

Nov. 16, 1943.

G. A. DAVIS

2,334,612

COKE OVEN REGENERATOR

Filed Sept. 6, 1941

4 Sheets-Sheet 1

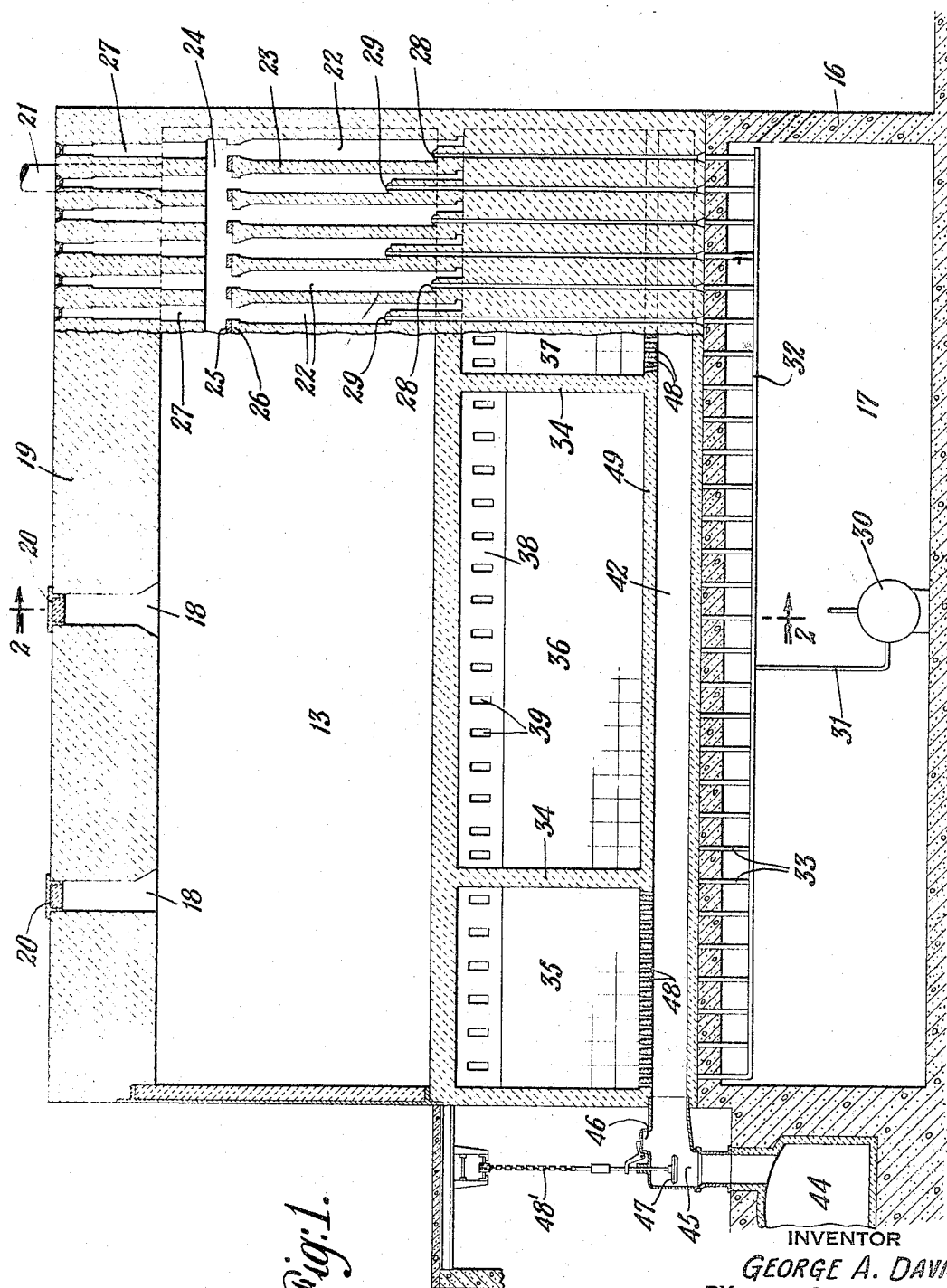


Fig. 1.

INVENTOR  
GEORGE A. DAVIS

BY  
*Benjamin Smedley*  
ATTORNEY

Nov. 16, 1943.

G. A. DAVIS

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4 Sheets-Sheet 2

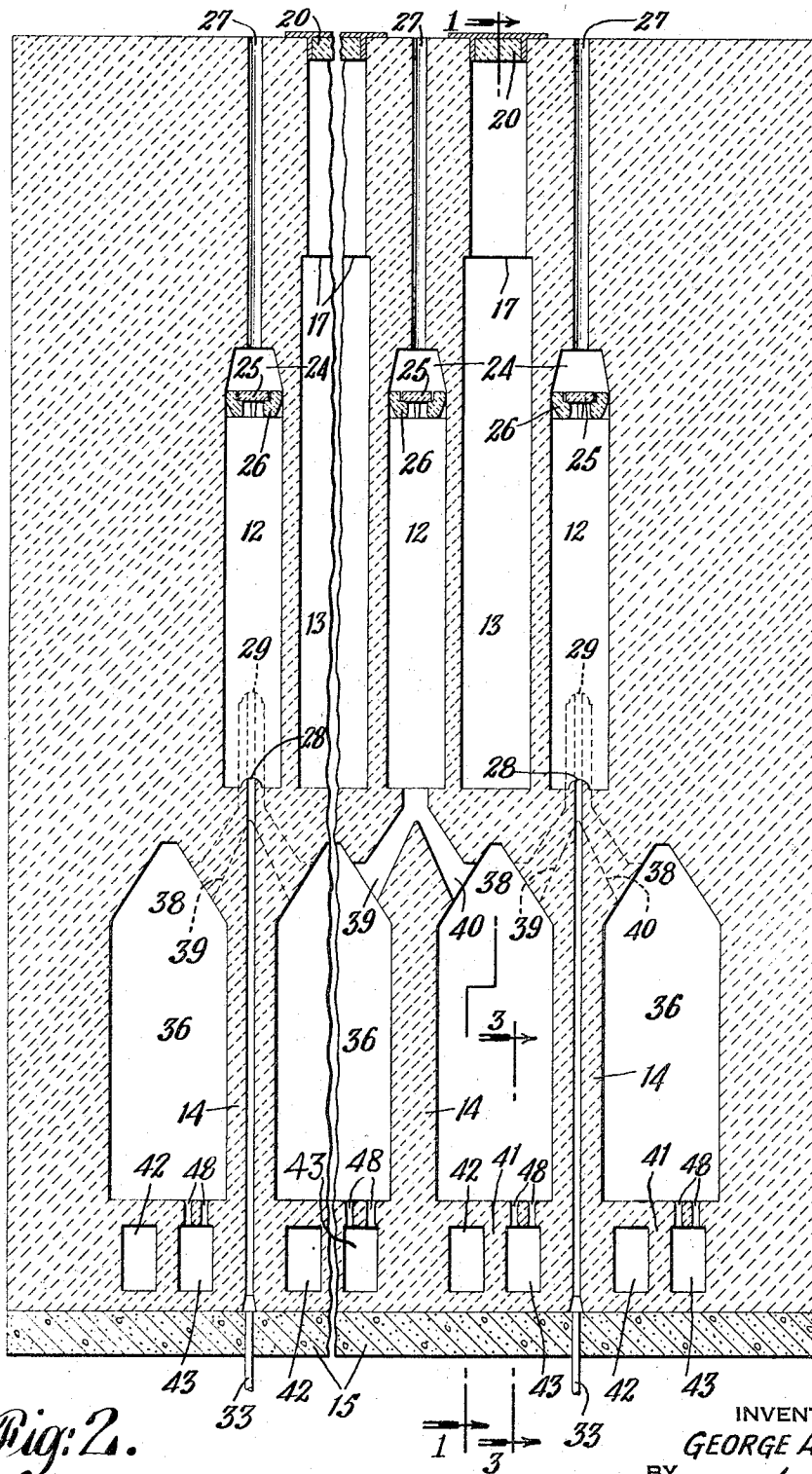


Fig. 2.

INVENTOR

GEORGE A. DAVIS

BY

Benjamin Sneedler  
ATTORNEY

Nov. 16, 1943.

G. A. DAVIS

2,334,612

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Fig. 4.

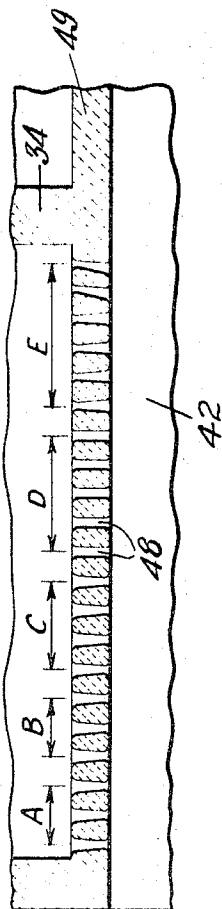


Fig. 5.

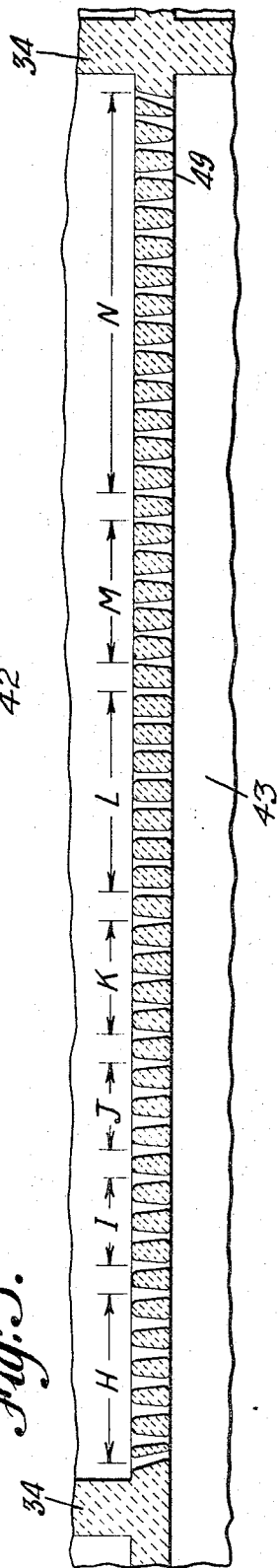


Fig. 6.

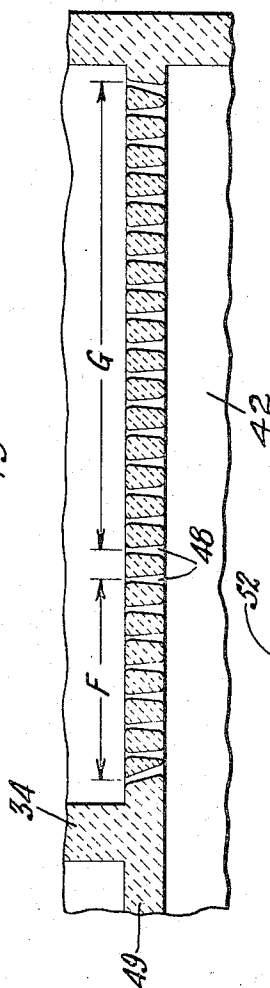


Fig. 8.

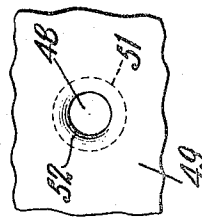
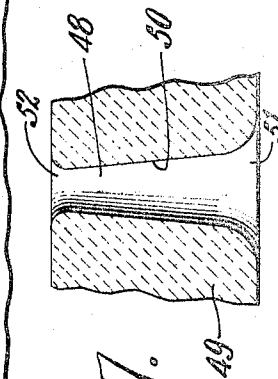


Fig. 7.



INVENTOR  
GEORGE A. DAVIS  
BY  
*Benjamin Sneed*  
ATTORNEY

Nov. 16, 1943.

G. A. DAVIS

2,334,612

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4 Sheets-Sheet 4

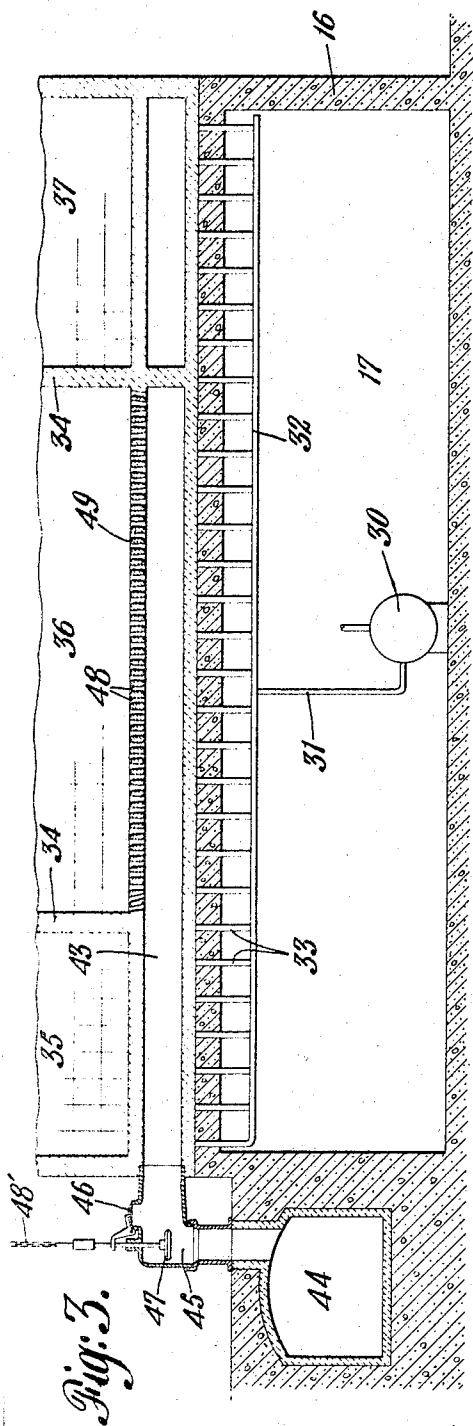


Fig. 3.

Fig. 17.

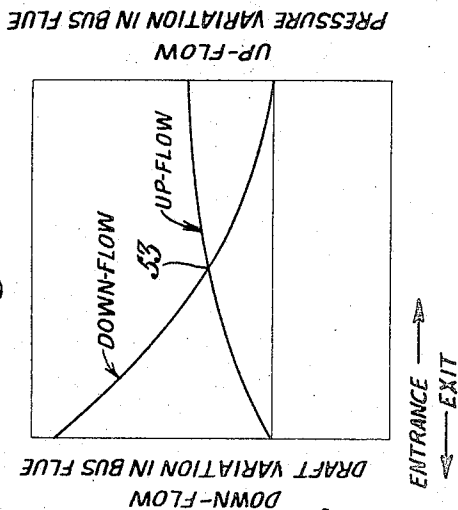


Fig. 15.

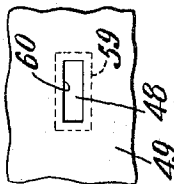


Fig. 13.

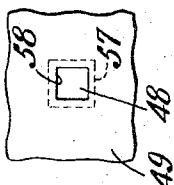


Fig. 11.

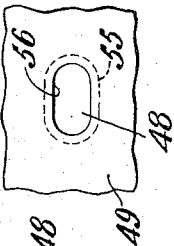


Fig. 9.

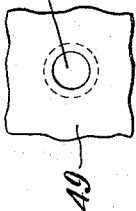


Fig. 16.

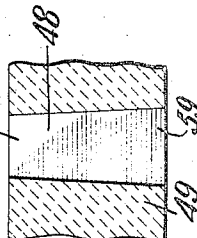


Fig. 14.

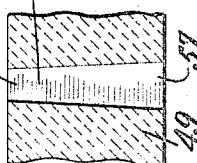


Fig. 12.

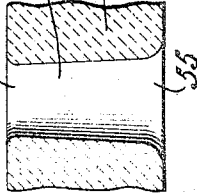
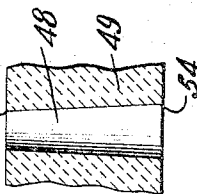


Fig. 10.



INVENTOR  
GEORGE A. DAVIS

BY  
Benjamin Sneedler  
ATTORNEY

## UNITED STATES PATENT OFFICE

2,334,612

## COKE OVEN REGENERATOR

George A. Davis, Mountain Lakes, N. J., assignor  
to Somet-Solvay Engineering Corporation, New  
York, N. Y., a corporation of New York

Application September 6, 1941, Serial No. 409,757

10 Claims. (Cl. 202-146)

This invention relates to regenerative coke ovens, and more particularly to the design and construction of the regenerators of a coke oven battery.

As is well known to those skilled in the art, the heating of a coke oven battery may conveniently be regarded as effected by two separate and distinct systems, namely, the regenerator and heating flue systems. In the case of a vertical heating flue coke oven, flow through the heating flues is controlled by ports in the base portions of the vertical flues and in the top horizontal flues connecting the top portions of the vertical flues. The sizes of these ports and the setting of the slide brick controlling the ports in the horizontal flues connecting the top portions of the vertical flues regulate the flow through the flues. The regenerators are each usually connected to the vertical flues communicating therewith through a sole flue disposed along the top of the regenerator. The sole flue serves to distribute the air or gas flowing through the regenerator to the vertical flues communicating therewith. In modern coke oven design these sole flues are so large that distribution of flow through the heating flue system is substantially independent of the distribution of flow through the regenerator system.

The regenerator system comprises individual regenerators, each provided with a bus flue running the length of regenerator for supplying air or gas, as the case may be, to the regenerator through ports disposed at spaced intervals along the length of the bus flue. In order to obtain uniform distribution of the air or gas through the regenerator necessary for maximum regenerator efficiency, it is important the ports be so designed that they produce a resistance to flow inversely proportional to the variation in pressure along the length of the bus flue during both the upflow and downflow periods of operation. To the best of my knowledge and belief, no design of regenerators known to the art prior to my invention achieves this desideratum; that is to say, while regenerators have been designed to take into account and compensate for factors such as friction or loss of velocity which, unless compensated for, result in uneven distribution of flow through the regenerators, no design of regenerators has properly taken into account substantially all such factors.

In order to properly understand the present invention it is believed consideration of certain fundamentals pertaining to the flow of fluids responsible for varying pressure conditions in the bus flues would be helpful. As is well recognized,

during the downflow period the pressure in any given bus flue is less than that in the communicating regenerator so that flow takes place from the regenerator through the bus flue, whereas during the upflow period the pressure in the said bus flue is greater than that in the communicating regenerator so that flow takes place from the bus flue into and through the regenerator. The expression "static draft" is used herein to characterize the negative pressure in the bus flue during the downflow period, whereas the expression "static pressure" is used to characterize the pressure in the bus flue during the upflow period. It is the static pressure during the inflow or upflow period and static draft during the downflow or outflow period in the bus flue which determines the flow through the regenerator communicating therewith. Further, this static pressure or static draft, as the case may be, is affected by changes in either the total pressure or velocity pressure in each bus flue. During the upflow period variations in static pressure in each bus flue are due to: (1) loss in total pressure due to friction, which loss, other factors, e. g. velocity pressure, remaining constant, tend to decrease the static pressure toward the inside or terminal end of the bus flue; and (2) decrease in velocity pressure toward the inside or terminal end of the bus flue tending to increase the static pressure toward the inside end of the bus flue.

Due to the downflow period variations in static draft in each bus flue are due to: (1) loss in total pressure due to friction tending to increase the static draft toward the exist end of the bus flue; (2) increase in velocity toward the exit end of the bus flue tending to increase the static draft toward the exit end of the bus flue; and (3) loss in total pressure toward the exit end of the bus flue due to an effect which, I have reason to believe, has not been appreciated by coke oven engineers, and which is hereinafter referred to as the "injector effect." This effect is due to the pressure lost by the main stream flowing through the bus flue in accelerating the successive side streams entering the main stream through the bus flue ports connecting the bus flue with the regenerator to the velocity of the main stream. As each side stream enters the main stream flowing through the bus flue from the regenerator above through its respective port the side stream must be accelerated to the velocity of the main stream. The energy required for this acceleration is imparted to the side stream by the main stream, resulting in loss of pressure by the main stream.

The variations in pressure conditions in an in-

ner bus flue of an oven battery of the type shown in the drawings hereinafter described, in which battery air or gas is supplied to the regenerators, and products of combustion withdrawn, at one and the same side of the battery, are shown graphically by the curves of Figure 17 of these drawings. It will be noted from the curve identified by the legend "upflow," which shows the pressure variation along the length of the inner bus flue during the upflow, that as the end of the bus flue is approached there is an increase in pressure. As above explained, this is due to friction losses and loss of pressure due to conversion of velocity head to static head. The curve identified by the legend "downflow" shows the draft variation along the length of the bus flue during the downflow. It will be noted that the pressure variations, as hereinabove explained, are substantially greater on downflow than on upflow.

It has been proposed to partially compensate for the adverse distributional effects of static and draft pressure variations in the bus flues by designing the oven battery so that air or lean gas is supplied through the bus flues from one side of the battery and products of combustion discharged at the opposite side of the battery and graduating the ports in the bus flues, each of which is of uniform cross-sectional area throughout the full height thereof, so that the ports offer a progressively increasing resistance to flow therethrough, which progressive increase in resistance follows the mean between the upflow and downflow velocity effects. This design does not take into account pressure variations due to the above-described injector effect, nor does it adequately compensate for loss in pressure due to friction which during the upflow period tends to decrease the static pressure toward the inside end of the bus flue and during the downflow period tends to increase the static draft toward the opposite end of the bus flue. At best it represents a compromise in that it involves graduation of the ports in each bus flue in accordance with the average or mean of the decrease in velocity toward the inside end of the bus flue during the upflow period and increase in velocity head toward the exit end of the bus flue during the downflow period.

It is an object of this invention to provide a regenerator design which will give substantially uniform flow throughout the regenerator during both upflow and downflow periods whereby maximum regenerator efficiency results.

It is another object of this invention to provide regenerator ports connecting a regenerator bus flue with the regenerator which ports are of simple design such that they can be made readily and inexpensively in clay shapes, and which ports effectively compensate for pressure variations in the bus flue due to friction losses, velocity and injector effects, during both upflow and downflow periods, resulting in uniform flow through the regenerators with consequent maximum regenerator efficiency. Other objects and advantages of this invention will appear from the following detailed description thereof.

In the accompanying drawings forming a part of this specification, and showing for purposes of exemplification a preferred form of this invention without limiting the claimed invention to such illustrative instance;

Figure 1 is a crosswise vertical composite section through a coke oven battery embodying the improvement of the present invention, the left hand portion of the view being taken longitudi-

nally through a coking chamber and regenerators therebeneath in a plane indicated by the line 1-1, Figure 2, and the right hand portion of the view being taken longitudinally through a heating wall flanking the coking chamber;

Figure 2 is a fragmentary vertical section through a coke oven battery taken longitudinally of the battery in a plane passing through the charging openings leading into the coking chambers indicated by the line 2-2 of Figure 1, the burners and gas supply conduit being omitted from the middle heating wall shown in this figure for the sake of clarity;

Figure 3 is a fragmentary crosswise vertical section through the base portion of a coking battery taken in the plane indicated by the line 3-3 of Figure 2;

Figure 4 is a fragmentary crosswise vertical section on an enlarged scale as compared with the scale of Figures 1 to 3 through an outer bus flue of a regenerator, showing an arrangement of ports connecting a bus flue with its regenerator;

Figure 5 is a fragmentary crosswise vertical section on the same scale as Figure 4 showing an arrangement of ports connecting an inner bus flue with its regenerator above;

Figure 6 is a fragmentary crosswise vertical section on the same scale as Figure 4 showing an arrangement of ports in another outer bus flue of each group of regenerators communicating with the heating wall, as will be hereinafter more fully explained;

Figure 7 is a detailed vertical section of one of the ports of Figures 4 to 6;

Figure 8 is a plan view of the port of Figure 7;

Figures 9 and 10 are plan and vertical sections respectively of a modified form of port;

Figures 11 and 12 are plan and vertical sections respectively of another modified form of port;

Figures 13 and 14 respectively are plan and vertical sectional views of another modified form of port;

Figures 15 and 16 respectively are plan and vertical sectional views of still another form of port which may be employed in the practice of this invention; and

Figure 17 shows curves representing the variations in pressure conditions along the length of the bus flue of a regenerator during both the upflow and downflow cycles of operation, which regenerator is supplied with air or gas at one side and which discharges products of combustion at the same side.

In the preferred embodiment illustrated in the drawings the invention is shown incorporated in a combination coke oven battery involving a single waste heat flue, and the present description will be confined to the present illustrated embodiment of the invention in such oven battery. It will be noted, however, that the novel features of the invention are susceptible to other applications, such, for example, as an oven battery having two waste heat flues as disclosed in Pavitt Patent 2,155,954 of April 25, 1939, or the regenerative coke oven batteries of the Koppers or Becker type, in which the flues on one side of the coking chamber communicate with those on the other side, or the well known Semet-Solvay regenerative coke oven battery involving horizontal flues in the heating walls of coking chambers. Furthermore, while this invention has been particularly developed for use in regenerative coke oven batteries, it will be appreciated that it has other applications in the field involving flow of fluids into a manifold supplying the fluid to a relatively large

chamber during the inflow periods alternating with the flow of the fluid from the chamber into the manifold during the outflow periods, to obtain a desired predetermined flow pattern during both the inflow and outflow periods through the afore-  
said chamber, the distributional flow pattern being uniform or not as desired, and being the same or different during the successive inflow and outflow periods of operation. An example of such other application of the invention is in controlling the flow of fluids in open hearth regenerators. Hence, the scope of this invention is not confined to the embodiment herein described.

In the drawings, referring to Figures 1 and 2, there is shown a combination by-product coke oven embodying in its construction a plurality of heating walls 12 and a plurality of intermediate crosswise-extending horizontally elongated coking chambers 13. The heating walls form the side walls of the respective coking chambers, the heating walls and the coking chambers, together with the superstructure of the oven battery, being supported by massive supporting walls 14 positioned directly beneath the heating walls 12. The supporting walls 14 rest on and are supported by a flat mat or platform 15 suitably supported by pillars 16 above a basement space 17 beneath the oven battery.

The coal or other material to be coked is charged into the coking chamber 13 through charging holes 18 located in the top 19 of the oven battery and positioned directly above and communicating with coking chambers 13. The charging holes are equipped with the usual removable covers 20 which are removed during charging of the individual coking chambers and are placed in position to close the tops of these coking chambers during the coking operation. The gases evolved in the coking chambers pass from the ducts through the usual ascension pipes 21 fragmentarily shown at the extreme right hand of Figure 1 into the usual gas collector main which communicates with the by-product recovery apparatus.

Each heating wall 12 is composed of a plurality of vertical combustion flues 22 formed by transverse flue walls 23. The flues of each heating wall are operatively disposed in two outer and an inner group of consecutive flues, with the flues of each group operating concurrently for flow in the same direction. During one period of operation the flues of the outer groups operate concurrently as inflow flues, while the inner group of flues operate concurrently as outflow flues. Upon reversal, the inner group of flues of each heating wall operates as inflow flues, while the outer groups of flues operate concurrently as outflow flues. The tops of the outer flue groups are communicably connected to the inner flue group by a horizontal passage or flue 24, placed at a level somewhat below the level of the charge in the coking chambers.

Flow through each flue may be regulated by a slide brick or damper brick 25 removable on ledge 26 (Figure 1) on the sides of the flues to vary the extent of the passage connecting the vertical flues 22 with the horizontal flue 24. Each slide brick 25 may be advanced more or less over the passage connecting the flue 22 with the horizontal flue 24 through access flues 27 which extend from the top of the vertical flues. The base of each flue is provided with a burner for supplying coke oven gas thereto; along the heating wall the flues 22 are provided with alternately low

and high burners 28, 29 respectively. Fuel gas such as coke oven gas is supplied to the flues 22 from a supply main 30 which, through a series of pipes 31, communicates with a series of headers 32, one for each heating wall, supplying gas to gas conduits 33 leading to the high and low burners 28, 29.

The regenerators of the battery are located beneath the coking chambers except the end regenerators shown in Figure 2, and extend crosswise of the battery parallel to the coking chambers 13 between the supporting walls 14. In lengthwise vertical planes of the battery disposed approximately one-quarter the distance of the width of the battery from each side of the battery, vertical partitions 34 are positioned running the full length of the battery and dividing the crosswise-extending regenerators into three regenerator units, identified by reference characters 35, 36 and 37. These partitions divide each crosswise regenerator system and communicably connected groups of flues into two sets of inflow and outflow regenerators and flues, one set being constituted of outer regenerators 35 and 37 and the communicably connected outer groups of flues, while the other set is constituted of inner regenerator 36 and the inner group of flues communicating therewith.

Lengthwise of the battery, each regenerator communicates with the heating flues on opposite sides of the coking chamber thereabove, through a large sole flue 38 and connecting channels 39, 40, as clearly appears from Figure 2. All the outer regenerators 35 and 37, lengthwise of the battery, during one period of operation of the battery operate for inflow into the outer groups of flues connected therewith, products of combustion passing down through the interior groups of flues into the inner regenerators 36, which operate for outflow. Upon reversal, the inner regenerators 36 along the length of the battery operate for inflow into the inner groups of flues communicating therewith, while the products of combustion pass down through the outer groups of flues into the regenerators 35 and 37, which operate for outflow. Thus, crosswise of the battery the outer regenerators 35 and 37 alternately operate for inflow and outflow, while the inner regenerators 36 operate for outflow and inflow, and longitudinally of the battery the regenerator units in longitudinal alignment are all in the same phase.

If it is desired to operate the battery by burning an extraneously derived gas such as producer gas or blast furnace gas in the flues, such gas may be supplied to alternate regenerators longitudinally of the battery, while the remaining regenerators longitudinally of the battery are used to preheat the air necessary for combustion of the gas in the flues. When operating with fuel gas, such as coke oven gas, fed directly to the flues, all the inflow regenerators are preferably used to preheat the air fed to the flues.

Each regenerator is a chamber provided with brickwork, commonly called "checkerbrick." In the base of each crosswise-extending regenerator is a short partition wall 41 parallel to the supporting walls 14 providing two bus flues 42, 43 for each crosswise-extending regenerator system. The bus flue 42, as clearly appears from Figure 1, communicates with the outer regenerator units 35 and 37; it does not communicate with the inner regenerator 36, and hence this bus flue is hereinafter referred to as the outer bus flue. The

bus flue 43 communicates with only the inner regenerator unit 36 and hence it is referred to as the inner bus flue.

As above indicated, a pair of bus flues 42, 43 is provided for each regenerator system extending crosswise of the battery. Each bus flue of each regenerator system communicates with a chimney flue or main waste heat flue 44 at one side of the battery by means of a valve-controlled passageway 45. Each such passageway, as well known in the art, is provided with a valve-controlled air port 46 for supplying air to the bus flues and a valve 47 which in open position places the bus flue in communication with the stack and in closed position prevents such communication. Valves 46 and 47 may be operated automatically, as by means of any well known type of reversing mechanism actuating chain 48, so that air valve 46 associated with the inner bus flue of each regenerator system is opened and valve 47 associated therewith closed to cause flow of air to take place into the inner bus flue, while simultaneously closing communication between the outer bus flue and the atmosphere, and placing the outer bus flue in communication with the chimney flue, and upon reversal, the air valve associated with the inner bus flue is closed and valve 47 associated therewith opened, and the air valve associated with the outer bus flues opened and valves 47 associated therewith closed. As the design and operation of such valve mechanism is well known in the art, no further description thereof is considered necessary.

Describing now in greater detail the bus flue and ports connecting the bus flues with the regenerators, with reference to Figures 4, 5 and 6, as above indicated, Figure 5 shows an enlarged section through that portion of an inner bus flue which communicates with regenerator unit 36. Figure 4 shows a section of that portion of the outer bus flue which communicates with regenerator unit 35, and Figure 6 shows a section through the portion of the outer bus flue which communicates with regenerator unit 37. The ports 48 connecting the bus flue with the regenerator thereabove extend through the top wall 49 of the bus flue and are of gradually diverging configuration, viewed from the tops of the ports, as shown in Figures 7 to 16 inclusive, the angle of divergence of the ports not exceeding 30°. By "angle of divergence" is meant the angle formed by the side walls of the port when extended to intersect.

When flow takes place through the bus flue then at substantially right angles through the gradually diverging ports having an angle of divergence not exceeding 30°, such as those shown in Figures 7 and 8, into the regenerator thereabove, i. e. during upflow or inflow, the pressure loss of each individual stream flowing through a port is approximately equal to the velocity pressure at the exit from the port into the regenerator. This pressure loss or velocity pressure is independent of the size of the base opening of the port. On the other hand, when the flow is in the opposite direction, i. e., outflow of products of combustion from the regenerator into the bus flue, through which flow takes place at right angles to the direction of flow through the regenerator, the pressure loss is approximately equal to the velocity head at the base opening of the port, and this pressure loss or velocity head at the base opening is substantially independent of the size of the top opening of the port. Accordingly, by choosing ports having the required

size and configuration of base and top openings, the upflow resistance through successive ports will progressively increase in accordance with the progressive increase in static pressure in the bus flue; and, independently of upflow, the downflow resistance through successive ports will progressively increase in accordance with the progressive increase in static draft in the bus flue. The size and configuration of the ports can be designed to maintain uniform distribution of both upflow and downflow through the regenerator or, should it be so desired, to maintain upflow through the regenerator along any desired predetermined distributional pattern and to maintain downflow through the regenerator along the same or any other desired predetermined distributional pattern. Thus, where the same resistance to flow in both directions is encountered, the base and top openings are made of the same size and shape, that is to say, the ports are of uniform cross-sectional area from top to bottom. Where it is desired to compensate for changes in velocity head and friction loss, during upflow, and such losses, plus injector effect, during the downflow, the ports are arranged so that along the length of the bus flue from the inlet to the terminal end thereof the base openings are of gradually increasing cross-sectional area and the top openings are of gradually decreasing cross-sectional area.

Figures 4 to 6 inclusive show an arrangement of ports in the bus flues of a coke oven battery such as hereinabove described, involving inner and outer bus flues communicating with one and the same chimney flue. This arrangement of ports has been found to be highly satisfactory for the type of coke oven battery shown in the drawings involving feed of air to the regenerators and withdrawal of products of combustion from the regenerators at one and the same side of the battery and having bus flues each having a cross-sectional area of 177 square inches. It will be noted from Figure 4 that the ports in the outer bus flue 42 are arranged in five groups, lettered A, B, C, D and E respectively, each group of each bus flue having two rows of ports (see Figure 2), only one such row appearing in the sections of Figures 4, 5 and 6. Two rows of ports are used in the design shown in the drawings because this structure is built up of brick shapes each having a pair of ports therein; a brick shape having two small holes will be found to be more durable than one having a single larger opening. The diameter of the top opening 52 of the ports of group A is 2" and the diameter of the bottom openings is 1 $\frac{7}{8}$ "; the diameter of the top openings of the ports of group B is 2" and the diameter of the bottom openings is 1 $\frac{1}{2}$ "; the diameter of the top openings of ports of group C is 2" and the diameter of the bottom openings is 1 $\frac{3}{4}$ "; the ports of group D are of uniform cross-sectional area throughout, having a diameter of 1 $\frac{3}{4}$ "; and the diameter of the top openings of the ports of group E is 1 $\frac{3}{4}$ " and of the bottom openings is 2". The ports in the outer bus flue 42 shown in Figure 6 are arranged in two groups, lettered F and G respectively. The diameter of the top openings of the ports in group F is 1 $\frac{1}{2}$ " and the diameter of the bottom openings is 1 $\frac{3}{4}$ "; the diameter of the top openings of the ports of group G is 1 $\frac{1}{2}$ " and the diameter of the bottom openings is 1 $\frac{3}{4}$ ". Each inner bus flue 43 has the ports arranged in seven groups, lettered H, I, J, K, L, M and N respectively. The diameter

of the top openings of the ports of group H is 2" and the diameter of the bottom openings is 1 1/8"; the diameter of the top openings of the ports of group I is 1 3/4" and the diameter of the bottom openings is 1 3/8"; the diameter of the top openings of the ports of group J is 1 3/4" and the diameter of the bottom openings is 1 7/8"; the diameter of the top openings of the ports of group K is 1 5/8" and the diameter of the bottom openings is 1 1/2"; the diameter of the top openings of the ports of group L is 1 5/8" and the diameter of the bottom openings is 1 5/8"; i. e., they are of uniform cross-sectional area throughout; the diameter of the top openings of the ports of group M is 1 1/2" and the diameter of the bottom openings is 1 3/4"; and the diameter of the top openings of the ports of group N is 1 1/2" and the diameter of the bottom openings is 2".

It will be noted from Figures 4, 5 and 6 that in both inner and outer bus flues the arrangement of ports is such that the top openings of the ports having the greatest diameter are disposed toward the inlet end of the bus flue, the top openings of smallest diameter are disposed at the inner or terminal end of the bus flue, and the intermediate ports are arranged in groups having top openings of gradually decreasing diameter from the inlet to the terminal end of the bus flue, thus compensating for the pressure variations which occur, as appears from the up-flow curve appearing on Figure 17, and which, as above indicated, shows the pressure variations in the inner bus flue; like pressure variations occur in the outer bus flue. Similarly, the bottom openings of the ports are arranged in the inner and outer bus flues with the openings at the terminal end of the bus flue of largest diameter, and those at the exit end of the bus flue, referring to the exit end during the outflow period, of smallest diameter, with the intervening ports from the terminal end of the flue to the exit end arranged so that they are of gradually decreasing diameter, thus compensating for the variations in draft which occur during the down-flow period.

The ports of group D and L, Figures 4 and 5, which are of uniform cross-sectional area throughout, occur intermediate the ends of the bus flue corresponding to the area of the curves represented by the reference character 53 of Figure 17. It will be noted that at the locality of the bus flue identified by the reference character 53, where the downflow and upflow curves intersect, the pressure loss during both upflow and downflow are the same. Hence, ports having uniform cross-sectional area, the opening of which, however, is properly proportioned to compensate for pressure losses, should be employed in this locality of the bus flue, and it is for this reason the ports of group D and L are of uniform cross-sectional area.

In the bus flue designed in accordance with applicant's invention the pressure variations in the bus flue are fully compensated; in other words, the flow through the several ports in each bus flue, both upflow and downflow, is the same, and the pressures existing above the ports are uniform on both upflow and downflow, resulting in uniform flow through the regenerator.

Figures 7 and 8 disclose a preferred form of port having diverging side walls 50, a substantially circular base opening 51 and top opening 52. As clearly appears from Figure 8, the inlet and outlet portions of the port are shaped so as

to give a streamline flow of fluid into the port and discharge of fluid therefrom.

Instead of a series of nozzles or ports, designed as shown in Figures 7 and 8, gradually diverging nozzles or ports such as shown in Figures 9 to 16 inclusive may be employed. The nozzles of Figures 9 and 10 differ from that of Figures 7 and 8 chiefly in that the ends thereof are not streamlined but extend at substantially right angles to the top and bottom walls of the port, as indicated by reference character 54. This form of port is considered not as well proportioned as that of Figures 7 and 8; however, for some purposes it may be found satisfactory. Figures 11 and 12 show another form of port which is of substantially elliptical shape, in horizontal cross-section, and gradually converges upwardly (diverges downwardly) from a larger elliptical streamlined base opening 55 to a smaller elliptical streamlined top opening 56. Figures 13 and 14 show still another modified form of port which is rectangular in cross-section, converging from a substantially square base opening 57 to a substantially smaller top opening 58. Figure 15 shows a port which is oblong in cross-section and converges gradually from an oblong base opening 59 to a smaller oblong top opening 60. In every case, the angle of divergence does not exceed 30°.

The invention as hereinabove described is embodied in a particular form of construction, but it may be variously embodied within the scope of the following claims.

Having now described my invention, what I claim as new and desire to secure by Letters Patent is:

1. In a coke oven, a regenerator, containing heat exchange material, for inflow of gaseous medium over said heat exchange material to heat the said medium, and outflow of waste gases after heat contained therein has been absorbed by the heat exchange material, and a bus flue through which said inflow into and outflow from the regenerator takes place, separated from the regenerator by a division wall, said division wall having a plurality of spaced ports therein, said ports having gradually diverging side walls connecting top and bottom openings in said wall defining the said ports, said top openings of said spaced ports being of predetermined different cross-sectional areas and the bottom openings of said spaced ports also being of predetermined different cross-sectional areas, the variation in cross-sectional areas of the top opening differing from the said variation in the cross-sectional areas of the bottom openings to compensate for different pressure conditions in the said bus flue during the inflow and outflow periods of operation.

2. A regenerator, containing heat exchange material, for inflow of gaseous medium over said heat exchange material to heat the said medium, and outflow of waste gases after heat contained therein has been absorbed by the heat exchange material, a bus flue through which said inflow into and outflow from said regenerator takes place, and a plurality of calibrated gradually diverging ports connecting the bus flue with the regenerator, each of said ports having a pair of openings through which flow takes place, one of said openings serving as an inlet to the port during the inflow period, and an outlet from the port during the outflow period, and the other of said openings serving as an inlet to the port during the outflow period and an outlet from the port

during the inflow period, the first-mentioned openings of said ports varying in cross-sectional area and the second-mentioned openings of said ports varying in cross-sectional area, the variation in cross-sectional area of the first-mentioned openings differing from the variation in cross-sectional area of the second-mentioned openings to compensate for different pressure conditions in the said bus flue during the inflow and outflow periods of operation.

3. A regenerator, containing heat exchange material, for inflow of gaseous medium over said heat exchange material to heat the said medium, and outflow of waste gases after heat contained therein has been absorbed by the heat exchange material, a bus flue through which said inflow into and outflow from said regenerator takes place separated from said regenerator by a division wall, said division wall having a plurality of spaced calibrated ports therein connecting the bus flue with said regenerator, said ports each having top and bottom openings connected by gradually diverging side walls, said top openings varying in cross-sectional area from the inlet to the terminal end of the bus flue, with the opening of largest cross-sectional area at the inlet end of said bus flue, and the bottom openings also varying in cross-sectional area from the inlet to the terminal end of the bus flue, the variation in cross-sectional area of the bottom openings differing from the variation in cross-sectional area of the top openings to compensate for different pressure conditions in the said bus flue during the inflow and outflow periods of operation.

4. In a coke oven, a regenerator, containing heat exchange material, for inflow of gaseous medium over said heat exchange material to heat the said medium, and outflow of waste gases after heat contained therein has been absorbed by the heat exchange material, a bus flue through which said inflow into and outflow from said regenerator takes place, separated from said regenerator by a division wall, and ports extending vertically in spaced relation through said division wall to provide right angle connections between said bus flue and said regenerator, said ports each having gradually diverging side walls connecting the bottom opening of the port with the top opening, said top openings of the ports varying in cross-sectional area from the inlet to the terminal end of the bus flue, with the opening of largest cross-sectional area at the inlet end of said bus flue, and the bottom openings also varying in cross-sectional area from the inlet to the terminal end of the bus flue, the variation in cross-sectional area of the top openings differing from the variation in cross-sectional area of the bottom openings to compensate for different pressure conditions in said bus flue during the inflow and outflow periods of operation.

5. In a coke oven, a regenerator, containing heat exchange material, for inflow of gaseous medium from one end of said regenerator over said heat exchange material, to heat the said medium, and outflow of waste gases after heat contained therein has been absorbed by the heat exchange material, at the same end as the gaseous medium enters during the inflow period, and a bus flue disposed in the base portion of the regenerator substantially the full length thereof through which said inflow into and outflow from said regenerator takes place, said bus flue being separated from the regenerator by a wall having a plurality of ports extending therethrough to provide a right angle connection between the

regenerator and the bus flue, said ports being defined by gradually diverging walls connecting the base opening in said wall with the top opening therein, said base openings being of varying cross-sectional area with the openings of smallest cross-sectional area at the inlet end of said bus flue and the openings of largest cross-sectional area at the terminal end of said bus flue, the said top openings also varying in cross-sectional area and being arranged with the openings of largest cross-sectional area disposed near the inlet end of the bus flue and the openings of smallest cross-sectional area disposed near the terminal end of said bus flue.

6. A regenerative coke oven battery constituted of heating walls and coking chambers arranged side by side, crosswise-extending regenerators disposed beneath the coking chambers, each regenerator communicating with the heating flues in the heating wall thereabove, a single chimney flue disposed at the side of the battery, each regenerator being provided in the base portion thereof with a bus flue for supplying gaseous medium to be preheated to the regenerator and through which waste gases produced in the heating flues pass from the regenerator to the single chimney flue, each of said bus flues being separated from the regenerator thereabove by a wall having a plurality of ports extending therethrough to provide a right angle connection between the regenerator and the bus flue, said ports being defined by gradually diverging walls connecting the base opening in said wall with the top opening therein, said base openings being of different cross-sectional areas with the openings of smallest cross-sectional area at the inlet end of said bus flue and the openings of largest cross-sectional area at the terminal end of said bus flue, the said top openings being also of different cross-sectional areas and being arranged so that the openings of largest cross-sectional area are disposed near the inlet ends of the bus flue and the openings of smallest cross-sectional area are disposed near the terminal ends of said bus flue.

7. A regenerative coke oven battery constituted of heating walls and coking chambers arranged side by side, each heating wall containing vertical flues arranged in two outer groups of consecutively operated flues and an inner group of consecutively operated flues, the outer groups of flues being communicably connected to the inner group of flues for upflow through the outer groups of flues and downflow through the inner group of flues, and, upon reversal, for upflow through the inner group of flues and downflow through the outer groups of flues, a crosswise-extending regenerator disposed beneath each coking chamber divided into two outer regenerator units and an inner regenerator unit, the outer regenerator units of each regenerator being connected with the outer groups of flues of a heating wall and the inner regenerator unit being connected with the inner group of flues of said heating wall, means for supplying air to the regenerators from one side only of the battery, a single chimney flue disposed at the side of the battery at which air is supplied to the battery for withdrawing products of combustion from the battery, and an inner and outer bus flue, each running the full width of the battery, at the base of each regenerator, the inner bus flue communicating only with the inner regenerator unit and the outer bus flue communicating only with the outer regenerator units, both of

said bus flues leading into the chimney flue, for alternately discharging products of combustion thereinto, and said bus flues being arranged to alternately receive air from said air supply means, each of said bus flues being separated from the regenerator unit thereabove by a wall having a plurality of ports each connecting a bottom opening in said wall with a top opening and certain of said ports having gradually diverging side walls, said ports in the inner bus flues being arranged with the bottom openings of smallest cross-sectional area disposed at the chimney flue end of the bus flue and the openings of largest cross-sectional area at the end of said bus flue remote from said chimney flue, with the intervening bottom openings of gradually increasing cross-sectional area, the said top openings of the said ports being also of different cross-sectional areas and arranged so that the openings of largest cross-sectional area are disposed at the chimney flue end of the bus flue and the openings of smallest cross-sectional area are disposed at the end of said bus flue remote from the chimney flue, and with the intervening top openings of

gradually decreasing cross-sectional area, and the outer bus flue having such ports connecting it with the outer regenerator units, the said ports having the bottom openings of gradually increasing cross-sectional area with the bottom opening of smallest cross-sectional area at the chimney flue end of said bus flue, and having the top openings of gradually decreasing cross-sectional area with the top opening of largest cross-sectional area at the chimney flue end of said bus flue, whereby substantially uniform flow of air and products of combustion takes place through the regenerators.

8. A coke oven regenerator as defined in claim 1 in which the angle of divergence of the side walls of the ports does not exceed 30°.

9. A regenerator as defined in claim 3 in which the angle of divergence of the side walls of the ports does not exceed 30°.

10. A coke oven regenerator as defined in claim 4 in which the angle of divergence of the side walls of the ports does not exceed 30°.

GEORGE A. DAVIS.