May 29, 1934. F. LJUNGSTRÖM 1,960,744

STEAM OR GAS TURBINE AGGREGATE

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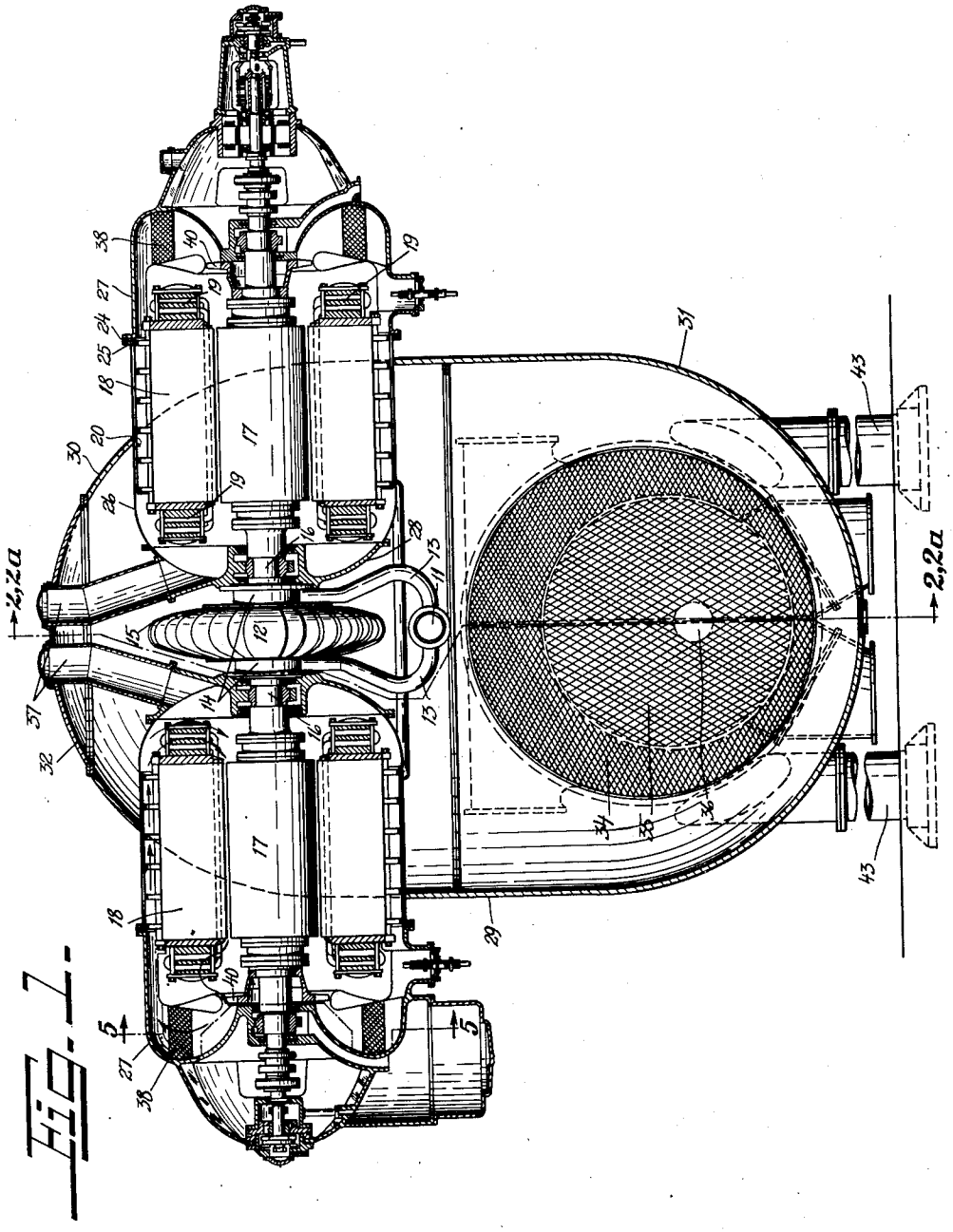


Fig. 1.

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Fig. 2.

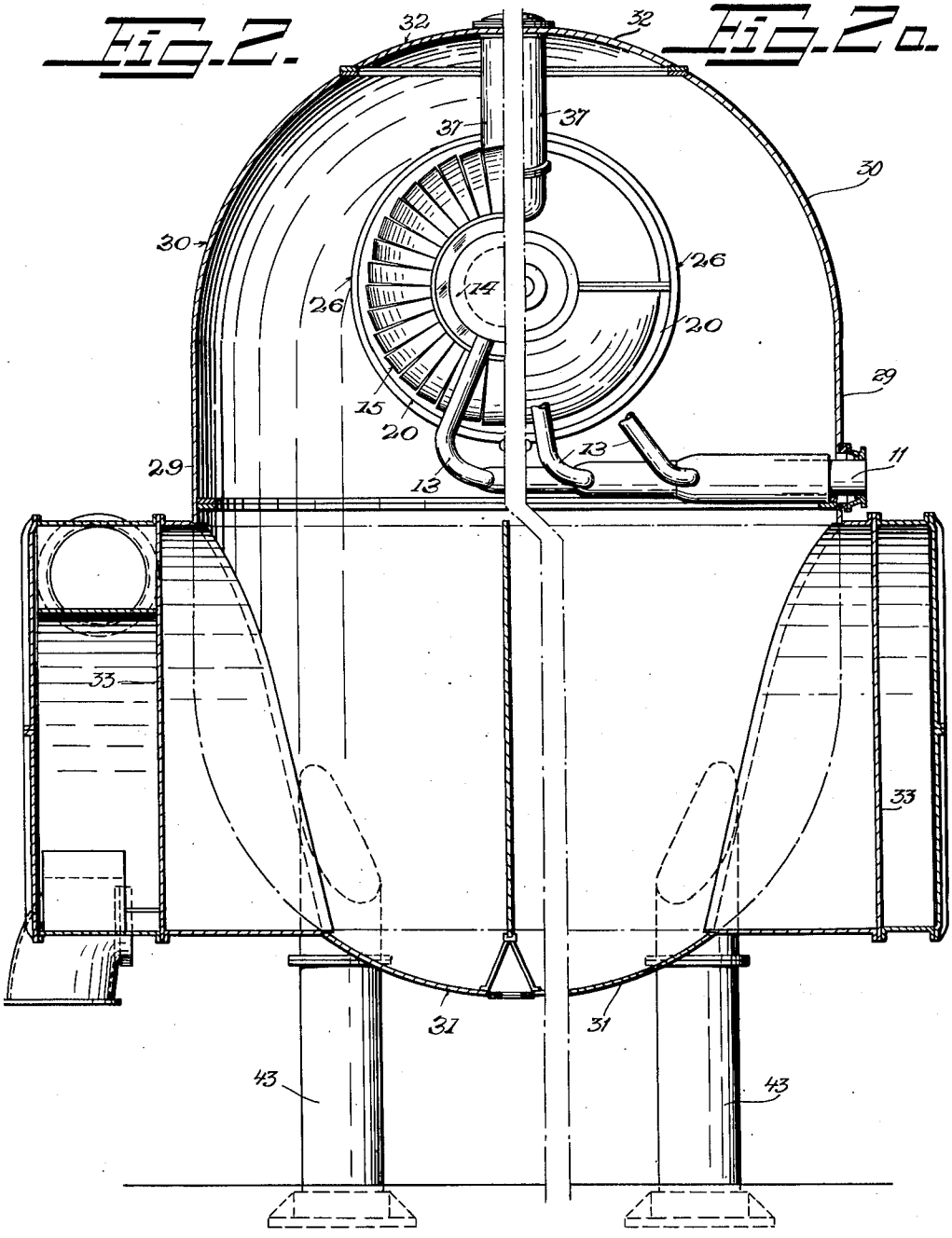


Fig. 2a.

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Fig. 5.

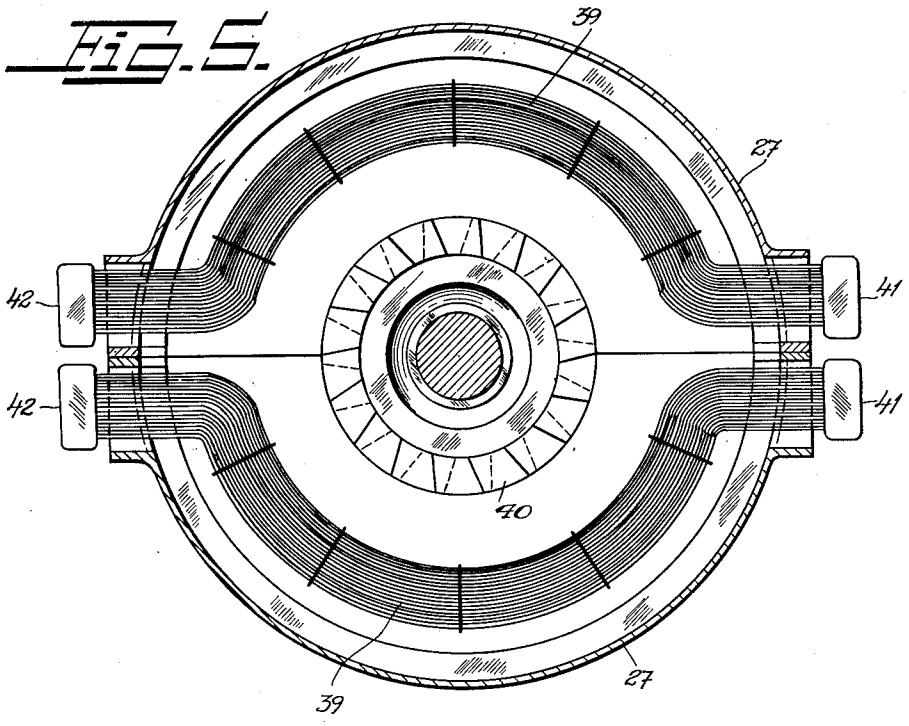


Fig. 3.

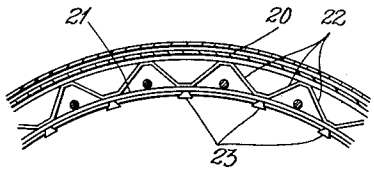
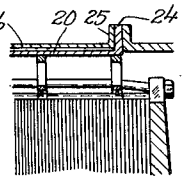


Fig. 4.



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Patented May 29, 1934 1,960,744

UNITED STATES PATENT OFFICE

1,960,744

STEAM OR GAS TURBINE AGGREGATE

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Application April 20, 1932, Serial No. 606,479
In Germany April 20, 1931

18 Claims. (Cl. 290—52)

My present invention relates to combined turbo-generators and more particularly to combinations of this type in which the turbines are of the double rotating type generally known under the denomination "Ljungström turbines" and still more particularly to combined turbo-generators in which the turbines are of the type disclosed in my Patent No. 1,897,172, granted February 14, 1933, and co-pending application Serial No. 561,565, filed September 8, 1931.

The principal object of my invention is to provide a combined turbo-generator of the above said type for great powers and high speeds of rotation in which the flow of exhaust steam from the turbine to the condenser is subjected to very small resistance so as to obtain a considerable reduction of the exhaust losses.

Another object of the invention is to provide a combined turbo-generator of the above said type which can be manufactured and installed at low costs and which has favourable and sufficient passages for the steam flowing from the turbine to the condenser.

A further object of the invention is to provide a combined turbo-generator of the above said type in which the generator or generators extend into and are carried by the turbine housing, the exhaust steam from the turbine sweeping along radially around said generators for a greater or less portion of the length thereof.

Still further objects of my invention will be apparent as the following description proceeds, reference being made to the accompanying drawings in which embodiments of the same are shown by way of example, and in this connection further features characterizing the invention will be set forth.

In the drawings:—

Fig. 1 is a view of a combined turbo-generator according to the present invention having a condenser located below the turbine, and which turbine is designed for great power and a high number of revolutions.

Fig. 2 is a half-sectional view taken on the line 2—2 of Fig. 1 but with the condenser tubing omitted for clearness;

Fig. 2*a* is a half sectional view taken on the line 2*a*—2*a* of Fig. 1 but with the rotor omitted as well as the condenser tubing and part of the steam supply conduits;

Figs. 3 and 4 illustrate on an enlarged scale a detail of the combination;

Fig. 5 is a sectional view of the air cooling means of the turbine taken on line 5—5 of Fig. 1 but on an enlarged scale.

As apparent from Fig. 1, the live steam supply conduit 11 of the turbine 12 is divided into branches 13 leading into the lateral chambers 14 of the turbine. Located between said lateral chambers are the turbine blade systems 15 rotating in opposite direction and connected to the shafts 16 of the two rotors 17 of the alternating current generators. The rotors 17 are surrounded by the stators 18 and the stator windings have end connections as shown at 19. The stators are located in the interior of a cylindrical casing 20 (see Figs. 1, 3 and 4) by means of rings or a sleeve 21 connected to casing 20 by means of stays 22 (Fig. 3) and preferably welded to said casing and rings so as to form a rigid unit with the same, said sleeve or rings 21 serving by means of dovetail strips 23 to receive the stator plates in known manner. By means of a flange 24 the casing 20 is secured to a flange 25 of a cap or housing 26 enclosing said casing and extending in the direction of the axis of the electric generators and the turbine into the exhaust steam chamber of the turbine so as to be surrounded on all sides for a certain part of its length by the exhaust steam. The cap 26, which encloses in this manner a greater or less part of the electric generator, is preferably welded to the outer wall of the exhaust chamber 29. The end of cap 26 which extends into the exhaust chamber, is closed by a curved end portion comprising a cover 28 serving to support the inside bearings of the turbine aggregate. On account of the exhaust chamber 29 of the turbine surrounding the generator on all sides the inner end-connections of the stator windings may also be placed within the cap 26 and, consequently, inside the exhaust chamber. As a consequence, the rotor 17 and their inside bearings may be placed very close to the blade system 15 of the turbine, permitting a short, compact and strong construction of the turbine generator and providing sufficient cross-sectional areas for the steam flowing from the turbine to the condensers by its encircling in part the generator.

By this means it is possible to use very high critical speeds in the largest units, for instance units of 100,000 kw. or more at 3000 revolutions, which is a matter of the greatest importance for attaining a quiet running and for using high numbers of revolution, for instance 3000 R. P. M., as well as in units for which such speeds have hitherto been out of question. The steam exhaust chamber 29 into which the generators extend more or less, e. g. to half of their longitudinal extension, and which according to the invention also surrounds the condenser placed

below the turbine, is preferably constituted by a cylindrical central portion closed at top and bottom by dome-shaped heads 30 and 31, respectively. One or both of these domes may be provided with a cover 32. The upper dome 30 in Fig. 1 is curved around the electric generators and the lower dome 31 around the cooling system of the condenser in which the cooling tubes extend between tube plates 33 in the usual manner (see Figs. 2 and 2a). The parts 29, 30 and 31 of the exhaust chamber may be manufactured of separate plates of convenient shape welded together. The design of the chamber described is suited to resist high outside over-pressures without requiring such special reinforcements as generally are necessary in large turbine units but which, on the other hand, always unfavourably affect the durability of the turbine as such reinforcements in the shape of flanges, ribs or the like are rather liable to cause destructive heat strains, particularly when they are located on the outside. In addition to the advantages mentioned above as a result of the shape of the steam exhaust passage, this design also facilitates a rapid starting of the units as in spite of its size the outer housing for the steam flowing from the turbine into the condenser may be constructed of fairly thin plates which may be quickly and uniformly heated, while still constituting a resistant structure on account of its spherical and cylindrical exterior without reinforcements. By way of example it may be mentioned that the diameter of the exhaust of a 100,000 kw. turbine may be about 6 m. or more and that the thickness of the sheet material used for the exhaust chambers generally only need be only about 15–20 mm.

Furthermore, a considerable advantage is attained by the special arrangement of the exhaust chamber in relation to the condenser. As well known, difficulties are frequently encountered in very large turbine units in introducing the steam into the inner cooling tubes of the condenser, as the steam is not able to flow quickly enough into the inner tube bundle of the condenser, with the consequence that said inner tubes do not attain full activity. This is particularly the case when the steam is admitted to the condenser only from above. Hitherto efforts have been made to eliminate this drawback by omitting a certain number of tubes thus producing wedge-shaped spaces through which part of the steam can be more or less directly admitted into the interior of the condenser tube bundle. By this means greater quantities of steam may be introduced into the condenser but part of the most effective condenser space is lost, i. e. spaces around the periphery of the tube bundle where a majority of the tubes can be placed. Evidently such missing tubes must be replaced by a corresponding number of tubes at other places causing a dimensional increase of the condenser.

According to the invention these difficulties are avoided in large turbo-generators by the lower dome-shaped part of the exhaust chamber being extended all around the cooling tubes of the condenser, permitting the steam to freely enter the cooling tube system radially from all sides. Thus there is no need for leaving out tubes in order to facilitate the introduction of steam into the interior of the tube bundle. The condenser according to the invention is, however, improved in still further respects. As obvious from Fig. 1 as compared with Figs. 2 and 2a the total cooling tube bundle of the condenser is divided into two groups 34 and 35, tube bundle 34 entirely enclosing tube bundle 35. Furthermore, group 35 is not arranged concentrically with relation to group 34 but is displaced eccentrically downwards in such a manner that group 34 is thicker, that is contains more tubes, at the top, i. e. in the direction from which the steam enters the tube system. The steam which enters the condenser from above has the shortest travel and, consequently, more time for penetrating the thicker portion of section 34 than the steam which first flows between the tube section 34 and the dome 31 downwardly to enter the tube bundle from below. Formed in the inner tube bundle 35 by leaving out a number of tubes is a passage 36 arranged eccentrically in relation to tube bundle 35 in the same manner and for the same reason as said bundle 35 is eccentric in relation to bundle 34. In known manner passage 36 serves the purpose of removing air from the condenser.

A condenser built according to the above description offers the least possible resistance to the passage of the entering steam, and for this reason the condenser and the tube plates may be kept at the smallest possible diameters, also improving the aggregate according to the invention in economical respects.

The caps 26 surrounded by the exhaust steam of the turbine or their covers 28 are connected to the atmosphere by means of channels 37 preferably of such great dimensions as to permit inspection of such parts of the electric generators etc. as require inspection. If desired, said channels may be so large as to permit the entrance of an attendant into the interior of the caps 26. On the outside the caps 26 which receive the generators are closed by dome-shaped covers 27 carrying the outside bearings of the generators. Arranged in said covers 27 are air-coolers 38 which in turn may be water cooled. In the present embodiment the coolers consist of cooling tubes 39 (see Fig. 5) through which cooling water is circulating in known manner and between which air for cooling the generators may be forced by means of fans 40 (Fig. 1). As apparent from Fig. 5, the water tube bundles are divided into two groups separately secured to each dome-shaped cover 27. These water tube groups are each provided with an inlet-chamber 41 and an outlet-chamber 42 which, as apparent from Fig. 5, are so arranged that the points where the water tubes enter said chambers are located outside the dome-shaped cover 27. This has the advantage that in case of leaks at these places, these leaks may easily be repaired, and that the leaking water is prevented from dropping into the generator where it might spoil the insulations. With the latter object in view it is desirable to use drawn tubes as leaks in such tubes are less likely to occur.

As evident from Figs. 1, 2 and 2a, the total turbine generator unit is supported by columns 43 of a number which evidently may be arbitrarily selected according to the prevailing conditions and the size of the generator. These supporting columns are preferably given such a shape as to favour a low number of vibrations of the unit in relation to the surroundings. For this purpose the walls of the columns should be selected as thin as possible, thus contributing to a quiet running of the generator and eliminating, as far as possible, phenomena of resonance between the unit and the surrounding or adjacent buildings.

What I claim is:—

1. In a turbo-generator of the character described, the combination of a turbine, a generator, a condenser, an exhaust passage for conveying exhaust steam from the turbine to the condenser and into which said generator projects into close adjacency to said turbine, and a housing surrounding the generator and isolating the same from said exhaust passage.

2. In a turbo-generator of the character described, the combination of a turbine, a pair of generators arranged symmetrically with relation to the turbine, a condenser, an exhaust passage for conveying exhaust steam from said turbine to said condenser and into which said generators project into close adjacency to said turbine, and housings surrounding the ends of said generator projecting into said exhaust conduit and isolating said generators from said exhaust conduit.

3. In a turbo-generator of the character described, the combination of a turbine, a generator or generators, a condenser, an exhaust passage for conveying exhaust steam from the turbine to the condenser and embracing said condenser, each generator projecting into said exhaust conduit into close adjacency to said turbine, and a housing surrounding each generator and isolating the same from said exhaust passage.

4. In a turbo-generator of the character described, the combination of a turbine, a generator or generators, a condenser, an exhaust passage for conveying exhaust steam from the turbine to the condenser and into which each generator projects into close adjacency to said turbine, a housing surrounding each generator and isolating the same from said exhaust passage, and means for cooling the end of each housing projecting into said exhaust conduit.

5. In a turbo-generator of the character described, the combination of a turbine, a generator or generators, a condenser, an exhaust passage for conveying exhaust steam from the turbine to the condenser and into which each generator projects into close adjacency to said turbine, a housing surrounding each generator and isolating the same from said exhaust passage, means for circulating air through the end of each housing projecting into said exhaust conduit, and water pipes within each housing for cooling the circulating air and having their connections exterior to said housing.

6. In a turbo-generator of the character described, the combination of a turbine, a generator or generators, a condenser composed of two sets of tubes one surrounding the other with the inner group disposed eccentrically with respect to the outer group and nearer the side of said condenser which is remote from the turbine, an exhaust passage for conveying exhaust steam from the turbine to the condenser and embracing said condenser, each generator projecting into said exhaust conduit into close adjacency to said turbine, and a housing surrounding each generator and isolating the same from said exhaust passage.

7. In a turbo-generator of the character described, the combination of a turbine, a generator or generators, a condenser open throughout its periphery for the radial admission of the exhaust steam thereto, an exhaust passage for conveying exhaust steam from the turbine to the condenser and completely surrounding said condenser, each generator projecting into said exhaust conduit into close adjacency to said turbine, and a housing surrounding each generator and isolating the same from said exhaust passage.

8. In a turbo-generator of the character described, the combination of a turbine, a condenser, a generally cylindrical casing having domed ends forming an exhaust passage for conveying exhaust steam from the turbine to the condenser, said casing embracing said condenser, a generator or generators projecting through the wall of said casing into close adjacency with said turbine, and a housing surrounding each generator and isolating the same from said exhaust passage.

9. In a turbo-generator unit of the character described, a casing forming an exhaust conduit, a turbine rotatably mounted within said casing and delivering steam thereto, a generator or generators projecting through the wall of said casing into close adjacency to said turbine, a housing for each generator isolating said generator from said exhaust conduit, and a condenser in communication with said casing.

10. In a turbo-generator unit of the character described, a casing forming an exhaust conduit, a turbine rotatably mounted within said casing and delivering steam thereto, a generator or generators projecting through the wall of said casing into close adjacency to said turbine, a housing for each generator isolating said generator from said exhaust conduit, and a condenser projecting laterally through the wall of said casing and entirely surrounded by said exhaust conduit.

11. In a turbo-generator of the character described, the combination of a turbine, a casing for said turbine forming an exhaust passage therefor and composed of cylindrical and hemispherical portions whereby said casing is relatively stiff against external pressures although constructed of relatively thin material, a generator or generators projecting through the wall of said casing into close adjacency with said turbine, and a housing surrounding each generator and isolating the same from said exhaust passage.

12. In a turbo-generator of the character described, the combination of a turbine, a casing for said turbine forming an exhaust passage therefor, a generator or generators projecting through the wall of said casing into close adjacency with said turbine, and a housing surrounding each generator and isolating the same from said exhaust passage, each housing being entirely supported by said casing where said housing passes through the wall of said casing whereby the passage for the exhaust steam around said housing is unobstructed.

13. In a turbo-generator of the character described, the combination of a turbine, a casing for said turbine forming an exhaust passage therefor, a generator or generators projecting through the wall of said casing into close adjacency with said turbine, a condenser in said casing and a housing surrounding each generator and isolating the same from said exhaust passage, said condenser and each generator housing being wholly supported by said turbine casing.

14. In a turbo-generator of the character described, the combination of a turbine, a casing for said turbine forming an exhaust passage therefor, a generator or generators projecting through the wall of said casing into close adjacency with said turbine, a condenser in said casing, a housing surrounding each generator and isolating the same from said exhaust passage, said condenser and each generator housing being wholly supported by said turbine casing, and a plurality of columns supporting said tur-

bine casing and constructed to vibrate at a different period from that of the surrounding structures.

15. In a turbo-generator of the character described, the combination of a turbine, a casing for said turbine forming an exhaust passage therefor, a generator or generators projecting through the wall of said casing into close adjacency with said turbine, a condenser in said casing, a housing surrounding each generator and isolating the same from said exhaust passage, and a passage communicating with the inner end of each housing and leading through the end of said casing whereby access may be readily gained to each generator.

16. In a turbo-generator of the character described, the combination of a turbine, a casing for said turbine forming an exhaust passage therefor, a generator or generators projecting through the wall of said casing into close adjacency with said turbine, a condenser in said casing, a housing surrounding each generator and isolating the same from said exhaust passage, the inner end of each housing including a cover, and a bearing for the turbo-generator carried by each cover.

17. In a turbo-generator of the character described, the combination of a turbine, a casing for said turbine forming an exhaust passage therefor, a generator or generators projecting through the wall of said casing into close adjacency with said turbine, a condenser in said casing, a housing surrounding each generator and isolating the same from said exhaust passage, and a sleeve carried by each housing and projecting inwardly with respect thereto, said sleeve providing a support for the stator of the generator.

18. In a turbo-generator of the character described, the combination of a turbine, a generator or generators, a condenser composed of two sets of tubes one surrounding the other with the inner group disposed eccentrically with respect to the outer group and nearer the side of said condenser which is remote from the turbine, a passage for withdrawing air from said condenser disposed within and eccentrically with respect to said inner group of tubes, an exhaust passage for conveying exhaust steam from the turbine to the condenser and embracing said condenser, each generator projecting into said exhaust conduit into close adjacency to said turbine, and a housing surrounding each generator and isolating the same from said exhaust passage.

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