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PATENTS ACT 1952

APPLICATION FOR A STANDARD PATENT

We

HITACHI LTD., of
6, Kanda Surugadai 4-chome,
Chiyoda-ku,
Tokyo,
Japan

hereby apply for the grant of a Standard Patent for an invention entitled:

"METHOD OF COMBINING PLURAlITY OF PARTS AND STRUCTURE
OF PLURALITY OF PARTS COMBINED BY SAME"

which is described in the accompanying complete specification.

Details of basic application(s):

<table>
<thead>
<tr>
<th>Number</th>
<th>Convention Country</th>
<th>Date</th>
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<tr>
<td>97843/1983</td>
<td>Japan</td>
<td>3 June, 1983</td>
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The address for service is care of DAVIES & COLLISON, Patent Attorneys, of 1 Little Collins Street, Melbourne, in the State of Victoria, Commonwealth of Australia.

Dated this 31st day of May, 1984.

To: THE COMMISSIONER OF PATENTS

(Lodged at Sub-Office 31 May 1984

Melbourne

Davies & Collison, Melbourne and Canberra.)
In support of the Application made for a patent for an invention entitled: "METHOD OF COMBINING PLURALITY OF PARTS AND STRUCTURE OF PLURALITY OF PARTS COMBINED BY SAME"

AKIO TAKAHASHI, of Hitachi, Ltd. of 6, Kanda Surugadai 4-chome, Chiyoda-ku, Tokyo, Japan

We do solemnly and sincerely declare as follows:

I am authorized by HITACHI, LTD.

1. (a) I am the applicant for the patent
or (b) I am authorized by the applicant for the patent

2. (a) I am the actual inventor of the invention
or (b) KAZUHIRO TSUROKU, of 532 Bouda Apt. 2593, Takaba, Katsuta-shi, Ibaraki-ken, Japan; HISANOBU KANAMARU, of 3449-7, Higashishikawa, Katsuta-shi, Ibaraki-ken, Japan; TAKEFUMI OHWADA, of 2428-233, Kouya, Katsuta-shi, Ibaraki-ken, Japan; ISSAO HAYASE, of 2920-116, Mawatari, Katsuta-shi, Ibaraki-ken, Japan; and MASAO MIZUKAMI, of 2917-49, Mawatari, Katsuta-shi, Ibaraki-ken, Japan are the actual inventor(s) of the invention and the facts upon which the applicant is entitled to make the application are as follows:

The applicant is the assignee of the said actual inventors.

3. The basic application was made in Japan on the 3rd June, 1983

4. The basic application referred to in paragraph 3 of this Declaration was the first application made in a Convention country in respect of the invention the subject of the application.

Declared at TOKYO this 22nd day of May, 1984.

Akio TAKAHASHI, Patent Attorney

DAVIES & COLLISON, MELBOURNE (Authorized Signing Officer)
UNITING TWO MEMBERS VIA EXPANSION OF A THIRD MEMBER

KAZUHIRO TSURUOKA, HISANOBU KANAMARU, TAKEFUMI OHWADA, ISAO HAYASE AND MASAO MIZUKAMI

Claim

1. A method of combining a plurality of parts, comprising the steps of arranging a first member to be combined, which has a first connecting bore, and a second member to be combined, which has a second connecting bore, in such a manner that one of said members is piled on the other with said first and second connecting bores substantially aligned with each other, inserting a connecting member into said first and second connecting bores in said first and second members to be combined, and expanding said connecting member to combine said first and second members together via said connecting member.
6. Structure of a plurality of combined parts, which is obtained by inserting a connecting tube into connecting bores in piled members to be combined, and expanding said connecting tube to combine said members together, comprising first and second members combined together in a piled state and having therein first and second connecting bores substantially aligned with each other, and a connecting tube inserted into both of said first and second connecting bores, said combined members being substantially fixed with the relative positions thereof kept properly, said connecting tube being expanded along the inner surfaces of said connecting bores to combine said members together.

THE CLAIMS DEFINING THE INVENTION ARE AS FOLLOWS:-
Complete specification for the invention entitled:

"METHOD OF COMBINING PLURALITY OF PARTS AND STRUCTURE OF PLURALITY OF PARTS COMBINED BY SAME"

The following statement is a full description of this invention, including the best method of performing it known to us.
TITLE OF THE INVENTION:

METOD OF COMBINING PLURALITY OF PARTS AND STRUCTURE OF PLURALITY OF PARTS COMBINED BY SAME

BACKGROUND OF THE INVENTION:

Field of the Invention:

This invention relates to a method of combining a plurality of parts and the structure of a plurality of parts combined by the same, and more particularly to a method of combining a plurality of parts, which is suitably used to secure an accurate positional relation between parts combined, and the structure of a plurality of parts combined by the same.

Description of the Prior Art:

A method of combining a plurality of parts by tubular rivets is disclosed in Japanese Patent Publication No. 6302/1978. In this method, the bores made in parts to be combined together must be limited to through bores. In addition, the length of a constant diameter portion of a head of a mandrel is substantially equal to the diameter of a rivet-driving bore. Therefore, if a bore in a bore-carrying part is shifted even slightly, the bore-carrying part is displaced by the radial force in accordance with the movement of the mandrel. This causes a decrease in the accuracy
in the relative positional relation between the bore-carrying part and mandrel.

Summary of the Invention:

An object of the present invention is to provide a method of combining a plurality of parts, which is suitably used to secure a high accuracy in the relative positional relation between parts to be combined, and the structure of a plurality of parts combined by the same.

The present invention provides a method of combining a plurality of parts with a high accuracy in the relative positional relation therebetween, consisting of the steps of putting together in a piled state a plurality of parts having connecting bores in opposed portions thereof, inserting a connecting tube into the connecting bores, and then expanding the connecting tube.

The present invention further provides a combined structure of a plurality of parts, consisting of a first member to be combined, which has a first connecting bore, a second member to be combined, which has a second connecting bore, and a connecting member inserted into the first and second connecting bores at once and expanded therein to combine the first and second members together.
A preferred embodiment of the present invention provides a method of combining a plurality of parts, consisting of the steps of arranging members to be combined, in which connecting bores are formed in advance, in a piled state in such a manner that the connecting bores are aligned with each other, substantially fixing these members with the relative positions thereof kept properly, inserting a connecting member into the connecting bores in the resultant members to be combined, and expanding the connecting member along the inner surfaces of the connecting bores to combine the fixed members together.

The above and other objects as well as advantageous features of the invention will become apparent from the following description of the preferred embodiment taken in conjunction with the accompanying drawings.

Brief Description of the Drawings:

Fig. 1 is a front elevational view partially in section of a rotary compressor to which the present invention is applied;

Fig. 2 is a side elevational view partially in section of the same rotary compressor;

Fig. 3 is an enlarged view of a principal portion of the compressor, showing a first step of the part-combining method according to the present invention; and
Fig. 4 is an enlarged view of the principal portion of the compressor, showing a second step of the same method.

Description of the Preferred Embodiment:

The accompanying drawings show an example of a rotary compressor to which a method of combining a plurality of parts according to the present invention is applied. Fig. 1 is a longitudinal section of a principal portion of the rotary compressor.

Referring to the drawing, a shaft 1, which is adapted to be driven by the external driving force, is combined unitarily with a rotor 2 fitted therein. The shaft 1 is supported at its both end portions on the central portions of first and second bushings 5, 6, i.e. parts to be combined, via bearings 3, 4. A cam ring (another part to be combined) 7, which is disposed on an outer circumferential surface of the rotor 2 and between the first and second bushings 5, 6, is tightened and fixed to the bushings 5, 6 in the axial direction with a plurality of through bolts 8. In the meantime, the accuracy in the relative positional relation between the first bushing 5 and cam ring 7, and the second bushing 6 and cam ring 7 is secured as will be described in detail later, by connecting tubes 9 inserted into connecting bores...
and consisting of copper tubes. These three parts are screw-combined fixedly by through bolts inserted through all thereof.

The rotor 2 is provided with radially-opened slits 2A, in which vanes 10 are provided, which always slidingly contact an inner circumferential surface of the cam ring 7 while the rotor is turned. These vanes 10 divide the spaces on the inner side of the cam ring 7 into suction chambers and compression chambers. The portions of the cam ring 7 which correspond to maximum compression points in the compression chambers are provided with discharge ports 1 closed with valves 11 adapted to be opened at a predetermined pressure. Reference numeral 13 denotes screw bores provided in side surfaces of the cam ring 7 and used for positioning the cam ring with respect to the bushings 5, 6 and screw-fixing the latter to increase the surface contact pressure between these parts.

A method of assembling the rotary compressor having the above-described construction will now be described. The shaft 1, on which the rotor 2 is mounted fixedly in advance, is held in the first bushing 5 via the bearing 3. The cam ring 7 is fitted around the rotor 2, and the bushing and cam ring are
screw-fixed to each other by utilizing the screw bores 13. The second bushing 6 is then fitted around the other end portion of the shaft 1 via the bearing 4 to be screw-fixed to the other side surface of the cam ring 7 by utilizing screw bores similar to those referred to above. In the resulting product, the cam ring 7 and bushings 5, 6 are combined firmly under a high surface pressure. A common connecting tube 9 is then inserted into a connecting through bore 5A and a connecting bottomed bore 7A in the bushing 5 and cam ring 7 so as to extend through all thereof as shown in Fig. 3. At least an outer diameter \( l \) of the connecting tube 9 is set smaller than a diameter \( L \) of a connecting bore. Accordingly, the connecting tube 9 can be inserted into the upper and lower connecting bores 5A, 7A smoothly even when these bores are slightly eccentric with respect to each other. As mentioned previously, the connecting tube 9 consists preferably of an easily-deformable material, such as a copper material, an aluminum material, brass, or soft iron. The connecting tube 9 is expanded under pressure by a tube-expanding punch 13 having a diameter \( D \) greater than an inner diameter \( d \) of the tube 9 and smaller than the diameter \( L \) of the connecting bores 5A, 7A, after the tube 9 has been inserted into
the connecting bores.

Fig. 4 shows the condition of the expanded connecting tube. When the punch 13 is lowered, it moves linearly along an inner surfaces of the connecting bores 5A, 7A. Accordingly, the bushing 5 and cam ring 7 come into close contact with the connecting tube 9 as the former are moved unitarily to a slight extent in both the lateral and longitudinal directions.

The cam ring 7 and bushing 5 are provided with connecting bores independently in advance in such a manner that the connecting bores are substantially aligned with each other when the cam ring 7 and bushing 5 are put together in a surface-contacting state. An amount of eccentricity of the cam ring and bushing is around 0–0.4mm. Accordingly, the punch can be lowered through the connecting tube with the cam ring and bushing moved only slightly. The same effect can, of course, be obtained when the punch is lowered as it is moved freely with the cam ring and bushing set in an immovable state.

When the lowered punch 13 reaches a bottom surface of the connecting bottomed bore 7A, the tube-expanding operation is completed. When the depth of the connecting bottomed bore 7A is selected suitably, a sufficient range of connection can be obtained.
The diameter of the connecting bore may be set greater than a maximum diameter $D$ of the punch to enable the punch to lower therethrough properly. It is preferable that the diameter of the connecting bore, through which the punch is lowered, be set greater than the maximum diameter $D$ of the punch and smaller than the outer diameter $\phi$ of the connecting tube $9$ so as to prevent the connecting tube $9$ inserted in the connecting bore from falling. When the connecting bore is formed in this manner, the connecting tube is held firmly at its lower surface in spite of a downward load applied thereto during the lowering of the punch; the connecting tube does not fall.

The punch is substantially in the shape of a bead on an abacus, and has a tube-expanding, circular ridge portion forming a maximum diameter portion $D$. Accordingly, when the punch is inserted into the connecting tube $9$, it is set in the substantially central position therein. When the punch is further pressed down, the connecting tube is expanded to closely contact the inner surface of the connecting bore as the connecting tube is plastically deformed. Even when the upper and lower connecting bores $6A$, $7A$ are a little eccentric with respect to each other, the opposed surfaces of the connecting tube $9$ and punch
can be brought into substantially linear contact with each other, so that the punch can be moved relatively to the connecting tube smoothly and freely. The same effect can, of course, be obtained when the punch is pulled out; the punch can be pulled out smoothly. A spherical punch and a hemispherical punch can also be used effectively.

According to the above-described embodiment, when the relative positions of the cam ring 7 and bushings 5, 6 are determined first to fix these parts therein, the connecting tube 9 is necessarily deformed along the inner surfaces of the connecting bores to closely contact the same. Namely, unlike the case where knock pins and screws are used, the fixed positions initially set do not vary. Therefore, the deformation strain does not occur in the cam ring and bushings. Also, these parts are not deformed due to the thermal cycle. Accordingly, the embodiment can display its performance stably as a rotary compressor.

The embodiment will now be discussed with respect to the assembling and manufacturing of a rotary compressor. Even when the connecting bores made with respect to each other, the accuracy in the relative positional relation between these parts can be
secured, so that the productivity of the rotary compressor increases markedly. Moreover, it is unnecessary during the assembling of these parts to give consideration to the centering of the connecting bores. This enables even an unexperienced person to assemble the parts easily. Also, the connecting tube can be inserted into and expanded in the connecting bores blindly by a simple press work. Although the above embodiment has been described with reference to the combining of plates with an annular part, the invention can also be applied effectively to the fixing of plates in a laminated state; the combining of plates with an annular part and the combining of plates only do not substantially differ.

The cam ring and bushings are combined preliminarily with screws. This preliminary combining work may be done by using pins or rivets. Any other combining means may be used provided that they enable the object parts to be kept in a substantially fixed state while the connecting tube is inserted into and expanded in the connecting bores. The cam ring and bushings can also be kept fixed in the same manner when a metal mold is used for this purpose. According to this part-combining method, it produces a
specially advantageous effect when it is applied to parts to be combined, which consist of an aluminum material, since they have a suitably high thermal expansion coefficient.
THE CLAIMS DEFINING THE INVENTION ARE AS FOLLOWS:

1. A method of combining a plurality of parts, comprising the steps of arranging a first member to be combined, which has a first connecting bore, and a second member to be combined, which has a second connecting bore, in such a manner that one of said members is piled on the other with said first and second connecting bores substantially aligned with each other, inserting a connecting member into said first and second connecting bores in said first and second members to be combined, and expanding said connecting member to combine said first and second members together via said connecting member.

2. A method of combining a plurality of parts, comprising the steps of arranging first and second members to be combined, in which first and second connecting bores are formed in advance, in such a manner that said first and second members are piled with said first and second connecting bores substantially aligned with each other, substantially fixing said first and second members with the relative positions thereof kept properly, inserting a connecting member into said connecting bores in said first and second members, and expanding said connecting member along the inner
surfaces of said connecting bores to combine said first and second members together.

3. A method of combining a plurality of parts according to Claim 2, wherein said connecting member consists of a metal, the hardness of which is not higher than that of said members to be combined.

4. A method of combining a plurality of parts according to Claim 1, wherein said connecting member is inserted into said first and second connecting bores in said first and second members to be combined, after one of said parts to be combined has been piled on the other, said connecting member being then expanded.

5. A method of combining a plurality of parts according to Claim 2, wherein said first and second members to be combined are piled on each other with said connecting member held there-between, said connecting member being then expanded.

6. Structure of a plurality of combined parts, which is obtained by inserting a connecting tube into connecting bores in piled members to be combined, and expanding said connecting tube to combine said members together, comprising first and second members
combined together in a piled state and having therein first and second connecting bores substantially aligned with each other, and a connecting tube inserted into both of said first and second connecting bores, said combined members being substantially fixed with the relative positions thereof kept properly, said connecting tube being expanded along the inner surfaces of said connecting bores to combine said members together.

7. Structure of a plurality of combined parts according to Claim 6, wherein said first connecting bore is a through bore, said second connecting bore being a bottomed bore.

8. A method of combining a plurality of parts, comprising the steps of arranging a first member to be combined, which has a first connecting bore, and a second member to be combined, which has a second connecting bore, in such a manner that one of said members placed adjacent the other with said first and second connecting bores substantially aligned with each other, inserting a connecting member into said first and second connecting bores in said first and second members to be combined, and expanding said connecting member to combine said first and second members together via said connecting member.
9. A method of combining a plurality of parts, substantially as hereinbefore described with reference to the drawings.

10. Structure of a plurality of combined parts, substantially as hereinbefore described with reference to the drawings.

11. The steps or features disclosed herein or any combination thereof.

Dated this 31st day of May, 1984.

HITACHI, LTD.
By its Patent Attorneys
DAVIES & COLLISON