May 15, 1962 H. JANSEN ET AL 3,034,775

AUTOMATIC CHANGE-OVER SYSTEM FOR BLAST STOVES FOR BLAST FURNACES

Filed Nov. 12, 1959 24 Sheets-Sheet 1

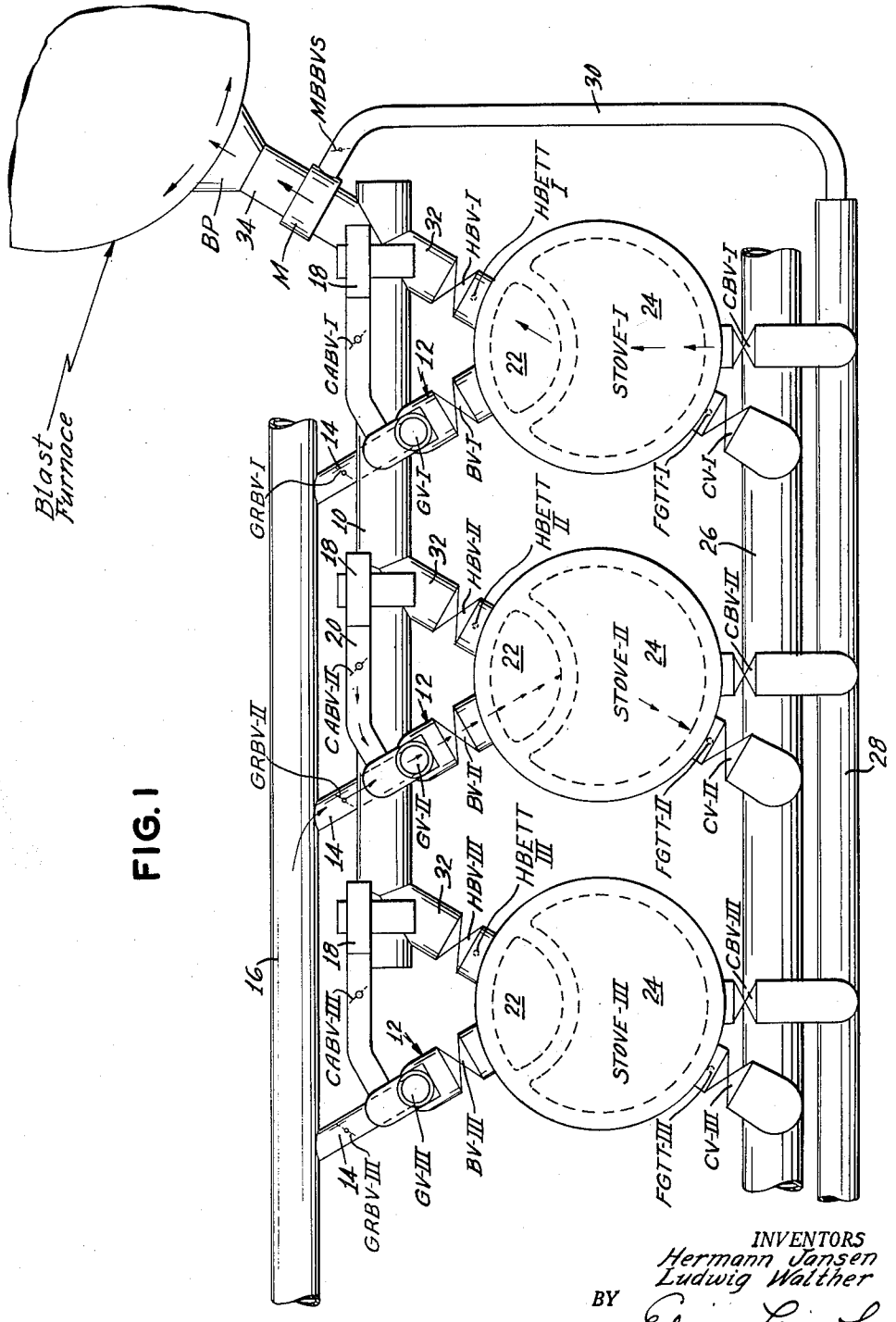


FIG. 1

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AUTOMATIC CHANGE-OVER SYSTEM FOR BLAST STOVES FOR BLAST FURNACES

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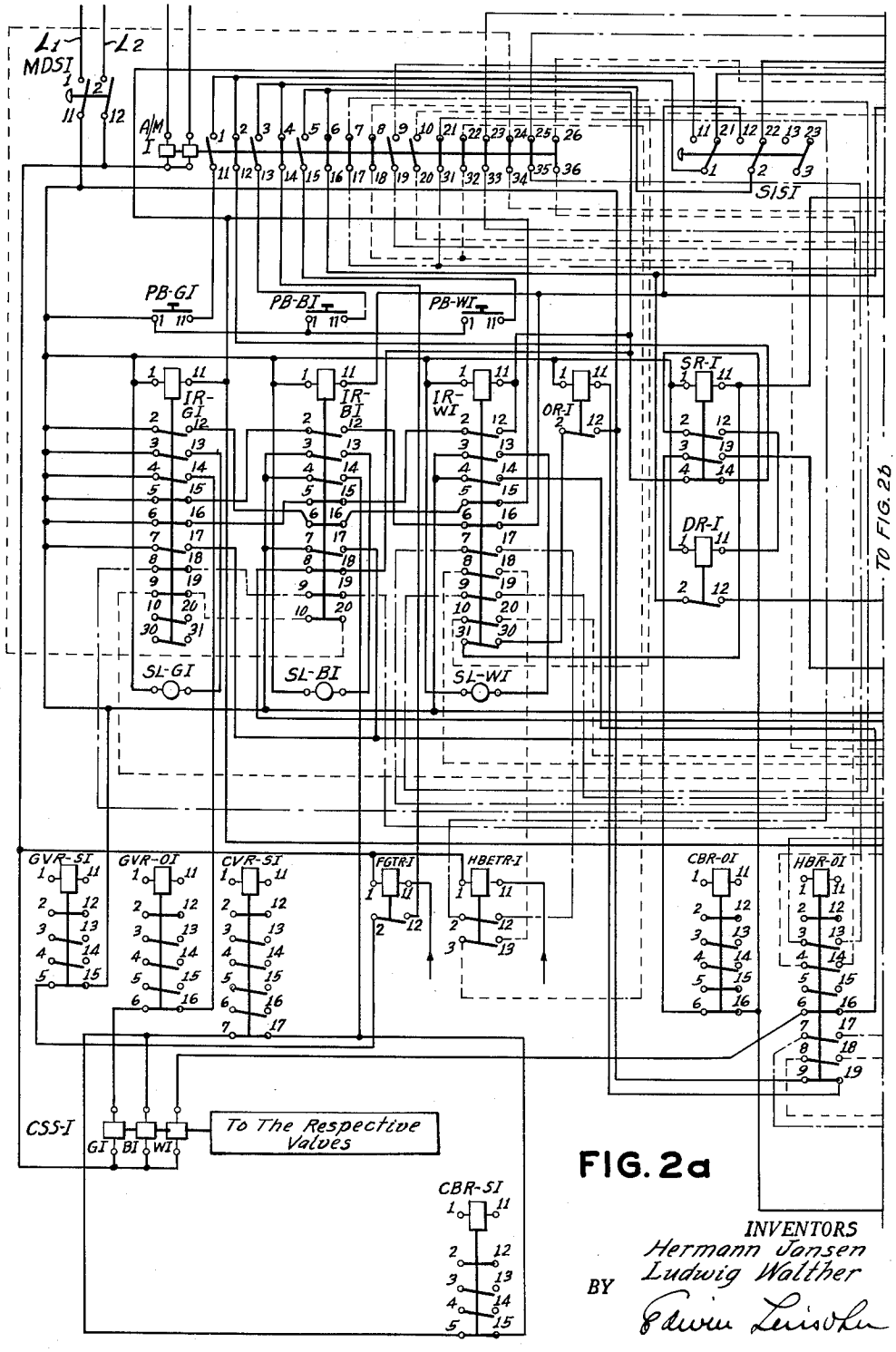


FIG. 2a

INVENTORS
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May 15, 1962 H. JANSEN ET AL 3,034,775

AUTOMATIC CHANGE-OVER SYSTEM FOR BLAST STOVES FOR BLAST FURNACES

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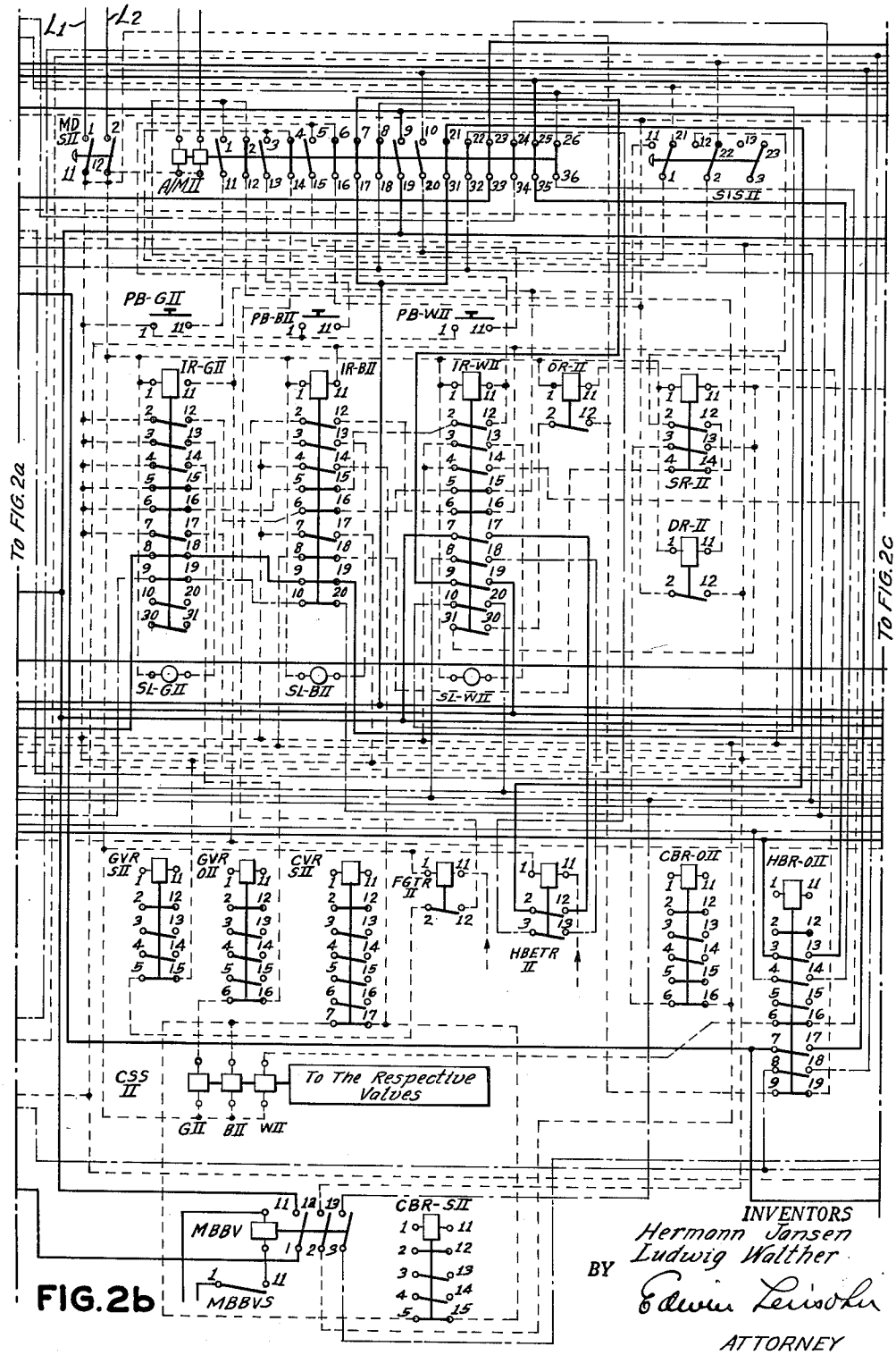


FIG. 2b

INVENTORS
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May 15, 1962 H. JANSEN ET AL 3,034,775

AUTOMATIC CHANGE-OVER SYSTEM FOR BLAST STOVES FOR BLAST FURNACES

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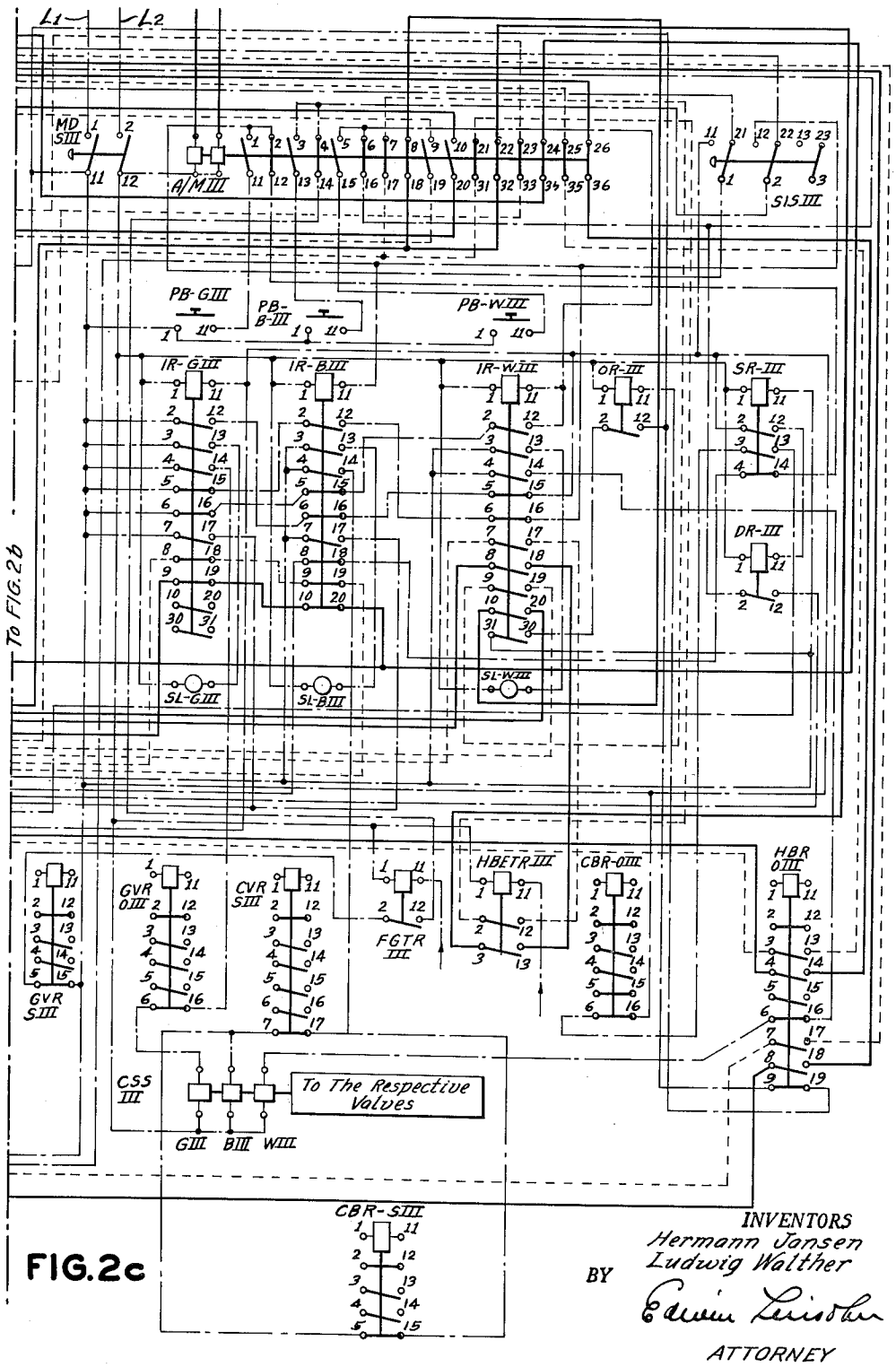


FIG. 2c

INVENTORS
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May 15, 1962 H. JANSEN ET AL 3,034,775

AUTOMATIC CHANGE-OVER SYSTEM FOR BLAST STOVES FOR BLAST FURNACES

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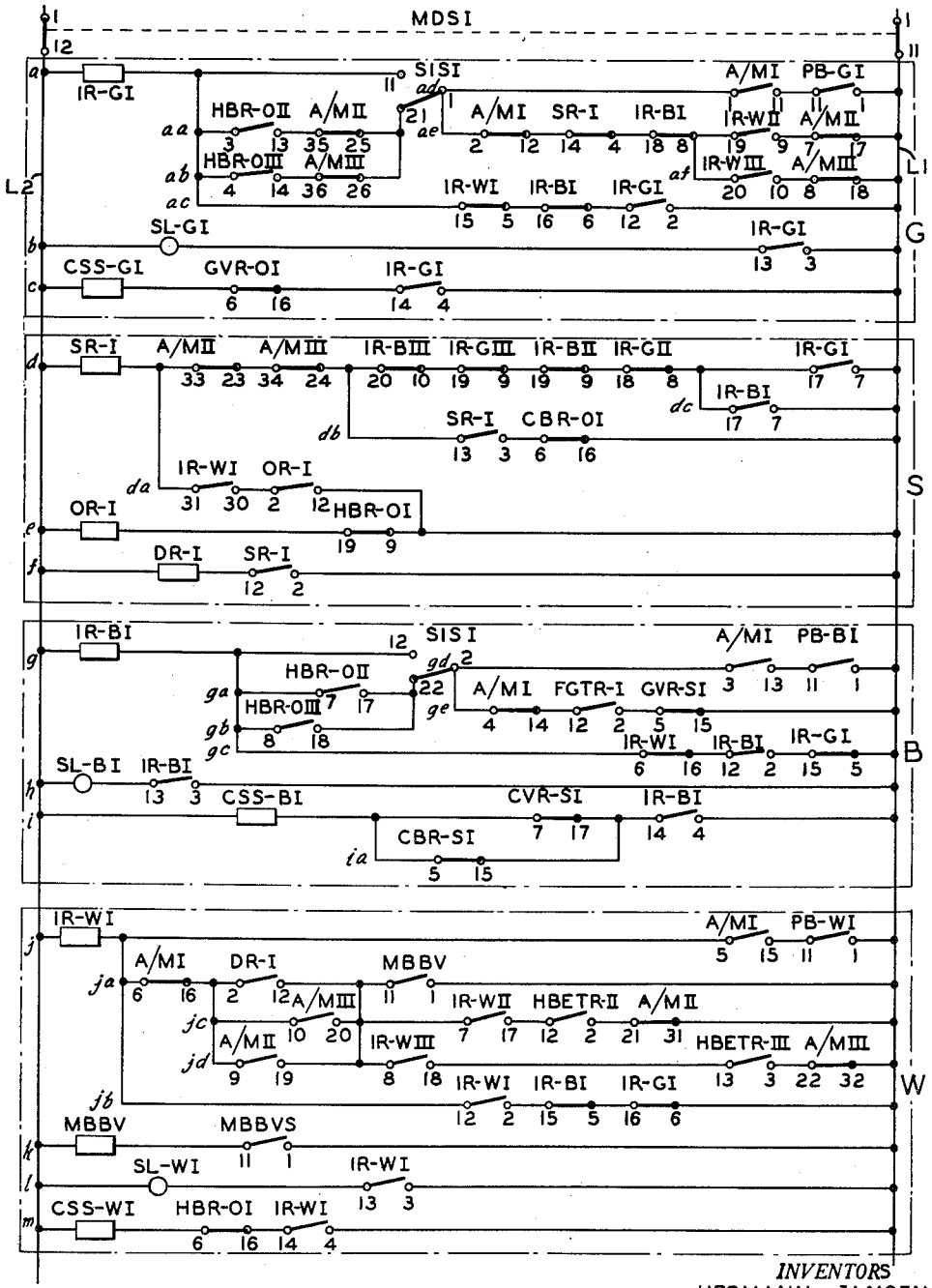


FIG. 3

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May 15, 1962 H. JANSEN ET AL 3,034,775

AUTOMATIC CHANGE-OVER SYSTEM FOR BLAST STOVES FOR BLAST FURNACES

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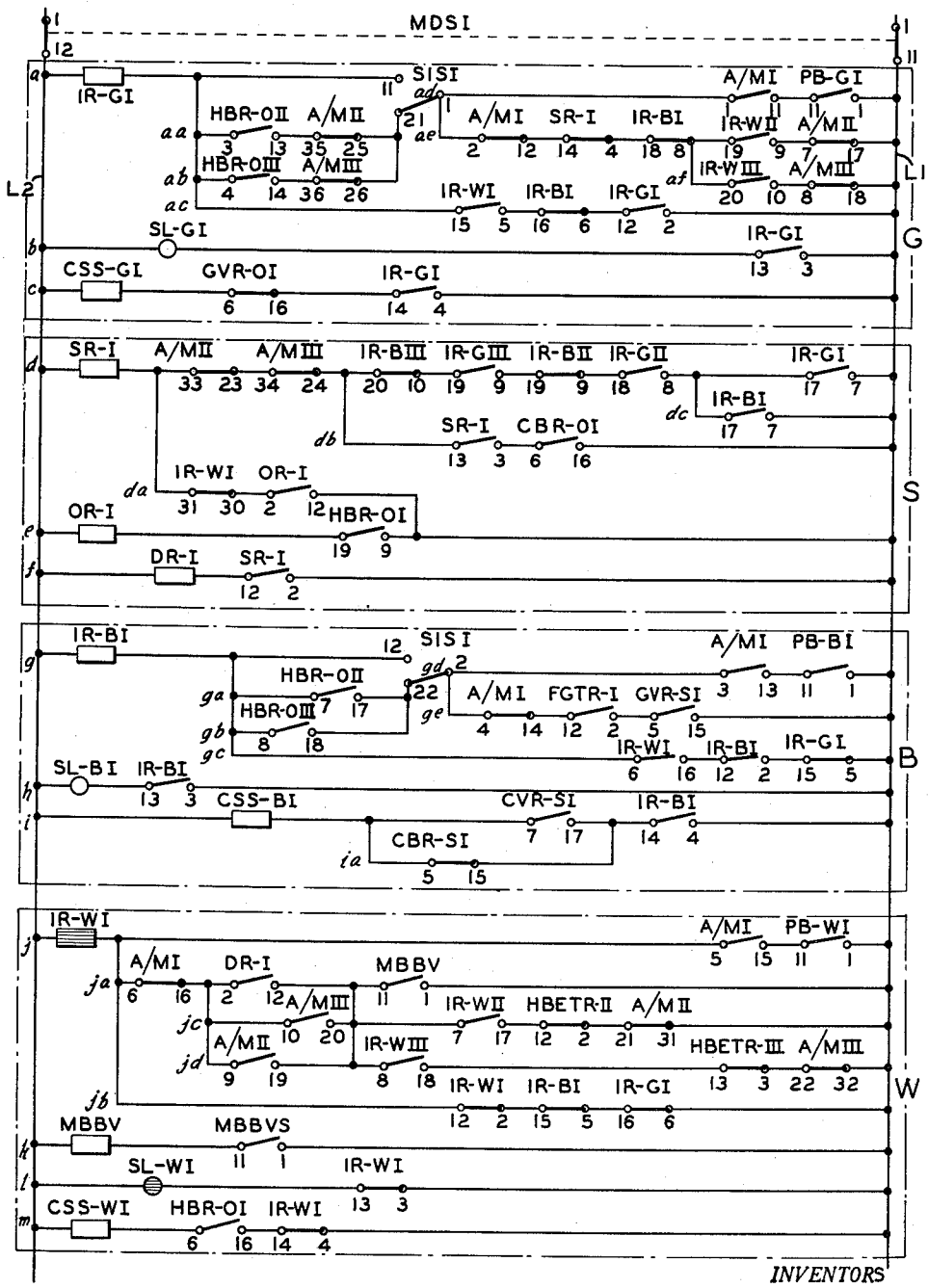


FIG. 4a

INVENTORS
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AUTOMATIC CHANGE-OVER SYSTEM FOR BLAST STOVES FOR BLAST FURNACES

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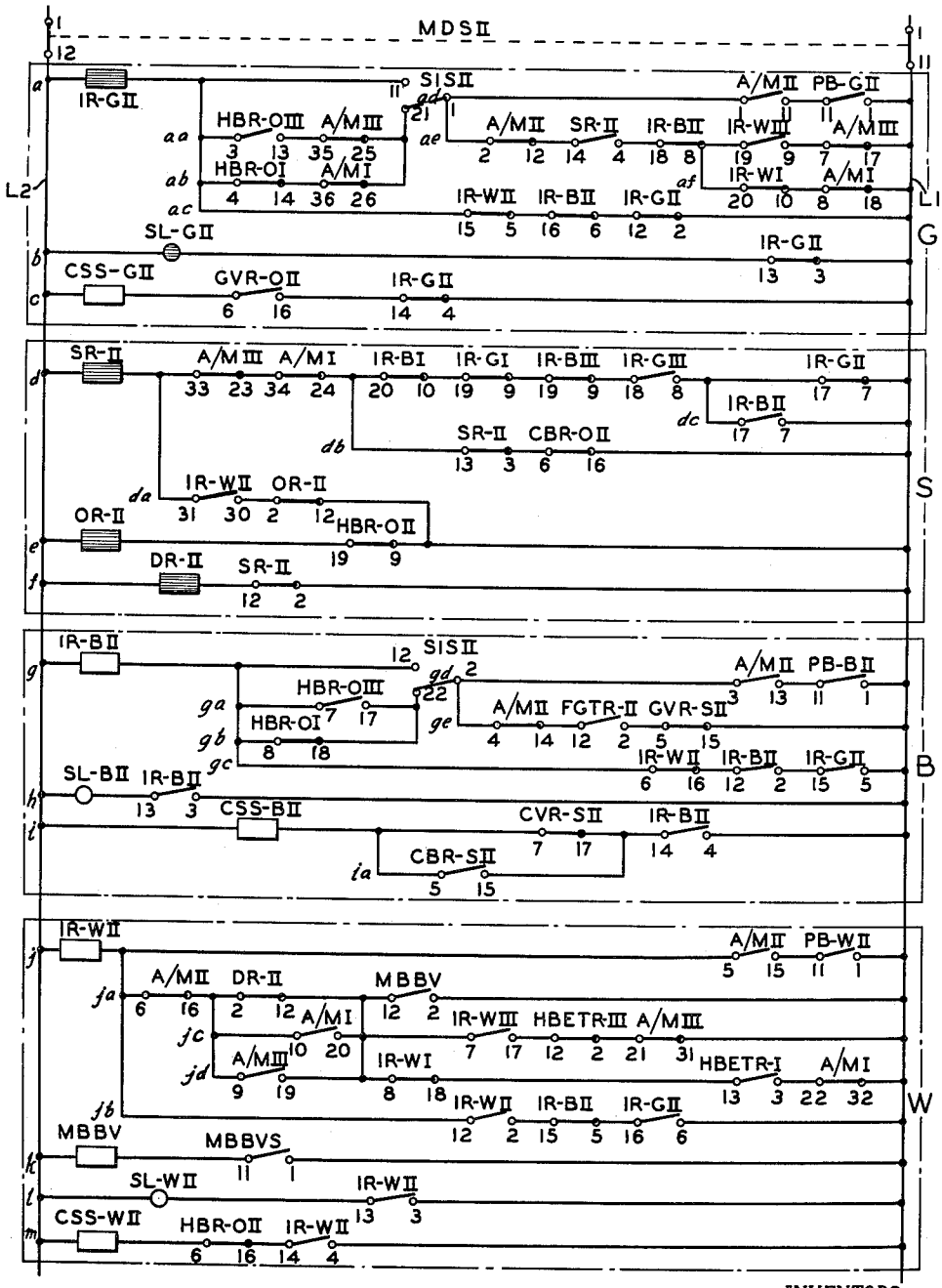


FIG. 4b

INVENTORS
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May 15, 1962 H. JANSEN ET AL 3,034,775

AUTOMATIC CHANGE-OVER SYSTEM FOR BLAST STOVES FOR BLAST FURNACES

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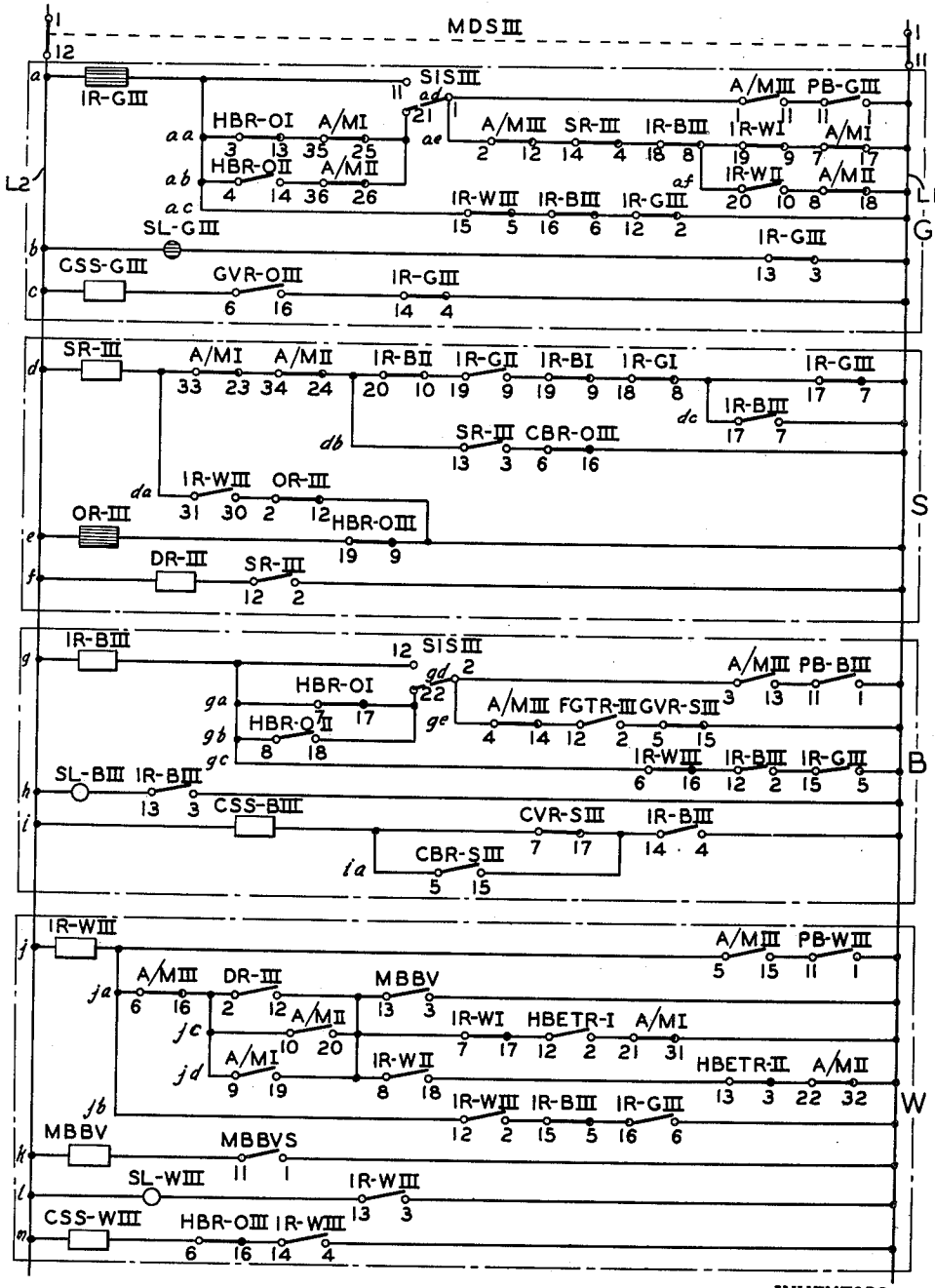


FIG. 4c

INVENTORS
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May 15, 1962 H. JANSEN ET AL 3,034,775

AUTOMATIC CHANGE-OVER SYSTEM FOR BLAST STOVES FOR BLAST FURNACES

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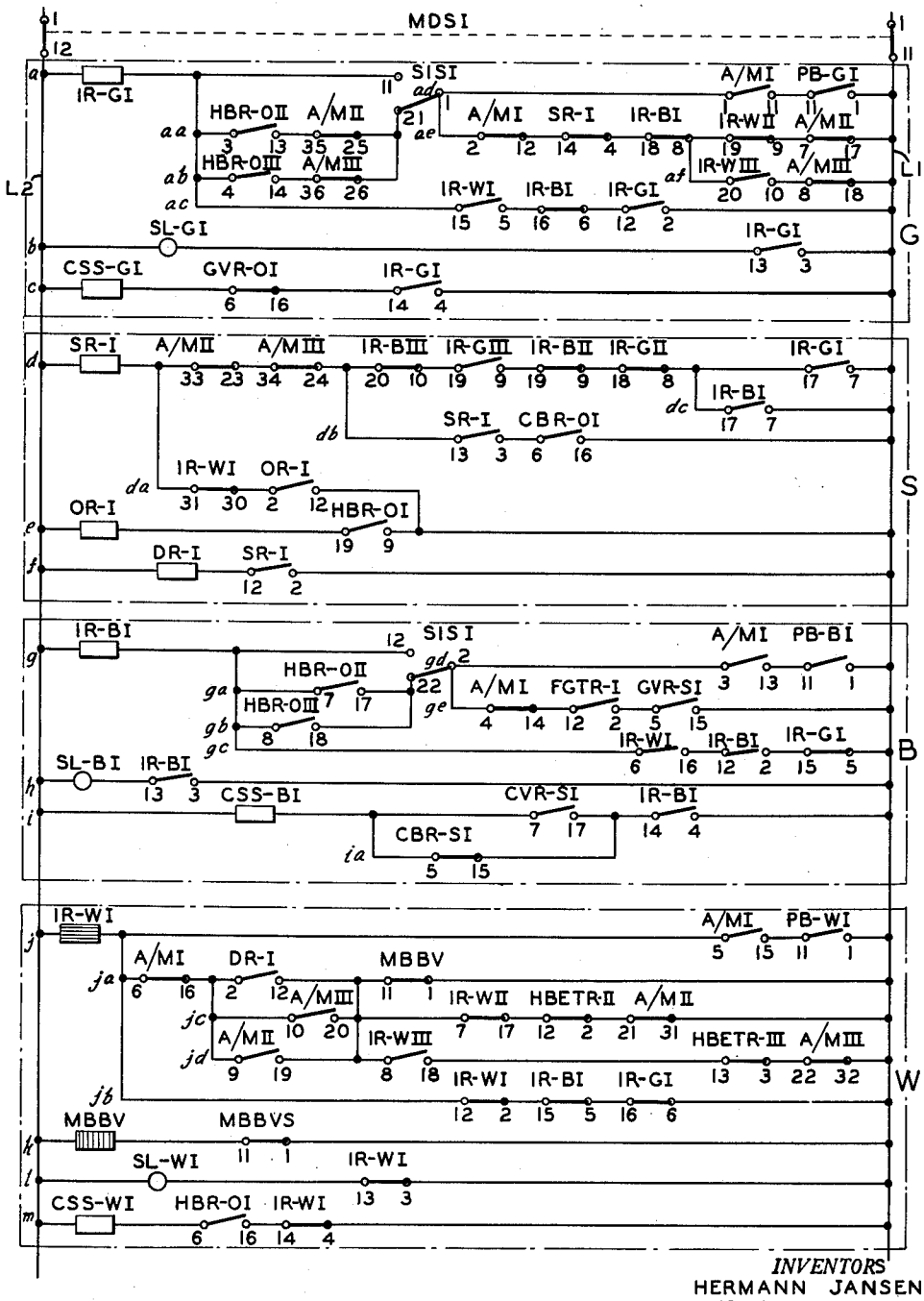


FIG. 5a

INVENTORS
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May 15, 1962 H. JANSEN ET AL 3,034,775

AUTOMATIC CHANGE-OVER SYSTEM FOR BLAST STOVES FOR BLAST FURNACES

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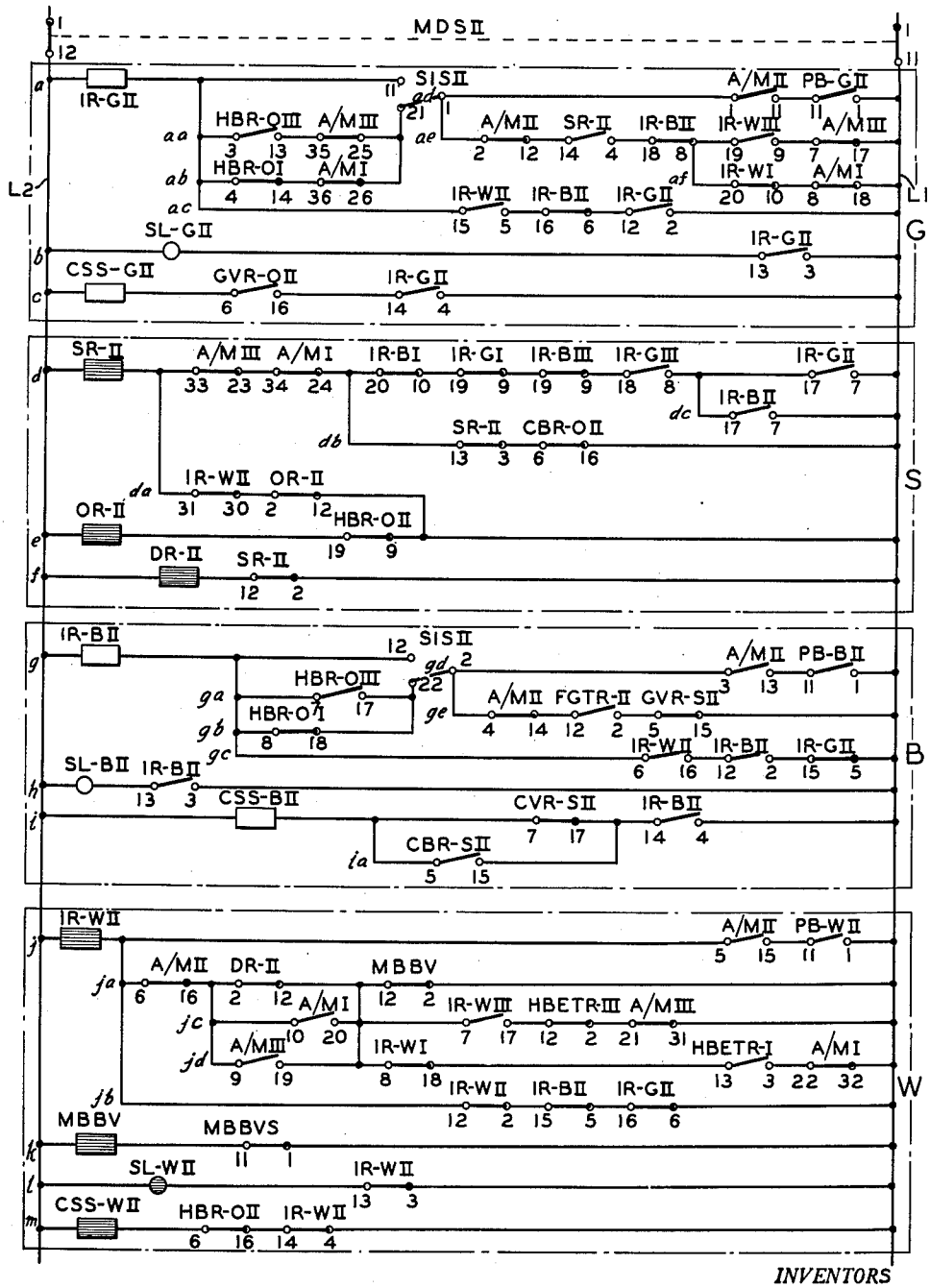


FIG. 5b

INVENTORS
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May 15, 1962 H. JANSEN ET AL 3,034,775

AUTOMATIC CHANGE-OVER SYSTEM FOR BLAST STOVES FOR BLAST FURNACES

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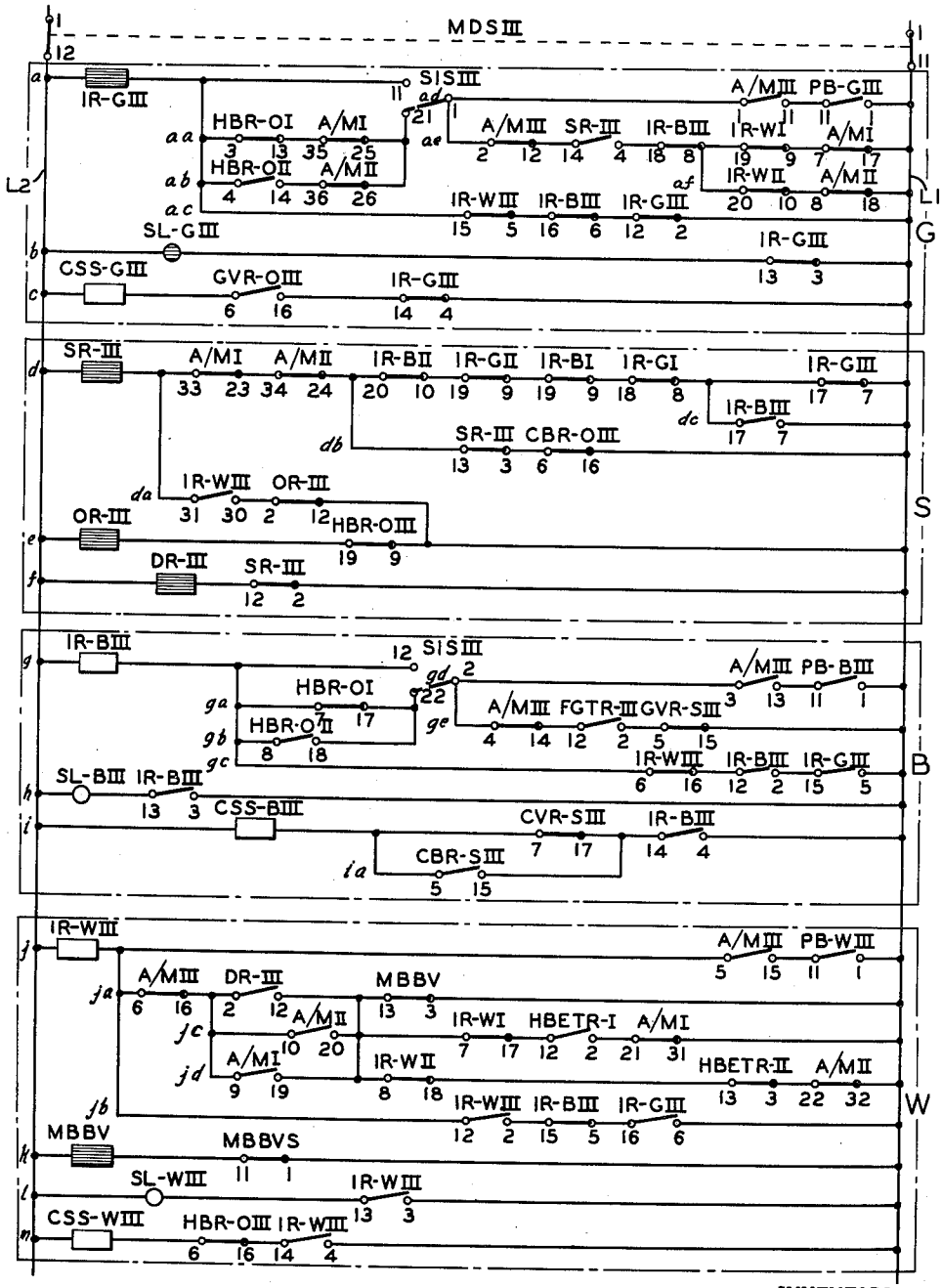


FIG. 5c

INVENTORS
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May 15, 1962 H. JANSEN ET AL 3,034,775

AUTOMATIC CHANGE-OVER SYSTEM FOR BLAST STOVES FOR BLAST FURNACES

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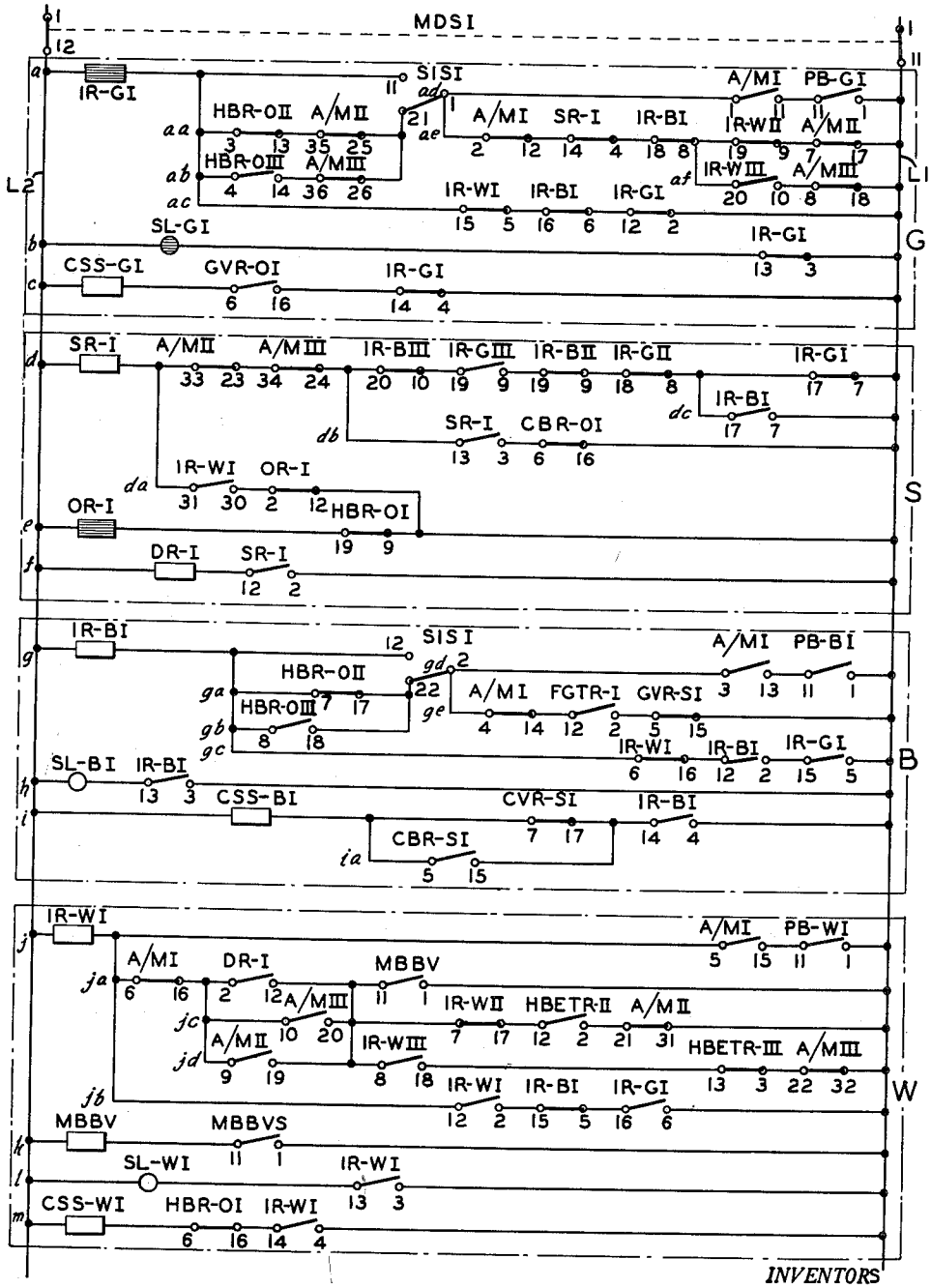


FIG. 6a

INVENTORS
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May 15, 1962 H. JANSEN ET AL 3,034,775

AUTOMATIC CHANGE-OVER SYSTEM FOR BLAST STOVES FOR BLAST FURNACES

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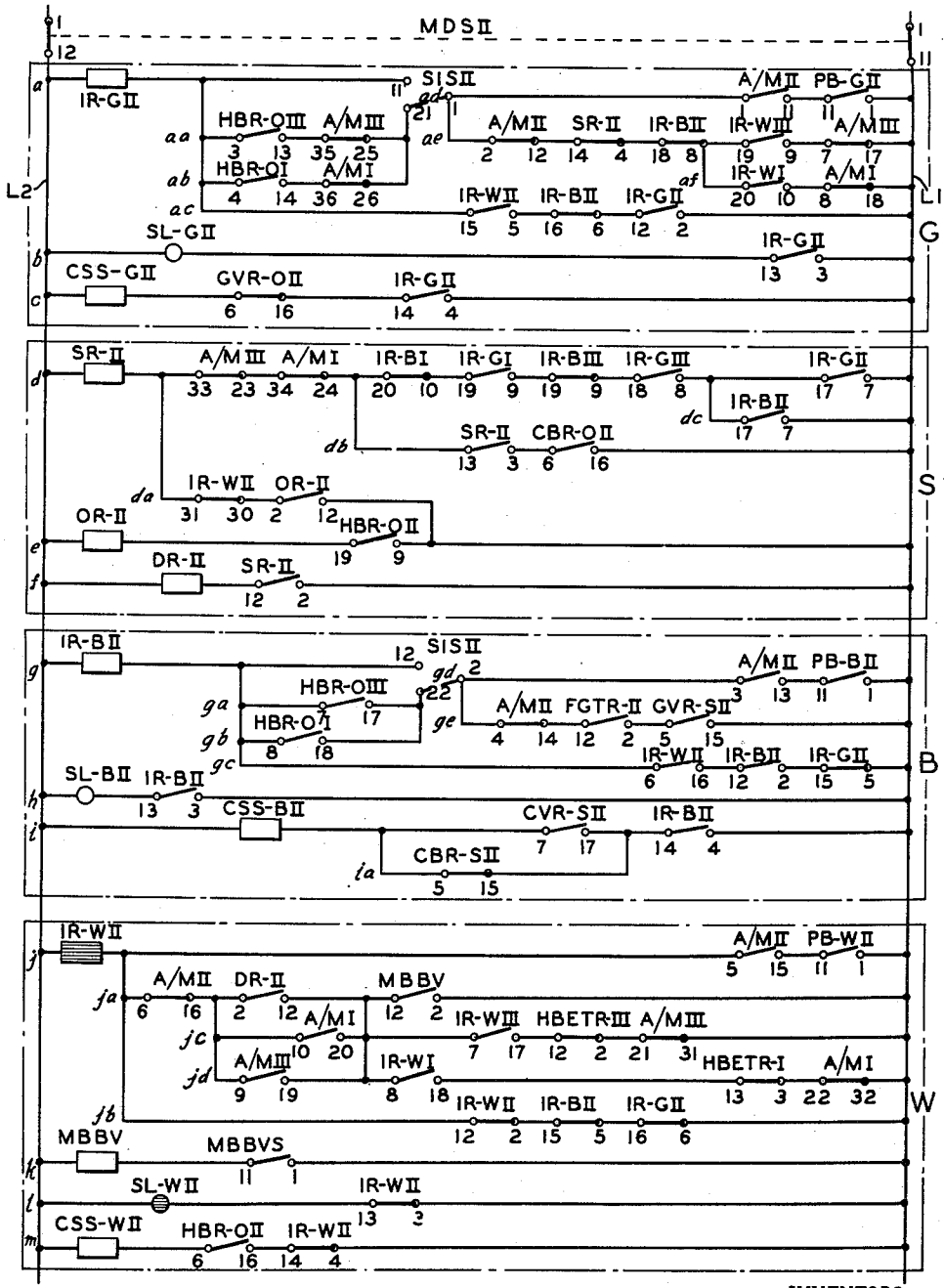


FIG. 6b

INVENTORS
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May 15, 1962 H. JANSEN ET AL 3,034,775

AUTOMATIC CHANGE-OVER SYSTEM FOR BLAST STOVES FOR BLAST FURNACES

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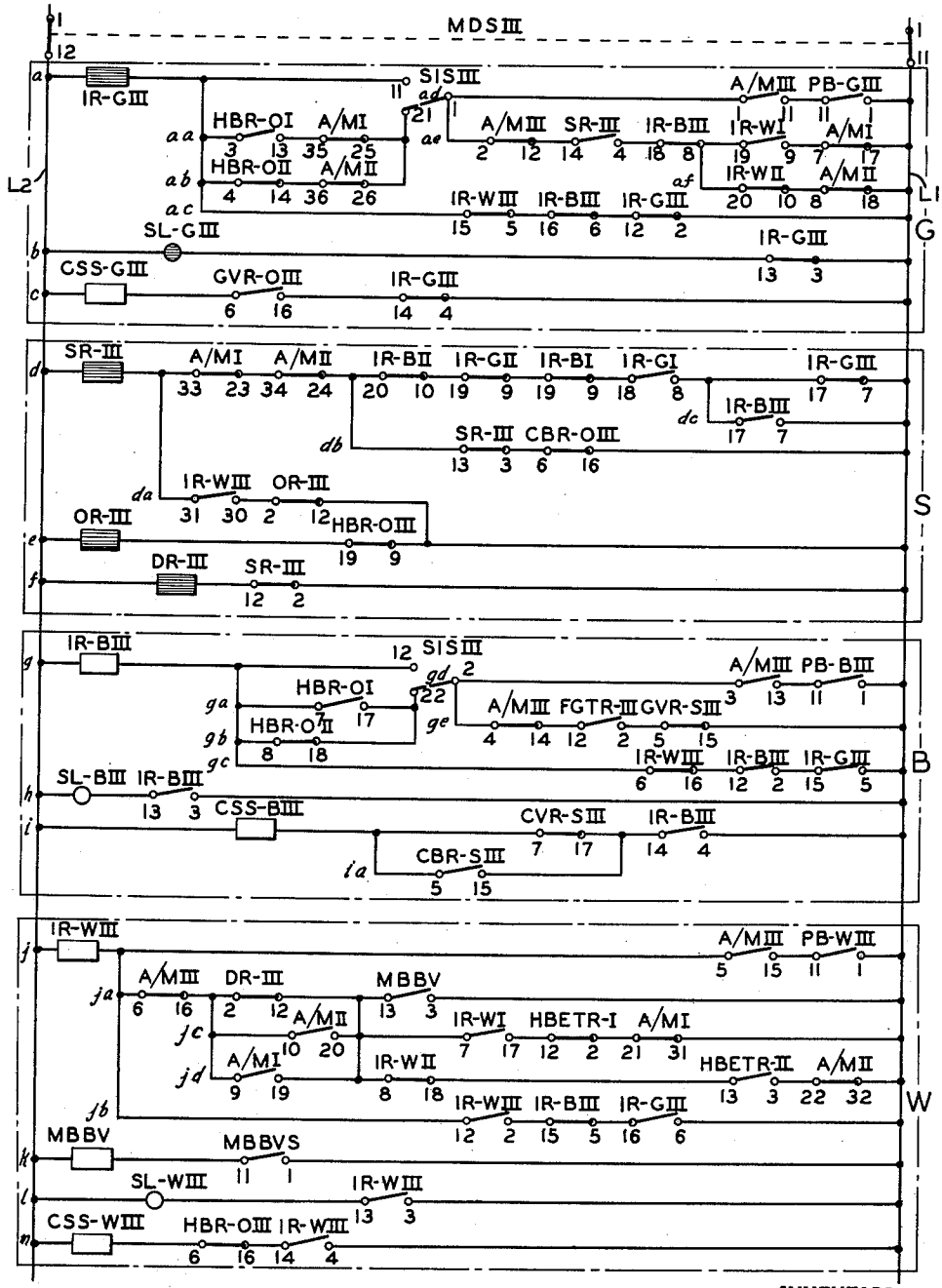


FIG. 6c

INVENTORS
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May 15, 1962 H. JANSEN ET AL 3,034,775

AUTOMATIC CHANGE-OVER SYSTEM FOR BLAST STOVES FOR BLAST FURNACES

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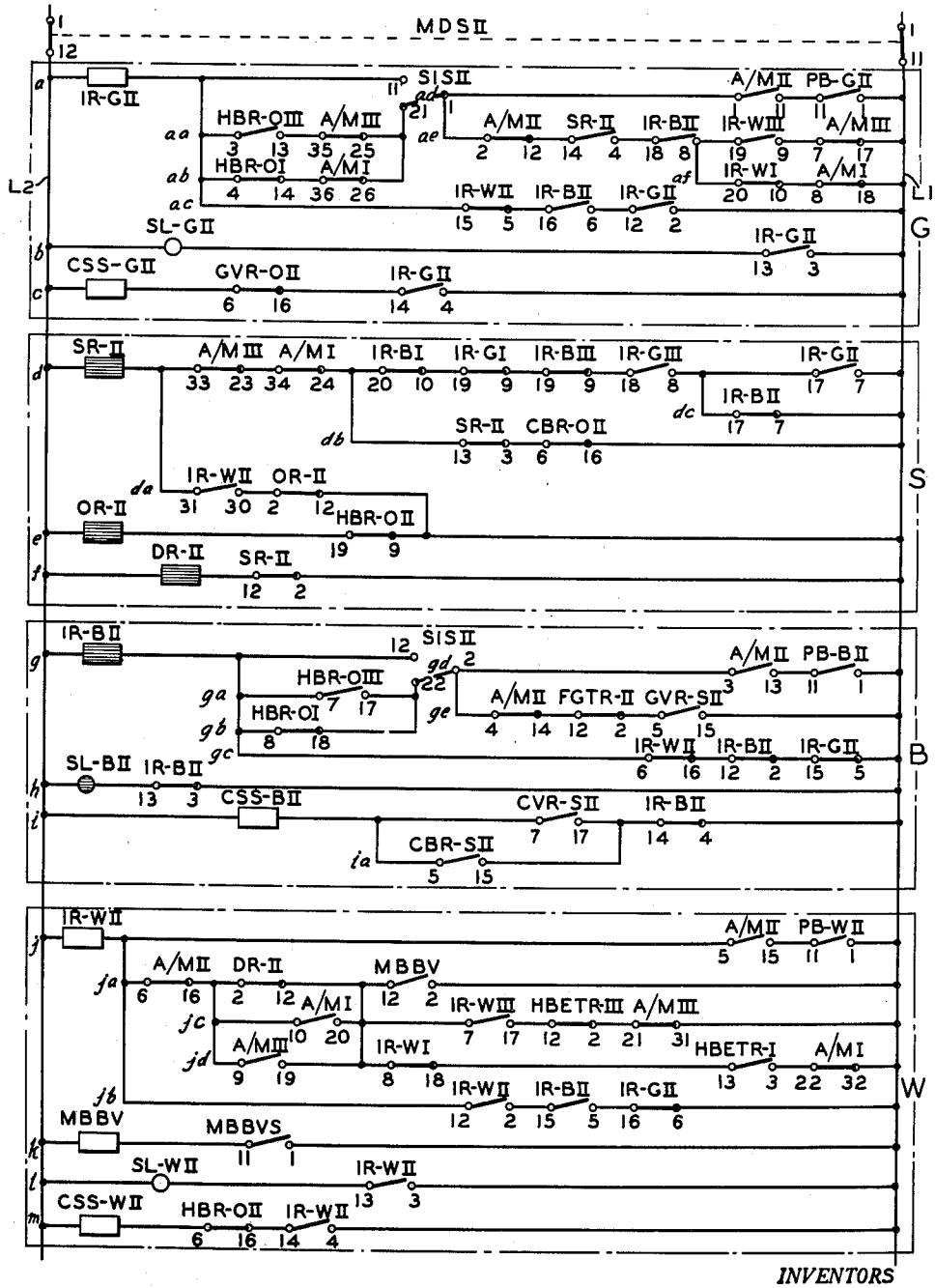


FIG. 7

INVENTORS
HERMANN JANSEN
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May 15, 1962 H. JANSEN ET AL 3,034,775

AUTOMATIC CHANGE-OVER SYSTEM FOR BLAST STOVES FOR BLAST FURNACES

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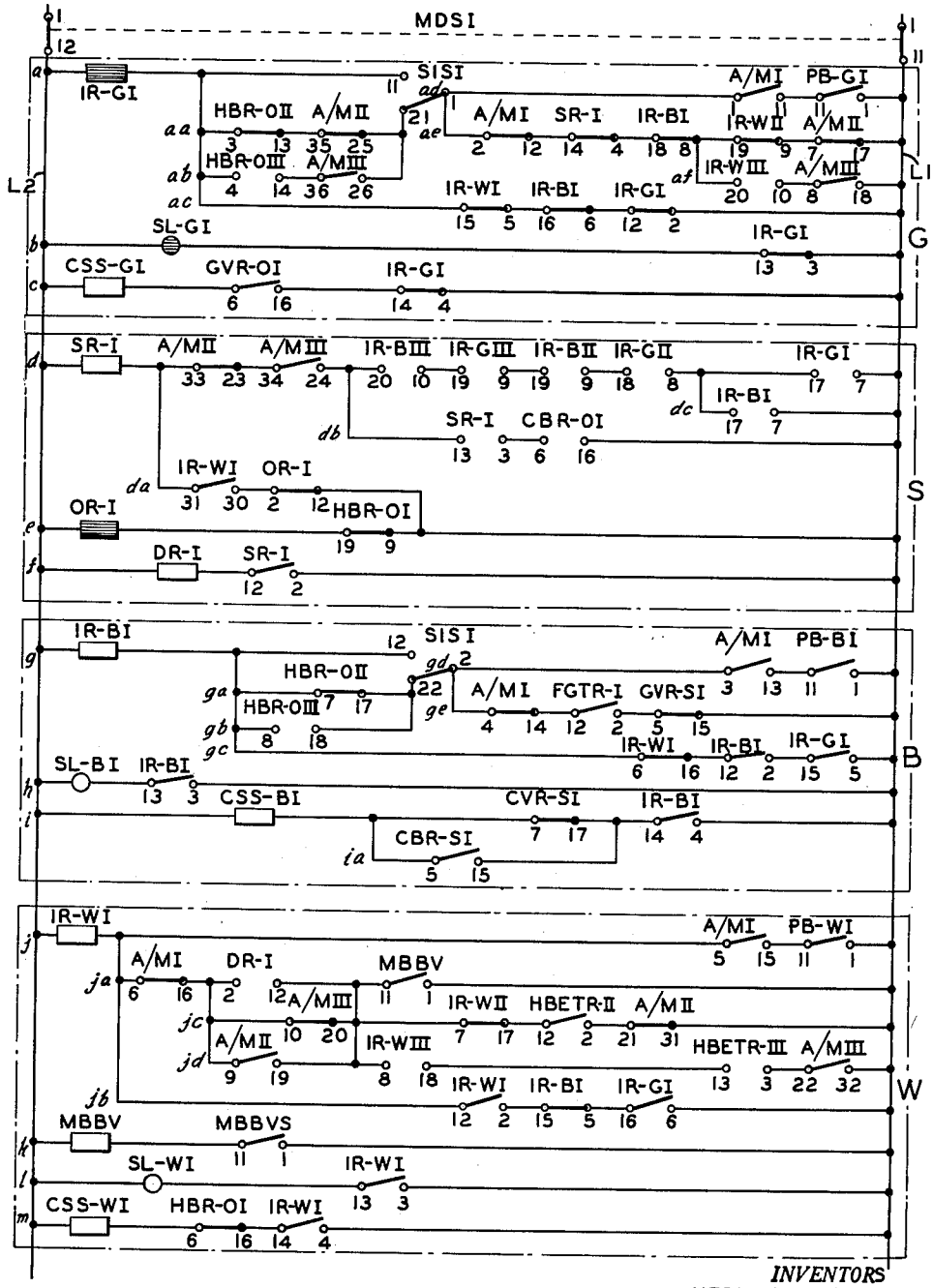


FIG. 8a

INVENTORS
HERMANN JANSEN
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May 15, 1962 H. JANSEN ET AL 3,034,775

AUTOMATIC CHANGE-OVER SYSTEM FOR BLAST STOVES FOR BLAST FURNACES

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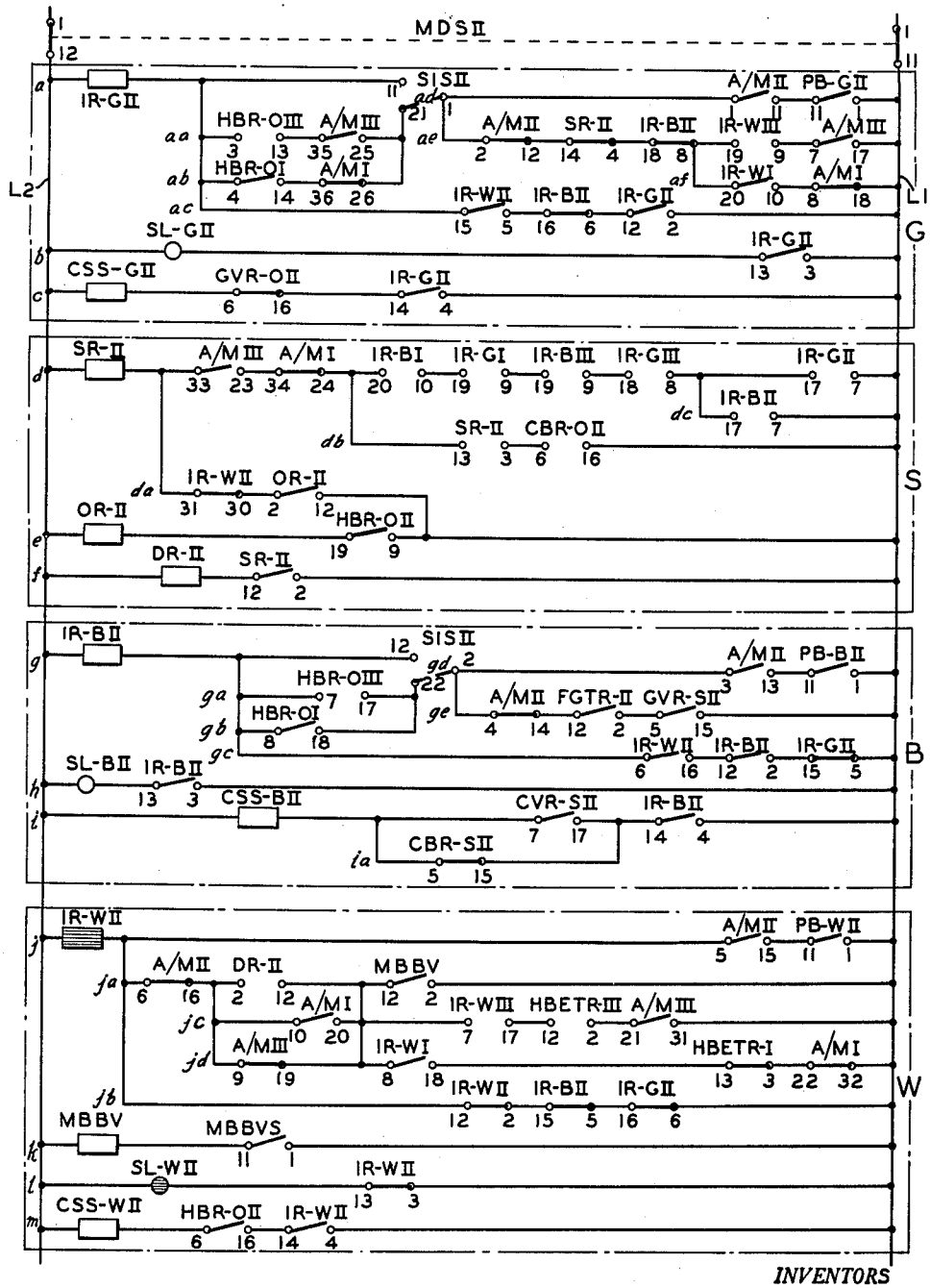


FIG. 8b

INVENTORS
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May 15, 1962 H. JANSEN ET AL 3,034,775

AUTOMATIC CHANGE-OVER SYSTEM FOR BLAST STOVES FOR BLAST FURNACES

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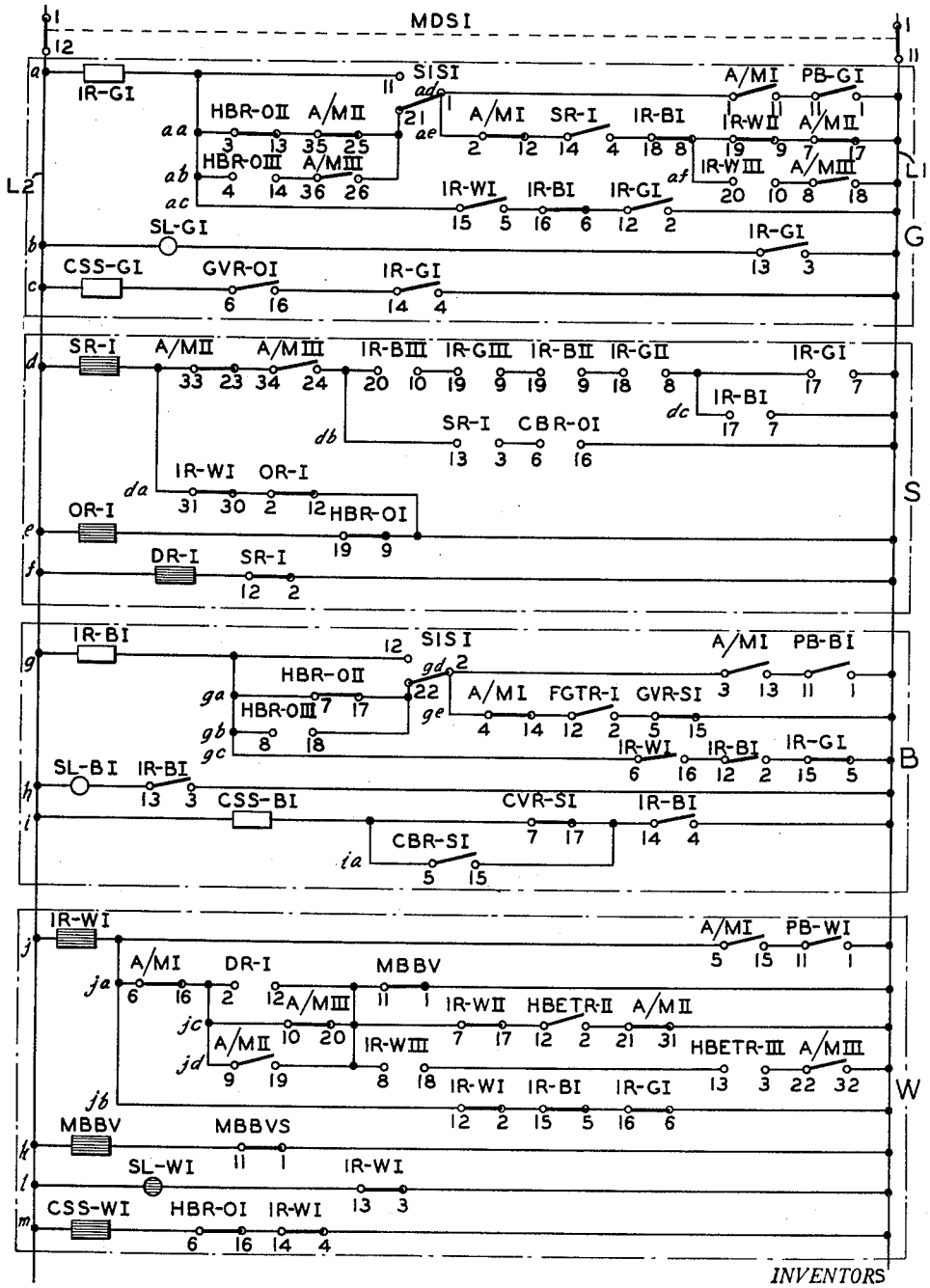


FIG. 9a

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May 15, 1962 H. JANSEN ET AL 3,034,775

AUTOMATIC CHANGE-OVER SYSTEM FOR BLAST STOVES FOR BLAST FURNACES

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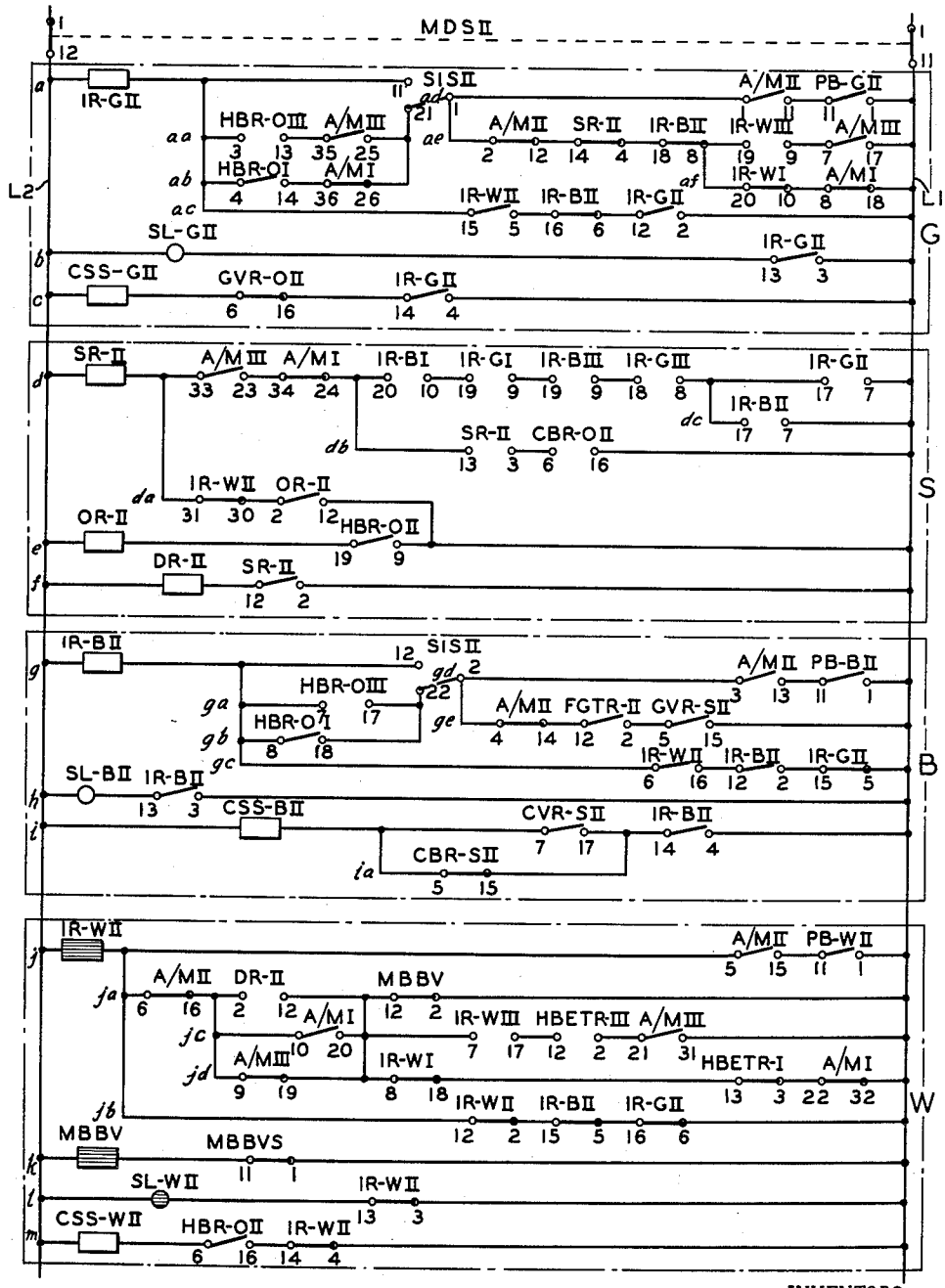


FIG. 9b

INVENTORS
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May 15, 1962 H. JANSEN ET AL 3,034,775

AUTOMATIC CHANGE-OVER SYSTEM FOR BLAST STOVES FOR BLAST FURNACES

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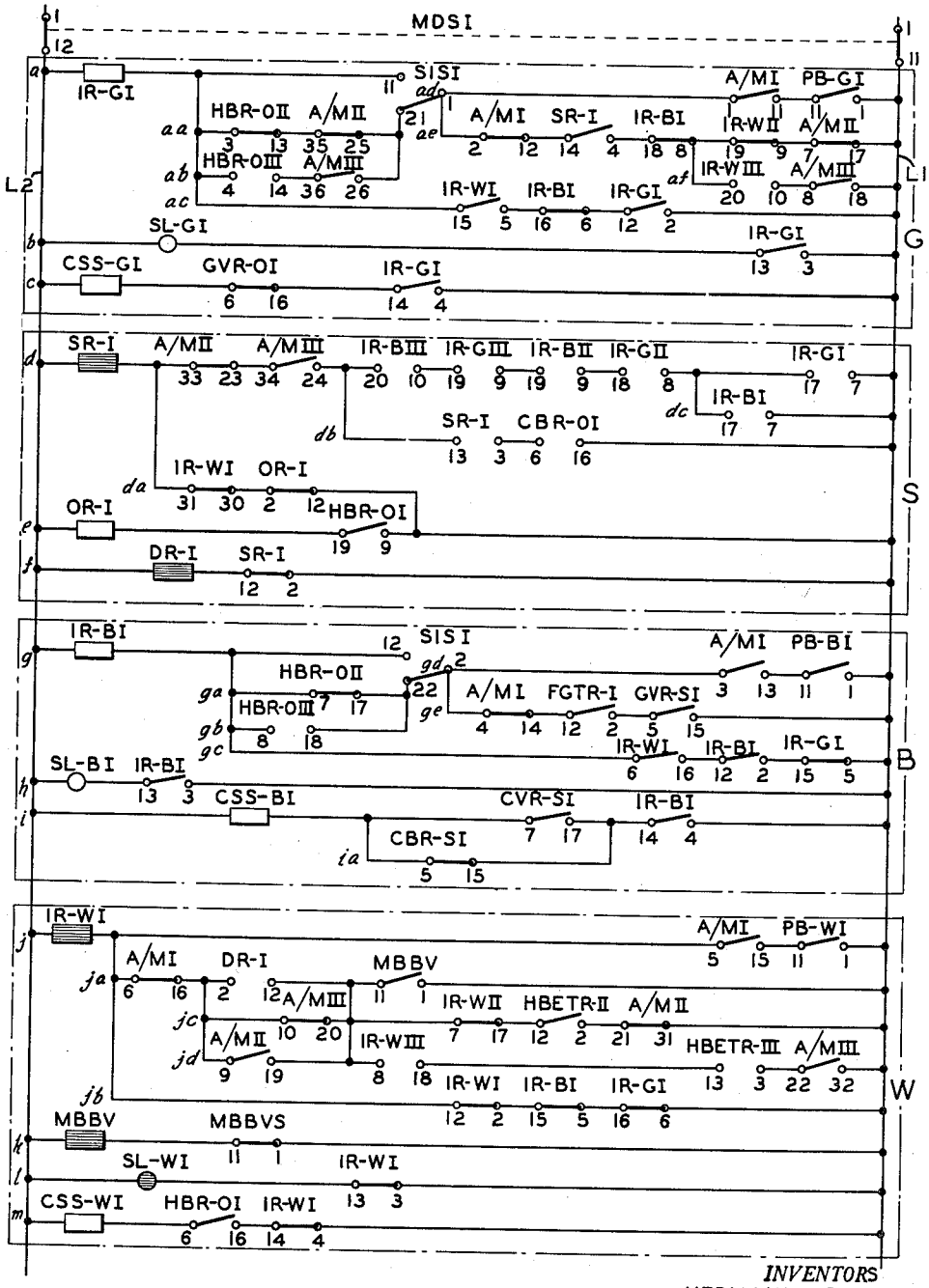


FIG. 10a

INVENTORS
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BY Edwin Leinsohn

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May 15, 1962 H. JANSEN ET AL 3,034,775

AUTOMATIC CHANGE-OVER SYSTEM FOR BLAST STOVES FOR BLAST FURNACES

Filed Nov. 12, 1959 24 Sheets-Sheet 21

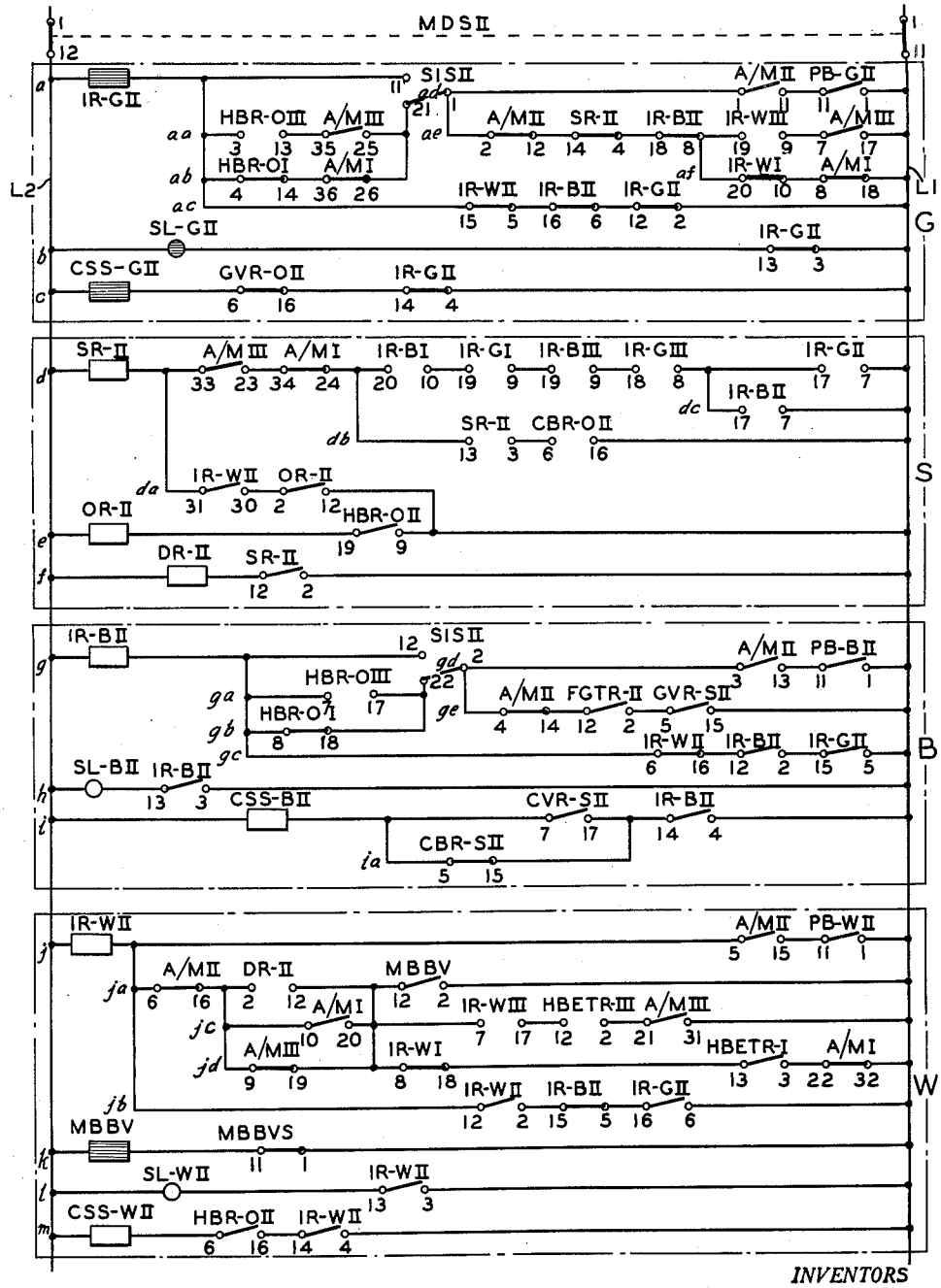


FIG. 10b

INVENTORS
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AUTOMATIC CHANGE-OVER SYSTEM FOR BLAST STOVES FOR BLAST FURNACES

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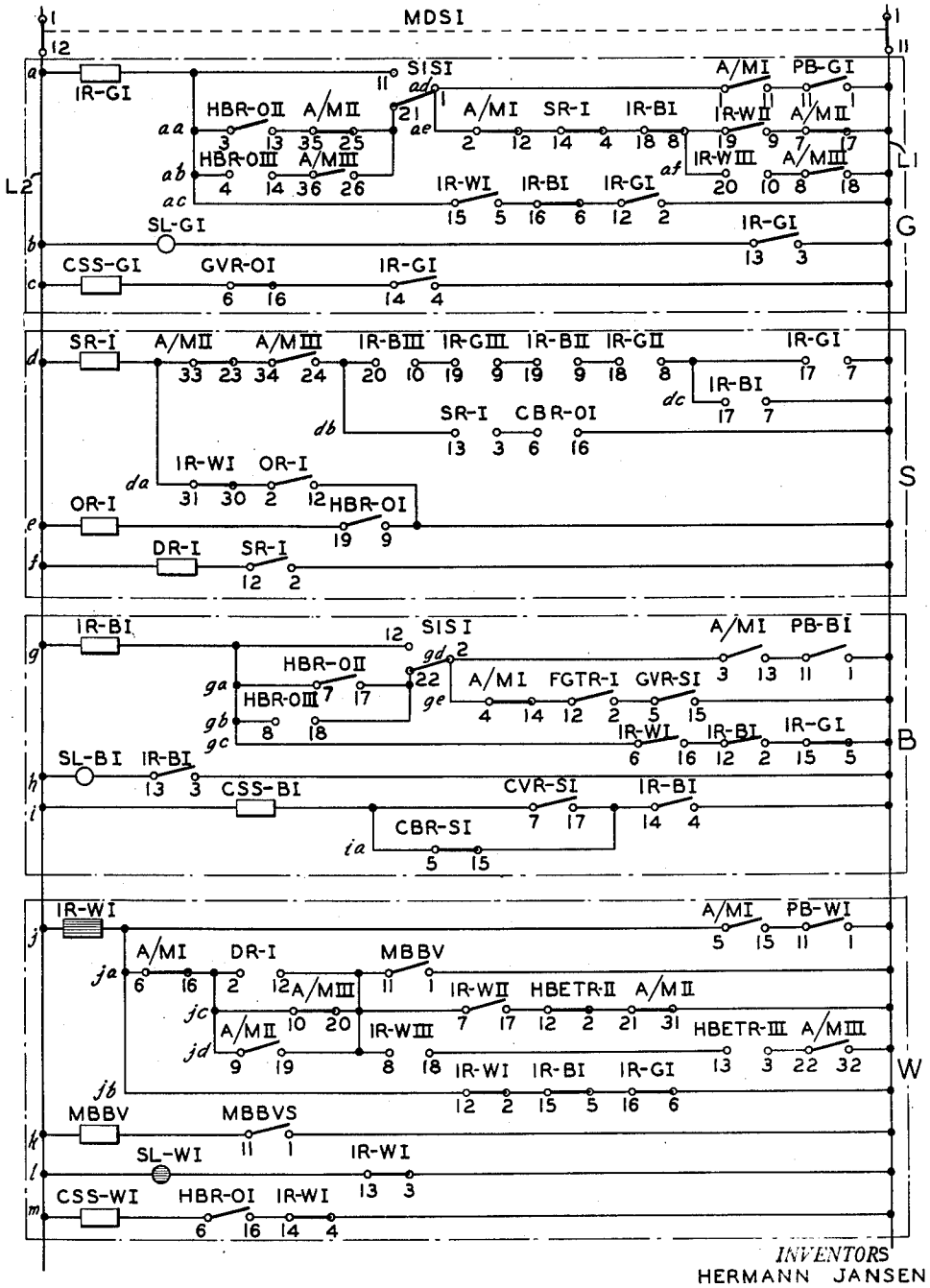


FIG. IIa

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ATTORNEY

AUTOMATIC CHANGE-OVER SYSTEM FOR BLAST STOVES FOR BLAST FURNACES

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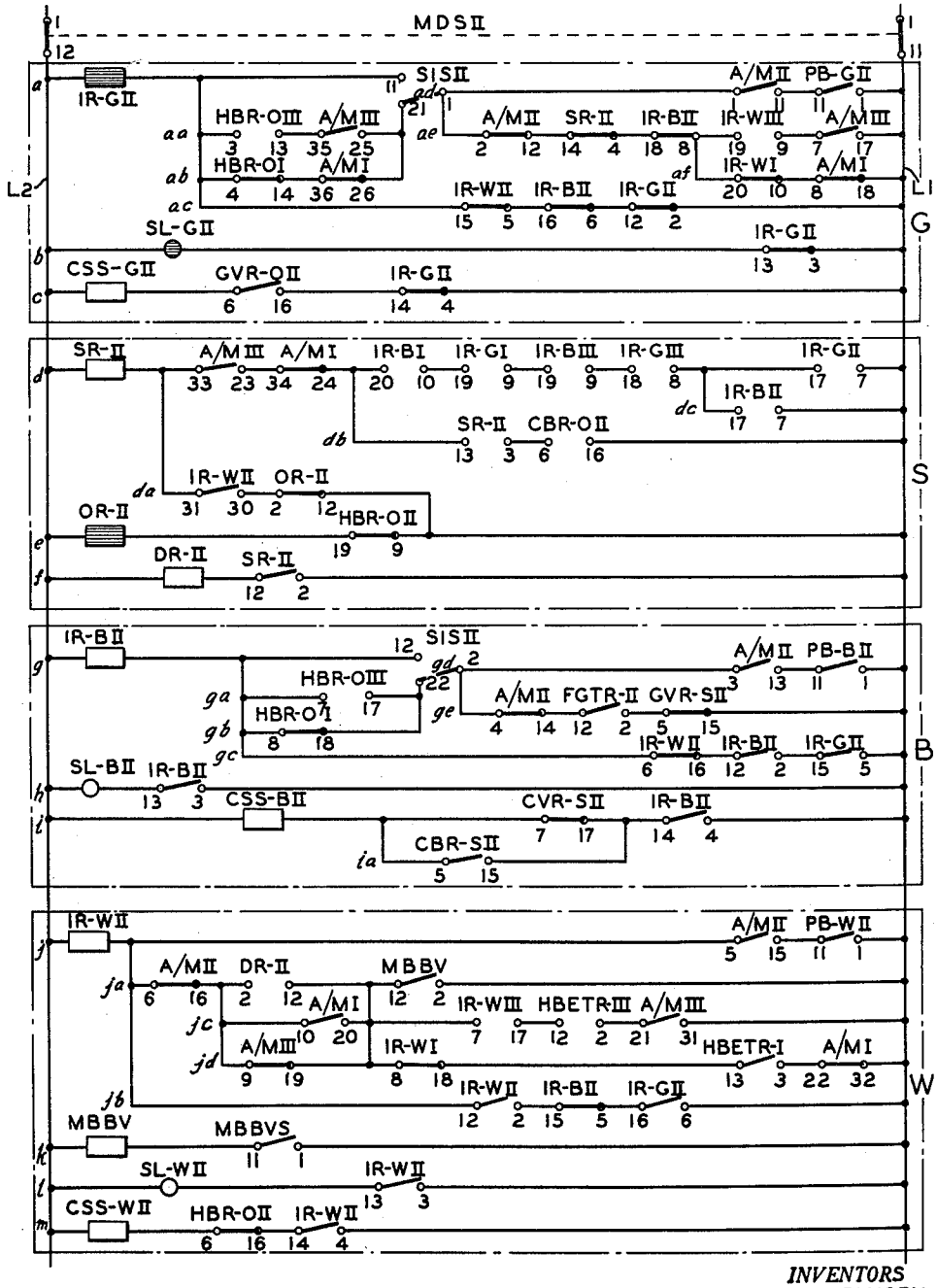


FIG. 11b

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May 15, 1962 H. JANSEN ET AL 3,034,775

AUTOMATIC CHANGE-OVER SYSTEM FOR BLAST STOVES FOR BLAST FURNACES

Filed Nov. 12, 1959 24 Sheets-Sheet 24

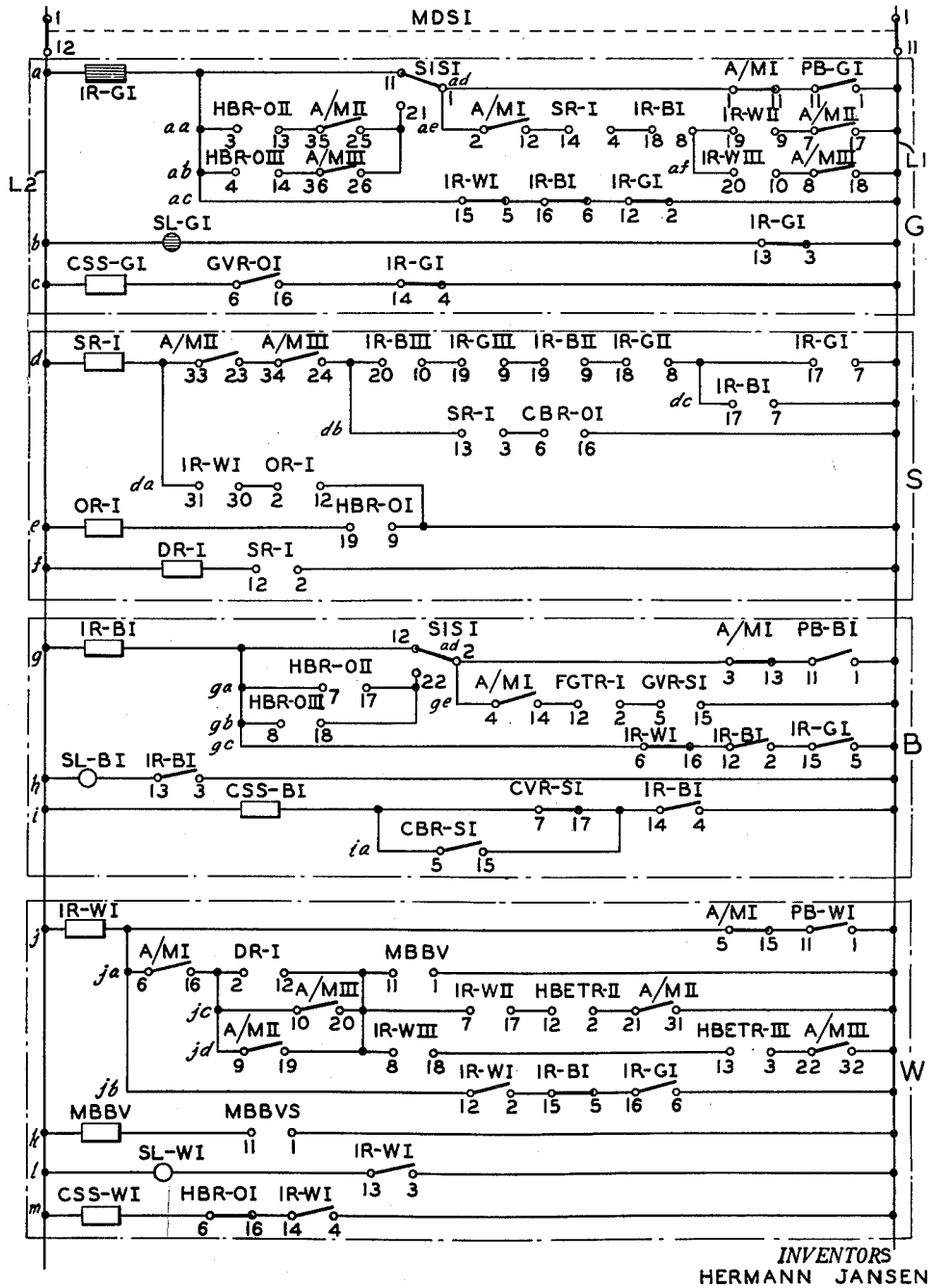


FIG. 12

INVENTORS
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LUDWIG WALTHER

BY Edwin Lewis Lee

ATTORNEY

United States Patent Office

3,034,775
Patented May 15, 1962

3,034,775

AUTOMATIC CHANGE-OVER SYSTEM FOR BLAST STOVES FOR BLAST FURNACES

Hermann Jansen and Ludwig Walther, Duren, Rhineland, Germany, assignors to Zimmermann & Jansen Gesellschaft mit beschrankter Haftung, Duren, Rhineland, Germany, a corporation of Germany

Filed Nov. 12, 1959, Ser. No. 852,370
Claims priority, application Germany July 16, 1959
30 Claims. (Cl. 263—19)

The present invention relates to an automatic change-over system for a plurality of hot blast stoves which are adapted to supply a continuous stream of hot blast to a blast furnace.

More specifically, the present invention relates to automatic means for continuously changing the operating conditions of the respective stoves in a multiple stove arrangement for a blast furnace, so that there is at all times at least one of the hot blast stoves which is in direct fluid communication with the blast furnace for supplying to the latter hot blast at a predetermined desired temperature.

In a multi-stove system, it is desirable to have one stove in the "On Blast" condition, while the remaining stove or stoves are either being heated and are in the "On Gas" condition or are already sufficiently heated and are in the "On Bottled" condition. When the stove that is "On Blast" is at the end of its operating cycle, it is no longer capable of supplying hot blast at the requisite or predetermined temperature to the blast furnace, and it is then necessary to place the remaining stove or one of the remaining stoves in the "On Blast" condition, so as to maintain a continuity of hot blast supplied to the blast furnace. Also, when such other stove is placed in the "On Blast" condition, the stove that has just been in the "On Blast" condition, must be placed in the "On Gas" condition so that it may be re-heated and placed "On Blast" again at a later time, in order to insure such continuity in the multi-stove system. According to this invention, there has been provided a fully automatic system for changing-over each of the respective stoves from one operating condition thereof to another, as may be required, in order to maintain the continuity of supplying hot blast to the blast furnace.

In a three-stove system, in accordance with the present invention, the automatic change-over means are operative to, not only place a new stove in the "On Blast" condition when such is necessary, but at the same time, such automatic change-over system is operative to select the hotter one of the two remaining stoves as the one which is to go next "On Blast." The automatic change-over system of this invention can also be used for the automatic change-over in a two-stove system, in which case there is an automatic alternation of the two stoves between the "On Blast" and "On Gas" conditions thereof.

According to another aspect of the present invention, it is possible to utilize the automatic change-over system of the three-stove system when only two stoves are intended to operate automatically while the third stove may be taken out of operation entirely or may be operated independently of the two-stove system.

It is, therefore, an object of the present invention to provide a change-over system for fully automatically changing-over the operating condition of the stoves in a multi-stove system, for supplying a continuous stream of hot blast to the blast furnace at a predetermined temperature, without the necessity of providing any attention to such installation for the continuous operation thereof.

Another object of the present invention is to provide a fully automatic change-over system in a three-stove system for supplying hot blast to a blast furnace, continuously, at a predetermined temperature.

Another object of the present invention is the provision in a three-stove system for a blast furnace, of an automatic change-over device which is adapted to automatically change-over the three stoves of the system, or only two stoves of the three stoves, as may be desired.

Another object of the present invention is the provision in a two-stove system for supplying hot blast to a blast furnace, of fully automatic means for changing the operating conditions of the two stoves for supplying a continuous stream of hot blast to the blast furnace at a predetermined temperature.

Another object of the present invention is the provision, in a blast furnace installation provided with a plurality of hot blast stoves for supplying a stream of hot blast to the blast furnace, of means for fully automatically placing one of the stoves in the "On Blast" condition when another stove which is then in the "On Blast" condition ceases to supply hot blast to the blast furnace at a predetermined temperature.

Another object of the present invention is the provision, in a blast furnace installation having a plurality of hot blast stoves for supplying a continuous stream of hot blast to said blast furnace, of means for automatically preventing a stove from being placed in the "On Gas" condition, unless there is at least one other stove which is in the "On Blast" condition.

Another object of the present invention is the provision, in a multi-stove blast furnace installation, of means for automatically selecting the hottest stove to be the one to go "On Blast" when it is necessary to place a new stove "On Blast."

Another object of the present invention is the provision of a fully automatic change-over system for a plurality of stoves in a blast furnace installation, which fully automatic system may be used to automatically change-over either (1) all of the stoves in the system, (2) two stoves of the system, or (3) which may be adapted, nevertheless, so that the stoves are operated one independently of another.

Another object of the present invention is the provision, in a stove adapted to supply hot blast to a blast furnace, of means for fully automatically placing such stove in the "On Bottled" condition, after such stove has been heated in the "On Gas" condition to a sufficient and desired extent.

The above and other objects, features and advantages of the present invention will be more fully understood from the following description considered in connection with the accompanying illustrative drawings.

In the drawings:

FIG. 1 is a schematic layout of a blast furnace installation utilizing three hot blast stoves, with flow lines for the different operating conditions of the stoves being shown therein;

FIGS. 2*a*, 2*b* and 2*c* represent the total circuitry associated with the fully automatic change-over operation of the multi-stove system, in accordance with the invention;

FIGS. 3 through 7, inclusive, are schematic circuit

diagrams of the circuitry associated with the three-stove fully automatic change-over operation, showing the respective stoves in the different operating conditions thereof during such fully automatic three stove operation of the system;

FIGS. 8 through 11, inclusive, are similar to FIGS. 3 through 7, and show the condition of stoves I and II during the fully automatic change-over operation for such two stoves, while stove III is taken out of automatic operation; and

FIG. 12 is a schematic circuit diagram similar to FIG. 3, and showing the circuit connections for stove I when it is on push button manual operation.

Referring now to the drawings in detail, FIG. 1 shows a diagrammatic or schematic layout illustrating an arrangement for a blast furnace served by three hot blast stoves, namely stove I, stove II and stove III. It will be understood that the Roman numerals I, II and III which identify the respective stoves are also used to identify the various valves, elements, components, relays, etc., associated with stove I, stove II and stove III, respectively. As is indicated above, the hot blast stoves serve to provide a continuous hot blast required for the blast furnace operation. In a multiple stove system it is necessary to have, at all times during which the blast furnace is expected to operate, at least one of the stoves "On Blast." Accordingly, at least one of the hot blast stoves is at all times in direct communication, by means of the hot blast main **10**, with the blast furnace, while one or both of the other hot blast stoves are being heated up by the combustion of blast furnace gas.

Each hot blast stove is provided with a burner, generally indicated by the reference numeral **12**, which has a flame for igniting the gas-air mixture. Burner **12** is connected via a connecting pipe **14** to the gas main **16**. In the connecting pipe to each burner a gas regulating butterfly valve GRBV is provided to control the gas flow. Each burner is provided with a conventional gas shut-off valve GV and a conventional burner shut-off valve BV. As is well known to those skilled in the art, the gas shut-off valve functions to isolate the burner from the gas main and the burner shut-off valve functions to isolate the burner from a hot blast stove. Each stove is provided with a fan **18**, which supplies the air required for combustion of the gas through a conventional combustion air butterfly valve CABV. The CABV valve is positioned in combustion air conduit **20** which extends between the fan **18** and the burner **12**.

The gas-air mixture is consumed in the combustion chamber **22** of each hot blast stove and the resultant hot flue gases heat up the checker work **24** in each of the hot blast stoves. After flowing past the checker work **24**, the flue gases leave the stove through a conventional chimney valve CV which functions to isolate the hot blast stove from the flue **26**. One or two chimney valves may be provided for each hot blast stove, only one chimney valve being illustrated in FIG. 1. The flue gases flow from the chimney valve through the flue **26** to a stack which is not illustrated.

A conventional cold blast valve CBV is provided for each stove and is connected to a cold blast main **28** and functions to isolate the hot blast stove from the cold blast main. The cold blast main extends into a mixing main **30** which is connected to the hot blast main **10** via a mixing device M, the mixing device functioning to mix hot blast and cold blast prior to its introduction into the bustle pipe BP of the blast furnace. Each stove is connected to the hot blast main **10** by means of a hot blast valve HBV, the hot blast main being provided with an extension pipe **32** for this purpose for each of the stoves. The hot blast main **10** is provided with a pipe **34** which communicates with the bustle pipe BP of the blast furnace.

In FIG. 1, stove I is shown, for purposes of illustration, in "On Blast" condition and stove II is shown in "On Gas" condition, and the flow lines for the fluids passing through each of these stoves are indicated in broken lines. For example, in the case of stove I, which is "On Blast," there is a flow of air from the cold blast main **28** through the open cold blast valve CBVI, through the stove and over the checker work **24** therein, through the open associated hot blast valve HBVI, through extension pipe **32**, through the hot blast main **10** and the mixing device M, into the bustle pipe BP of the blast furnace BF.

In stove II, which is shown in FIG. 1 as being in "On Gas" condition, there is a flow of gas from the gas main **16** through connecting pipe **14**, through the open gas shut-off valve GVII into the associated burner **12** where it is ignited, through the open burner shut-off valve BVII, and into the stove. At the same time, there is a flow of combustion air fed from associated fan **18** through the associated air conduit **20** into the burner, for mixture with the gas, the gas-air mixture being burned in the associated combustion chamber **22** of the stove. The resultant flue gases pass from the checker work **24** of the stove into the stack via the open chimney valve CVII.

It is thus seen that when stove I is in "On Blast" condition, the gas shut-off valve GVI, the burner shut-off valve BVI and the chimney valve CVI are closed while the cold blast valve CBVI and the hot blast valve HBVI are open to permit the total blast coming from the cold blast main **20** to be heated as it flows past the checker work **24** of the stove, and into the bustle pipe BP of the blast furnace by way of the mixing device M.

With respect to stove II, which is shown in "On Gas" condition, it will be noted that the condition of its respective valves is exactly opposite to that of the corresponding valves in stove I which is in "On Blast" condition. More specifically, in stove II, the cold blast valve CBVII and the hot blast valve HBVII are closed, while the gas shut-off valve GVII, the burner shut-off valve BVII and the chimney valve CVII are open, so as to provide an unimpeded flow into the stove of a combustible air-gas mixture, as well as to provide an unimpeded flow of the consumed mixture or flue gases from the stove to the stack.

In addition to the "On Blast" condition, as just described in connection with stove I, and the "On Gas" condition, just described in connection with stove II, there is another condition in which a stove may be, depending on the manner of operation of the three stoves, as will hereinafter be described in great detail. Such other condition is the "On Bottled" condition. In such condition of a stove all its valves are closed, namely the gas valve, the burner valve, the hot blast valve, the cold blast valve and the chimney valve. A stove may be in such a condition either (1) when it is completely taken out of operation, or (2) when it has been "On Gas" for a long enough period of time so that its checker work is sufficiently hot and need not be additionally heated, at which time all its valves are closed and such a stove is kept in heated "On Bottled" condition until it is time for it to be placed "On Blast."

It is therefore seen that a stove can be in either one of three conditions, namely the "On Gas" condition, the "On Blast" condition, or the "On Bottled" condition. For each of these conditions the valves of the stoves must be in their positions described above. In order to place a stove in the "On Blast" condition from the "On Gas" condition, it valves are operated in the following sequence:

(1) The gas shut-off valve is closed;
(2) The burner shut-off valve is closed;
(3) The chimney valve is closed;
(4) The cold blast valve is opened; and
(5) The hot blast valve is opened.

In order to place a stove in the "On Gas" condition from the "On Blast" condition, its valves are operated in the following sequence:

(1) The hot blast valve is closed;
(2) The cold blast valve is closed;

(3) The chimney valve is opened;
(4) The burner shut-off valve is opened; and
(5) The gas shut-off valve is opened.

In order to place a stove in the "On Bottled" condition, from the "On Gas" condition, its valves are operated in the following sequence:

(1) The gas shut-off valve is closed;
(2) The burner shut-off valve is closed; and
(3) The chimney valve is closed.

An apparatus for the automatic sequential operation of the valves of the stoves, as described above, is shown and described in United States Patent application Serial No. 682,913, filed September 9, 1957, now Patent No. 2,931,635, issued April 5, 1960 and assigned to the assignee of the present application.

Each stove is provided with a thermo-sensitive device FGTT, such as a thermo-couple, which is, as shown in FIG. 1, in the path of the exiting flue gases of the stove, and such thermo-sensitive device is thus responsive to the temperature of the exiting flue gases. The flue gas temperature thermostat FGTT can be set to a desired setting so that it is operative to energize a flue gas temperature relay FGTR (not shown in FIG. 1) when the flue gases reach a correspondingly predetermined maximum temperature, for reasons which will be more fully explained hereinafter. Each stove is also provided with a thermo-sensitive device HBETT, as shown in FIG. 1, which is responsive to the temperature of the exiting hot blast of the associated stove. This thermo-sensitive device HBETT is positioned in the path of the hot blast exiting from the stove, as for example near the hot blast valve HBV as shown in FIG. 1 or in the dome of the stove, and is set to a predetermined desired setting so that when the temperature of the hot blast falls below a predetermined value, the device is operative to energize a hot blast exit temperature relay HBETR (not shown in FIG. 1), for reasons which will be fully explained hereinafter.

In connection with the foregoing description it will be understood that the gas regulating butterfly valve GRBV controls the volume of the gas which enters the hot blast stove. This makes it possible, by means of a gas volume control, to predetermine the number of calories to be stored in the checker work of each hot blast stove and, by controlling the combustion air volume via the combustion air butterfly valve CABV, to provide a gas-air ratio necessary for good combustion. Since the hot blast flowing from a stove which is "On Blast" has a gradually decreasing temperature during the blast period, it is necessary, in order to keep the hot blast temperature in the bustle pipe BP of the blast furnace constant, to mix cold blast with the hot blast flowing from the stove before reaching the bustle pipe of the blast furnace. This is done in previously discussed mixer M, which is fully shown and described in United States Patent application Serial No. 651,603, filed April 9, 1957, and assigned to the assignee hereof.

For example, immediately after a stove is put "On Blast" the hot blast temperature exiting from the stove may be at a temperature of about 1050° C. and may fall during the blast period down to 900° C. If the required temperature of the hot blast in the bustle pipe of the blast furnace is 900° C. then a greater cold blast volume must be mixed with the hot blast at the beginning of the blast period so that the resulting temperature of 900° C. is obtained in the bustle pipe. As the temperature of the hot blast drops during the blast period, less cold blast is mixed with the hot blast in order to maintain the required temperature in the bustle pipe, until the end of the blast period at which time little or no cold blast is required.

As was stated before, the supply of cold blast to the hot blast main, before the entry of the hot blast into the blast furnace, is effected through the previously mentioned mixing main **30** located between the cold blast main **28** and the pipe **30** extending from the hot blast main **10**. The volume of the cold blast is controlled by a conventional mixed blast butterfly valve MBBVS built into the mixing main **30**, as indicated in FIG. 1. When valve MBBVS closes at the end of the blast period for a particular stove, said valve is opperative to energize a three pole delay relay MBBV (FIG. 2*b*), for reasons which will be fully explained hereinafter.

In a three-stove system, as shown in FIG. 1, it is desirable to have one stove in "On Blast" condition, while the other two stoves are in "On Gas" condition. When the stove that is "On Blast" has operated for its full cycle, one of the other stoves that was "On Gas" is placed in "On Blast," the stove which was "On Blast" is placed "On Gas" and the other stove which was "On Gas" remains "On Gas" for a second cycle. In this way, a stove is "On Gas" for two cycles and "On Blast" for one cycle. In this connection, it is obvious that the stove which has been "On Gas" for the longest period of time, is the one which is selected to go "On Blast" in the next succeeding cycle. In prior art multi-stove systems, the change-over operation in which a stove was changed from "On Gas" to "On Blast" was done manually, and the selection of which particular stove was to go "On Blast" was likewise done manually. According to one of the aspects of the present invention, the change-over is effectuated fully automatically, and such fully automatic change-over operation includes the making of a fully automatic selection of the stove which has been "On Gas," for the longest period of time, to go on next "On Gas."

In connection with the above, reference is made to Chart No. 1 below:

CHART NO. 1

	Stove No. I	Stove No. II	Stove No. III
0	Unheated	Unheated	Unheated.
1	"On gas" 1st cycle	do	Do.
2	"On gas" 2nd cycle	"On gas" 1st cycle	Do.
3	"On blast"	"On gas" 2nd cycle	"On gas" 1st cycle.
3a	do	"On blast"	"On gas".
4	"On gas" 1st cycle	do	"On gas" 2ndcycle.
4a	"On gas"	do	"On blast."
5	"On gas" 2nd cycle	"On gas" 1st cycle	Do.

Line 0 shows the initial conditions of the system in which all three stoves are unheated. Under manual operation, the following steps would be done to place the three-stove system in operation. Stove I is placed manually "On Gas," while the other stoves remain in their unheated conditions, this being shown in line No. 1. After stove I has been heated for a time period equivalent to one cycle (approximately one hour) stove II is placed manually "On Gas" for its first cycle, while stove I continues to be "On Gas" for its second cycle, and stove III remains unheated, this being shown in line No. 2. After stove I has been heated for its full second cycle, it is placed manually "On Blast," while stove II remains "On Gas" to be heated for its second cycle and stove III is placed manually "On Gas" to be heated for its first cycle, this condition being shown in line No. 3.

When stove I, which is "On Blast," is no longer capable of supplying sufficient hot blast in accordance with the blast furnace requirement, the change-over was accomplished as follows in the prior art: stove II, which is the one which has been "On Gas" for the longest period of time and which is thus the hottest, was manually selected to go "On Blast." For a short interval, therefore, stove II would be placed in "On Blast" while stove I is still "On Blast" and stove III remains "On Gas." This condition is shown in line No. 3*a* and normally lasts for just a few minutes, just enough time for stove II to go fully "On Blast." Once stove II has been placed fully in "On Blast" condition, i.e., its hot blast valve is fully opened,

stove I is placed manually in "On Gas" condition, such being shown in line No. 4.

When stove II is no longer capable of supplying sufficient hot blast to the blast furnace, stove III, being the one that has been "On Gas" twice, is now placed manually "On Blast," stove II remains "On Blast" for the short interval and stove I remains "On Gas," such being shown in line No. 4*a*. Once stove III is fully "On Blast," stove II is placed manually "On Gas" for its first cycle, while stove I continues to be "On Gas" for its second cycle, such being shown in line No. 5.

According to Chart No. 1, it is thus seen that whenever a change-over occurs, there is an interval in which two stoves are "On Blast," namely, the stove which was "On Blast" at the time of the change-over and the stove which has been "On Gas" for two cycles and is thus going into "On Blast" condition.

The various steps effectuating the manual change-over operation, as explained above in connection with Chart No. 1, have been substituted by a completely automatic system in accordance with the present invention, which will now be explained in greater detail with reference to FIGS. 2*a*, 2*b*, 2*c* and 3.

THE THREE-STOVE FULLY AUTOMATIC CHANGE-OVER SYSTEM

Description of FIGS. 2a, 2b and 2c

Referring now to FIGS. 2*a*, 2*b* and 2*c*, these represent all the circuitry associated with the three stoves for the fully automatic change-over operation. FIG. 2*a* represents that part of the total circuitry associated with stove I, FIG. 2*b* represents that part of the total circuitry associated with stove II, and FIG. 2*c* represents that part of the total circuitry associated with stove III. In this connection it will be noted that the Roman numerals I, II and III are used to identify the various elements, components, relays, etc., associated with stove I, stove II and stove III, respectively. It will thus be noted that FIGS. 2*a*, 2*b* and 2*c* are substantially identical in all respects except in the addition to the different components shown therein of the Roman numerals associated with the stove in question.

Each stove is provided with an A/M switch which is a manually operated two-way drum type switch. The A/M switch sets the stove it is associated with into either complete automatic condition or semi-automatic condition. (The semi-automatic and manual operation of the stoves will be fully explained hereinafter.) More specifically, stove I is provided with switch A/MI (FIG. 2*a*), stove II is provided with switch A/MII (FIG. 2*b*), and stove III is provided with switch A/MIII (FIG. 2*c*). Each of the A/M switches operates a plurality of different sets of contacts, namely contacts **1—11, 2—12, 3—13, 4—14, 5—15, 6—16** . . . etc. The respective A/M switches of each stove are shown in FIGS. 2*a*, 2*b* and 2*c* in their position for completely automatic operation in which, as shown, some of the sets of contacts are closed and others are open. It will be understood that in the other position of the A/M switches, namely the position thereof for manual operation the contacts shown open in FIGS. 2*a*, 2*b* and 2*c* will be closed, and vice versa. A main disconnecting switch MDS is provided for each stove for connecting the circuitry thereof to the main power lines **L–1** and **L–2**.

There are also associated with each stove three push button switches, namely a PB–G switch, a PB–B switch and a PB–W switch. These switches are used for the manual operation of the respective stoves, and are shown in the open positions thereof in the respective figures, which correspond to the positions of the switches for automatic operation of the respective stoves. More specifically, the PB–G switch is used in connection with a particular stove which is under manual operation, to place the latter in the "On Gas" condition, the PB–B switch is used to place the associated manually operated stove in "On Bottled" condition, and the PB–W switch is used to place the associated manually operated stove in "On Blast" condition. In this connection it will be noted that the initials G, B and W, used immediately before the stove identifying Roman numerals, are used to identify the use of these switches in connection with the "On Gas," "On Bottled," and "On Blast" conditions, respectively, of the associated stoves.

Each stove is provided with an interlocking relay for the gas condition (IR–G), and an interlocking relay for the bottled condition (IR–B), and an interlocking relay for the blast condition (IR–W). Each of these interlocking relays controls a plurality of sets of contacts. For example, as shown in FIG. 2*a*, interlocking relay IR–GI controls the contacts **2—12, 3—13, 4—14, 5—15, 6—16**, . . . etc. FIG. 2*a*, as well as FIGS. 2*b* and 2*c*, represent all the relays shown therein in their de-energized condition. Accordingly, in the un-energized condition of interlocking relay IR–GI, contacts **2—12, 3—13** and **4—14**, for example, are open, while contacts **5—15** and **6—16**, for example, are closed. It will be understood that when interlocking relay IR–GI is energized, it will be operative to close contacts **2—12, 3—13, 4—14**, and to open contacts **5—15** and **6—16**. Similarly, interlocking relays IR–BI and IR–WI control a plurality of sets of contacts, as shown in FIG. 2*a*. Also, as shown in FIGS. 2*b* and 2*c*, the respective interlocking relays associated with stoves II and III control a plurality of sets of contacts.

Each stove is also provided with a selector relay SR, a delay relay DR, and a delay relay OR, each of these being shown in FIGS. 2*a*, 2*b* and 2*c* in the de-energized conditions thereof for the associated stove. The functions of selector relay SR and delay relays DR and OR for each stove will be more fully explained hereinafter. Each stove is also provided with a stove interlocking switch SIS which is manually operated and which has two positions thereof, for reasons which will also be fully explained hereinafter.

As previously discussed, each stove is provided with a gas valve, a burner valve, at least one chimney valve, a cold blast valve and a hot blast valve. The gas valve is provided with a pair of limit switches (not shown) which are actuated when the gas valve is in the fully opened and fully closed position, respectively. Each of these limit switches is connected to a relay. More specifically, the upper limit switch, which is actuated when the gas valve is fully open, is operative to energize relay GVR–O, and similarly, the lower limit switch which is actuated when the gas valve is fully shut is operative to energize relay GVR–S. These relays for stoves I, II and III, respectively, are shown in FIGS. 2*a*, 2*b* and 2*c*, respectively. Each of these relays, GVR–O and GVR–S, are associated with a plurality of sets of contacts, and are shown in these figures in the de-energized conditions thereof. The cold blast valve at each stove is also provided with an upper and lower limit switch which are operative to energize relays CBR–O and CBR–S, respectively. More specifically, the upper limit switch of the cold blast valve, which is actuated when the cold blast valve is fully open, is operative to energize relay CBR–O, and similarly, the lower limit switch of the cold blast valve, which is actuated when the cold blast valve is fully closed, is operative to energize relay CBR–S. The hot blast valve at each stove is also provided with an upper and lower limit switch which are operative to energize a pair of relays. More specifically, the upper limit switch of the hot blast valve, which is actuated when the hot blast valve is fully open, is operative to energize relay HBR–O. The HBR–O relays for the three stoves are shown, respectively, in FIGS. 2*a*, 2*b* and 2*c*, in the de-energized condition thereof, together with the sets of contacts controlled thereby. The function of the lower limit switch for the hot blast

valve is not described as it is not pertinent to the invention herein, such function being related instead to the automatic sequential operation of the stove valves similar to that described in previously mentioned U.S. Patent No. 2,931,635, assigned to the assignee hereof.

The chimney valve of each stove is provided with a pair of limit switches which are actuated when the chimney valve is in the fully opened and fully closed position, respectively. Each of these chimney valve limit switches is connected to a relay. The lower limit switch of the chimney valve which is actuated when the chimney valve is fully closed, is operative to energize the chimney valve relay CVR–S. These relays CVR–S for stoves I, II and III, respectively, are shown in FIGS. 2*a*, 2*b* and 2*c*. Each of these CVR–S relays is associated with a plurality of sets of contacts, and are shown in these figures in the unenergized condition thereof. The upper limit switch of the chimney valve, which is actuated when the chimney valve is fully opened, performs a function not related to the invention herein, but relates instead to the invention described in previously mentioned U.S. Patent No. 2,931,635, assigned to the assignee hereof.

As previously discussed, each stove is provided with a flue gas temperature thermostat FGTT placed in the path of the flue gases. Thermostat FGTT is operative, when the flue gases have reached a predetermined maximum temperature, to energize a flue gas temperature relay FGTR. The flue gas temperature relays FGTR for each stove are shown in the unenergized condition thereof in FIGS. 2*a*, 2*b* and 2*c*, respectively, together with the set of contacts operated thereby. As previously stated, each stove is provided with another thermo-sensitive device HBETT which is responsive to the temperature of the exiting hot blast of the associated stove. This thermo-sensitive device can be set so that when the hot blast exiting from a stove falls below a predetermined temperature, said device is operative to energize a hot blast exit temperature relay HBETR. The HBETR relay for each stove is shown in FIGS. 2*a*, 2*b* and 2*c*, respectively, in the unenergized condition thereof.

Each stove is provided with a control selector switch CSS which is similar to a drum type switch. The CSS switch has three positions associated therewith, namely the G position in which the control selector switch is operative to place all the valves of the associated stove in proper sequence in the positions necessary to place the latter in the "On Gas" condition, the B position in which the control selector switch is operative to place the valves of the associated stove in proper sequence in the positions necessary to place the latter in the "On Bottled" condition, and the W position in which the control selector switch is operative to place all the valves of the associated stove in proper sequence in the positions necessary to place the latter in the "On Blast" condition. The CSS switch is provided with three relays, G, B and W, and the energization of any one of these relays is operative to cause said switch to place the valves associated with the stove under control of said switch, in their appropriate positions. In other words, and with reference to FIG. 2*a*, when relay GI of CSS–I (hereinafter sometimes also referred to as CSS–GI) is energized, CSS–I is operative to (1) close the hot blast valve, (2) close the cold blast valve, (3) open the chimney valve, (4) open the burner shut-off valve, and (5) open the gas shut-off valve. The CSS switches for the respective stoves are shown in FIGS. 2*a*, 2*b* and 2*c*, respectively.

Each stove is provided with three signal lamps, namely SL–G, SL–B and SL–W, which are adapted to light up when the associated stove begins to go into the "On Gas," "On Bottled" and "On Blast" conditions, respectively. These signal lamps for stoves I, II and III, respectively, are shown in FIGS. 2*a*, 2*b* and 2*c*.

As previously discussed, a mixed blast butterfly valve MBBVS is provided in the path of the cold blast just before the latter reaches the mixer, as shown in FIG. 1. This butterfly valve is operative, when closed, to energize relay MBBV. Relay MBBV is a three-pole delay relay and operates in the following manner: When it is energized by virtue of the closing of valve MBBVS, it is operative to close its three sets of contacts, **1—11**, **2—12**, and **3—13** (FIG. 2*b*) for an adjustable, short period of time (about five seconds). At the end of this short, adjustable period of time the contacts **1—11**, **2—12**, and **3—13** will be opened again. In order to close these contacts, **1—11**, **2—12** and **3—13** again, it is necessary for contacts **1—11** of MBBVS to open and close once more. Although shown only in FIG. 2*b*, contacts **1—11**, **2—12**, and **3—13**, respectively, of MBBV are associated with stoves I, II and III, respectively. It will be understood that FIGS. 2*a*, 2*b* and 2*c* are all part of one circuit and are electrically interconnected as shown. In this connection, the heavy interconnecting lines are used to show the connections associated with the operation of stove I, the dashed lines are used to show the connections associated with the operation of stove II, and the dot-and-dash lines are used to show the connections associated with the operation of stove III.

Description of FIGURE 3

Referring now to FIG. 3, there is shown a schematic circuit diagram of the circuitry associated with the change-over operation for stove I, but arranged differently from the way the same circuitry is shown in FIGS. 2*a*, 2*b* and 2*c*, for the purpose of more clearly understanding the change-over operation. As shown, the circuit diagram in FIG. 3 has been divided into four main sub-divisions: The sub-division enclosed by box G, the sub-division enclosed by box S, the sub-division enclosed by box B, and the sub-division enclosed in box W. Sub-division G encloses the circuitry which is operative to place stove I in the "On Gas" condition; sub-division S encloses the circuitry which is operative to select stove I to go "On Blast"; sub-division B encloses the circuitry which is operative to place stove I in the "On Bottled" condition; sub-division W encloses the circuitry which is operative to place stove I in "On Blast" condition. For purposes of clearer reference to the respective elements in the circuitry of FIG. 3, each of the horizontal lines in the circuit diagram has been given identifying reference letters in small letters. In this connection, it will be noted that in sub-division G the small letters, *a*, *b* and *c* are used to identify the three principal horizontal lines which start off on the left side of the circuit diagram. In the same way, the small letters *d*, *e* and *f* have been used in sub-division S, *g*, *h* and *i* have been used in sub-division B, and the small letters *j*, *k*, *l* and *m* have been used in sub-division W. In addition, some of the horizontal lines divide into a plurality of branches which have been identified with double small letters. In this connection it will be noted that the horizontal lines branching from line *a* are identified as *aa*, *ab*, *ac*, *ad*, *ae* and *af*. The branches of the other lines *b* through *m* have been similarly identified.

The circuitry in FIG. 3 is represented, for the purposes of explanation and understanding thereof, in its condition in which all the relays therein are unenergized, and in which all the appropriate switches are in a position for automatic three-stove operation. This condition of the circuitry of FIG. 3 corresponds to the condition of the corresponding circuitry in FIGS. 2*a*, 2*b* and 2*c*. In such condition of FIG. 3, the manually operated main disconnecting switch MDS–I is closed so that contacts **1—11** and **2—12** thereof are closed.

Sub-Division G

The position of each of the contacts in sub-division G of FIG. 3 is also shown in Chart No. 2 which also indicates the reason for the position of each of the respective contacts. In this connection it must be remembered that FIG. 3, just like FIGS. 2*a*, 2*b* and 2*c*, shows the posi-

tions of the contacts when the switches are all set for automatic three-stove operation, and when all the relays are in their unenergized condition.

CHART NO. 2

Positions of Contacts in Sub-Division G of FIG. 3

Line	Relay or switch	Contacts	Position	Reason
aa	A/M—II	25-35	Closed	A/M—II is shown in position for automatic operation in which contacts 25-35 thereof are closed.
aa	HBR—OII	3-13	Open	HBR—OII is unenergized and contacts 3-13 thereof are open in such unenergized condition.
ab	AM—III	26-36	Closed	A/M—III is shown in position for automatic operation in which contacts 26-36 thereof are closed.
ab	HBR—OIII	4-14	Open	HBR—OIII is unenergized and contacts 4-14 thereof are open in such unenergized condition.
ac	IR—GI	2-12	do	IR—GI is unenergized and contacts 2-12 thereof are open in such unenerigized condition.
ac	IR—BI	6-16	Closed	IR—BI is unenergized and contacts 6-16 thereof are closed in such unenergized condition.
ac	IR—WI	5-15	do	IR—WI is unenergized and contacts 5-15 thereof are closed in such unenergized condition.
ad	PB—GI	1-11	Open	PB—GI switch is shown in position for automatic operation in which contacts 1-11 thereof are open.
ad	SIS—I	1-21	Closed	SIS—I is shown in position for automatic operation in which contacts 1-21 thereof are closed.
ad	A/M—I	1-11	Open	A/M—I is shown in position for automatic operation in which contacts 1-11 thereof are open.
ae	A/M—I	2-12	Closed	A/M—I is shown in position for automatic operation in which contacts 2-12 thereof are closed.
ae	SR—I	4-14	do	SR—I relay is unenergized and contacts 4-14 thereof are closed in such unenergized condition.
ae	IR—BI	8-18	do	IR—BI relay is unenergized and contacts 8-18 thereof are closed in such unenergized condition.
ae	IR—WII	9-19	Open	IR—WII relay is unenergized and contacts 9-19 thereof are open in such unenergized condition.
ae	A/M—II	7-17	Closed	A/M—II is shown in position for automatic operation in which contacts 7-17 thereof are closed.
af	IR—WIII	10-20	Open	IR—WIII relay is unenergized and contacts 10-20 thereof are open in such unenergized condition.
af	A/M—III	8-18	Closed	A/M—III is shown in position for automatic operation in which contacts 8-18 thereof are closed.
b	IR—GI	3-13	Open	IR—GI relay is unenergized and contacts 3-13 thereof are open in such unenergized condition.
c	IR—GI	4-14	do	IR—GI relay is unenergized and contacts 4-14 thereof are open in such unenergized condition.
c	GVR—OI	6-16	Closed	GVR—OI is unenergized and contacts 6-16 thereof are closed in such unenergized condition.

With further reference to FIG. 3, it will be remembered that sub-division G encloses the circuitry which is operative to place stove I in the "On Gas" condition. Referring now particularly to line *ae*, it will be noted that upon the energization of relay IR–WII (which energization occurs the instant that stove II begins to change-over to "On Blast," as will hereinafter be more fully explained), contacts **9—19** of IR–WII would be closed and a circuit will be complete from power line L–**1**, through all of line *ae*, to contact **21** of SIS–I. Referring to line *af*, it will also be noted that in the event that relay IR–WIII is energized (which energization occurs the instant that stove III begins to change-over to "On Blast," as will hereinafter be more fully explained), contacts **10—20** of IR–WIII would be closed and a circuit would be completed from line L–**1** to contact **21** of SIS–I, through line *af* and part of line *ae*. Thus it will be noted that in the event that either stove II or stove III begins to go into "On Blast" condition, a circuit will be complete to contact **21** of SIS–I. Further it will be noted, referring to lines *aa* and *ab*, that if either HBR–OII or HBR–OIII were energized (corresponding to the hot blast valve of stove II or stove III being fully opened when stove II or stove III is fully "On Blast"), a circuit would be complete from contact **21** of SIS–I to power line L–**2**. Accordingly, it is seen that if either stove II or III is fully "On Blast" whereby its hot blast valve is fully opened, a circuit will be complete in stove I to energize the IR–GI relay (line *a*) thereof. Furthermore, the energization of relay IR–GI, as just described, is operative to close contacts **2—12** of said relay shown in line *ac*. Line *ac* constitutes a holding circuit for relay IR–GI. More specifically, if after relay IR–GI has been energized (closing the holding circuit), one or more of the contacts in line *ae* is caused to open, relay IR–GI will nevertheless remain energized by virtue of the holding circuit. The energization of relay IR–GI is also operative to close contact **3—13** thereof in line *b* which completes the circuit through signal lamp SL–GI. The energization of relay IR–GI also causes the closing of contacts **4—14** thereof in line *c* to in turn energize relay GI of the control selector switch CSS–I for stove I. As previously described, the energization of relay GI of CSS–I (sometimes referred to as CSS–GI) is operative to place stove I in the "On Gas" condition. In other words, the energization of CSS–GI initiates or causes the following:

(1) Closes the hot blast valve;
(2) Closes the cold blast valve;
(3) Opens the chimney valve;
(4) Opens the burner shut-off valve; and
(5) Opens the gas shut-off valve.

Once the gas shut-off valve is fully opened, stove I is fully in the "On Gas" condition. When the gas shut-off valve is fully opened, the previously mentioned upper limit switch thereof is operative to energize GVR–OI to thereby open contacts **6—16** thereof (line *c*), and in turn deenergize relay GI of the control selector switch CSS–I (CSS–GI). It will also be noted that the signal lamp SL–GI is lit as soon as stove I begins to go "On Gas" and remains lit while stove I is in the "On Gas" condition.

Thus it is seen that sub-division G of FIG. 3 is automatically operative to place stove I in the "On Gas" condition in response to one of the other stoves going into "On Blast" position. In this connection it must be remembered that stove I, during the normal operation of the system, goes in the "On Gas" condition from an "On Blast" condition. With reference to line *aa* and line *ab*, it will be noted that the IR–GI relay of stove I cannot be energized to initiate the placing of stove I in the "On Gas" condition until the hot blast valve of one of the other stoves is fully opened. This is a safety feature which prevents a stove from going "On Gas" until another stove is fully "On Blast."

Sub-Division S

The position of each of the contacts in sub-division S of FIG. 3 is also shown in Chart No. 3 which also indicates the reason for the position of each of the respective contacts. In this connection it must be remembered that FIG. 3, just like FIGS. 2*a*, 2*b* and 2*c*, shows the positions of the contacts when the switches are all set for automatic three-stove operation and when all the relays are in their unenergized condition.

CHART NO. 3

Position of Contacts in Sub-Division S of FIG. 3

Line	Relay or switch	Contacts	Position	Reason
d	A/M—II	23-33	Closed	A/M—II is shown in position for automatic operation in which contacts 23-33 are closed.
d	A/M—III	24-34	do	A/M—III is shown in position for automatic operation in which contacts 24-34 are closed.
d	IR—BIII	10-20	do	IR—BIII relay is unenergized and contacts 10-20 thereof are closed in such unenergized condition.
d	IR—GIII	9-19	do	IR—GIII relay is unenergized and contacts 9-19 thereof are closed in such unenergized condition.
d	IR—BII	9-19	do	IR—BII relay is unenergized and contacts 9-19 thereof are closed in such unenergized condition.
d	IR—GII	8-18	do	IR—GII relay is unenergized and contacts 8-18 thereof are closed in such unenergized condition.
d	IR—GI	7-17	Open	IR—GI relay is unenergized and contacts 7-17 thereof are open in such unenergized condition.
da	IR—WI	30-31	do	IR—WI relay is unenergized and contacts 30-31 thereof are open in such unenergized condition.
da	OR—I	2-12	do	OR—I relay is unenergized and contacts 2-12 thereof are open in such unenergized condition.
db	SR—I	3-13	do	SR—I relay is unenergized and contacts 3-13 thereof are open in such unenergized condition.
db	CBR—OI	6-16	Closed	CBR—OI relay is unenergized and contacts 6-16 thereof are closed in such unenergized condition.
dc	IR—BI	7-17	Open	IR—BI relay is unenergized and contacts 7-17 thereof are open in such unenergized condition.
e	HBR—OI	9-19	Closed	HBR—OI relay is unenergized and contacts 9-19 thereof are closed in such unenergized condition.
f	SR—I	2-12	Open	SR—I relay is unenergized and contacts 2-12 thereof are open in such unenergized condition.

The circuitry in sub-division S is for the purpose of automatically making the selection of the stove which is to go in the "On Blast" condition.

In this connection reference is made to Chart No. 1. As previously discussed in connection with said chart, during the change-over operation there is a short interval in which two stoves are in the "On Blast" condition. This is shown in Chart No. 1 at lines 3*a* or 4*a*. During these intervals, only one stove is "On Gas," namely the stove that has just completed its first cycle in the "On Gas" condition. More specifically, referring to line 3*a*, it is noted that stove I is "On Blast," stove II is "On Blast" and stove III is the only one which is "On Gas," and has been that way for one entire cycle. This stove III is the one which should be the one to go "On Blast" in the next change-over operation, as shown in line 4*a*. It is during the interval when two stoves are "On Blast" (stove I and stove II in line 3*a*) that the selection is made of the remaining stove (stove III in line 3*a*, the only one which is not "On Blast") to go "On Blast" in the next succeeding change-over operation, as shown in line 4*a*. The selection, as described above, is automatically made through the circuitry in sub-division S, as will now be described.

Referring therefore to sub-division S of FIG. 3, it will be noted that line *d* contains contacts 8—18 of relay IR–GII, 9—19 of relay IR–BII, 9—19 of relay IR–GIII, 10—20 of relay IR–BIII, and 7—17 of relay IR–GI. The first four sets of contacts just described are shown in closed position, because FIG. 3 shows the positions of these contacts when the associated relays are in their unenergized condition, namely relays IR–GII, IR–BII, IR–GIII and IR–BIII. In actual operation, the IR–GII relay is energized (opening contacts 8—18 thereof) only when stove II is in the "On Gas" condition, the IR–BII relay is energized (opening contacts 9—19 thereof) only when

stove II is "On Bottled," the IR–GIII relay is energized (opening contacts 9—19 thereof) only when stove III is "On Gas," and the relay IR–BIII is energized (opening contacts 10—20 thereof) only when stove III is "On Bottled." Also, contacts 7—17 of relay IR–GI (line *d*) is energized only when stove I is "On Gas." Accordingly, only in the event that stoves II and III are "On Blast" and stove I is "On Gas" will there be a complete circuit through line *d* from power line L–1 to power line L–2 to energize relay SR–I in line *d*. This condition occurs only during the interval of change-over, and it is only then that the SR relay of the one stove which is not "On Blast" is energized.

Referring to line *dc* in sub-division S, it will be noted that there is in parallel with previously discussed contacts 7—17 of IR–GI, the contacts 7—17 of IR–BI. The line *dc* has been provided so that if, during the change-over interval, the one stove that is not "On Blast" happens to be "On Bottled," that stove will nevertheless still have its selector relay SR energized. Thus it is seen that whenever two stoves are "On Blast," the selector relay SR of the other stove (the only one which is not "On Blast") is energized.

The energization of SR–I (line *d*) is operative to close contacts 3—13 thereof, line *db*, which constitutes a holding circuit for the selector relay SR–I. Accordingly, once SR–I is energized during the interval in which stoves II and III are "On Blast," it will remain energized through the holding circuit, even after one or more of the contacts in line *d* opens after the interval. The energizaiton of relay SR–I in line *d*, as just described, is operative to close contacts 2—12 thereof in line *f* to in turn complete a circuit to delay relay DR–I. The relay DR–I is a time-delay relay and is operative only after a given predetermined period of time after it is energized, at which time it will close contacts 2—12 thereof in line *ja*, of sub-division W in FIG. 3, for reasons which will be more fully explained hereafter. It must also be noted that as soon as selector relay SR–I in line *d* is energized, it is operative to open contacts 4—14 thereof in line *ae*. When contacts 4—14 of SR–I in line *ae* are so opened, relay IR–GI (line *a*) remains energized nevertheless through the previously discussed holding circuit therefore in line *ac*. It will also be noted, at this time, that relay SR–I will remain energized through line *db*, until contacts 6—16 of CBR–OI (line *db*) are opened. These contacts will be opened when the cold blast valve of stove I is fully opened, and this will not happen until after stove I is placed in the "On Blast" condition.

It will be noted, at this time, that relay SR–I (line *d*) can also remain energized by way of line *da* which contains contacts 30—31 of IR–WI and contacts 2—12 of OR–I. Line *e* contains relay OR–I in series with contacts 9—19 of HBR–OI. Relay OR–I is a delay relay which operates in the following fashion: As soon as it is energized, its contacts will close; however, when relay OR–I, is de-energized, the opening of its contacts is delayed for an adjustable, short period of time (about ten or fifteen seconds). It is also seen that in the event that relay OR–I and relay IR–WI are each energized, closing contacts 30—31 of IR–WI and contacts 2—12 of OR–I, in line *da*, respectively, another holding circuit for selector relay SR–I is established. The purpose of this holding circuit will be more fully explained hereinafter. However, at this time it will be noted that relay OR–I is energized only when contacts 9—19 of HBR–OI (line *e*) are closed, such being the case at all times except when the hot blast valve of stove I is fully opened. When the hot blast valve of stove I is opened, contacts 9—19 thereof in line *e* will open to de-energize relay OR–I. However, the contacts of relay OR–I will not open until there has been a delay of a short period of time. Accordingly, in the event that relay SR–I (line *d*) is energized via the holding circuit in line *da*, such holding circuit will be opened in order to de-energize relay SR–I a short period

of time after the hot blast valve of stove I has been fully opened.

Sub-Division B

The position of the contacts in sub-division B of FIG. 3 is also shown in Chart No. 4 which also indicates the reason for the position of the respective contacts. In this connection, it must be remembered that FIG. 3, just like FIGS. 2*a*, 2*b* and 2*c*, shows the position of the contacts when the switches are all set for automatic operation, and when all the relays are in their unenergized condition.

CHART NO. 4

Position of Contacts in Sub-Division B of FIG. 3

Line	Relay or switch	Contacts	Positions	Reasons
ga	HBR—OII	7-17	Open	HBR—OII relay is unenergized and contacts 7-17 thereof are open in such unenergized condition.
gb	HBR—OIII	8-18	do	HBR—OIII relay is unenergized and contacts 8-18 thereof are open in such unenergized condition.
gc	IR—GI	5-15	Closed	IR—GI relay is unergized and contacts 5-15 thereof are closed in such unenergized condition.
gc	IR—BI	2-12	Open	IR—BI relay is unenergized and contacts 2-12 thereof are open in such unenergized condition.
gc	IR—WI	6-16	Closed	IR—WI relay is unenergized and contacts 6-16 thereof are closed in such unenergized condition.
gd	PB—BI	1-11	Open	PB—BI is shown in position for automatic operation in which contacts 1-11 thereof are open.
gd	A/M—I	3-13	do	A/M—I is shown in position for automatic operation in which contacts 3-13 thereof are open.
gd	SIS—I	2-22	Closed	SIS—I is shown in position for automatic operation in which contacts 2-22 thereof are closed.
ge	GVR—SI	5-15	do	GVR—SI is unenergized and contacts 5-15 thereof are closed in such unenergized condition.
ge	FGTR—I	2-12	Open	FGTR—I is unenergized and contacts 2-12 thereof are open in such unenergized condition.
ge	A/M—I	4-14	Closed	A/M—I is shown in position for automatic operation in which contacts 4-14 thereof are closed.
h	IR—BI	3-13	Open	IR—BI relay is unenergized and contacts 3-13 thereof are open in such unenergized condition.
i	IR—BI	4-14	do	IR—BI relay is unenergized and contacts 4-14 thereof are open in such unenergized condition.
i	CVR—SI	7-17	Closed	CVR—SI relay is unenergized and contacts 7-17 thereof are closed in such unenergized condition.
ia	CBR—SI	5-15	do	CBR—SI relay is unenergized and contacts 5-15 thereof are closed in such unenergized condition.

With reference to FIG. 3, it will be remembered that subdivision B encloses the circuitry which is operative to place stove I in the "On Bottled" condition. In this connection, it will be noted, with reference to Chart No. 1, that the sequential operation of the respective stoves described therein shows that a stove is normally "On Gas" for two cycles after which it goes in "On Blast" condition. However, it is possible that during the time the stove which is "On Blast" is supplying hot blast at the predetermined temperature, the stove which is "On Gas" for the second time has been heated sufficiently and no additional heating thereof is required. Under these circumstances, it is desirable to place that stove in "On Bottled" condition, which means:

(1) Closing its gas shut-off valve;
(2) Closing its burner shut-off valve; and
(3) Closing its chimney valve.

(It will be remembered that, as here described, the stove goes to "On Bottled" from "On Gas" condition, in which latter condition its cold blast valve and hot blast valve are closed.) When the chimney valve is completely closed, the stove in question is fully in "On Bottled" condition and remains that way until the next change-over occurs and causes the stove in question to go from "On Bottled" to "On Blast."

The determination of when a stove has been heated sufficiently is made by the previously described thermo-sensitive device FGTT responsive to the flue gas temperature of the stove in question. In other words, when the flue gas temperature of a stove reaches a predetermined maximum value, the thermo-sensitive device FGTT is actuated and operative to energize the flue gas temperature relay FGTR.

Referring now to sub-division B of FIG. 3, it will be noted that in the event that the temperature of the flue gases of stove I reaches the predetermined maximum temperature set therefor, it will be operative to energize relay FGTR–I so as to close contacts **2—12** thereof, shown in line *ge*. When this occurs, a circuit is completed from line L–1, through line *ge*, to contact **22** of SIS–I. Furthermore, if either of the other two stoves, namely stove II or stove III is in the "On Blast" condition, either contacts **7—17** of HBR–OII in line *ga* or contacts **8—18** of HBR–OIII in line *gb* would be closed to complete a circuit from line L–1 to line L–2 through relay IR–BI.

With reference to Chart No. 1, it will be noted that when one of the stoves which is "On Gas" has been heated sufficiently to go "On Bottled," then in the stove which is going "On Bottled" either line *ga* or line *gb* will be closed. Accordingly, upon the closing of the contacts **2—12** of FGTR–I in line *ge*, a circuit will immediately be completed to relay IR–BI. What the circuitry in lines *ga* and *gb* does is to act as a safety feature to prevent a stove from going "On Bottled" unless one of the other stoves is fully "On Blast."

The energization of relay IR–BI, as just described, is operative to close contacts **2—12** thereof in line *gc*. Line *gc* constitutes a holding circuit for relay IR–BI. More particularly, if after relay IR–BI has been energized (closing the holding circuit), one or more of the contacts in line *ge* is caused to be opened, relay IR–BI will nevertheless remain energized by virtue of the holding circuit. The energization of relay IR–BI is also operative to close contacts **3—13** thereof in line *h* which completes the circuit through the signal lamp SL–BI which will thus be lit to indicate the beginning of the placing of stove I in the "On Bottled" condition. At the same time, the energization of relay IR–BI is operative to close contacts **4—14** thereof in line *i* to in turn energize relay CSS–BI of the control selector switch CSS–I for stove I. As previously indicated, the energization of relay CSS–BI is operative to place stove I in the "On Bottled" condition. In other words, the energization of CSS–BI initiates or causes the following:

(1) Closes the gas shut-off valve;
(2) Closes the burner shut-off valve; and
(3) Closes the chimney valve.

Once the chimney valve is fully closed, stove I is fully in the "On Bottled" condition. It must also be noted that as soon as relay IR–BI in line *g* is energized, it is also operative to open contacts **8—18** thereof in line *ae* and contacts **6—16** thereof in line *ac* of sub-division G in FIG. 3. This immediately opens the circuit to relay IR–GI in line *a* which results immediately in the re-opening of contacts **3—13** of relay IR–GI in line *b* in order to put out signal lamp SL–GI, and thereby indicate that stove I is no longer in the "On Gas" condition. When the gas valve is fully closed (under the control of CSS–BI, as previously described), the lower limit switch thereof is operative to energize relay GVR–SI to thereby open contacts **5—15**

of relay GVR–SI (line *ge*). This acts as a safety precaution to prevent stove I from going in "On Bottled" condition when that stove has its gas valve fully shut. In other words, according to the circuitry in line *ge*, it is only when stove I is in "On Gas" condition that it can go to the "On Bottled" condition. Referring to line *ia*, it will be noted that there is provided therein contacts **5—15** of relay CBR–SI. As can be seen from FIG. 2*a* as well as FIG. 3, these contacts are closed when relay CBR–SI is unenergized. In other words, contacts **5—15** of CBR–SI are open at all times when the cold blast valve is in the closed position, which means that these contacts **5—15** are open at all times when the associated stove is either "On Gas" or "On Bottled." Accordingly, during the three-stove automatic operation of the system, line *ia* is open at all times except when the stove is "On Blast" and line *ia* is of no concern during such three-stove automatic operation. The purpose of line *ia* is for manual operation which will be described hereinafter in greater detail. Referring now to line *i*, it will be noted that as soon as the chimney valve is fully closed (under the control of CSS–BI as previously described), the lower limit switch of the chimney valve is actuated and is then operative to energize relay CVR–SI to thereby open contacts **7—17** thereof (line *i*), and in turn de-energize relay CSS–BI of the control selector switch CSS–I.

Thus it is seen that sub-division B of FIG. 3 is automatically operative to place stove I in the "On Bottled" condition in response to the temperature of the flue gases thereof reaching a predetermined maximum temperature. It is also seen that the provision of contacts **5—15** of GVR–SI in the line *ge* prevents stove I from going "On Bottled" from any condition except "On Gas," and the provision of contacts **7—17** of HBR–OII (line *ga*) and of contacts **8—18** of HBR–OIII (line *gb*) prevents stove I from going "On Bottled" during the three-stove automatic operation, unless one of the other two stoves is "On Blast."

Sub-Division W

The position of the contacts in sub-division W of FIG. 3 is also shown in Chart No. 5 which also indicates the reason for the position of the respective contacts. In this connection, it must be remembered that FIG. 3, just like FIGS. 2*a*, 2*b* and 2*c*, shows the position of the contacts when the switches are all set for automatic operation, and when all the relays are in their unenergized condition.

CHART NO. 5

Position of Contacts in Sub-Division W of FIG. 3

Line	Relay or switch	Contacts	Position	Reason
j	PB—WI	1-11	Open	PB—WI is shown in position for automatic operation in which contacts 1-11 therefore are open.
j	A/M—I	5-15	do	A/M—I is shown in position for automatic operation in which contacts 5-15 thereof are open.
ja	A/M—I	6-16	Closed	A/M—I is shown in position for automatic operation in which contacts 6-16 thereof are closed.
ja	DR—I	2-12	Open	DR—I is unenergized and contacts 2-12 thereof are open in such unenergized condition.
ja	MBBV	1-11	do	MBBV is shown in its unenergized condition in which contacts 1-11 thereof are open.
jb	IR—GI	6-16	Closed	IR—GI relay is unenergized and contacts 6-16 thereof are closed in such unenergized condition.
jb	IR—BI	5-15	do	IR—BI is unenergized and contacts 5-15 thereof are closed in such unenergized condition.
jb	IR—WI	2-12	Open	IR—WI relay is unenergized and contacts 2-12 thereof are open in such unenergized condition.
jc	A/M—III	10-20	do	A/M—III is shown in position for automatic operation in which contacts 10-20 are open.
jc	IR—WII	7-17	Open	IR—WII relay is unenergized and contacts 7-17 thereof are open in such unenergized condition.
jc	HBETR—II	2-12	do	HBETR—II is unenergized and contacts 2-12 thereof are open in such unenergized condition.
jc	A/M—II	21-31	Closed	A/M—II is shown in position for automatic operation in which contacts 21-31 thereof are closed.
jd	A/M—II	9-19	Open	A/M—II is shown in position for automatic operation if which contacts 9-19 thereof are open.
jd	IR—WIII	8-18	do	IR—WIII is unenergized and contacts 8-18 thereof are open in such unenergized condition.
jd	HBETR—III	3-13	do	HBETR—III is unenergized and contacts 3-13 thereof are open in such unenergized condition.
jd	A/M—III	22-32	Closed	A/M—III is shown in position for automatic operation in which contacts 22-32 thereof are closed.
k	MBBVS	1-11	Open	MBBVS is shown in its open condition in which contacts 1-11 thereof are are open.
l	IR—WI	3-13	do	IR—WI is unenergized and contacts 3-13 thereof are open in such unenergized condition.
m	IR—WI	4-14	do	IR—WI is unenergized and contacts 4-14 thereof are open in such unenerzized condition.
m	HBR—OI	6-16	Closed	HBR—OI is unenergized and contacts 6-16 thereof are closed in such unenergized condition.

With reference to FIG. 3, it will be remembered that sub-division W encloses the circuitry which is operative to place stove I in the "On Blast" condition.

As previously stated, the butterfly valve MBBVS (FIG. 1) is disposed in the path of the cold blast just before the latter reaches the mixer M, as shown in FIG. 1. The cold blast passing by the butterfly valve is provided in the system for the purpose of being mixed with the hot blast coming from one of the stoves, in order that the temperature of the blast going into the blast furnace may be kept uniform throughout the operation. More specifically, at the beginning of an "On Blast" cycle for a stove, the hot blast it supplies is hottest. At that stage, a relatively large amount of cold blast which passes through the butterfly valve MBBVS is provided to mix with the hot blast so that the desired temperature of the blast going into the blast furnace is obtained. After the stove which is "On Blast" has been in that condition for awhile, the hot blast which it supplies is at a lower temperature so that the amount of cold blast to be mixed therewith in order to maintain a uniform temperature for the blast going into the blast furnace is lower, and the butterfly valve MBBVS is partially closed. Thus it is seen that as the temperature of the hot blast exiting from a stove becomes lower, the butterfly valve which controls the amount of cold blast (the butterfly valve MBBVS) keeps on closing until it is completely closed. When the butterfly valve MBBVS is completely closed, it is time for another stove to go "On Blast."

Referring now to line *k* in sub-division W, it will be noted that when the butterfly valve MBBVS closes, relay MBBV becomes immediately energized. Such energization of relay MBBV in line *k* will cause the immediate closing of contacts **1—11** thereof in line *ja* (for an adjustable, short period of time), thereby completing a circuit in line *ja* from line L–1 to contact **12** of relay DR–I.

At this time it will be remembered that contacts **2—12** of DR–I will be closed in stove I only if, during the previous change-over operation, selector relay SR–I of

stove I is energized. In other words, contacts **2—12** of DR–I (line *ja*) are closed in stove I only if stove I has, during the previous change-over interval, been selected to go "On Blast" in the next succeeding change-over operation. Accordingly, if stove I is the one that has been pre-selected, contacts **2—12** of DR–I (line *ja*) will be closed, and upon the closing of contacts **1—11** of relay MBBVS (due to the fact that the stove presently "On Blast" is no longer supplying hot blast at a sufficiently high temperature), a circuit will be completed from power line L–1, through line *ja*, to power line L–2, thereby energizing relay IR–WI. The energization of relay IR–WI (line *j*), as just described, is operative to close contacts **2—12** thereof in line *jb*. Line *jb* constitutes a holding circuit for relay IR–WI. More specifically, if after relay IR–WI has been energized (closing the holding circuit), one or more of the contacts in line *ja* is caused to open, relay IR–WI will nevertheless remain energized by virtue of the holding circuit. It must be noted that immediately upon the energization of relay IR–WI, contacts **5—15** thereof in line *ac* (sub-division G) and contacts **6—16** thereof in line *gc* (sub-division B) are opened, so as to immediately interrupt the holding circuits for relays IR–GI and IR–BI, respectively. Thus it is seen that as soon as relay IR–WI is energized, the previously energized interlocking relay in stove I, whether it be IR–GI or IR–BI, will be de-energized.

It will also be remembered, at this time, that relay MBBV is a delay relay and that contacts **1—11** thereof in line *ja* will re-open a short time after they have been closed. However, when they re-open, IR–WI in line *j* will nevertheless remain energized by virtue of the holding circuit in line *jb*.

The energization of IR–WI (line *j*) as described above, is operative to immediately close contacts **3—13** thereof in line *l* which completes a circuit through signal lamp SL–WI which will thus be lit to indicate the beginning of placing stove I in the "On Blast" condition. At the same time, the energization of relay IR–WI (line *j*) is operative to close contacts **4—14** thereof in line *m* to in turn energize relay CSS–WI of the control selector switch CSS–I for stove I. As previously stated, the energization of relay CSS–WI is operative to place stove I in the "On Blast" condition. In other words, the energization of CSS–WI initiates or causes the following:

(1) Closes the gas shut-off valve;
(2) Closes the burner shut-off valve;
(3) Closes the chimney valve;
(4) Opens the cold blast valve; and
(5) Opens the hot blast valve.

The above steps will automatically take place if stove I has its IR–WI relay energized at the time when said stove I is in "On Gas." However, it is clear that if at the time of the energization of relay IR–WI in stove I, said stove is in the "On Bottled" condition, (for reasons previously explained), the gas shut-off valve, burner shut-off valve and chimney valve of stove I have already been closed, and accordingly the energization of CSS–WI will cause only:

(1) The opening of the cold blast valve; and
(2) The opening of the hot blast valve.

Under either of these two conditions, stove I will be fully "On Blast," when its hot blast valve is fully opened.

Once the hot blast valve of stove I is fully opened, relay HBR–OI will be energized to cause contacts **6—16** thereof in line *m* to open, and in turn to cause the de-energization of relay CSS–WI of the control selector switch CSS–I. In summary, it is seen that upon the closing of the butterfly valve MBBVS, the stove which has been pre-selected in the previous change-over operation will automatically go into "On Blast" condition.

Referring to line *jc* of sub-division W, it will be noted that in the event that contacts **7—17** of IR–WII were closed and contacts **2—12** of HBETR–II were also closed, a circuit would be completed in stove I to contact **12** of DR–**1**, and if contacts **2—12** of DR–I are also closed (because stove I is the pre-selected stove), relay IR–WI would become energized to place stove I in "On Blast," regardless of the condition of relay MBBV. Said contacts **7—17** of IR–WII would be closed only if stove II were "On Blast," and said contacts **2—12** of HBETR–II would be closed only if the temperature of the exiting hot blast from stove II were to fall below a predetermined temperature (as explained before). In other words, in the event that the temperature of the exiting hot blast of another stove which is "On Blast" falls below a predetermined value, stove I will automatically go "On Blast." Line *jd* is similar in all respects to line *jc*, but will be operative to complete a circuit to contact **12** of DR–I in the event of that stove III is "On Blast" and the temperature of the exiting hot blast thereof falls below a predetermined value.

Thus it is seen that stove I will automatically go "On Blast" upon the happening of any one of the following events:

(1) The butterfly valve MBBVS closes, or
(2) Either one of the other two stoves is "On Blast" and fails to supply a hot blast at the predetermined temperature.

It will be understood that while the discussion of FIG. 3 related only to the circuitry associated with stove I, there is similar circuitry associated with each of stoves II and III which operates in the same manner.

The fully automatic change-over operation of the three-stove system will now be described with particular reference to FIGS. 4*a–c*, 5*a–c*, and 6*a–c*.

FIG. 4*a* represents all the circuitry associated with stove I for the automatic change-over operation thereof, with the contacts thereof shown in the position they are in when stove I is fully "On Blast," corresponding to the condition of stove I shown in line 3 of Chart No. 1. FIG. 4*b* represents all the circuitry associated with stove II for the automatic change-over operation thereof, with the contacts thereof shown in the position they are in when stove II is fully "On Gas" for its second cycle, corresponding to the condition of stove II shown in line 3 of Chart No. 1. Fig. 4*c* represents all the circuitry associated with stove III for the automatic change-over operation thereof, with the contacts thereof shown in the position they are in when stove III is fully "On Gas" for its first cycle, corresponding to the condition of stove III shown in line 3 of Chart No. 1. In other words, FIGS. 4*a*, 4*b* and 4*c* represent the exact circuitry of the respective stoves when they are in the condition shown in line 3 of Chart No. 1.

Description of FIGURE 4a

Referring now specifically to FIG. 4*a*, it will be noted that all the A/M, PB–G and SIS contacts are in the identical position as that shown in FIG. 3, since FIG.4*a* shows the fully automatic arrangement for the system. It will further be noted that since stove I is "On Blast," relay IR–WI (line *j*) is energized whereby:

(1) Contacts **2—12** thereof (line *jb*) are closed;
(2) Contacts **3—13** thereof (line *l*) are closed, whereby signal lamp SL–WI in line *l* is lit;
(3) Contacts **4—14** thereof (line *m*) are closed;
(4) Contacts **5—15** thereof (line *ac*) are open;
(5) Contacts **6—16** thereof (line *gc*) are open; and
(6) Contacts **30—31** thereof (line *da*) are closed.

Since stove I is fully "On Blast":

(1) Its hot blast valve is fully opened, whereby HBR–OI is energized and (*a*) contacts **6—16** thereof (line *m*) are open; and (*b*) contacts **9—19** thereof (line *e*) are open:

(2) Its cold blast valve is fully open, whereby (*a*) CBR–OI is energized and contacts **6—16** thereof (line *db*) are open; and (*b*) relay CBR–SI is unenergized and contacts **5—15** thereof (line *ia*) are closed;

(3) Its gas valve is fully closed, whereby (*a*) relay

GVR–OI is unenergized and contacts **6—16** thereof (line *c*) are closed; and (*b*) relay GVR–SI is energized and contacts **5—15** thereof (line *ge*) are open;

(4) Its chimney valve is closed, whereby relay CVR–SI is energized and contacts **7—17** (line *i*) thereof are open.

It will also be noted that relay IR–BI (line *g*) is unenergized because both lines *ge* and *gc* are open. Since relay IR–BI (line *g*) is unenergized it is obvious that:

(1) Contacts **2—12** thereof (line *gc*) are open;

(2) Contacts **3—13** thereof (line *h*) are open, and signal lamp SL–BI in line *h* is unlit;

(3) Contacts **4—14** thereof (line *i*) are open;

(4) Contacts **5—15** thereof (line *jb*) are closed;

(5) Contacts **6—16** thereof (line *ac*) are closed;

(6) Contacts **7—17** thereof (line *dc*) are open; and

(7) Contacts **8—18** thereof (line *ae*) are closed.

Referring to line *e*, it will be noted that contacts **9—19** of HBR–OI are open, whereby delay relay OR–I is de-energized. Due to the de-energization of relay OR–I (and looking at FIG. 4*a* after the adjustable delay time of OR–I has elapsed), contacts **2—12** of OR–I in line *da* are open thereby opening the circuit to relay SR–I via line *da*. Also, referring to line *db* it will be noted that due to the fact that contacts **6—16** of CBR–OI are open (because the cold blast valve of stove I is fully opened), the holding circuit for relay SR–I via line *db* is also open. Accordingly, relay SR–I is de-energized in the condition of stove I shown in FIG. 4*a*, namely when stove I is fully "On Blast." As a result of the de-energized condition of relay SR–I (line *d*):

(1) Contacts **2—12** thereof (line *f*) are open, whereby to de-energize relay DR–I (line *f*);

(2) Contacts **3—13** of SR–I (line *db*) are open; and

(3) Contacts **4—14** thereof (line *ae*) are closed.

Due to the de-energized condition of relay DR–I (line *f*), contacts **2—12** thereof (line *ja*) are open.

As previously stated, FIG. 4*a* shows stove I in its condition represented by line 3 in Chart No. 1 at which time stove II and stove III are both "On Gas." Since stoves II and III are "On Gas," relays IR–WII and IR–WIII are unenergized. Due to the deenergized condition of relay IR–WII:

(1) Contacts **9—19** thereof (line *ae*) are open; and

(2) Contacts **7—17** thereof (line *jc*) are open.

Due to the de-energized condition of relay IR–WIII:

(1) Contacts **10—20** thereof (line *af*) are open; and

(2) Contacts **8—18** thereof (line *jd*) are open.

Also, since neither stove II nor stove III is "On Blast," their hot blast valves are fully closed. Accordingly, HBR–OII and HBR–OIII are unenergized and:

(1) Contacts **3—13** of HBR–OII (line *aa*) are open;

(2) Contacts **7—17** of HBR–OII (line *ga*) are open;

(3) Contacts **4—14** of HBR–OIII (line *ab*) are open; and

(4) Contacts **3—18** of HBR–OIII (line *gb*) are open.

Referring to lines *aa*, *ab* and *ac*, it will be apparent that all the circuits to relay IR–GI (line *a*) are open so that said relay IR–GI is unenergized. Due to the unenergized condition of IR–GI:

(1) Contacts **2—12** thereof (line *ac*) are open;

(2) Contacts **3—13** thereof (line *b*) are open;

(3) Contacts **4—14** thereof (line *c*) are open;

(4) Contacts **5—15** thereof (line *gc*) are closed;

(5) Contacts **6—16** thereof (line *jb*) are closed; and

(6) Contacts **7—17** thereof (line *d*) are open.

Referring to line *d* in FIG. 4*a*, it will be noted that cince both stoves II and III are "On Gas," relays IR–GII and IR–GIII are unenergized, whereby contacts **8—18** of IR–GII and contacts **9—19** of IR–GIII are open. Also, due to the fact that stove II and stove III are "On Gas," relays IR–BII and IR–BIII, respectively, are unenergized, and contacts **9—19** of IR–BII (line *d*) as well as contacts **10—20** of IR–BIII (line *d*) are closed.

It will be remembered that FIG. 4*a* represents stove I when it is fully "On Blast," and when it is supplying hot blast at a sufficiently high temperature to the blast furnace. Accordingly, the butterfly valve MBBVS is open whereby contacts **1—11** thereof (line *k*) are open, and relay MBBV (line *k*) is unenergized. Due to the unenergized condition of relay MBBV, contacts **1—11** thereof (line *ja*) are open. Also, since neither stove II nor stove III is "On Blast," the exiting hot blast temperature of either stove II or stove III is below the prescribed value set therefor whereby HBETR–II and HBETR–III are energized (it will be remembered that the HBETR relays are energized when the temperature of the exciting hot blast falls below a predetermined value). Due to the energized condition of HBETR–II and HBETR–III, contacts **2—12** of HBETR–II (line *jc*) are closed, as are contacts **3—13** of HBETR–III in line *jd*.

Description of FIGURE 4b

Referring now specifically to FIG. 4*b*, it will be remembered that FIG. 4*b* represents all the circuitry associated with stove II for the automatic change-over thereof, with the contacts thereof shown in the position therein when stove II is fully "On Gas" for its second cycle, corresponding to the condition of stove II shown in line 3 of Chart No. 1. It will be noted that all the A/M, PB–G and SIS contacts are in their position for fully automatic three-stove operation in the manner similar to that explained in connection with FIG. 3. It will be further noted that since stove II is "On Gas" (for its second cycle), relay IR–GII is energized, whereby:

(1) Contacts **2—12** thereof (line *ac*) are closed;

(2) Contacts **3—13** thereof (line *b*) are closed, whereby signal lamp SL–GII is lit to indicate that stove II is "On Gas";

(3) Contacts **4—14** thereof (line *c*) are closed;

(4) Contacts **5—15** thereof (line *gc*) are open;

(5) Contacts **6—16** thereof (line *jb*) are open;

(6) Contacts **7—17** thereof (line *d*) are closed; and

(7) Contacts **8—18** thereof (line *d* in FIG. 4*a*) are open, as previously discussed in connection with FIG. 4*a*.

Since stove II is fully "On Gas";

(1) Its gas valve is fully open, whereby (*a*) GVR–OII is energized and contacts **6—16** thereof (line *c*) are open; and (*b*) relay GVR–SII is unenergized and contacts **5—15** thereof (line *ge*) are closed;

(2) Its chimney valve is fully open, whereby relay CVR–SII is unenergized and contacts **7—17** thereof (line *i*) are closed;

(3) Its cold blast valve is fully closed, whereby (*a*) relay CBR–OII is unenergized and contacts **6—16** thereof (line *db*) are closed; and (*b*) relay CBR–SII is energized and contacts **5—15** thereof (line *ia*) are open; and

(4) Its hot blast valve is fully closed, whereby HBR–OII is unenergized and (*a*) contacts **9—19** thereof (line *e*) are closed; (*b*) contacts **6—16** thereof (line *m*) are closed; and (*c*) contacts **3—13** thereof (line *aa* of FIG. 4*a*) and contacts **7—17** thereof (line *ga* of FIG. 4*a*) are open, as previously discussed in connection with FIG. 4*a*.

It will also be noted that since stove II is fully "On Gas" its flue gas temperature has not reached the maximum temperature at which the flue gas temperature relay is energized, so that contacts **2—12** of FGTR–II (line *ge*) are open.

Since stove II is fully "On Gas," relay IR–BII (line *g*) is unenergized, as can be readily seen due to the fact that lines *ge* and *gc* are open. Due to the unenergized condition of relay IR–BII (line *g*), it is obvious that:

(1) Contacts **2—12** thereof (line *gc*) are open;

(2) Contacts **3—13** thereof (line *h*) are open, whereby signal lamp SL–BII is unlit;

(3) Contacts **4—14** thereof (line *i*) are open;

(4) Contacts **5—15** thereof (line *jb*) are closed;

(5) Contacts **6—16** thereof (line *ac*) are closed;

(6) Contacts **7—17** thereof (line *dc*) are open;

(7) Contacts **8—18** thereof (line *ae*) are closed; and

(8) Contacts **9—19** thereof (line *d* of FIG. 4*a*) are

closed, as previously discussed in connection with FIG. 4*a*.

As previously stated, it must be remembered that at the same time that FIG. 4*b* shows stove II in "On Gas" for the second time, stove I is "On Blast" and stove III is "On Gas" for the first time. Since stove I is "On Blast" (as shown in FIG. 4*a*):

(1) Relay IR–WI is energized, whereby (*a*) contacts **8—18** of relay IR–WI (line *jd*) are closed; and (*b*) contacts **10—20** of IR–WI (line *af*) are closed;

(2) Relay IR–BI is unenergized, whereby contacts **10—20** of line *d* are closed;

(3) Relay IR–GI is unenergized, whereby contacts **9—19** thereof (line *d*) are closed; and

(4) The hot blast valve of stove I is fully opened, whereby relay HBR–OI is energized, and (*a*) contacts **4—14** of HBR–OI (line *ab*) are closed; and (*b*) contacts **8—18** of HBR–OI (line *gb*) are closed.

Since stove III is "On Gas," while stove II is in the condition thereof shown in FIG. 4*b*:

(1) Relay IR–GIII is energized, whereby contacts **8—18** thereof (line *d*) are open;

(2) Relay IR–BIII is unenergized, whereby contacts **9—19** thereof (line *d*) are closed;

(3) Relay IR–WIII is unenergized, whereby (*a*) contacts **7—17** thereof (line *jc*) are open; and (*b*) contacts **9—19** thereof (line *ae*) are open;

(4) The hot blast valve of stove III is fully closed, whereby relay HBR–OIII is unenergized, and (*a*) contacts **3—13** thereof (line *aa*) are open; and (*b*) contacts **7—17** thereof (line *ga*) are open; and

(5) There is no exiting hot blast from stove III so that the temperature of thermo-sensitive device HBETT–III is below the predetermined value, whereby relay HBETR–III is energized and contacts **2—12** thereof (line *jc*) are closed.

As previously stated, FIG. 4*b* represents the condition of stove II at the same time that stove I is fully "On Blast" and is supplying hot blast at a sufficiently high temperature to the blast furnace. Accordingly, the butterfly valve MBBVS (line *k*) is open and contacts **2—12** of relay MBBV (line *ja*) are open. Also, contacts **3—13** of HBETR–I (line *jd*) are open.

Since stove II is fully "On Gas," relay IR–WII is unenergized, as can be seen from the fact that all circuits to relay IR–WII (line *j*) are open. Since relay IR–WII is unenergized:

(1) Contacts **2—12** thereof (line *jb*) are open;

(2) Contacts **3—13** thereof (line *l*) are open, whereby signal lamp SL–WII is unlit;

(3) Contacts **4—14** thereof (line *m*) are open;

(4) Contacts **5—15** thereof (line *ac*) are closed;

(5) Contacts **6—16** thereof (line *gc*) are closed;

(6) Contacts **7—17** thereof (line *jc* of FIG. 4*a*) and contacts **9—19** thereof (line *ae* of FIG. 4*a*) are open, as previously discussed in connection with FIG. 4*a*; and

(7) Contacts **30—31** thereof (line *da*) are open.

Referring to line *e* in FIG. 4*b*, it will be noted that a circuit is complete to delay relay OR–II which is thus energized, and contacts **2—12** thereof (line *da*) are closed.

Since both lines *d* and *da* are open, relay SR–II (line *d*) should be de-energized but is shown as being energized for reasons now to be discussed.

Referring to Chart No. 1, it will be noted that the stoves have been brought to the conditions thereof shown in line 3 manually, and it is not until after they are operating as shown in line 3 that they are ready for fully automatic operation. Accordingly, it is necessary at this time to manually select stove II as the one which is to go "On Blast" next. As soon as this is done, the system is ready to operate in fully automatic operation, as will be fully seen hereinafter. But it is necessary at this time to manually energize relay SR–II (line *d*) and also look at FIG. 4*b* in the condition it is in a sufficient time after SR–II has been energized so that delay relay DR–II (line *f*) has become operative. Due to such manual energization of relay SR–II:

(1) Contacts **3—13** thereof (line *db*) are closed, thereby providing a holding circuit for maintaining relay SR–II energized;

(2) Contacts **2—12** of SR–II (line *f*) are closed; and

(3) DR–II (line *f*) is energized and contacts **2—12** thereof (line *ja*) are closed.

Contacts **4—14** of SR–II (line *ae*) are opened. (At this time it will be noted that the holding circuit in line *ac* is the only circuit which keeps relay IR–GII in a line *e* energized.)

Referring now to sub-division W of FIG. 4*b*, it will be noted that upon the closing of either:

(1) Contacts **2—12** of MBBV (line *ja*), or

(2) Contacts **3—13** of HBETR–I (line *jd*), a circuit will be completed to relay IR–WII (line *j*) to initiate the placing of stove II "On Blast." This will happen only when stove I is either:

(1) No longer capable of supplying hot blast to the blast furnace at a sufficiently high temperature so that the butterfly valve MBBVS closes, or

(2) When the temperature of the hot blast within stove I falls below the predetermined temperature set therefor to render operative thermosensitive device HBETT–II.

Thus it is noted that when a stove is "On Gas" for its second cycle, as stove II is in FIG. 4*b*, the circuitry in sub-division W of FIG. 4*b* is operative to automatically initiate the placing of such stove "On Blast" in response to the failure of the stove that is then "On Blast" to supply hot blast at the requisite temperature.

Description of FIGURE 4c

Referring now specifically to FIG. 4*c*, it will be remembered that FIG. 4*c* represents all the circuitry associated with stove III for the three-stove automatic changeover operation, with the contacts thereof shown in the position they are in when stove III is fully "On Gas," for its first cycle corresponding to its condition of stove III in line 3 of Chart No. 1. It will be noted that the A/M, PB–G and SIS contacts in FIG. 4*c* are in their posittion for the three-stove fully automatic operation in a manner similar to that explained in connection with FIG. 3.

Since stove III is, as shown in FIG. 4*c*, "On Gas" (for its first cycle) relay IR–GIII (line *a*) is energized, whereby:

(1) Contacts **2—12** thereof (line *ac*) are closed;

(2) Contacts **3—13** thereof (line *b*) are closed, whereby signal lamp SL–G is lit;

(3) Contacts **4—14** thereof (line *c*) are closed;

(4) Contacts **5—15** thereof (line *gc*) are open;

(5) Contacts **6—16** thereof (line *jb*) are open;

(6) Contacts **7—17** thereof (line *d*) are closed;

(7) Contacts **8—18** thereof (line *d* of FIG. 4*b*) are open, as previously discussed in connection with FIG. 4*b*; and

(8) Contacts **9—19** thereof (line *d* of FIG. 4*a*) are open, as previously discussed in connection with FIG. 4*a*.

Since stove III is fully "On Gas":

(1) Its gas valve is fully open, whereby (*a*) relay GVR–O is energized and contacts **6—16** thereof (line *c*) are open; and (*b*) relay GVR–S is unenergized and contacts **5—15** thereof (line *ge*) are closed;

(2) Its chimney valve is fully open, whereby relay CVR–SIII is unenergized and contacts **7—17** thereof (line *i*) are closed;

(3) Its cold blast valve is fully closed, whereby (*a*) relay CBR–OIII is unenergized and contacts **6—16** thereof (line *db*) are closed; and (*b*) relay CBR–SIII is energized and contacts **5—15** thereof (line *ia*) are open; and

(4) Its hot blast valve is fully closed, whereby relay HBR–OIII is unenergized and (*a*) contacts **9—19** thereof (line *e*) are closed; (*b*) contacts **6—16** thereof (line *m*)

are closed; (*c*) contacts **3—13** thereof (line *aa* in FIG. 4*b*) and contacts **7—17** thereof (line *ga* in FIG. 4*b*) are open, as previously discussed in connection with FIG. *db*; and (*d*) contacts **4—14** thereof (line *ab* in FIG. 4*a*) and contacts **8—18** thereof (line *gb* in FIG. 4*a*) are open, as previously discussed in connection with FIG. 4*a*.

Since FIG. 4*c* shows stove III when it is still "On Gas," and before its flue gas temperature has reached the predetermined value at which the flue gas temperature relay FGTR–III is enrgized, contacts **2—12** of FGTR–III (line *ge*) are open.

It is noted that relay IR–BIII (line *g*) is uenergized because the circuits leading thereto are open. Since relay IR–BIII (line *g*) is unenergized:

(1) Contacts **2—12** thereof (line *gc*) are open;

(2) Contacts **3—13** thereof (line *h*) are open, whereby signal lamp SL–BIII is unlit;

(3) Contact **4—14** thereof (line *i*) are open;

(4) Contacts **5—15** thereof (line *jb*) are closed;

(5) Contacts **6—16** thereof (line *ac*) are closed;

(6) Contacts **7—17** thereof (line *dc*) are open;

(7) Contacts **8—18** thereof (line *ae*) are closed;

(8) Contacts **9—19** thereof (line *d* of FIG. 4*b*) are closed, as previously discussed in connection with FIG. 4*b*; and

(9) Contacts **10—20** thereof (line *d* of FIG. 4*a*) are closed, as previously discussed in connection with FIG. 4*a*.

As previously discussed, it must be remembered that at the same time that FIG. 4*c* shows stove III in "On Gas" for the first cycle, stove I is "On Blast," and stove II is "On Gas" for the second cycle. Since stove I is "On Blast":

(1) Relay IR–WI is energized, whereby (*a*) contacts **7—17** thereof (line *jc*) are closed; and (*b*) contacts **9—19** thereof (line *ae*) are closed;

(2) Relay IR–BI is unenergized, whereby contacts **9—19** thereof (line *d*) are closed;

(3) Relay IR–GI is unenergized, whereby contacts **8—18** thereof (line *d*) are closed; and

(4) The hot blast valve of stove I is fully open, so that relay HBR–OI is energized, whereby (*a*) contacts **3—13** of HBR–OI (line *aa*) are closed; and (*b*) contact **7—17** of HBR–OI (line *ga*) are closed.

Since stove II is "On Gas" while stove III is in the condition thereof shown in FIG. 4*c*;

(1) Relay IR–GII is energized, whereby contacts **9—19** thereof (line *d*) are open;

(2) Relay IR–BII is unenergized, whereby contacts **10—20** thereof (line *d*) are closed;

(3) Relay IR–WII is unenergized, whereby: (*a*) contacts **8—18** thereof (line *jd*) are open; and (*b*) contacts **10—20** thereof (line *af*) are open;

(4) The hot blast valve of stove II is fully closed, whereby relay HBR–OII is unenergized, and (*a*) contacts **4—14** thereof (line *ab*) are open; and (*b*) contacts **8—18** thereof (line *gb*) are open; and

(5) There is no exiting hot blast from stove II, whereby the temperature at HBETT–II is below the predetermined value and relay HBETR–II is energized, whereby contacts **3—13** thereof (line *jd*) are closed.

Since FIG. 4*c* represents the condition of stove III at the same time that stove I is fully "On Blast" and is supplying hot blast at a sufficiently high temperature to the blast furnace, the butterfly valve MBBVS is open (line *k*) as are contacts **3—13** of relay MBBV (line *ja*). Also, HBETR–I is unenergized and contacts **2—12** thereof (line *jc*) are open.

Since stove III, in the condition shown in FIG. 4*c*, is "On Gas," relay IR–WIII is unenergized (as can be seen due to the fact that all circuits thereto are open). As a result of the unenergized condition of relay IR–WIII (line *j*):

(1) Contacts **2—12** thereof (line *jb*) are open;

(2) Contacts **3—13** thereof (line *l*) are open, whereby signal lamp SL–WIII is unlit;

(3) Contacts **4—14** thereof (line *m*) are open;

(4) Contacts **5—15** thereof (line *ac*) are closed;

(5) Contacts **6—16** thereof (line *gc*) are closed;

(6) Contacts **7—17** thereof (line *jc*) of FIG. 4*b*) and contacts **9—19** thereof (line *ae* of FIG. 4*b*) are open, as previously described in connection with FIG. 4*b*;

(7) Contacts **8—18** thereof (line *jd* in FIG. 4*a*) and contacts **10—20** thereof (line *af* of FIG. 4*a*) are open, (as previously described in connection with FIG. 4*a*); and

(8) Contacts **30—31** thereof (line *da* in FIG. 4*c*) are open.

Referring to line *e*, it will be noted that relay OR–III is energized whereby contacts **2—12** thereof (line *da*) are closed. However, all circuits leading to relay SR–III (line *d*) are open, and said relay is accordingly unenergized, whereby:

(1) Contacts **3—13** thereof (line *db*) are open;

(2) Contacts **4—14** thereof (line *ae*) are closed; and

(3) Contacts **2—12** thereof (line *f*) are open, whereby delay relay DR–III is unenergized.

As a result of the de-energized condition of relay DR–III (line *f*), contacts **2—12** thereof (line *ja*) are open.

Comparing FIG. 4*b* with FIG. 4*c* it will be noted that the two are in identical condition, except that in FIG. 4*b* relays SR–II and DR–II are energized, whereas in FIG. 4*c* relays SR–III and DR–III are unenergized. This similarity between stove II and stove III is to be expected since they are both in "On Gas," but stove II has been "On Gas" for a longer period of time and is the one which is selected to go next "On Blast."

It will also be noted, referring to sub-division S, line *d* in FIG. 4*c*, that in the event contacts **9—19** of IR–GII close, relay SR–III will immediately become energized. This will happen the instant that stove II leaves the "On Gas" condition to go "On Blast."

Now that we have completely described the conditions of stoves I, II and III, as shown in line 3 of Chart No. 1, we shall discuss the change-over operation, with particular reference to FIGS. 5*a*, 5*b* and 5*c*.

FIGS. 5*a*, 5*b* and 5*c* represent the conditions of the stoves as shown in line 3*a* of Chart No. 1. FIG. 5*a* is similar to FIG. 4*a*, but shows the contacts in the position they are in during the change-over operation; FIG. 5*b* is similar to FIG. 4*b*, but shows the contacts in the position they are in during the change-over operation; and FIG. 5*c* is similar to FIG. 4*c*, but shows the contacts in the position they are in during the change-over operation.

Description of FIGURE 5b

As previously stated, the change-over operation takes place automatically when the stove that is currently "On Blast" is incapable of supplying hot blast at the desired temperature. When this happens, the butterfly valve MBBVS closes, or, in the alternative, the hot blast exit temperature of the stove that is "On Blast" falls below the predetermined value. Let us assume that it is the butterfly valve that closes. Referring to FIG. 4*b*, it will be noted that as soon as the butterfly valve closes, contacts **1—11** of MBBVS (line *k*) close to energize relay MBBV. This in turn causes contacts **2—12** of relay MBBV in line *ja* to close to thereby immediately complete a circuit to relay IR–WII (line *j*), which immediately becomes energized. This is shown in FIG. 5*b*. As soon as relay IR–WII is energized, the following takes place (shown in FIG. 5*b*):

(1) Contacts **2—12** of IR–WII (line *jb*) are closed; and

(2) Contacts **5—15** of IR–WII (line *ac*) are open. This immediately interrupts the holding circuit for relay IR–GII so that the latter instantly de-energizes, causing contacts **6—16** of IR–GII (line *jb*) to close, so that the holding circuit in line *jb* for relay IR–WII is now completed;

(3) Contacts **3—13** of IR–WII (line *l*) are closed to immediately cause signal lamp SL–WII to be lit and thus indicate that stove II is going to go "On Blast";

(4) Contacts **6—16** of IR–WII (line *gc*) are open;

(5) Contacts **30—31** of IR–WII (line *da*) are closed; and

(6) Contacts **4—14** of IR–WII (line *m*) are closed.

(The energization of relay IR–WII also affects contacts **7—17** and **9—19** in stove I and **8—18** and **10—20** in stove III, which will be discussed hereafter.)

Referring to line *m*, it will be noted that upon the closing of contacts **4—14** of IR–WII therein, a circuit will be immediately completed to relay CSS–WII of control selector switch CSS–II. As previously discussed, the energization of CSS–WII is operative to immediately place stove II "On Blast." More specifically, such energization of relay CSS–WII will:

(1) Close the gas valve of stove II;

(2) Close the burner valve of stove II;

(3) Close the chimney valve of stove II;

(4) Open the cold blast valve of stove II; and

(5) Open the hot blast valve of stove II.

Referring to line *da* in FIG. 5*b*, it will be noted that the previously described closing of contacts **30—31** of IR–WII therein is operative to complete a circuit to relay SR–II, so that the latter is now energized via line *da* as well as line *db*.

FIG. 5*b* shows the condition of stove II at the instant that relay CSS–WII is energized, at which time stove II begins to go "On Blast," but before any of the valves under the control of CSS–WII actually have been operated.

As previously described, the energization of relay IR–WII due to the closing of the butterfly valve MBBVS caused the de-energization of relay IR–GII in line *a*. As a result of such de-energization of relay IR–GII, the following, shown in FIG. 5*b*, occurs immediately:

(1) Contacts **2—12** thereof (line *ac*) open;

(2) Contacts **3—13** thereof (line *b*) open, thereby extinguishing the light in signal lamp SL–GII;

(3) Contacts **4—14** thereof (line *c*) open;

(4) Contacts **5—15** thereof (line *gc*) close;

(5) Contacts **6—16** thereof (line *jb*) close, to complete, as previously discussed, the holding circuit to relay IR–WII;

(6) Contacts **7—17** thereof (line *d*) open; and

(7) Contacts **8—18** and contacts **9—19** thereof, affecting stoves I and III, respectively, close, as will be hereafter discussed in connection with these stoves.

Description of FIGURE 5a

Referring now to FIG. 5*a*, the latter shows the changes which took place in stove I as a result of stove II having received the impulse to go "On Blast," as just described in connection with FIG. 5*b*. More specifically, we note the following has occurred in stove I, as shown in FIG. 5*a*, in comparison with FIG. 4*a* (which showed the condition of stove I before stove II received the impulse to go "On Blast"):

(1) Contacts **1—11** of MBBV (line *ja*) are closed. (This has no effect whatsoever on stove I since contacts **2—12** of DR–I in line *ja* are open);

(2) Contacts **7—17** of IR–WII (line *jc*) are closed. (This has no effect on stove I);

(3) Contacts **8—18** of IR–GII (line *d*) are closed. (This has no effect on stove I because contacts **9—19** of IR–GIII in line *d* are still open); and

(4) Contacts **9—19** of IR–WII (line *ae*) are closed. This is the important effect on stove I as a result of stove II having begun to go "On Blast." More specifically, it will be noted in FIG. 5*a*, that as a result of the closing of contacts **9—19** of IR–WII in line *ae*, a circuit is completed to contact **21** of SIS–I. Now all that is necessary in stove I is for contacts **3—13** of HBR–OII (line *aa*) to be closed in order to energize IR–GI (line *a*) in stove I. This will, of course, not happen until the hot blast valve of stove II is fully opened, as will hereafter be seen. In this connection it will be remembered that FIG. 5*a* shows the condition of stove I at exactly the same moment that stove II is in the condition shown by FIG. 5*b*, namely when stove II is just beginning to go "On Blast" and its hot blast valve has not been opened yet.

Referring now to FIGS. 5*a* and 5*b*, it will be noted that the IR–W relays of stove I and stove II are both energized which indicates that they are both "On Blast," such condition existing during the interval shown in line 3*a* of Chart No. 1.

Description of FIGURE 5c

Referring now to FIG. 5*c* which shows the condition of stove III at the beginning of the change-over operation, that is in the condition it is in when stoves I and II are in their conditions shown in FIGS. 5*a* and 5*b*, respectively. Accordingly, it will be noted that contacts **1—11** of MBBVS (line *k*) are closed whereby relay MBBV is energized and contacts **3—13** thereof (line *ja*) are closed. Also, since relay IR–WII is energized, as shown in FIG. 5*b*, contacts **8—18** thereof (line *jd*) in FIG. 5*c*, are closed and contacts **10—20** thereof (line *af* of FIG. 5*c*) are also closed.

As a result of the de-energization in stove II of relay IR–GII (as discussed in connection with FIG. 5*b*), contacts **9—19** of IR–GII (line *d* of FIG. 5*c*) are closed to immediately complete the circuit to selector relay SR–III in line *d*. Thus it is seen that at this moment of change-over, stove I and stove II being "On Blast" simultaneously (IR–WI and IR–WII being energized), a circuit is completed to the selector relay of the one stove (stove III) which is not "On Blast." The energization of SR–III (line *d* of FIG. 5*c*) immediately closes contacts **3—13** thereof in line *db* to complete the holding circuit for relay SR–III. At the same time, contacts **2—12** of SR–III are closed in line *f* to energize delay relay DR–III. Contacts **2—12** of delay relay DR–III (line *ja*), however, remain open for a predetermined period of time set for delay relay DR–III. This delay is necessary, as is evident from an examination of line *ja* in FIG. 5*c*. More specifically, if contacts **2—12** of DR–III (line *ja*) were to be closed immediately, a circuit would then be completed to relay IR–WIII (line *j*) to immediately initiate the placing of stove III "On Blast." This would result in having all three stoves "On Blast" at the same time. To avoid this possibility, contacts **2—12** of DR–III remain open for a predetermined period of time during which the contacts **3—13** (line *ja*) of relay MBBV will have reopened in the manner previously described in connection with the operation of relay MBBV. After these contacts **3—13** of MBBV (line *ja* of FIG. 5*c*) have been opened, then contacts **2—12** are closed under the operation of delay relay DR–III. The energization of SR–III, however, does immediately open contacts **4—14** thereof in line *ae* of FIG. 5*c* so that relay IR–GIII (line *a*) remains energized only by virtue of the holding circuit in line *ac*.

Thus it is seen that during the change-over interval, the only stove which is "On Gas" is pre-selected so that it will be the one to go "On Blast" at the next change-over interval.

FIGS. 6*a*, 6*b* and 6*c* show the conditions of stoves I, II, and III, respectively, after the change-over interval, when the stoves are operating fully in their new conditions. More specifically, FIGS. 6*a*, 6*b* and 6*c* show the stoves in the condition shown in line 4 of Chart No. 1.

Referring back to FIG. 5*b*, it will be remembered that said figure shows the condition of stove II at the instant that the change-over operation began, that is, at the instant that CSS–WII was energized to initiate the placing of stove II from "On Gas" to "On Blast."

Description of FIGURE 6b

FIG. 6*b* represents the condition of stove II after it

has been placed fully "On Blast," that is, after CSS–WII has been operative to:

(1) Close the gas valve of stove II;
(2) Close the burner valve of stove II;
(3) Close the chimney valve of stove II;
(4) Open the cold blast valve of stove II; and
(5) Open the hot blast valve thereof.

Also, FIG. 6*b* represents the condition of stove II after the latter is supplying hot blast at a high enough temperature so that the butterfly valve MBBVS is once more open. Accordingly, in FIG. 6*b* we observe the following:

(1) Contacts **1—11** of MBBVS (line *k*) are open;
(2) Contacts **2—12** of MBBV (line *ja*) are open;
(3) Due to the fact that the gas valve is fully closed, (*a*) relay GVR–SII is energized, whereby contacts **5—15** thereof (line *ge*) are open; and (*b*) relay GVR–OII is de-energized, whereby contacts **6—16** thereof (line *c*) are closed;
(4) Due to the fact that the chimney valve is fully closed, relay CVR–SII is energized and contacts **7—17** thereof are open (line *i*);
(5) Due to the fact that the cold blast valve is fully open: (*a*) relay CBR–SII is unenergized, whereby contacts **5—15** thereof (line *ia*) are closed; and (*b*) relay CBR–OII is energized, whereby contacts **6—16** thereof (line *db*) are open (this interrupts the holding circuit for relay SR–II in line *db* as soon as the cold blast valve is fully open, but at that instant relay SR–II remains energized nevertheless throught the holding circuit in line *da*); and
(6) When the hot blast valve is fully open, relay HBR–OII is energized, whereby: (*a*) contacts **6—16** thereof (line *m*) are open; and (*b*) contacts **9—19** thereof (line *e*) are open. (At the instant that the hot blast valve is fully open, contacts **9—19** in line *e* of HBR–OII will open to de-energize relay OR–II in line *e*. However, it will be remembered that relay OR–II is a delay relay and its contacts will not be open until a predetermined period of time has elapsed after the relay OR–II has been de-energized. After the predetermined period of delay of OR–II has elapsed, contacts **2—12** thereof in line *da* are open so as to then interrupt the holding circuit in line *da* for relay SR–II in order to deenergize the latter. The reason for the delay relay OR–II will be explained more fully hereafter.)

Due to the de-energization of relay SR–II (line *d*) as just described:

(1) Contacts **2—12** thereof (line *f*) are open to thereby de-energize relay DR–II and open contacts **2—12** thereof in line *ja*;
(2) Contacts **3—13** of relay SR–II (line *db*) are open; and
(3) Contacts **4—14** of SR–II (line *ae*) are closed.

As previously stated, FIG. 6*b* shows the condition of stove II corresponding to line 4 of Chart No. 1 in which stove I is fully "On Gas." Accordingly:

(1) Relay IR–WI is de-energized causing (*a*) contacts **8—18** thereof (line *jd*) to open; and (*b*) contacts **10—20** thereof (line *af*) to open;
(2) Relay IR–GI is energized, causing contacts **9—19** thereof (line *d*) to open;
(3) The hot blast valve of stove I is fully closed, whereby relay HBR–OI is unenergized and (*a*) contacts **4—14** thereof (line *ab*) are open; and (*b*) contacts **8—18** thereof (line *gb*) are open; and
(4) Stove I is fully "On Gas" so that the hot blast exit temperature of stove I is below the predetermined value and contacts **3—13** of HBETR–I (line *jd*) are closed.

Due to the fact that stove III is in exactly the same condition, that is, fully "On Gas," as it was during the changeover operation, or in other words the condition of stove III shown in line 3*a* of Chart No. 1 is the same as that shown in line 4 of Chart No. 1—the circuitry in stove II relating to stove III is the same in FIG. 6*b* as it was in FIG. 5*b*.

FIG. 6*b* is thus seen to represent stove II when it is fully "On Blast," corresponding to its condition shown in line 4 of Chart No. 1. In this connection it will be interesting to observe that such condition of stove II is identical to the condition that stove I was in at line 3 of Chart No. 1. A comparison of FIG. 4*a* (showing stove I fully "On Blast") with FIG. 6*b*, (showing stove II fully "On Blast"), shows that the two figures are identical in all respects.

Description of FIGURE 6a

Referring now to FIG. 6*a*, it will be remembered that FIG. 6*a* shows the condition of stove I automatically resulting from the placing of stove II in the condition thereof shown in FIG. 6*b*. In this connection let us compare FIG. 5*a* with FIG. 6*a* to see how the placing of stove II "On Blast" (as described in connection with FIG. 6*b*) automatically places stove I "On Gas." It will be remembered that, as shown in FIG. 5*a*, at the beginning of the change-over operation a circuit was completed in FIG. 5*a* from L–1 to contact **21** of SIS–I. As soon as stove II is fully "On Blast" (as fully described above in connection with FIG. 6*b*), the hot blast valve of stove II was fully opened so that relay HBR–OII was energized. Such energization of relay HBR–OII was operative to immediately close contacts **3—13** thereof (line *aa* of FIG. 6*a*), and contacts **7—17** thereof (line *ga*). The closing of contacts **3—13** of HBR–OII in line *aa* will immediately complete the circuit to relay IR–GI (line *a*) and energize the latter instantaneously. As a result of such energization of IR–GI, in direct response to stove II going "On Blast" fully, the following occurs in stove I is shown in FIG. 6*a*;

(1) Contacts **6—16** thereof (line *jb*) are opened (this immediately interrupts the circuit to relay IR–WI (line *j*) and de-energizes the latter. As a result of the de-energization of relay IR–WI, contacts **5—15** thereof (line *ac*) are closed);
(2) Contacts **2—12** of IR–GI are closed (this immediately completes the holding circuit for relay IR–GI);
(3) Contacts **3—13** (line *b*) of IR–GI close to light up signal lamp SL–GI;
(4) Contacts **4—14** of IR–GI (line *c*) close. (The closing of these contacts **4—14**, as can be seen in FIG. 5*a*, are immediately operative to energize relay CSS–GI of control selector switch CSS–I. This will immediately cause: (*a*) the closing of the hot blast valve of stove I; (*b*) the closing of the cold blast valve of stove I; (*c*) the opening of the chimney valve in stove I; (*d*) the opening of the burner valve in stove I; and (*e*) the opening of the gas valve of stove I. As soon as the gas valve is fully opened, contacts **6—16** of GVR–OI in line *c* are open to interrupt the circuit to CSS–GI. Since FIG. 6*a* shows stove I after it is fully "On Gas," the contacts **6—16** of GVR–OI in line *c* are shown as open);
(5) Contacts **5—15** of IR–GI (line *gc*) are open; and
(6) Contacts **7—17** of IR–GI (line *d*) are closed.

Due to the de-energization of relay IR–WI (line *j*), as previously described, in addition to the closing of contacts **5—15** thereof in line *ac*, the following happens:

(1) Contacts **2—12** thereof (line *jb*) open;
(2) Contacts **6—16** thereof (line *gc*) close;
(3) Contacts **3—13** thereof (line *l*) open (this extinguishes signal lamp SL–WI);
(4) Contacts **4—14** thereof (line *m*) open; and
(5) Contacts **30—31** (line *da*) open.

As previously stated, the energization of relay CSS–GI caused:

(1) The hot blast valve in stove I to be fully closed; whereby (*a*) contacts **6—16** of HBR–OI (line *m*) are closed; and (*b*) contacts **9—19** of HBR–OI (line *e*) are closed;
(2) The cold blast valve in stove I to be fully closed, whereby (*a*) contacts **6—16** of CBR–OI (line *db*) are

closed; and (*b*) contacts 5—15 of CBR–SI (line *ia*) are opened;

(3) The chimney valve in stove I to be fully opened, whereby contacts 7—17 of CVR–SI (line *i*) are closed; and

(4) The gas valve in stove I to be fully opened, whereby contacts 5—15 of GVR–SI (line *ge*) are closed.

Due to the closing of contacts 9—19 of HBR–OI in line *e*, relay OR–I is energized. This in turn causes the closing of contacts 2—12 of relay OR–I in line *da*. Comparing at this time line *da* in FIG. 5*a* and FIG. 6*a*, it will be noted that the condition of the two sets of contacts in line *da* have been reversed, going from FIG. 5*a* to FIG. 6*a*. In other words, in FIG. 5*a* the contacts of relay IR–WI were closed while the contacts of OR–I were opened, and in FIG. 6*a* the contacts of OR–I are closed while the contacts of IR–WI are open. It must be noted, however, that when line *da* changes from its condition shown in FIG. 5*a* to that shown in FIG. 6*a*, the contacts 30—31 of relay IR–WI open before the contacts of OR–I close. In that way, relay SR–I remains continuously unenergized as stove I goes fully "On Gas."

Since while stove I is fully "On Gas" as in line 4 of Chart No. 1, stove II is fully "On Blast" and supplying hot blast at a sufficiently high temperature:

(1) The butterfly valve MBBVS is once again open, whereby contacts 1—11 thereof (line *k*) are open;

(2) Contacts 1—11 of relay MBBV (line *ja*) are open; and

(3) Contacts 2—12 of HBETR–II (line *jc*) are open.

With respect to FIG. 6*a*, all contacts shown therein other than those discussed above are in the same condition they are in in FIG. 5*a*.

FIG. 6*a* thus represents the condition of stove I after the change-over operation when it is fully "On Gas" corresponding to its condition shown in line 4 of Chart No. 1. This condition of stove I is identical to the condition that stove III was in at line 3 of Chart No. 1, and a comparison of FIG. 6*a* (showing stove I fully "On Gas" for the first cycle) with FIG. 4*c* (showing stove III fully "On Gas" for the first cycle) shows that the two figures are in all respects identical.

It is thus seen, from the discussion of FIG. 6*a*, that stove I, which was "On Blast," automatically is placed "On Gas," in response to another stove going fully "On Blast."

At this time we refer back to FIGS. 5*b* and 6*b* in order to explain the reason for the use of delay relay OR–II in line *e*. It will be remembered that the contacts of delay relay OR–II do not open until an adjustable delay period after the relay has been de-energized. It will be remembered that FIG. 6*b* shows stove II going on and staying fully "On Blast." When it is fully "On Blast," its hot blast valve is fully open, opening contacts 9—19 of HBR–OII in line *e* to de-energize relay OR–II. If the de-energization of relay OR–II were to immediately cause the opening of contacts 2—12 of OR–II in line *da* (instead of after an adjustable delay period), then relay SR–II would become de-energized at the very instant that the hot blast valve of stove II is fully opened, as best seen in FIG. 5*b*. Such instantaneous de-energization of relay SR–II (line *d*) would, of course, immediately be operative to close contacts 4—14 of relay SR–II in line *ae*. As can best be seen in FIG. 5*b*, if contacts 4—14 of relay SR–II (line *ae*) were to be closed while the hot blast valve of stove I is still open, namely, while (in FIG. 5*b*) contacts 4—14 of HBR–OI (line *ab*) are closed and contacts 10—20 of IR–WI (line *af*) are still closed, then stove II, which had just gone "On Blast" would have its relay IR–GII energized to immediately start going "On Gas" again. In this connection, it will be remembered that stove I (as best seen in FIG. 6*a*) begins to go "On Gas" the instant that the hot blast valve of stove II is fully opened (i.e., the instant contacts 3—13 of HBR–OII in line *aa* of FIG. 6*a* are closed). Accordingly, were it not for delay relay OR–II, contacts 4—14 of SR–II in line *ae* of FIG. 5*b* would close the very instant that contacts 10—20 of IR–WI (line *af*) would open. This would create the possibility of the difficulty previously pointed out, namely that stove II would suddenly begin going "On Gas" again. By delaying, through delay relay OR–II, the de-energization of SR–II, this difficulty is obviated since, referring to line *ae* in FIG. 5*b*, contacts 4—14 of relay SR–II would not close until the adjustable delay time set for delay relay OR–II, at which time contacts 10—20 of IR–WI (line *af*) are sure to be open.

Description of FIGURE 6c

Referring now to FIG. 6*c*, it will be remembered that FIG. 6*c* shows the condition of stove III in which it is fully "On Gas" for its second cycle, corresponding to its condition shown on line 4 of Chart No. 1. Comparing FIG. 6*c* with FIG. 5*c*, it will be noted that the following changes have taken place.

First, the delay relay DR–II has been energized a time longer than the delay period thereof so that, as shown in FIG. 6*c*, relay DR–II is operative to close contacts 2—12 thereof in line *ja*.

The only other change in stove III (shown in FIG. 6*c*) results from the change in the conditions of stove I and stove II. More specifically, since stove I is fully "On Gas":

(1) Relay IR–WI is unenergized, whereby: (*a*) contacts 9—19 thereof (line *ae*) are open; and (*b*) contacts 7—17 thereof (line *jc*) are open;

(2) The hot blast valve of stove I is now fully closed, whereby (*a*) contacts 3—13 of HBR–OI (line *aa*) are open, and (*b*) contacts 7—17 of HBR–OI (line *ga*) are open;

(3) Relay IR–GI is energized, whereby contacts 8—18 thereof (line *d*) are open; and

(4) Stove I is no longer "On Blast" and its hot blast exit temperature is below the predetermined value set by HBETT–I, whereby contacts 2—12 of HBETR–I (line *jc*) are closed.

Since stove II is now fully "On Blast":

(1) The hot blast valve of stove II is fully open, whereby: (*a*) contacts 4—14 of HBR–OII are closed; and (*b*) contacts 8—18 of HBR–OII (line *gb*) are closed; and

(2) Stove II is supplying hot blast at a sufficiently high temperature, whereby (*a*) contacts 3—13 of HBETR–II (line *jd*) are open; and (*b*) contacts 1—11 of MBBVS (line *k*) and contacts 3—13 of MBBV (line *ja*) are open.

It is thus seen that FIG. 6*c* shows the condition of stove III when it is "On Gas" for the second cycle. As previously stated, stove III is the one which will go "On Blast" automatically as soon as stove II, which is now "On Blast," fails to supply hot blast at a sufficiently high temperature. The condition of stove III shown in FIG. 6*c* is identical to the condition that stove II was in at line 3 of Chart No. 1. Accordingly, a comparison of FIG. 6*c* (showing stove III "On Gas" for the second cycle) with FIG. 4*b* (showing stove II "On Gas" for the second cycle) shows that the two figures are identical in all respects.

It is thus seen that FIGS. 6*a*, 6*b* and 6*c* represent the conditions of stoves I, II and III, respectively, corresponding to line 4 of Chart No. 1. It will, of course, be apparent that as soon as stove II fails to supply hot blast at the requisite temperature, an automatic change-over will once more take place in the same manner as previously described, resulting in placing the respective stoves in the conditions thereof shown in line 4*a* of Chart No. 1.

THE "ON BOTTLED" CONDITION

Description of FIG. 7

As previously discussed, provision is made in the automatic three-stove system for placing a stove in the "On

Bottled" condition when it has been heated to the desired temperature, and the time has not yet come for such stove to go "On Blast." This is, of course, most likely to occur to a stove which is "On Gas" for its second cycle.

Referring to FIG. 4*b*, it will be noted that such figure shows the condition of stove II when it is "On Gas" for its second cycle. In the event that such stove becomes heated to the desired temperature so that it is desirable to place stove II in the "On Bottled" condition, the following will happen, as illustrated in FIG. 7. The flue gas temperature having reached the desired predetermined value, thermo-sensitive device FGTT–II becomes operative to energize relay FGTR–II. This, in turn, causes contacts **2—12** of relay FGTR–II (line *ge*) to close. As best seen in subdivision *b* of FIG. 4*b*, the closing of these contacts instantaneously completes the circuit to relay IR–BII (line *g*) which thus becomes immediately energized. The energization of relay IR–BII causes the following (shown in FIG. 7):

(1) The closing of contacts **2—12** of relay IR–BII in line *gc*;

(2) The opening of (*a*) contacts **6—16** of IR–BII (line *ac*); and (*b*) contacts **8—18** of IR–BII (line *ae*). This immediately causes the de-energization of relay IR–GII (line *a*) to, in turn, cause the immediate closing of the contacts **5—15** of relay IR–GII in line *gc*, to thereby immediately complete the holding circuit of line *gc* for relay IR–BII;

(3) The closing of contacts **3—13** of IR–BII (line *h*). This causes signal lamp SL–BII to be lit;

(4) The closing of contacts **4—14** of IR–BII (line *i*). This immediately energizes relay BII of control selector switch CSS–BII (line *i*);

(5) The opening of contacts **5—15** of IR–BII (line *jb*); and

(6) The closing of contacts **7—17** of IR–BII (line *dc*) It will be noted that this has no effect on the energized condition of relay SR–II, since the latter remains energized by virtue of the holding circuit therefor in line *db*.

The energization of CSS–BII causes:

(1) The closing of the gas valve, whereby: (*a*) relay GVR–OII is de-energized, and contacts **6—16** thereof (line *c*) are closed; and (*b*) relay GVR–SII is energized and contacts **5—15** thereof (line *ge*) are open; and

(2) The closing of the chimney valve, whereby relay CVR–SII (line *i*) is energized and contacts **7—17** thereof are open. At that moment the circuit to CSS–BII is opened and stove II is fully in "On Bottled" condition.

Due to the de-energization of relay IR–GII caused by stove II going "On Bottled":

(1) Contacts **2—12** of relay IR–GII (line *ac*) are open;

(2) Contacts **3—13** of relay IR–GII (line *b*) are open—this extinguishes signal lamp SL–GII;

(3) Contacts **4—14** of IR–GII (line *c*) are open;

(4) Contacts **7—17** of IR–GII (line *d*) are open. This has no effect on the energized condition of relay SR–II (line *d*), since the latter remains energized through the holding circuit therefor in line *db*; and

(5) Contacts **6—16** of relay IR–GII (line *jb*) are closed.

By comparing FIG. 7 to FIG. 4*b*, it is noted that a stove is very simply and automatically placed "On Bottled" in response to its flue gas temperature reaching a predetermined temperature value. It is also seen that the placing of stove II in "On Bottled" automatically de-energizes he interlocking relay for the gas condition, namely relay IR–GII. Also, it will be seen that the placing of stove II in "On Bottled" condition in no way affects the circuitry for such stove in sub-divisions S and W thereof. Accordingly, such stove, which is "On Bottled," will proceed to automatically go "On Blast' at the next change-over operation, in a manner identical as described previously in connection with stove II and FIGS. 5*b* and 6*b*.

While FIG. 7 describes the placing in the "On Bottled" condition of a stove which is "On Gas" for its second cycle, it will be apparent that a stove which is "On Gas" during its first cycle can also be placed in the "On Bottled" condition if its flue gas temperature were to reach the predetermined value. More specifically, it will be noted that the circuitry of sub-division B (which is the circuitry which places a stove in the "On Bottled" condition) does not contain any circuitry which distinguishes between a stove being "On Gas" for the first cycle or for the second cycle. The only difference between a stove being "On Gas" for its first cycle or for its second cycle is in the circuitry of sub-division S. It will be noted, however, that sub-division S contains contacts **7—17** of IR–GII (line *d*) in parallel with contacts **7—17** of IR–BII (line *dc*). Accordingly, whether stove II is "On Gas" or "On Bottled," it will be selected at the time when the other two stoves are "On Blast," to go "On Blast" in the next succeeding change-over.

It will be understood, of course, that when stove II which is "On Bottled," as shown in FIG. 7, goes "On Blast" by virtue of the energization of relay CSS–WII, the latter will be operative to open only the cold blast valve and the hot blast valve of stove II, since the burner valve, gas valve and chimney valve of stove II have already been closed in stove II when the latter went in the "On Bottled" condition.

AUTOMATIC CHANGE-OVER OPERATION FOR TWO-STOVE SYSTEM

According to another aspect of the present invention, it is possible to take one of the three stoves out of automatic operation and utilize only the remaining two stoves for supplying hot blast to a blast furnace.

In a two-stove system, it is necessary to have, at all times, one of the stoves in the "On Blast" condition, so that hot blast may be supplied to the blast furnace continuously. The sequence of operation in a two-stove fully automatic system will be discussed in connection with Chart No. 6 below:

CHART NO. 6

	Stove No. I	Stove No. II	Stove No. III
0	Unheated	Unheated	Taken out of automatic operation.
1	do	"On gas"	
2	"On gas"	"On blast"	
2*a*	"On blast"	do	
3	do	"On gas"	
3*a*	do	"On blast"	
4	"On gas"	do	

Line 0 shows the initial conditions of the system in which both stoves I and II are unheated. Stove II is then placed in the "On Gas" condition while stove I remains unheated, such being shown in line 1 of Chart No. 6. When stove II has been heated sufficiently, it is placed in the "On Blast" condition, while stove I is placed in the "On Gas" condition so that it may be heated, such being shown in line 2 in Chart No. 6. When stove II is no longer capable of supplying hot blast to the blast furnace at the desired temperature, the change-over is accomplished automatically as follows: stove I is automatically placed "On Blast" while stove II remains "On blast" for the time interval required for the placing of stove I fully "On Blast," such being shown in line 2*a* of Chart No. 6. When stove I has been fully placed "On Blast," that is, when the hot blast valve of stove I is fully opened, then stove II is automatically placed "On Gas," such being shown in line 3 of Chart No. 6. From then on the change-over will automatically take place as shown in lines 3*a* and 4 of Chart No. 6.

The two-stove fully automatic change-over operation as shown in Chart No. 6 will now be described in connection with FIGS. 8*a* and 8*b*, 9*a* and 9*b*, 10*a* and 10*b*, and 11*a* and 11*b*.

Description of FIGURE 8a

FIG. 8*a* represents stove I while it is fully "On Gas" for its two-stove automatic change-over operation in conjunction with stove II. FIG. 8*a* shows the condition of stove I while stove II is fully "On Blast," corresponding to line 2 of Chart No. 6.

Referring to sub-division G of FIG. 8*a*, it will be noted that, since stove III is taken out of automatic operation:

(1) Contacts **8—18** of A/MIII (line *af*) are open. This removes line *af* from consideration in the two-stove automatic operation and the other contacts in such line have been omitted; and

(2) Contacts **26—36** of A/MIII (line *ab*) are open. This removes line *ab* from consideration in the two-stove automatic operation and the other contacts in such line have been omitted. Accordingly, it is seen that the influence of stove III on stove I has been removed in sub-division G.

In sub-division S, since stove III is out of automatic operation, contacts **24—34** of A/MIII are open. This removes all the contacts in lines *d* (except for relay SR–I), *db* and *dc* from consideration in the two-stove automatic operation. The reason for such removal is obvious since in the two-stove system there is no necessity for selecting a particular stove to go "On Blast" next, since there is only one stove which can do so.

Referring to sub-division B in FIG. 8*a*, it will be noted that there is nothing in this sub-division which makes the operation thereof different in the two-stove operation as compared with the three-stove operation.

Referring to sub-division W, it will be noted that due to the fact that stove III is out of automatic operation, contacts **10—20** of A/MIII (line *jc*) are closed, and contacts **22—32** of A/MIII (line *jd*) are open. The closing of contacts **10—20** of A/MIII short circuits contacts **2—12** of relay DR–I which is thus removed from consideration during the two-stove operation. The reason for this is again apparent since there is no necessity for a selection to be made. The opening of contacts **22—32** of A/MIII in line *jd* removes such line from the two-stove automatic operation to thereby remove any influence of stove III on sub-division W. In other words, regardless of what happens to stove III, it will have no effect whatsoever on stove I.

All the other contacts in FIG. 8*a* are shown in the positions in which they are in when stove I is fully "On Gas" while stove II is fully "On Blast."

Description of FIGURE 8b

FIG. 8*b* shows the condition of stove II while it is fully "On Blast," and while it is being operated in fully automatic two-stove change-over operation with stove I, corresponding to line 2 of Chart No. 6. It is seen that the respective A/M switches are shown similarly to FIG. 8*a*, in the condition they are in for two-stove automatic operation, with the influence of stove III removed from the system. The other contacts in stove II are shown in the positions they are in when stove II is fully "On Blast," similar to the manner described previously in connection with the three-stove system.

Description of FIGURE 9a

FIG. 9*a* represents the condition of stove I during the change-over operation, corresponding to line 2*a* of Chart No. 6. In other words, let us assume that stove II, which is "On Blast," is unable to supply hot blast at the desired temperature as a result of which the butterfly valve MBBVS closes. Referring to FIG. 9*a*, it will be noted therefore that contacts **1—11** of MBBVS (line *k*) are closed to energize relay MBBV. The energization of relay MBBV causes the closing of contacts **1—11** thereof (line *ja*). This results in immediately closing the circuit to relay IR–WI (line *j*). Due to the energization of relay IR–WI:

(1) Contacts **30—31** thereof (line *da*) close. This immediately energizes relay SR–I (line *d*), which in turn immediately opens contacts **4—14** of relay SR–I in line *ae*;

(2) Contacts **5—15** of relay IR–WI (line *ac*) open. The simultaneous opening of these contacts **5—15** of IR–WI and of contacts **4—14** of SR–I, as explained in "1" above, immediately deenergizes relay IR–GI (line *a*). This in turn immediately closes contacts **6—16** of relay IR–GI in line *jb*;

(3) Contacts **2—12** of IR–WI (line *jb*) close to complete the holding circuit for relay IR–WI;

(4) Contacts **3—13** of relay IR–WI (line *l*) close to light up signal lamp SL–WI; and

(5) Contacts **4—14** of IR–WI (line *m*) close to energize CSS–WI which initiates the placing of stove I "On Blast."

The other contacts in FIG. 9*a*, not discussed above, are in their positions resulting from the energization of relay IR–WI, in a manner similar to that resulting in a change-over in the three-stove operation. FIG. 9*a* shows the condition of stove I at the instant that CSS–WI is energized, but before it has been operative to actuate the valves.

Description of FIGURE 9b

FIG. 9*b* shows the condition of stove II resulting from the changes which occurred in stove I as shown in FIG. 9*a*, that is, the condition of stove II corresponding to the condition of stove I at the instant its control selector switch CSS–WI is about to perform its functions.

Comparing FIG. 9*b* with FIG. 8*b*, it will be noted that the only changes which occurred in stove II as the result of stove I beginning to go "On Blast" are the following:

(1) Contacts **1—11** of MBBVS (line *k*) are closed;

(2) Relay MBBV (line *k*) is energized;

(3) Contacts **2—12** of MBBV (line *ja*) are closed;

(4) Contacts **10—20** of relay IR–WI (line *af*) are closed; and

(5) Contacts **8—18** of relay IR–WI (line *jd*) are closed.

The only significant change in stove II is that, as shown in FIG. 9*b*, a circuit is now complete from line L–1 to contact **21** of SIS–I.

Description of FIGURE 10a

FIG. 10*a* shows the condition of stove I after control selector switch CSS–WI has been operative to perform all its functions, namely after CSS–WI has been operative to:

(1) Close the gas valve of stove I, whereby: (*a*) contacts **6—16** of GVR–OI (line *c*) are closed; and (*b*) contacts **5—15** of GVR–SI (line *ge*) are open;

(2) Close the burner valve of stove I;

(3) Close the chimney valve of stove I, whereby contacts **7—17** of CVR–SI (line *i*) are open;

(4) Open the cold blast valve of stove I, whereby contacts **5—15** of relay CBR–SI (line *ia*) are closed; and

(5) Open the hot blast valve of stove I, whereby: (*a*) contacts **6—16** of HBR–OI (line *m*) are open; and (*b*) contacts **9—19** of HBR–OI (line *e*) are open.

FIG. 10*a* shows the condition of stove I the instant the hot blast valve is fully opened, and obviously before stove I has had an opportunity to be fully "On Blast."

Referring to line *e*, it will be remembered that as soon as the hot blast valve was fully opened, contacts **9—19** of HBR–OI (line *e*) were opened to de-energize delay relay OR–I. Due to the fact that FIG. 10*a* represents stove I the instant the hot blast valve of stove I was fully opened, the adjustable time period for delay relay OR–I has not passed so that contacts **2—12** of delay relay OR–I (line *da*) are still closed to maintain relay SR–I (line *d*) energized. This, in turn, maintains contacts **4—14** of relay SR–I (line *ae*) open. At the very instant that the hot blast valve of stove I is fully opened, relay

IR–WII in stove II becomes deenergized (as will be seen in connection with the discussion of FIG. 10*b*). Accordingly, were it not for delay relay OR–I, at the very same instant that contacts 4—14 of SR–I in line *ae* would close, contacts 9—19 of relay IR–WII in the same line would open, and there would be the resulting possibility that stove I which has just gone "On Blast," would get the impulse to go "On Gas." This, of course, is very undesirable. Accordingly, the closing of contacts 4—14 of relay SR–I in line *ae* is delayed for a short, adjustable period of time, by means of delay relay OR–I, so as to make sure that when contacts 4—14 in line *ae* do close, contacts 9—19 of relay IR–WII in line *ae* are open.

Also, it will be noted in FIG. 10*a*, that though said figure shows the condition of stove I before it is fully "On Blast" and supplying hot blast at the desired temperature, nevertheless contacts 1—11 of MBBV (line *ja*) are open. This is due to the previously explained fact that relay MBBV is a delay relay which will cause the contacts thereof to be opened a short period of time after it has been energized. The reason for this will be apparent hereafter in connection with the discussion of FIG. 10*b*. It will be noted, however, that the opening of contacts 1—11 of MBBV in line *ja* does not affect the energized condition of relay IR–WII (line *j*) since the latter remains energized by virtue of the holding circuit in line *jb*.

Description of FIGURE 10b

FIG. 10*b* represents the condition of stove II at the instant that the hot blast valve of stove I has been fully opened, that is, at the time stove I is in the condition thereof shown in FIG. 10*a*. As a result of the opening of the hot blast valve of stove I, contacts 4—14 of HBR–OI (line *ab*) of FIG. 10*b* close to thereby immediately complete the circuit to relay IR–GII (line *a*).

The energization of relay IR–GII, in a manner similar as previously described in connection with the three-stove changeover system, is operative to:

(1) Energize relay GII of control selector switch CSS–GII (line *c*); and

(2) De-energize relay IR–WII.

All the resulting changes in the positions of the contacts are shown in FIG. 10*b*.

It will be noted that due to the manner of operation of relay MBBV, contacts 2—12 of said relay (line *ja*) are open, though the butterfly valve MBBVS is closed as shown in line *k*. The reason for the use of relay MBBV is apparent from FIG. 10*b*, where it is seen that, were contacts 2—12 of MBBV (line *ja*) to remain closed at all times when the butterfly valve MBBVS remains closed, then stove II, in the condition thereof shown in FIG. 10*b*, would be receiving the impulse to go "On Blast" immediately after it has just received the impulse to go "On Gas." The undesirability of such condition is obvious, and the delay relay MBBV, which is operative to reopen its contacts thereof a short period of time after it has been energized, cures this problem.

The energization of relay CSS–GII will, of course, be operative to:

(1) Close the hot blast valve of stove II;
(2) Close the cold blast valve of stove II;
(3) Open the chimney valve of stove II;
(4) Open the burner valve of stove II; and
(5) Open the gas valve of stove II.

The condition of stove II, when all these steps have been performed by relay CSS–GII, is shown in FIG. 11*b*, and FIG. 11*a* shows the condition of stove I when stove II is in the condition thereof shown in FIG. 11*b*. In other words, FIGS. 11*a* and 11*b* show the conditions of the respective stoves after the change-over has been completely effectuated corresponding to line 3 of Chart No. 6. In this connection it will be noted that FIG. 11*a* (which shows stove I fully "On Blast") is identical to FIG. 8*b* (which shows stove II fully "On Blast"), and FIG. 11*b* (which shows stove II fully "On Gas") is identical in all respects to FIG. 8*a* (which shows stove I fully "On Gas"), all during the automatic two-stove operation.

It will be apparent from an examination of FIGS. 8 through 11, that the two-stove automatic operation includes the feature of automatically placing a stove that is "On Gas" in the "On Bottled" condition in the event that flue gas temperature in such stove reaches the predetermined temperature value at which contacts 2—12 of relay FGTR in line *ge* will be closed.

It will also be apparent that in the event a stove has gone in the "On Bottled" condition, it will go automatically "On Blast" at the next change-over operation.

THE MANUAL OPERATION

Description of FIGURE 12

As described above, it is seen that the present invention provides a fully automatic change-over operation for a three-stove system as well as for a two-stove system. Each stove may be, if desired, operated manually and independently of the condition of any of the other stoves.

Referring to FIG. 12, there is shown the connections of stove I for manual operation. It will be noted that the conditions of the respective A/M switch is exactly opposite to the conditions thereof in the fully automatic three-stove change-over operation shown in FIG. 3.

Referring to sub-division G, it will be noted that due to such conditions of the A/M switches, lines *aa, ab, ae* and *af* are completely removed from the circuit. (The contacts in the lines removed from the circuit have been omitted in FIG. 12). Also, in the SIS switch, contacts 1—11 are interconnected so as to by-pass lines *aa* and *ab*. FIG. 12 shows, as an example, stove I while it is fully "On Gas." In this condition of stove I, relay IR–GI is energized and remains that way by means of the holding circuit in line *ac*.

Subdivision S has no bearing whatsoever in the manual operation, since all the contacts of relays SR and DR are not in the circuits of subdivisions G, B and W when a stove is on manual push-button operation.

In subdivision B, the SIS switch is closed at 2—12 and lines *ga, gb* and *ge* are completely out of the circuit.

In subdivision W, lines *ja, jc* and *jd* are likewise completely removed from the circuit, due to the position of the respective A/M switches. Also, line *k* is of no effect since the contacts of MBBV are in line *ja*.

Looking at FIG. 12, if it were desired to place stove I in the "On Bottled" position, all that is necessary to be done is the following:

(1) Push-button switch PB–BI (line *g*) would be actuated to immediately energize relay IR–BI. This, as previously seen, would immediately open up the holding circuit in line *ac* for relay IR–GI and in turn immediately cause the closing of the holding circuit in line *gc* for relay IR–BI. The closing of the holding circuit in line *gc* takes place almost instantaneously upon the actuation of push-button switch PB–BI, so that the latter need only be actuated for an instant. With the energization of relay IR–BI, stove I is automatically placed in the "On Bottled" condition in the manner similar to that previously described.

In the event that it is desired to place stove I in the "On Blast" condition, all that would be necessary to do is to actuate push-button switch PB–WI (line *j*) and this would immediately be operative to energize relay IR–WI in line *j* as well as close the holding circuit therefor in line *jb*. The energization of relay IR–WI will, of course, be operative to energize relay CSS–WI and place stove I in the "On Blast" condition.

It will be apparent from an examination of FIG. 12 that a stove may be placed "On Blast" from either the "On Gas" condition or the "On Bottled" condition, by merely actuating push-button PB–WI (line *j*). Also, stove I can be placed in the "On Gas" condition from either the "On

Bottled" or "On Blast" conditions, simply by actuating push-button switch PB–GI. Similarly, a stove can be placed in the "On Bottled" condition either from the "On Gas" condition or the "On Blast" condition by actuating push-button switch PB–BI (line *g*). It will be noted that in the event that push-button switch PB–BI is actuated at a time when stove I is "On Gas," then the circuit to relay CSS–BI (line *i*) will be completed via contacts **7—17** of relay CVR–SI, since when stove I is "On Gas" the chimney valve is not fully closed and contacts **7—17** of CVR–SI are thus closed. However, in the event that push-button switch PB–BI of stove I is actuated at a time when stove I is "On Blast," contacts **7—17** of relay CVR–SI (line *i*) would be open and the circuit to CSS–BI (line *i*) will be completed via contacts **5—15** of relay CBR–SI (line *ia*), since when stove I is "On Blast" its cold blast valve is not fully closed and contacts **5—15** of CBR–SI are closed.

SUMMARY

In view of the foregoing description, it will be seen that applicants have provided a completely and fully automatic change-over system for a multiple stove system, so that a continuous stream of hot blast may be supplied to the blast furnace on an unattended, day-by-day, twenty-four hour basis, without any interruption or necessity of manual operation.

The automatic change-over system described hereabove is adapted to operate with all three stoves in the system, or with any two of the three stoves of the system, as may be desired. In each of these manners of operation, the change-over operation is fully automatic. Furthermore, it is the identical circuitry which is utilized for operating the change-over system both on three-stove or two-stove fully automatic. If desired, each of the stoves may be operated independently of the other stoves under the push-button manual operation described in connection with FIG. 12.

It will be understood that while the automatic change-over system of the present invention has been described in connection with a two- and three-stove system, it could equally well be adapted for a system having more than three stoves.

Also, while the system has been described in connection with a plurality of circuit components which function as safety features, the latter need not necessarily be included to have a satisfactory fully automatic multi-stove change-over operation. For example, and referring to FIG. 3, the SIS switches may be set under special circumstances if so desired, in position so that contacts **1—11** thereof and **2—12** thereof are closed. Under such an arrangement, it would be possible to operate the multi-stove system automatically, while dispensing with certain features previously discussed. Also, and referring to FIG. 12, it would be possible, if desired, to place the SIS switches so that contacts **1—21** and **2—22** thereof are closed during the manual push-button operation, and in that way add to the manual push-button operation certain desired safety features. Other modifications, changes and alterations in the circuitry can be readily made without substantially effecting the automatic operation or the manual operation of the system.

While we have shown and described the preferred embodiments of our invention, it will be understood that the invention may be embodied otherwise than as herein specifically illustrated or described, and that in the illustrated embodiment certain changes in the details of construction and in the form and arrangement of parts may be made without departing from the underlying idea or principles of this invention within the scope of the appended claims.

Having thus described our invention, what we claim and desire to secure by Letters Patent is:

1. In a blast furnace installation, in combination, three hot blast stoves adapted to supply a continuous stream of hot blast to a blast furnace, control means associated with each of said stoves for the placing thereof in a plurality of operating conditions including an "On Gas" condition in which the associated stove is being heated and an "On Blast" condition in which the associated stove is supplying hot blast to the blast furnace, said blast furnace being adapted to be supplied with hot blast from one stove at the time which is then "On Blast" during which time the remaining two stoves are in an operating condition different from the "On Blast" condition, and means for automatically selecting the one of the remaining stoves which has been in an operating condition different from the "On Blast" condition for the longest period of time and for automatically actuating the control means of said one of the remaining stoves for placing the latter in the "On Blast" condition in response to the failure of said one stove which is then in the "On Blast" condition to supply hot blast at a predetermined temperature, said automatically selecting means comprising circuit means for each stove adapted to be energized in response to the condition of the other two stoves.

2. In a blast furnace installation in which a continuous stream of hot blast is adapted to be supplied to a blast furnace from a multi-stove system in which each one of the stoves is alternately and sequentially in the "On Blast" condition while the remainder of the stoves are in a condition different from the "On Blast" condition; means for automatically placing a particular one of the remainder of the stoves into the "On Blast" condition when the one stove that is in the "On Blast" condition fails to supply hot blast to the blast furnace at a predetermined temperature, and means for automatically placing the stove which fails to supply hot blast at a predetermined temperature in the "On Gas" condition only after said particular one of the remainder of the stoves has been completely placed in the "On Blast" condition, and means for automatically selecting the one of said remainder of the stoves which has been in said different condition for the longest period of time to be the particular one of the said remainder of the stoves, said particular stove automatically selecting means comprising electrical circuit means for each stove which becomes energized in response to the condition of the other stoves.

3. In a blast furnace installation in which a continuous stream of hot blast is adapted to be supplied to a blast furnace from a three blast-stove system in which each one of the stoves alternately and sequentially is in the "On Blast" condition while the other two stoves are in a condition different from the "On Blast" condition; means for for automatically placing a particular one of the two stoves which are in said different condition into the "On Blast" condition when the stove that is in the "On Blast" condition fails to supply hot blast to the blast furnace at a predetermined temperature and means for automatically placing the stove which fails to supply hot blast at a predetermined temperature in the "On Gas" condition only after said particular one of the two stoves has been completely placed in the "On Blast" condition, and means for automatically selecting the one of said two stoves which has been in said different condition for the longest period of time to be the particular one of said two stoves, said particular stove automatically selecting means comprising electrical circuit means for each stove which beomes energized when the other two stoves are simultaneously in the "On Blast" condition.

4. In a blast furnace installation in which a continuous stream of hot blast is adapted to be supplied to a blast furnace from a plurality of hot blast stoves each of which is equipped with a hot blast valve, a cold blast valve, a chimney valve, a gas valve and a burner valve; means for actuating said valves for placing each of said stoves in a plurality of operating conditions thereof including the "On Gas" and "On Blast" conditions, control means for initiating the operation of said valve actuating means for each of the operating conditions of the stoves, said blast furnace being adapted to be supplied with hot blast from

one stove at the time, which is then in the "On Blast" condition, while the remainder of the stoves are in another operating condition, means automatically actuating the control means of a particular one of said remainder of the stoves for initiating the operation of the valve actuating means of said particular stove for placing the latter in the "On Blast" condition when said one stove that is then "On Blast" ceases to supply hot blast at a predetermined temperature, and means for automatically selecting as the particular stove the one of said remainder stoves which has been in a condition different from the "On Blast" condition for the longest period of time, said particular stove automatically selecting means comprising electrical circuit means for each stove which becomes energized in response to the condition of the other stoves.

5. In a blast furnace installation in which a continuous stream of hot blast is adapted to be supplied to a blast furnace from a plurality of hot blast stoves each of which is equipped with a hot blast valve, a cold blast valve, a chimney valve, a gas valve and a burner valve; means for actuating said valves for placing each of said stoves in a plurality of operating conditions thereof including the "On Gas" and "On Blast" conditions, control means for initiating the operation of said valve actuating means for each of the operating conditions of the stoves, said blast furnace being adapted to be supplied with hot blast from one stove at the time, which is then in the "On Blast" condition, while the remainder of the stoves are in another operating condition, means automatically actuating the control means of a particular one of said remainder of the stoves for initiating the operation of the valve actuating means of said particular stove for placing the latter in the "On Blast" condition when said one stove that is then "On Blast" ceases to supply hot blast at a predetermined temperature, and means for automatically selecting as the particular stove the one of said remainder stoves which has been in a condition different from the "On Blast" condition for the longest period of time, and means automatically actuating the control means of said one stove which is then "On Blast" for initiating the operation of the valve actuating means thereof for the placing thereof in the "On Gas" condition when the hot blast valve of said particular stove is fully opened under the control of the valve actuating means thereof when it has been completely placed in the "On Blast" condition, said particular stove automatically selecting means comprising electrical circuit means for each stove which becomes energized in response to the condition of the other stoves.

6. In a blast furnace installation in which a continuous stream of hot blast is adapted to be supplied to a blast furnace from three hot blast stoves each of which is equipped with a hot blast valve, a cold blast valve, a chimney valve, a gas valve and a burner valve, means for actuating said valves for placing each of said stoves in any one of a plurality of operating conditions including an "On Gas" and an "On Blast" condition, control means for initiating the operation of said valve actuating means for each of the operating conditions of each of said stoves, each stove having first circuit means adapted, when energized, to actuate the control means thereof for the placing thereof in the "On Gas" condition, each stove having second circuit means adapted, when energized, to actuate the control means thereof for the placing thereof in the "On Blast" condition, said blast furnace being normally adapted to be supplied with hot blast from one stove at the time, which is then "On Blast," while the remaining two stoves are in an operating condition different from the "On Blast" condition, means for automatically energizing the second circuit means of a particular one of said remaining two stoves when the one stove which is then "On Blast" ceases to supply hot blast to the furnace at a predetermined temperature, whereby a change-over automatically occurs in which said particular stove is automatically placed in the "On Blast" condition while said stove which is then "On Blast remains "On Blast" during the change-over interval, means for automatically energizing the first circuit means of said one stove which is then "On Blast" when said particular remaining stove has been completely placed in the "On Blast" condition at the end of the change-over interval whereby to automatically place said one stove which is then "On Blast" in the "On Gas" condition, and means for automatically selecting as said particular stove the one of said two remaining stoves which has been in an operating condition different from the "On Blast" condition for the longest period of time.

7. In a blast furnace installation in which a continuous stream of hot blast is adapted to be supplied to a blast furnace from three hot blast stoves each of which is equipped with a hot blast valve, a cold blast valve, a chimney valve, a gas valve and a burner valve, means for actuating said valves for placing each of said stoves in any one of a plurality of operating conditions including an "On Gas" and an "On Blast" condition, control means for initiating the operation of said valve actuating means for each of the operating conditions of each of said stoves, each stove having first circuit means adapted, when energized, to actuate the control means thereof for the placing thereof in the "On Gas" condition, each stove having second circuit means adapted, when energized, to actuate the control means thereof for the placing thereof in the "On Blast" condition, said blast furnace being normally adapted to be supplied with hot blast from one stove at the time, which is then "On Blast," while the remaining two stoves are in an operating condition different from the "On Blast" condition, means for automatically energizing the second circuit means of a particular one of said remaining two stoves when the one stove which is then "On Blast" ceases to supply hot blast to the furnace at a predetermined temperature, whereby a change-over automatically occurs in which said particular stove is automatically placed in the "On Blast" condition while said stove which is then "On Blast" remains "On Blast" during the change-over interval, means for automatically energizing the first circuit means of said one stove which is then "On Blast" when said particular remaining stove has been completely placed in the "On Blast" condition at the end of the change-over interval whereby to automatically place said one stove which is then "On Blast" in the "On Gas" condition, and means for automatically selecting as said particular stove the one of said two remaining stoves which has been in a condition different from the "On Blast" condition for the longest period of time, said automatically selecting means comprising third circuit means for each stove adapted, when energized, to close a set of contacts in the second circuit means thereof, whereby the second circuit means of any stove is prevented from being energized unless the third circuit means thereof is also energized.

8. In a blast furnace installation in which a continuous stream of hot blast is adapted to be supplied to a blast furnace from three hot blast stoves each of which is equipped with a hot blast valve, a cold blast valve, a chimney valve, a gas valve and a burner valve, means for actuating said valves for placing each of said stove in any one of a plurality of operating conditions including an "On Gas" and an "On Blast" condition, control means for initiating the operation of said valve actuating means for each of the operating conditions of each of said stoves, each stove having first circuit means adapted, when energized, to actuate the control means thereof for the placing thereof in the "On Gas" condition, each stove having second circuit means adapted, when energized, to actuate the control means thereof for the placing thereof in the "On Blast" condition, said blast furnace being normally adapted to be supplied with hot blast from one stove at the time, which is then "On Blast," while the remaining two stoves are in an operating condition different from the "On Blast" condition, means for automatically energizing the second cir-

cuit means of a particular one of said remaining two stoves when the one stove which is then "On Blast" ceases to supply hot blast to the furnace at a predetermined temperature, whereby a change-over automatically occurs in which said particular stove is automatically placed in the "On Blast" condition while said stove which is then "On Blast" remains "On Blast" during the change-over interval, means for automatically energizing the first circuit means of said one stove which is then "On Blast" when said particular remaining stove has been completely placed in the "On Blast" condition at the end of the change-over interval whereby to automatically place said one stove which is then "On Blast" in the "On Gas" condition, and means for automatically selecting as said particular stove the one of said two remaining stoves which has been in a condition different from the "On Blast" condition for the longest period of time, said automatically selecting means comprising third circuit means for each stove adapted, when energized, to close a set of contacts in the second circuit means thereof, whereby the second circuit means of any stove is prevented from being energized unless the third circuit means thereof is also energized, and means for automatically energizing, during the change-over interval, the third circuit means of the one stove which is not "On Blast" during said change-over interval, for selecting such stove to be the particular stove to go "On Blast" during the next succeeding change-over interval.

9. In a blast furnace installation in which a continuous stream of hot blast is adapted to be supplied to a blast furnace from three hot blast stoves each of which is equipped with a hot blast valve, a cold blast valve, a chimney valve, a gas valve and a burner valve, means for actuating said valves for placing each of said stoves in any one of a plurality of operating conditions including an "On Gas" and an "On Blast" condition, control means for initiating the operation of said valve actuating means for each of the operating conditions of each of said stoves, each stove having first circuit means adapted, when energized, to actuate the control means thereof for the placing thereof in the "On Gas" condition, each stove having second circuit means adapted, when energized, to actuate the control means thereof for the placing thereof in the "On Blast" condition, said blast furnace being normally adapted to be supplied with hot blast from one stove at the time, which is then "On Blast," while the remaining two stoves are in an operating condition different from the "On Blast" condition, means for automatically energizing the second circuit means of a particular one of said remaining two stoves when the one stove which is then "On Blast" ceases to supply hot blast to the furnace at a predetermined temperature, whereby a change-over automatically occurs in which said particular stove is automatically placed in the "On Blast" condition while said stove which is then "On Blast" remains "On Blast" during the change-over interval, means for automatically energizing the first circuit means of said one stove which is then "On Blast" when the hot blast valve of said particular remaining stove has been completely opened to place said particular stove completely in the "On Blast" condition at the end of the change-over interval whereby to automatically place said one stove which is then "On Blast" in the "On Gas" condition, and means for automatically selecting as said particular stove the one of said two remaining stoves which has been in an operating condition different from the "On Blast" condition for the longest period of time.

10. In a blast furnace installation in which a continuous stream of hot blast is adapted to be supplied to a blast furnace from three hot blast stoves each of which is equipped with a hot blast valve, a cold blast valve, a chimney valve, a gas valve and a burner valve, means for actuating said valves for placing each of said stoves in any one of a plurality of operating conditions including an "On Gas" and an "On Blast" condition, control means for initiating the operation of said valve actuating means for each of the operating conditions of each of said stoves, each stove having first circuit means adapted, when energized, to actuate the control means thereof for the placing thereof in the "On Gas" condition, each stove having second circuit means adapted, when energized, to actuate the control means thereof for the placing thereof in the "On Blast" condition, said blast furnace being normally adapted to be supplied with hot blast from one stove at the time, which is then "On Blast," while the remaining two stoves are in an operating condition, different from the "On Blast" condition, means for automatically energizing the second circuit means of a particular one of said remaining two stoves when the one stove which is then "On Blast" ceases to supply hot blast to the furnace at a predetermined temperature, whereby a change-over automatically occurs in which said particular stove is automatically placed in the "On Blast" condition while said stove which is then "On Blast" remains "On Blast" during the change-over interval, means for automatically energizing the first circuit means of said one stove which is then "On Blast" when the hot blast valve of said particular remaining stove has been completely opened to place said particular stove completely in the "On Blast" condition at the end of the change-over interval whereby to automatically place said one stove which is then "On Blast" in the "On Gas" condition, and means for automatically selecting as said particular stove the one of said two remaining stoves which has been in an operating condition different from the "On Blast" condition for the longest period of time, said automatically selecting means comprising third circuit means for each stove adapted, when energized, to close a set of contacts in the second circuit means thereof, whereby the second circuit means of any stove is prevented from being energized unless the third circuit means thereof is also energized.

11. In a blast furnace installation in which a continuous stream of hot blast is adapted to be supplied to a blast furnace from three hot blast stoves each of which is equipped with a hot blast valve, a cold blast valve, a chimney valve, a gas valve and a burner valve, means for actuating said valves for placing each of said stoves in any one of a plurality of operating conditions including an "On Gas" and an "On Blast" condition, control means for initiating the operation of said valve actuating means for each of the operating conditions of each of said stoves, each stove having first circuit means adapted, when energized, to actuate the control means thereof for the placing thereof in the "On Gas" condition, each stove having second circuit means adapted, when energized, to actuate the control means thereof for the placing thereof in the "On Blast" condition, said blast furnace being normally adapted to be supplied with hot blast from one stove at the time, which is then "On Blast," while the remaining two stoves are in an operating condition different from the "On Blast" condition, means for automatically energizing the second circuit means of a particular one of said remaining two stoves when the one stove which is then "On Blast" ceases to supply hot blast to the furnace at a predetermined temperature, whereby a change-over automatically occurs in which said particular stove is automatically placed in the "On Blast" condition while said stove which is then "On Blast" remains "On Blast" during the change-over interval, means for automatically energizing the first circuit means of said one stove which is then "On Blast" when the hot blast valve of said particular remaining stove has been completely opened to place said particular stove completely in the "On Blast" condition at the end of the change-over interval whereby to automatically place said one stove which is then "On Blast" in the "On Gas" condition, and means for automatically selecting as said particular stove the one of said two remain-

ing stoves which has been in an operating condition different from the "On Blast" condition for the longest period of time, said automatically selecting means comprising third circuit means for each stove adapted, when energized, to close a set of contacts in the second circuit means thereof whereby the second circuit means of any stove is prevented from being energized unless the third circuit means thereof is also energized, and means for automatically energizing, during the change-over interval, the third circuit means of the one stove which is not "On Blast" during said change-over interval, for selecting such stove to be the particular stove to go "On Blast" during the next succeeding change-over interval.

12. In a blast furnace installation in which a continuous stream of hot blast is adapted to be supplied to a blast furnace from a plurality of hot blast stoves each of which is equipped with a hot blast valve, a cold blast valve, a chimney valve, a gas valve and a burner valve, means for actuating said valves for placing each of said stoves in any one of a plurality of operating conditions including an "On Gas," an "On Blast" and an "On Bottled" condition, control means for initiating the operation of said valve actuating means for each of the operating conditions of each of said stoves, each stove having first circuit means adapted, when energized, to actuate the control means thereof for the placing thereof in the "On Gas" condition, each stove having second circuit means adapted, when energized, to actuate the control means thereof for the placing thereof in the "On Blast" condition, each stove having another circuit means adapted, when energized, to actuate the control means thereof for the placing thereof in the "On Bottled" condition, said blast furnace being normally adapted to be supplied with hot blast from one stove at the time, which is then "On Blast," while the remainder of the stoves are in an operating condition different from the "On Blast" condition, means responsive to the ability of the stove which is then "On Blast" to supply hot blast at a predetermined temperature for energizing the second circuit means of one of said remainder of the stoves when the one stove which is then "On Blast" ceases to supply hot blast to the furnace at a predetermined temperature, whereby a change-over occurs in which said one of the remainder stoves is automatically placed in the "On Blast" condition while said stove which is then "On Blast" remains "On Blast," and means for automatically energizing the first circuit means of said one stove which is then "On Blast" when said one of the remainder stoves has been completely placed in the "On Blast" condition whereby to automatically place said one stove which is then "On Blast" in the "On Gas" condition.

13. In a blast furnace installation in which a continuous stream of hot blast is adapted to be supplied to a blast furnace from a plurality of hot blast stoves each of which is equipped with a hot blast valve, a cold blast valve, a chimney valve, a gas valve and a burner valve, means for actuating said valves for placing each of said stoves in any one of a plurality of operating conditions including an "On Gas," an "On Blast" and an "On Bottled" condition, control means for initiating the operation of said valve actuating means for each of the operating conditions of each of said stoves, each stove having first circuit means adapted, when energized, to actuate the control means thereof for the placing thereof in the "On Gas" condition, each stove having second circuit means adapted, when energized, to actuate the control means thereof for the placing thereof in the "On Blast" condition, each stove having another circuit means adapted, when energized, to actuate the control means thereof for the placing thereof in the "On Bottled" condition, said blast furnace being normally adapted to be supplied with hot blast from one stove at the time, which is then "On Blast," while the remainder of the stoves are in an operating condition different from the "On Blast" condition, means responsive to the ability of the stove which is then "On Blast" to supply hot blast at a predetermined temperature for energizing the second circuit means of one of said remainder of the stoves when the one stove which is then "On Blast" ceases to supply hot blast to the furnace at a predetermined temperature, whereby a change-over occurs in which said one of the remainder stoves is automatically placed in the "On Blast" condition while said stove which is then "On Blast" remains "On Blast," and means for automatically energizing the first circuit means of said one stove which is then "On Blast" when said one of the remainder stoves has been completely placed in the "On Blast" condition whereby to automatically place said one stove which is then "On Blast" in the "On Gas" condition, and means for automatically energizing said another circuit means of any one of said plurality of stoves when the latter is in the "On Gas" condition and its flue gas temperature reaches a predetermined value.

14. In a blast furnace installation in which a continuous stream of hot blast is adapted to be supplied to a blast furnace from three hot blast stoves each of which is equipped with a hot blast valve, a cold blast valve, a chimney valve, a gas valve and a burner valve, means for actuating said valves for placing each of said stoves in any one of a plurality of operating conditions including an "On Gas," an "On Blast" and an "On Bottled" condition, control means for initiating the operation of said valve actuating means for each of the operating conditions of each of said stoves, each stove having first circuit means adapted, when energized, to actuate the control means thereof for the placing thereof in the "On Gas" condition, each stove having second circuit means adapted, when energized, to actuate the control means thereof for the placing of the latter in the "On Blast" condition, said blast furnace being normally adapted to be supplied with hot blast from one stove at the time, which is then "On Blast," while the remaining two stoves are in an operating condition different from the "On Blast" condition, means for automatically energizing the second circuit means of a particular one of said remaining two stoves when the one stove which is then "On Blast" ceases to supply hot blast to the furnace at a predetermined temperature, whereby a change-over automatically occurs in which said particular stove is automatically placed in the "On Blast" condition while said stove which is then "On Blast" remains "On Blast" during the change-over interval, means for automatically energizing the first circuit means of said one stove which is then "On Blast" when said particular remaining stove has been completely placed in the "On Blast" condition at the end of the change-over interval whereby to automatically place said one stove which is then "On Blast" in the "On Gas" condition, and means for automatically selecting as said particular stove the one of said two remaining stoves which has been in an operating condition different from the "On Blast" condition for the longest period of time, said automatically selecting means comprising third circuit means for each stove adapted, when energized, to close a set of contacts in the second circuit means thereof, whereby the second circuit means of any stove is prevented from being energized unless the third circuit means thereof is also energized, and fourth circuit means for each stove adapted, when energized, to actuate the control means thereof for placing the latter in the "On Bottled" condition.

15. In a blast furnace installation in which a continuous stream of hot blast is adapted to be supplied to a blast furnace from three hot blast stoves each of which is equipped with a hot blast valve, a cold blast valve, a chimney valve, a gas valve and a burner valve, means for actuating said valves for placing each of said stoves in any one of a plurality of operating conditions including an "On Gas," an "On Blast" and an "On Bottled" condition, control means for initiating the operation of said valve actuating means for each of the operating conditions of each of said stoves, each stove having first circuit means adapted, when energized, to actuate the control means thereof for the placing thereof in the "On Gas" condition,

each stove having second circuit means adapted, when energized, to actuate the control means thereof for the placing thereof in the "On Blast" condition, said blast furnace being normally adapted to be supplied with hot blast from one stove at the time, which is then "On Blast," while the remaining two stoves are in an operating condition different from the "On Blast" condition, means for automatically energizing the second circuit means of a particular one of said remaining two stoves when the one stove which is then "On Blast" ceases to supply hot blast to the furnace at a predetermined temperature, whereby a change-over automatically occurs in which said particular stove is automatically placed in the "On Blast" condition while said stove which is then "On Blast" remains "On Blast" during the change-over interval, means for automatically energizing the first circuit means of said one stove which is then "On Blast" when said particular remaining stove has been completely placed in the "On Blast" condition at the end of the change-over interval whereby to automatically place said one stove which is then "On Blast" in the "On Gas" condition, and means for automatically selecting as said particular stove the one of said two remaining stoves which has been in an operating condition different from the "On Blast" condition for the longest period of time, said automatically selecting means comprising third circuit means for each stove adapted, when energized, to close a set of contacts in the second circuit means thereof, whereby the second circuit means of any stove is prevented from being energized unless the third circuit means thereof is also energized, and means for automatically energizing, during the change-over interval, the third circuit means of the one stove which is not "On Blast" during said change-over interval, for selecting such stove to be the particular stove to go "On Blast" during the next succeeding change-over interval, and fourth circuit means for each stove adapted, when energized, to actuate the control means thereof for the placing thereof in the "On Bottled" condition.

16. In a blast furnace installation in which a continuous stream of hot blast is adapted to be supplied to a blast furnace from three hot blast stoves each of which is equipped with a hot blast valve, a cold blast valve, a chimney valve, a gas valve and a burner valve, means for actuating said valves for placing each of said stoves in any one of a plurality of operating conditions including an "On Gas," an "On Blast" and an "On Bottled" condition, control means for initiating the operation of said valve actuating means for each of the operating conditions of each of said stoves, each stove having first circuit means adapted, when energized, to actuate the control means thereof for the placing thereof in the "On Gas" condition, each stove having second circuit means adapted, when energized, to actuate the control means thereof for the placing thereof in the "On Blast" condition, said blast furnace being normally adapted to be supplied with hot blast from one stove at the time, which is then "On Blast," while the remaining two stoves are in an operating condition different from the "On Blast" condition, means for automatically energizing the second circuit means of a particular one of said remaining two stoves when the one stove which is then "On Blast" ceases to supply hot blast to the furnace at a predetermined temperature, whereby a change-over automatically occurs in which said particular stove is automatically placed in the "On Blast" condition while said stove which is then "On Blast" remains "On Blast" during the change-over interval, means for automatically energizing the first circuit means of said one stove which is then "On Blast" when said particular remaining stove has been completely placed in the "On Blast" condition at the end of the change-over interval whereby to automatically place said one stove which is then "On Blast" in the "On Gas" condition, and means for automatically selecting as said particular stove the one of said two remaining stoves which has been in an operating condition different from the "On Blast" condition for the longest period of time, said automatically selecting means comprising third circuit means for each stove adapted, when energized, to close a set of contacts in the second circuit means thereof, whereby the second circuit means of any stove is prevented from being energized unless the third circuit means thereof is also energized, and means for automatically energizing, during the change-over interval, the third circuit means of the one stove which is not "On Blast" during said change-over interval, for selecting such stove to be the particular stove to go "On Blast" during the next succeeding change-over interval, and fourth circuit means for each stove adapted, when energized, to actuate the control means thereof for the placing thereof in the "On Bottled" condition, and means for automatically energizing the fourth circuit means of any one of said stoves when the latter is in the "On Gas" condition and its flue gas temperature reaches a predetermined value.

17. In a blast furnace installation in which a continuous stream of hot blast is adapted to be supplied to a blast furnace from two hot blast stoves each of which is equipped with a hot blast valve, a cold blast valve, a chimney valve, a gas valve and a burner valve, means for actuating said valves for placing each of said stoves in any one of a plurality of operating conditions including an "On Gas," an "On Blast" and an "On Bottled" condition, control means for initiating the operation of said valve actuating means for each of the operating conditions of each of said stoves, each stove having first circuit means adapted, when energized, to actuate the control means thereof for the placing thereof in the "On Gas" condition, each stove having second circuit means adapted, when energized, to actuate the control means thereof for the placing thereof in the "On Blast" condition, each stove having another circuit means adapted, when energized, to actuate the control means thereof for the placing thereof in the "On Bottled" condition, said blast furnace being normally adapted to be supplied with hot blast from one of the stoves, which is then "On Blast," while the other stove is in an operating condition different from the "On Blast" condition, means for automatically energizing the second circuit means of the stove that is in said different condition when the stove that is then "On Blast" ceases to supply hot blast at a predetermined temperature, whereby a change-over occurs in which said one stove that is in said different condition is automatically placed in the "On Blast" condition while said stove which is then "On Blast" remains "On Blast," and means for automatically energizing the first circuit means of said stove which is then "On Blast" when said one stove that is in said different condition has been completely placed in the "On Blast" condition whereby to automatically place the stove which is then "On Blast" in the "On Gas" condition, and means for automatically energizing said another circuit means of any one of said plurality of stoves when the latter is in the "On Gas" condition and its flue gas temperature reaches a predetermined value, said last mentioned automatic energizing means comprising means responsive to the flue gas temperature and disposed in the path thereof.

18. In a blast furnace installation in which a continuous stream of hot blast is adapted to be supplied to a blast furnace from a plurality of hot blast stoves each of which is equipped with a hot blast valve, a cold blast valve, a chimney valve, a gas valve and a burner valve, said hot blast being adapted to be mixed with an adjustable amount of cold blast controlled by a mixed blast regulating means; means for actuating said valves for placing each of said stoves in any one of a plurality of operating conditions including an "On Gas" and an "On Blast" condition, control means for initiating the operation of said valve actuating means for each of the operating conditions of each of said stoves, each stove having first circuit means adapted, when energized, to actuate the control means thereof for the placing thereof in the "On Gas" condition, each stove having second circuit means adapted, when ener-

gized, to actuate the control means thereof for the placing thereof in the "On Blast" condition, said blast furnace being normally adapted to be supplied with hot blast from one stove at the time. which is then "On Blast," while the remainder of the stoves are in an operating condition different from the "On Blast" condition, means for automatically energizing the second circuit means of one of said remainder of the stoves when the one stove which is then "On Blast" fails to supply hot blast to the furnace at a predetermined temperature, said last mentioned means comprising electrical means responsive to said mixed blast regulating means whereby a change-over occurs in which said one of the remainder stoves is automatically placed in the "On Blast" condition while said stove which is then "On Blast" remains "On Blast," and means for automatically energizing the first circuit means of said one stove which is then "On Blast" when said one of the remainder stoves has been completely placed in the "On Blast" condition whereby to automatically place said one stove which is then "On Blast" in the "On Gas" condition.

19. In a blast furnace installation in which a continuous stream of hot blast is adapted to be supplied to a blast furnace from three hot blast stoves each of which is equipped with a hot blast valve, a cold blast valve, a chimney valve, a gas valve and a burner valve, said hot blast being adapted to be mixed with an adjustable amount of cold blast controlled by a mixed blast regulating means; means for actuating said valves for placing each of said stoves in any one of a plurality of operating conditions including an "On Gas" and an "On Blast" condition, control means for initiating the operation of said valve actuating means for each of the operating conditions of each of said stoves, each stove having first circuit means adapted, when energized, to actuate the control means thereof for the placing thereof in the "On Gas" condition, each stove having second circuit means adapted, when energized, to actuate the control means thereof for the placing thereof in the "On Blast" condition, said blast furnace being normally adapted to be supplied with hot blast from one stove at the time, which is then "On Blast," while the remaining two stoves are in an operating condition different from the "On Blast" condition, means for automatically energizing the second circuit means of a particular one of said remaining two stoves when the one stove which is then "On Blast" fails to supply hot blast to the furnace at a predetermined temperature, said last mentioned means comprising electrical means responsive to said mixed blast regulating means whereby a change-over automatically occurs in which said particular stove is automatically placed in the "On Blast" condition while said stove which is then "On Blast" remains "On Blast" during the change-over interval, means for automatically energizing the first circuit means of said one stove which is then "On Blast" when said particular remaining stove has been completely placed in the "On Blast" condition at the end of the change-over interval whereby to automatically place said one stove which is then "On Blast" in the "On Gas" condition, and means for automatically selecting as said particular stove the one of said two remaining stoves which has been in an operating condition different from the "On Blast" condition for the longest period of time.

20. In a blast furnace installation in which a continuous stream of hot blast is adapted to be supplied to a blast furnace from three hot blast stoves each of which is equipped with a hot blast valve, a cold blast valve, a chimney valve, a gas valve and a burner valve, said hot blast being adapted to be mixed with an adjustable amount of cold blast controlled by a mixed blast regulating means; means for actuating said valves for placing each of said stoves in any one of a plurality of operating conditions including an "On Gas" and an "On Blast" condition, control means for initiating the operation of said valve actuating means for each of the operating conditions of each of said stoves, each stove having first circuit means adapted, when energized, to actuate the control means thereof for the placing thereof in the "On Gas" condition, each stove having second circuit means adapted, when energized, to actuate the control means thereof for the placing thereof in the "On Blast" condition, said blast furnace being normally adapted to be supplied with hot blast from one stove at the time, which is then "On Blast," while the remaining two stoves are in an operating condition different from the "On Blast" condition, means for automatically energizing the second circuit means of a particular one of said remaining two stoves when said mixed blast regulating means is closed in direct response to the failure of the one stove which is then "On Blast" to supply hot blast to the furnace at a predetermined temperature, whereby a change-over automatically occurs in which said particular stove is automatically placed in the "On Blast" condition while said stove which is then "On Blast" remains "On Blast" during the change-over interval, means for automatically energizing the first circuit means of said one stove which is then "On Blast" when said particular remaining stove has been completely placed in the "On Blast" condition at the end of the change-over interval whereby to automatically place said one stove which is then "On Blast" in the "On Gas" condition, and means for automatically selecting as said particular stove the one of said two remaining stoves which has been in an operating condition different from the "On Blast" condition for the longest period of time, said automatically selecting means comprising third circuit means for each stove adapted, when energized, to close a set of contacts in the second circuit means thereof, whereby the second circuit means of any stove is prevented from being energized unless the third circuit means thereof is also energized.

21. In a blast furnace installation in which a continuous stream of hot blast is adapted to be supplied to a blast furnace from three hot blast stoves each of which is equipped with a hot blast valve, a cold blast valve, a chimney valve, a gas valve and a burner valve, said hot blast being adapted to be mixed with an adjustable amount of cold blast controlled by a mixed blast regulating means; means for actuating said valves for placing each of said stoves any one of a plurality of operating conditions inincluding an "On Gas" and an "On Blast" condition, control means for initiating the operation of said valve actuating means for each of the operating conditions of each of said stoves, each stove having first circuit means adapted, when energized, to actuate the control means thereof for the placing thereof in the "On Gas" condition, each stove having second circuit means adapted, when energized, to actuate the control means thereof for the placing thereof in the "On Blast" condition, said blast furnace being normally adapted to be supplied with hot blast from one stove at the time, which is then "On Blast," while the remaining two stoves are in an operating condition different from the "On Blast" condition, means for automatically energizing the second circuit means of a particular one of said remaining two stoves when said mixed blast regulating means is closed in direct response to the failure of the one stove which is then "On Blast" to supply hot blast to the furnace at a predetermined temperature, whereby a change-over automatically occurs in which said particular stove is automatically placed in the "On Blast" condition while said stove which is then "On Blast" remains "On Blast" during the change-over interval, means for automatically energizing the first circuit means of said one stove which is then "On Blast" when said particular remaining stove has been completely placed in the "On Blast" condition at the end of the change-over interval whereby to automatically place said one stove which is then "On Blast" in the "On Gas" condition, and means for automatically selecting as said particular stove the one of said two remaining stoves which has been in an operating condition different from the "On Blast" condition for the longest period of time, said automatically selecting means comprising third circuit means for each stove adapted, when energized, to close a set of contacts in the

second circuit means thereof, whereby the second circuit means of any stove is prevented from being energized unless the third circuit means thereof is also energized, and means for automatically energizing, during the change-over interval, the third circuit means of the one stove which is not "On Blast" during said change-over interval, for selecting such stove to be the particular stove to go "On Blast" during the next succeeding change-over interval.

22. In a blast furnace installation in which a continuous stream of hot blast is adapted to be supplied to a blast furnace from a plurality of hot blast stoves each of which is equipped with a hot blast valve, a cold blast valve, a chimney valve, a gas valve and a burner valve, said hot blast being adapted to be mixed with an adjustable amount of cold blast controlled by a mixed blast regulating means; means for actuating said valves for placing each of said stoves in any one of a plurality of operating conditions including an "On Gas," an "On Blast" and an "On Bottled" condition, control means for initiating the operation of said valve actuating means for each of the operating conditions of each of said stoves, each stove having first circuit means adapted, when energized, to actuate the control means thereof for the placing thereof in the "On Gas" condition, each stove having second circuit means adapted, when energized, to actuate the control means thereof for the placing thereof in the "On Blast" condition, each stove having another circuit means adapted, when energized, to actuate the control means thereof for the placing thereof in the "On Bottled" condition, said blast furnace being normally adapted to be supplied with hot blast from one stove at the time, which is then "On Blast," while the remainder of the stoves are in an operation condition different from the "On Blast" condition, means for automatically energizing the second circuit means of one of said remainder of the stoves when said mixed blast regulating means is closed in direct response to the failure of the one stove which is then "On Blast" to supply hot blast to the furnace at a predetermined temperature, whereby a change-over occurs in which said one of the remainder stoves is automatically placed in the "On Blast" condition while said stove which is then "On Blast" remains "On Blast," and means for automatically energizing the first circuit means of said one stove which is then "On Blast" when said one of the remainder stoves has been completely placed in the "On Blast" condition whereby to automatically place said one stove which is then "On Blast" in the "On Gas" condition.

23. In a blast furnace installation in which a continuous stream of hot blast is adapted to be supplied to a blast furnace from three hot blast stoves each of which is equipped with a hot blast valve, a cold blast valve, a chimney valve, a gas valve and a burner valve, said hot blast being adapted to be mixed with an adjustable amount of cold blast controlled by a mixed blast regulating means; means for actuating said valves for placing each of said stoves in any one of a plurality of operating conditions including an "On Gas," an "On Blast" and an "On Bottled" condition, control means for initiating the operation of said valve actuating means for each of the operating conditions of each of said stoves, each stove having first circuit means adapted, when energized, to actuate the control means thereof for the placing thereof in the "On Gas" condition, each stove having second circuit means adapted, when energized, to actuate the control means thereof for the placing thereof in the "On Blast" condition, said blast furnace being normally adapted to be supplied with hot blast from one stove at the time, which is then "On Blast," while the remaining two stoves are in an operating condition different from the "On Blast" condition, means for automatically energizing the second circuit means of a particular one of said remaining two stoves when said mixed blast regulating means is closed in direct response to the failure of the one stove which is then "On Blast" to supply hot blast to the furnace at a predetermined temperature, whereby a change-over automatically occurs in which said particular stove is automatically placed in the "On Blast" condition while said stove which is then "On Blast" remains "On Blast" during the change-over interval, means for automatically energizing the first circuit means of said one stove which is then "On Blast" when said particular remaining stove has been completely placed in the "On Blast" condition at the end of the change-over interval whereby to automatically place said one stove which is then "On Blast" in the "On Gas" condition, and means for automatically selecting as said particular stove the one of said two remaining stoves which has been in an operating condition different from the "On Blast" condition for the longest period of time, said automatically selecting means comprising third circuit means for each stove adapted, when energized, to close a set of contacts in the second circuit means thereof, whereby the second circuit means of any stove is prevented from being energized unless the third circuit means thereof is also energized, and means for automatically energizing, during the change-over interval, the third circuit means of the one stove which is not "On Blast" during said change-over interval, for selecting such stove to be the particular stove to go "On Blast" during the next succeeding change-over interval, and fourth circuit means for each stove adapted, when energized, to actuate the control means thereof for placing the latter in the "On Bottled" condition.

24. In a blast furnace installation in which a continuous stream of hot blast is adapted to be supplied to a blast furnace from three hot blast stoves each of which is equipped with a hot blast valve, a cold blast valve, a chimney valve, a gas valve and a burner valve, said hot blast being adapted to be mixed with an adjustable amount of cold blast controlled by a mixed blast regulating means; means for actuating said valves for placing each of said stoves in any one of a plurality of operating conditions including an "On Gas," an "On Blast" and an "On Bottled" condition, control means for initiating the operation of said valve actuating means for each of the operating conditions of each of said stoves, first circuit means for each stove adapted, when energized, to actuate the control means of the associated stove for placing the latter in the "On Gas" condition, second circuit means for each stove adapted, when energized, to actuate the control means of the associated stove for placing the latter in the "On Blast" condition, said blast furnace being normally adapted to be supplied with hot blast from one stove at the time, which is then "On Blast," while the remaining two stoves are in an operating condition different from the "On Blast" condition, means for automatically energizing the second circuit means of a particular one of said remaining two stoves when said mixed blast regulating means is closed in direct response to the failure of the one stove which is then "On Blast" to supply hot blast to the furnace at a predetermined temperature, whereby a change-over automatically occurs in which said particular stove is automatically placed in the "On Blast" condition while said stove which is then "On Blast" remains "On Blast" during the change-over interval, means for automatically energizing the first circuit means of said one stove which is then "On Blast" when said particular remaining stove has been completely placed in the "On Blast" condition at the end of the change-over interval whereby to automatically place said one stove which is then "On Blast" in the "On Gas" condition, and means for automatically selecting as said particular stove the one of said two remaining stoves which has been in an operating condition different from the "On Blast" condition for the longest period of time, said automatically selecting means comprising third circuit means for each stove adapted, when energized, to close a set of contacts in the second circuit means of the asso-

ciated stove, whereby the second circuit means of any stove is prevented from being energized unless the third circuit means thereof is also energized, and means for automatically energizing, during the change-over interval, the third circuit means of the one stove which is not "On Blast" during said change-over interval, for selecting such stove to be the particular stove to go "On Blast" during the next succeeding change-over interval, and fourth circuit means for each stove adapted, when energized, to actuate the control means of the associated stove for placing the latter in the "On Bottled" condition, and means for automatically energizing the fourth circuit means of any one of said stoves when the latter is in the "On Gas" condition and its flue gas temperature reaches a predetermined value.

25. In a blast furnace installation in which a continuous stream of hot blast is adapted to be supplied to a blast furnace from two hot blast stoves each of which is equipped with a hot blast valve, a cold blast valve, a chimney valve, a gas valve and a burner valve, said hot blast being adapted to be mixed with an adjustable amount of cold blast controlled by a mixed blast regulating means; means for actuating said valves for placing each of said stoves in any one of a plurality of operating conditions including an "On Gas" and an "On Blast" condition, control means for initiating the operation of said valve actuating means for each of the operating conditions of each of said stoves, each stove having first circuit means adapted, when energized, to actuate the control means thereof for the placing thereof in the "On Gas" condition, each stove having second circuit means adapted, when energized, to actuate the control means thereof for the placing thereof in the "On Blast" condition, said blast furnace being normally adapted to be supplied with hot blast from one of the stoves which is then "On Blast," while the other stove is in an operating condition different from the "On Blast" condition, means for automatically energizing the second circuit means of the stove that is in said different condition when the one stove which is then "On Blast" fails to supply hot blast at a predetermined temperature, said last mentioned means comprising electrical means responsive to said mixed blast regulating means whereby a change-over occurs in which said one stove that is in said different condition is automatically placed in the "On Blast" condition while said stove which is then "On Blast" remains "On Blast," and means for automatically energizing the first circuit means of said stove which is then "On Blast" when said one stove that is in said different condition has been completely placed in the "On Blast" condition whereby to automatically place the stove which is then "On Blast" in the "On Gas" condition.

26. In a blast furnace installation in which a continuous stream of hot blast is adapted to be supplied to a blast furnace from two hot blast stoves each of which is equipped with a hot blast valve, a cold blast valve, a chimney valve, a gas valve and a burner valve, said hot blast being adapted to be mixed with an adjustable amount of cold blast controlled by a mixed blast regulating means; means for actuating said valves for placing each of said stoves in any one of a plurality of operating conditions including an "On Gas," an "On Blast" and an "On Bottled" condition, control means for initiating the operation of said valve actuating means for each of the operating conditions of each of said stoves, each stove having first circuit means adapted, when energized, to actuate the control means thereof for the placing thereof in the "On Gas" condition, each stove having second circuit means adapted, when energized, to actuate the control means thereof for the placing thereof in the "On Blast" condition, each stove having another circuit means adapted, when energized, to actuate the control means thereof for the placing thereof in the "On Bottled" condition, said blast furnace being normally adapted to be supplied with hot blast from one of the stoves, which is then "On Blast," while the other stove is in an operating condition different from the "On Blast" condition, means for automatically energizing the second circuit means of the stove that is in said different condition when the one stove which is then "On Blast" fails to supply hot blast at a predetermined temperature, said last mentioned means comprising a set of electrical contacts which are closed when said mixed blast regulating means is closed, whereby a change-over occurs in which said one stove that is in said different condition is automatically placed in the "On Blast" condition while said stove which is then "On Blast" remains "On Blast," and means for automatically energizing the first circuit means of said stove which is then "On Blast" when said one stove that is in said different condition has been completely placed in the "On Blast" condition whereby to automatically place the stove which is then "On Blast" in the "On Gas" condition, and means for automatically energizing said another circuit means of any one of said plurality of stoves when the latter is in the "On Gas" condition and its flue gas temperature reaches a predetermined value.

27. In a blast furnace installation in which a continuous stream of hot blast is adapted to be supplied to a blast furnace from three hot blast stoves each of which is equipped with a hot blast valve, a cold blast valve, a chimney valve, a gas valve and a burner valve, means for actuating said valves for placing each of said stoves in any one of a plurality of operating conditions including an "On Gas" and an "On Blast" condition, each of said stoves having a thermo-sensitive device disposed in the path of the hot blast exiting therefrom, control means for initiating the operation of said valve actuating means for each of the operating conditions of each of said stoves, each stove having first circuit means adapted, when energized, to actuate the control means thereof for the placing thereof in the "On Gas" condition, each stove having second circuit means adapted, when energized, to actuate the control means thereof for the placing thereof in the "On Blast" condition, said blast furnace being normally adapted to be supplied with hot blast from one stove at the time, which is then "On Blast," while the remaining two stoves are in an operating condition different from the "On Blast" condition, means for automatically energizing the second circuit means of a particular one of said remaining two stoves when the one stove which is then "On Blast" ceases to supply hot blast to the furnace at said predetermined temperature, whereby a change-over automatically occurs in which said particular stove is automatically placed in the "On Blast" condition while said stove which is then "On Blast" remains "On Blast" during the change-over interval, means for automatically energizing the first circuit means of said one above which is then "On Blast" when said particular remaining stove has been completely placed in the "On Blast" condition at the end of the change-over interval whereby to automatically place said one stove which is then "On Blast" in the "On Gas" condition, and means for automatically selecting as said particular stove the one of said two remaining stoves which has been in an operating condition different from the "On Blast" condition for the longest period of time, said means for automatically energizing the second circuit means of said particular stove comprising a set of contacts which are automatically closed in response to the energization of the thermo-sensitive device of the one stove which is then "On Blast," whereby a change-over occurs automatically when the temperature of the exiting hot blast of the stove which is then "On Blast" falls below said predetermined temperature.

28. In a blast furnace installation in which a continuous stream of hot blast is adapted to be supplied to a blast furnace from a plurality of hot blast stoves each of which is equipped with a hot blast valve, a cold blast valve, a chimeny valve, a gas valve and a burner valve, means for actuating said valves for placing each of said stoves in any one of a plurality of operating conditions

including an "On Gas," an "On Blast" and an "On Bottled" condition, each of said stoves having a thermo-sensitive device disposed in the path of the hot blast exiting therefrom, control means for initiating the operation of said valve actuating means for each of the operating conditions of each of said stoves, each stove having first circuit means adapted, when energized, to actuate the control means thereof for the placing thereof in the "On Gas" condition, each stove having second circuit means adapted, when energized, to actuate the control means thereof for the placing thereof in the "On Blast" condition, each stove having another circuit means adapted, when energized, to actuate the control means thereof for the placing thereof in the "On Bottled" condition, said blast furnace being normally adapted to be supplied with hot blast from one stove at the time, which is then "On Blast," while the remainder of the stoves are in an operating condition different from the "On Blast" condition, means for automatically energizing the second circuit means of one of said remainder of the stoves when the one stove which is then "On Blast" ceases to supply hot blast to the furnace at said predetermined temperature, whereby a change-over occurs in which said one of the remainder stoves is automatically placed in the "On Blast" condition while said stove which is then "On Blast" remains "On Blast," means for automatically energizing the first circuit means of said one stove which is then "On Blast" when said one of the remainder stoves has been completely placed in the "On Blast" condition whereby to automatically place said one stove which is then "On Blast" in the "On Gas" condition, said means for automatically energizing the second circuit means of said one of the remainder of the stoves comprising a set of contacts which are automatically closed in response to the energization of the thermo-sensitive device of the one stove which is then "On Blast," whereby a change-over occurs automatically when the temperature of the exiting hot blast of the stove which is then "On Blast" falls below said predetermined temperature, and thermosensitive means in each stove disposed in the path of the flue gases and adapted to energize said another circuit means when the flue gas temperature reaches a predetermined value.

29. In a blast furnace installation in which a continuous stream of hot blast is adapted to be supplied to a blast furnace from three hot blast stoves each of which is equipped with a plurality of valves, means for actuating said valves for placing each of said stoves in any one of a plurality of operating conditions including an "On Gas" and an "On Blast" condition, control means for initiating the operation of said valve actuating means for each of the operating conditions of each of said stoves, each stove having first circuit means adapted, when energized, to actuate the control means thereof for the placing thereof in the "On Gas" condition, each stove having second circuit means adapted, when energized, to actuate the control means thereof for the placing thereof in the "On Blast" condition, said blast furnace being normally adapted to be supplied with hot blast from one stove at the time, which is then "On Blast," while the remaining two stoves are in an operating condition different from the "On Blast" condition, means for automatically energizing the second circuit means of a particular one of said remaining two stoves when the one stove which is then "On Blast" ceases to supply hot blast to the furnace at a predetermined temperature, whereby a change-over automatically occurs in which said particular stove is automatically placed in the "On Blast" condition while said stove which is then "On Blast" remains "On Blast" during the change-over interval, means for automatically energizing the first circuit means of said one stove which is then "On Blast" when said particular remaining stove has been completely placed in the "On Blast" condition at the end of the change-over interval whereby to automatically place said one stove which is then "On Blast" in the "On Gas" conidtion, and means for automatically selecting as said particular stove the one of said two remaining stoves which has been in an operating condition different from the "On Blast" condition for the longest period of time.

30. In a blast furnace installation in which a continuous stream of hot blast is adapted to be supplied to a blast furnace from a plurality of hot blast stoves, each of which is equipped with a plurality of valves, means for actuating said valves for placing each of said stoves in any one of a plurality of operating conditions including an "On Gas," an "On Blast," and an "On Bottled" condition, control means for initiating the operation of said valve actuating means for each of the operating conditions of each of said stoves, each stove having first circuit means adapted, when energized, to actuate the control means thereof for the placing thereof in the "On Gas" condition, each stove having second circuit means adapted, when energized, to actuate the control means thereof for the placing thereof in the "On Blast" condition, each stove having another circuit means adapted, when energized, to actuate the control means thereof for the placing thereof in the "On Bottled" condition, and means for automatically energizing said another circuit means of any one of said plurality of stoves when the latter is in the "On Gas" condition and its flue gas temperature reaches a predetermined value, whereby to automatically place such stove having said another circuit means thereof energized in the "On Bottled" condition, said last mentioned automatic energizing means comprising thermo-sensitive means disposed in the path of the flue gas and responsive to the temperature thereof.

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