Aug. 2, 1966 W. W. ROBSON, JR 3,263,655

COAL FIRED FURNACE

Filed Oct. 23, 1963 2 Sheets-Sheet 1

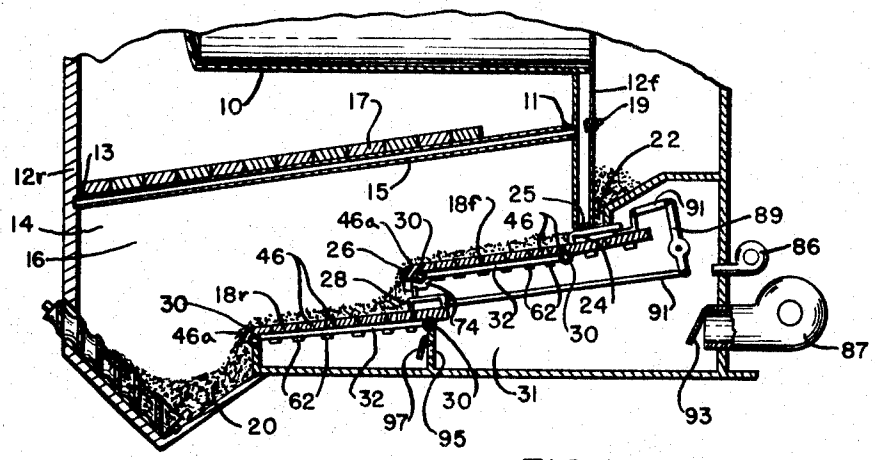


FIG. 1

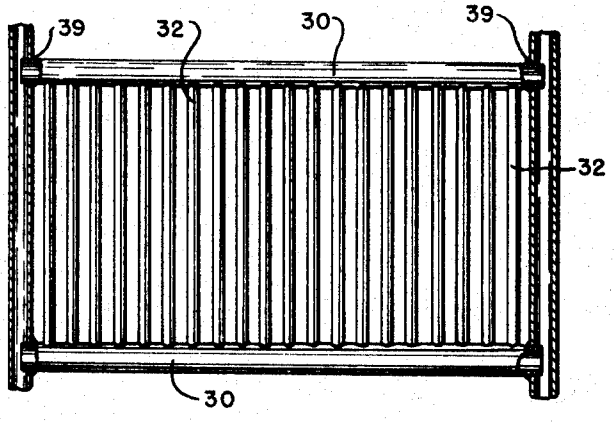


FIG. 2

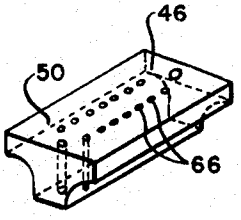


FIG. 5

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COAL FIRED FURNACE

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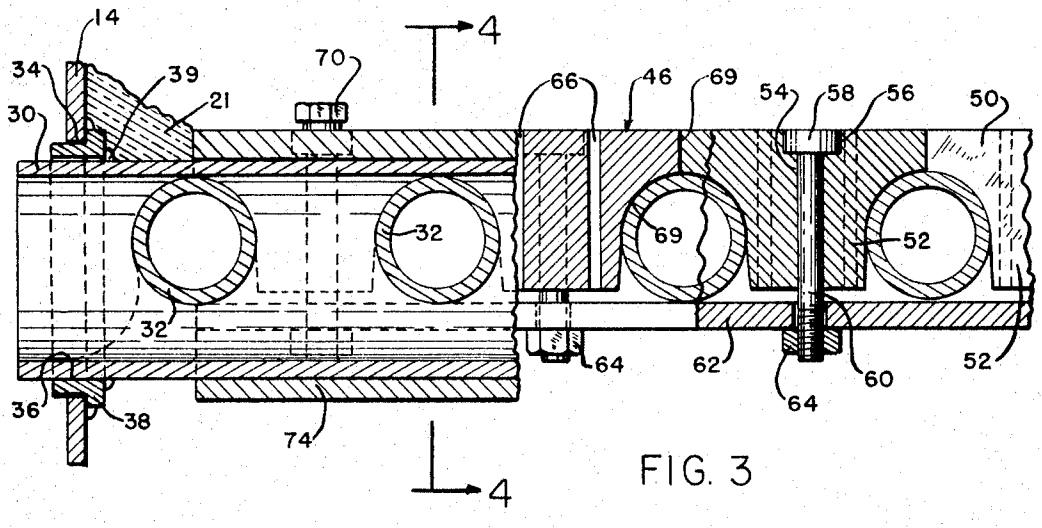


FIG. 3

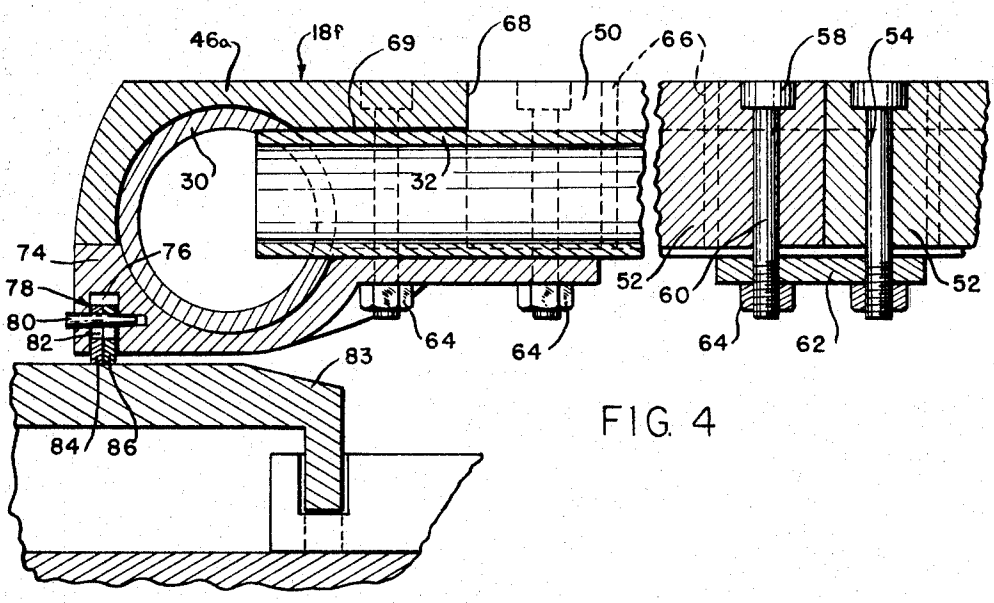


FIG. 4

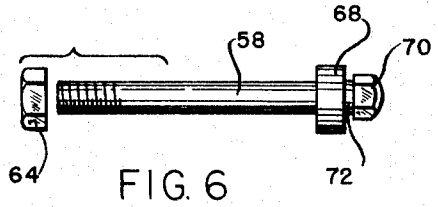


FIG. 6

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COAL FIRED FURNACE

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5 Claims. (Cl. 122—376)

This invention relates generally to furnaces burning hard fuels such as coal to heat water and particularly to improvements in water-cooled stationary grates and furnace walls.

Most coal-fired boiler furnaces have water-cooled walls around the combustion chamber for heat conservation, efficiency, and wall life. Also water-cooled grates have been employed as integrally supported on water jackets set in the combustion chamber and connected by pipes to the boiler. The coal is supported on the grates and supplied with air for burning. Grates employed have taken various forms, many of them traveling or reciprocating to handle the coal, advance the fuel bed and discharge the ash automatically while permitting primary air and secondary air to be supplied thereto, for combustion purposes, preferably under forced draft. However, most of the grates are stationary and are either of a shaker type if the furnace is fed by hand or by a spreader, or are of an inclined bar type down which the coal is advanced by reciprocating pusher blocks.

The grates are generally made of comparatively inexpensive alloyed cast iron and in order to prevent their rapid deterioration, it is highly desirable to cool the grate elements that are in direct contact with the hot coals. Cooling can be acomplished in several ways, and although some cooling is accomplished with the flow of primary air through the grates, this is minor and actually results in greater heat inducement in the coals contacting the grate. However, main cooling can be accomplished either by air with special grates for great fuel economy as described in my co-pending application Serial No. 130,858, or, by water. Preferably the water is circulated from the boiler so that the thermal units of combustion rejected through the grates to the cooling water are conserved for boiler heating.

Water-cooled grates are of particular interest in the present invention and preferably contemplate ladder-like cooling units in which a series of parallel stationary water pipes is inclined lengthwise downwardly from the coal door or feeder to the ash pit. Although one cooling unit generally suffices, two or more can be used arranged in successive steps or stages. Each cooling unit includes header tubes cross connecting the ends of the parallel water pipes as a manifold and supporting them free of any intermediate weight bearing elements that might contact the cooling unit.

Heretofore, the header tubes have in turn been integrated at opposite ends with flat elongated water tanks or jackets sometimes referred to as water walls along with supporting legs and bracers. Tuyeres are then fastened in place and the integrated assembly is then shipped and when received it is slid into the combustion chamber, shored up and connected by pipes to the boiler. Combustion chambers or furnace compartments involve a wide range of shapes and sizes and without any standardizations being established, each integrated assembly has to be made up special for each furnace either as original or replacement equipment and are quite expensive. Replacement orders require months to fill and involve irritating and costly delays.

Although much of this special treatment and handling is excused on the grounds of attaining the greatest efficiency in the space available for economically operating the furnace, such still is not attained to the fullest possible extent. The available furnace space for maximum grate air is materially reduced and either the furnace is designed to be oversized because of this or the "on" cycle becomes lengthened to make up for it for a same furnace rating.

Also installing such a bulky unitized article with adequate clearances in the furance space contributes many difficulties, particularly in close quarters. Moreover, since assembly, shipping, and installation strains accompanying the installation and replacement of a bulky unitized article might cause damage to the assembly and also discrepancies in special dimensions might require some "springing" of the elements to get them to "make-up," all of which is generally experienced with special orders, the assembly is "beefed up" with extra stock and size a great deal more than otherwise required. This is a further burden on the price, the cost of shipping and of labor in handling.

Furthermore, very often the water cooling elements themselves do not require replacement but only tuyeres carried by the pipes and tubes. The tuyeres directly contact the bed of hot coals and conduct primary air to the bed and may deteriorate more in one spot than another. Also, they are clamped in intimate heat exchange contact with the pipes and tubes and any overclamping may damage the pipes while underclamping endangers rapid deterioration of tuyeres for lack of proper cooling.

Accordingly, one of the objects of the present invention is to provide a water-cooled grate unit as an inventoried stock item for wide ranges of furnace sizes, irrespective of shapes, which is simple in construction, which can be cut to a slight oversize on the job and installed with minimum time and expense with conventional tools used by furnace men.

Another object is to provide an improved assembly arrangement for tuyeres which can be properly installed after the cooling unit portion of the grate has been installed, or which can be assembled with the cooling unit on the spot to provide a unitized grate as original or replacement equipment.

A further object of the invention is to provide a clamping device which automatically provides the proper clamping tightness for tuyeres with the use of standard hand wrenches without any protruding elements remaining to be engaged and eroded by the hot coals, yet can be easily removed for replacement of one or more tuyeres at any time.

The invention is characterized by an improved mounting of a water-cooled grate which makes available the entire furnace space as the combustion space. The grate is readily installed with minimum time and expense in fused or welded relationship directly to the water cooling walls of the boiler itself for better water circulation yet can be cut free quickly and easily, removed and replaced without damage to the boiler or any coal handling mechanisms therein.

A further object of the invention is to provide standard lengths of water-cooled grates which can be cut and fitted on the job to any width for installation in any furnace with or without utilization of any special equipment that might be present including extra water walls, coal pushers and wind boxes or plenums.

A further object of the invention resides in a multistep grate arrangement with the primary air plenum sealed in an improved way against movement of air except through the tuyeres.

A further object of the invention is to provide an improved water-cooled grate construction which is inexpensive to make, use and service, easily handled as a standard item for different installations and which is economical of materials and readily handled or assembled with standard tools.

These being among the objects of the invention, other and further objects will be noted from the description to follow taken in conjunction with the accompanying drawings in which:

FIG. 1 is a side elevation of a heating plant partly in section longitudinally through the furnace portion showing the grate and associated devices.

FIG. 2 is a plan view of the pipe and tube assembly portion furnished as a stock item.

FIG. 3 is a vertical cross-sectional view through the furnace at a header tube of the grate with a portion taken a short distance therefrom.

FIG. 4 is a section taken on line 4—4 of FIG. 3.

FIG. 5 is a perspective view of a tuyere assembly prior to their clamped securement.

FIG. 6 is a side elevation of a preferred form of securement means for the tuyeres.

Referring now to FIG. 1, a heating plant comprising a boiler **10** having end walls **12** and side walls **14** defining a furnace space **16** is shown with two partially overlapping water cooled grates **18** embodying the invention. The grates are inclined downwardly and rearwardly towards the ash pit **20**. The upper front grate **18***f* has its upper end in close proximity to the bottom of the coal hopper **22** from which it is fed fresh coal by a spreader device or a pusher block **24** that is made of a U-beam section and reciprocated conventionally in controlled relationship with a leg and a part of the web of the beam section closing the coal opening **25** in its resting position between pushes.

The lower rear end **26** of the front grate **18***f* is spaced above and overlaps the front end of the rear grate **18***r*. Hot coals moving from off the lower end of the front grate drop upon the front end of the rear grate. A second pusher block **28** coordinated with the first and reciprocating in the space between the overlapping ends keeps the coals moving across the face of the rear grate. The resting position of the second pusher block is in retracted position. The resting positions of the pushers between pushes are implemented for the full use and supply of primary air upwardly through the grates to the coals on top thereof without any loss thereof through the pusher openings.

The construction of the cooling units of the grates is shown in FIG. 2 in which water pipe tubes forming cross headers **30** serve as manifolds for a ladder of longitudinally extending water pipes **32** that are preferably spaced from one another a distance approximately equal to their outside diameter. Although the spacing can be graduated from their median outwardly, it has been found that with the headers connected directly to the sides of the water wall of the boiler to embody the invention, equal spacing of the pipes **32** for manufacturing convenience is adequate even for a continuously heavily fired boiler.

A characteristic of the invention is that the headers **30** can be supplied in several predetermined lengths and the length differential therewith involved with many different widths of individual furnace spaces are corrected by cutting down the length of longer header to the length desired. In conjunction therewith the water walls are apertured with vertically spaced openings **34** for grate incline, at distances equal to the spacing of the headers **30**. The headers **30** are then cut to a desired length few inches greater than the width between the walls. Thereupon the headers are inserted at one of their ends into the openings **34** on one of the water walls whereupon the other ends of the headers are lifted and the cooling unit slid reversely into the openings on the other water wall until equal lengths of the headers extend into the water walls above the mud ring. Thereafter, the joints around the headers at the openings are seam welded at **36**. The boiler is then pressure tested against leaks.

By way of assisting this installation, collars **38** can be welded in the openings as located by a sheet metal grid template (not shown) and stops **39** placed on said other end of the headers to locate the headers ends at equal depths in the respective openings. Collars need not be used where the tuyeres are to extend to the boilers water jacket wall. The seam weld can be directly between wall and tube. Thereby an uninterrupted flat wall surface is provided against which the tuyeres can be fitted throughout their length.

Where collars are employed the headers can be brazed in place to the collars (lower melting point) and then when the grates are replaced the headers can be flame or saw cut adjacent thereto. The cooling unit would then be dropped and removed and the stubs unbrazed for removal without any need to rework the water walls of the boiler. However, it has been found that a direct weld of the headers to the water walls seldom if ever is disturbed because of the increased longevity of the grates embodying the invention.

It should be noted that wear and corrosion on the tuyeres may require their renewal or servicing, in whole or part, several times during the life of the cooling unit. For this purpose, the preferred construction of a tuyere **46** is shown in FIGS. 3 through 5 as having a cross-sectionally T-shaped member whose head defines arms **50** resting on the pipes and terminating halfway over adjacent pipes **32**. A central leg portion **52** extends downwardly between the pipes a little distance short of the bottom extremity of the pipes. The underside of the arms **50** and the top edges of the leg closely follow the contour of the pipes **32**. Bolt holes **54** are cast in the leg portions and are recessed at the top at **56** to receive a rounded head **58** of the bolt **60**. Cross tie bars **62** engage bottoms of the tuyere legs **52**. The bolt ends extend through the tie bars to receive nuts **64** thereon.

The bolts **60** are of a novel construction, to be described, to clamp the tuyeres **46** snugly in place with a high heat conductive aluminum plastic bonding material **69** squeezed between the tuyeres and pipes and between the tuyeres themselves at their sides and ends for transmission of heat between them at a high rate.

Also, vertically through the legs **52** one or more rows of air holes are cast or drilled for the movement of the primary air from the plenum **31** to the coal on the tuyeres for a clean burn out.

Referring now to the construction of the bolts **60**, these bolts constitute bolt portions **58** having circular head portions **68** received snugly in circular recesses **56** flush with the top of the tuyeres and also embedded in high heat conductive aluminum plastic. As an auxiliary element threaded into or made integrally with the head **58**, a wrenching head portion **70** is provided that is undercut as at **72** to provide a weakened section which will break away when a predetermined tightening torque force is exerted thereon. The break-away head **70** may have an externally hexagonal contour, as shown, or an internal Allen wrench socket. Either way they are designed to receive standard wrenches. Thus, the bolts **58** can be tightened manually or with power wrenches with any exertion of torque forces desired, but when the proper tightness is reached, the wrenching element **70** will break off leaving an upper face end flush with the upper tuyere surface with adequate clamping effort and without damage to the pipes **32**.

The lower end of the bolt can be threaded into the tie bars **62** themselves directly, or, preferably as shown, into nuts **64** so that later on when it becomes desirable to remove one or more tuyeres the appropriate nuts **64** can be loosened with the hardened aluminum plastic around the heads **68** holding them against turning for the ready release of the bolts **58** and removal of the tuyere.

The tie bar **74** along the lower rear end of the front grate **18***f* is constructed to provide a running air seal

fit with the front end of the rear grate **18***r* and preferably this is accomplished with the tie bars **74** being cast in sections with a downwardly opening groove **76** spaced from the rear edge of the front grate **18***f*.

An air sealing element **78** is gravity mounted in the groove **76** as supported by pins **80** press fitting or threaded into place in the tie bar **74** with the ends intersecting the groove **76** and being received in vertically elongated slots **82** in the sealing element. In this connection it is to be noted that the front upper corner of the push block **28** is beveled at **83** so that the block can be removed rearwardly from under the forward grate **18***f* when desired and returned without blocking interference therewith. The bevel **83** cams the sealing element upwardly without otherwise disturbing the assembly upon such occasions.

The sealing element **78** is laminated with a bronze rear layer **84** and an iron front layer **86**. As initially provided the bronze layer extends slightly below the iron layer on the bottom edge. This permits the bronze under the weight of the sealing member to wear rather rapidly into a contour matching the surface irregularities of the pusher block and when the iron, preferably an alloy metal, begins to make contact with the pusher block, it carries the weight and further wear is inhibited on the bronze leaving a close working seal of excellent longevity between the two elements and thereby preventing loss of pressure from the plenum. It should be noted that the air pressure is effective against the front of the sealing element and the bronze layer is on the back side in contact with the back wall of the groove. The organization is thereby favorable to the seal maintained even with extra loose manufacturing tolerances that assist assembly and fitting of cooperating members. Thereby they generally can be made of sand castings with very little machine finishing being required for excellent operation.

By way of further understanding of the invention the furnace is provided with the opening **25** (FIG. 1) across the bottom front end and if an ignition arch is not already provided such is installed by drilling holes through the front end wall **12***f* as at **11** and into the rear end wall **12***r* as at **13** whereupon the ignition arch tubes **15** are slipped through the front wall **12***f* and welded into place to receive fire brick **17** thereon. The external entry openings are then plugged as at **19**.

The side walls **14** are drilled out and the headers **30** of the cooling units cut to length and installed as already described. The tuyeres **46** are fastened in place with any gaps between the grate tuyeres and the side walls sealed with furnace cement **21** (FIG. 3) whereupon a compact operating unit which includes the main blower **87**, the push block activating mechanism **89** are fitted at the center front of the opening **25** with the push blocks **24** and **28** cut to proper lengths, installed and hooked up to actuating push rods **91**. The control equipment is then hooked up and the electrical power connected ready for operation. It should be noted at this time that the relative elevation of the components is to locate the lowest header of the grates just above the mud line of the furnace and the ignition arch between 18 and 22 inches above and parallel with the grates.

Ignition is established in the usual way with a bed of coal advanced on the front grate and thereafter the main blower **87** provides primary air for peak firing as controlled by adjustable damper **93**. Primary air to the rear grate is supplied through aperture **95** as controlled by damper **97**.

Whereas the grates disclosed in said application Serial No. 130,858 maintain combustion temperatures in the coals thereon when air pressure is shut down on the off cycle, the cooling efficiency of the present invention for the longevity of inexpensive tuyeres is such that the coals can be chilled below their ignition temperature.

While it is possible to turn on and off the main blower approximately every 15 minutes during off-peak firing periods for a minute or two to maintain ignition, it is preferred to provide the small, economical auxiliary blower **86** of low capacity for continuous service during off-peak firing periods to fan the coals and maintain ignition. Although flue conditions might maintain such ignition in some installations, it is preferred that such be assured by the small blower. Accordingly, a miniature auxiliary blower having a conduit size of approximately 1 to 2 inches in diameter runs on the off cycle to fan the coals with enough air to sustain combustion temperatures between "on" cycles.

Having thus explained and described this invention, the functions and preferred constructions of the elements, it will be understood by those skilled in the art how the objects are attained and how other and further changes can be made in the preferred embodiments shown without departing from the spirit of the invention, the scope of which is commensurate with the appended claims.

What is claimed is:

1. In combination with a boiler having a coal feed opening and a fuel combustion space therebeyond defined laterally by vertical water walls defining a water space on one side, a grate comprising two horizontally spaced header tubes in said combustion space interconnecting and extending at their opposite ends through said water walls in sealed relationship therewith and in open communication with said water space therein, the header tube adjacent to the feed opening being disposed below the level of the feed opening and the header tube remote from the feed opening being disposed below the level of the first mentioned header tube, a plurality of coplanar water pipes interconnecting said header tubes spaced from each other in a direction lengthwise of said headers and at their ends in open communication therewith, plural rows of end abutting tuyeres having legs disposed between each pair of asid pipes and abutting the edges of adjacent rows of tuyeres above the center of said pipes, said legs terminating downwardly at a planar level above the plane of the lowest sides of said pipes, transverse tie bars engaging the lowest sides of said pipes, metal clamping means flush with the top of the tuyeres extending through said legs and tie bars for clamping said tuyeres against said pipes, high heat conductive means intimately interconnecting the interfaces of said tuyeres and pipes and said tuyeres and clamping means.

2. In combination with a boiler having a coal feed opening and a fuel combustion space therebeyond defined laterally by vertical water walls defining a water space on one side, a first grate comprising two horizontally spaced header tubes in said combustion space interconnecting and extending at their opposite ends through said water walls in sealed relationship therewith and in open communication with said water space, the header tube adjacent to the feed, a plurality of coplanar water pipes interconnecting said header tubes in open communication therewith, plural rows of end abutting tuyeres having legs disposed between each pair of said pipes and abutting the edges of adjacent rows above the center of said pipes, means for clamping the tuyeres on said pipes including a rear element engaging in part a header tube and having a downwardly opening groove therein, a second grate below the first, a coal push block reciprocably received between the grates where they overlap, and air sealing means slidable in said groove and resting on said push block in sealed relationship.

3. In combination with a boiler having a coal feed opening and a fuel combustion space therebeyond defined laterally by vertical water walls defining a water space on one side, a first grate comprising two horizontally spaced header tubes in said combustion space interconnecting and extending at their opposite ends through said water walls in sealed relationship therewith and in open communication with said water space, the header tube adjacent to the feed, a plurality of coplanar water

pipes interconnecting said header tubes in open communication therewith, plural rows of end abutting tuyeres having legs disposed between each pair of said pipes and abutting the edges of adjacent rows above the center of said pipes, means for clamping the tuyeres on said pipes including a rear element engaging in part a header tube and having a downwardly opening groove therein, a second grate below the first, a coal push block reciprocably received between the grates where they overlap, air sealing means slidable in said groove and resting on said push block in sealed relationship, an air plenum below said first grate, means for intermittently supplying primary air to said plenum during on-peak burning cycles, and means for supplying a low volume of air to said plenum alternately for fanning the coals to maintain ignition during off-peak burning cycles.

4. In combination with a boiler having a coal feed opening and a fuel combustion space therebeyond defined laterally by vertical water walls defining a water space on the sides, a first grate comprising two horizontally spaced header tubes in said combustion space interconnecting and extending at their opposite ends directly through said water walls, means for securing the ends of the header tubes in sealed relationship with the water walls and in open communication with said water space, the header tube adjacent to the feed opening being disposed below the level of the feed opening and the header tube remote from the feed opening being disposed below the level of the first mentioned header, a plurality of coplanar water pipes interconnecting said header tubes spaced from each other in a direction lengthwise of said headers and at their ends in open communication therewith, plural rows of end abutting tuyeres having legs disposed between each pair of said pipes and abutting the edges of adjacent rows above the center of said pipes, said rows of tuyeres extending to a point below said opening, means for feeding coal through said opening onto the top of said tuyeres, said legs terminating downwardly at a planar level above the plane of the lowest sides of said pipes, transverse tie bars engaging the lowest sides of said pipes, the tie bar along the rear end of said grate having a groove therein opening downwardly, metal clamping means flush with the top of the tuyeres extending through said legs and tie bars for clamping said tuyeres against said tubes and pipes, high heat conductive means intimately interconnecting the interfaces of said tuyeres and pipes and said tuyeres and clamping means,

a second grate below the first grate at said groove, pusher means siding on said second grate below said groove, air sealing means slidable vertically in said groove and engaging said pusher means in air sealed relationship, and air plenum means below said first grate.

5. In combination with a boiler having a coal feed opening and a fuel combustion space therebeyond defined laterally by vertical water falls defining water spaces on opposite sides of said combustion space, two inclined vertically spaced grates in marginal overlapping relationship, each grate comprising two horizontally spaced header tubes in said combustion space interconnecting and extending at their opposite ends through said water walls in sealed relationship therewith and in open communication with said water spaces, a plurality of coplanar water pipes interconnecting said header tubes spaced from each other in a direction lengthwise of said headers and at their ends in open communication therewith, plural rows of end abutting tuyeres having legs disposed between each pair of said pipes and abutting the edges of adjacent rows above the center of said pipes, said legs terminating downwardly at a planar level above the plane of the lowest sides of said pipes, the upper header tube of the front grate adjacent to the feed opening being disposed below the level of the feed opening and the header tube remote from the feed opening being disposed below the level of the first mentioned header, the upper header tube of the grate remote from the feed opening being disposed below the level of said remote header tube of the front grate and the lower header tube of said remote grate being above the mud ring of the boiler; push block means reciprocating between said grates at said overlap, air seal means between said front grate and said pusher block means, and primary air plenum means below said front grate.

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