opening.

When the gas shutoff valve is fully opened, contact 4 of limit switch GSLS opens to interrupt energization of contactor GSO and contact 2 of limit switch GSLS closes to energize relay GSOR across lines L1 and L2. Contactor GSO recloses its interlocking contact 4 in the circuit of contactor GSC and reopens its contacts 1, 2 and 3 to disconnect power from gas shutoff valve motor M1 to stop the motor. Relay GSOR opens its contact 2 to deenergize lamps LP3 and LP4 to extinguish gas shutoff valve graphic indication GS2 and closes its contact 1 to energize lamps LP1 and LP2 across lines L1 and L2. This causes gas shutoff valve graphic indicator GS to be lighted to exhibit indication GS1 to show that the gas shutoff valve is fully open. Relay GSOR also closes its contact 3 to establish a maintaining circuit for contactor SFM in shunt of contact 1 of relay GBOR and contact 1 of relay GCR to maintain the stove fan operating so long as the gas shut-off valve is open. Relay GSOR also closes its contact 5 to energize relay GAS through contact 1 of relay BLAST and contact 3 of relay GCR across lines L1 and L2. Relay GAS opens its interlocking contact 1 to prevent concurrent energization of relay BLAST, and opens its contact 2 to deenergize lamp LP63 to extinguish upper main indication UM3. Relay GAS also closes its contact 3 to energize lamp LP65 through contact 8 of relay GCR across lines L1 and L2. This causes upper main indicator UM to be lighted to exhibit indication UM5 to show that the stove is in its gas condition. Relay GAS also opens its contact 4 to interrupt energization of cycle stop timer CST and thereby causes the timer to be reset before the timer has timed out.

In the event the system fails to operate properly and due to such failure contact 4 of relay GAS fails to open a predetermined time interval after the closure of contact 4 of relay BLAST when the latter is deenergized, timer CST will time out and close its time closing contact 1 to energize relay CSTR across lines L1 and L2. Relay CSTR closed its contacts 1 and 2 to energize lamps LP66 and LP67, respectively, across lines L1 and L2. Lamp LP66 lights the lower main indicator to exhibit indication LM1 to show that the cycle has stopped. Lamp LP67 lights the same lower main indicator to exhibit indication LM2 which is a red background to indicate an emergency condition. When the trouble which caused the failure has been corrected, timer CST is deenergized to cause the latter to reset and open its contact 1. This interrupts energization of relay CSTR to cause the latter to open its contacts 1 and 2 to deenergize lamps LP66 and LP67.

Relay GSOR also closes its contact 4 to energize the timer of igniter IG across lines L1 and L2 and to render the igniter effective to ignite the gas for a predetermined time interval. After such predetermined time interval which is sufficient to insure that the gas has been ignited, the timer of igniter IG times out and opens its timed opening contact 1 to deenergize the igniter. Igniters of this type are well known.

The stove is now in its gas condition. In this condition, the cold blast valve, the cold mixer valve, the hot blast valve and the blowoff valve are closed; the chimney valve, the gas burner valve and the gas shutoff valve are open; and the stove fan is on.

This gas condition of the stove is indicated on the stove No. 1 graphic signaling and indicating devices exhibiting indications CB1, CM1, HB1, BO1, CH1, CB1, GS1 and SF1 as shown in FIGS. 2 and 5a through 5d. A

summary of this gas condition of the stove is indicated on the stove No. 1 upper main indicator UM by exhibiting indication UM5 (Gas) as shown in FIGS. 2 and 5e.

If it is desired to open air control damper ACD, pushbutton switch PB3 in FIG. 5d is pressed to close contact 1 and to open contact 2 thereof. Contact 2 of switch PB3 opens a point in the circuit of the lower winding of motor M9. Contact 1 of switch PB3 energizes the upper winding of motor M9 through contact 1 of pushbutton switch PB4 and contact 4 of limit switch ACLS to cause the motor to operate in one direction to open the air control damper. When the air control damper is fully open, contact 4 of limit switch ACLS opens and contact 2 thereof closes. Contact 4 of limit switch ACLS interrupts energization of the upper winding of motor M9 to stop the motor. Contact 2 of limit switch ACLS energizes relay ACOR. As a result, a normally closed contact 2 of relay ACOR opens to interrupt energization of lamps LP51 and LP52 and normally open contact 1 thereof closes to energize lamps LP49 and LP50. This causes air control damper graphic indicator AC to be lighted to exhibit indication AC1 to show that the air control damper is fully open. When switch PB3 is released, contact 1 reopens and contact 2 thereof recloses.

If it is desired to open gas control regulator GCV, pushbutton switch PB5 in FIG. 5e is pressed to close contact 1 and to open contact 2 thereof. Contact 2 of switch PB5 opens a point in the circuit of the lower winding of motor M10. Contact 1 of switch PB5 energizes the upper winding of motor M10 through contact 1 of pushbutton switch PB6 and contact 4 of limit switch GCLS to cause the motor to operate in one direction to open the gas control regulator. When the gas control regulator is fully open, contact 4 of limit switch GCLS opens and contact 2 thereof closes. Contact 4 of limit switch GCLS interrupts energization of the upper winding of motor M10 to stop the latter. Contact 2 of limit switch GCLS energizes relay GCOR. As a result, normally closed contact 2 of relay GCOR opens to interrupt energization of lamps LP57 and LP58 and normally open contact 1 thereof closes to energize lamps LP55 and LP56. This causes gas control regulator graphic indicator GC to be lighted to exhibit indication GC1 to show that the gas control regulator is fully open. When switch PB5 is released, contact 1 thereof reopens and contact 2 thereof recloses.

If it is desired to operate air control damper ACD in the closing direction, pushbutton switch PB4 in FIG. 5d is pressed to open contact 1 and to close contact 2 thereof. Contact 1 of switch PB4 opens a point in the circuit of the upper winding of motor M9 and contact 2 thereof energizes the lower winding of motor M9 through contact 2 of pushbutton switch PB3 and contact 3 of limit switch ACLS. As a result, motor M9 operates in the reverse direction to actuate the air control damper in the closing direction. When the air control damper starts to close, contact 4 of limit switch ACLS closes in the circuit of the upper winding of motor M9 and contact 2 of limit switch ACLS opens to interrupt energization of relay ACOR. Relay ACOR opens contact 1 to deenergize lamps LP49 and LP50 to extinguish air control damper indication AC1 and closes contact 2 to energize lamps LP51 and LP52 through contact 1 of relay ACCR. This causes air control damper graphic indicator AC to be lighted to exhibit indication AC2 to show that the air control damper is partially open. It will be seen that the air control damper can be operated to any position between its fully closed position and its fully open position by pressing pushbutton switch PB3 or PB4 and that in each of these positions other than the fully closed position and the fully open position, indication AC2 will be exhibited.

Motor M9 continues to run in its reverse direction as long as switch PB4 is pressed until the air control damper

reaches its fully closed position. Normally, however, the air control damper is not fully closed when the stove is in its gas condition. If it is desired to operate the air control damper to its fully closed position, switch PB4 is maintained depressed. When such fully closed position is reached, contact 8 of limit switch ACLS opens and contact 6 thereof closes. Contact 8 of limit switch ACLS interrupts energization of the lower winding of motor M9 to stop the motor whereafter switch PB4 may be released to allow contact 1 thereof to reclose and contact 2 thereof to reopen. Contact 6 of limit switch ACLS energizes relay ACCR to open contact 1 and to close contact 2 of the latter. Contact 1 of relay ACCR interrupts energization of lamps LP57 and LP52 to extinguish air control damper indication AC2. Contact 2 of relay ACCR energizes lamps LP53 and LP54. This causes air control damper graphic indicator AC to be lighted to exhibit indication AC3 to show that the air control damper is fully closed.

If it is desired to operate gas control regulator GCV in the closing direction, pushbutton switch PB6 in FIG. 5e is pressed to open contact 1 and to close contact 2 thereof. Contact 1 of switch PB6 opens a point in the circuit of the upper winding of motor M10 and contact 2 thereof energizes the lower winding of motor M10 through contact 2 of pushbutton switch PB5 and contact 3 of limit switch GCLS. As a result, motor M10 operates in the reverse direction to actuate the gas control regulator in the closing direction. When the gas control regulator starts to close, contact 4 of limit switch GCLS closes in the circuit of the upper winding of motor M10 and contact 2 of limit switch GCLS opens to interrupt energization of relay GCOR. Relay GCOR opens contact 1 to deenergize lamps LP55 and LP56 to extinguish gas control regulator indication GC1 and closes contact 2 to energize lamps LP57 and LP58 through contact 1 of relay GCCR. This causes gas control regulator graphic indicator GC to be lighted to exhibit indication GC2 to show that the gas control regulator is partially open. It will be seen that the gas control regulator can be operated to any position between its fully closed position and its fully open position by pressing pushbutton switch PB5 or PB6 and that in each of these positions other than the fully closed position and the fully open position, indication GC2 will be exhibited.

Motor M10 continues to run in its reverse direction as long as switch PB6 is pressed until the gas control regulator reaches its fully closed position. Normally, however, the gas control regulator is not fully closed when the stove is in its gas condition. If it is desired to operate the gas control regulator to its fully closed position, switch PB6 is maintained depressed. When such fully closed position is reached, contact 8 of limit switch GCLS opens and contact 6 thereof closes. Contact 8 of limit switch GCLS interrupts energization of the lower winding of motor M10 to stop the motor whereafter switch PB6 may be released to allow contact 1 thereof to reclose and contact 2 thereof to reopen. Contact 6 of limit switch GCLS energizes relay GCCR to open contact 1 and to close contact 2 of the latter. Contact 1 of relay GCCR interrupts energization of lamps LP57 and LP58 to extinguish gas control regulator indication GC2. Contact 2 of relay GCCR energizes lamps LP59 and LP60. This causes gas control regulator graphic indicator GC to be lighted to exhibit indication GC3 to show that the gas control regulator is fully closed.

Means are also provided for indicating on the lower main indicator LM additional emergency conditions including high chamber temperature, high chimney temperature, high dome temperature and low blast temperature. If the temperature in the stove chamber rises too high, recorder HCT closes switch CTR to energize relay HCTR in FIG. 5f across lines L1 and L2. Relay HCTR closes contact 1 to energize lamp LP67 and closes con-

tact 2 to energize lamp LP68. Lamp LP68 causes lower main indicator LM to be lighted to exhibit indication LM3 to show that the stove chamber temperature is too high. Lamp LP67 lights the same lower main indicator LM to exhibit indication LM2 which constitutes a red, lighted background for indication LM3 to show that there is an emergency condition.

In like manner, if the stove chimney or stack temperature rises too high, recorder HST closes switch STR to energize relay HSTR across lines L1 and L2. Relay HSTR closes contacts 1 and 2 to energize lamps LP67 and LP69, respectively, across lines L1 and L2. This lights lower main graphic indicator LM to exhibit indication LM4 on the red background LM2. In like manner, if the temperature at the stove dome, that is, the temperature at the hemispherical upper part of the stove leading to the stove chimney rises too high, recorder HDT closes switch DTR to energize relay HDTR and closes contacts 1 and 2 to energize lamps LP67 and LP70. This causes the lower main indicator LM to exhibit indication LM5 to show that the dome temperature is too high and to exhibit a red background indication LM2 to indicate the emergency condition. In like manner, when the temperature in the hot blast line is too low, recorder LBT closes switch BTR to energize relay LBTR and close its contacts 1 and 2 to energize lamps LP67 and LP71. This causes lower main indicator LM to exhibit indication LM6 on the red background indication LM2 to indicate that the blast temperature is too low and that this is an emergency condition.

While the apparatus hereinbefore described is effectively adapted to fulfill the objects stated, it is to be understood that we do not intend to confine our invention to the particular preferred embodiment of graphic signaling and indicating system disclosed, inasmuch as it is susceptible of various modifications without departing from the scope of the appended claims.

We claim:

1. In a graphic signaling and indicating system for indicating the operating positions of a plurality of control valves and for indicating the operating condition of a controllable device which is controlled by said valves, each said valve having a fully closed position and a fully open position and an intermediate partially open position, in combination, an indicator panel having thereon a diagram of the controllable device and graphic indicators for said valves and flow stripes representative of the flow passages through said valves, said indicators exhibiting strips perpendicular to said flow stripes in all closed positions of said valves and parallel to said flow stripes in all open positions of said valves, and a control system comprising first indicator control means operative when said controllable device is in a first operating condition wherein the valves of a first group thereof are fully closed and the valves of a second group thereof are fully open for energizing said indicators to exhibit strips upon said graphic indicators for said valves oriented perpendicular to the flow stripes to indicate a fully closed condition of the respective valve and oriented parallel to said flow stripes to be illustrative of the fully open position of the respective valve in said first operating condition of the controllable device, a switch, operation control means responsive to operation of said switch for automatically changing said controllable device to a second operating condition wherein the valves of a different first group thereof are fully closed and the valves of a different second group thereof are fully open, and second control means responsive to said changing of said controllable device to a second operating condition for extinguishing the first mentioned graphic indications and for reenergizing said indicators to exhibit strips upon said graphic indicators for said valves oriented perpendicular and parallel to said flow stripes to be illustrative of the respective closed and open conditions of the different groups of valves in said second operating condition of the con-

trollable device, said first and second indicator control means comprising means operative during the transitory condition when said controllable device is being changed from one of said operating conditions to the other operating condition for energizing the indicators to exhibit strips while said valves are in their intermediate positions to show that the valves are partially open, the latter strips being oriented at an angle different from and between the perpendicular strips illustrative of said fully closed condition of said valves and the parallel strips illustrative of said fully open condition of said valves.

2. In a graphic signaling and indicating system for a heating stove system of the type adapted for preheating air for a blast furnace wherein said stove system has a gas operating condition during which the stove is heated and a successive blast operating condition during which air is forced through the stove into a blast furnace; and said stove system comprises a plurality of stove control valve means including a gas shut-off valve, a gas burner valve and a chimney valve which are open when the stove is in its gas condition while the remaining control valve means are closed; and further including a cold blast valve, and a hot blast valve which are open when the stove is in its blast condition while the first mentioned control valve means are closed; the improvement comprising an indicator panel having thereon a graphic diagram of the stove system; said graphic diagram comprising a graphic figure of the stove, a plurality of visual indicators for graphically indicating the operating conditions of said stove control valve means, said indicators being mounted on said panel in positions graphically depicting the actual positions thereof relative to one another and to said stove, and flow stripes representative of the flow passages through said stove control valve means; said indicators exhibiting strips perpendicular to said flow stripes in all closed positions of said stove control valve means and parallel to said flow stripes in all open positions of said stove control valve means; a gas-to-blast control switch; and control circuit means for operating said control valve means and said indicators; said control circuit means comprising means responsive to operation of said gas-to-blast control switch for automatically closing in sequence said gas shut-off valve, said gas burner valve, and said chimney valve and subsequently automatically opening said cold blast valve and said hot blast valve to change said stove from its gas condition to its blast condition; means responsive to said operation of said control valve means for energizing said indicators to exhibit indications illustrative of the fully closed and open positions of said control valve means; means operative during the transitory period when said stove is being changed from its gas condition to its blast condition for energizing said indicators to exhibit indications while said control valve means are in their intermediate positions to show that said control valve means are partially open; said graphic indicators comprising both a legend and a strip upon the indicator of each control valve means, said legend being descriptive of the operating position of the respective control valve means when said stove is in each of said operating conditions, said strip being oriented perpendicular to the respective flow stripe to indicate a closed position, said strip being oriented parallel to the respective flow stripe to indicate an open position, and said strips being oriented diagonally between said parallel and said perpendicular positions to indicate a partially open position of the respective control valve means.

3. In a graphic signaling and indicating system for a heating stove system of the type adapted for preheating air for a blast furnace wherein said stove system has a gas operating condition during which the stove is heated and a blast operating condition during which air is forced through the stove into a blast furnace; and said stove system comprises a plurality of stove control valve means including a gas shut-off valve, a gas burner valve and a

chimney valve which are open when the stove is in its gas condition while the remaining control valve means are closed; and further including a cold blast valve, a cold mixer valve, and a hot blast valve which are open when the stove is in its blast condition while the first mentioned control valve means are closed; and still further including a blowoff valve, the improvement comprising an indicator panel having thereon a graphic diagram of the stove system; said graphic diagram comprising a graphic figure of the stove, a plurality of visual indicators for graphically indicating the operating conditions of said stove control valve means, said indicators being mounted on said panel in positions graphically depicting the actual positions thereof relative to one another and to said stove, and flow stripes representative of the flow passages through said stove control valve means; said indicators exhibiting strips perpendicular to said flow stripes in all closed positions of said stove control valve means and parallel to said flow stripes in all open positions of said stove control valve means; a blast-to-gas control switch; and control circuit means for operating said control valve means and said indicators; said control circuit means comprising means responsive to operation of said blast-to-gas control switch for automatically and in sequence closing said cold blast valve, said cold mixer valve, and said hot blast valve, opening said blowoff valve, closing said blowoff valve, and subsequently automatically opening in sequence said chimney valve, said gas burner valve and said gas shut-off valve to change said stove from its blast condition to its gas condition; means responsive to said operation of said control valve means for energizing said indicators to exhibit indications illustrative of the positions of said control valve means; means operative during the transitory period when said stove is being changed from its blast condition to its gas condition for energizing said indicators to exhibit indications while said control valve means are in their intermediate positions to show that said control valve means are partially open; said graphic indications comprising a strip depicted upon the indicator of each control valve means, said strip being oriented perpendicular to the respective flow stripe to indicate a closed position, said strip being oriented parallel to the respective flow stripe to indicate an open position, and said strip being oriented diagonally between said parallel and said perpendicular positions to indicate a partially open position of the respective control valve means.

4. In a graphic signaling and indicating system for indicating the operating positions of a plurality of control valves and for indicating the operating condition of a controllable device which is controlled by said valves, each said valve having a fully closed position and a fully open position and an intermediate partially open position, in combination, an indicator panel having thereon a diagram of the controllable device and graphic indicators for said valves and diagrammatic means extending therebetween representative of the actual connections between said controllable device and said valves, and a control system comprising first indicator control means operative when said controllable device is in a first operating condition wherein the valves of a first group thereof are fully closed and the valves of a second group thereof are fully open for energizing said indicators to exhibit graphic indications of the positions in which the valves are in said first operating condition of the controllable device, a switch, operation control means responsive to operation of said switch for automatically changing said controllable device to a second operating condition wherein the valves of a different first group thereof are fully closed and the valves of a different second group thereof are fully open, and second indicator control means responsive to said changing of said controllable device to a second operating condition for extinguishing the first mentioned graphic indications and for reenergizing said indicators to exhibit graphic indications of the different positions in which the

valves are in said second operating condition of the controllable device, a main indicator for said controllable device, said control system further comprising means operative when said controllable device is in said first operating condition for energizing said main indicator to exhibit a summary indication thereof, and main indicator control means responsive to operation of said control means when said controllable device is changed to said second operating condition for extinguishing the first mentioned summary indication and for energizing said main indicator to exhibit another summary indication to show that said controllable device is in said second operating condition, said first mentioned and said second main indicator control means comprising means operative during the transitory condition when said controllable device is being changed from said first operating condition to said second operating condition for energizing said main indicator to exhibit a summary indication of said transitory condition.

5. The invention defined in claim 4, wherein said control means further comprises a second switch, means in said operation control means responsive to operation of said second switch for automatically changing said controllable device from said second operating condition back to said first operating condition, and second main indicator control means responsive to said operation control means when said controllable device is changed back to said first operating condition for extinguishing said other summary indications and for energizing said main indicator to exhibit said first mentioned summary indication, said first mentioned and said second main indicator control means comprising means operative during the second transitory condition when said controllable device is being changed from said second operating condition to said first operating condition for energizing said main indicator to exhibit a summary indication of said second transitory condition.

6. In a graphic signaling and indicating system for a heating stove system of the type adapted for preheating air for a blast furnace wherein said stove system has a gas operating condition during which the stove is heated and a successive blast operating condition during which air is forced through the stove into a blast furnace, and said stove system comprises a plurality of stove control valve means including gas control valve means and chimney control valve means which are open when the stove is in its gas condition while the remaining control valve means are closed, and further including cold air control valve means and hot blast control valve means which are open when the stove is in its blast condition while the first mentioned control valve means are closed, the improvement comprising an indicator panel having thereon a graphic diagram of the stove system, said graphic diagram comprising a graphic figure of the stove, a plurality of visual indicators for indicating the operating conditions of said stove control valve means, said indicators being mounted on said panel in positions graphically depicting the actual positions thereof relative to one another and to said stove, and flow stripes on said panel indicating conduits extending between said stove figure and said indicators to exhibit a graphic diagram of said stove system, a gas-to-blast control switch and a blast-

to-gas control switch, and control circuit means for operating said control valve means and said indicators, said control circuit means comprising means responsive to operation of said gas-to-blast control switch for automatically opening said cold air control valve means and hot blast control valve means and closing said gas control valve means and chimney control valve means to change said stove from its gas condition to its blast condition, means responsive to said operation of said control valve means for energizing said indicators to exhibit indications illustrative of the positions of said control valve means, means responsive to operation of said blast-to-gas control switch for automatically opening said gas control valve means and chimney control valve means and closing said cold air control valve means and hot blast control valve means to change said stove from its blast condition back to its gas condition, and means responsive to such reoperation of said control valve means to change said stove from its blast condition to its gas condition for extinguishing the first mentioned indications and for energizing said indicators to exhibit indications illustrative of the gas condition positions of said control valve means, a main indicator for said stove, means operative when said stove is in one of its operating conditions for energizing said main indicator to exhibit a summary indication of the operating condition of said stove, main indicator control means responsive to operation of said gas-to-blast control switch or said blast-to-gas control switch when said stove is changed to its other operating condition for extinguishing the first mentioned summary indication and for energizing said main indicator to exhibit a second summary indication that said stove is in said other operating condition, said main indicator control means including means operative during the transitory condition when said stove is being changed from gas condition to blast condition for energizing said main indicator to exhibit a summary indication that said stove is in the transitory condition of being changed from gas condition to blast condition, said main indicator control means further including means operative during the transitory condition when said stove is being changed from blast condition to gas condition for energizing said main indicator to exhibit a summary indication that said stove is in the transitory condition of being changed from blast condition to gas condition.

7. The invention defined in claim 6, wherein said main indicator comprises means responsive to said main indicator control means for displaying legends on said main indicator which legends are descriptive of the operating conditions of said stove and of the transitory conditions of said stove.

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