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Csanady, Jr. et al.
[11] 3,910,381
[45] Oct. 7, 1975

[54] LUBRICATING OIL SYSTEM INTEGRAL WITH STRUCTURAL STEEL TURBINE FOUNDATION

[75] Inventors: **Michael Csanady, Jr.**, Ridley Park; **Frank O. Burckhalter**, Newtown Square, both of Pa.

[73] Assignee: **Westinghouse Electric Corporation**, Pittsburgh, Pa.

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[52] **U.S. Cl.** **184/6;** 60/DIG. 3; 60/39.31; 290/52

[51] **Int. Cl.**[2] **F01M 5/00**

[58] **Field of Search** 184/6, 6.11, 39.08, 39.31; 60/DIG. 3; 165/72; 290/DIG. 7, 52

[56] **References Cited**

UNITED STATES PATENTS

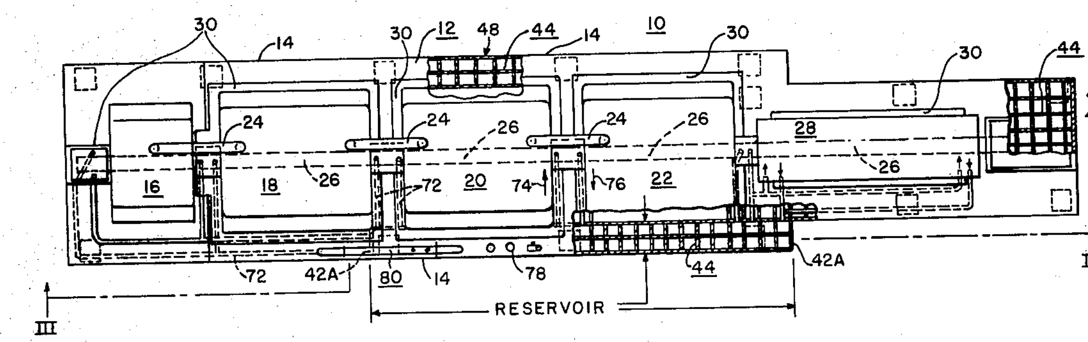
2,124,395	7/1938	Caughey	184/6
3,005,518	10/1961	Jassniker	184/6.11
3,290,793	1/1967	Davies	184/6
3,623,573	11/1971	Csanady	184/6

Primary Examiner—Richard C. Pinkham
Assistant Examiner—Marvin Siskind
Attorney, Agent, or Firm—G. M. Medwick

[57] **ABSTRACT**

A support foundation for a turbogenerator power plant having an oil lubricating system integral with the structural steel of the foundation. An oil reservoir with associated pumping and conduit arrangements are disposed within the structural steel box beams utilized to fabricate the turbine foundation. Provision of the reservoir and associated pumping and conduit arrangements within the structural steel box beams provides a more efficient utilization of available operating floor space and a more efficient operation of the lubricating system.

8 Claims, 4 Drawing Figures



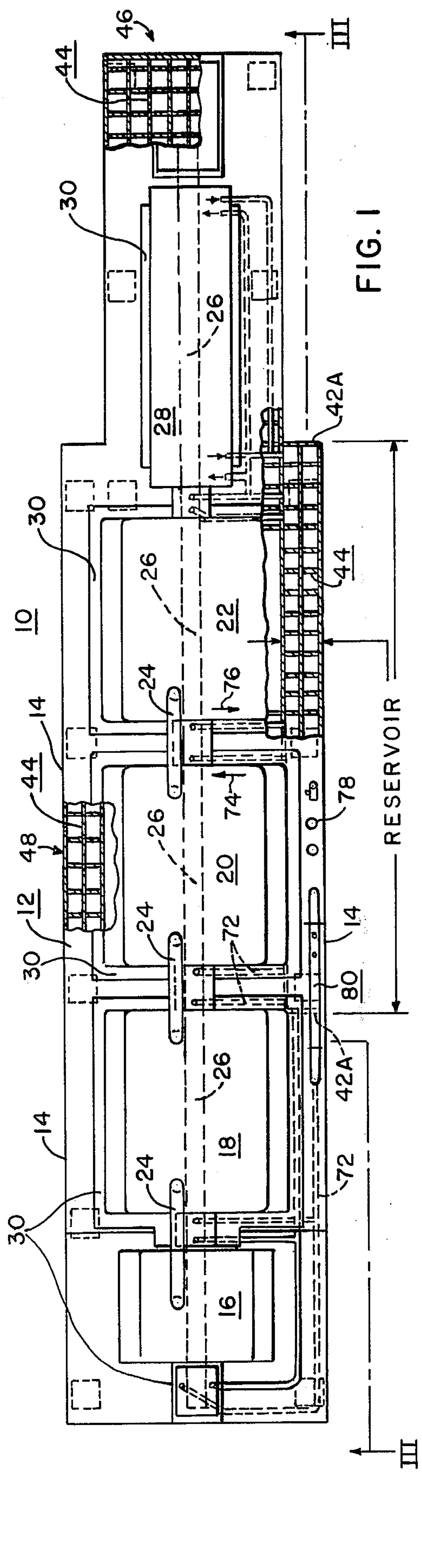


FIG. 1

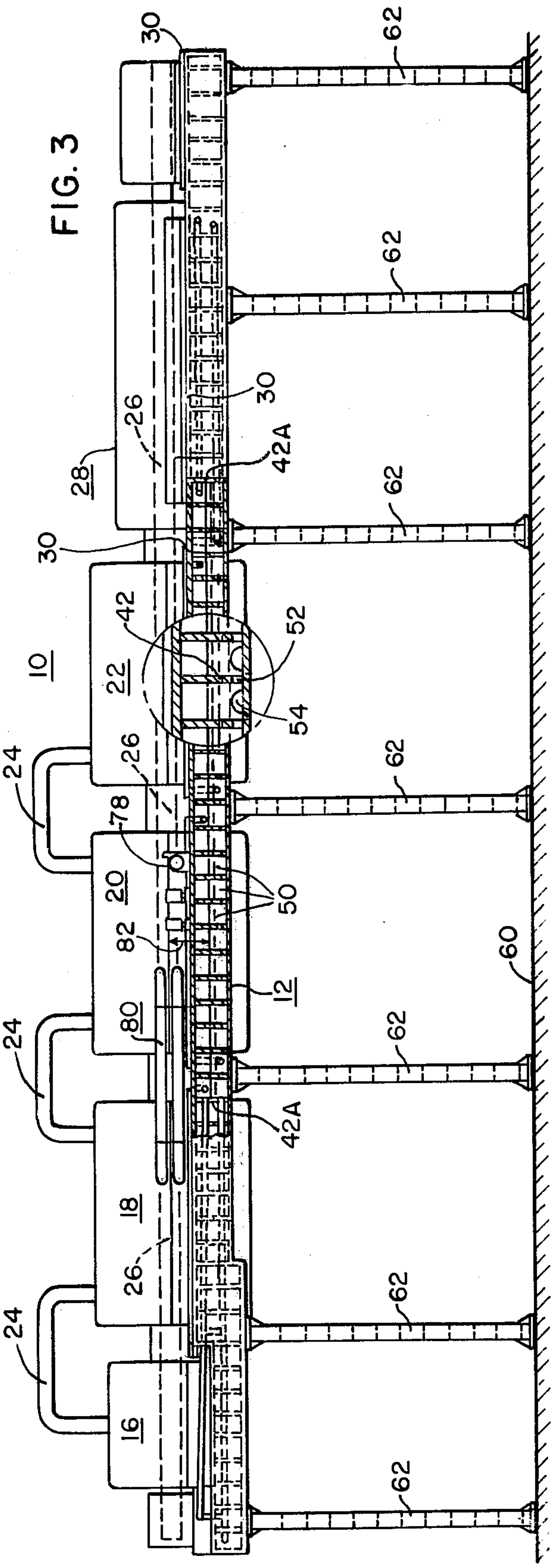


FIG. 3

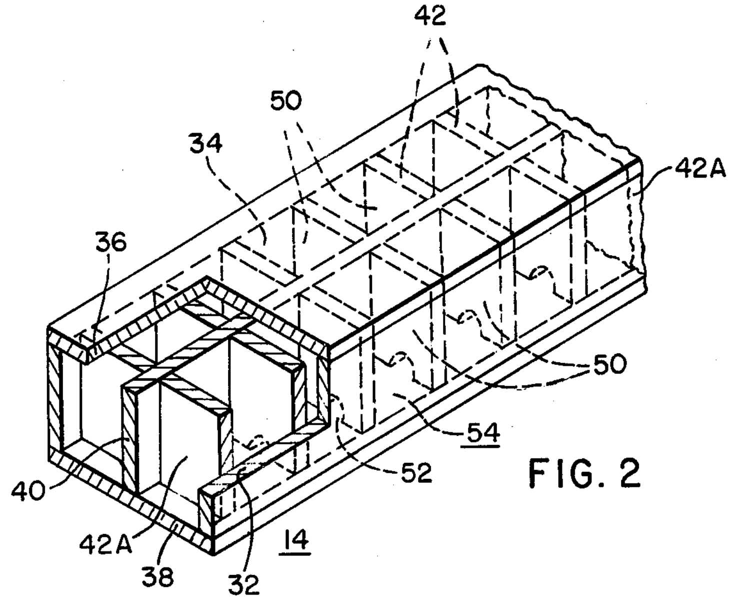


FIG. 2

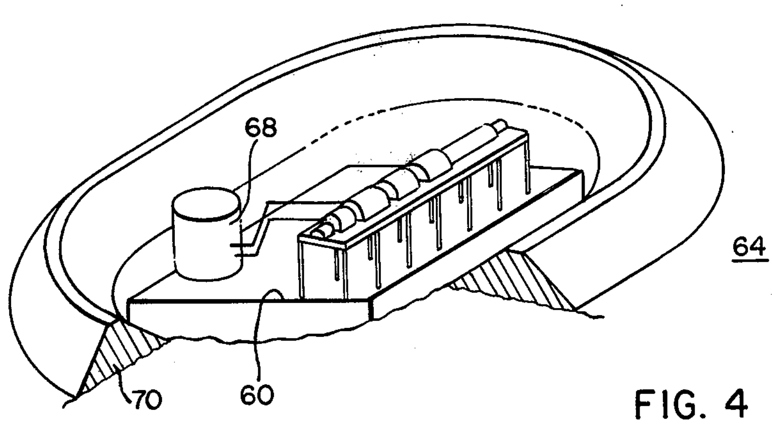


FIG. 4

LUBRICATING OIL SYSTEM INTEGRAL WITH STRUCTURAL STEEL TURBINE FOUNDATION

BACKGROUND OF THE INVENTION

1. Field of the Invention

This invention relates to foundations for turbogenerator power plants, and in particular, to an oil lubricating system for the turbine and generator units disposed integral with the foundation itself.

2. Description of the Prior Art

Foundations for large steam turbine power plant systems are typically fabricated of reinforced concrete and have a turbogenerator unit mounted thereon. The turbogenerator unit usually includes a high-pressure turbine element connected to an intermediate or low-pressure turbine element, the turbines providing rotational mechanical energy for an electric generator element. The elements which would comprise the turbogenerator are usually disposed in an end-to-end configuration on an operating floor supported away from a lower floor level by the reinforced concrete foundation.

Since floor space on the operating floor level is usually at a premium, necessary lubricating systems for both the turbines and the generator elements, including oil reservoirs and associated pumps and conduits, are disposed on the lower floor level beneath the operating floor. An example of the typical environment for a steam turbine generator power plant is shown in U.S. Pat. No. 3,623,573, issued to Csanady, et al., and assigned to the assignee of the present invention.

Such a power plant configuration having the lubricating reservoir beneath the operating level as shown in Csanady, above, or in Wilson, U.S. Pat. No. 2,975,600, is useful and efficient, from a space utilization standpoint, in a land-based turbogenerator station. However, there are serious drawbacks attendant with the traditional configuration when it is sought to be utilized in a floating barge unit now being constructed.

A floating barge unit is an integrated power plant facility which will provide electrical energy to coastal cities. The barge unit will be disposed within a large breakwater structure and the entire plant, including nuclear reactor facility, is to be located approximately three to five miles off-shore of the coastal areas. Power generated in these barge units will be utilized by the high-density urban areas along the seaboard, areas where expansion of traditional land-based power generating units, whether nuclear or fossil fuel, is limited because of environmental or safety considerations. It is evident that efficient utilization of space on the barge unit is a necessity both to increase the operating efficiency of the barge unit, and to decrease the cost factor involved in fabricating such a large, floating power plant.

In prior art systems, such as shown in Csanady, above, the lubricating oil reservoir is disposed beneath the operating floor level. Such a disposition of a separate oil reservoir engenders a number of serious disadvantages, disadvantages which are exacerbated by the planned disposition of a power generation facility on a floating barge unit.

First of all, it is apparent that such a separate oil reservoir requires a large area of operating space within the power plant. Also since the lubricating oil reservoir is usually located approximately 30–50 feet below the

level of the user apparatus, an extensive conduit system is required to interconnect the lubrication reservoir and the user apparatus. Such an extensive conduit system necessitates an elaborate system of conduit supports and hangers, in addition to a large area of space occupied by the exposed conduit system.

The conduit system requires not only that piping necessary to conduct the lubricating fluid to and from the user apparatus be provided, but also requires a "guard pipe" arrangement to protect the turbogenerator apparatus from damage if rupture occurs to the influent or effluent piping.

Normally, the layout of power generating facilities follows a "right hand-left hand" configuration. By this it is meant that when the turbogenerator unit is viewed toward the generator element, the steam system conduits usually occupy the right hand side of the associated elements, while the necessary lubricating conduits occupy the left hand side of the interconnected elements. Such a disposition is mandated by both space and safety considerations.

The guard pipe is disposed to surround both the vertical conduits extending between the reservoir and the operating units, and also surrounds the piping for a horizontal distance on the operating floor. Presently however, the guard pipe extends horizontally only in the area of the turbogenerator, since economic considerations preclude further guard piping in the area of the generator unit.

Since the oil reservoir is located beneath the user apparatus, separate considerations involving large energy expenditures are required merely to get the lubricating oil from the reservoir to the user apparatus level. Such large energy expenditures required to operate the pumping apparatus detract from the overall efficiency of the power plant. In addition, other pumping apparatus is interconnected with the rotating shaft of the turbogenerator unit which aids in the pumping of the lubricating fluid to the apparatus once the generator unit is placed on line. However, when a shut-down of the turbogenerator unit occurs, usually during off-load hours, auxiliary pumping, and therefore auxiliary energy sources, are required in order to maintain the flow of lubricant to the user apparatus.

In addition, various design considerations, such as the requirement that an amount of oil equal to 5 to 10 times the normal lubricant flow is to be maintained within the oil reservoir at all times, increase the cost of a prior art lubrication system. It is apparent, therefore, that an improved lubricating system that would reduce cost, insure better safety, and improve the efficiency of the entire power plant is required.

SUMMARY OF THE INVENTION

This invention provides a foundation structure for a turbogenerator power plant fabricated of a plurality of structural steel box beams having a lubricating oil reservoir disposed integral with the steel foundation within the box beams. The box beams are disposed within the foundation for the turbogenerator plant itself and provide a storage volume for the disposition of lubricating fluid therein. Associated conduit means for conducting the fluid lubricant from within the storage volume within the box beam to the associated turbine and generator elements for the power plant are disposed within the storage volume. Suitable pumping means for pumping the lubricant fluid to the turbine and generator elements of the power plant are disposed on the foundation.

It is an object of this invention to provide a foundation for a turbogenerator power plant having disposed integral therewith within a structural steel box beam a lubricating fluid reservoir. It is a further object of this invention to reduce the cost and improve the overall efficiency of a turbogenerator power plant by disposing integral with the foundation an oil lubricating reservoir and associated pumping and conduit means.

BRIEF DESCRIPTION OF THE DRAWINGS

The invention will be more fully understood from the following detailed description of a preferred embodiment, taken in connection with the accompanying drawings, in which:

FIG. 1 is a plan view of a support foundation for a steam turbine power plant embodying the teachings of this invention;

FIG. 2 is a perspective view of a box beam member utilized by a support foundation for a steam turbine power plant embodying the teachings of the invention;

FIG. 3 is an elevation view of a support foundation for a steam turbine power plant taken along lines III—III of FIG. 1; and,

FIG. 4 is a perspective view of a floating barge power generation facility utilizing a support foundation embodying the teachings of the invention.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Throughout the following description, similar reference characters refer to similar elements in all figures of the drawings.

Referring now to FIG. 1, a plan view of a turbogenerator power plant **10** having a foundation **12** fabricated of a plurality of structural steel box beams **14** and supporting a predetermined number of turbogenerator elements thereon is shown. In FIG. 1, the foundation **12** is shown as providing support for a high-pressure turbine element **16**, and three low-pressure turbine elements **18**, **20** and **22**. The turbine elements **16**, **18**, and **20** and **22** are interconnected by steam conduit means **24**. The turbine elements **16**, **18**, **20** and **22** have a common shaft **26** which is connected in a driving relationship to a generator element **28** mounted on the foundation **12**. All turbine elements and generating equipment are mounted upon suitable seating plates **30** disposed on the foundation **12**. The turbine elements convert high-pressure high-temperature steam into rotational mechanical energy which turns a rotor member disposed within the generator element **28** to provide electrical energy for an associated electrical load (not shown).

Referring now to FIG. 2, a view of a structural steel box beam **14** which comprise the foundation **12** of the power plant **10** is shown. The structural steel box beam **14** shown in FIG. 2 is a substantially rectangular member fabricated of two side plates **32** and **34**, a cover plate **36** and a base plate **38**. In order to give structural stability to the box beam **14**, a longitudinal stiffener member **40** and a plurality of transverse stiffener members **42** are disposed within the box beam **14**. The stiffeners provide the box beam **14** with a "honeycomb" construction, when viewed in plan, as indicated by reference numeral **44** in FIG. 1. It is also noted that any predetermined number of longitudinal stiffeners **40** and transverse stiffeners **42** may be used between side plates **32** and **34** to provide any individual box beam with any predetermined dimension. For example, the foundation construction near the generator end **46** of the power plant, that is, near the right hand edge as shown in FIG. 1, is required to be wider than the foundation construction along the side walls, as indicated near reference numeral **48** in FIG. 1. Accordingly, a greater number of longitudinal stiffeners are disposed between side plates used to construct the foundation near the end **46** than are used to construct the foundation near the side walls at **48**.

However, since the integral lubricating fluid reservoir taught by this invention is disposed along the side walls, a representative box beam structure utilized in this area is shown in FIG. 2. The box beam shown is on the order of 6 feet wide and 8 feet wide, and extends for a longitudinal distance of approximately 20 feet. Although each stiffener member **40** or **42** normally extends fully between the cover plate **36** and the base plate **38** when fabricated to provide the honeycomb, a predetermined number of the transverse stiffeners **42** do not fully extend between the cover plate **36** and the base plate **38**. Thus, instead of individually compartmentalized and segregated cells defined in the typical honeycomb construction, the volumes of several adjacent cells, indicated by reference numerals **50**, communicate with each other through channels **52** provided by the shortened stiffeners to provide an extended storage volume **54** disposed within the individual box beam **14**. Of course, the storage volume **54** may be totally enclosed by providing full stiffener members **42A**. Further, the longitudinal stiffener member **40** may itself have a cut out, or channel therein, to increase the capacity of the storage volume **54** defined within the box beams **14**. It should be noted that although FIG. 1 indicates the oil reservoir is between stiffeners **42A** on one side of the foundation **10**, the reservoir may be split into compartments and a compartment disposed on each side of the foundation. Such a disposition of reservoir volume tends to evenly distribute stresses imposed by the lubricating fluid on the foundation.

Referring now to FIG. 3, an elevational view of the power plant **10** having a foundation **12** fabricated of structural steel box beam members **14** and taken along lines III—III of FIG. 1 is shown. In FIG. 3 the foundation **12** is shown as supported away from a support plane **60** by seven steel pillar members **62**. The pillars **62** are fabricated in a manner similar to that described in connection with FIG. 2.

Although the support plane **60** can be any suitable support member, the structural steel foundation **12** fabricated by box beam members **14** is supported by the pillars **62** away from the barge unit **64** (FIG. 4). It is to be understood, however, the teachings of this invention apply to any fossil fuel or nuclear power plant, either on-shore or on a barge unit, which utilizes a box beam foundation.

The barge unit **64** itself completely supports the power plant **10** mounted on the foundation **12** and an associated steam supply facility **68** within a protective breakwater **70**. The protective breakwater **70** is located a predetermined distance off-shore in coastal waters and provides an integrated power plant facility for the generation of electrical energy utilized by large urban concentrations located geographically adjacent to the coast. It is seen from FIG. 4 that space within the barge unit 64 is a valuable commodity and that efficient use of the available space is reflected in decreased overall cost of individual power generating barge units 64.

Referring again to FIG. 1, it is well known that the rotating shaft 26 of the interconnected turbine and generator elements are supported by bearing members located at each axial end of each turbine element 16, 18, 20 and 22 and at each axial end of the generator element 28. It is also well known that to insure proper functioning of the turbine and generator elements, a fluid lubrication system to provide a flow of fluid lubricant to the bearing members and other portions of the power plant 10 which require lubrication is necessary.

In prior art power plants, the lubricating system comprised an oil reservoir usually disposed below the operating level of the turbine and generator elements and disposed on elaborate and extensive conduit network to provide fluid lubrication to the bearings and other portions of the power plant which required lubrication.

Since however the power plant 10 is to be disposed within a barge unit 64, space for the ordinary separate oil reservoir of the prior art is not available. Also, to enlarge the barge unit 64 to provide for a separate oil reservoir would be economically prohibitive.

Utilizing the teachings of this invention, as described in FIG. 2 above, a predetermined number of box beam members 14 disposed within the structural steel foundation 12 of the power plant 10 is partitioned by suitable stiffener members 42A so as to segregate the predetermined continuous storage volume 54 defined by adjacent cells 50 in the honeycomb structure of the foundation 12 itself. By disposing the supply of fluid lubricant formerly housed within the separate oil reservoir structure within the storage volume 54 defined by the interior of adjacent box beam structures 14 and segregated by stiffener members 42A, an oil reservoir integral with the foundation structure 12 of the power plant is provided.

Conduit means 72 provide a continuous flow of fluid lubricant from the integral oil reservoir within the box beam members 14 to the bearings and other portions of the turbine and generator elements which require lubrication. The flow of fluid lubricant to and from the bearing members are indicated by flow arrows 74 and 76. The flow into and out of the bearing members being provided by pumping means 78 disposed on the structural steel foundation 12. In addition, a lubricant cooling facility 80 is provided on the structural steel foundation 12.

The disposition of the fluid lubricant reservoir 54 within the storage volume generated by the communication of several volumes of cells 50 within the box beam members 14 provides advantages over the separate oil reservoir structure of the prior art in addition to the obvious space saving feature of an oil reservoir integral with the structural steel foundation 12.

For example, in the prior art, the oil reservoir is typically located approximately 30 to 50 feet below the user apparatus. Since this is the case, an extensive exposed conduit network and the associated hangers and conduit supports is required to interconnect the oil reservoir to the user apparatus. In addition, extra exposed conduit is required due to the right hand-left hand configuration of the prior art. The right hand-left hand configuration refers to the disposition of steam interconnections on either the right or the left side of the power plant when viewing the turbogenerator toward the generator elements and the elements and the disposition of the lubricant bearing conduit on the side opposite the steam interconnection. Such physical segregation of steam from lubricant is prescribed as a safety measure. Conformance to the right hand-left hand configuration requires an increased expense to provide sufficient exposed conduit in order to interconnect the separate oil reservoir from the bearings and other lubricant requiring sections of the turbine generator.

In addition to conduit necessary to carry the influent and effluent lubricating fluid to the oil requiring portions of the turbine generator, a guard pipe is necessary in order to protect against the danger of rupture of the conduits. The guard pipe surrounds those vertical portions of the conduits between the oil reservoir and the foundation, and extends around the horizontal portions of the conduits in the area of the turbine elements. No guard pipe is provided in the area of the generator elements in the prior art.

A lubrication system embodying the teachings of this invention and having an oil reservoir disposed within the box beam members 14 eliminates all of the aforementioned disadvantages of the prior art. In addition to being integral with the foundation 12, and thus eliminating the separate reservoir and the space occupied thereby, no external conduits interconnecting the reservoir to the turbine and generator elements are required. The conduits 72 are disposed completely within the hollow volumes 54 within the box beam members 14. No external hangers or support members are required and no guard pipe is necessary. Since the conduits are completely surrounded by the box beam member 14, protection against any rupture of the conduit members 72 is provided. In addition, the conduits 74 providing lubricant to the generator element 28 are surrounded by the box beam members 14 adjacent the generator element 28 and provide a function similar to a guard pipe function which was not available in the prior art. Since the conduits are within the structure of the foundation 12 itself, access to and repair of the conduits in event of the rupture is facilitated. Also, the internal conduit 72 may be prefabricated into the structure of the box beam members 72 themselves, again generating a substantial cost savings.

In addition to the conduit requirements of the prior art, energy was required in order to convey the lubricating fluid from the separate oil reservoir approximately 30–50 feet below the operating floor of the power plant to those portions of the turbine generators which required lubrication. Such a large expenditure of energy is eliminated with a foundation 12 embodying the teachings of this invention. As is apparent from FIG. 3, the oil reservoir disposed within the volume 54 within the box beam members 14 is a predetermined distance 82 beneath the centerline of the turbine generator elements. The distance 82 is on the order of 70–108 inches, thus reducing the energy requirement that must be expended to conduct lubricating fluid from the reservoir to the bearings. Since this is so, the associated pump means 78 require less energy from the power plant 10, increasing the efficiency of the power plant 10.

The prior art disposed a centrifugal pump attached to the rotating shaft of the turbogenerator elements, which provides suction to assist in transporting fluid from the separate oil reservoir to the bearings while the turbine power plant was operating at rated speed. However, when the turbine element reduced operating speed, such as during off-load hours, auxiliary pumping means are required in order to maintain the flow of fluid lubricant.

Since the distance between the oil reservoir and the central line of the power plant **10** is on the order of 70–100 inches, the suction pump mounted on the rotating shaft is sufficient to maintain the flow of fluid lubricant to the bearings without the necessity of auxiliary pumping means.

Relevant standards require that the oil reservoir contains five to ten times the amount of lubricating fluid utilized by the bearings. In the prior art, with its extensive network of exposed conduits, the amount of oil necessary to maintain the prescribed safety level within the reservoir is increased since such a great volume of oil is in the conduits away from the reservoir. A power plant **10** having an integral oil reservoir embodying the teachings of this invention reduces the amount of oil necessary to be maintained within the integral reservoir to meet the appropriate standards.

It is thus seen that by provision of an oil reservoir **54** within the central volume of the box beam members **14** of a structural steel foundation **12** provides a more efficient, safer and cheaper power plant than is available in the prior art. The integral oil reservoir so defined provides a more efficient, safer, and less costly power plant foundation **12** for use on floating barge unit power plants.

We claim:

1. The steam turbine power plant comprising:

a foundation supporting thereon a steam turbine element, said foundation being fabricated of structural steel box beams, said box beams providing a storage volume therein,

a lubrication system for said turbine element disposed integral with said foundation,

a first and a second stiffener member disposed within said box beam foundation, said stiffener members defining a lubricant reservoir within said storage volume, a supply of fluid lubricant being disposed within said reservoir defined between said stiffener members.

2. The steam turbine power plant of claim **1,** wherein said lubrication system for said turbine comprises,

conduit means for conducting fluid lubricant from said reservoir to said turbine element, said conduit means being disposed within said storage volume provided within said structural steel box beams.

3. The steam turbine power plant of claim **2,** wherein an electrical generator element is supported on said foundation, and

a lubrication system for said electrical generator element is disposed integral with said foundation, said lubrication system for said electrical generator element comprises conduit means for conducting fluid lubricant from said reservoir to said electrical generator element, said conduit means for said electrical generator element being disposed within said storage volume provided within structural steel box beams.

4. The steam turbine power plant of claim **2,** wherein an axis extending through said reservoir is disposed substantially parallel to the axis extending through said turbine element.

5. The steam turbine power plant of claim **1,** wherein said foundation has a first and a second lateral sidewall, each of said sidewalls being fabricated of structural steel box beams, each sidewall having a storage volume provided therein,

said lubricant reservoir being defined by said stiffener members within each storage volume within each sidewall, theaxis the axis each reservoir being substantially parallel to the axis extending through said turbine element.

6. The steam turbine power plant of claim **5** wherein said lubrication system for said turbine comprises conduit means for conducting fluid lubricant from said reservoir within each sidewall to said turbine element, said conduit means being disposed within said storage volumes provided within each sidewall.

7. The steam turbine power plant of claim **6,** wherein an electrical generator element is supported on said foundation;

a lubrication system for side electrical generator element is disposed integral with said foundation, said lubrication system for said electrical generator element comprises conduit means for conducting fluid from said reservoir within each sidewall to said generator element, said conduit means being disposed within said storage volumes provided within each sidewall.

8. The steam turbine power plant of claim **2,** wherein said lubrication system for said turbine element further comprises,

pump means associated with said conduit means for pumping fluid lubricant from said reservoir to said turbine element; and,

fluid lubricant cooling means associated with said conduit means and said pump means for cooling said lubricant;

both said pump means and said cooling means being disposed on said foundation adjacent said turbine element.

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