Sept. 2, 1952 R. M. HARDGROVE 2,608,938

MOBILE STEAM GENERATOR

Original Filed Nov. 29, 1944 5 Sheets-Sheet 1

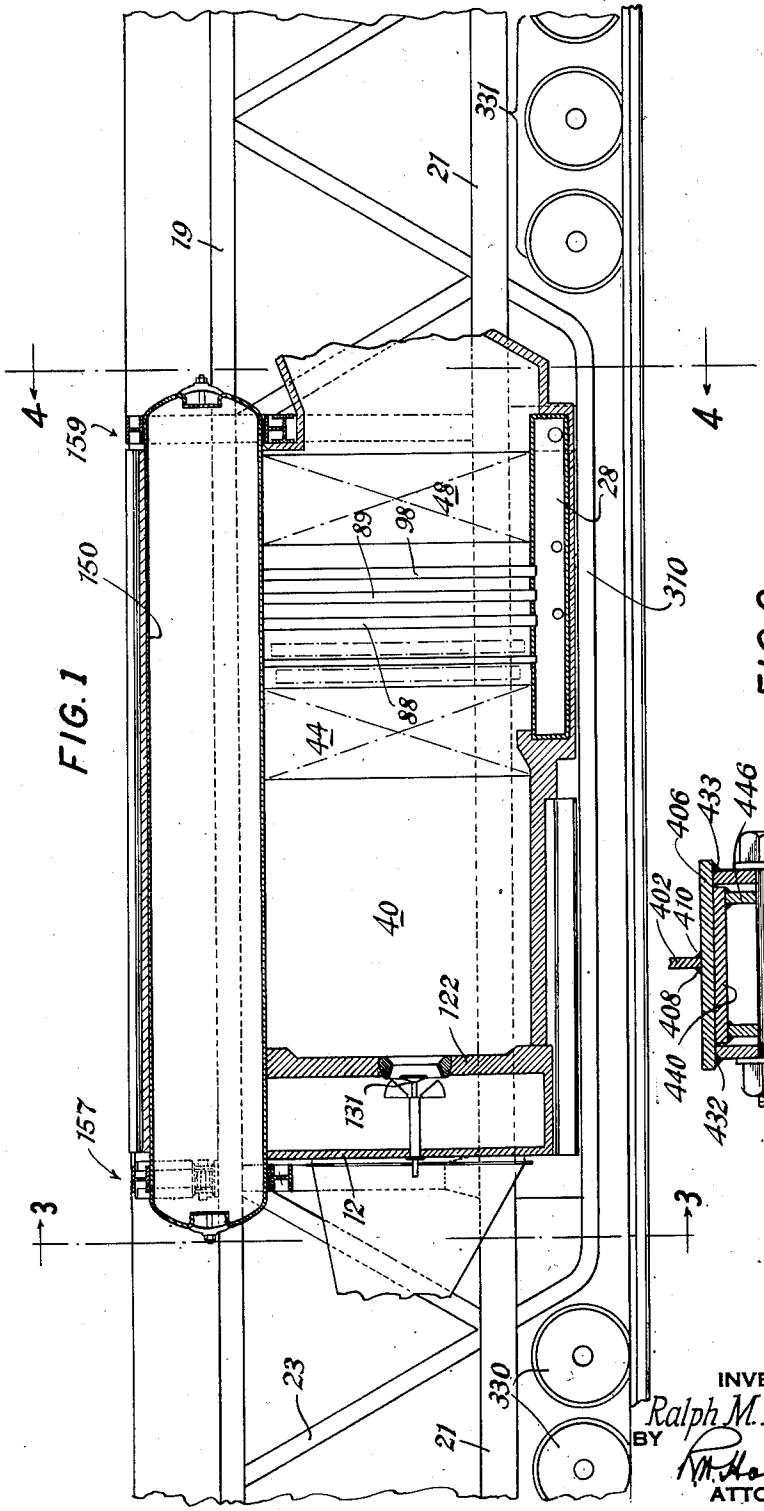


FIG. 1

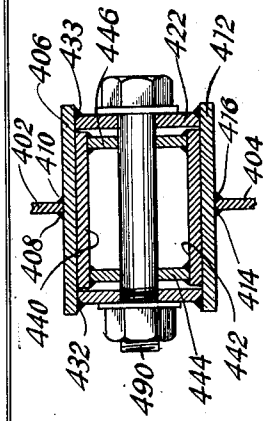


FIG. 6

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MOBILE STEAM GENERATOR

Original Filed Nov. 29, 1944 5 Sheets-Sheet 2

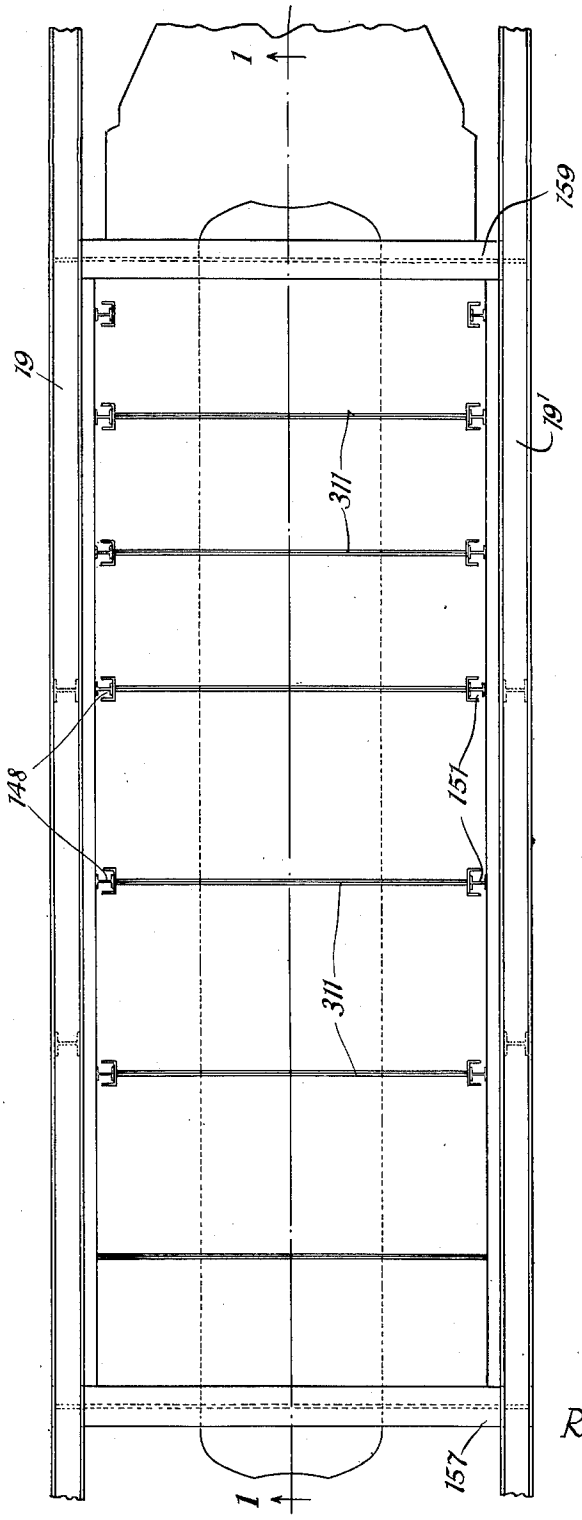


FIG. 2

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MOBILE STEAM GENERATOR

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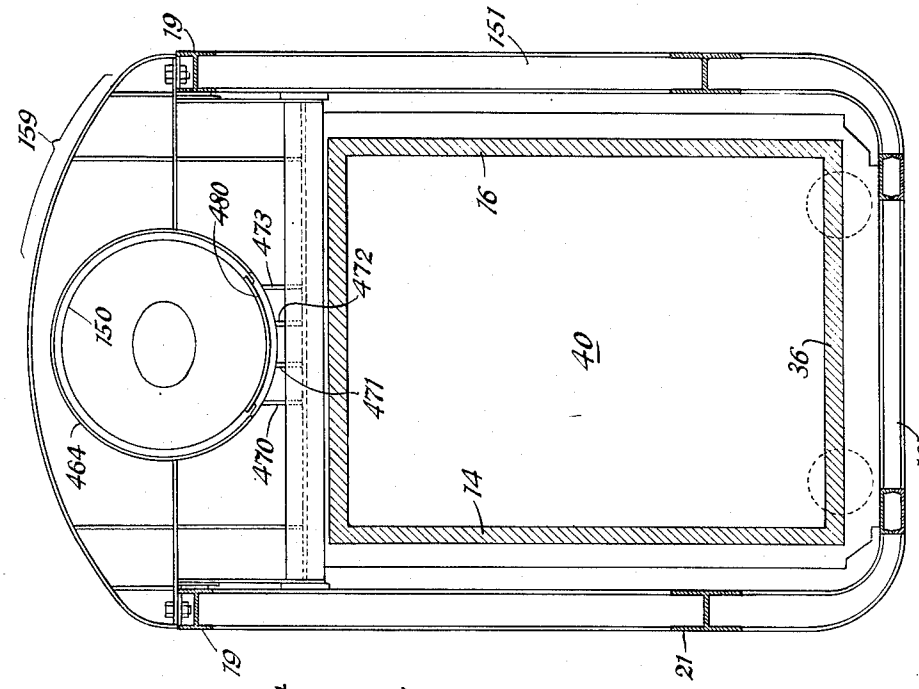


FIG. 4

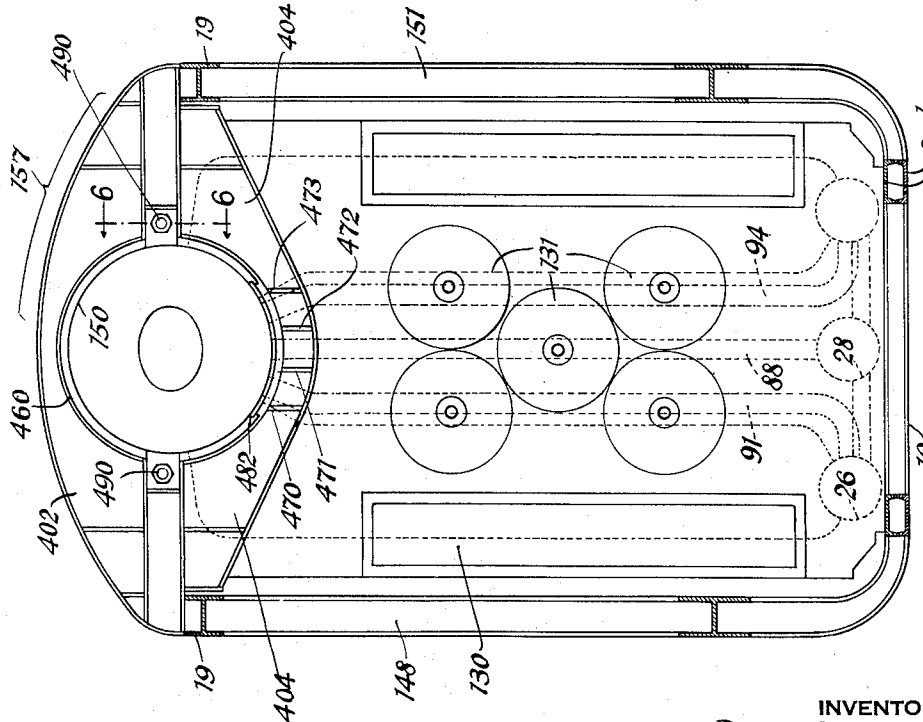


FIG. 3

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MOBILE STEAM GENERATOR

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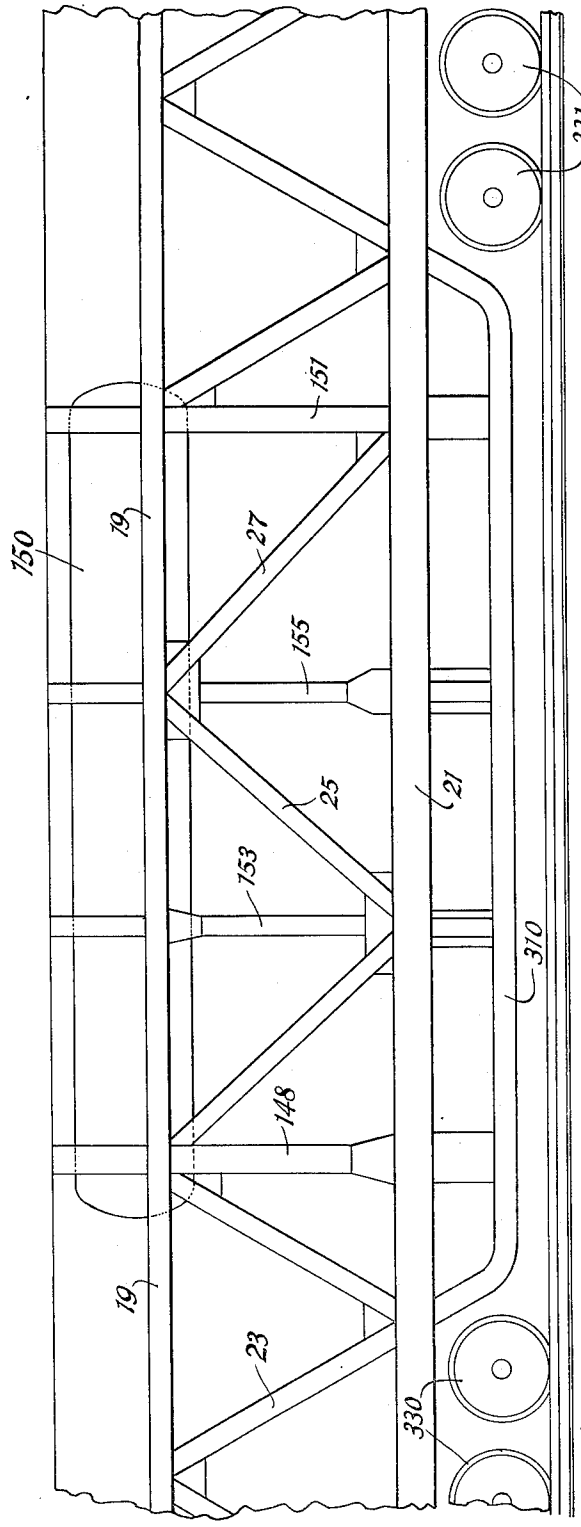


FIG. 5

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MOBILE STEAM GENERATOR

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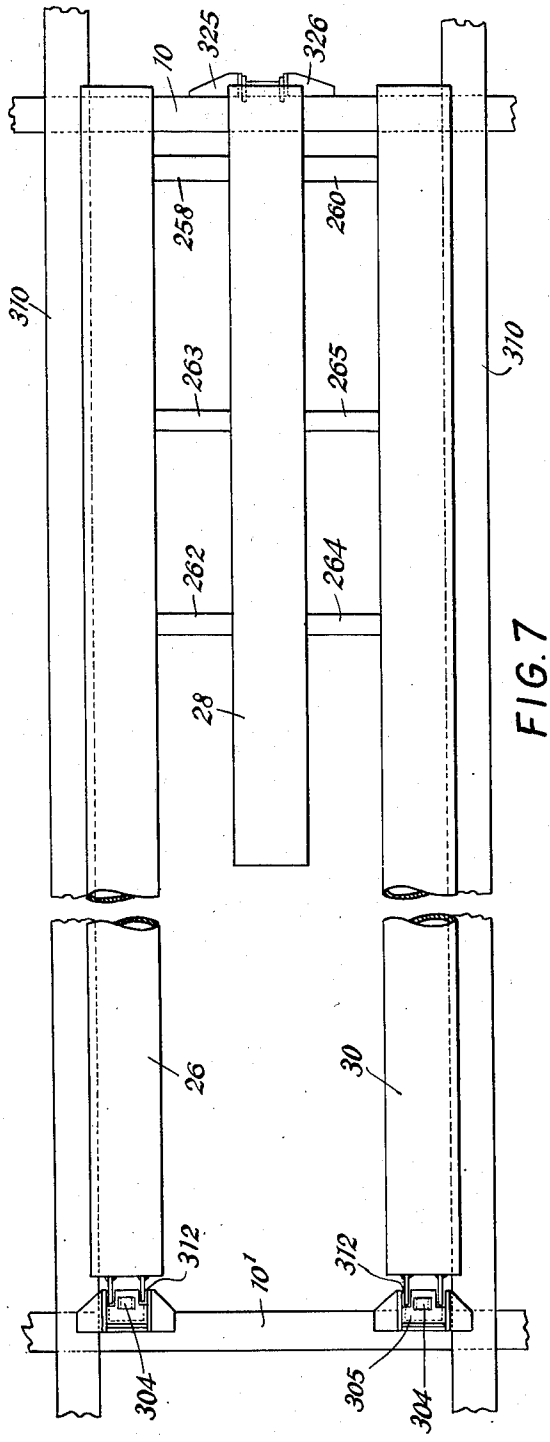


FIG. 7

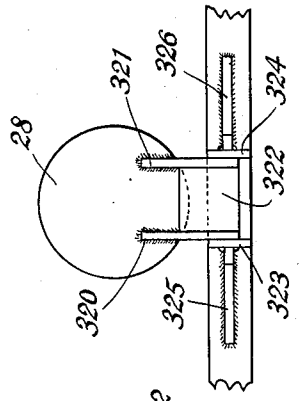


FIG. 11

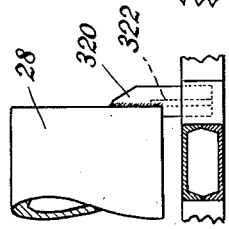


FIG. 10

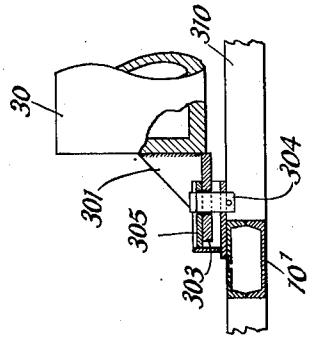


FIG. 9

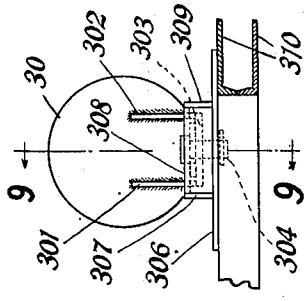


FIG. 8

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UNITED STATES PATENT OFFICE

2,608,938

MOBILE STEAM GENERATOR

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Original application November 29, 1944, Serial No. 565,602. Divided and this application May 8, 1948, Serial No. 25,931

13 Claims. (Cl. 105—238)

1

The invention is particularly concerned with a water tube steam generator which, because of the particular arrangements of its parts, is adapted to effectively operate as a part of a mobile railway power plant.

An object of the invention is to provide a steam generator so combined with a railway car construction that the generator will long remain in effective high capacity operating condition despite the exigencies of considerable railway travel.

The invention involves a water tube steam generator including a steam and water drum disposed at the upper part of the installation. The drum itself is of considerable weight, and, in addition, the drum carries in a pendent manner, the major part of the weight of the remaining components of the steam generator. These components include lower headers at the base of the installation, banks of intervening steam generating tubes, and other tubes such as tubes defining the furnace of the steam generator. In this construction, provision must be made for upward or downward movements of the lower parts of the installation relative to the drum, resulting from temperature changes. Nevertheless, the lower parts of the installation must be maintained in operative relation to the drum during such movements, and, to accomplish this result, the relationships of the lower parts of the railway car construction and the steam generator must be coordinated. In addition, the steam and water drum and the entire steam generator installation is of considerable length, longitudinally of the railway car construction, and this necessitates provision for relative movement between one end of the steam generator and the corresponding part of the railway car construction, when the opposite end of the steam generating installation is fixed with reference to the car construction.

In addition to the above indicated problems of coordinating the steam generator construction and the railway car construction, these two components are so related that the swaying, swerving, torsional, and warping movements of the railway car framework as the car passes over uneven roads, do not impose such stresses upon the steam generator construction that it will be damaged in such a way as to substantially detract from its operating effectiveness. To this end the railway car construction is of the well type providing a well between the front and rear trucks of the car in order that the lower parts of the steam generator may be disposed as closely

2

as possible to the track level. The car construction involves heavy side members in the form of trusses which are rigidly connected at positions near the front and rear ends of the steam generator drum by heavy transverse beam constructions. The latter support the weight of the drum and the major part of the weight of the remainder of the steam generator. The steam generator is also supported in such a manner that one end of the drum and steam generator may have longitudinal movement relative to the car construction by reason of expansion or contraction movements resulting from differential temperatures. In addition to the drum supporting beam constructions the car construction includes upper and lower transverse struts rigidly connected to the side trusses. Some of these struts are disposed below the bottommost parts of the steam generator and others are disposed above the steam generator drum. Side sway of the lowermost parts of the steam generator relative to the car construction are prevented by securing one end of the steam generator to the car frame construction, and permitting the other ends of the lower parts of the steam generator to have vertical as well as longitudinally horizontal movements relative to the car frame. Such movements are permitted by vertically related guided members on the lower headers of the steam generator and upon the lower transverse struts joining the side trusses of the car construction.

In the drawings:

Fig. 1 is a sectional elevation of the illustrative steam generator on the line 1—1 of Fig. 2;

Fig. 2 is a plan;

Fig. 3 is a vertical section on the line 3—3 of Fig. 2.

Fig. 4 is a vertical section on the line 4—4 of Fig. 1;

Fig. 5 is a side elevation showing the steel work for the railway car and boiler setting;

Fig. 6 is the longitudinal vertical section taken on the line 6—6 of Fig. 3, and looking in the direction of the arrows;

Fig. 7 is a diagrammatic plan showing the arrangement of the lower headers relative to the car construction;

Fig. 8 is an elevation of the structure at the left hand end of one of the longer water headers of Fig. 7;

Fig. 9 is a vertical section of the 9—9 of Fig. 8;

Fig. 10 is a fragmentary side elevation of the structure at the right hand of the intermediate header of the Fig. 7 arrangement; and

Fig. 11 is an end elevation of Fig. 10.

The illustrative steam generator is provided for furnishing steam as a part of a complete power plant of high capacity, and it is so constructed that it is adapted as rolling stock for railway use. Such a power unit is of particular value in connection with the maintenance of adequate power supplies during war times when normal power supply may be interrupted. It is intended for use for a limited time in one locality and then for railway transportation for use at another locality. To facilitate such use, the installation is mounted for railway transportation and the steam generator is so structurally coordinated with the railway mount that the generator will maintain its operative characteristics even after the installation has been subjected to the many hazards of railway travel.

It is a desideratum that the capacity of the steam generator should be as great as possible relative to the space or volume occupied by it, and the problems of attaining this characteristic were increased by the various railway limitations imposed. Some of these are limitations of weight and space, as well as overall clearance limitations. The illustrative steam generator and its combined railway mount attains a high steam generating capacity while still keeping within these limitations. The problem of maintaining these conditions and still keeping the installation in operative condition after considerable transportation is aggravated by two additional factors springing from the structure of the steam generator construction. One is the high center of gravity of the natural circulation water tube steam generator employed. The other is the manner of supporting the steam generator from its steam and water drum at the top of the installation. This is particularly advantageous because of the weight of the drum and the construction of elements providing the steam generating surfaces which would not readily permit of bottom support.

For attaining the above results, the illustrative installation includes a railway mount with heavy side girders or trusses having their lower chords at about the car coupling level and their upper chords at a maximum elevation for supporting the drum of the steam generator. The ends of the drum are carried by transverse beam constructions rigidly secured to the upper chords of the side trusses. This effective arrangement is limited by the importance of having the steam generating tubes (extending downwardly from the drum) as long as possible in order to obtain the maximum steam generating capacity with a minimum of parts. To this end the illustrative installation has the pressure parts of the steam generator extending to a position within a few inches of the track level. In other words, the drum and the remaining pressure parts of the steam generator are set within a well between the trusses, and between the trucks of the railway mount, and their lower limits are close to the track level. The transverse beam constructions supporting the drum are advantageously located at positions near the ends of the well.

With this construction, and by reason of the fact that the side trusses provide the loading carrying members for the combined steam generator and railway mount, these trusses may be considered a part of the steam generator setting which also includes the steam generator enclosing walls **14** and **16**; the roof sections **18**, **20**, and **22**; and the steam generator furnace floor elements **26**, **28**, **30**, **32**, **34**, **36**, and **38** (Figs. 3, 4, and 1). One of the side truss constructions is indicated in Fig. 5 of the drawings. It includes the upper chord **19** and the heavy lower chord **21**, rigidly connected by diagonals such as **23**, **25**, and **27**, and by uprights such as **150**, **151**, **153**, and **155**.

The side truss at the other side of the installation is similar to that just described including uprights such as **148**, Figs. 3 and 4.

Within the boiler setting are the pressure parts of the installation, a substantial part of the total steam generating surface being formed by wall tubes of the combustion chamber **40**. Other steam generating surfaces are formed by banks of upright steam generating tubes **44** and **45**, inclusive. These tubes connect one or more of the submerged headers **26**, **28**, and **30**, directly to the steam and water drum **50** disposed at the upper part of the setting, as illustrated in the drawings.

The drum **50** has trunnion mountings at its forward end, this end of the drum being fixed so that the drum expands from that position rearwardly. The trunnion mounting is particularly shown in Fig. 6, there being a trunnion mounting at each side of the drum. Each mounting is interposed between the upper and lower parts, **402** and **404**, respectively, of the web of the transverse beam construction **157**. The upper web **402** is welded to a plate section **406** as indicated at **408** and **410** in Fig. 6 and a lower plate **412** is similarly welded at **414** and **416** to the lower web part **404**. Between the plates **406** and **412** are the parallel plate sections **420** and **422** welded to the plates **406** and **412** at **430**—**433**. Disposed within the supports thus formed are hollow built-up beam-like constructions secured to opposite sides of the drum. Each of the latter includes the upper and lower plate sections **440** and **442** welded at their inner ends to the drum **50**, and the associated upright plate sections **444** and **446** which are welded to the plate sections **440** and **442** as shown in Fig. 6, and are also welded at their ends to the drum.

Extending through aligned openings in the plates **420**, **422**, **444**, and **446** of the trunnion constructions are bolts **490**.

The transverse beam-like constructions **157** and **159** (Figs. 3, 4, and 6) of the setting steel work and car superstructure have circular openings **460**, **464** for receiving the drum, and the central parts of each beam construction beneath the drum are reinforced by the ribs such as **470**–**473**, inclusive (Fig. 3). Above these reinforced parts are arcuate pads **480** and **482** upon which the drum rests.

The lower part of the stream generator also has its forward end secured to the steel work of the car so that it may expand rearwardly from that position. For this purpose and also to prevent any side sway of the lower part of the steam generator relative to the steel work, the forward ends of the headers **26** and **30** are secured to the steel work as indicated in Figs. 7–9, inclusive. As here shown, the forward end of each of these headers has welded thereto two upright gusset plates **301** and **302** with their lower horizontal portions welded to the base plate **303**. The latter is provided with a central aperture to receive a pin **304** which also extends through aligned openings in the upper and lower plates **305** and **306**, respectively, of a fixed guide block construction secured to the steel work. As indicated in Figs. 8 and 9, the upper and lower plates **305** and **306** are spaced vertically so as to provide for vertical

ends of the drum and combining therewith to form the load carrying supports for the drum, parts of said beam constructions forming seats receiving the opposite end portions of the drum, the remainder of the steam generator depending from the drum, upper transverse struts extending over the drum and rigidly joining the opposite side constructions, and lower transverse struts extending beneath the steam generator and rigidly joining the side constructions.

3. In a steam generator installation having a railway car mounting, the railway car having end trucks and heavy upright side truss constructions having intermediate underslung portions between which a well extends downwardly to a position near the track level, said underslung intermediate portions of the side trusses disposed between the end trucks and at a level below the top level of the trucks, a water tube steam generator extending into the well and having a steam and water drum disposed longitudinally between said sides, the steam generator also having water headers near the track level and disposed along said intermediate underslung portions, transversely extending means rigidly joining said side constructions at their upper parts and combining therewith to take the load of the drum and the remainder of the steam generator, additional means rigidly joining said side constructions, upper parts of said additional means being disposed above the drum and lower parts thereof disposed below said headers, and guide means having relatively movable parts secured respectively to said headers and a lower part of said additional means for preventing sidesway of the lower part of the steam generator while allowing relative vertical movements of the headers and the railway car.

4. In a steam generating installation including a railway car mounting, a water tube steam generator including an elevated steam and water drum, steam generating tubes depending from the drum and enclosing a furnace combustion chamber, means including downcomers and headers establishing communication between the lower part of the drum and the lower ends of the steam generating tubes, a railway car construction including end trucks and having side constructions with heavy upright side trusses, transverse beam constructions rigidly joining the upper chords of the opposite trusses at opposite ends of the drum near the end trucks and combining with the trusses to provide load carrying supports for said drum and the remainder of the steam generator, upper, transverse struts rigidly joining the upper chords of the trusses and extending over the drum, the lower ends of the steam generating tubes and the steam generator furnace extending into a car well to a position near the railway track level, lower transverse struts extending under the steam generator and rigidly joining the lower chords of said trusses and guide means on the headers and the lower struts preventing lateral movement of the headers relative to said side constructions while allowing vertical movements of the headers resulting from temperature changes in the steam generator.

5. In a steam generating installation including a railway car mounting, a longitudinally extending water tube steam generator including a steam and water drum at the upper part of the generator and the car, steam generating tubes depending from the drum with some of said tubes enclosing a furnace combustion chamber, a railway car construction including end trucks and having heavy upright side trusses, said trusses having intermediate portions below the level of the truck axles to form the sides of an intermediate car well, transverse beam constructions rigidly joining the upper chords of the opposite trusses at opposite ends of the drum near the end trucks and combining with the trusses to provide load carrying supports for said drum and the remainder of the steam generator, the lower ends of the steam generating tubes and the steam generator furnace extending into a car well to a position near the railway track level, lower transverse struts extending under the steam generator and rigidly joining the lower chords of said trusses, inter-acting means associated with the lower transverse struts and the lower parts of the steam generator to allow relative longitudinal contraction and expansion movements between the car frame and said lower steam generator parts and yet prevent sidesway of said lower parts relative to the associate car frame parts.

6. In a steam generator installation including a well type of railway car construction including end trucks, heavy upright side constructions for the car, said side constructions having intermediate portions disposed at a level lower than their end portions, a water tube steam generator having a drum longitudinally disposed between said side constructions with some of remaining steam generating parts extending into the car well to a level adjacent the track level and the level of the truck axles, transverse beam constructions rigidly joining the upper parts of said side constructions near the ends of the drum and combining therewith to form load carrying supports for the drum, the remainder of the steam generator depending from the drum, said beam constructions having aligned openings through which the drum is disposed, upper transverse struts rigidly joining the opposite side constructions, and lower transverse struts extending beneath parts of the steam generator and rigidly joining the side constructions.

7. In a steam generator installation having a railway car mounting including end trucks, the railway car having heavy upright side constructions forming the sides of a car well extending downwardly to a position near the track level, said side constructions having end parts supported by the trucks and intermediate portions disposed at a level lower than that of the end parts, a water tube steam generator having parts extending into the well and having a steam and water drum disposed longitudinally between said sides, the steam generator also having water headers near the track level, transversely extending means rigidly joining said side constructions at their top parts and combining therewith to take the load of the drum and the remainder of the steam generator, additional means rigidly joining said side constructions, the lower parts of said additional means being disposed below said headers, and guide means having relatively vertically movable parts secured respectively to said headers and a lower part of said additional means for preventing sidesway of the lower part of the steam generator while allowing relative vertical and longitudinal movements of the headers and the railway car.

8. In a steam generating installation including a railway car mounting including end trucks, a water tube steam generator including an elevated steam and water drum, steam generating tubes depending from the drum, some of said tubes en-

movement of the movable guide block plate **303** therebetween. This permits the lower part of the steam generator to be freely moved vertically within narrow limits as the temperature of the pressure parts of the steam generator changes.

The upper plate **305** of the fixed guide block construction is welded to enclosing plates **307**, **308**, and **309** which are, in turn, welded together, and welded to the base plate **306**.

The base plate **306** is fixed to one of the transverse members **10'** of the steel work. These transverse members extend underneath the pressure parts of the steam generator as indicated in Figs. 3 and 4 and they are rigidly secured at their ends to the members **310** of the car side constructions.

The base plate **306** for the guide block constructions shown in Fig. 8 also may be secured to the longitudinal steel work components such as **310**. These components consist of channel sections **310'** rigidly secured together. Preferably, they are bent upwardly at their ends so as to be anchored to the lower truss chords **21**. They extend beneath the steam generator where they are joined to the transverse members **10** in a manner indicated in Fig. 4. The upper part of the installation is similarly strengthened by the transversely extending steel work components **311** which are rigidly secured at their ends to the upper chords **19** of the side truss constructions. Preferably, the roof of the installation is formed by plates secured to the members **311**.

Referring back to constructions shown in Figs. 7–11, inclusive, side sway of the lower part of the steam generator relative to the steel work (or car frame) is prevented by the pins **304** passing vertically through the guide block constructions between the forward ends of the headers **26** and **30** and the transverse member. Limited vertical movement of the headers **26** and **30** is permitted by the spacing of the upper and lower guide block plates **305** and **306**, and during any such movement the gusset plates **301** and **302** move vertically within slots **312** in the fixed guide block plates **305**.

Figs. 7, 10, and 11 also indicate a guide block construction secured to the rear end of the intermediate header **28** and the transverse steel work (or car frame) member **10'**. This construction prevents side sway at the rear end of the boiler construction relative to the car frame, but permits relative vertical and horizontal movements resulting from expansion and contraction of the headers or other pressure parts. One of these guide block constructions is sufficient at this end of the steam generator because of the pressure parts such as the equalizer tubes **258**, **260**, **262**, **263**, **264**, and **265**, rigidly joined to the headers **26**, **28**, and **30**.

The guide block construction at the rear end of the header **28** consists of vertical plate sections **320** and **321** having their upper parts welded to the header. These plate sections are joined by transverse web **322**.

As the pressure parts of the steam generator are subject to temperature changes, the lower ends of the plate sections **320** and **321** may be moved vertically or horizontally in a guide way formed by the upright bar or plate elements **323** and **324**. These elements are preferably welded to the vertical face of the transverse steel work member **10''** and are further held in their operative positions by the horizontal gusset plates **325** and **326** disposed in the angles between the vertical face of the member **10''** and the elements **323** and **324** and preferably welded thereto.

The relationships of the railway car components to the pressure parts of the steam generator are further indicated in Figs. 5, 8, and 9. Fig. 5, in particular, shows the construction by which pressure parts of maximum overall height may be utilized. This is permitted by the disposition of associated pressure parts of the steam generator in a well between the railway car trucks **330** and **331**, the bottom of the well construction being indicated by the disposition of the horizontal steel work components **310** beneath the side trusses extending from one railway truck to the other. Between the trucks, the bottom of the installation is close to the track level, or the tops of the rails **333**. At the ends of the installation the car construction with its floor at the level of the lower chords **21** is indicated in Fig. 7.

This application is a division of my pending application, Serial No. 565,602, filed November 29, 1944, entitled "Steam Generator," now Patent No. 2,550,066.

While in accordance with the provisions of the statutes I have illustrated and described herein the best form of my invention now known to me, those skilled in the art will understand that changes may be made in the form of the apparatus disclosed without departing from the spirit of the invention covered by my claims, and that certain features of my invention may sometimes be used to advantage without a corresponding use of other features.

What is claimed is:

1. In a steam generating installation including a railway car mounting, a water tube steam generator including an elevated steam and water drum, steam generating tubes depending from the drum and enclosing a furnace combustion chamber, means including downcomers establishing communication between the lower part of the drum and the lower ends of the steam generating tubes, a railway car construction including end trucks and heavy upright side trusses having underslung mid-portions disposed between said trucks and extending downwardly to a level below that of the truck axles, transverse beam constructions rigidly joining the upper chords of the opposite trusses at opposite ends of the drum and combining with the trusses to provide load carrying supports for said drum and the major portion of the remainder of the steam generator, upper transverse struts rigidly joining the upper chords of the trusses and extending over the drum, the lower ends of the steam generating tubes and the steam generator furnace extending into the car well to a position near the underslung portions of the side trusses lower transverse struts extending under the steam generator and rigidly joining the lower chords of said trusses, and means associating the lower transverse struts and the lowermost parts of the steam generator to prevent sidesway of the lower part of the steam generator and to maintain their operative relationships during relative vertical and longitudinal movements.

2. In a steam generator installation including a well type of railway car construction, heavy upright side constructions for the car, a water tube steam generator having a drum longitudinally disposed between said side constructions with remaining parts extending into the car well, transverse beam constructions rigidly joining the upper parts of said side constructions near the

closing a furnace combustion chamber, means including downcomers and headers establishing communication between the lower part of the drum and the lower ends of the steam generating tubes, a railway car construction including said end trucks and side constructions with heavy upright side trusses, transverse beam constructions rigidly joining the upper chords of the opposite trusses at opposite ends of the drum near the end trucks and combining with the trusses to provide load carrying supports for said drum and the remainder of the steam generator, the lower ends of the steam generating tubes and the steam generator furnace extending into a car well between said side constructions to a position near the railway track level, lower transverse struts extending under the steam generator and rigidly joining the lower chords of said trusses, and interengaging and relatively vertically movable guide members on the headers and the lower struts preventing lateral movement of the headers relative to said side constructions while allowing vertical movements of the headers resulting from temperature changes in the steam generator.

9. In a steam generator installation including a railway car construction including end trucks, heavy upright side constructions for the car having intermediate portions at a level lower than that of the end portions and adjacent the level of the truck axles, a water tube steam generator having a drum longitudinally disposed between said side constructions with remaining parts extending into the car well between said side constructions and between the trucks, transverse beam constructions rigidly joining the upper parts of said side constructions near the ends of the drum and combining therewith to form the load carrying supports for the drum, the major parts of the remainder of the steam generator depending from the drum, lower transverse struts extending beneath the steam generator and rigidly joining the side constructions, said remainder including water headers parallel to the drum and disposed adjacent said lower struts, steam generating tubes connecting the drum to said headers, inter-engaging and relatively movable vertical guide members secured respectively to the headers and said lower struts and preventing sidesway of the headers relative to said side constructions.

10. In a mobile steam generator installation including a railway car frame construction having underslung side trusses, transverse supports secured to the trusses at positions spaced longitudinally thereof and formed with openings aligned longitudinally of the car, a water tube steam generator including a drum disposed longitudinally of the car and having its end portions extending through said openings, other pressure parts of the steam generator including steam generating furnace wall tubes supported by longitudinal lower headers secured to the tubes depending from said drum, and means fixed to opposite sides of the drum and secured to one of said supports to provide a two-point support for one end of the drum, the other end of the drum movably resting on a part of the other support, guide means including vertically relatively movable parts secured respectively to the car frame construction and the ends of the headers corresponding to the fixed end of the drum, and other guide means at the opposite ends of the headers permitting longitudinal and vertical relative movements of the associated header ends and the car frame construction.

11. In a mobile steam generator installation including a railway car frame construction having underslung side trusses, upright supports secured transversely to the side trusses at positions spaced longitudinally thereof and formed with openings aligned longitudinally of the car, a water tube steam generator including a drum disposed longitudinally of the car and having its end portions extending through said openings, other pressure parts of the steam generator including lower headers and steam generating furnace wall tubes supported by and depending from said drum, guide means fixed to opposite sides of the drum and fixed to one of said supports to provide a two-point support for one end of the drum, said means being fixed against movement longitudinally of the car, the other end of the drum movably resting on a part of the other of said supports, guide means including vertically relatively movable parts secured respectively to the car frame construction and the ends of the headers corresponding to the fixed end of the drum, and other guide means at the opposite ends of the headers permitting relative longitudinal and vertical movements of the associated header ends and the car frame construction.

12. In a mobile steam generator installation including a railway car frame construction having underslung side trusses, upright transverse supports secured to the side trusses at positions spaced longitudinally thereof, a water tube steam generator including a drum disposed longitudinally of the car and having its end portions resting on said supports, other pressure parts of the steam generator including lower headers and steam generating furnace wall tubes supported by and depending from said drum, opposite trunnion means fixed to opposite sides of the drum near one end and secured to parts of one of said supports to provide a two-point support for that end of the drum, said means being fixed against movement longitudinally of the car, the other end of the drum movably resting on another part of said supports, guide means including vertically relatively movable parts secured respectively to the car frame construction and the ends of the headers corresponding to the fixed end of the drum, and other guide means at the opposite ends of the headers permitting relative longitudinal and vertical movements of the associated header ends and the car frame construction.

13. In a mobile steam generator installation including a railway car frame construction having underslung side trusses, upright transverse supports secured to the side trusses at positions spaced longitudinally thereof, a water tube steam generator including a drum disposed longitudinally of the car and having its end portions resting on said supports, other pressure parts of the steam generator including lower headers and steam generating furnace wall tubes supported by and depending from said drum, means fixed to opposite sides of the drum and secured to one of said supports to provide a two-point support for one end of the drum, said means being fixed against movement longitudinally of the car, the other end of the drum movably resting on a part of the other of said supports, guide means including vertically relatively movable parts secured respectively to the car frame construction and the ends of the headers corresponding to the fixed end of the drum, and other guide means at

the opposite ends of the headers permitting relative longitudinal and vertical movements of the associated header ends and the car frame construction.

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