

S. Z. DE FERRANTI.

PROCESS FOR ATTACHING TURBINE BLADES TO THEIR CARRYING ELEMENTS.

APPLICATION FILED DEC. 15, 1905.

906,400.

Patented Dec. 8, 1908.

3 SHEETS—SHEET 1.

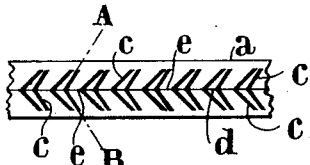


Fig. 1.

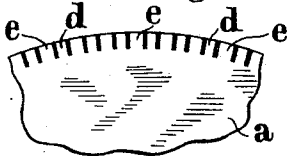


Fig. 3.

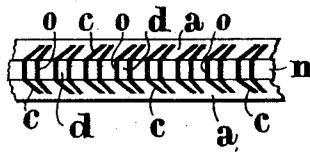


Fig. 5.

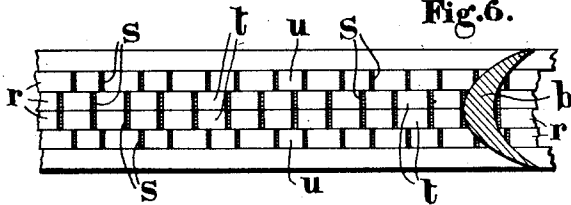


Fig. 7.

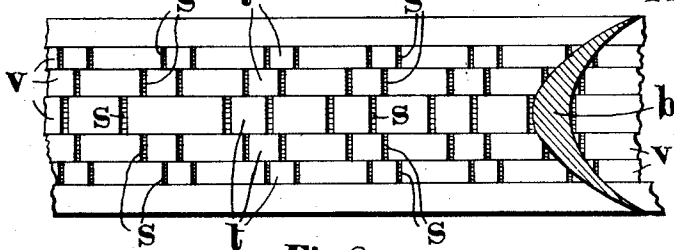


Fig. 8.

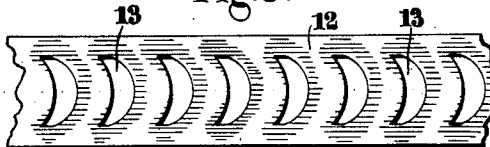


Fig. 17.

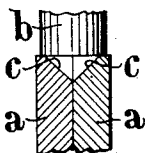


Fig. 2.



Fig. 4.

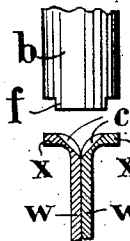


Fig. 9.

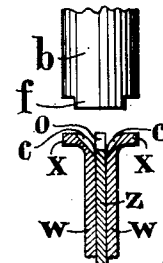


Fig. 10.

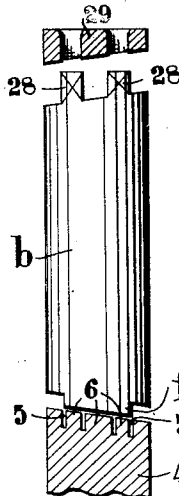


Fig. 12.

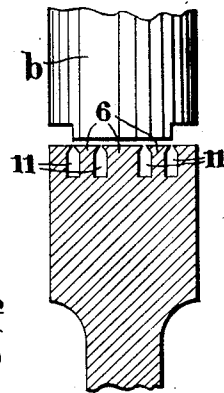


Fig. 15.

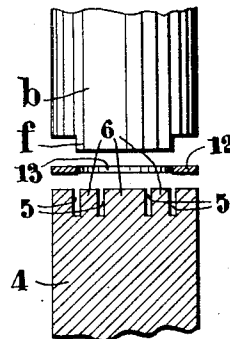


Fig. 16.

Attest:

Edward L. Folsom
Edward N. Sartor

Inventor,

Sebastien Jigari de Ferranti,
By *Spencer Widdell*, *Durand* *Spencer*
Attys.

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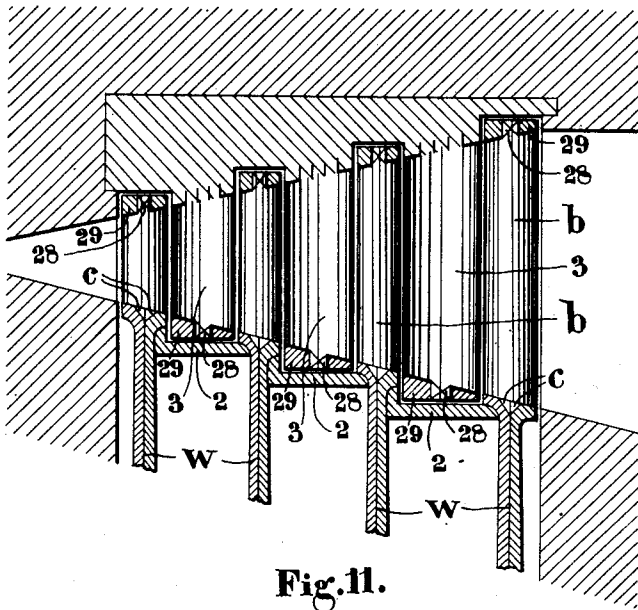


Fig. 11.

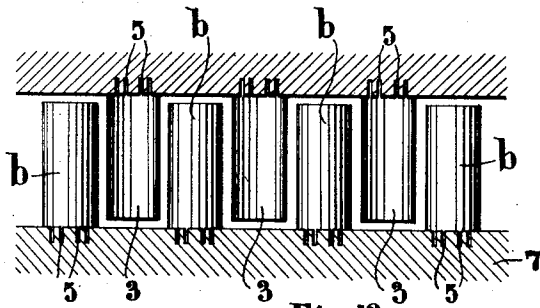


Fig. 13.

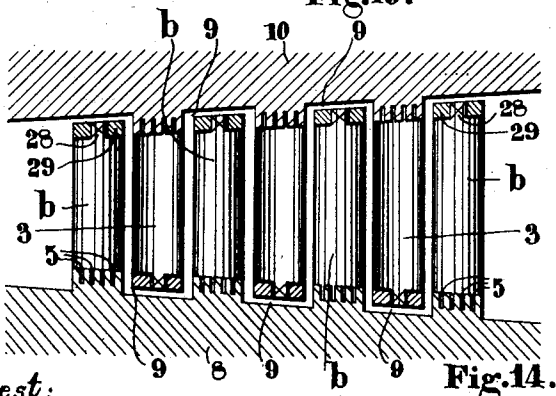


Fig. 14.

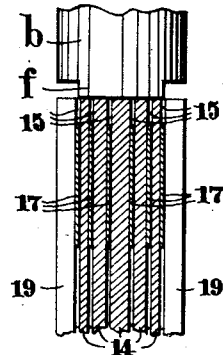


Fig. 18.

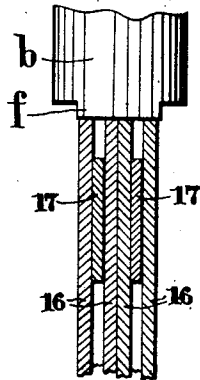


Fig. 19.

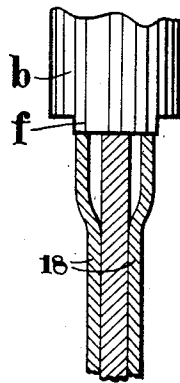


Fig. 20.

Attest:

Edward L. Tolson
Edward N. Sartou

Inventor,

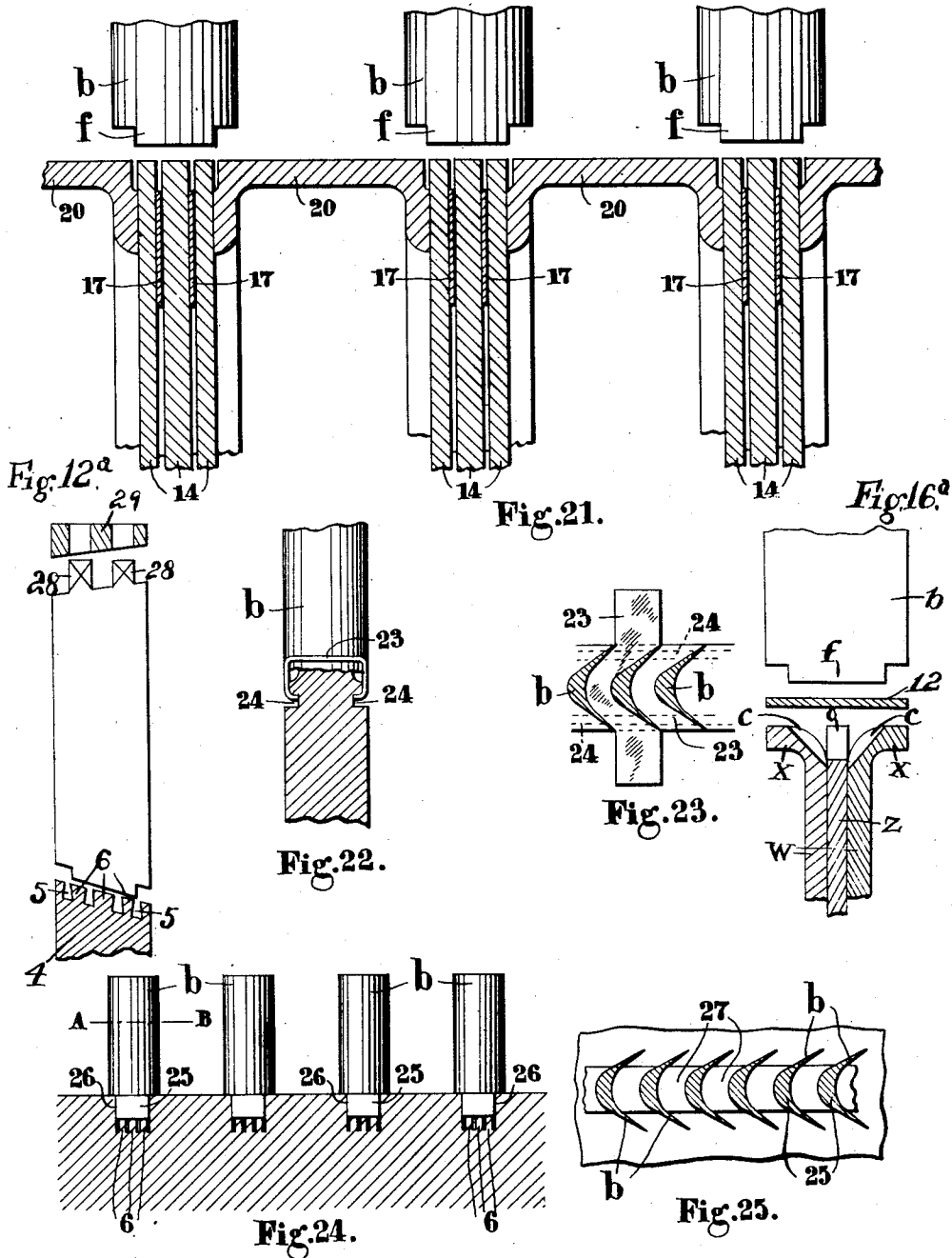
Sebastian Ziani de Ferranti
 By *Speer, Middleton, Donaldson & Speer*
 Attys.

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3 SHEETS—SHEET 3.



Attest:

Edward L. Tolson
Edward N. Sartor

Inventor,

Sebastian J. de Ferranti
 By *Spear, Middleton, Dorell & Spear*
 Attys.

UNITED STATES PATENT OFFICE.

SEBASTIAN ZIANI DE FERRANTI, OF HAMPSTEAD, LONDON, ENGLAND.

PROCESS FOR ATTACHING TURBINE-BLADES TO THEIR CARRYING ELEMENTS.

No. 906,400.

Specification of Letters Patent.

Patented Dec. 8, 1908.

Application filed December 15, 1905. Serial No. 291,933.

To all whom it may concern:

Be it known that I, SEBASTIAN ZIANI DE FERRANTI, a subject of the King of Great Britain and Ireland, and residing at 31 Lyndhurst road, Hampstead, London, N. W., England, have invented certain new and useful Improvements in Processes for Attaching Turbine-Blades to Their Carrying Elements, of which the following is a specification.

This invention relates to the welding of turbine blades on to the wheels, rings or drums carrying them and also to apparatus used in connection therewith.

The object of my present invention is to improve upon processes at present employed for electrically welding turbine blades to their carrying elements so as to obtain with greater certainty a stronger weld and therefore a better attachment of the blade.

A further object of my invention is to effect the weld with less disturbance of the neighboring metal so as to obtain a smooth passage through the blades.

It has heretofore been proposed to make the disk, ring or drum at the point at which each blade is welded of approximately the same section and conductivity as the blade itself. According to one method which has been proposed a wheel of rather less thickness at the rim than at the width of the blades is taken and grooves cut across the rim thus leaving teeth of the necessary section projecting therefrom on to which the blades were welded. This construction left the projecting tooth on to which the blade was welded of a different cross section from that of the blade itself, the metal in the neighborhood of the root of the welded blade being consequently rough and irregular and offering considerable frictional resistance to the passage of the working fluid. According to another method the blades are welded on to circumferentially formed rings in the rim of the wheel or other part on to which the welding was to be done; the passage between the blades in the neighborhood of the weld was however even more irregular according to this method than according to that described above.

Now the present invention consists in so forming the ends of the blades and the parts upon which they are welded that a smooth path of any desired form is made and that a weld of great strength not only in resisting

centrifugal force but also tangential force is produced.

Referring now to the accompanying drawings which form part of the specification:— Figure 1 shows a developed edge view of part of a wheel built up of two disks, each provided with angled slits, Fig. 2 being a corresponding section taken on the line A B of Fig. 1, and Fig. 3 a part elevation looking on one of the adjacent faces of a disk; Fig. 4 shows an elevation of a turbine blade having a welding shank or tag; Figs. 5 and 6 correspond respectively to Figs. 1 and 2, the wheel however being built up of three disks instead of two; Fig. 7 is a developed edge view of part of a wheel built up of several disks of equal thickness assembled stepwise as regards the welding teeth. Fig. 8 being similar generally but showing a wheel built up of disks of different thickness; Fig. 9 shows a section through the rim portion of a wheel built up of two flanged disks, Fig. 10 being a similar view of a modified form in which a center disk is added to the above; Fig. 11 shows a multiple wheel built up of component wheels of the type shown in Fig. 9; Fig. 12 illustrates a method of welding in which circumferential grooves are cut in a wheel, while Fig. 12^a shows a modification of the wheel shown in Fig. 12 but with V-shaped grooves. Figs. 13 and 14 show the same plan adapted to multistage turbines having cylindrical and conical drums respectively; Fig. 15 shows a wheel in which the circumferential rings are burred or rolled over; Figs. 16 and 17 illustrate a method of welding in which a punched strip is interposed between the turbine wheel and blade; Fig. 16^a shows a modification of the method illustrated in Figs. 16 and 17, and in which an unperforated strip is interposed between the wheel and the blade. Figs. 18, 19 and 20 show wheels built up of disk portions of graded thickness and spaced at the edges so as to form circumferential grooves; Fig. 21 shows a drum built up of individual wheels having circumferential grooves; Fig. 22 shows a section through the rim portion of a turbine wheel in which strips are inserted between adjacent blades, Fig. 23 being a corresponding edge view showing a strip before bending over; Fig. 24 shows a form in which the welding takes place at the bottom of a comparatively deep groove, packing pieces being calked into this groove between adja-

cent blades, Fig. 25 is a corresponding part section taken on the line A B of Fig. 24.

I wish it to be understood that in order to avoid undue complexity in the drawings, they are to a large extent of a diagrammatic nature.

Where desirable the same reference symbols are used to denote corresponding parts in the different figures.

10 According to one method of carrying the invention into effect, (see Figs. 1 to 3) I make the wheel of two disks, *a*, of slightly more combined width at their rims than the width of the blades, *b*.

15 Across one circumferential corner or edge of each wheel disk, *a*, I cut grooves or slits, *c*, by means of a fine circular saw or other convenient means, the plane of each cut, (i.e., the plane of the saw, if a saw is used) being 20 inclined at an angle of 45° or thereabouts to the center plane of its wheel disk and intersecting this latter plane in a radial line. Consecutive cuts are put at an angle to each other as shown so that when the two wheel 25 disks, *a*, which are cut right and left hand, are put together, the cuts mark off on the edges of the disks a series of parts, *d*, which approximate in shape to that portion of the root of the blade to be welded to them. The 30 metal, *e*, of the wheel rim is not cut away between these parts, *d*, but is left standing, the rim thus consisting of partially cut "teeth"; *d* and *e*, alternately disposed, the blades being welded to those marked *d*, 35 while those marked *e* are left blank.

The blade ends I form by punching or other suitable means with a shank, *f*, (see Fig. 4) which may stand out from the body of the blade say one twentieth of an inch.

40 The blades when being welded are held in closely fitting jaws shaped to clear adjacent blades the blade being placed in the jaws so that only the shank, *f*, projects.

In cutting the tooth on to which, the 45 welding takes place and in proportioning the end of the blade and the conductivity of the jaws which hold it, I am careful to arrange the various sections, sizes, and conductivities so that the tooth on to which 50 welding is to take place is at first heated more rapidly than the shank of the blade. The effect of this and the above described arrangement is that the principal heating first takes place between the blade and the 55 tooth, i. e., on the surface of the part on to which welding is to be effected. A very considerable pressure is applied during the process, and this results, when the above arrangement is carried out, in the actual 60 welding surface being forced into the wheel or other part and the surface of the wheel being left clean and smooth and untouched by the disturbing bur which takes place at the weld. Moreover, the forcing into the 65 wheel of the blade shank spreads the metal

under the heat of welding and largely fills up the saw cuts in the rim. This has the effect of allowing a good weld to be made with a fair amount of metal crushed out, which is a very desirable feature. It also 70 makes the welded end of the blade fit the side of the grooves into which it is forced and so greatly supports the blade against side strain. So fully is this carried out in practice when the blade welding is done according 75 to my present invention, that it is possible to hammer over the blades at right angles to their original position without cracking the metal of the weld, thus showing that great strength and rigidity are obtained accord- 80 ing to the method of my present invention.

The arrangement above described as typical of my invention may be varied in many ways. Thus according to a modification, the wheel instead of being built up of two disks, 85 *a*, as shown in Fig. 1, may be formed of three disks, (see Figs. 5 and 6)—a center one, *n*, which has slits, *o*, cut straight across the edge from face to face instead of at an angle and two side disks, *a*, disposed one on each side of 90 the center one, *n*, to make up the thickness of the finished wheel as desired, the side disks being right and left hand and having grooves or slits, *c*, cut in them at an angle, as already described. The section, *d*, of the 95 face of each "tooth" on to which the welding is to be effected approaches even more closely to the section of the blade according to this method than in the arrangement above described. The complete wheel may thus by 100 an obvious extension of the method of the preceding paragraph be made up of any number of separate disks that is found convenient, provided that the above described methods are adhered to of separating those 105 portions on to which the welding is to take place.

According to another method, when the wheel is built up of several disks instead of cutting some or all of the slits at an angle, 110 each disk is provided with slits, such as those shown at *o*, Figs. 5 and 6, cut straight across the edge but in this case the width of the "teeth" on to which welding is to take place must be graded and stepped round so as to 115 approximate as closely as possible to the section of the blade. Thus referring to Fig. 7, a wheel is indicated as built up of six disks, *r*, of equal thickness, the combined thickness of the central four being equal to the width of 120 the blade shank. Cross slits, *s*, are cut as indicated so as to leave broad welding teeth, *t*, on the two central disks and narrower teeth, *u*, on the second and fifth disks. By assembling the disks in a stepped manner as shown, 125 the welding surfaces can be arranged to follow closely the section of the blade. According to a modification of this method, (see Fig. 8) the disks, *v*, to which the blades are welded may conveniently be made of dif- 130

ferent thicknesses and assembled in a symmetrical manner with the thickest in the middle, the thicknesses of succeeding plates decreasing towards the sides. The disks are provided with cross slits, *s*, as before so as to leave welding teeth, *t*, of different widths. By thus combining disks of different thicknesses with welding teeth of different breadths arranged in a stepped manner, it is easy with straight cross grooving to provide an isolated welding surface which approximates very closely to the shape desired.

According to another modification of the above described methods, where I desire to weld on to a smooth face of either cylindrical or conical section and where owing to the moderate speed of the turbine the disks can be made of thin metal, I form the wheel, (see Fig. 9) of say two disks, *w*, which are dished at the rims so as to provide flanges, *x*, or in other words, they are turned over from the form of a disk into the form of a cylinder at the rims. Two disks thus formed are put together as shown in Fig. 9 with the disk parts touching and cylindrical parts, *i. e.*, the flanges, *x*, projecting outwards. The surface thus presented is grooved from the center dividing line outwards towards the edges of the cylindrical portion, the grooves or slits, *c*, being cut at an angle so as to isolate portions of the faces where the welding is to be done in a manner precisely similar to that already described above with reference to Figs. 1 to 3. This method, for example, may be carried into effect with two disks each of say one tenth of an inch in thickness and turned over sufficiently round the periphery to present a surface half an inch in width to correspond to the width of the blades.

The method just described may itself be modified by making the wheel of three thin disks, namely a central one, *Z*, and two side ones bent over as above described, (see Fig. 10), the center one being provided with slits, *c*, cut straight across the edge as in the form described with reference to Figs. 5 and 6, and the side disks being cut at an angle through a circumferential corner as before. The welding then takes place across the edges of all three disks.

When multiple wheels of this description are built to go on a shaft, the spaces in between the rims (see Fig. 11) may be filled up with circumferential rings, 2, of channel section or the like into which the shrouded ends of the standing blades, 3, project thus forming an effective guard and preventing undue friction with the working fluid. The shrouding ring of the running and the standing blades may be attached by any of the well known methods.

According to another method I weld the blades upon wheels, rings, or drums, the welding surface of which is cut up into rings by means of circumferential grooves of the

desired width and spacing run round about them; but, unlike the arrangement of my previous invention, I leave a smooth face with comparatively narrow grooves cut in them, and I also grade the width of the circumferential rings which are left between the grooves in such a way that the surface presented under each part of the blade is approximately of the same width as the surface at right angles of the blades, *i. e.*, the thickness of the blades, at each part. Moreover, I form the blade with a projecting shank as already described herein, and carry it in jaws as already described. Welding may then be most satisfactorily effected between the blade shank and the ring surface, the shank of the blade being forced into this and a smooth path being left between the blades, any little disturbance on the surface, due to the weld, being flattened by the jaws, which are flush with the end of the blade proper and which come in contact with the surface on to which the welding is done, but only after the current has been automatically cut off. Thus referring to Fig. 12, the rim portion of a wheel, 4, is shown having circumferential grooves or slits, 5, separating continuous rings of metal, 6, of graded thicknesses as explained above. A blade, *b* having a welding shank, *f*, is shown in the figure in a position, closely adjoining the prepared wheel rim, a shrouding ring, 29, being attached by any known method. The welding may be effected on to any number of the circumferential rings, 6, and these may have any desired graded widths to suit the particular case in point as explained above. It is convenient to cut four circumferential slits, 5, thus leaving three rings, 6, on to which to weld, a central wide one and a narrower one on each side, the exterior rings against which the cut ends of the blade butt when pressed home not being used for welding.

Referring to Fig. 13, the circumferential groove method is shown applied to both the running blades, *b*, and the standing blades, 3, of a multistage turbine having a cylindrical drum, 7, while in Fig. 14, a conical drum, 8, is shown all the blades being provided with shrouding rings; in this latter case, however, I prefer to cut grooves or recesses, 9, into which the shrouding rings on the standing and the running blades may enter both in the conical drum, 8, and in the casing, 10, respectively.

Where I desire to get a still smoother face, *i. e.* rim surface, than is obtained with the plain circumferential grooving on to which the tag or shank of the blade is welded, I may, after providing the wheel or the like with grooves, 11, as before (see Fig. 15), roll its surface, *i. e.*, the surface of the rings, 6, formed on the wheel, so as to close the grooves over, although the inner part of the slot remains and so insulates the heat that

welding takes place satisfactorily as already explained. In order to facilitate the burring over of the surface of the rings, 6, I may make the grooves of V section Fig. 12^a instead of the section shown in Fig. 12. When the burring roller is then applied, the metal spreads out more readily so as to close over the grooves; after the rolling, the wheel may have its surface machined or ground so, as to finish it.

According to another method I obtain a smoother passage between the root portions of the blades by means of covering the ringed surface or edge of a wheel prepared as shown in Fig. 12 with a thin strip of metal, 12, continuous or in sections (see Figs. 16 and 17) out of which holes, 13, are punched of a similar shape to but larger than the cross section of the tag or shank of the blade. The tags, 20, are then put through the punched holes, 13, in the strip direct on to the circumferential rings, 6, for welding. The tag is made rather longer according to this process and the edges of the blades coming down on to the side portions of the strip hold it in position apart from any attachment which is obtained by the fusing together of the parts in welding.

According to another method Fig. 16^a, I may cover the circumferential grooves with a very thin strip of metal, such as that numbered 12 in Fig. 16, but without holes punched in it; the welding is then effected just in the same way as though the strip was not present. Special care must be taken when working according to this method as regards the proportioning of the opposing sections and the adjusting of the welding current so that the parts may be satisfactorily welded together.

According to a modification of the circumferential grooving method, I may form the wheels of disks, 14, put side by side (see Fig. 18) with spaces 15, in between them which correspond to the grooves or slits, 5, already described above. The thickness of metal between the spaces, 15, are so proportioned that their section is suitable for welding in relation to the section of the blade at the particular part concerned. I may accomplish this either by adopting individual disks of different thicknesses as shown in Fig. 18 or I may use disks, 16, of the same thickness as shown in Fig. 19, and group them together so as to give the effect desired.

The individual disks may either be assembled with intervening packing rings or distance pieces, 17, as shown in Figs. 18 and 19 or the outer disks, 18, may be dished as in Fig. 20. I form the blades with shanks and hold them in jaws as already described, the welding then being effected in a most satisfactory manner. Additional disks, 19, as shown in Fig. 18, may be put on each side of the wheel in the first instance or after-

wards; these disks are of the same diameter as those on which the blade shank is actually welded but owing to this projecting shank and the cutting away of the other part of the blade end, welding does not take place on to these additional disks and they merely act as shrouds. Or according to a modified arrangement as shown in Fig. 21, I may fasten rings, 20, in between the peripheries of the circumferentially grooved wheels in such a manner that a smooth or grooved path is formed circumferentially in between the blade ends thus giving the structure the external appearance of a drum. I may so form and assemble the component parts of the complete drum according to this modification that the welding takes place on a conical surface as in Fig. 11, the path through the blades taken by the working fluid then expanding in area so as to allow for the change in velocity of the fluid as it does work.

I deal with any irregular surface that may be left after welding by means of stampings, 23, (see Figs. 22 and 23) which are put in between each pair of adjacent blades; the ends of these stampings are turned over and pressed into grooves, 24, cut round each side of the wheel rim as shown. It will be evident that according to this method the path traversed by the working fluid between the blades may either remain constant in area as in Fig. 13 or expand as in Fig. 14.

According to another method, (see Figs. 24 and 25), I may form the blades with long shanks, 25, say $\frac{1}{4}$ inch or thereabouts and weld these shanks on to circumferential rings, 6, formed at the bottom of grooves, 26, running round the drum or the like in positions corresponding to the rings of blades to be welded. In this case the welding jaws not only entirely contain the blades but also about $\frac{3}{16}$ inch of the blade shank. Welding is then effected as already described on to the projecting rings, 6, within the main groove, 26, the edges of the blades left from the cutting of the shank coming down into contact with the surface of the wheel or drum on to which the welding is done. After the welding is complete, packing pieces, 27, formed to the shape of the blades on two sides and to the width of the main groove, 26, on the other two sides are pressed in between the blades into the main groove and are then held in position by means of calking, the calked packing piece adding to the tangential stiffness and the weld at the bottom of the groove absolutely insuring the holding of the blade in position.

All the blades already described may have their ends cut either square or oblique to their length and where the blades are short, as for certain purposes, the smooth ends, i. e., the ends remote from the blade carrier,

may be left unsupported, this method of construction being satisfactory owing to the great strength of fixing afforded by all the methods described according to this invention.

I wish it to be understood that the examples of welded blade carrying members hereinbefore described are to be regarded as illustrative of my invention and not in any way limiting the scope thereof as it is evident that other modifications will readily suggest themselves to persons in the art.

What I claim as my invention and desire to secure by Letters Patent is:—

1. A process for welding turbine blades to their carriers consisting in adjusting the relative heat capacities of the parts to be welded so that the welding part of the carrier is heated more quickly than that of the blade, and forcing the weld formed between said parts underneath the surface of said carrying member.

2. A process for welding turbine blades to their carriers consisting in partially isolating the welding parts of the carrier from the main portion thereof and forcing the weld formed between the blade and such isolated parts underneath the surface of said parts, as set forth.

3. A process for welding turbine blades to their carriers consisting in partially isolating the welding parts of the carrier from the main portion thereof by circumferential grooves and forcing the weld formed between the blade and said isolated parts underneath the surface of said parts, as set forth.

4. A process for welding turbine blades to their carriers consisting in partially isolating the welding parts of the carrier from the main portion thereof by transverse slits, the sur-

face so isolated approximating in section to that of the blades to be attached thereto and forcing the weld formed between the blade and said isolated parts underneath the surface of said parts, as set forth.

5. A process for welding turbine blades to their carriers consisting in partially isolating the welding parts of the carrier from the main portion thereof and forcing the weld formed between the blade and the said isolated parts underneath the surface of said parts so that the metal crushed out during welding is incorporated with the parts of the carrier contiguous to said welding parts, as set forth.

6. A process for welding turbine blades to their carriers consisting in partially isolating the welding parts of the carrier from the main portion thereof by cutting transverse slits in the disk members forming said carrier the said isolated parts approximating in cross section to that of the blades to be attached to said carrier and forcing the weld formed between the blade and said isolated welding parts underneath the surface of said welding parts.

7. A process for welding turbine blades to their carriers consisting in partially isolating the welding parts of the carrier by spacing the disk members forming said carrier and forcing the weld formed between the blade and said carrier, underneath the surface of said carrier.

In testimony whereof I have signed my name to this specification in the presence of two subscribing witnesses.

SEBASTIAN ZIANI DE FERRANTI.

Witnesses:

ALBERT E. BARKER,
BERTRAM H. MATTHEWS.