Aug. 4, 1953 L. G. SROGI 2,647,685

CENTRIFUGAL IMPELLER STRUCTURE

Filed Dec. 13, 1947

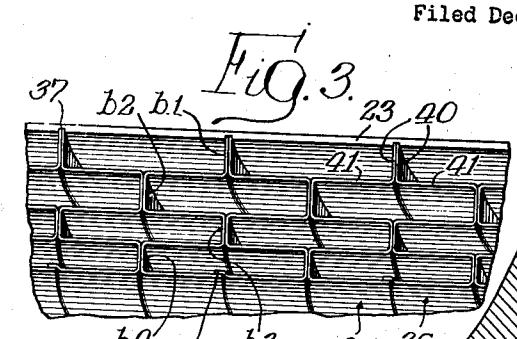


Fig. 3.

Fig. 1.

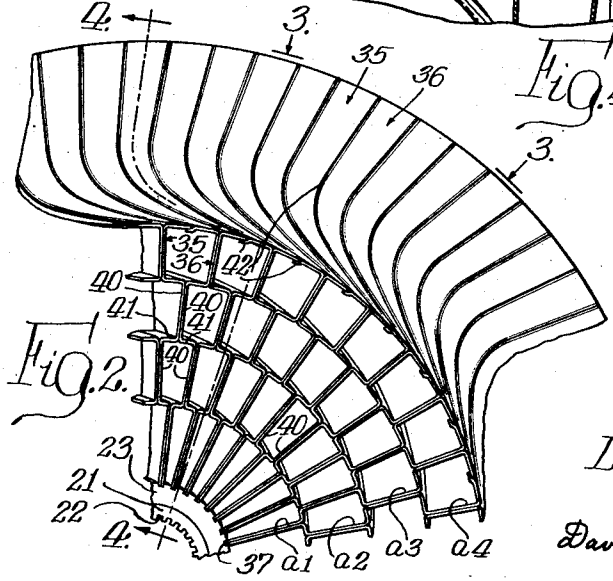


Fig. 2.

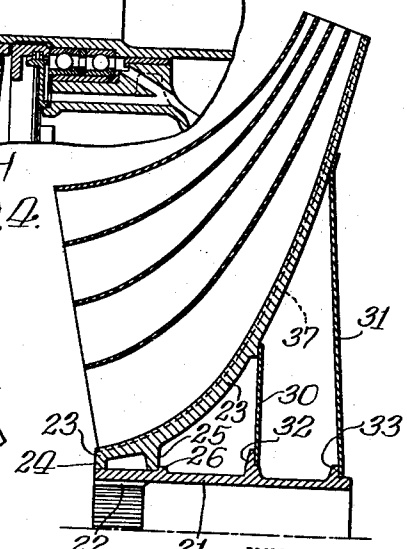


Fig. 4.

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Patented Aug. 4, 1953

2,647,685

UNITED STATES PATENT OFFICE

2,647,685

CENTRIFUGAL IMPELLER STRUCTURE

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Application December 13, 1947, Serial No. 791,566

5 Claims. (Cl. 230—134)

1

The invention relates generally to centrifugal impeller structures and more particularly to the structure of an air impeller utilized in a turbo-jet engine.

The general object of the invention is to provide a novel structure for a centrifugal impeller of the foregoing general character, facilitating manufacture of the impeller and reducing the cost thereof.

Another important object is to provide a novel centrifugal impeller structure which is relatively light in weight but at the same time has a high degree of stiffness and rigidity substantially eliminating difficulties due to vibration encountered in other constructions.

Another object is to provide a centrifugal impeller structure which has no limitation as to the size of the impeller and permits the manufacture of larger impellers of the foregoing character, than have heretofore been considered practicable.

A further object is to provide a centrifugal impeller structure which permits the use of steel instead of the aluminum alloys heretofore employed, so that the structure when in operation will not be materially weakened by the elevated temperatures occurring as a result of the high compression of the air.

Still another object is to provide a novel centrifugal impeller structure which reduces undesirable circulation within the air passage therein and which smoothes out the flow therethrough.

A still further object is to provide a novel centrifugal impeller structure having vanes which are much thinner than the vanes used in cast structures, thereby increasing the available area of the passage for the flow of air.

Other objects and advantages will become apparent from the following description taken in connection with the accompanying drawing, in which:

Figure 1 is a fragmentary longitudinal sectional view of a turbo-jet engine having a centrifugal impeller embodying the features of the invention.

Fig. 2 is a fragmentary front elevational view of the impeller.

Fig. 3 is a fragmentary view of the impeller as viewed in the direction indicated by the line 3—3 of Fig. 2.

Fig. 4 is a diagrammatic sectional view of the impeller, similar to the view thereof in Fig. 1, but taken substantially on the line 4—4 of Fig. 2.

In a turbo-jet engine, an inlet opening is provided at the front of the engine for admitting

2

air to be utilized in supporting combustion and generation of the power stream developed in the engine. The air is drawn in through such inlet and supplied to the combustion chamber section of the engine by a compressor driven by a gas turbine positioned to receive energy from the power stream. Usually, such compressor or air impeller is mounted on one end of a shaft, the other end of which carries the rotor of the turbine so that there is a direct connection between the impeller and the turbine rotor. While impellers utilized in engines of this character may be of different types, the present invention is illustrated in the form of a centrifugal impeller producing a mixed flow, that is, having an axial and radial discharge.

To illustrate this type of impeller and to disclose the environment in which such impeller functions, I have shown in Fig. 1 a fragmentary sectional view of the front portion of a turbo-jet engine. Thus, in this figure I show an inlet cover 10 provided with a front opening or air inlet 11 positioned coaxially with the structure of the engine. Extending transversely in the opening 11 is a plurality of struts 12 supporting a bearing 13 carrying the front end of the main shaft of the engine, the main shaft being shown at 14. Within the inlet cover 10 and mounted on the shaft 14 is the centrifugal impeller, indicated generally at 15. The shaft 14 may also be supported by a thrust bearing 16 in the frame structure 17 of the engine, the shaft 14 extending rearwardly in an axial position in the engine and carrying at its rear end the turbine rotor (not shown).

The centrifugal impeller 15 draws air inwardly through the inlet opening or eye 11 and discharges such air into a diffuser section, indicated generally at 20. From the diffuser section the air passes rearwardly to the combustion chamber of the engine where the power stream is generated. It will be noted, from the structure shown in Fig. 1, that the impeller herein contemplate is of the mixed flow type, that is, air compressed thereby is discharged into the diffuser section 20 in a combined radial and axial direction.

Heretofore, impellers of this type have usually been of cast metal construction or have been made by an elaborate machining process to provide the desired air vane form to produce a suitable air flow. With either of these types, it is obvious that a relatively heavy structure is involved with difficulties encountered in coordinating the desired air passage form with the strength

requirements of the impeller. The difficulties resulting from the weight of the impeller may be compensated to some extent by the use of light aluminum alloys. However, the speed at which an impeller of this character operates is exceedingly high and, consequently, to obtain the desired strength for operation at such speeds, even with light aluminum alloys, a large bulk of material must be used. Questions of stiffness and rigidity of the parts of the compressor, because of such speeds, also enter into the problem of providing a suitable impeller. Furthermore, the compression of the air is such that considerable heat is generated in the impeller so that aluminum alloys are not entirely satisfactory because of their loss of strength at elevated temperatures.

The present invention provides an impeller structure which eliminates or at least greatly decreases such difficulties and attains the various results and has the advantages heretofore stated in the objects of the invention. To this end, an impeller embodying the features of the invention comprises a core structure adapted to be mounted on the shaft 14 and having mounted thereon air impelling structure of a novel character. The core structure includes a hub portion adapted to fit over the shaft 14 and an outer shell shaped to provide the inner periphery of the air passage through the impeller. The air impelling structure in the present instance is in the form of sheet-metal parts so formed as to provide with the shell the desired air passage and being particularly constructed to provide the desired strength with a minimum of weight. Broadly, the air impeller structure comprises a plurality of corrugated sheet-metal members extending generally radially from the shell of the core structure and providing an air passage of cellular construction.

Referring to the particular structure shown in the drawing, the core structure of the impeller includes an elongated hub 21 adapted to fit over the drive shaft 14 and to be driven thereby. In the present form, the driving connection between the hub 21 and the shaft 14 is effected by means of a spline connection 22 at the front end of the hub 21. Mounted on the hub 21 is a shell 23. The latter curves rearwardly and outwardly from its front end to form the inner periphery of the air passage through the impeller. Thus, the smaller end of the shell 23 is the front end, and for rigidly securing the shell to the hub 21, the front end of the shell may be provided with a pair of inwardly directed flanges 24 and 25 embracing the hub 21. To secure the hub and shell in proper longitudinal relation, the hub may be provided with an external rib 26 adapted to abut the flange 25. The flanges 24 and 25 are rigidly secured to the hub as by welding or brazing. Since the shell 23 curves outwardly and rearwardly, a rather widespread skirt portion is thereby formed. To stiffen such skirt portion and hold it concentric with the hub 21, a pair of stiffening diaphragms 30 and 31 may be provided. In the present instance, such diaphragms are shown as being made of sheet metal and are secured to the hub 21 by welding or brazing them to flanges 32 and 33 formed on the exterior of the hub. The outer peripheries of the diaphragms 30 and 31 are similarly secured to the shell, as by welding or brazing.

The air impeller structure carried by the core structure is, as heretofore mentioned, of sheet-metal construction. Broadly stated, such structure comprises a plurality of sheet-metal members corrugated along lines following the air passage through the impeller and secured to one another and to the shell 23 to form a cellular structure constituting the air passage. The air passage may be said to be generally spiral in form and to decrease in radial width, although increasing in actual diameter, from front to rear of the impeller. The sheet-metal members thus extend in such spiral direction with the corrugations varying in width and depth to provide an air passage conforming to the conditions required for the desired air flow. The present invention, of course, is not limited to any particular contour for the sheet-metal members, since these are determined by theoretical considerations determining the air flow and will vary with different impellers. The invention, however, is applicable to impellers having any desired air passage contour demanded by such theoretical consideration. The particular cross-sectional form of the individual cells constituting the air passage may be varied by the form of corrugations placed in the sheet-metal members, although in the more limited aspects of the invention, the particular cross-sectional form provides certain advantages over other forms, as will become apparent from the following detailed description.

In the particular structure shown in the drawing, two types of sheet-metal members are employed to form the cellular structure. These two types of members are similar but may be said to be of opposite hand. Thus, as shown in Fig. 2, I provide one form of sheet metal member, indicated generally at 35, and another form of sheet-metal member, indicated generally at 36, the two being similar but having their corrugations formed in the opposite direction to provide the cellular structure. Each of the members 35 and 36 is provided with a plurality of radially extending portions 40 and circumferentially extending portions 41 forming the corrugations in each of the members. It will be noted from an inspection of Fig. 2 that the circumferentially extending portions 41 extend in opposite directions from the radially extending portions 40 in the respective members 35 and 36. While the number of radially extending portions 40 and consequently the number of circumferentially extending portions 41 in each member are of no importance except from the standpoint of providing the desired strength, in the present instance I have shown four radially extending portions in each of the members and consequently three interconnecting circumferentially extending portions 41.

The members 35 and 36 are so positioned, and their corrugations are so dimensioned that the radially extending portions 40 of one member are in abutment with similar portions of the adjoining members and are secured thereto as by welding or brazing, so that a rigid cellular structure is formed. The inner edges of the members 35 and 36 are secured to the shell 23 by being mounted in grooves 37 therein, and welded or brazed. The outer portions of the members 35 and 36 are bent to extend circumferentially and are secured to similar portions on the adjoining members, so that a completely closed exterior is provided. In the present instance, the circumferentially bent portions of the members 35 and 36 at their outer edges are overlapped as at 42 and are brazed or welded to one another to form the periphery of the impeller. The cells formed by the corrugations may be said to be arranged

in concentric sets or groups with cells of each set circumferentially related to one another. The number of cells in each set is the same and, in the present instance, thirty-six of each of the members **35** and **36** are employed to form thirty-six cells in each set or row.

The members **35** and **36** extend rearwardly and also are placed in a position which may be described more or less as spiral to provide an air passage to conform to theoretical considerations. Furthermore, the corrugations therein decrease in radial width because of the compression of the air that takes place within the air passage of the impeller. The corrugations, however, increase in circumferential depth because of the increase in diameter toward the rear of the impeller. Thus, in Fig. 1, which is a view taken in an axial plane through the impeller, such plane is shown as intersecting a number of the cells formed by the corrugated members **35** and **36** because of the generally spiral position of these members. In Fig. 4, there is diagrammatically shown the position of the cells with the spiral aspect thereof eliminated. The decrease in radial width is thus illustrated in Fig. 4. The increase in circumferential depth as well as the decrease in radial width is illustrated by a comparison of Figs. 2 and 3, the respective figures showing the front and rear ends of the cells constituting the air passage.

Preferably, the corrugations are so dimensioned as to provide cells of equal cross-sectional area at any point in the air passage. Thus, considering the four cells indicated at *a1*, *a2*, *a3* and *a4* at the front end of the impeller, the corrugations forming these cells are so dimensioned that the area of *a1* equals the area of *a2*, equals the area of *a3*, and equals the area of *a4*. Similarly, as shown in Fig. 3, the areas of four cells indicated at *b1*, *b2*, *b3* and *b4* are all equal to each other. The same relation exists between the areas of the respective cells at any point intermediat the front and rear ends thereof.

As heretofore stated, the invention is not limited to cells of any particular cross-sectional shape. However, in the present instance, I have shown cells of substantially rectangular or segmental shape which provide certain advantages. With the substantially rectangular cross-sectional shape for the cells, the circumferentially extending portions **41** together form a support for the structure functioning in the nature of a plurality of concentric hoops in radially spaced position relative to each other. Since the radially extending portions **40** of the members are rigidly secured to one another throughout the entire circumference of the impeller, the portions **41** are held in a truly circumferential position and thus are incapable of flexing out of such circumferential position. The portions **41**, therefore, function to rigidly maintain the radially extending portions **40** in their intended position. The portions **40**, of course, constitute the vane structure of the impeller and are given the contour demanded by the theoretical air flow considerations involved in the design of the impeller.

Manufacture of an impeller of the foregoing construction is readily accomplished since each of the members **35** and **36** may be formed on dies from a flat sheet of metal. Once the dies are made, absolute uniformity of the various members is attained automatically and the production of the sheet-metal members may be performed at a relatively low cost. Assembly thereof

obviously will not be an expensive operation, so that the entire production cost of an impeller of this character is substantially less than that of the cast or machined form of impeller. The use of sheet-metal members greatly reduces the total weight of the structure and, at the same time, provides a high degree of stiffness because of the provision of the circumferentially extending members **41** constituting hoops holding the radially extending portions **40** in a set position. The stiffness inherent in this structure is of particular importance, since it eliminates vibration of the vane structure encountered in other constructions for impellers. The sheet-metal construction also is not limited as to size and, consequently, permits construction of impellers larger than has heretofore been considered practicable. The sheet-metal members may be made of steel instead of the lighter aluminum alloys, so that relatively thin sheet material may be employed and the impeller may be operated at higher temperatures without loss of strength of the metal, since the type of steel employed may be of a character which maintains its strength at elevated temperatures. The use of relatively thin sheets increases the available area of the air flow passage, because the thickness of the sheets may be much less than the thickness of the vanes in a cast or machined structure. The cellular arrangement resulting from the use of the corrugated members also has an advantage in that it reduces undesirable circulation within the air passage and tends to smooth out the flow therethrough.

I claim:

1. A centrifugal impeller comprising a core structure, and a plurality of radially disposed sheet-metal members fixed thereto, said members being bent along lines extending in three dimensions following substantially in the direction of air flow through the impeller, each of said members having a plurality of radially extending portions and connecting portions in each member, the radially extending portions of adjoining members being secured to each other in face to face contact whereby concentric sets of cells positioned one within another are formed by said portions.

2. A centrifugal impeller comprising a flared core structure, and a plurality of radially disposed sheet-metal members fixed thereto, said members being bent along lines extending in three dimensions following substantially in the direction of air flow through the impeller, each of said members having a plurality of radially extending portions and circumferentially extending portions, the radially extending portions of adjoining members being secured to each other in face to face contact whereby said secured members provide a plurality of substantially spiral cells each having a generally rectangular cross section, said cells being arranged in concentric sets one within another.

3. A centrifugal impeller comprising a core structure having circumferential axial and radial dimensions, and a plurality of radially disposed sheet-metal members secured to said core structure and extending generally radially therefrom, said members being corrugated generally in their radial dimension and being also formed to smooth flowing curvilinear lines in their axial dimension, said members being secured to one another to provide a cellular structure with each cell extending spirally throughout the length of the

air passage in the impeller, the cells varying in cross-sectional area between the ends of the impeller but being of equal areas at any point throughout the length of the passage, the cells being arranged in concentric rows with the same number of cells in each row.

4. A centrifugal impeller comprising a core structure having an external surface curving rearwardly and outwardly axially from the front end of the impeller, and a plurality of sheet-metal members secured edgewise to said surface and extending generally radially therefrom, said members being formed to a smooth curvilinear shape in an axial direction with respect to said core, said members also being corrugated in a direction generally parallel to said secured edge and secured to one another to provide a cellular structure, the corrugations decreasing in width from front to rear of the impeller but following generally the curvature of said surface.

5. A centrifugal impeller comprising a core structure comprising a hub adapted to be mounted on a drive shaft, a shell curving rearwardly and outwardly from the front end of the impeller and secured at its front end to said hub, and stiffening diaphragms secured to said shell and said hub intermediate the ends thereof to

support the rearward portion of said shell, and an air impelling structure comprising a plurality of corrugated sheet-metal members extending generally radially from the outer surface of said shell and having their inner edges secured thereto, the corrugations of adjoining members being secured to each other to form a cellular structure.

LADISLAW G. SROGI.

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