May 5, 1953 H. A. ALTORFER 2,637,277

GAS TURBINE LOCOMOTIVE

Filed March 3, 1950

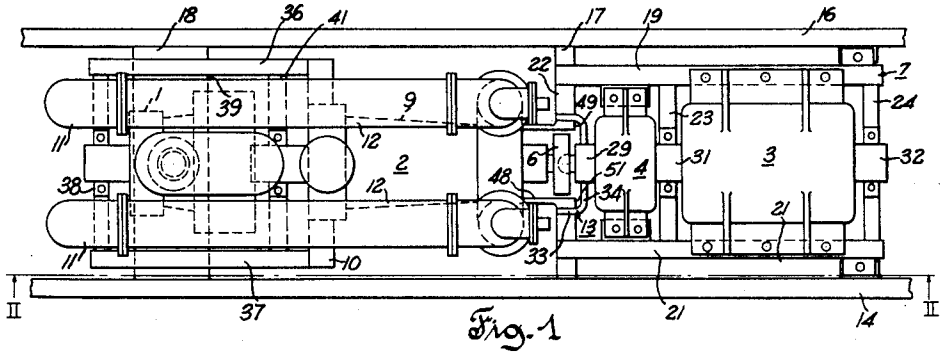


Fig. 1

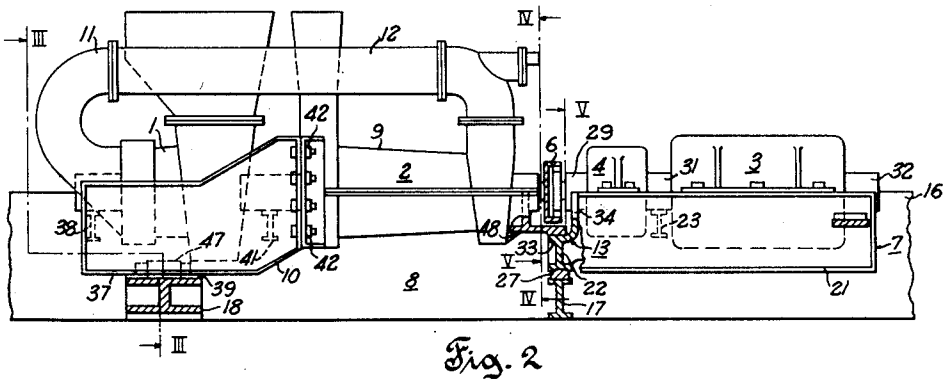


Fig. 2

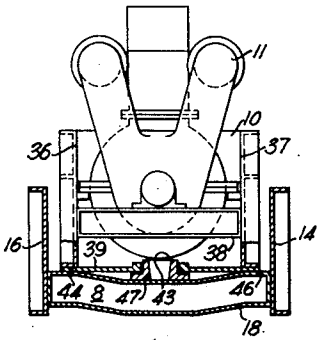


Fig. 3

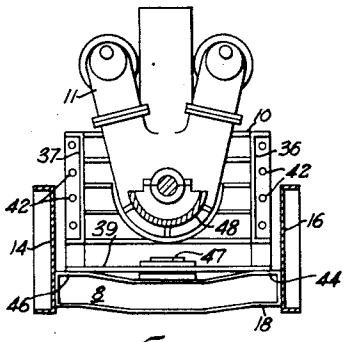


Fig. 4

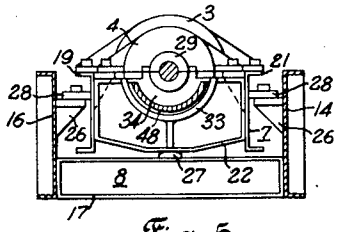


Fig. 5

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GAS TURBINE LOCOMOTIVE

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3 Claims. (Cl. 105—36)

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This invention relates generally to supporting structures for rotary machine units and more specifically to support structures which coact with foundations subject to longitudinal twisting. A principal object of this invention is the provision of new and improved apparatus of this type.

In locomotives having turbine driven power plants, it is necessary to mount rotary machine units in tandem upon a common foundation frame which is subject to longitudinal twisting resulting from irregularities in the roadbed. If such twisting is transmitted to the rotary units, misalignment of the shafts thereof will result. It is therefore an object of this invention to provide a novel supporting structure for rotary units of this type whereby longitudinal twisting of the foundation frame will be rendered harmless.

It has been proposed to mount a plurality of aligned rotary units in a cradle structure and to support the cradle with a three point support structure coacting with a foundation frame. Such an arrangement necessitates a cradle of substantial weight which is objectional in a locomotive installation. This invention contemplates the utilization of the casings of rotary machine units as structural members to effect a unitary structure of minimum weight. The provision of such a structure constitutes an object of this invention.

Still another object of this invention is the provision of a light weight supporting structure for a plurality of axially aligned rotary units which will permit limited rotation of at least one of the units with respect to the others about their common axis and which will obviate the possibility of misalignment resulting therefrom.

A further object of this invention is the provision of an improved locomotive construction in which the power plant is supported upon the foundation frame so that twisting of the foundation frame is rendered harmless and translatory movement of the power plant relative to the foundation frame is limited in a novel manner.

Other objections will appear hereinafter as the description of the invention proceeds.

The novel features of the invention and how the objections are attained will appear more fully from this specification and the accompanying drawings showing one embodiment of the invention and forming a part of this application, and all the novel features are intended to be pointed out in the claims.

In the drawing:

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Fig. 1 is a diagrammatic plan view of a locomotive power plant embodying this invention;

Fig. 2 is a sectional view taken on the line II—II of Fig. 1 looking in the direction of the arrows and having a central portion thereof broken away;

Fig. 3 is a sectional view taken on the line III—III of Fig. 2 looking in the direction of the arrows;

Fig. 4 is a sectional view taken on the line IV—IV of Fig. 2 looking in the direction of the arrows; and

Fig. 5 is a sectional view taken on the line V—V of Fig. 2 looking in the direction of the arrows.

Referring to the drawing, it will be seen that the power plant herein illustrated comprises a gas turbine 1, a rotary compressor 2, and an electric generator 3 adapted to supply electric power to a plurality of traction motors (not shown). The turbine 1 is operatively connected in torque transmitting relation to the rotor of the compressor 2, which in turn is operatively connected to the generator 3 through a reduction gear 4 and a flexible coupling 6.

A first cradle 7 carries the reduction gear 4 and electric generator 3, the cradle 7 being supported on a foundation frame 8 at three points symmetrically disposed with respect to the longitudinal axis of the foundation frame. The compressor 2 includes a casing 9 which is rigidly secured to a second cradle 10 adapted to support the turbine 1, and the compressor and turbine are connected by ducting 11 which includes two combustion chambers 12, the connections between the compressor casing 9, the turbine 1 and the turbine cradle 10 being effective to form the compressor 2 and turbine 1 into a rigid unit. One end of the turbine-compressor unit is supported by the foundation frame 8 at two points. The other end of the unit being pivotally and slidably supported on the first cradle 7 by an articulate support structure 13 which is disclosed and claimed in the copending application of Hans P. Dahlstrand, Serial No. 128,185, filed November 18, 1949.

The frame forming the foundation for supporting the power plant may comprise a pair of horizontally spaced parallel and longitudinally extending beam members 14, 16, connected together at longitudinally spaced points by cross members 17, 18 which may be fusibly united with the beam members 14, 16 at their inner surfaces.

The first cradle 7 may be generally rectangular

in shape and comprise two parallel side members 19, 21 and three longitudinally spaced transverse members 22, 23, 24. The midportion of the transverse member 22 of the cradle 7 is supported on the midportion of the cross member 17 of the foundation frame by a supporting member 27, and the side members 19, 21 of the cradle 7 are rigidly supported at the ends distal the transverse member 22 by any suitable means here shown as inwardly extending brackets 26 welded to the webs of the beam members 14, 16 respectively. The brackets 26 are rigidly secured to lugs 28 which in turn are rigidly secured to the side members 19, 21 of the cradle 7 at points symmetrically arranged with respect to the longitudinal axis thereof, the rigidity of the bracket mountings 26 preventing relative horizontal movements between the cradle 7 and the foundation frame 8. The supporting member 27 which may be provided with spherical bearing surfaces, is constructed in such a manner as to permit pivotal movement between the cradle 7 and the cross member 17. The generator 3 and reduction gear 4 are arranged in tandem, operatively interconnected and supported in the cradle 7 in any suitable manner. The generator and reduction gear include rotary shafts journaled in three bearing structures 29, 31, 32, which are secured to and supported by the transverse members 22, 23, 24 respectively. As best shown in Figs. 2 and 5, the midportion of the transverse member 22 is provided with a longitudinally extended semiannular element 33 having one open end adjacent the compressor 2; the other end of the element is closed by a transverse plate 34 which comprises that part of the transverse member 22 supporting the bearing structure 29 as hereinbefore described. The inner surface of the semiannular element 33 is coaxial with the shaft of the reduction gear 4.

The second cradle 10, in which the turbine 1 is mounted in any suitable manner, may also be generally rectangular in shape and comprise two parallel side members 36, 37 and three longitudinally spaced transverse members 38, 39, 41. Each of the side members 36, 37 being rigidly secured at one end to the compressor casing by any suitable means, here shown as bolts 42, so that the cradle 10 and the compressor 2 form a rigid unit. The center transverse cradle member 39 may comprise a horizontal shock plate secured to the bottoms of the side members 36, 37 in the medial portion thereof and provided with a circular opening 43 in its central portion. The foundation frame cross member 18 is disposed beneath the shock plate member 39 and the end portions 44, 46 thereof are disposed substantially above the medial portion thereof to engage the end portions of the plate 39 thereby providing a two point support for the turbine cradle 10. Rigidly secured to the medial portion of the foundation frame cross member 18 is a generally cylindrical element 47 which extends vertically into the opening 43 in the shock plate 39. The fit of the cylindrical element 47 in the opening 43 is such that the plate member 39 will be free for vertical and rotational movement relative to the cylindrical element but relative translatory movement therebetween will be negligible. The plate 39 and the cylindrical element 47 will coact to prevent substantial relative horizontal movement between the turbine cradle-compressor unit and the foundation frame 8. As best shown in Figs. 2, 4 and 5, the end of the compressor 2 adjacent the cradle 7 is supported on the transverse member 22 of the cradle 7 by a semiannular supporting element 48 secured to the compressor casing 9 in cantilever relation thereto, the semiannular element 48 being substantially coaxial with the semiannular element 33 and disposed in telescoped relation therewith; the outer peripheral wall of the supporting element 48 pivotally and slidably engages the inner semicylindrical surface of the element 33.

The shaft of the compressor 2 is connected in torque transmitting relation with the shaft of the reduction gear 4 by the flexible shaft coupling 6 which may be of any suitable type. The coupling here shown is of the claw type and is constructed to permit relative angular misalignment of the shafts while maintaining a torque transmitting relation therebetween. The center of the flexible coupling lies in a transverse vertical plane which passes through the articulate support 13 and the supporting member 27, the reason for which will more fully appear.

With the frame arrangement shown, the turbine-compressor group and the reduction gear-generator group each comprises a rigid unit which is unaffected by torsional movements of the foundation frame. When the foundation frame is subjected to twisting about its longitudinal axis, the brackets 26 and the attached cradle 7 will rotate relative to the foundation frame across member 17 and relative the turbine-compressor unit, such rotation being permitted by the pivotal mounting of one end of the cradle 7 on the supporting member 27 and the pivotal mounting of one end of the compressor 2 on the cradle 7. Since the cooperating bearing surfaces of the articulate support structure 13 are coaxial with the axis of rotation of the turbine and compressor shafts, rotational movement of the turbine-compressor group relative to the cross member 17 and cradle 7 resulting from longitudinal twisting of the frame 8 will be about the common axis of the turbine and the compressor and such rotation will not affect alignment of the shafts. The three point supporting arrangement for the turbine-compressor unit which includes the articulate supporting structure 13 will, under longitudinal twisting of the foundation frame, permit the supporting points of the unit to be maintained in a single plane which rotates relative to the cross member 17.

Sudden starts and stops and other shocks applied to the locomotive frame will tend to produce a translatory movement of the power plant relative to the foundation frame due to the inertia of the plant. To overcome this inertia, it is necessary to transmit large horizontal forces from the frame to the power plant; in the present invention such forces are transmitted through the cooperable shock plate 39 and cylindrical element 47.

As hereinbefore described, the three point supporting structures for the power plant permit the rotary machine units to be maintained as rigid units unaffected by torsional movement of the foundation frame. To maintain the effectiveness of these supporting structures, it is essential that they be the sole means of support; accordingly, the shock plate 39 and the cylindrical element 47 are so constructed that there will be clearance between their contiguous surfaces in normal operation. Thus, when the frame 8 is subjected to longitudinal twisting under normal operation, the shock plate 39 and the element 47 may move relative to each other to produce no inhibiting effects upon the relative rotational

movements of the foundation frame and power plant. When the foundation frame is subjected to sudden changes in velocity, the power plant will move relative to the foundation frame a distance sufficient to bring the shock plate 39 into engagement with the element 47 establishing a connection through which forces sufficient to overcome the inertia of the power plant are transmitted.

In the preferred embodiment, the cross section of the element 47 is circular to insure adequate strength for the transmission of forces regardless of the direction of the change in velocity of the foundation frame. It will be apparent that the relative distance through which the power plant moves will be equal to the clearance between the shock plate 39 and the element 47; such distance will obviously be relatively small and the movement of part of the plant through such distance will be taken up in the flexible coupling 6.

If the foundation frame is subject to hogging or sagging, as for example, in a locomotive or ship frame, the turbine-compressor group will swing through a vertical arc relative to the cradle 7 about a horizontal transverse axis defined by the points at which the diametrically opposed upper corners 49, 51 of the semiannular element 48 engage the inner semicylindrical surface of the element 33. It is desirable that the center of the flexible coupling 6 be disposed on or near this horizontal axis in order that relative longitudinal displacement of the compressor and reduction gear shafts resulting from such swinging will be precluded or minimized to a degree which will not impair the torque transmitting functions of the flexible coupling for it will be apparent that relative swinging of the units about a horizontal transverse axis passing through the center of the flexible coupling 6 will result in angular misalignment of the shafts but not in eccentric displacement of the ends thereof.

The side members 19, 21, 36, 37 of the cradles 7, 10 acting as beams supported at each end will have spans which are less than half the span of a single prior art cradle supporting the entire power plant, and since it is well known that the approximate safe load of a beam of a given cross sectional shape varies inversely as its length and directly as its cross sectional area, it will be apparent that the shorter spans as disclosed herein will permit the use of side members having a smaller cross sectional area and a saving in overall weight commensurate with the reduction in each cross sectional area will be achieved. It will also be apparent that the arrangement herein disclosed, wherein the casing of the compressor 2 of a gas turbine power plant is utilized as a structural member to form an integral part of the supporting structure, will eliminate the necessity of a cradle member about such casing and effect a substantial saving in weight over prior art structures.

Attention is directed to the fact that the supporting structures and arrangement herein disclosed are susceptible of many applications where it is necessary to mount a plurality of rotary machines in tandem and is not necessarily restricted to the application of a gas turbine power plant in a locomotive.

It will be apparent to those skilled in the art that the structure herein described provides a new and improved supporting structure for a plurality of rotary machine units and accordingly accomplishes the objects of the invention. It will also be obvious to those skilled in the art that the illustrated embodiment may be variously changed and modified, or features thereof, singly or collectively, embodied in other combinations than those illustrated without departing from the spirit of the invention or sacrificing all of the advantages thereof and that accordingly the disclosure herein is illustrative only, and the invention is not limited thereto.

It is claimed and desired to secure by Letters Patent:

1. A gas turbine power plant comprising in combination a foundation capable of twisting and flexing movement, a first cradle structure, first mounting means fixedly securing one end of said cradle structure to said foundation, second means independent of said first mounting means and spaced therefrom pivotally mounting the other end of said first cradle structure on said foundation, a generator having a rotatable shaft, said generator being rigidly mounted on said first cradle structure with the axis of said shaft extending longitudinally of said foundation, a compressor with a casing having one end slidably supported on said second mounting means for rotation relative to said foundation about said longitudinally extending axis, said compressor having a rotatable shaft coupled to said generator shaft in torque transmitting relation, said compressor shaft having an axis of rotation substantially coincident with said longitudinally extending axis, a second cradle structure pivotally mounted on said foundation for rotation about an axis extending through said cradle structure normal to said foundation, one end of said second cradle structure being rigidly secured to the other end of said compressor casing, a gas turbine having a rotatable shaft, said turbine being rigidly mounted on said second cradle structure so as to align said turbine shaft with said compressor shaft, and means coupling said turbine shaft and said compressor shaft in torque transmitting relation.

2. A gas turbine power plant comprising in combination a foundation capable of twisting and flexing movement, a first cradle structure, first mounting means fixedly securing one end of said cradle structure to said foundation, second means independent of said first mounting means and pivotally mounting the other end of said first cradle structure on said foundation, a generator having a rotatable shaft, said generator being rigidly mounted on said first cradle structure with the axis of said shaft extending longitudinally of said foundation, a compressor with a casing having one end slidably supported on said second mounting means for rotation relative to said foundation about said longitudinally extending axis and for movement longitudinally of said foundation, said compressor having a rotatable shaft flexibly coupled to said generator shaft in torque transmitting relation, said shaft having an axis of rotation substantially coincident with said longitudinally extending axis, a second cradle structure pivotally mounted on said foundation for rotation relative to said foundation about an axis extending through said cradle normal to said foundation, one end of said second cradle structure being rigidly secured to said compressor casing, a gas turbine having a rotatable shaft, said turbine being rigidly mounted on said second cradle structure so as to align said turbine shaft with said compressor shaft, and means coupling said turbine shaft and said compressor shaft in torque transmitting relation.

3. A gas turbine power plant comprising in combination a foundation capable of twisting and flexing movement, a first cradle structure, first mounting means fixedly securing one end of said cradle structure to said foundation, second means independent of said first mounting means and pivotally mounting the other end of said first cradle structure on said foundation, a generator having a rotatable shaft, said generator being rigidly mounted on said first cradle with the axis of said shaft extending longitudinally of said foundation, a compressor with a casing having one end slidably supported on said mounting means for rotation relative to said foundation about said longitudinally extending axis and for movement longitudinally of said foundation, said compressor having a rotatable shaft coupled to said generator shaft in torque transmitting relation, said shaft having an axis of rotation substantially coincident with said longitudinally extending axis, a second cradle structure pivotally mounted on said foundation for rotation about an axis normal to said foundation, said second

cradle structure having one end thereof fixedly secured to said compressor casing, said pivotal mounting of said second cradle coacting with said second cradle structure and said foundation to afford limited movement of said second cradle structure radially about said axis of said pivotal mounting relative to said foundation, a turbine rigidly mounted on said second cradle structure and having a rotatable shaft aligned with said compressor shaft, and means coupling said turbine shaft and said compressor shaft in torque transmitting relation.

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