L. D. LOVEKIN.

TURBINE BLADING AND METHOD OF ASSEMBLING SAME.

APPLICATION FILED APR. 28, 1914.

1,166,530.

Patented Jan. 4, 1916.

3 SHEETS—SHEET 1.

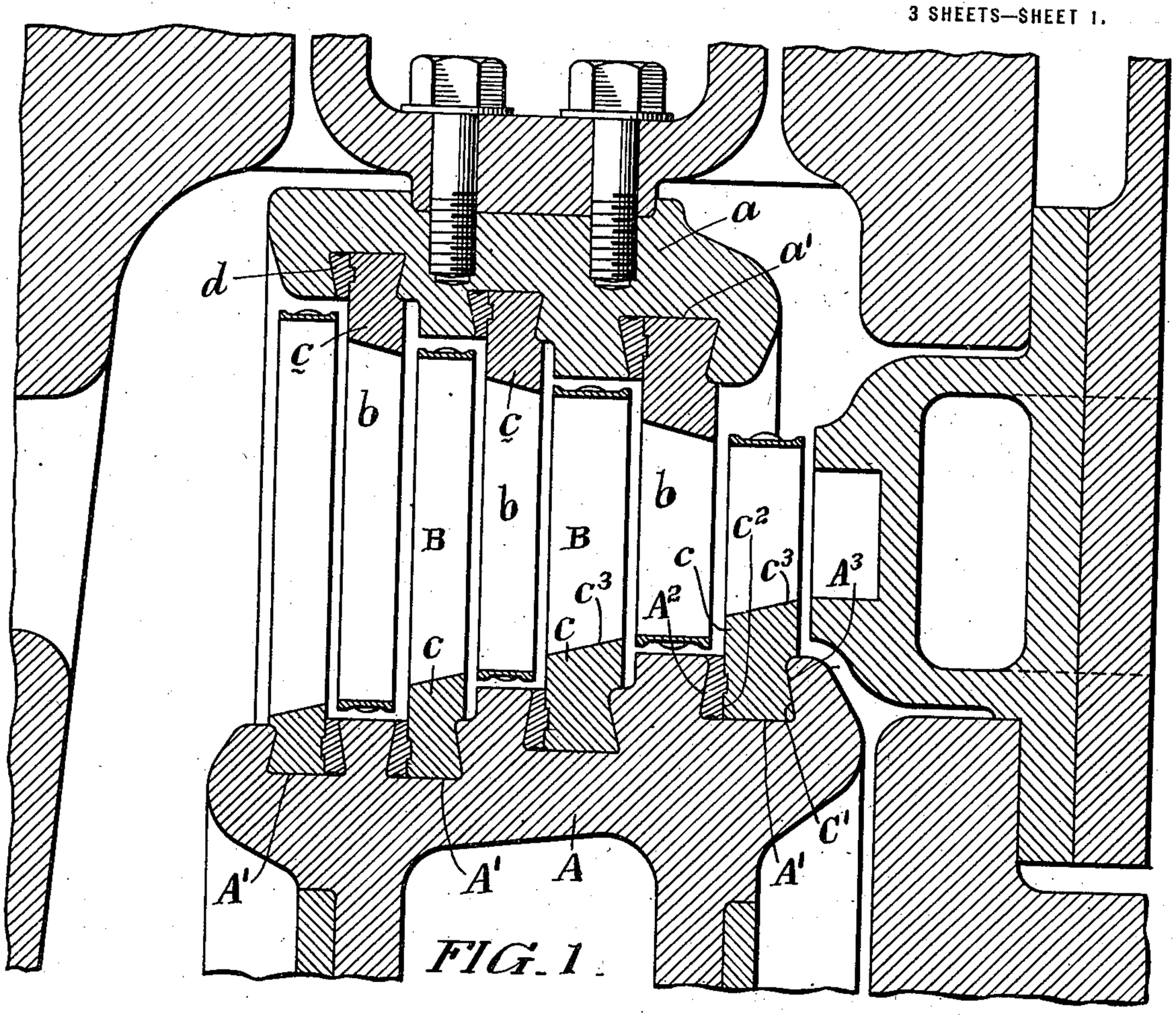

FIG. 1.

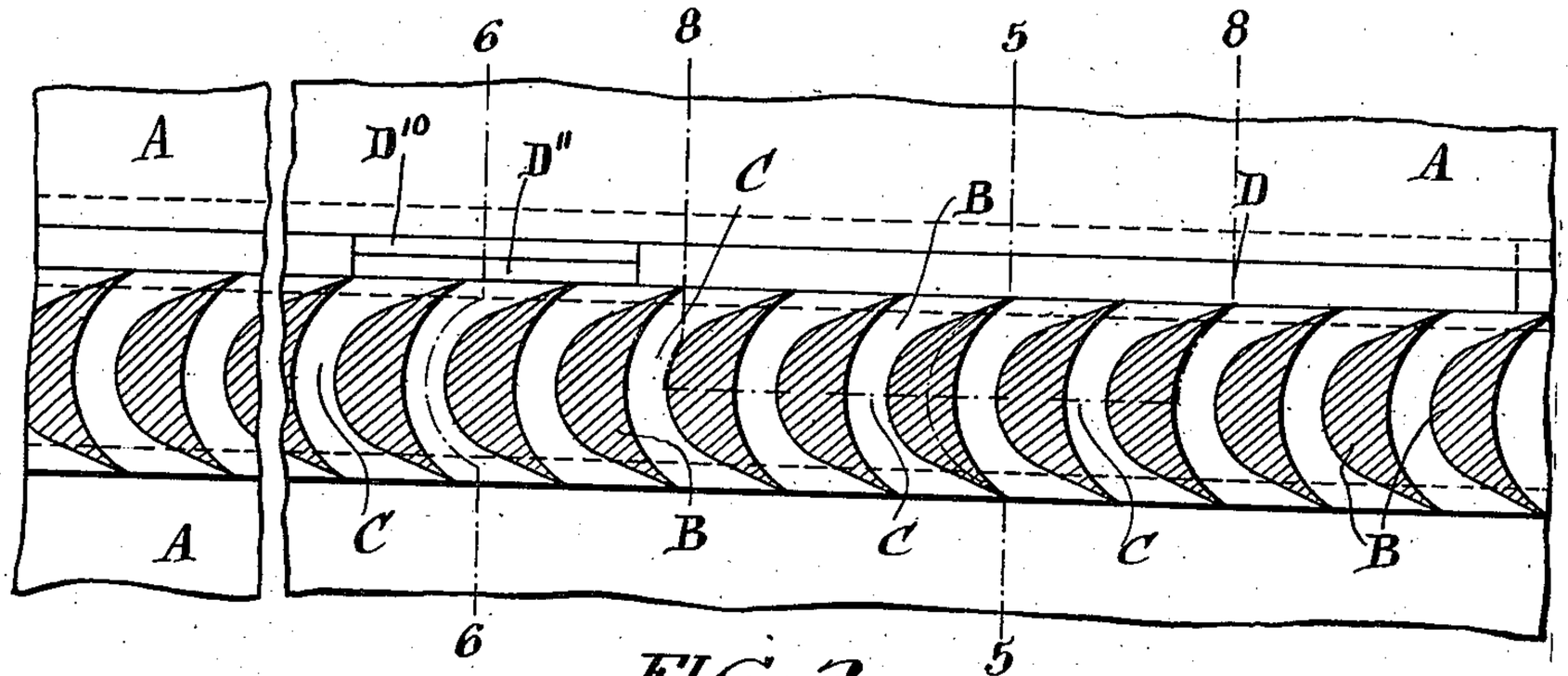

FIG. 2.

WITNESSES

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FIG. 3.

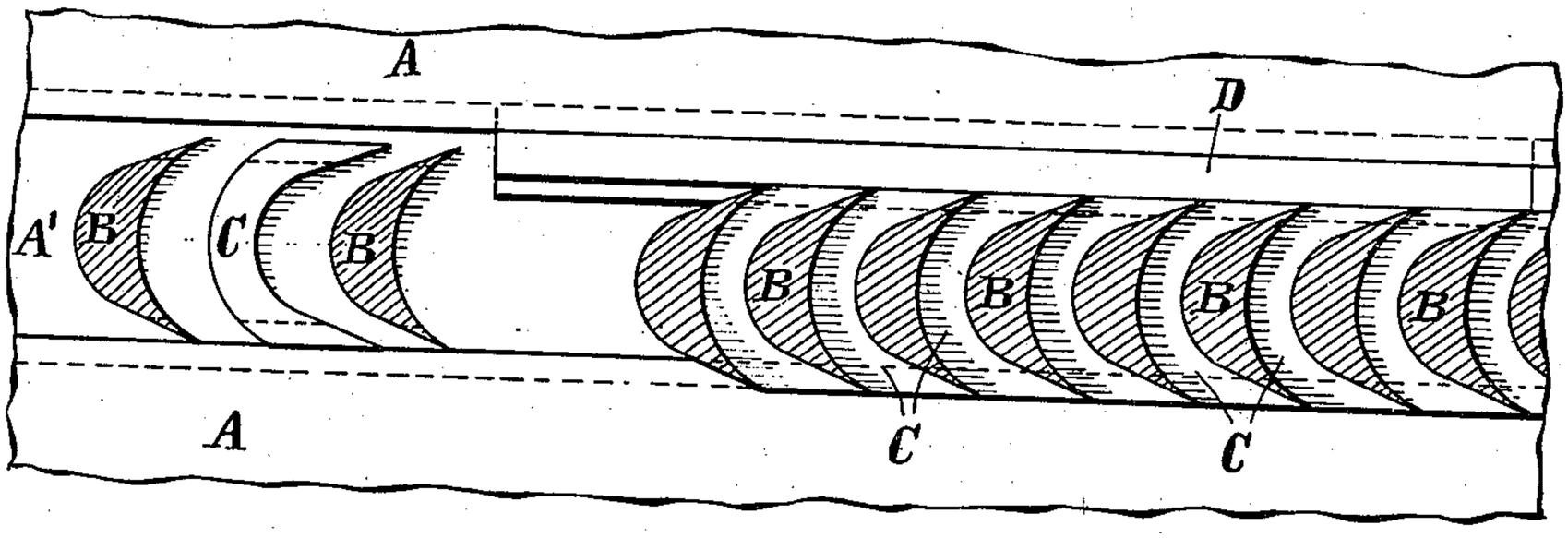


FIG. 5.

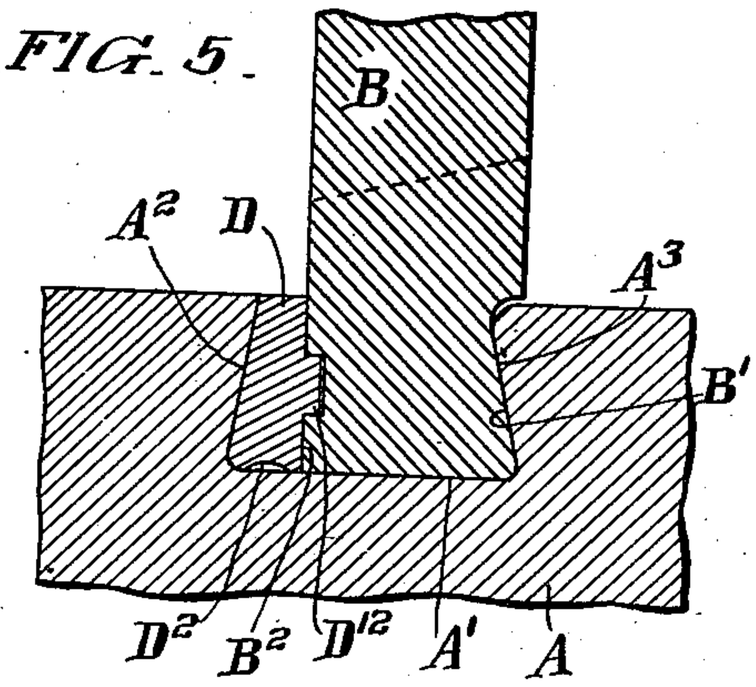


FIG. 4.

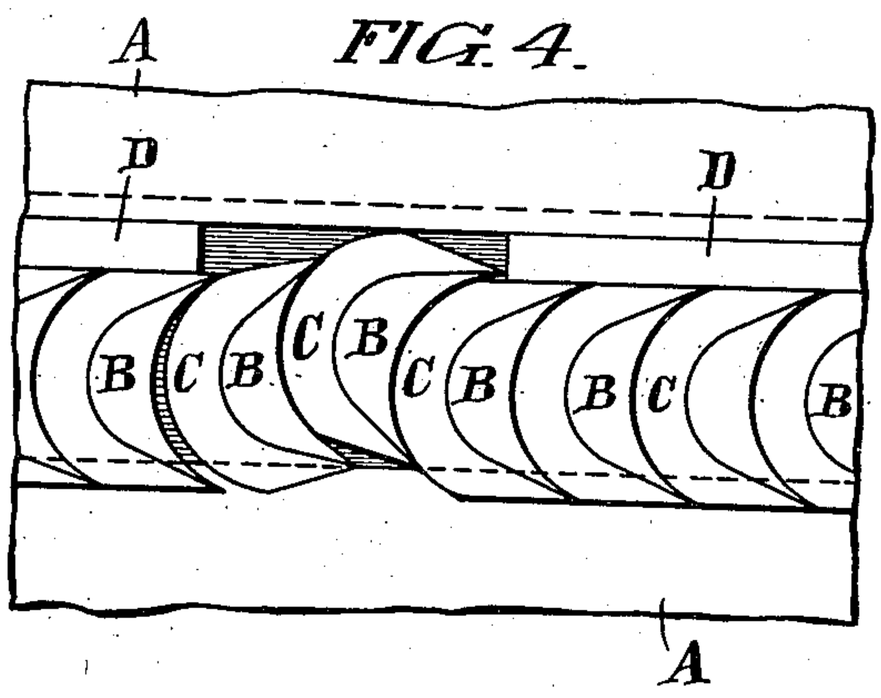


FIG. 6.

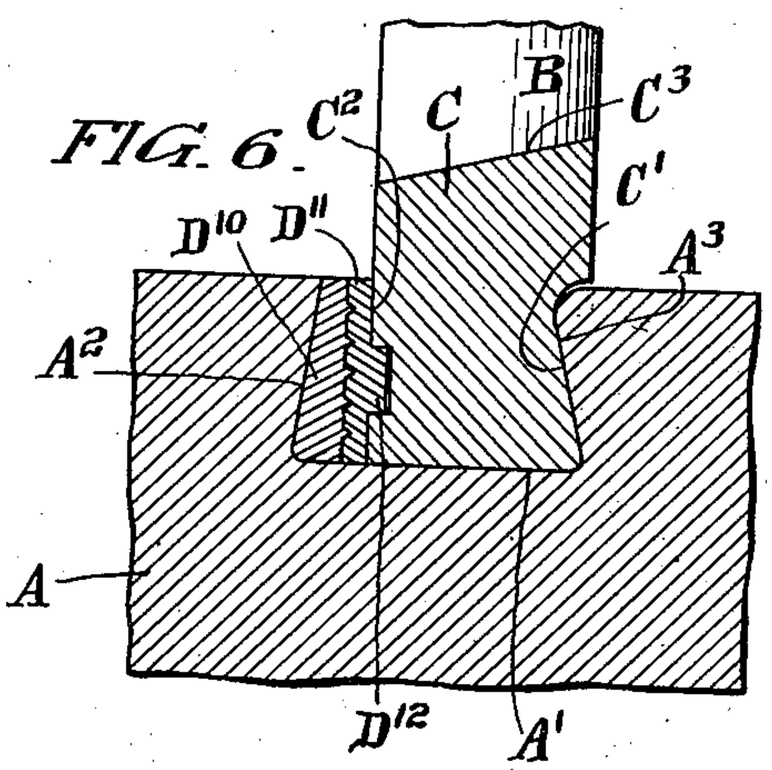
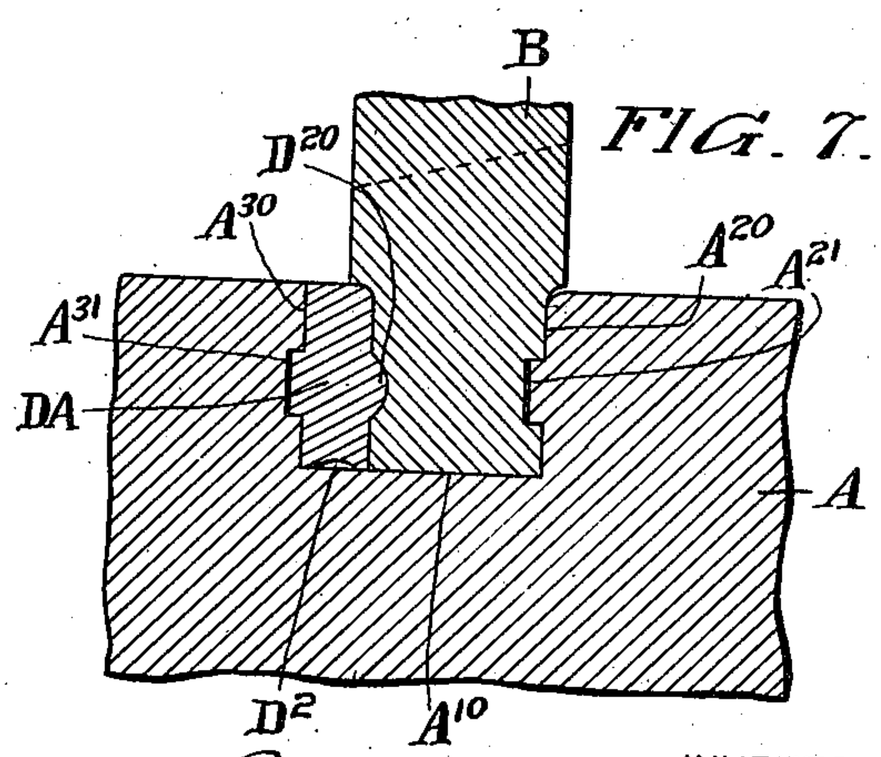


FIG. 7.



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3 SHEETS—SHEET 3.

FIG. 8.

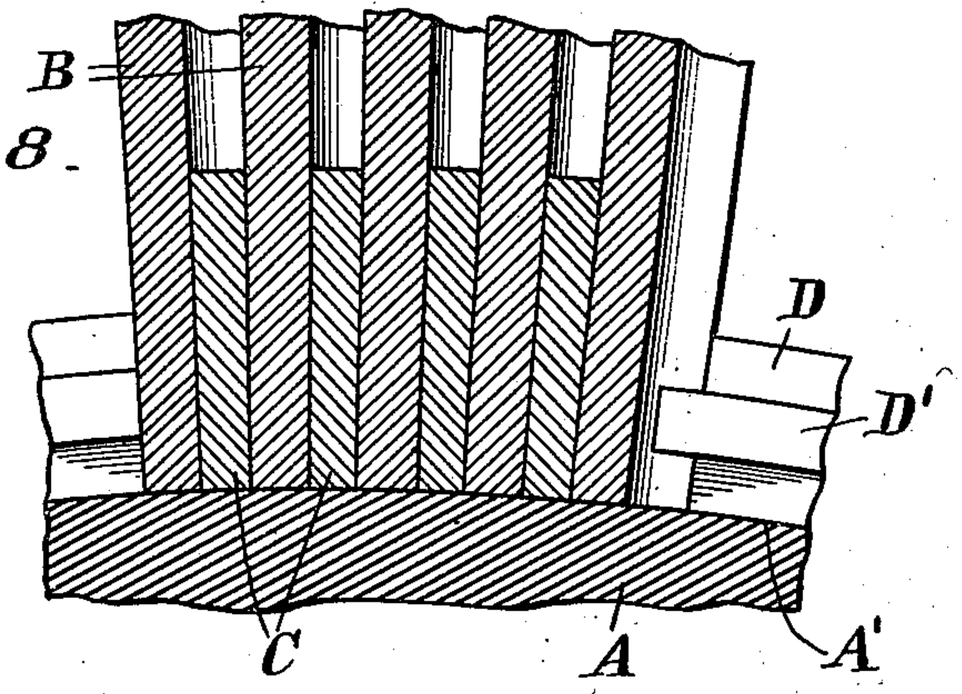


FIG. 9.

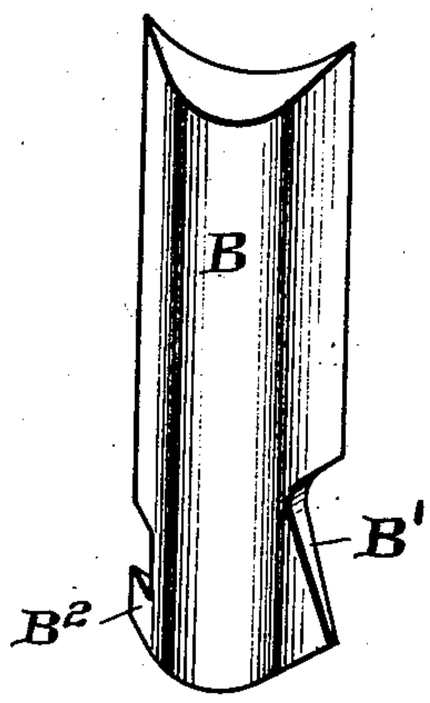


FIG. 10.

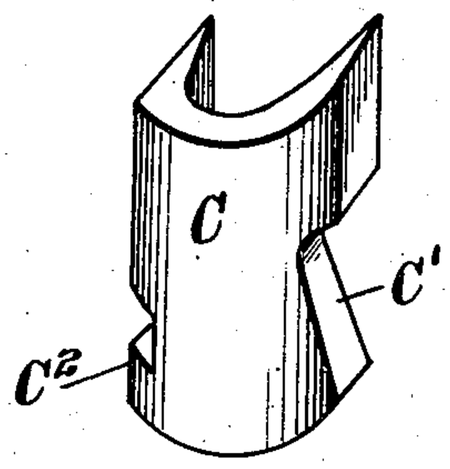
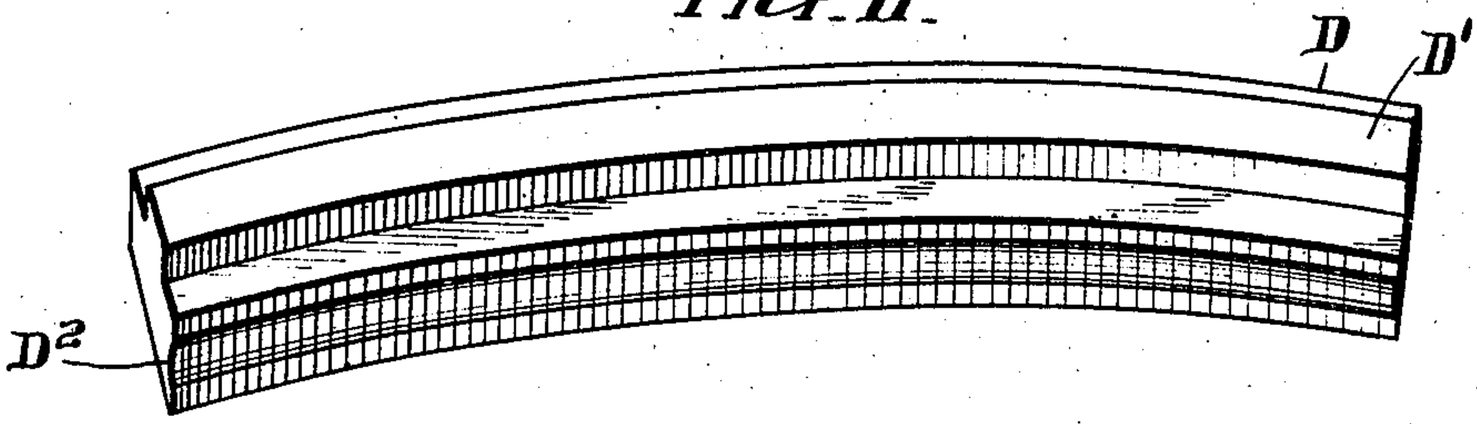


FIG. 11.



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TURBINE-BLADING AND METHOD OF ASSEMBLING SAME.

1,166,530. Specification of Letters Patent. Patented Jan. 4, 1916.

Application filed April 28, 1914. Serial No. 834,889.

To all whom it may concern:

Be it known that I, LUTHER D. LOVEKIN, a citizen of the United States of America, residing in the city and county of Philadelphia, in the State of Pennsylvania, have invented certain new and useful Improvements in Turbine-Blading and Methods of Assembling Same, of which the following is a true and exact description, reference being had to the accompanying drawings, which form a part thereof.

My present invention comprises an improvement in the means employed for securing the blades or vanes of turbines, and particularly steam turbines, to the parts by which the blades are carried, and comprises also a novel method of assembling the blades and securing them in place.

General objects of my invention are to simplify and reduce the cost of constructing the blade securing provisions and of assembling and securing the blades in place and to facilitate and cheapen the operations of removing and reinserting blades when this is necessary; and to insure a connection between the blades to their supports of definite, uniform and desirably great strength.

A further object of my invention is to secure the strength and rigidity of the blade connection with but little calking of parts and without the necessity of calking or deforming the blade supporting elements.

The various features of novelty which characterize my invention are pointed out with particularity in the claims annexed to and forming a part of this specification. For a better understanding of the invention however and its objects and advantages, reference should be had to the accompanying drawings and descriptive matter in which I have illustrated and described forms of apparatus embodying my invention considered as a structure, and illustrating also the method forming a part of my invention.

Of the drawings: Figure 1 is a sectional elevation of a portion of a steam turbine. Fig. 2 is a developed plan of a portion of the periphery of the rotor of the turbine shown in Fig. 1, with the turbine blades in section. Fig. 3 is a view taken similarly to Fig. 2 with some of the blades and distance pieces secured in place and others in the positions occupied by them during the assembling operation. Fig. 4 is another view, taken similarly to Fig. 2, illustrating the mode of inserting the final blade and distance piece needed to complete a ring of blades and distance pieces. Fig. 5 is a partial section taken on the line 5—5 of Fig. 2. Fig. 6 is a partial section taken on the line 6—6 of Fig. 2. Fig. 7 is a section taken similarly to Fig. 5, showing a modified construction. Fig. 8 is a partial section taken on the line 8—8 of Fig. 2. Fig. 9 is a perspective view of one of the blades. Fig. 10 is a perspective view of one of the spacers interposed between the blades, and Fig. 11 is a perspective view of one of the locking segments.

In the preferred embodiment of my invention illustrated in the drawings, A represents the rotor and *a* the stator of a steam turbine. The peripheral ring of the rotor A is formed with a plurality of circumferential blade receiving grooves A^1, each of which has its opposite side walls A^2 and A^3 undercut. Each of the blades B received in each groove, has one edge B′ of its groove entering portion shaped to fit against the undercut side wall A^3. Similarly each of the interposed distance pieces C, employed as is usual, has one edge C′ of its groove entering portion similarly shaped to fit against the wall A^3. The edges B^2 and C^2 of the blades and distance pieces remote from the wall A^3 unite to form a surface of revolution when the blades and distance pieces are assembled. The locking ring which fills the remainder of the groove comprises a number of similar segments D, which are assembled end to end and form an elongated segment extending for nearly, but not quite the entire circumferential length of the latter. Each ring segment D, which is of uniform cross section from one end to the other, and may advantageously be made from a bar of extruded metal cut into lengths and bent prior to its insertion in the groove A′ to give it the proper curvature. One side edge of each segment D is shaped to fit against the undercut groove wall A^2, and its other side edge is shaped to fit against the adjacent blade and distance piece edges C^2 and B^2. Advantageously the edges B^2 and C^2 of the blades B and distance pieces C are notched to provide a groove receiving a rib D′ formed on the adjacent side of the corresponding locking ring segment D. With this arrangement, each locking ring segment D is directly interlocked

with the corresponding group of blades B and distance pieces C, and each locking ring segment, and the corresponding group of blades and distance pieces, directly restrain axial displacement of the other, as well as indirectly prevent such displacement by holding the other against the corresponding side wall of the groove receiving the segments, blades and distance pieces.

In the preferred mode of assembling and securing the blades and distance pieces in place, a segment D is first inserted in place in the groove A′, and it will be readily apparent that the segment may be readily passed radially inward through the narrow outer edge of the groove. The corresponding group of blades B and distance pieces C are then inserted in the groove A′, at one end of the segment D. The blades and distance pieces are then moved lengthwise in the groove A′, relative to the segment D to bring them alongside of the latter. The blades and distance pieces may be inserted one at a time, and this is the mode of assembly illustrated in Fig. 3, or in lieu of this the blades and distance pieces may be preliminarily assembled into a connected unit as by sweating them together with solder. It will be understood of course that, except with the possible exception of the last segment D to be inserted, and the corresponding group of blades and distance pieces, each group of blades and distance pieces may first be inserted in the groove and the corresponding segment D then inserted in the groove A′ and thereafter moved in the groove A′, lengthwise of the latter, to bring the segment alongside of the previously inserted group of blades and distance pieces. As before stated the segments D inserted in each groove A′ unite to form a nearly complete ring or elongated segment. The gap left between the ends of this elongated segment is filled after all the blades and distance pieces have been inserted by a suitable locking and filling device, which, as shown in Figs. 2 and 5, comprises pieces D^{10} and D^{11}. The piece D^{10} which fits against the groove wall A^3 is wedge shaped in cross section with the thick edge of the wedge at the bottom of the groove. The coöperating strip D^{11} is inserted between the strip D^{10} and the adjacent blade and distance piece edges B^2 and C^2 while in the form of a flat strip rectangular in cross section. After insertion the piece D^{11}, which is advantageously of highly ductile metal such as copper, is calked, or upset by pressure, to cause it to flow into the groove formed by the notches in the adjacent blades and distance pieces. D^{12} represents the notch filled rib thus formed on the piece D^{11} by the calking or upsetting operation. When the front and back walls of the blade B and distance pieces C are curved, as shown, and this is the usual arrangement, the final blades and distance pieces necessary to complete the ring of blades and distance pieces in any one groove, may be assembled as shown in Fig. 4. By manipulating the parts, as shown in Fig. 4, it is possible to readily insert the final blades and distance pieces into a length of groove space not appreciably longer than that occupied by these finally inserted blades and distance pieces in the completed ring. After each group of blades and distance pieces, and the corresponding segments D have been assembled side by side in the curve receiving them, nothing need be done to prevent their accidental displacement during the operation of assembling and securing in place the remaining blades and distance pieces received in the groove. The interlocking prevents radial displacements, and the frictional resistance to the movement of the parts lengthwise of the groove is sufficient to prevent undue accidental displacement in that direction. At the same time it is readily possible to remove some or all of the blades and distance pieces at this time if necessary in order to insert blades and distance pieces of slightly different thicknesses in order to insure the proper spacing of the blades in the complete ring. This spacing may also be made uniform by spreading the blades or distance pieces a trifle if the original assembly leaves a gap in the ring of blades and distance pieces which it is desired to take up in this manner. After the ring of blades and distance pieces is assembled, the outer ends of the distance pieces may be calked somewhat to tighten up the ring. This is especially desirable of course, where the blades and distance pieces have been spread slightly to secure the desired uniformity in spacing.

With the construction and mode of assembly described, it will be apparent that the blades and distance pieces are very securely anchored in place, against radial displacement; while the cost of constructing the interlocking parts and the labor cost of assembling and securing them in place is comparatively small. Advantageously, in some cases at least, the locking ring segments D may be calked slightly after each corresponding ring of blades and interposed pieces are inserted, in order to tighten up the structure, and for this reason I advantageously form a groove D^2 in the bottom of the segment D, so that when the pieces D are peripherally calked the effect is to insure extra tightness both at the inner ends and at the outer ends of the portions of the blades and distance pieces received in the groove A′. By proceeding in this manner, the blades may be connected to the holder practically as rigidly as though formed in one integral structure therewith, and a very accurate radial disposition of each blade is

insured. The calking to which the segments D are subjected need not be great enough to materially change the cross section of the segments, and is not relied upon as the primary means or step for preventing radial displacement of the blades and distance pieces. The cross section given the locking ring segments prior to their introduction into the groove insures the really essential interlocking. Owing to the relatively small changes in shape it is necessary to give the segments D and distance pieces C by calking operations, the segments D and distance pieces C may well be made out of material substantially less ductile than copper or brass, and advantageously may be made out of mild steel or Monel metal. An important result of this is that the strength of the connection of the different blades and distance pieces with the holding element is not only made large, but is also made certain and uniform, which is not the case where it is attempted, as has been proposed, to insert a calking strip rectangular in cross section in the groove space along side the blades and distance pieces, and after its insertion to calk or upset this strip in an endeavor to make it fill a groove space which may be similar in shape, for instance, to the space occupied by the segment D, as shown in Fig. 1. When the turbine blades are secured in place by such a method it is impossible, with reasonable care and labor cost, to be certain that the calking strip receiving space is entirely filled at all points along its length, and in consequence, while some blades may thus be adequately secured, others will not be secured in place with the desired strength.

In some cases it may be desirable to calk the outer edges of the distance pieces slightly, in order to tighten up the ring of blades and distance pieces, but this calking is not necessary to secure the parts in place, and in any event is small in amount and does not appreciably deform the distance pieces. In consequence the proper stream lines for the steam may be obtained by a proper initial shaping of the ends C^3 of the distance pieces.

It will of course be understood that the invention may be employed in securing turbine blades in place where no separate distance pieces are interposed between the blades. In such case the distance pieces are in effect formed integral with the turbine blades.

With the illustrated mode of securing the blades in place the blade holding element need not be calked, nor otherwise distorted in shape, in the blade assemblage, and when therefore it may become necessary to remove an injured or defective blade or blades, this may be accomplished by cutting the defective blade or blades and the adjacent portion of the engagement segment D away, leaving the walls of the blade receiving groove in their original condition, so that a new blade or blades may be secured in place, as by means of calking provisions similar to those formed by the closing up and calking parts D^{10} and D^{11} illustrated in Figs. 2 and 4.

The invention is especially useful in the case of the blade of the rotating element of the turbine, where the great strength characteristic of the invention is highly desirable. The relatively low cost of constructing and securing blades and distance pieces in place, in accordance with the present invention, however, makes this construction a desirable one to employ in the case of the stators of turbines; and in Fig. 1 I have shown blades and distance pieces *b* and *c* respectively, secured in grooves *a'* of the stator element *a* by means of locking segments *d* in a manner similar to that in which the blades B and distance pieces C are secured in the groove A' of the rotor A by means of the locking segments D.

I prefer to undercut the side walls of the blade receiving slots by simply inclining these walls, and to make the ribs D' on the segments D rectangular in cross section as illustrated in Figs. 1 and 4. The operation of turning the blade receiving grooves when the side walls are inclined in Figs. 1 and 4 may be most simply and expeditiously carried out and an ample interlock between the blades, distance pieces and locking segments with the side walls of the slot is thus obtained. The rectangular form of the rib D', which is necessarily thin measured parallel to the turbine axis insures a very positive and strong interlock between the segments D and the blades and distance pieces. The parts may obviously be varied in shape in these respects however, and in Fig 7 I have illustrated a construction in which one side wall A^{20} of the blade receiving groove A^{10} is formed with a projecting rib A^{21} rectangular in cross section, and the other side wall A^{30} is formed with a groove A^{31} rectangular in cross section. In this construction the locking segments D A are each shown as formed with a rectangular rib on one side entering the groove A^{31}, and with a notch and distance piece engaging rib D^{20} on its other side, the outer surface of which is curved.

While in accordance with the provisions of the statutes I have illustrated and described the best forms of my invention now known to me, it will be apparent to those skilled in the art that changes may be made in the forms of apparatus disclosed without departing from the spirit of my invention and that under some conditions certain features of my invention may be used without a corresponding use of other features.

Having now described my invention, what I claim as new and desire to secure by Letters Patent is,

1. The method of securing turbine blades to a blade holding element, which consists in providing the latter with a circumferential groove having both side walls undercut; and in forming the blades and separate interposed distance pieces, if any, and the locking ring segments so that each segment, and the blades and distance pieces alongside the segment, will fill the space between the side walls of the groove, with the ring segment engaging one of said side walls and the blades and distance pieces the other, and with the joint between the assembled segments, and the blades and distance pieces a surface of revolution; and in inserting each segment and the corresponding group of blades and distance pieces in longitudinally displaced portions of the said groove, and then moving the segment relative to the corresponding group of blades and distance pieces in the direction of the length of the groove to bring the group of blades and distance pieces along side of the segment.

2. The method of securing turbine blades to a blade holding element, which consists in providing the latter with a circumferential groove having both side walls undercut; and in forming the blades and separate interposed distance pieces, if any, and the locking ring segments so that each segment, and the blades and distance pieces along side the segment, will fill the space between the side walls of the groove, with the ring segment engaging one of said side walls and the blades and distance pieces the other, and with the joint between the assembled segments, and the blades and distance pieces a surface of revolution; and in inserting each segment and the corresponding group of blades and distance pieces in longitudinally displaced portions of the said groove, and then moving the segment relative to the corresponding group of blades and distance pieces in the direction of the length of the groove to bring the groups of blades and distance pieces along side of the segment, and after sufficient segments and distance pieces have been inserted to form a complete ring of blades and distance pieces and a nearly but not quite complete ring formed of said segments, inserting in the gap a calking strip or strips and calking the same.

3. A turbine blade holder formed with a circumferential blade receiving groove having both side walls undercut, a ring of blades and interposed distance pieces inserted in said groove and shaped to fit against one of said side walls and to leave an annular space of uniform cross section between the other side wall of the groove and the adjacent edges of the blades and distance pieces, a plurality of similar locking ring segments inserted end to end in said space and uniting to form an elongated segment of nearly but not quite the circumferential length of said groove, each segment being made of steel or like material and being shaped prior to its insertion in said space to have practically the same cross section as said space, and a calking strip or strips inserted in said space in the gap between the adjacent ends of said elongated segment and upset after insertion to fill the gap.

4. A turbine blade holder formed with a circumferential blade receiving groove having both side walls undercut, a ring of blades and interposed distance pieces inserted in said groove and shaped to fit against one of said side walls and to leave an annular space of uniform cross section between the other side wall of the groove and the adjacent edges of the blades and distance pieces, a plurality of similar locking ring segments inserted end to end in said space and uniting to form an elongated segment of nearly but not quite the circumferential length of said groove, each segment being shaped prior to its insertion in said space to have practically the same cross section as said space, and other locking means inserted in said space in the gap between the adjacent ends of said elongated segment.

5. A turbine blade holder formed with a circumferential blade receiving groove having both side walls undercut, a ring of blades and interposed distance pieces inserted in said groove and shaped to fit against one of said side walls and to leave an annular space of uniform cross section between the other side wall of the groove and the adjacent edges of the blades and distance pieces, a plurality of similar locking ring segments inserted end to end in said space and uniting to form an elongated segment of nearly but not quite the circumferential length of said groove, each segment being shaped prior to its insertion in said space to have practically the same cross section as said space, and a calking strip or strips inserted in said space in the gap between the adjacent ends of said elongated segment and upset after insertion to fill the gap.

6. The method of securing turbine blades to a blade holding element, which consists in providing the latter with a circumferential groove having both side walls undercut; and in forming the blades and separate interposed distance pieces, if any, and the locking ring segments so that each segment, and the blades and distance pieces along side the segment, will fill the space between the side walls of the groove, with the ring segment engaging one of said side walls and the blades and distance pieces the other, and with the joint between the assembled

segments, and the blades and distance pieces a surface of revolution; and in inserting each segment and the corresponding group of blades and distance pieces in longitudinally displaced portions of the said groove, and then moving the segment relative to the corresponding group of blades and distance pieces in the direction of the length of the groove to bring the groups of blades and distance pieces alongside of the segment, and after sufficient segments and distance pieces have been inserted to form a complete ring of blades and distance pieces and a nearly but not quite complete ring formed of said segments, inserting in the gap a calking strip or strips and calking the same, and calking said distance pieces to more rigidly secure the blades in place.

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Witnesses:

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