Dec. 21, 1954 A. KIRKPATRICK 2,697,790

UNIT TURBINE-GENERATOR PLANT WITH SURFACE CONDENSER ARRANGEMENT AND SUPPORT

Filed Jan. 6, 1953

3 Sheets-Sheet 1

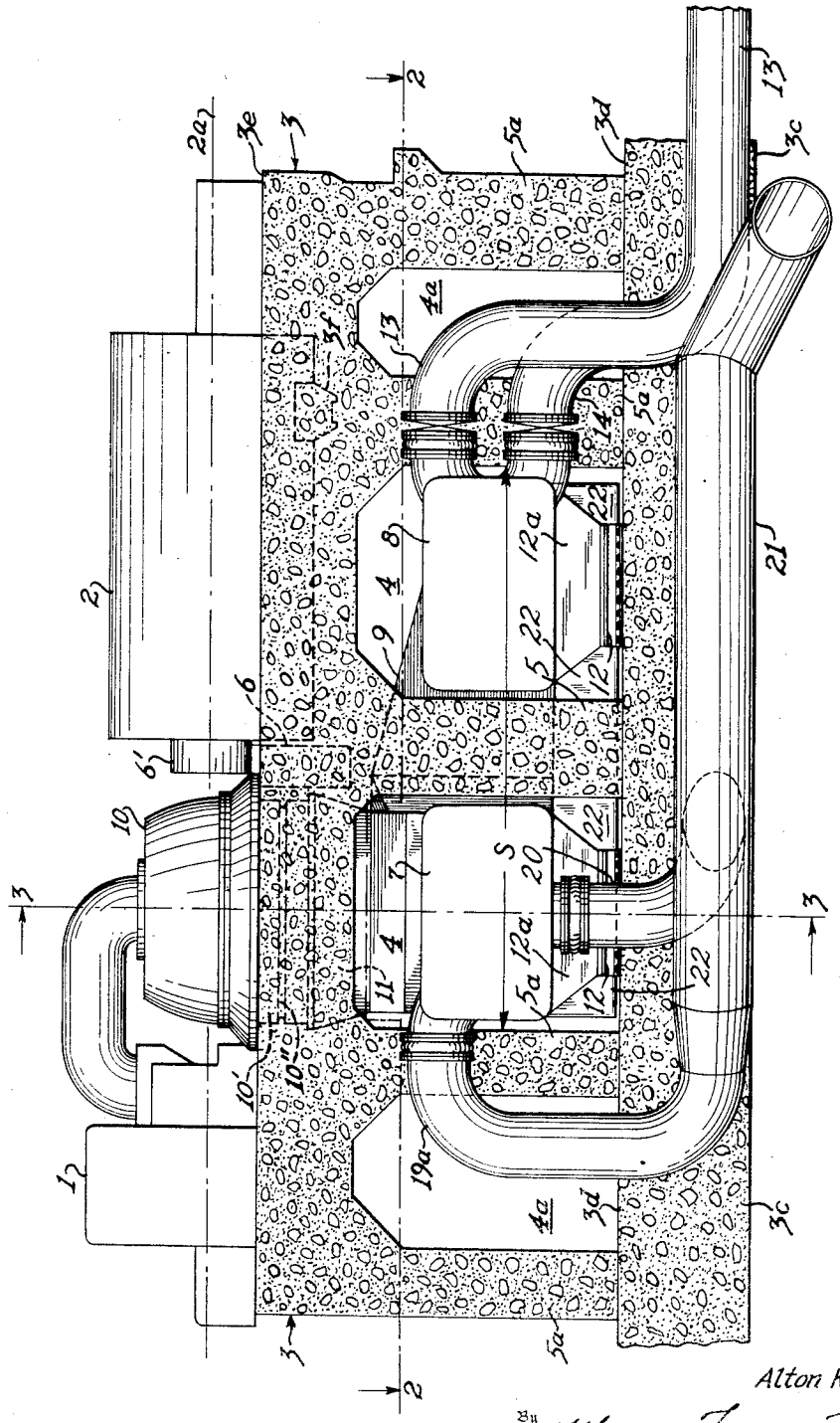


Fig. 1

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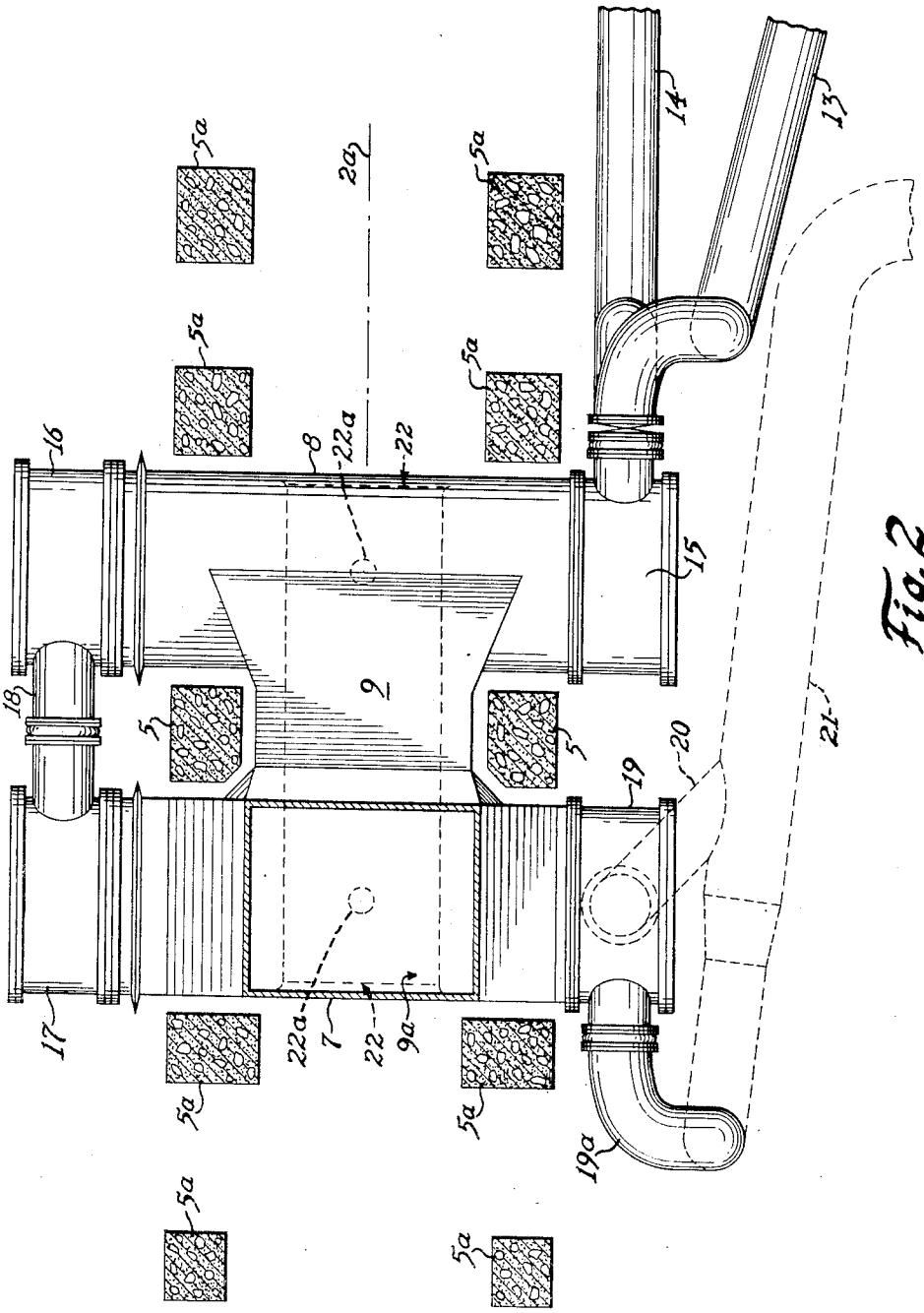


Fig. 2

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Fig. 3

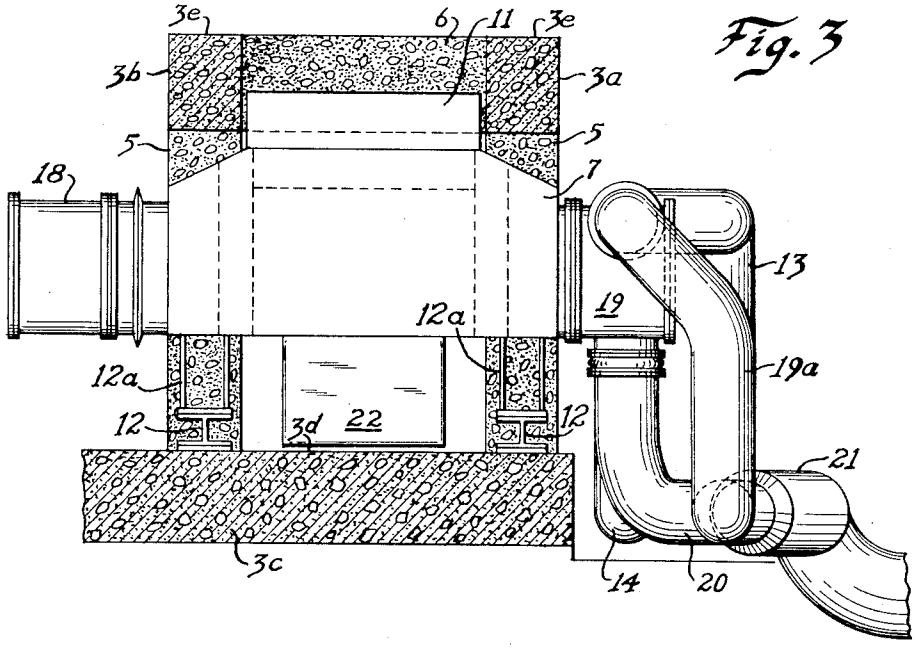
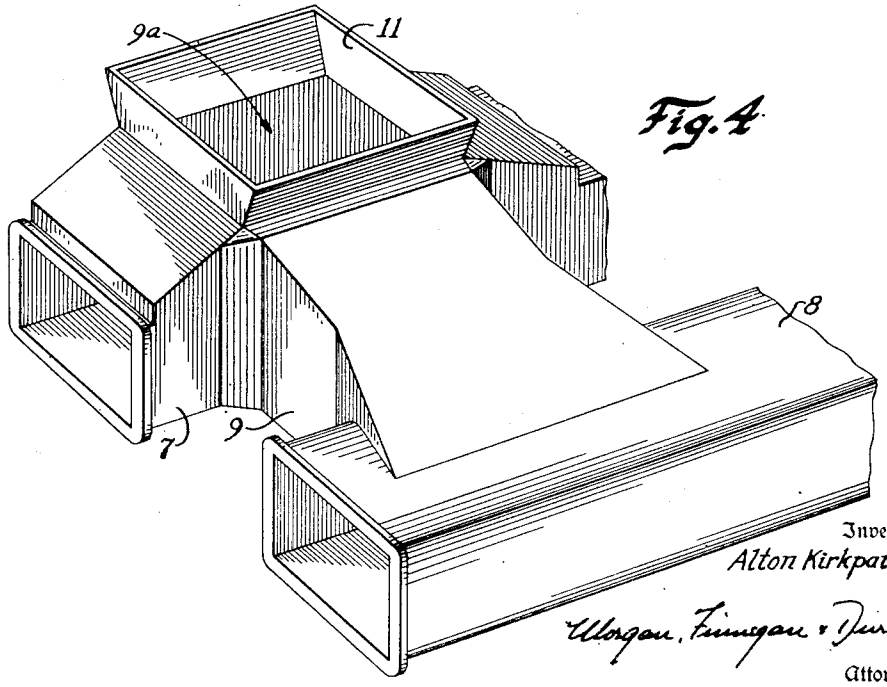


Fig. 4



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UNIT TURBINE-GENERATOR PLANT WITH SURFACE CONDENSER ARRANGEMENT AND SUPPORT

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Application January 6, 1953, Serial No. 329,898

14 Claims. (Cl. 290—52)

This invention relates to power plants having a turbine driving a generator and exhausting to a condenser such as are employed in steam electric power stations and relates more particularly to the construction and arrangement of the foundation and the auxiliary surface-condensing equipment in such power plants.

The invention consists in the novel parts, constructions, arrangements, combinations and improvements herein shown and/or described.

Heretofore, large condensers required as auxiliary surface condensing equipment for the proper and efficient operation of large turbine generator units have conventionally been of the so-called single shell type. Such condensers are ordinarily located between the turbine generator floor and the condenser floor directly under the turbine generator unit, either crosswise thereof or in longitudinal alignment therewith. Also, in prior practices, where a two pass condenser was utilized, the condenser was constructed with the passes side-by-side, in an integral single shell unit either in longitudinal alignment with the turbine generator unit or crosswise thereof.

These prior arrangements have been devised to maintain satisfactory condensing equipment performance and to provide sufficient structural support for the turbine generator unit. However, these practices have resulted in excessive construction costs and other difficulties as well, traceable in substantial measure to the large so-called floor-to-floor height between the condenser floor and turbine generator unit floor.

Speaking generally, the present invention provides a construction and arrangement of the foundation and auxiliary surface condensing equipment for turbine generator units of the nature aforesaid, wherein ample structural support for such unit and equipment is provided but with substantially less floor-to-floor height and with less span of the condenser portal than has heretofore been deemed possible for a given unit, thus substantially reducing construction costs without materially increasing condenser cost or adversely affecting performance of the condensing equipment.

Briefly, this is accomplished by providing a novel divided condenser unit, crosswise of the turbine generator-condenser foundation and the turbine-generator axis, comprising separate but interconnected condenser sections which lie substantially side-by-side, spaced apart one from the other, between the turbine generator floor and the condenser floor of the foundation. The shell of one condenser section is disposed directly below the turbine exhaust and the other below the generator. Advantageously, the condenser section below the turbine exhaust may be the second water pass and the condenser section below the generator the first water pass. If found desirable, the water passes may be interchanged between the condenser sections. The two condenser sections are interconnected on the water side by suitable pipe connections between their water boxes. On the steam side the shells are interconnected by a steam distributor extending from the side of one shell to the nearer side of the other. This steam distributor is so designed that preferably part of the steam from the turbine exhaust is diverted by turning vanes or other suitable baffle means to the first pass condenser section below the generator. The remaining steam flows to and through the condenser section below the turbine exhaust and thence to the first pass condenser section below the generator. The foundation for the turbine generator unit and divided condenser unit is suitably fashioned to provide

a condenser portal in which the condenser unit is installed with a hot well common to both condenser sections and the interconnecting steam distributor. Preferably, part of the foundation is of a configuration to provide intermediate structural columns in the condenser portal between the two condenser sections at both ends, the columns rising vertically from the condenser floor to the portal cap. These portal columns, by reducing the span of the condenser portal, serve to strengthen the structure and to provide additional structural support for the turbine-generator unit over the portal span. Preferably, also a beam is provided for supporting the bearing between the turbine and generator above the generator floor. This beam connects between the portal columns and spans the foundation over the interconnecting steam distributor.

The accompanying drawings, referred to herein and constituting a part hereof, illustrate a typical and illustrative embodiment of the invention and, together with the description, serve to explain the principles of the invention.

Of the drawings:

Fig. 1 is a side elevational view of the typical and illustrative embodiment showing the general arrangement of the parts in a typical power station installation, and the manner in which certain of the structural columns of the foundation shorten the portal span in particular;

Fig. 2 is a view in section, with the condenser installation in plan, taken along the line **2—2** of Fig. 1;

Fig. 3 is a view in section, with the condenser installation in elevation, taken along the line **3—3** of Fig. 1; and

Fig. 4 is a fragmentary view in perspective of the outer shell of the divided condenser unit of Figure 2, showing details of the steam distributor interconnecting the shells of the condenser sections.

Referring now in detail to the illustrative embodiment of the invention shown in the accompanying drawings, a turbine generator unit comprising a steam driven turbine **1** and generator **2** (driven by the turbine) is supported at a determined level above the base grade by a foundation indicated generally by the numeral **3**, the rotational axis of the unit being indicated generally by the numeral **2***a*.

The foundation **3** is preferably a concrete structure and is characterized generally by spaced parallel right hand and left hand side walls **3***a* and **3***b*, respectively, as best seen in Fig. 3, rising from a suitable base **3***c* whose top is horizontal and forms a condenser floor **3***d*. The side walls terminate at their top each in a horizontal surface **3***e*, the surfaces **3***e* together forming a turbine floor. The turbine generator unit is supported by and between the side walls in conventional manner as by suitable supporting members carried by the side walls.

Each of the side walls **3***a* and **3***b* is of a configuration to provide in each a pair of openings **4** together forming with corresponding openings in the opposite side wall a condenser portal of span S as indicated in Fig. 1. The portion of each side wall between the pair of openings **4** forms a load-supporting portal column **5** which, in effect, reduces the span of the portal, and serves to strengthen the foundation and to provide additional structural support for the turbine generator unit over the portal span. Advantageously, the side walls **3***a* and **3***b* are also of a configuration providing a number of other portals **4***a* and supporting column portions **5***a* in order to achieve savings in construction cost and provide for necessary access within the foundation.

A cross beam **6** spans the foundation **3** between the portal columns **5** and serves to support the bearing **6'** between the turbine and generator above the turbine floor **3***e*. In the construction shown, the portal columns are located substantially on the center line of the beam **6** which is the preferred structural design although under some circumstances it may be advantageous to have the cross beam **6** and portal columns **5** separated longitudinally of the turbine generator axis.

A divided condenser unit comprising shell and tube condenser sections **7** and **8** and an interconnecting steam distributor **9** is disposed cross-wise of the turbine-generator axis **2***a* in the condenser portal formed by the openings **4**. The condenser sections are positioned side-by-side but are separated one from the other (spaced

apart) by the portal columns 5 rising upwardly therebetween at both ends of the condenser unit. The condenser sections are interconnected on the steam side by the interconnecting steam distributor 9 providing a steam connection leading from the side of one condenser shell to the nearer side of the other.

The condenser section 7 is disposed directly beneath the turbine exhaust unit 10 to which the interconnecting steam distributor 9 is suitably joined by means of a steam inlet coupling flange 11 coacting with the turbine exhaust neck 10', the latter providing an expansion joint 10'' between the turbine exhaust unit 10 and the underlying condenser section. The expansion joint 10'' serves to preclude the possibility of imposing undue moments on the turbine exhaust unit 10. The condenser section 8 is disposed beneath the generator 2.

The steam distributor 9 is so constructed and arranged that part of the steam from the turbine exhaust unit 10 is diverted to the condenser section 8 below the generator, while the remaining portion flows directly to and through the condenser section 7. Turning vanes or other suitable directing baffle means (not shown) are provided in the steam distributor 9 adjacent its main inlet opening 9a, for diverting part of the steam to the condenser section 8. It will be understood that in the case of a double flow low pressure turbine element, the maximum steam velocity will be approximately beneath the last row of blades and this condition is well suited to the use of a divided condenser in accordance with this invention.

The condenser sections 7 and 8 are supported on I-beams or other suitable support members 12 carried by the foundation floor 3d, by means of brackets 12a integral with and extending downwardly from the respective shell sections 7 and 8 adjacent the ends of each. By reason of the expansion joint 10'' between the turbine exhaust unit and the condenser section 7, the latter may be securely bolted down to its support members 12 in a plane through the exhaust center line. The condenser section 8 under the generator may be permitted to move longitudinally of the foundation in which case its support members 12 may be slotted longitudinally to permit necessary sliding movement of the hold-down bolts (not shown). No expansion joint is then required between the condenser sections.

In the divided condenser embodiment illustrated, the condenser section 7 beneath the turbine exhaust constitutes the second water pass, the condenser section 8 beneath the generator the first water pass. To this end, cooling water inlet pipes 13 and 14 lead into the forward water box 15 of the first pass condenser section 8 whose rear water box 16 is connected to the rear water box 17 of the second pass condenser section 7, by transfer pipes 18. The forward water box 19 of the condenser section 7 is connected by cooling water outlet pipes 19a and 20 to the header outlet pipe 21. Suitable water connections when the first pass is beneath the turbine exhaust and the second pass beneath the generator will be apparent to those skilled in the art as is obvious from the foregoing.

A suitable hot well section unit 22 common to both condenser sections 7 and 8 and to their interconnecting steam distributor 9 is disposed therebelow for receiving the steam condensate therefrom, and may be provided in known manner with a suitable condensate draw-off (not shown).

In the operation of the above-described device, high velocity steam leaving the last row of blades of the turbine 1 is conducted by the turbine exhaust unit 10 through the main steam inlet 9a into the shell of the condenser section 7 via the passageway formed by the turbine exhaust neck 10' and the coupling flange 11 of the steam distributor 9. The turning vanes or other baffle means disposed in the inlet opening of the steam distributor 9 divert a part of the entering stream laterally through the distributor 9 into the shell of the first pass condenser section 8. The remaining steam flows directly into the shell of the second pass condenser section 7, is condensed in part therein, and the uncondensed portion conducted by the distributor 9 into the shell of the first pass condenser section.

Condensation of the exhaust steam in the condenser sections is effected by indirect heat exchange with the cooling water circulated through the requisite tube bundles in the respective condenser sections. In general, cooling water supplied by the inlet pipes 13 and 14 to the forward water box 15 passes seriatim therefrom through the tube bundle in condenser 8, rear water box 16, transfer pipes 18, rear water box 17, the tube bundle in condenser section 7, front water box 19 and cooling water outlet pipes 19a and 20 to the discharge header 21. The steam condenses on the condenser tubes and the resulting condensate flows by gravity from suitable openings 22a in the bottom of the respective condenser section shells into the common hot well unit 22 from which it is discharged in any suitable manner.

With the divided condenser arrangement illustrated and described, the vertical height between the condenser floor and the turbine floor may be substantially less than is obtainable under prior practices.

This is illustrated by, but not restricted to, the following example: A condenser of 65,000 square feet condensing surface area and an 80,000–100,000 kilowatt turbine-generator unit, disposed as described and illustrated, requires a condenser floor to turbine floor height of only 20 feet. This compares to a floor-to-floor height of 29 feet-6 inches required for this size condenser in a conventional single shell, and for smaller units the floor-to-floor height could be reduced to 18 feet. Moreover, the construction described and illustrated provides needed direct support at the precise point required, i. e., the bearing between the turbine and generator above the turbine floor.

It will be understood that this invention is not limited to the details described above and illustrated in the drawings, except as appears hereinafter in the appended claims.

What is claimed is:

1. A power plant comprising an axially aligned steam turbine and generator unit; a two-pass condenser positioned in a horizontal plane beneath said unit, the passes disposed side-by-side but spaced apart one from the other crosswise of the axis of said turbine-generator unit; a structure to support said turbine-generator unit and condenser, part of said structure extending upwardly through the space separating said passes to provide support for said turbine-generator unit; and, means to discharge exhaust steam from the turbine of said unit into said condenser.

2. A power plant comprising an axially aligned steam turbine and generator unit; a two-pass condenser positioned in a horizontal plane beneath said unit, the passes disposed side-by-side but spaced apart one from the other; a structure to support said turbine-generator unit and condenser, part of said structure extending upwardly through the space separating said passes to provide support for said turbine-generator unit; and, means to discharge exhaust steam from the turbine of said unit into said condenser.

3. A power plant comprising a steam turbine; a generator driven by said turbine, the axes of said turbine and generator being coaxially aligned; a floor to carry said turbine and generator; a two-pass condenser positioned in a horizontal plane beneath said turbine and generator, each of the passes being crosswise of the axis of said turbine and generator and disposed side by side spaced apart one from the other; means to discharge exhaust steam from said turbine into said condenser; a foundation floor to support said condenser; and, means extending upwardly from said foundation floor to the first mentioned floor to support said first mentioned floor, part of the second mentioned means extending upwardly through the space separating said passes.

4. A power plant comprising a turbine-generator unit including a horizontal turbine having an exhaust unit for exhausting steam downwardly to a condensing surface, and a generator in axial alignment with said turbine to be driven thereby; a foundation for supporting said turbine-generator unit constructed and arranged to provide a condenser floor, a turbine generator floor, and a condenser portal between said floors, said foundation having a load-supporting structural column portion vertically dividing said portal between its top and said condenser floor into side-by-side openings; and, a divided condenser unit in said portal cross-wise of the turbine-generator axis, said condenser unit comprising a first condenser section in one of said openings at one side of said column portion directly below said turbine exhaust unit, a second condenser section disposed in the other of said openings at the other side of said column portion below said generator, and a steam distributor interconnecting said condenser sections for directing

steam from said turbine exhaust unit to the said condenser unit.

5. A power plant comprising a turbine-generator unit including a horizontal turbine having an exhaust unit for exhausting steam downwardly to a condensing surface, and a generator in axial alignment with said turbine to be driven thereby, and a bearing between said turbine and generator; a foundation for supporting said turbine-generator unit constructed and arranged to provide a condenser floor and a turbine-generator floor, said foundation having parallel side walls each apertured to provide a condenser portal between said turbine and condenser floors and each having a load-supporting portal column intermediate the portal side walls whereby the span of said portal is reduced and pairs of aligned openings are provided at opposite sides of said portal columns; a cross beam for supporting the bearing between said turbine and generator above the turbine floor, said cross beam connecting said side walls substantially at said turbine floor; and, a divided condenser unit in said portal cross-wise of the turbine-generator axis, said condenser unit comprising a first condenser section disposed in the pair of aligned openings at one side of said portal columns directly below said turbine exhaust unit, a second condenser section disposed in the pair of aligned openings at the opposite side of said portal columns below said generator, and a steam distributor interconnecting said condenser sections for directing steam from said turbine exhaust unit to said condenser unit.

6. A power plant in accordance with claim 5 in which said cross-beam connects between said portal columns and spans said interconnecting steam distributor.

7. A power plant in accordance with claim 5 in which said condenser sections are each a shell and tube unit connected on the shell side by said steam distributor, said steam distributor being connected to said turbine exhaust unit and being constructed and arranged to divert a portion of the steam from said exhaust unit into the shell of said second condenser section and to direct the remaining portion directly into and through the shell of said first condenser section into the shell of said second condenser section.

8. A power plant in accordance with claim 7 in which said steam distributor is flexibly coupled to said turbine exhaust unit.

9. A power plant in accordance with claim 5 in which said condenser sections are connected on the water side to provide a two-pass condenser.

10. A power plant in accordance with claim 5 in which said first condenser section is the second water pass.

11. A power plant in accordance with claim 5 including means carried by the condenser floor of said foundation in the openings at each side of said intermediate load-supporting portal columns for supporting said divided condenser unit.

12. A power plant in accordance with claim 11 in which said first condenser section is fixedly supported by said supporting means and said second condenser section is flexibly supported by said supporting means for horizontal movement relative to said first condenser section.

13. A power plant in accordance with claim 5 including a hot well common to said condenser sections and said steam distributor.

14. A power plant comprising a steam turbine; a generator driven by said turbine, the axes of said turbine and generator being coaxially aligned; a floor to carry said turbine and generator; a two-pass condenser positioned in a horizontal plane beneath said turbine and generator, each of the passes being crosswise of the axis of said turbine and generator and disposed side by side spaced apart one from the other; means to discharge exhaust steam from said turbine into said condenser; a foundation floor to support said condenser; and, means extending upwardly from the space separating said passes to said first mentioned floor, for supporting said first mentioned floor.

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