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V. J. CARLI ET AL
METHOD FOR ASSEMBLING TONGUE-AND-GROOVE
MEMBERS WITH LOCKING KEYS

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2 Sheets-Sheet 1

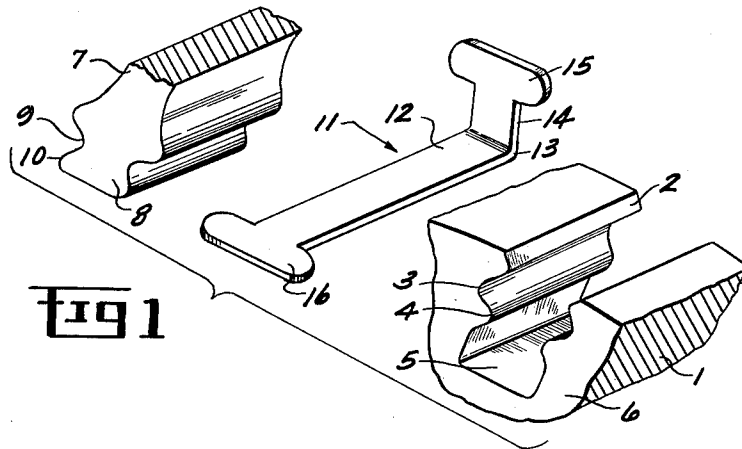


Fig 1

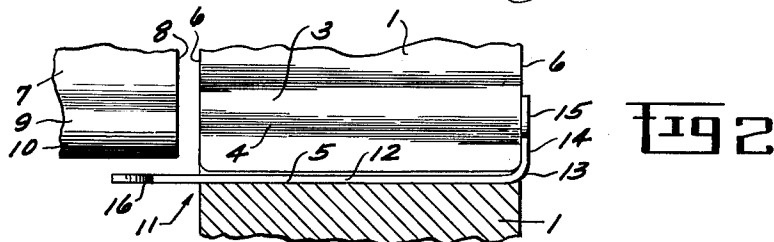


Fig 2

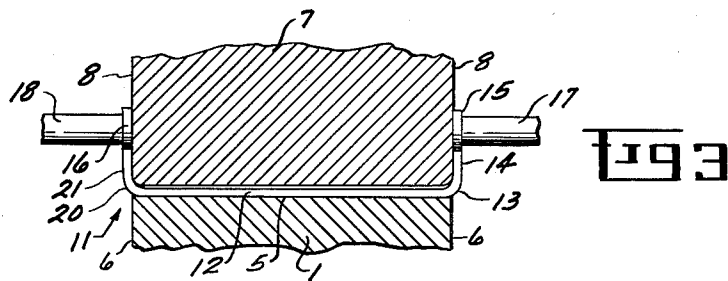


Fig 3

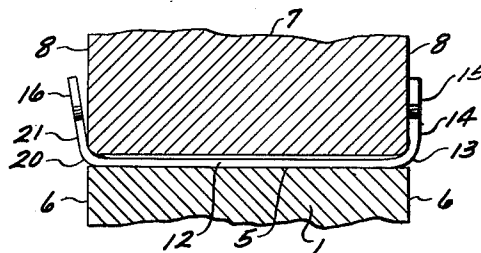


Fig 4

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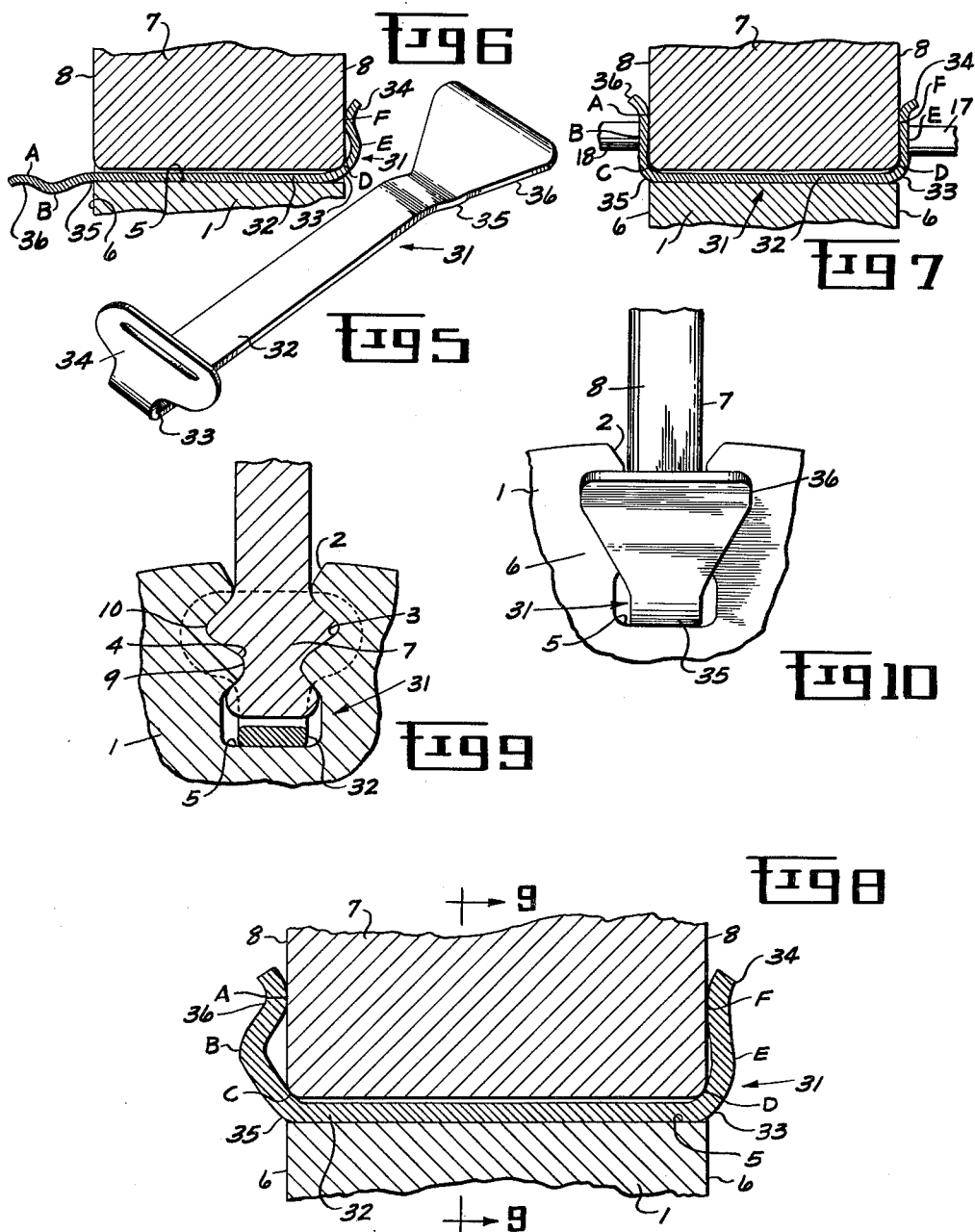
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METHOD FOR ASSEMBLING TONGUE-AND-GROOVE MEMBERS WITH LOCKING KEYS

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4 Claims. (Cl. 29—156.8)

This invention relates to an improved method for assembling tongue-and-groove members with locking keys, and more particularly to an improved method for assembling blades with locking keys in slots formed in the periphery of a rotor wheel.

A method of assembling blades in rotor wheels in common use utilizes a locking key initially formed with a thin flat strip portion having locking tabs of increased width at its ends. One of the locking tabs is initially bent-up transversely to the strip portion. The locking key is inserted in the base of a slot or groove cut axially through the periphery of the rotor wheel, with the bent-up tab engaging an axial face of the wheel adjacent the slot. The blade root, comprising a tongue member, is shaped to conform to the slot, and is next axially slid into engagement therewith, overlying the strip portion of the key. An axial face of the blade root abuts the bent-up tab. The slot and root are generally formed irregularly to restrain the blade radially in the slot. Finally, the unbent tab of the locking key is bent-up by means of a punch, to engage the opposite axial face of the wheel and to overlie the opposite face of the blade root. The blade root is thus retained axially in the slot, against axial forces which are set up by gas loading on the blade during operation of an associated turbine engine.

However, the inherent resiliency of the material of the locking key prevents the bent-up tabs from snugly engaging the disk and blade root after removal of the bending punch, when the above method of application is used. The locking key is formed of resilient material, and the removal of the bending stress allows the material at the bend of the strip, bent by the punch, to return that tab slightly toward the unbent position, away from the wheel and blade root. This phenomenon is known as "spring-back." Vibratory reciprocation of the blade in the slot results, and induces rapid wear and frequent fatigue failure of the blade and the locking strip.

It is the object of our invention to provide an improved method for assembling a tongue member, such as a blade root, with a locking key of the kind described, in a slot of a rotor wheel or other grooved member, which results in a snug fit between the locking tabs of the key and the tongue and grooved members, so that reciprocation of the tongue member in the grooved member is minimized.

Briefly stated, in accordance with one form of our invention, we first form the locking tabs of a conventional locking key of the kind previously described, with reverse bends forming protrusions offset from the plane of the flat strip portion of the key, and spaced from the extremities of the key. One of the locking tabs is then bent-up transversely to the strip portion, and the locking key is inserted in conventional manner in a slot cut axially through the periphery of a turbine wheel, or other grooved member, with the extremity of the bent-up tab engaging a face of the grooved member and a face of the tongue member. The protrusion of the previously bent-up tab is spaced away from the face of the tongue member. Next, a bending punch is applied upon the protrusions of each of the locking tabs, and the previously unbent tab is bent-up until its extremity engages opposite faces of the tongue and grooved members. Each of the tab protrusions is axially spaced from the opposite faces of the

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tongue and grooved members at this point. The bending punches are then further actuated to force the tab protrusions against the opposite faces of the tongue and grooved members distorting the reverse bends of the tabs in a resilient manner. The punches are then withdrawn, and the protrusions spring-back toward their undistorted positions, tending to draw the extremities of the tabs inwardly against the opposite faces of the tongue and grooved members. This spring-back offsets the spring-back caused by the material at the bend of the strip previously bent by the punch, which tends to draw the tabs away from the tongue and grooved members. Spring-back is thus offset, and a snug fit between the tabs, tongue member or blade root, and grooved member or wheel results.

While the specification concludes with claims particularly pointing out and distinctly claiming the subject matter which we regard as our invention, it is believed that the invention will be better understood from the following description, taken in conjunction with the accompanying drawings, in which:

FIG. 1 is an exploded view in perspective of a conventional locking key, together with cut-away portions of a tongue member or blade root and a grooved member or wheel for mounting the blade root;

FIG. 2 is a cross-sectional view of the elements of FIG. 1, showing an initial step in a conventional method of assembly;

FIG. 3 is a view similar to FIG. 2, but showing a subsequent step of the assembly;

FIG. 4 is a view similar to FIG. 2, but showing the elements completely assembled;

FIG. 5 is a pictorial view of a conventional locking key on which initial steps of our improved assembly method have been performed;

FIG. 6 is a cross-sectional view of a wheel and blade root with the key of FIG. 5, showing a further step in our method;

FIG. 7 is a view similar to FIG. 6, but showing a further step;

FIG. 8 is a view similar to FIG. 5, but showing the elements completely assembled according to our method;

FIG. 9 is a view in section of the assembly, taken along line 9—9 in FIG. 8, looking in the direction of the arrows;

And FIG. 10 is an end view of the assembly of FIG. 8.

Referring to FIGS. 1—4, a conventional method for assembling tongue-and-groove members, such as a bladed wheel, is shown. A grooved member or rotor wheel 1, which may be an axial-flow compressor or turbine wheel, is formed in its periphery with an axially extending slot 2 for each blade to be attached to the wheel. Slot 2 has a base portion 5, and several convoluted recesses 3 and ridges 4, for the purpose of receiving a blade in axially slidable but radially restrained relationship. Wheel 1 is also formed with opposite axial faces 6.

A tongue member or blade root 7 is formed with opposite axial faces 8, and with several convoluted recesses 9 and ridges 10, conforming to the contours of slot 2. The convolutions of the root and slot thus prevent their radial separation after assembly, but further means must be provided to prevent their axial separation. These means conventionally comprise a locking key generally designated 11, having a flat strip portion 12 intermediate locking tab portions 15 and 16 of increased width, at its ends.

As the first step in a conventional method of assembling these elements, one of the tabs 15 of key 11 is bent-up transversely to strip portion 12. The key is then inserted in slot 2 with strip portion 12 lying along base portion 5, as shown in FIG. 2. Tab 15 axially abuts and

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overlies a face 6 of wheel 1, adjacent slot 2. Root 7 is then slid axially into slot 2 until it also abuts tab 15, and axial faces 8 of the root lie in the same planes as axial faces 6 of the wheel.

After the insertion of the blade root in the slot, bending punches 17 and 18 are applied to tabs 15 and 16, respectively, and tab 16 is bent-up transversely to strip portion 12, as shown in FIG. 3. Tab 16 then overlies the second one of the axial faces 6 and 8 of wheel 1 and root 7, respectively, to restrain the blade root against axial separation from the slot. The material of the strip portion is thus bent about corner portions 13 and 20, and the bending stresses produced by the last-mentioned operation are principally set up in the material in the vicinity of corner 20.

As bending punches 17 and 18 are released to relieve the bending stresses on the locking key, the resiliency of strip portion 12 causes the material in the vicinity of corner 20 to spring-back, drawing tab 16 away from root 7 and wheel 1. The final position of tab 16 is shown in FIG. 4, axial spaced from axial faces 6 and 8. Because of this axial spacing resulting from assembly by the conventional method just described, root 7 is thus subject to some degree of vibratory movement axially in slot 2. Fatigue and eventual failure of the blade root and locking key result from such vibratory movement.

Our improved method of assembly, which affords a snug fit between the tabs of a conventional locking key and the axial faces of the wheel and blade root, is shown in FIGS. 5-10. The initial step of the process is shown in FIG. 5. Prior to the assembly of tongue member or blade root 7 in a slot of the grooved member or rotor wheel 1, we form locking tabs 34 and 36 of a conventional locking key, generally designated 31, with reverse bends forming protrusions E and B in the tabs, respectively. The protrusions E and B are located intermediate the ends of the tabs 34 and 36, respectively, and the strip portion 32 of the locking key. Key 31 is initially formed as a flat member (not illustrated), and protrusions E and B are thus initially offset from the plane of a strip portion 32 of the locking key; however, the reverse bends are so made that ends F and A of tabs 34 and 36, respectively, lie substantially in the plane of the strip portion.

One of the locking tabs 34 is then bent-up transversely to the plane of strip portion 32 in a direction opposite the direction of bend of the protrusions E and B, forming a bend portion 33 and a corner D in the strip portion. Key 31 is then inserted in slot 2 of wheel 1, with strip portion 32 lying along base portion 5, as shown in FIG. 6. Tab 34 axially abuts and overlies a face 6 of wheel 1, adjacent slot 2. Root 7 is then slid axially into slot 2 until it abuts tab 34, and axial faces 8 of the root lie in the same planes as axial faces 6 of the wheel. Root 7 and slot 2 are formed as in the conventional assembly of FIGS. 1-4, including convoluted recesses 3 and 9, and ridges 4 and 10, which restrain the blade root against radial disassembly from the wheel.

Referring to FIG. 7, we next apply bending punches 17 and 18 to tabs 34 and 36 at protrusions E and B, respectively, in order to bend-up tab 36 transversely to strip portion 32. Tab 36 bends about a corner C and a bend portion 35 in a direction opposite the direction of bend of the protrusions E and B, formed by root 7, until end A abuts a face 8 of the root and a face 6 of the wheel.

If the punches 17 and 18 were released at this stage, the resiliency of the material at bend portion 35 would spring-back to space end A axially away from faces 6 and 8. In order to secure a snug fit between end A and faces 6 and 8, we carry out the further step of bending protrusions B and E further inwardly until they abut faces 6 and 8. Ends A and F, abutting faces 6 and 8, resiliently oppose this further bending, and the material in the vicinity of the protrusions is stressed in such a direction as to tend to spring-back away from the faces, but to urge ends A and F toward the faces.

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Punches 17 and 18 are then released, and tabs 34 and 36 spring-back to the positions shown in FIG. 8, in which protrusions B and E are axially spaced apart from faces 6 and 8. While bends C and D have sprung-back to carry protrusions B and E away from the faces of the blade root and wheel, protrusions B and E have also sprung-back to urge ends A and F into snug contact with these faces.

By bending both of protrusions B and E into abutment with the faces of the blade root and wheel, spring-back is utilized in both locking tabs to offset the effects of spring-back at bend C. However, it will be apparent that the same beneficial effect may be partially secured by bending only protrusion B into abutment upon the faces of the wheel and root.

It will be understood that bending punches 17 and 18 represent only illustrative means for carrying out the bending operations, and that the steps of our improved process may be carried out by hand, or by various well-known mechanical means. The application of the process, as previously pointed out, is not limited to the assembly of bladed rotors, but may be more generally applied to assembling tongue members in grooved members with retaining keys of the type described, having locking tabs abutting opposite surfaces of the joined members.

It will be apparent from the foregoing description that we have provided an improved method for assembling a tongue member or blade with a locking key in a slot of a grooved member or rotor wheel, which affords a snug fit between locking tabs of the key and the tongue and grooved members, to minimize reciprocation of the tongue member in the grooved member. While we have shown and described a particular embodiment of our invention, it will be obvious to those skilled in the art that various changes and modifications may be made without departing from our invention in its broader aspects. We therefore intend in the appended claims to cover all such changes and modifications as fall within the true spirit and scope of our invention.

What we claim and desire to secure by Letters Patent of the United States is:

1. The method of assembling a tongue member with a locking key in a grooved member adapted to receive said tongue member in axially slidable relation therein, said key having locking tab portions at the ends thereof and a flat strip portion intermediate said tab portions, a first one of said tab portions being bent transversely to said strip portion, which comprises the steps of: forming the second one of said locking tabs with a reverse bend forming a protrusion offset from the plane of said strip portion in a direction opposite the direction of bend of said first tab portion and spaced from the end of said second tab portion intermediate said second tab portion end and said flat strip portion; inserting said locking key in the groove of said grooved member so that said first tab portion abuts a first face of said grooved member adjacent said groove; inserting the tongue of said tongue member in said groove with a first face of said tongue in abutment upon said first tab portion; bending said second tab portion transversely to said strip portion so that said end of said second tab portion abuts second faces of said tongue and grooved members opposite said first faces, respectively, and said protrusion of said second tab portion is spaced apart from said tongue and grooved members; and further bending said protrusion into abutment upon said second faces of said tongue and grooved members; such that said protrusion when released springs-back to urge said end of said second tab portion into resilient engagement with said second faces of said tongue and grooved members.

2. The method of assembling a blade root with a locking key in a slot formed in the periphery of a wheel to receive said blade root in axially slidable relationship therein, said key having locking tab portions at the ends thereof and a flat strip portion intermediate said tab por-

tions, a first one of said tab portions being bent transversely to said strip portion, which comprises the steps of: forming the second one of said locking tabs with a reverse bend forming a protrusion offset from the plane of said strip portion in a direction opposite the direction of bend of said first tab portion and spaced from the end of said second tab portion intermediate said second tab portion end and said flat strip portion; inserting said locking key in said slot so that said first tab portion abuts a first axial face of said wheel; inserting said blade root in said slot with a first axial face of said blade root abutting said first tab portion; bending said second tab portion transversely to said strip portion so that said end of said second tab portion abuts second axial faces of said wheel and said blade root; and said protrusion of said second tab portion is axially spaced apart from said wheel and said blade root; and further bending said protrusion into abutment upon said second axial faces of said wheel and said blade root; such that said protrusion when released springs-back to urge said end of said second tab portion into resilient engagement with said second axial faces of said wheel and said blade root.

3. The method of assembling a tongue member with a locking key in a grooved member adapted to receive said tongue member in axially slidable relation therein, said key having locking tab portions at the ends thereof and a flat strip portion intermediate said tab portions, which comprises the steps of: forming said tab portions with reverse bends forming protrusions offset from the plane of said strip portion and spaced from the ends of said tab portions intermediate said ends of said tab portions and said flat strip portion; bending a first one of said tab portions transversely to said strip portion in a direction opposite the direction of bend of said protrusions; inserting said locking key in the groove of said grooved member so that the end of said first tab portion abuts a first face of said grooved member adjacent said groove and said protrusion of said first tab portion is spaced apart from said grooved member; inserting the tongue of said tongue member in said groove with a first face of said tongue in abutment upon said end of said first tab portion; bending the second of said tab portions transversely to said strip portion in a direction opposite the direction of bend of said protrusions so that the end of said second tab portion abuts second faces of said tongue and grooved members

opposite said first faces, respectively, and said protrusion of said second tab portion is spaced apart from said tongue and grooved members; and further bending said protrusions into abutment upon said first and second faces of said tongue and grooved members, respectively; such that said protrusions when released spring-back to urge said ends of said locking tabs into resilient engagement with said first and second faces of said tongue and grooved members, respectively.

4. The method of assembling a blade root with a locking key in a slot formed in the periphery of a wheel to receive said blade root in axially slidable relationship therein, said key having locking tab portions at the ends thereof and a flat strip portion intermediate said tab portions, which comprises the steps of: forming said tab portions with reverse bends forming protrusions offset from the plane of said strip portion and spaced from the ends of said tab portions intermediate said ends of said tab portions and said flat strip portion; bending a first one of said tab portions transversely to said strip portion in a direction opposite the direction of bend of said protrusions; inserting said locking key in said slot so that the end of said first tab portion abuts a first axial face of said wheel and said protrusion of said first tab portion is axially spaced apart from said wheel; inserting said blade root in said slot with a first axial face of said blade root abutting said end of said first tab portion; bending the second of said tab portions transversely to said strip portion in a direction opposite the direction of bend of said protrusions so that the end of said second tab portion abuts second axial faces of said wheel and said blade root and said protrusion of said second tab portion is axially spaced apart from said wheel and said blade root; and further bending said protrusions into abutment upon said axial faces of said wheel and said blade root; such that said protrusions when released spring-back to urge said ends of said locking tabs into resilient engagement with said axial faces of said wheel and said blade root.

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