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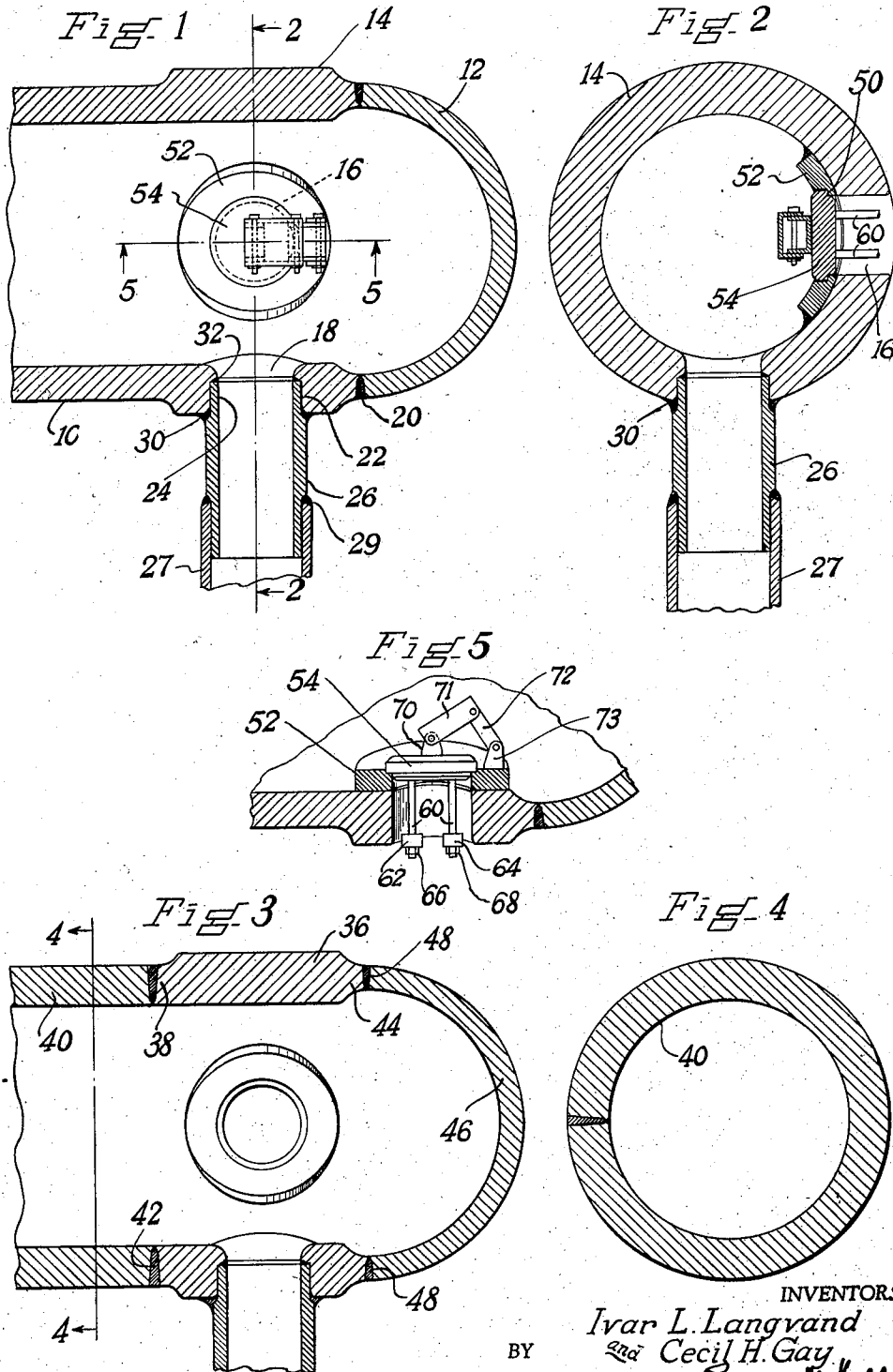
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2,271,652

WELDED PRESSURE VESSEL

Filed July 1, 1939

3 Sheets-Sheet 1



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3 Sheets-Sheet 2

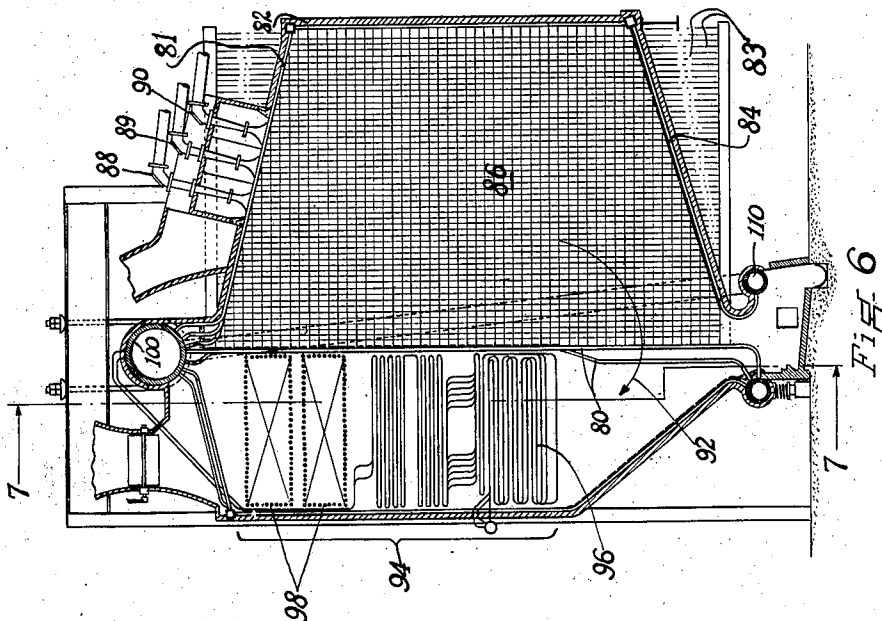


Fig. 6

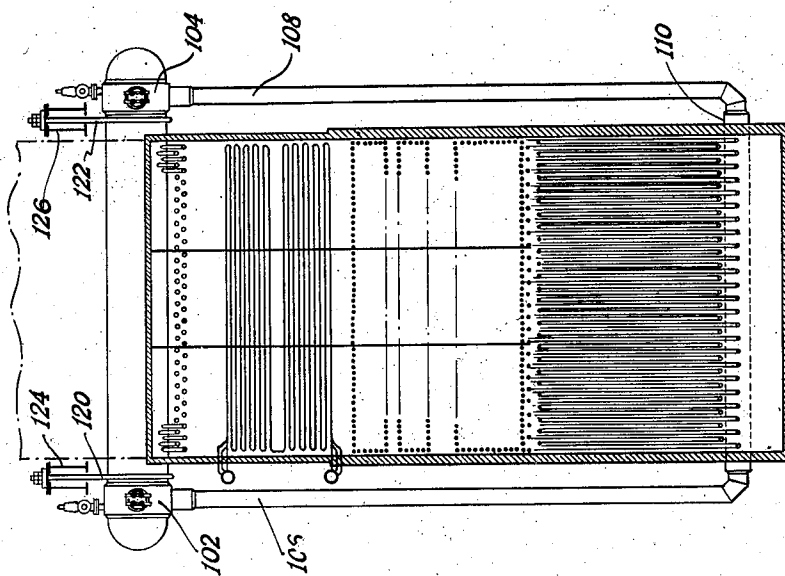


Fig. 7

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Fig. 8

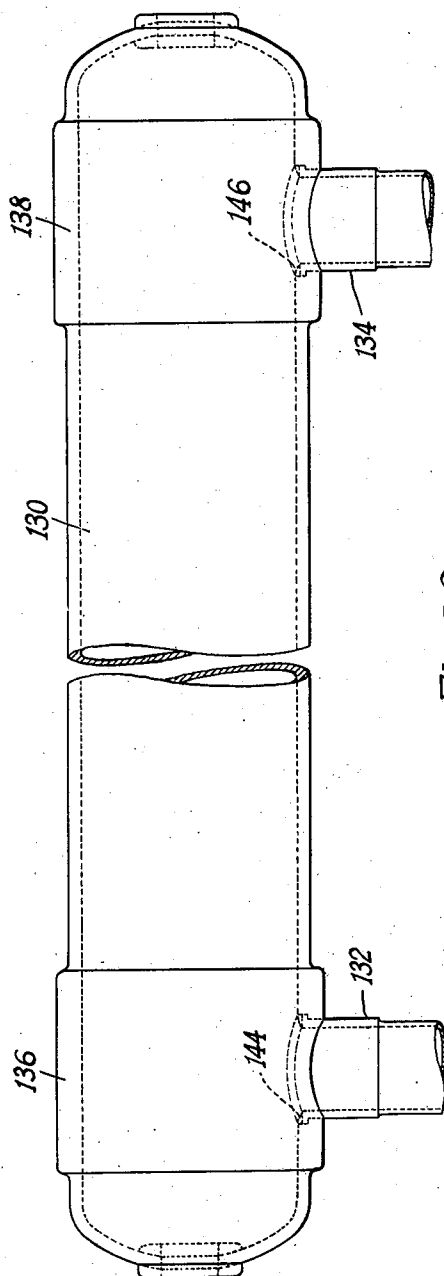
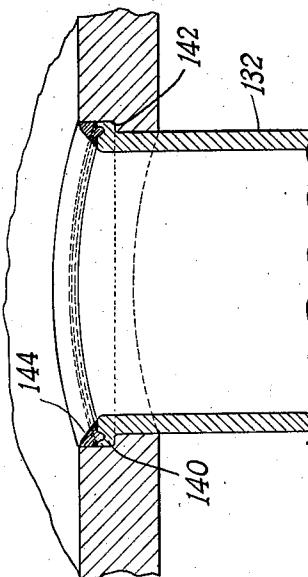


Fig. 9



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UNITED STATES PATENT OFFICE

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WELDED PRESSURE VESSEL

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6 Claims. (Cl. 122—365)

The invention relates to pressure vessels and more particularly to the heated class of pressure vessels of which steam boiler drums typify a commercially important group. These drums are constructed to operate at high pressure and with water and vapor at high temperatures as well. They must be so constructed that the necessary water and steam connections can be suitably made; in addition, they must be so constructed that they can be readily inspected and that such internal apparatus as is found desirable for high pressure steam generators can be readily inserted or replaced.

The advent of vapor pressures of over 1000 lb. per sq. in., together with temperature conditions encountered in present day steam generator practice, and in other industries such as oil treatment and distillation processes for other products, has out-moded certain practices in the construction and manufacture of pressure vessels due to the fact that the behavior of the metal in walls of great thickness required to withstand heavy pressures and subjected to severe temperature difference between outer and inner wall surfaces is of a character different from that where relatively low pressures and thin walls are used.

In the manufacture of relatively thin wall pressure vessels of metal of comparatively low tensile strength and of considerable ductility, and where the temperature difference between outer and inner wall surfaces is small, it has been the practice to permit of certain self-adjustments the vessel walls to take care of localized bending effects and stress conditions resulting from causes, such as eccentricity, out of roundness in cylindrical vessels, non-uniform radial dilation over the head and shell, and temperature effects; and such self-adjustments have taken place under predetermined working pressures and temperatures to relieve localized high stress conditions without serious consequences by reason of the fact that relatively low pressures and temperature conditions are involved and there is sufficient ductility of the thinner metal to permit of such compensatory adjustments.

However, in walls of extreme thickness, such as 4 inches or greater, and with material of a tensile strength of the order of 70,000 lb., ductility and mobility practically disappear; consequently, with pressures of 1000 lb. per sq. in. or more, and temperature differences of large magnitude between outer and inner wall surfaces due to greater wall thickness, self-adjustments may no longer be depended upon, and factors increas-

ing local stresses must be eliminated. This is one object of the present invention.

With higher pressures of the order of 1400 lb. per sq. in. and upward, the ratio of the specific weight of water to the specific weight of vapor decreases and as the differential heads inducing natural circulation in the usual boiler vary directly with that ratio it will be appreciated that such high pressure vapor generators must have good circulatory characteristics in order to secure effective and safe circulation and separation of vapor and liquid. (Ratio at 600 lb. per sq. in.=37; at 1400 lb. per sq. in.=13; at 2000 lb. per sq. in.=7.3.)

Large diameter downcomer conduits which are used to effect circulation improvement under such conditions cannot be effectively connected to the drum by a multiplicity of small expanded tubular conduits or by riveted flanged nozzles which are adequate with lower pressure units, for the connections must be such as to avoid appreciable fluid flow resistance, yet be of adequate structural strength to carry the loads imposed under varying temperature and pressure conditions.

It is an object of this invention to provide a boiler drum of the high pressure type, providing large diameter liquid connectors and access openings, in a manner which is adequate to meet the operating conditions and at the same time at a lower cost than in the prior constructions.

Another object of the invention is to provide a welded pressure vessel which has adequate ligament strength between openings formed in the vessel for a tubular connection or for access openings, without adding or leaving excess metal elsewhere.

Another object of the invention is to provide a pressure vessel of non-uniform wall thickness with no excess metal above the strength requirement when tubular connections are joined to the vessel at certain zones.

A further objective is to provide a cylindrical pressure vessel of the heavy wall, high pressure type with hemispherical heads, and in which the required openings are located in a special zone in a manner which introduces no appreciable stress raisers as respects the body and head, the heads being of thinner metal than the body or any portion of it.

Additionally, it may be stated that the invention provides a pressure vessel in which openings for external connections and for access are provided in such a manner that undesirable stress conditions are avoided.

In pressure vessels for fluid under high pressure there must be provided connections for fluid movement and for access to the vessels. Pressure vessels used for industrial fluid processes usually have cylindrical bodies with heads of some suitable form and when diameters are large or pressure high, or both, their walls must be quite thick, perhaps several inches, to keep metal stresses within safe limits. Such connections or openings as must be provided are for the admission or discharge of fluid, for safety valves, and for other accessories, and in some cases openings are also provided for periodic inspection.

For numerous purposes to which pressure vessels are adapted these connections must be radially located in the wall of the cylindrical body with a consequent tendency to weaken the structure. To remedy this condition many different ways of re-inforcing the metal near the holes have been devised and used but all have limitations, especially when the walls are quite thick as is required for large diameters and high pressures. Pressure vessels of this class are now normally fabricated from rolled steel plate bent to cylindrical shape and with edges fusion welded together. This invention provides a method of constructing fusion welded pressure vessels with high safety factors in spite of the fact that they are provided with radial connections of large diameter.

The invention provides a pressure vessel having a short cylindrical section of the same internal diameter as the main cylindrical body of the pressure vessel but of larger external diameter and of greater wall thickness, and having the openings in the short and thick section for the large openings necessary for said connections. The length and thickness of the short cylindrical section is such as to keep the necessary metal stresses low enough for safety. The ends of this section are reduced in thickness to the same thickness as that of the cylindrical section to which it is fusion welded, or to the head, thus insuring equal diametrical expansion under internal pressure of the metal on both sides of the circumferential weld. To avoid local concentration of stresses in the thicker section due to its lesser thickness at its end than in its body, the change of thickness is made gradual.

An additional feature of the invention resides in the manner and method by which connections are made to the thick cylindrical section.

With the above and other objects in view the invention will now be described in detail in connection with the accompanying drawings illustrating the same.

In the drawings:

Fig. 1 is a longitudinal vertical section of a portion of a pressure vessel constructed in accordance with the present invention;

Fig. 2 is a sectional view on the line 2—2 of Fig. 1 looking in the direction of the arrows;

Fig. 3 is a view similar to Fig. 1 of a modified form of pressure vessel;

Fig. 4 is a sectional view on the line 4—4 of Fig. 3, looking in the direction of the arrows;

Fig. 5 is a fragmentary sectional view on the line 5—5 of Fig. 1, showing the particular construction by which the manhole cover is arranged relative to the drum;

Fig. 6 is a vertical section of a steam generating installation in which the illustrative pressure vessel is employed;

Fig. 7 is a vertical section on the line 7—7 of Fig. 6;

Fig. 8 is a side elevation of a drum with which downtake elements are associated in a modified manner; and

Fig. 9 is a detail view indicating in section the manner of securing the downtake connections of the Fig. 8 drum.

The pressure vessel indicated in Fig. 1 has two components, namely, the body 10 and the hemispherical head 12 welded thereto. The body 10 may be a forging or the like integral with which is a port section 14 having a wall thickness greater than the remainder of the body 10, or the head 12. This accommodates large openings or ports 16 and 18, the increase in wall thickness compensating for the weakening due to the size of the openings. The end of the port section 14 is graduated in thickness down to the thickness of the hemispherical drum head 12 so that good welding conditions are provided.

The drum head 12 has its center in the longitudinal axis of the drum and is hemispherical in outline. This head is united with the port section 14 by a suitable girth weld 20.

One of the openings 16 or 18 may be counter-bored as shown at 22 to receive the reduced end 24 of a tubular downcomer connector or the like 26. The connector is strength welded as at 30 to the port section 14 while a seal weld 32 unites the thinner end 24 with the port section 14 on the drum interior. A large diameter downcomer 27 may be telescoped over the lower end of the connector 26 and welded thereto as indicated at 29.

It is to be noted that while the body 10 of the drum, the port section 14, and the hemispherical head 12 are of different wall thicknesses, nevertheless all are concentric so that there is a minimum of "out-of-roundness" to set up stresses and, furthermore, the body 10 and port section 14 are of the same internal diameter.

In Figs. 3 and 4 the construction is like that disclosed and described in reference to Fig. 1 except that the port section 36 is separate and at one end has a reduced section 38 of the same thickness as the body 40 for welding as at 42. The other end of the port section 36 is tapered as at 44 for effective union with the spherical head 46 by the weld 48.

The port or opening 16 indicated in Figs. 1, 2, and 3 may be of sufficient size to admit a workman to the interior of the drum and it may be closed by a flanged plug or manhole cover 54 having its flange arranged within the drum and fitting a seat 50 formed in a manhole cover seat ring 52 welded to the drum, as shown.

The cover 54 for the access opening 16 is shown in Fig. 5 to be in its drum closing position. It is held in this position by mechanical means involving the stud bolts 60. These bolts are preferably rigid with the cover and they extend through yokes 62 and 64 which are disposed across the opening. Nuts 66 and 68 are screw-threaded upon the bolts and tightened against the yokes 62 and 64 to maintain the cover in its operative position.

The cover 54 is also so arranged with reference to its seat in the ring 52 that the pressure of steam within the drum tends to maintain the cover tightly seated against the ring. The cover is supported within the drum by pivotally connected elements 70—73 which are so arranged as to permit the cover and its securing bolts 60 to be initially moved toward the interior of the drum without any substantial pivotal movement of the cover itself. After the bolts 60 have moved

to a position within the drum the cover and its attached bolts may be swung to one side so as to permit access to the drum. The cover is, however, so held by the elements 70-73 that, when it is swung toward closing position, it will be accurately seated within the recess formed therefor in the ring 52.

Figs. 6 and 7 of the drawings illustrate the high pressure water tube steam generator in which the illustrative drum construction is employed. This installation operates at steam pressures of the order of 2200 lb. per sq. in., the major part of the steam being generated in the wall tubes 80-84 defining the boundaries of the furnace 86. Burning fuel is projected downwardly into this furnace by the action of the burners 88-90 and the furnace gases flow from the furnace as indicated by the arrow 92 to a convection section 94 which includes the superheater 96 and the economizer 98.

The drum 100 of the illustrative steam generator is constructed at each end in the manner previously described, the thicker annular sections 102 and 104 near the ends of the drum having the large diameter downcomers 106 and 108 connected thereto. These downcomers are shown as communicating at their lower ends with the header 110 which may supply fluid for the furnace wall steam generating tubes 81-84.

The drum 100 is supported by straps 120 and 122 arranged adjacent the thicker drum sections 102 and 104 and secured at their upper ends to the beams 124 and 126.

By reason of the securement of many of the steam generating tubes of the unit directly to the drum 100 the drum, between its supports 124 and 126, acts as a support for a considerable part of the entire unit. However, the arrangement of the hangers or drum straps 120 and 122 between the central part of the drum and the downcomers 106 and 108 affords an arrangement of elements wherein the load comprising the weight of the drum and the parts secured thereto is advantageously distributed.

The illustrative method of pressure vessel construction involving the addition of an annular section at the end of the drum where the manhole openings and other large connections are made affords an advantageous means for supplying the annular section required for such openings and results in improved stress conditions in the entire shell of the vessel. Furthermore, it affords manhole connections or other tubular connections in which there is a possibility of X-raying the weld. This method of providing downcomer connections also eliminates a great number of smaller tubes which would otherwise be required and this, in turn, greatly reduces the length of the drum and effects a consequent saving in material.

In heavy drums for high pressures, it is practically impossible to fabricate drum heads having manholes of adequate thickness to safely withstand the pressures. This invention meets this situation by affording a method of drum manufacture in which the manhole can be placed in some other part of the drum. The hemispherical drum head construction involved in the illustrative drum permits the manufacturer to use drum head plate which is much thinner than that which would otherwise be required. Such a drum head is subject to comparatively accurate analysis and the relative thickness of the port section of the drum and the hemispherical drum head can be accurately set to eliminate all tran-

verse bending stresses throughout the head and the shell adjacent the head. This is a highly advantageous feature in the manufacture of thick drum shells, because localized bending effects become very dangerous in thick plate constructions due to the great reduction in the ductility over the section of such plates. The illustrative construction reduces to a minimum the localized bending effects due to eccentricity and non-uniform radial dilations over the head and shell. Furthermore, the elimination of manhole openings from the drum head and the use of unpierced hemispherical heads results in the very reasonable head thickness and thickness of girth weld to the shell for the highest pressure, thus greatly facilitating the fabrication of such vessels.

The drum 130 shown in Fig. 8 of the drawings may be constructed in accordance with the above described methods, but the downtake elements 132 and 134 are so associated with the re-enforced drum sections 136 and 138 that the entire load is transmitted directly to those sections. This takes place by reason of the seating of the shoulders 140 in correspondingly formed recesses 142 in the drum wall. This method of attaching the downcomer connections eliminates the necessity of relying entirely upon weld metal for the safety of the structures. The shoulders on the downcomer elements 132 and 134 take the full pressure load without any assistance from the welds 144 and 146. In this modification these welds are primarily seal welds, their main function being to maintain pressure-tight joints between the downcomer connections and the drum.

What is claimed is:

1. In a drum adapted to withstand high fluid pressures, a main body portion provided with a plurality of small diameter tube seats for lateral tube connections, a dished end section adapted to close the end of the drum, and an intermediate annular section of a wall thickness greater than that of the main body portion and also greater than the wall thickness of the end section, said intermediate section being provided with a large diameter access opening, said end section being united with one end of the intermediate section and in axial alignment therewith by a girth weld, said main body portion being also circumferentially welded to the other end of the intermediate section and in axial alignment therewith.

2. A welded pressure vessel comprising, a main body portion of one wall thickness, an annular section of greater wall thickness and provided with circulation and access openings, and a head of hemispherical outline and of a wall thickness less than that of said annular section; the head, annular section, and body portion being welded together.

3. In a pressure vessel, a first annular body in the form of a hollow cylinder, a second annular body of the same internal diameter as the first body and united with the first body by a circumferential weld, the ends of the structure formed by the two bodies being normal to the longitudinal axis of the structure, the second body being of greater external diameter and greater wall thickness than the first body and being provided with a lateral opening with its axis passing through and normal to the axis of the entire structure, and an imperforate hollow head of substantially hemispherical outline welded to the second annular section to close an end of the vessel.

4. In a cylindrical pressure vessel, a hollow

cylindrical body having an annular section formed with large diameter access and circulation openings, said annular section being of a wall thickness greater than the remainder of said body to compensate for the weakening effect of said openings, and end sections of substantially hemispherical contour welded to said body to close the ends of the vessel.

5. In a drum adapted to withstand high fluid pressures, having a main body portion provided with a plurality of small diameter tube seats for lateral tube connections, a dished end section adapted to close the end of the drum, an intermediate annular section at least a part of which is of a wall thickness greater than that of the main body portion and also greater than the wall thickness of the end section, said intermediate section being provided with a large diameter opening, and a large diameter tubular element fitting within said opening to extend outwardly of the drum and having a circumferential flange seated outwardly against the drum metal marginal to said opening, said first mentioned section being united with one end of the intermediate section and in axial alignment therewith by a girth weld, said main body portion being also circumferentially welded to the other end of the intermediate section and in axial alignment therewith.

6. In a pressure vessel or drum adapted to withstand high fluid pressures, a main body portion provided with a plurality of small diameter tube seats for lateral tube connections, a dished end section adapted to close the end of the drum, an intermediate annular section at least a part of which is of a wall thickness greater than that of the main body portion and also greater than the wall thickness of the end section, said intermediate section being provided with a large diameter opening, the thicker metal of said intermediate annular section marginal to said opening being formed to provide a circumferential shoulder facing inwardly of the drum, and a tubular member extending laterally of the drum and having a circumferential flange seated against said shoulder and welded to the adjacent drum metal, said first mentioned section being united with one end of the intermediate section and in axial alignment therewith by a girth weld, said main body portion being also circumferentially welded to the other end of the intermediate section and in axial alignment therewith.

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