

Jan. 17, 1939.

J. E. BRINCKERHOFF ET AL

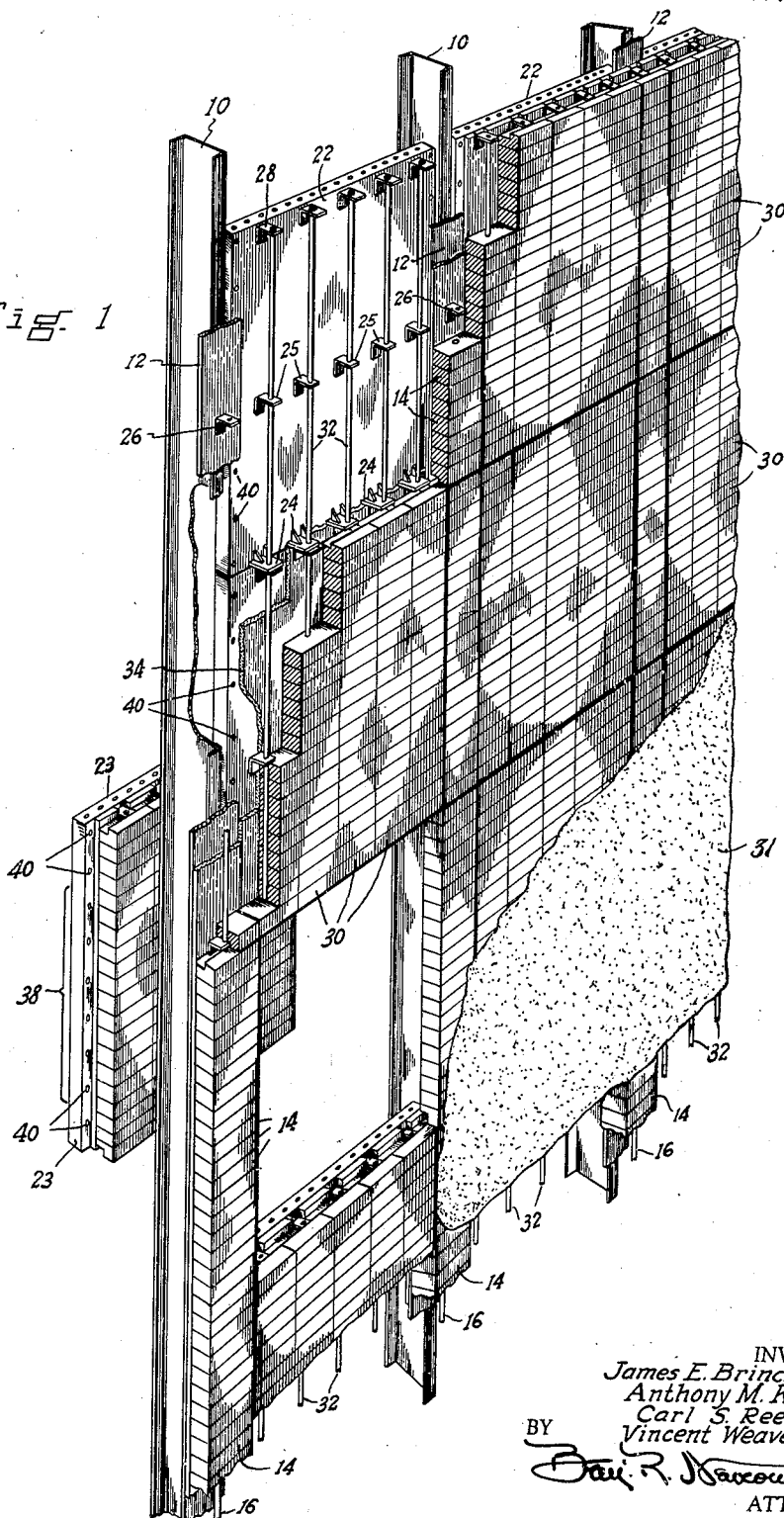
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PANEL WALL CONSTRUCTION

Filed May 14, 1935

9 Sheets-Sheet 1

Fig. 1



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9 Sheets-Sheet 2

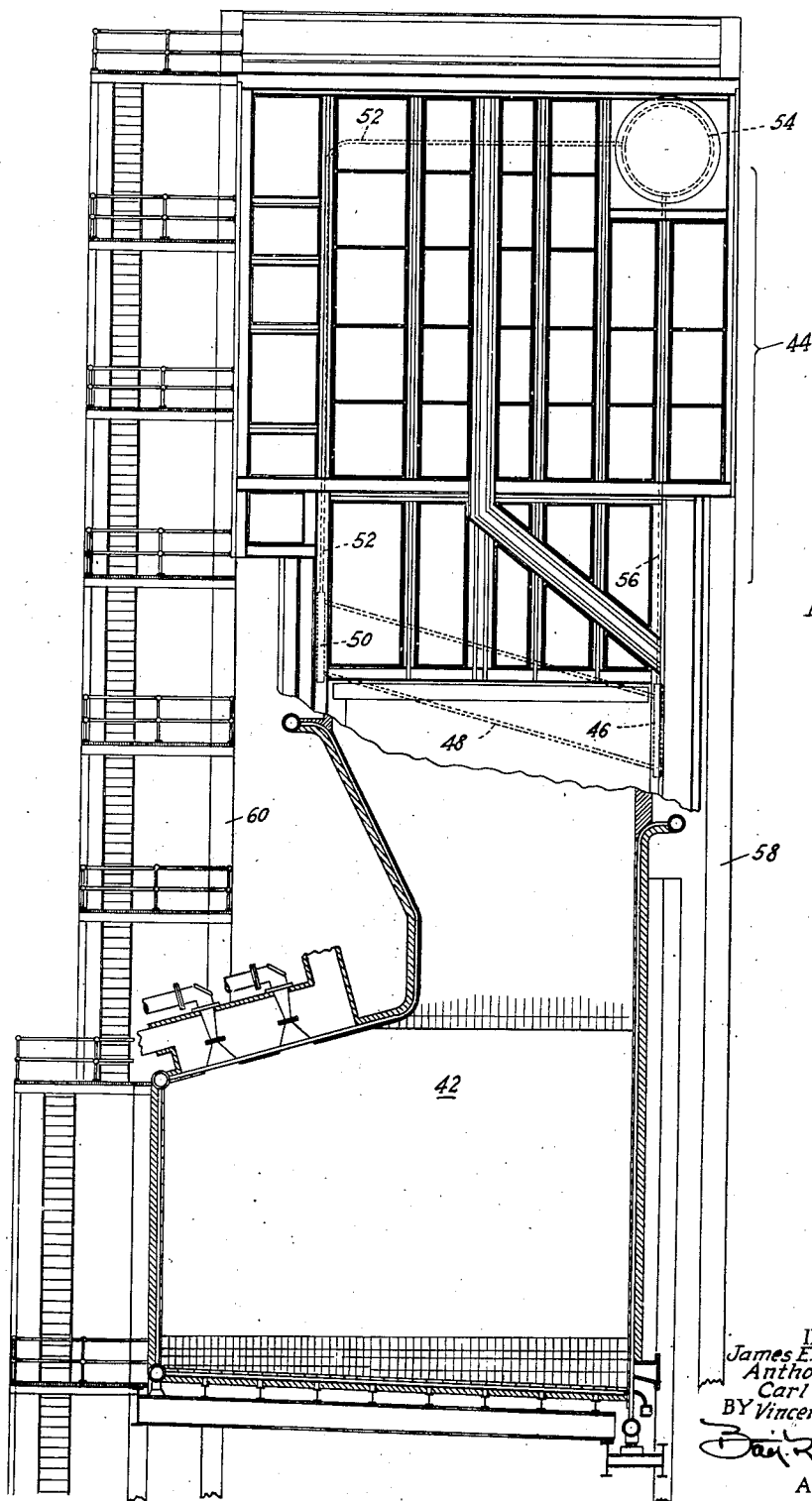


Fig. 2

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PANEL WALL CONSTRUCTION

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Fig. 6

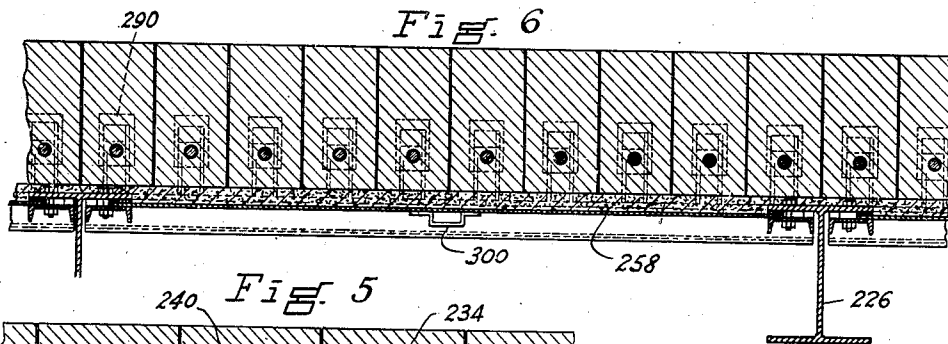


Fig. 5

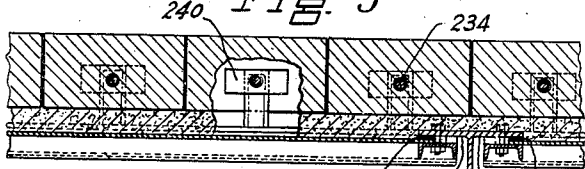


Fig. 4

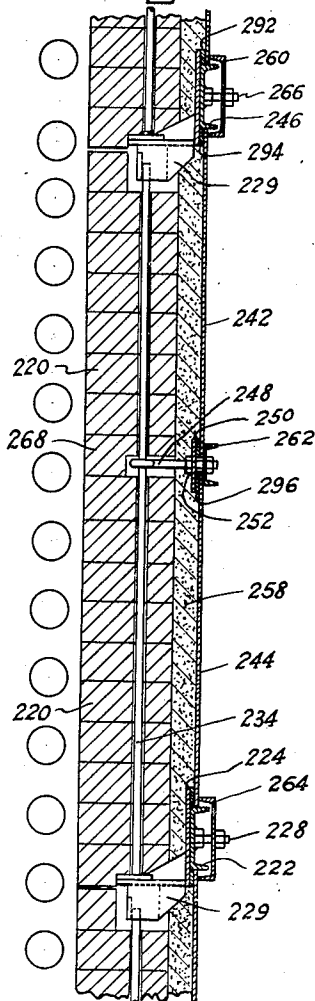
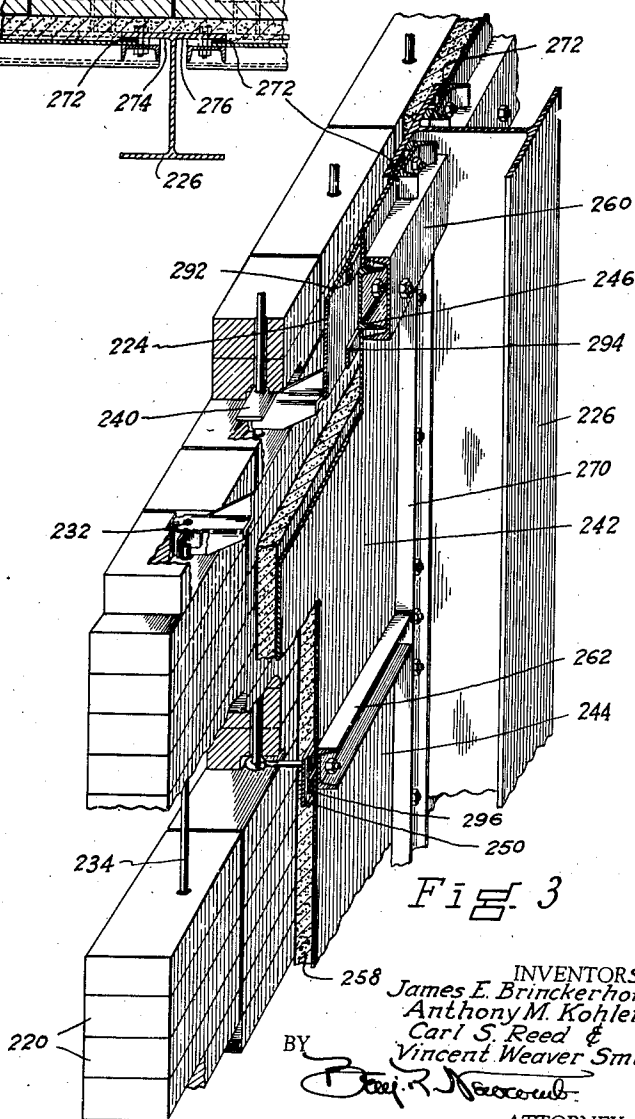


Fig. 3

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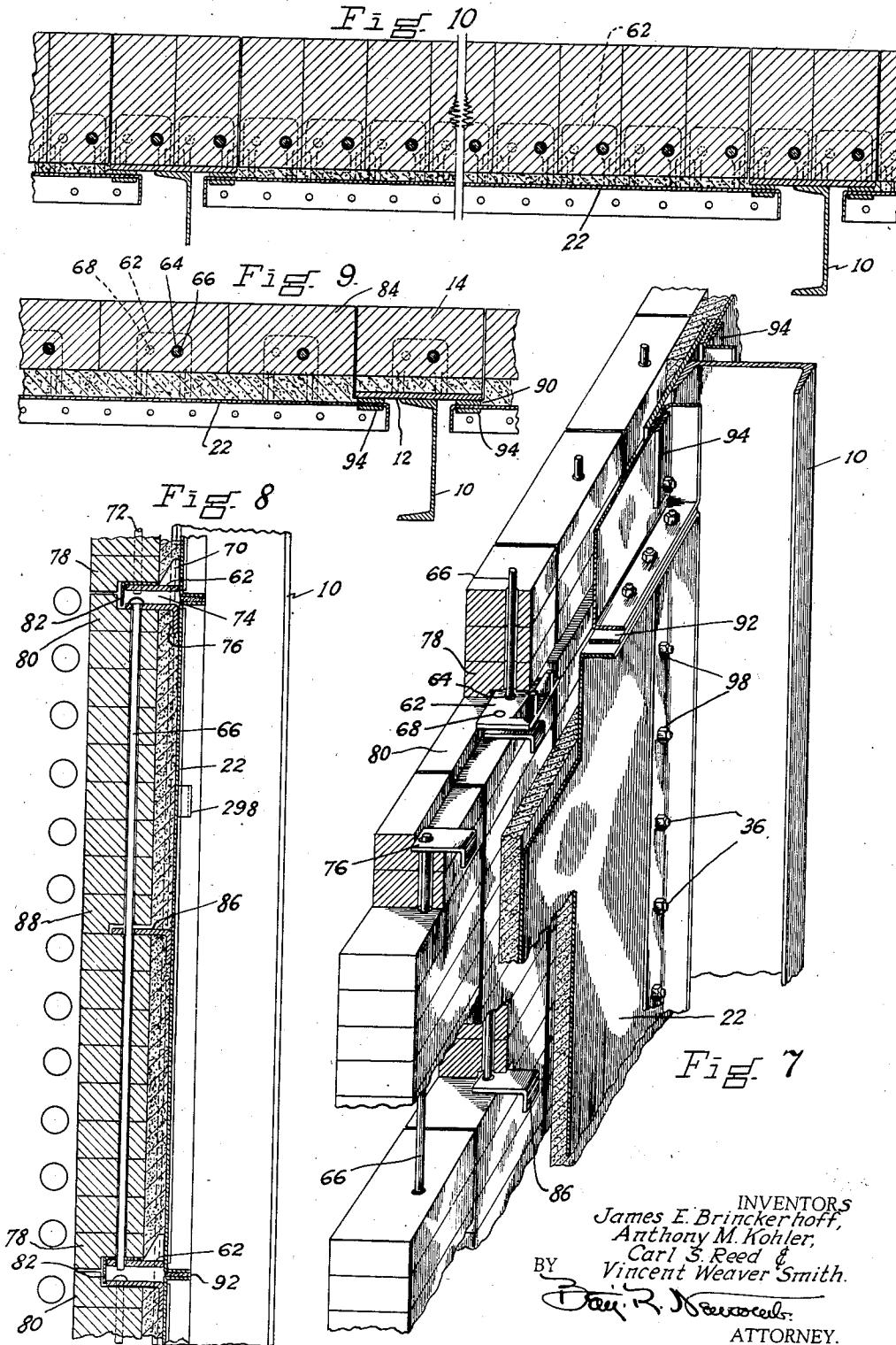
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Fig. 11

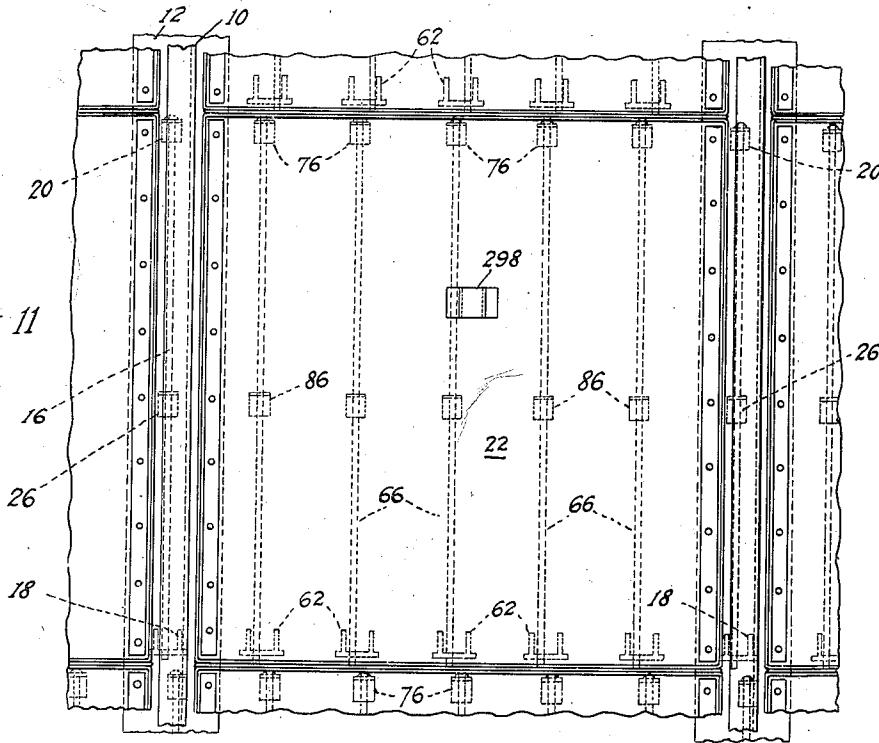
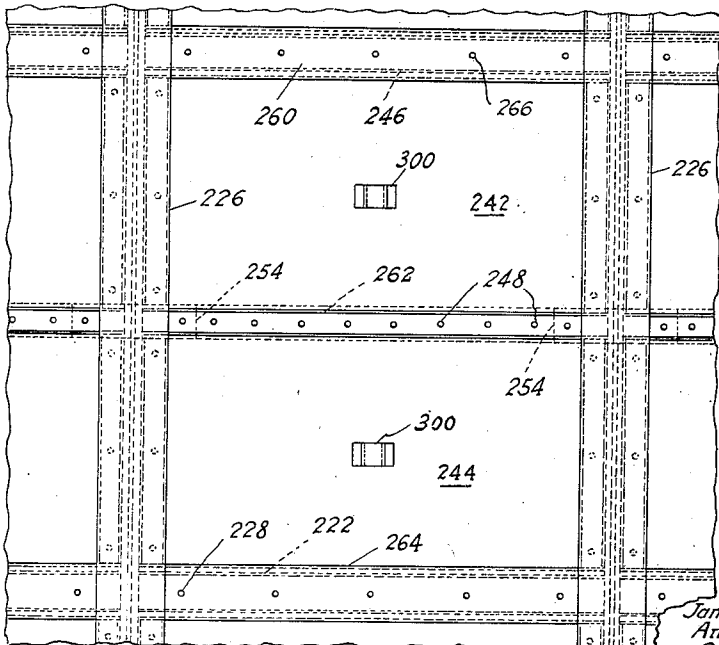


Fig. 12

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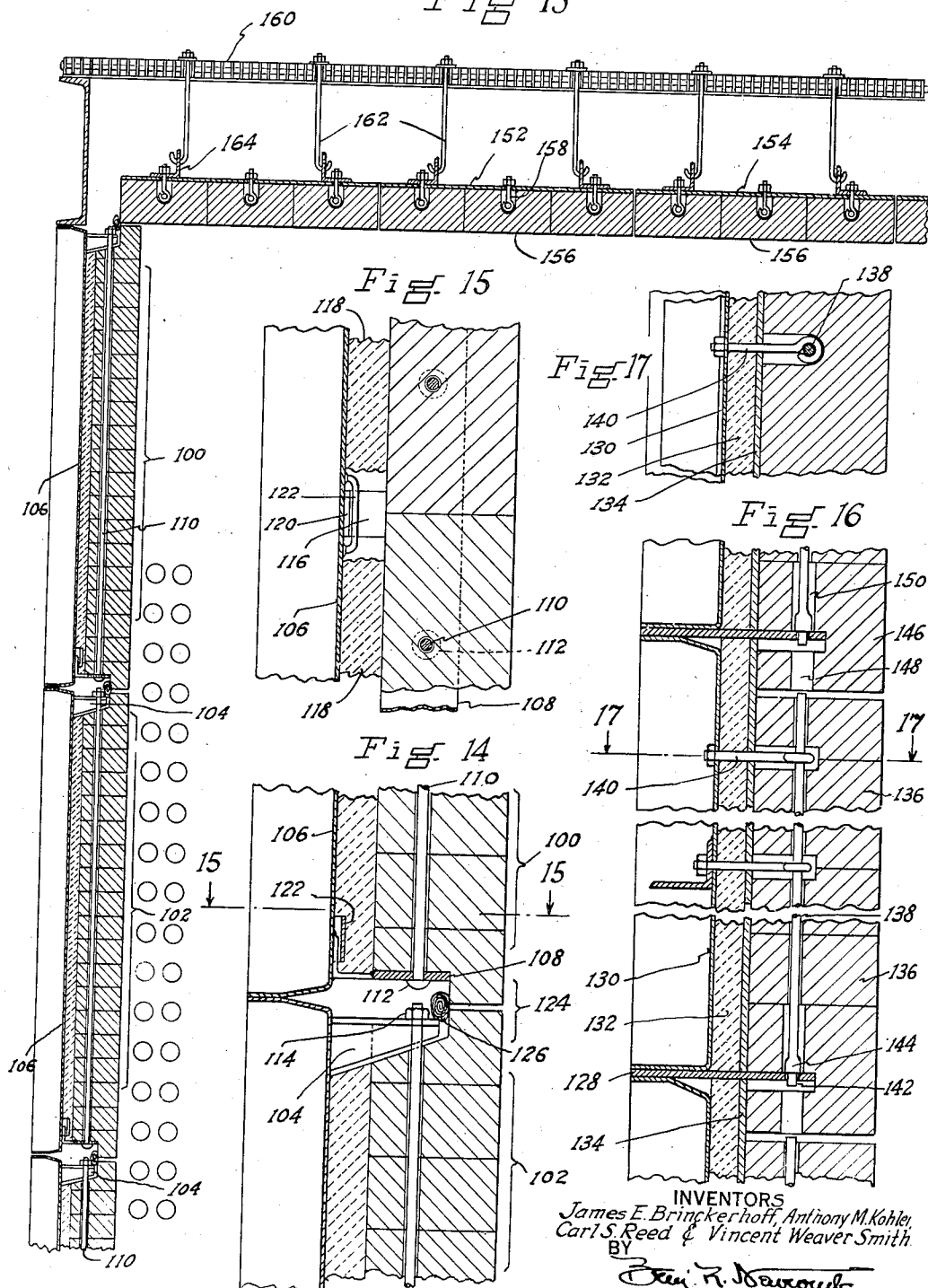
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PANEL WALL CONSTRUCTION

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Fig 13



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PANEL WALL CONSTRUCTION

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Fig. 18

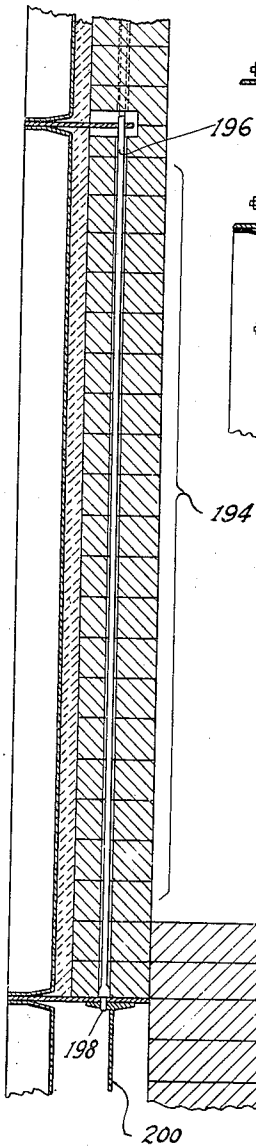


Fig. 19

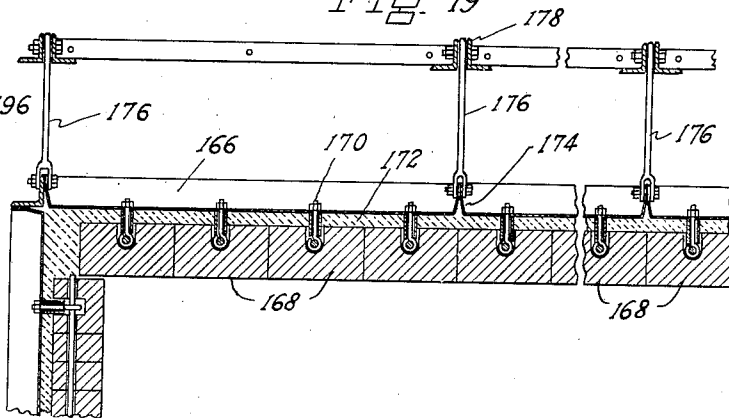


Fig. 20

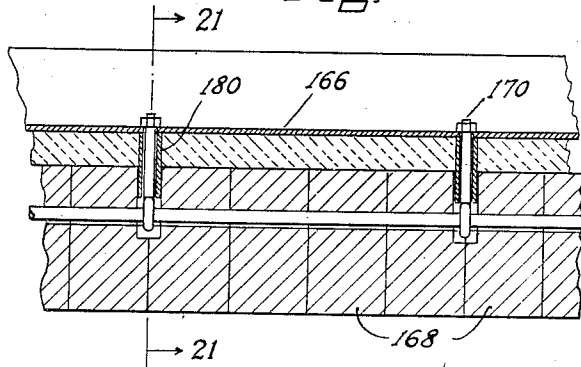


Fig. 21

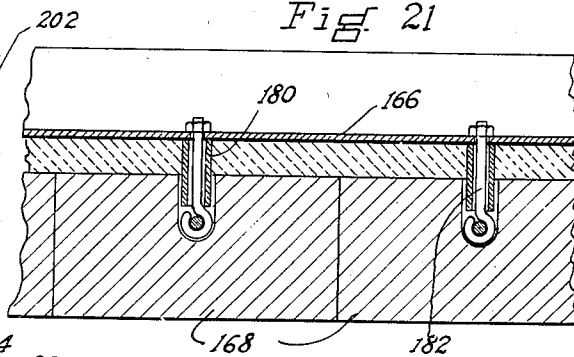
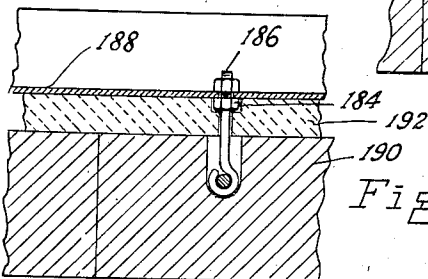


Fig. 30

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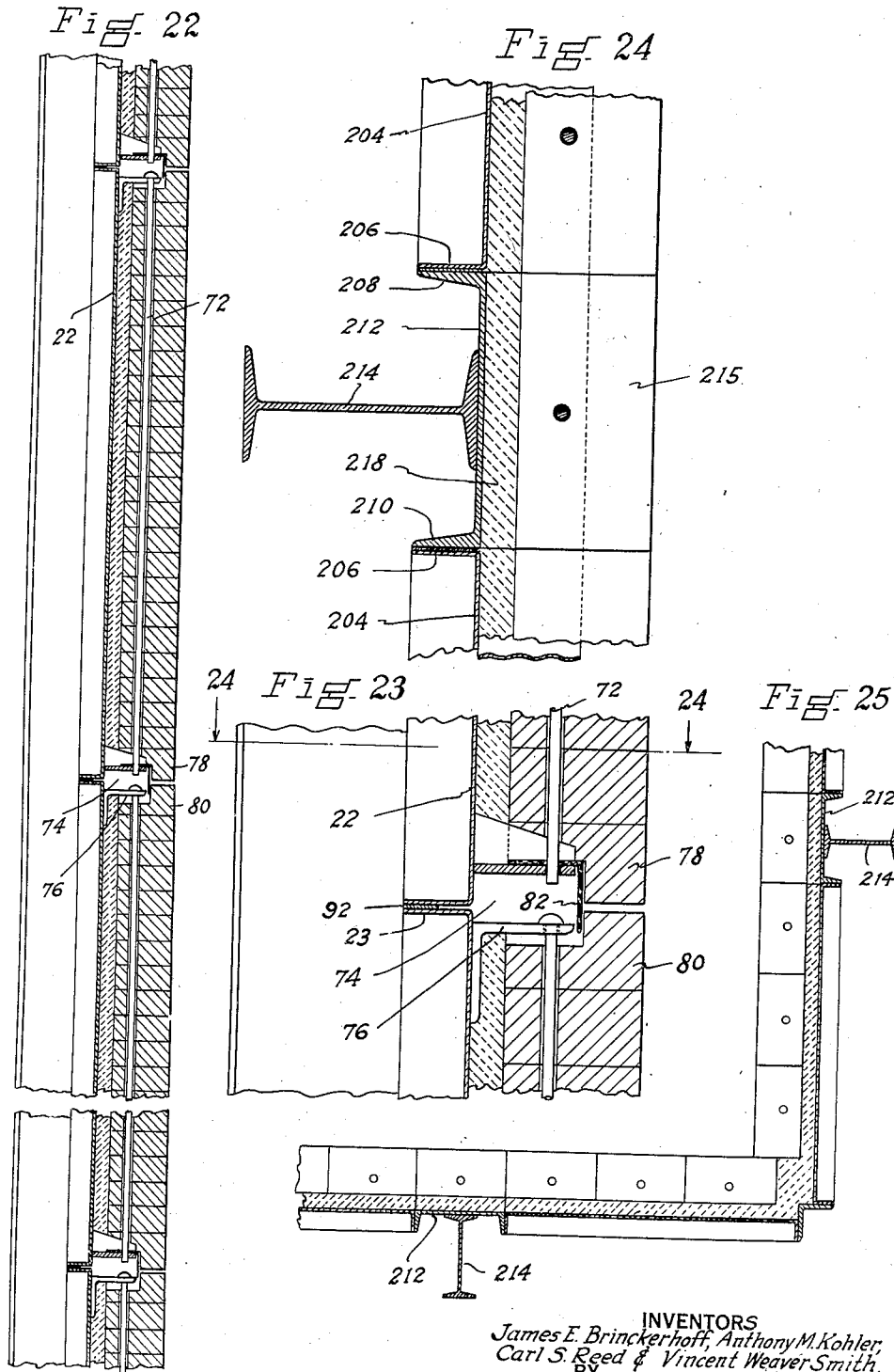
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PANEL WALL CONSTRUCTION

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9 Sheets-Sheet 8



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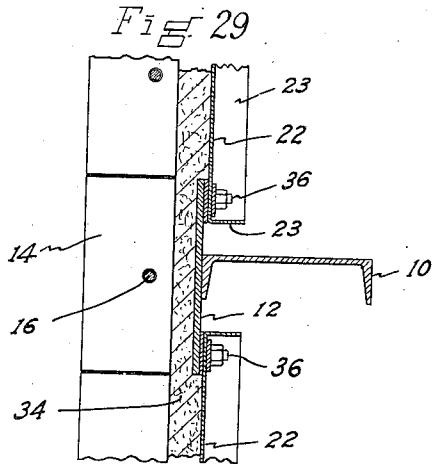
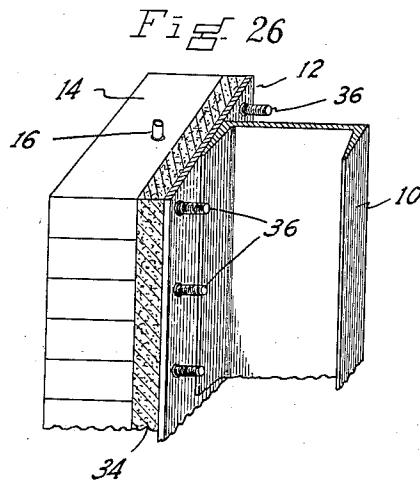
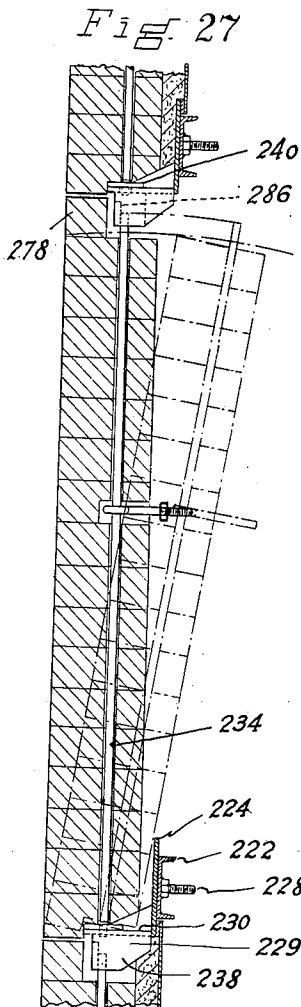
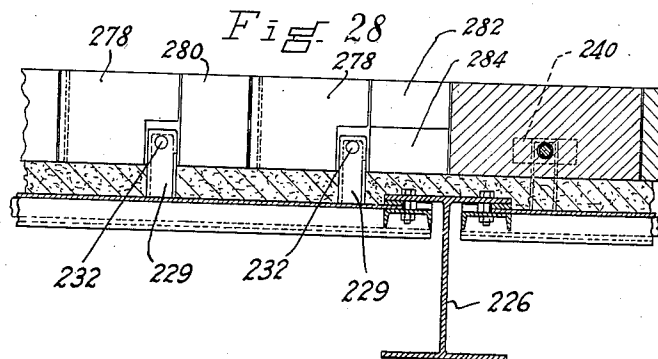
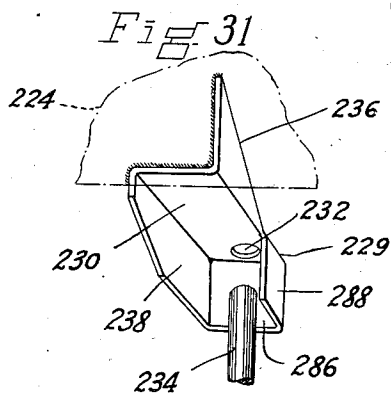
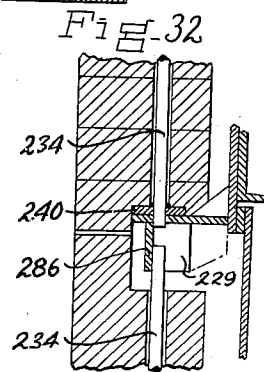
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PANEL WALL CONSTRUCTION

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9 Sheets-Sheet 9



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UNITED STATES PATENT OFFICE

2,144,598

PANEL WALL CONSTRUCTION

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Application May 14, 1935, Serial No. 21,406

10 Claims. (Cl. 110—1)

This invention relates to furnaces and other refractory faced constructions exposed to high temperatures. It is exemplified herein as a thin, lightweight, air tight encasement for steam boilers.

It is an object of the invention to provide a sectional refractory faced encasement including independently replaceable panel sections having an exceptionally low coefficient of thermal conductivity relative to its weight. The insulating firebrick used in these sections are lightweight refractories having the ability to withstand furnace conditions at high temperatures with low heat conductivity.

It is a further object of the invention to promote power supply economies by providing a furnace encasement construction which is especially advantageous for the upper sections of generating station boilers which are of great height.

Not only does the invention promote the dependability of power generation by reducing boiler "outage", but installation and repair costs are also substantially reduced thereby. The time necessary to make repairs is also materially reduced.

In the construction of modern central station power units, of which the Potomac Electric Power Company's latest unit is an example, efficiency and economy considerations have led to furnace and boiler structures of great wall expanse and of considerable height. In many cases heavy pressure parts of the boilers are located at distances from 75 to 100' above the station floors. In order to attain high efficiencies, high steam pressures and high combustion rates are involved. To effect the high combustion rates means are employed for inducing high drafts. In order that such means may be effective the present invention provides a boiler and furnace encasement which is airtight. The induced draft will not be lost by leakage. Because of the lightweight of the illustrative encasement units they may be handled with facility at the high elevations of the upper parts of power plants. This characteristic also eliminates a considerable portion of original installation cost which would be involved in connection with boiler encasements employing standard firebrick and the many heavy castings and consequent heavier supporting steel of prior art structures.

Among other objects of the invention are: the provision of a boiler and furnace encasement having independently replaceable and removable panel units interfitting with the steel framework and adjacent units in airtight relationship and

including a refractory brick lining, insulation, and sheet metal outer closure combined in a rigid unit; the provision of a sectional panel encasement combination in which separate columns of bricks in a panel may be removed separately after the removal of the sheet metal casing section, and; the provision of furnace encasement panel elements adapted by a change in their spacing to form parts of a 9" or a 4½" refractory wall when firebrick of standard dimensions are employed.

Other objects of the invention will appear as the accompanying description proceeds.

The invention will be described with reference to the accompanying drawings in which illustrative embodiments of the invention are indicated.

In the drawings:

Fig. 1 is a perspective view showing a section of the boiler wall.

Fig. 2 illustrates the upper part of the encasement wall in side elevation, the lower part of the structure showing the furnace in vertical cross section.

Fig. 3 is a broken away perspective view of one embodiment of the invention.

Fig. 4 is a vertical sectional view of the embodiment illustrated in Fig. 3.

Fig. 5 is a partial horizontal section showing the Fig. 3 embodiment and including a 4½" refractory wall.

Fig. 6 is a horizontal section of the Fig. 3 embodiment showing the insulating firebrick arranged to form a 9" refractory wall.

Fig. 7 is a broken away perspective view of another embodiment of the invention.

Fig. 8 is a vertical section of the Fig. 7 embodiment.

Fig. 9 is a horizontal section of the Fig. 7 embodiment when its parts are arranged to form a 4½" refractory wall.

Fig. 10 is a horizontal section of a 9" refractory wall constructed in accordance with the Fig. 7 embodiment.

Fig. 11 is a partial side elevation of the embodiment indicated in Figs. 7 and 8.

Fig. 12 is a partial side elevation of the embodiment illustrated in Figs. 3 and 4.

Fig. 13 is a vertical section through a furnace wall and a furnace arch embodying additional features of the invention.

Fig. 14 is a partial enlarged sectional section of a part of the wall structure indicated in Fig. 13.

Fig. 15 is a small horizontal section taken upon the line 15—15 of Fig. 14.

Fig. 16 is a vertical section of another embodiment of the invention.

Fig. 17 is a partial horizontal section on the line 17—17 of Fig. 16.

5 Fig. 18 is a vertical section showing a bottom supported wall panel structure.

Fig. 19 is a vertical section taken at the upper corner of a furnace structure and showing a suspended arch in which means are provided for permitting the anchor rods to be tightly secured against the sheet metal panels without fracturing the bricks.

Fig. 20 is an enlarged detail of the suspended arch shown in Fig. 19.

15 Fig. 21 is a vertical section taken upon the line 21—21 of Fig. 20.

Fig. 22 is a vertical section of a panel wall furnace construction having means for sealing the expansion joints between the panels.

20 Fig. 23 is a vertical section showing the expansion joint construction of the Fig. 22 embodiment on an enlarged scale.

Fig. 24 is a partial horizontal section taken on the line 24—24 of Fig. 23 and showing the relation of the buckstay steel to adjacent panels.

25 Fig. 25 is a horizontal section through a corner of a boiler and furnace encasement showing the relative arrangement of the panels and the buckstay steel.

30 Fig. 26 is a partial perspective view showing the arrangement of elements in the column construction of the Fig. 1 furnace.

Fig. 27 is a vertical sectional view illustrating the manner in which the refractory sub-units are independently removed from the sectional panel wall construction.

Fig. 28 is a partial horizontal section of the Fig 3 wall taken at a level just above the tops of the upper ends of the upright anchor rods.

40 Fig. 29 is a detail of the Fig. 26 column construction, illustrating in a horizontal section the relationship of the panels to the column construction.

Fig. 30 is a partial section of another embodiment. This figure represents furnace constructions in which a panel encasement wall may be employed in connection with rods which are passed through openings in the tile 190. Breakage of the tile by excessive force exerted by the tension member 36 is prevented by reason of the stop 184.

Fig. 31 is a perspective view of the tier bracket. Figure 32 is an enlarged transverse vertical section through a part of the wall structure indicated in Figure 27 of the drawings. This figure shows a section through bracket 229 and indicates the extension of the brick aligning member 234 through an opening in the bracket.

The efficiency of furnaces including the illustrative insulating firebrick refractories in the panel furnace constructions shown in the drawings is increased (with reference to furnaces using solid firebrick) by the reduction of radiation losses. This is due to their very low heat transmission. When they are used in certain types of furnaces which are in intermittent operation, as is the case in heat-treating furnaces, the efficiency is also increased by reason of the fact that only a small amount of heat is necessary to bring the walls up to operating temperature. The latter figure is about 6% of the B. t. u.'s required to similarly heat to the same temperature a furnace of equal wall area and equal radiant heat loss built of solid firebrick.

75 A panel wall construction similar to that shown

in Fig. 9 or in Fig. 5 of the drawings with a $4\frac{1}{2}$ " brick thickness will have a heat flow of 350 B. t. u. per square foot per hour with a hot face temperature of 1800 deg. Fahr., or less than half of an 18" solid firebrick wall in which the heat flow is about 720 B. t. u. per square foot per hour.

Considering wall constructions such as those indicated in Figs. 6 and 10 as having insulating firebrick weighing about 40 lbs. per cubic foot, the outside casing temperature of the panel with 9" brick thickness and with a hot face temperature of 2000 deg. Fahr. will be approximately the same as that of a $13\frac{1}{2}$ " solid firebrick wall with 2" of insulation.

The separate ceramic refractories which constitute the inner parts of the furnace constructions described herein are of lightweight. They are porous to a certain extent and their thermal conductivity is of such an order that there may be a temperature in excess of 2000 deg. Fahr. at their furnace ends while the temperature at their opposite ends when the bricks are considered the long way is not above 100 deg. Fahr., the heat conductivity of the bricks being only 25 to 40% of standard heavy refractories where their weight is only $\frac{1}{3}$ that of the heavy refractories. Their weight may vary from $\frac{1}{2}$ to $\frac{1}{6}$ the weight of standard heavy ceramic firebricks.

In connection with the above advantages it is interesting to note a comparison in the weights of the panel wall constructions shown in the drawings when compared to walls using solid, or standard firebrick. The weight of a panel consisting of 9" of the illustrative brick, $\frac{1}{4}$ " mill-board casing, and buckstays, (referring to such a structure as that shown in Fig. 10) is approximately 45 lbs. per square foot. Referring to such a construction as that shown in Fig. 9, the weight of the panel with $4\frac{1}{2}$ " of the illustrative brick, $1\frac{1}{2}$ " of block insulation, casing and buckstays is approximately 35 lbs. per square foot. These weights are in marked contrast with an 18" firebrick wall, or with a conventional type sectional firebrick wall of standard firebrick with 9" of firebrick, 4" of insulation, casing and castings. Such a wall weighs about 130 lbs. per square foot. This comparison shows a saving of 95 lbs. per square foot of wall area. This amounts to a saving in weight of over 40 tons in one side 30' section of a boiler encasement. Assuming that the section 44 of the installation indicated in Fig. 2 is of such dimensions there will be a saving in weight of approximately 80 tons deadweight. From this it will be appreciated that the cost of the entire installation will be materially decreased.

These large savings in weight and the consequent greater savings in installation costs resulting from use of the illustrative constructions are possible only with the use of refractories having low heat conductivity and lightweight, together with such other properties that they may be readily machined, drilled or sawed. This is impossible with the standard refractory firebrick, and by reason of these properties very lightweight steelwork may be used in the wall construction. This steelwork receives adequate protection with a relatively small thickness of refractory in front of it, by reason of the low heat conductivity of the illustrative insulating firebrick. The protection against damage afforded thereby prevents the steelwork and the supporting structure from attaining weakening temperatures. By reason of

the above described properties of the illustrative insulating firebrick, it is possible to build a dry assembled wall because the bricks can be made so uniform by sawing and grinding that they present a substantially complete furnace face with no wide joints between the courses of brick or the bricks themselves. Such perfect fitting of the bricks is impossible with standard firebrick.

The manufacture of the illustrative refractories and the materials from which they are made are such that they constitute a building structure in which there are small uniformly distributed voids of the same order of magnitude. The extent of the voids is indicated by the fact that they may constitute up to 80% of the volume of the individual refractories. Also, the rigidity of the refractories, and their resistance to crushing stresses are sufficient to permit them to be arranged in bottom supported columns, the height of which corresponds generally to the heights of the illustrative panels.

In general, the drawings show two types of the panel construction for furnace. The first type is what will be called herein a an integral panel construction. In this type the entire panel structure, or wall section, may be manufactured as a unit in the factory or at some location apart from the actual site of the furnace. Such units may be shipped as separate articles to the site at which the furnace is to be erected and separately handled and placed in position. This type is shown in Fig. 1 of the drawings. Figs. 7, 8, 11, 14, 15, 16, 17 and 19 also show different modifications of this type.

The second, or sectional panel construction is indicated in Figs. 3 and 4 of the drawings. In this type the refractories are carried by supporting steelwork which is independent of the panels or casing plates. Upon removal of the casing and the insulation, the separate refractory tiers in the panel area may be removed separately.

In both types of illustrative panel furnace constructions the sections consist of porous insulating firebrick backed by insulating material and a steel casing member. In either case, the wall sections are arranged between and supported by vertical columns. These are shown in Fig. 1 as the upright channels 10. Together with the upright plates 12 they constitute the columns of the supporting framework of the furnace. These plates are fixedly secured tightly against the inner flanges of the column in the embodiment indicated in Figs. 1 and 9 of the drawings. In these figures, as well as in Fig. 7, the plates are shown as extending considerably beyond the columns at either side. It is to these extensions that the wall sections are secured.

As indicated in Fig. 1 and more clearly in Fig. 9 of the drawings, the plates 12 are protected by the insulation 34 constituting a backing for the insulating firebrick 14 which have a length corresponding to the width of the plates. These refractories are held in position by reason of the fact that they are threaded upon restraining rods 16 which pass through brackets 18 welded to the plates. Near the top of each wall section these rods pass through clips 28 which are also welded to the plates. Similar but centrally positioned clips 26 are indicated in Fig. 11 of the drawings.

Between adjacent plates 12 and between adjacent columns, integral panel sections 22 are arranged. They preferably consist of sheet steel plates which have flanges 23 around their marginal portions. Along the lower edge of each steel panel, foot brackets 24 are welded to the

panels. They are spaced in a manner corresponding to the length or width of the refractory elements to be supported thereby, depending upon the arrangement of those elements. Above each bracket 24 there is a clip 25 which is in alignment with an upper clip 28. Both clips are preferably welded to the steel panel.

After the clips are welded to the steel panel the refractory elements 30 are placed in position. Thereafter a restraining rod 32 may be threaded through aligning openings in each set of clips, the refractories, and the brackets to hold a tier of the refractories in position. Insulation material 34 in the form of millboard blocks, or in the form of loose asbestos material, may be inserted between the steel panels and the refractory 30.

Fig. 1 shows a part of a furnace wall with the insulation 34 and one of the columns 10 broken away in the interest of clarity. Many of the insulating firebrick 30 are also omitted in order that the steelwork and the panels 22 may be more clearly shown. This view clearly indicates the construction of the columns and the means for holding the firebrick thereon. This means includes the plates 12 and the anchor rods 25 which maintain the column bricks 14 in position.

Fig. 1 also clearly indicates the panels 22 as having the outwardly extending flanges 23 around all sides. When the panels are in their operative positions the horizontal flanges of adjacent panels between the said pair of columns are bolted together, copper covered asbestos gaskets being interposed.

Along the upright marginal portions of the panels apertures 40 are provided for the reception of screw threaded panel aligning studs 36. They are fixed to the plates 12 so as to extend outwardly therefrom. This detail of the furnace structure is clearly indicated in Fig. 26 of the drawings.

After one of the main wall units, such as the unit 38 of the Fig. 1 disclosure, is elevated to approximate alignment with the wall opening which is to receive it the unit is moved toward the wall so that the studs 36 are received within the apertures 40 along the upright margins of the unit. The unit is thus aligned with the opening so that it may be brought into operative position without destructive effects upon the gaskets which are arranged along the margins of the unit. This feature of the invention makes for a furnace encasement which is substantially airtight, thereby promoting increased furnace efficiency and permitting a close control of the furnace operation.

Fig. 1 shows the wall section unit 38 about to be placed in an opening within the wall between the first two columns 10 and upper and lower sections which have already been installed. This view may also be taken as indicating the manner in which the wall unit may be removed, for an inspection of the interior of the furnace or the repair or replacement of some of the insulating refractories. Even when the units cover a furnace wall area of approximately 3' x 4' the weight of each unit is such that it can be readily lifted and handled by two workmen. Its weight is of the order of 350 lbs.

Fig. 2 illustrates a steam boiler construction in which the illustrative furnace encasement is employed at a relatively high elevation. The installation here indicated corresponds generally to that of the central station referred to above. It includes a furnace 42 of considerable height. Superposed relative to the furnace is an encase-

ment 44 having the main panel wall units indicated in the drawings by heavy black lines. Such panel units, or sections are shown arranged in upright rows between spaced columns.

5 Within the encasement 44 there are arranged fluid heat exchange devices such as superheater sections, economizer sections, and a steam generating section. The latter includes the upright
10 dowlake headers 46 which are connected by a bank of steam generating tubes 48 to uptake headers 50. The latter are connected by circulators 52 to a steam and water drum 54. From the water space of the latter dowlake tubes 56 lead to the headers 46.

15 In many steam boiler installations similar to that indicated in Fig. 2 the furnaces themselves are located at a considerable distance above the foundation, and when the steam generating sections as well as the economizer and superheater
20 sections are superposed relative to the furnace, the entire installation reaches an elevation which in many cases is of the order of 100' above the foundation. Considering the Fig. 2 installation to be of such height, it will be readily appreciated
25 that the invention involves large decreases in construction costs because of savings in the weight of materials. Eighty tons may be saved merely in the upper part of the installation (such as the encasement 44). Without sacrificing operative
30 advantages, this saving alone is no mean accomplishment, but this is not the only saving. There is also a large saving in the cost of the framework, and particularly in the columns such as those shown at 58 and 60 in Fig. 2. These col-
35 umns support the boiler and its casing.

In the embodiments of the invention indicated in Figs. 7, 8, 9 and 10 of the drawings the tier sustaining brackets 62 are welded to the steel
40 panels or plates 22 so that the general arrangement of these elements is the same as it is in the Fig. 1 embodiment. However, as distinguished from the Fig. 1 embodiment, each bracket is provided with two apertures. One of these is indicated at 64 as receiving the lower end of the anchor rod 66. The other aperture is indicated at
45 68. When these brackets are in vertical alignment on successive panels in the same vertical row the lower end of the rod 66 will be received in the aperture 64, but in the aligned bracket 70 of the wall section immediately above, the anchor rods 72 will be received in the bracket
50 opening corresponding to 68. Thus the rods of vertically successive panels in the same row are offset in the plane of the wall so that expansion of the rods may be taken up with a minimum
55 of expansion joint spaces such as those indicated at 74 in Fig. 8. As shown, these spaces are between the brackets of an upper panel wall unit and the clips 76 of the next lower unit.

60 Fig. 8 shows the lowermost bricks 78 of the upper unit to be upwardly recessed at their rearward portions and the upper bricks 80 of the next lower unit to be downwardly recessed at their rearward portions so as to provide insulating refractory heat protecting wall portions in front of
65 the metal parts in the expansion joint spaces. This heat protection may be supplemented by a firefelt curtain 82 which is shown in Fig. 8 as resting upon the ledge afforded by the bracket 70, and hanging down in front of that bracket and the clip 76.
70

The construction indicated above involves the boring of the bricks at off-center positions to provide apertures for receiving the anchor rods. This
75 will be apparent from an inspection of Fig. 9 of

the drawings. Considering the brick 84 indicated in this figure it will be seen that the aperture for the anchor rod is toward the right of the center of the brick. When the brackets 62 on successive wall panel units in the same vertical row are in upright alignment and the bricks immediately below the brick 84 are in upright alignment therewith these lower bricks are reversed with reference to the brick 84 so that the brick apertures will be in alignment with the bracket aperture 68.

Fig. 10 shows a 9" refractory lined wall in which the same brackets 62 are used. For this wall the brackets need only be arranged with a closer spacing across the panels. The anchor rod receiving apertures must, of course, be bored at different positions in the bricks of this wall, but these bricks may still be all bored uniformly. The bricks of the wall section below that indicated in Fig. 10 need merely be reversed to bring the anchor rods in offset positions at the joints between the units. It will thus be seen that each main panel wall section has fixed thereto a number of independently supported tiers of insulating firebrick. This permits the replacement of bricks in any one tier without disturbing the bricks of any other tier in the same panel. Likewise the column bricks 14 may be removed or replaced when access is provided thereto by the detachment and removal of one of the wall units.

When the main panel units of the wall are large, intermediate restraining clips 86 may be employed along the central parts of the panels, as clearly indicated in Figs. 7 and 8. They are received within recesses in some of the intermediate refractories 88 and are preferably welded to the panels.

Figs. 7, 8 and 9 indicate the column gaskets 90 and the inter-panel gaskets 92 which may be of copper covered asbestos construction. In order that the column gaskets may be compressed uniformly batten strips 94 are used. They uniformly distribute the pressure applied when the nuts 98 are tightened upon the panel aligning studs 36 to bind the wall parts in airtight relationship.

In the furnace wall shown in Figs. 13, 14 and 15, the panel wall units 100 and 102 have their tiers of refractory elements supported from brackets 104 which are preferably welded to the steel plates or panels 106. At the base of each panel wall unit there may be separate supports for the tiers, but in this instance there is shown a single bar 108 which extends across a plurality of tiers and acts as a bottom support. The anchor rods 110 pass through apertures in the insulating firebrick. They are secured at their tops to the brackets 104 and their lower ends act as direct supports for the bars 108, thus forming top hung supports for brick tiers in an integral panel construction in which the bricks expand upwardly while the anchor rods or hanger elements expand downwardly. In this way the two expansions tend to compensate each other, materially minimizing the problem of providing an airtight furnace encasement which will remain tight over wide ranges of furnace temperatures.

In the present instance rods 110 are threaded through holes in the bars 108 and are provided with heads 112 which engage the lower surfaces of the bars. When a plurality of bars 108 is provided, each tier of bricks may be separately removed by unbolting the supporting panel and removing the nut 114 from the top of the hanger rod for that tier.

Each bar 108 may be provided with devices at

the lower portions of the panels for preventing movement of the tiers away from the panels while permitting independent up and down movements of the tiers resulting from expansion and contraction. Such devices may include slip brackets 116 rigid with the bar and extending through the insulation 118. As shown, they are provided alongside the inner surface of the metal panel 108 with lugs 120 which are freely movable through expansion clips 122 fixed to the casing plate or panel.

The expansion joint construction of the Fig. 13 wall is well illustrated in Fig. 14. Here the tiers of the panel 102 are free to move upwardly for a limited distance and the refractories of the panel 100 may move downwardly by reason of the slip bracket construction just described. At the expansion joint 124, recessed bricks similar to those described with reference to the Fig. 8 construction are provided. Excessive heating of the brick supporting metal back of these recessed bricks at the expansion joint is prevented by compressible heat insulating means such as the roll of asbestos 126.

The wall construction indicated in Figs. 16 and 17 includes supports 128 between which there are secured the casing panels 130. The supports extend inwardly of the panels through the insulation layer 132 and the insulation layer 134 to positions intermediate the front and rear faces of the firebrick wall. This wall includes the refractories 136 strung upon upright anchor rods 138 which are engaged by eye-bolts 140 holding the insulation, the refractories, and the panels in a rigid compact structure. The rods 138 have reduced dowel-like ends 142 extending through apertures in the supports 128. Further downward movement of the rods through these apertures is prevented by reason of the engagement of shoulders upon the rods with the supports. In the present instance these shoulders are increased through the intermediacy of enlarged rod portions 144.

The supports 128 of the Fig. 16 wall are protected by means of specially formed refractories 146. They are recessed to receive the inner ends of the supports so that the latter will be protected on all sides from direct exposure to the heat of the furnace. Each of these special bricks 146 is also provided with a bore 148 which will permit the upper end of the rod of the next lower section to be moved upwardly so that the tiers of bricks may be released from interlocking engagement with the supports. The bores 150 in the upper parts of these specially formed bricks permit the enlarged rod portions 144 to move upwardly to an extent sufficient to free the extensions 142 from the supports 128. The members 128 may be supported by buckstay columns similar to the columns 10 shown in Fig. 1, and the plate 130 may be bolted to the columns and the members 128. The corresponding members shown in Fig. 18 may be similarly supported.

The furnace arch shown in the upper section of Fig. 13 includes metal casing plates 152 and 154 to which insulating firebricks 156 are secured by means of rod and eye-bolt devices 158 similar to those which have already been described in connection with the wall structures. The separate panels of casing plates and firebricks are supported at distributed positions from open steelwork 160 which is preferably made up of steel grilles similar to those used as subway grating. They not only provide walkways for workmen when the furnace arch is to be cleaned, repaired

or inspected, but they also act as supports which will provide adequate ventilation for cooling the top of the furnace.

In the arch construction shown, hangers 162 depend from the subway grille 160 and are engaged with brackets 164 secured to the panel sections of the arch.

Fig. 19 illustrates an arch construction in which sheet metal panels 166 have the insulating firebrick 168 secured thereto by rod and eye-bolt means 170 which extends through a layer of thermal insulation 172. The sheet metal panels are flanged as indicated at 174 and the panels of adjoining arch sections are secured together at their flanges by means which also secures the hangers 176 thereto. These hangers are fixed at their upper ends to steelwork 178.

When the tiers or courses of the firebrick 168 are tightened against the insulation 172 so as to form a tight compact arch panel structure the firebrick are apt to be broken if excessive pressure is exerted, and this pressure does not have to be so great, because of the fragility of the illustrative insulating firebrick. Such breakage is prevented by means which are illustrated in Figs. 19, 20, 21 and 30. In the Fig. 21 structure the eye-bolts 170 pass through sleeves 180 which abut at one end against the plate 166 and at their other end against the eye portion of the eye-bolt or the anchor rod 182. These sleeves act as stops to limit the pressure which can be applied to the firebrick 168.

In the Fig. 30 modification the stops 184 are threaded upon the eye bolts 186 before the latter are inserted through the openings in the panel 188. The position to which the stop nuts are threaded along eye bolts determine the pressure to be exerted on the firebrick 190 and the insulation 192 as well as the positioning and alignment of the firebricks relative to the panel.

Fig. 18 shows a wall panel structure 194 in which the tiers of firebrick are threaded upon long anchor rods 196 having reduced lower ends 198 passing through openings in the eye-beam 200. The tiers of refractories may be removed by moving the rods 196 upwardly to disengage them from the beam 200. The bottom of a tier may be thereafter moved outwardly after removal of the top bricks of the laterally adjacent wall 202. In this construction there is an adequate support for a high panel wall, all of the refractories being in contact to act as compression supports throughout the vertical extent of the wall.

Figs. 24 and 25 indicate an arrangement of outwardly flanged panels with reference to column constructions which provide panel recesses having surfaces normal to the furnace wall and tightly receiving the outer surfaces of the panels. Fig. 24, for instance, shows the panel plates 204 having right angle flanges 206 tightly received against the flanges 208 and 210 of the channel 212 which is secured to the column 214. With this construction the joints between the columns and the main panel units are of greater depth. In considering this construction in the present manner, the column construction is taken as including the insulating firebricks 215, the length of which is the same as the width of the channel 212. The thermal insulation 218 is also included as a part of the column construction which is disposed between adjacent main wall panel units. The plates indicated in Figures 13, 16, 18, 19, and 24 may be secured together in the manner indicated in Fig. 7 of the drawings.

Sectional panel construction

Figs. 3, 4, 5, 27 and 28 relate to a sectional panel construction in which the insulating firebricks are not carried by the casing plates. They are carried by supporting steelwork so that, after the separate casing plates are detached and the intermediate insulation is removed, each brick tier in a panel unit can be independently removed for the purpose of inspection or repairs. Referring particularly to Figs. 4 and 27 the insulating firebricks 220 are carried in separate tiers, the weight of the tiers being borne by panel structures which include the channel sections 222. These sections are rigid with plates 224 extending between the steelwork columns 226 and fixed thereto at the ends of the beams. As shown, the webs of the channel sections are in contact with the plates 224 and this structure is unified by welding. Stud bolts 228 have their heads welded to the webs of the channel sections, as shown.

Extending inwardly of each composite beam including a channel section 222 and a plate 224 and preferably welded thereto, are brackets 229 each of which directly takes the load of a brick tier. These brackets have flat portions 230 which are formed with apertures 232 near their inner ends for receiving the anchor rods or brick restraining rods 234. On one side of each bracket there is a flange 236 increasing in height as the casing plate end of the bracket is approached. At the other side of the bracket there is a flange 238 which may also afford at its outer end an increased vertical metallic surface along which the bracket is welded to the plate 224. Both flanges also act together with the intermediate portion 230 to form a structure in the nature of a combination of angle stiffeners for the brackets, besides increasing the area of the weld seam which secures the bracket to the plate 224. The weld seam, as indicated in Fig. 31 is of a Z-shaped outline, and it may be deposited by fusion welding.

Each of the vertical anchor rods 234 is welded near its lower end to a bar 240 which rests upon the flat portion 230 of a bracket 229. Below this bar the rod 234 extends through the bracket in order to prevent any substantial lateral movement of the tier of bricks supported by it while permitting the tier to be tilted as indicated below.

The flat panel casing plates 242 and 244 act as panels fitting between the lower and upper channel sections 222 and 246 respectively, and the intermediate anchor rod restraining eye-bolts 248. These eye-bolts pass through a removable horizontal bar 250 inside the casing. This bar may be backed up by fixed nuts 252 on the eye-bolts. It is preferably bolted at each end to short gusset plates 254 (see Fig. 12) secured to the steel columns 226.

Considering the tiers of bricks of the Fig. 4 structure and the contacting insulation layer 258 to be in the positions shown, and that the casing plates 242 and 244 are held against the insulation, the plates may be then clamped in position by tightening the clamping channels 260, 262 and 264 against the wall. The channels 260 and 264 are placed in position upon the studs 228 and 266 so that they cover the outwardly opening channel sections 246 and 222, whereas the intermediate channel stiffener 262 is positioned upon the eye-bolts 248 and thereafter has its web tightened against the surfaces of the plates 242 and 244 with relatively large bearing surfaces in contact. The manner in which all of these channels will be tightened to secure the casing plates

against the wall will be clear from an inspection of Fig. 4.

As also indicated in Fig. 4 the vertical restraining rods, or anchor rods 234 are threaded through the eye-bolts 248 along the center of the panel height, or at some position or positions intermediate the upper and lower ends of the tiers of bricks. The eye-bolts are received within recesses formed in the insulating firebrick 268. Bowing of the anchor rods is thereby prevented.

Besides the channel sections above described for tightening the casing plates against the wall there are vertical channels 270 which act as batten strips to bind the remaining edges of the casing plates against gaskets 272 interposed relative to the vertical channels and the outwardly facing flanges 274 and 276 of the columns 226.

When it is desired to remove any tier of insulating firebrick from the illustrative sectional panel construction the three horizontal channels 260, 262 and 264 are detached and then the vertical channels 270 are removed. The casing plates 242 and 244 may then be taken from their wall forming positions. Thereafter the insulation layer 258 is taken out. This is easily done when this layer is in the form of millboard sections which are in the nature of long flat slabs or blocks. Thereafter the bar 250 is detached from the gussets 254 and removed. Then any tier of firebrick may be moved, as clearly indicated in Fig. 27. This is accomplished by tilting the upward end of the tier outwardly after the removal of the loose key brick 278, 280 and 282. (See Fig. 28.)

The key brick 280 may be easily pulled outwardly of the furnace because they are not threaded upon the anchor rods 234. When such bricks are removed their complementary bricks 278 may be removed by turning them around the adjacent brackets 229. Similarly all of the key brick may be removed including the sections 282 and 284. After a tier is moved to the dotted line position indicated in Fig. 27 of the drawings it may be lifted bodily away from its supporting bracket 229, the bar 240 and the anchor rod 234 maintaining the tier as a unit while it is being lifted out of its wall forming position.

A reversal of the above operations is involved in the replacing of any individual tier of firebrick. The lower end of the tier is first moved over the top of the plate 224 and is allowed to rest on the bracket 229 with the lower end of its anchor rod extending through the opening 232. The upper end of the tier is then tilted inwardly of the furnace until the upper end of the rod 234 contacts with the stop 286 which is integrally formed as part of the bracket 229. This stop cooperates with the flange 238 and with an opposite downwardly extending flange 288 also preferably formed integrally on the bracket to form a pocket which keeps the rod 234 in its operative alignment and allows it to expand upwardly, room for such upward expansion being indicated in Fig. 27 of the drawings.

In order that each tier of firebrick in the sectional panel wall construction may be adequately supported as a separate sub-unit when it is being removed or replaced with reference to the remaining parts of the wall the bars 240 are arranged lengthwise of the bricks when a $4\frac{1}{2}$ " refractory faced wall is provided after the manner indicated in Fig. 5 of the drawings. When a 9" refractory wall is provided with the ends of the bricks in contact with the insulation 258, as indicated in Fig. 6 of the drawings, wider foot

bars 290 may be welded to the anchor rod 234, or the bars 290 may be employed at positions at right angles to those shown in Fig. 5.

As shown in Figs. 3 and 4 of the drawings, copper covered asbestos gaskets 292 and 294 may be employed between the plates 242 and 244 and the flanges of the channel sections 260. Similar gaskets 296 may be employed between the bars 250 and the other horizontal margins of the plates 242 and 244.

Elevating brackets 298 and 300 (as indicated in Figs. 11 and 12) may be provided to facilitate the removal of the panels and the plate sections when parts of the wall constructions are to be taken out of their operative positions.

In connection with any of the furnace constructions described herein fly-ash erosion of the brick may be minimized by applying a refractory coating to the furnace faces of the brick walls after the furnace is otherwise completed. Such a coating may be applied as a liquid which, when subjected to high furnace temperatures, forms a protective glazed layer over the inner surfaces of the furnace. Such a coating, or layer, is indicated by the numeral 31, in Fig. 1 of the drawings.

What is claimed is:

1. In a panel wall construction for furnaces, casing plates; tiers of firebrick; thermal insulating material between the firebrick and the plates; restraining rods extending through apertures in the firebricks and maintaining them in alignment and readily movable through the firebrick for releasing the tiers from their operative positions; bottom supports located at the lower parts of the panels and having apertures through which the lower ends of the rods extend; and means extending from the plates through the insulation to engage the rods for holding the respective tiers in rigid compact relationship to the plates and holding all of the wall elements together in a rigid compact wall structure.

2. In a furnace wall, means including columns delineating panel areas in the wall, tiltable tiers of refractories including key bricks, and means including steel casing plates affording lateral support for said tiers in groups with each group covering a panel area, said means pressing the plates and tiers of each panel area against a layer of thermal interposed insulation material, the individual tiers of each panel area being separately removable after the removal of the plates and the insulation and their key bricks, said separate removal of the tiers beginning with the tilting of the tops of the tiers outwardly of the furnace.

3. In a sectional panel wall furnace construction, a furnace supporting framework including columns connected by horizontal beams defining wall panel areas, wall panels including a group of tiers of insulating firebrick for each panel area, casing plates spaced outwardly of said tiers, thermal insulating material between the tiers and the plates, means secured to the beams and extending through the insulation to provide bottom supports for said tiers, stops preventing the tops of the tiers from tilting inwardly of the furnace, and means for binding the plates and the tiers against opposite sides of the insulation, said last named means including tiltable structures maintaining the bricks of each tier in vertical alignment.

4. In a steam boiler furnace, buckstay steel-work including columns, steel casing plates secured to the columns, tiers of insulating firebrick spaced inwardly of the plates, a layer of thermal

insulation between the tiers and the plates, means extending through the layer to support the tiers, restraining rods threaded through said means and through apertures in the firebrick, and foot brackets rigid with the rods to sustain the bricks on the rods when the tiers are separately removed or replaced.

5. In a panel furnace construction; identical main wall units, each unit comprising an outer casing plate, tiers of insulating refractories, and interposed thermal insulation held tightly together and constituting the entire wall thickness of a furnace capable of withstanding temperatures in excess of 2000° F. with a minimum of heat loss; a plurality of holding devices for the tiers of each main wall unit, the devices extending from the plate and into the tiers of refractories to hold the plate and the refractories against opposite sides of the insulation; means so combining the refractories of the separate tiers that they constitute separate refractory sub-units which may be separately assembled and handled as self-sustaining component parts of the main units; and inter-engaging supports maintaining the separate sub-units in operative positions as parts of the main units while permitting each sub-unit to move independently of other sub-units of the same main unit.

6. In a furnace wall; independent wall sections each including exterior sheet metal casing plates and independently removable tiers of insulating firebrick secured together to form a rigid compact structure with a layer of insulating material between them; expansion joints at the junctures of upper and lower tiers; and metallic means secured at positions adjacent the junctions of the sections for maintaining the tiers in position; the bottom bricks of an upper section being upwardly recessed at their rearward parts and the top brick structure of an adjoining lower section being co-operatively recessed at their rearward parts to provide for expansion and contraction and for a space in which said means are located.

7. In a furnace construction, metallic panels, means co-acting with the panels to form an airtight furnace encasement, insulating firebrick refractories arranged in courses interiorly of the panels, retaining members extending through the refractories, exterior supports for the refractories, thermal insulating material between the panels and the refractories, anchor means holding the refractories and the panels against the insulation, and stop devices on said anchor means preventing breakage of the refractories by excessive pressure against the insulation.

8. In a furnace, buckstays, composite wall units, means connecting the units to the buckstays, and means connecting adjacent units to form an airtight furnace encasement; each unit combining in a separate structure; an insulating firebrick lining, thermal insulation, and an exterior sheet metal panel with the insulation held in position between the lining and the panel by metallic bonding devices extending from the panel into the lining to directly tie those elements together while permitting relative movements of the firebrick and the associated panel, said firebrick lining formed by independently removable tiers of insulating firebrick.

9. In a furnace construction, an exterior wall structure including sheet metal panels forming parts of a furnace encasement, supports to which said panels are secured in alignment, an inner wall including superposed insulating firebrick

arranged in separate groups individually extending across the wall area covered by a panel, means for so supporting said firebrick groups that they may be removed when a panel is removed
 5 and without disturbing adjacent firebrick groups which have similar relations to adjacent panels, and bonding devices separate from the supporting means and arranged transversely of the inner
 10 said walls together, said bonding devices having their inner ends anchored within the inner wall and their outer ends secured to the panels, said bonding devices also acting to maintain normal
 15 wall relationships while permitting relative movements of the inner and outer walls due to temperature changes.

10. In a furnace construction, an exterior wall structure including sheet metal panels forming parts of a furnace encasement, supports to which
 20 said panels are secured in alignment, an inner wall including superposed insulating firebrick

arranged in separate groups individually extending across the wall area covered by a panel, means for so supporting said firebrick groups that they may be removed when a panel is removed and
 5 without disturbing adjacent firebrick groups which have similar relations to adjacent panels, and bonding devices separate from the supporting means and including bolt-like elements arranged transversely of the inner and outer walls
 10 and operating to directly tie said walls together, said bonding devices having their inner ends anchored within the inner wall and their outer ends secured to the panels, said bonding devices
 15 also maintaining the brick in vertical alignment and acting to maintain normal wall relationships while permitting relative movements of the inner and outer walls due to temperature changes.

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