United States Patent

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[33] **Switzerland**
[31] **2021/67**
Original application Jan. 24, 1968, Ser. No. 700,191, now Patent No. 3,538,579.
Divided and this application Jan. 21, 1970, Ser. No. 8,121

[54] **METHOD OF ASSEMBLING A PLURALSTAGE AXIAL COMPRESSOR**
4 Claims, 9 Drawing Figs.

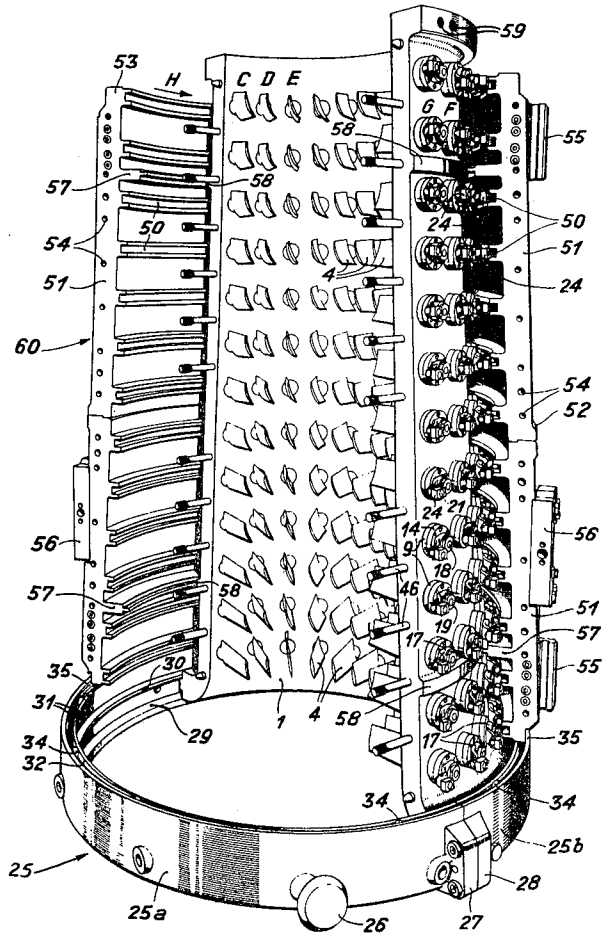
[52] **U.S. Cl.** ..... **29/156.4 R,** 29/156.8 R
[51] **Int. Cl.** **B23p 15/00**
[50] **Field of Search** ..... 29/156.4 R, 156.8 R, 156.8 FC, 156.8 CF, 200, 200 P, 200 J, 406

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ABSTRACT: For assembly of a plural stage axial compressor in which a blade carrier divided into plural parts along an axial plane and provided with a plurality of variable pitch blades is to be assembled to a pitch adjusting sheath, likewise divided into plural parts along an axial plane, with pins on adjusting levers of the blades being engaged in grooves on the inside of the sheath, there is disclosed a method comprising the steps of supporting a separate part of the carrier and a separate part of the sheath coaxially, rotating those separate parts with respect to each other about their common axis to engage the pins on the separate carrier part in the grooves of the separate sheath part, and fastening the separate parts together. There is also disclosed a fixture for use in assembling together such a blade carrier and sheath, this fixture comprising a ring demountable along a diameter into two parts and having two plane, parallel and coaxial annular surfaces, one for support of one blade carrier part and the other for support of one sheath part, and two cylindrical surfaces coaxial with each other and with those annular surfaces, one for centering of the blade carrier part and the other for centering of the sheath part.



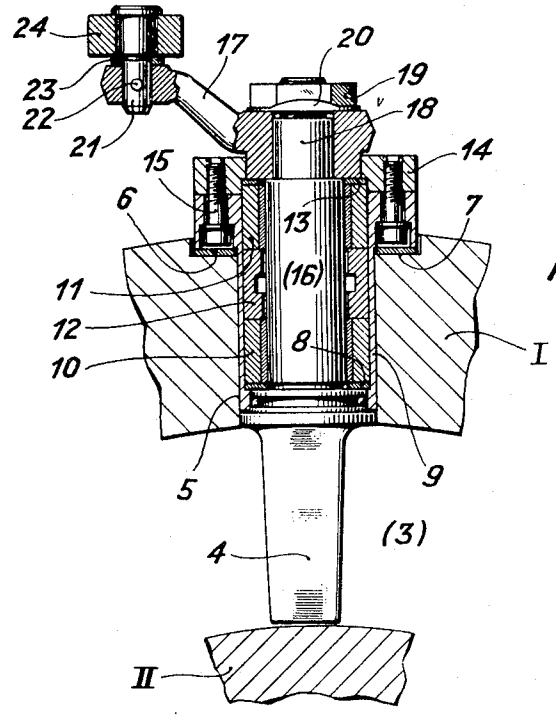


Fig. 1

Fig. 4

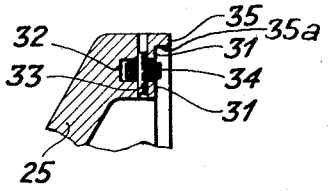


Fig. 2

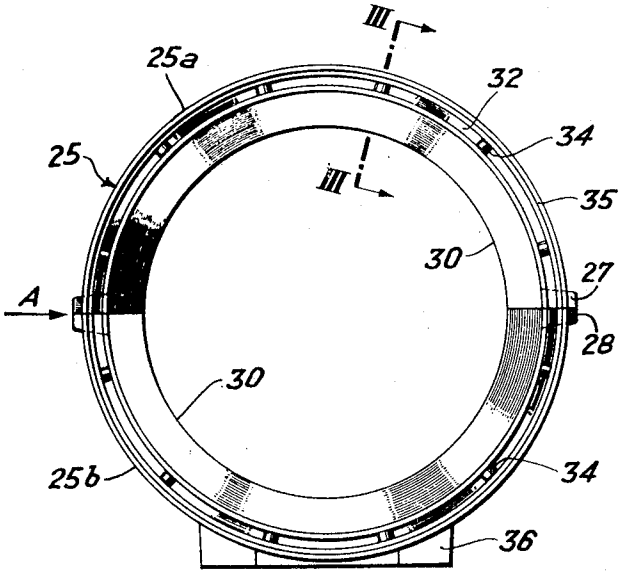
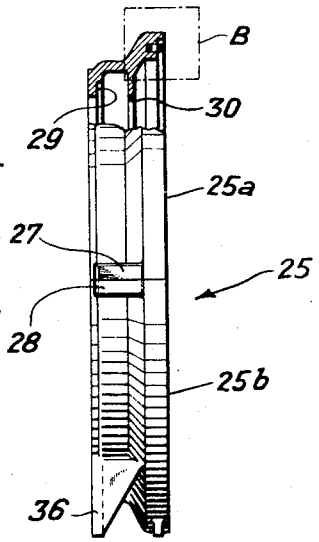


Fig. 3



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Fig. 5

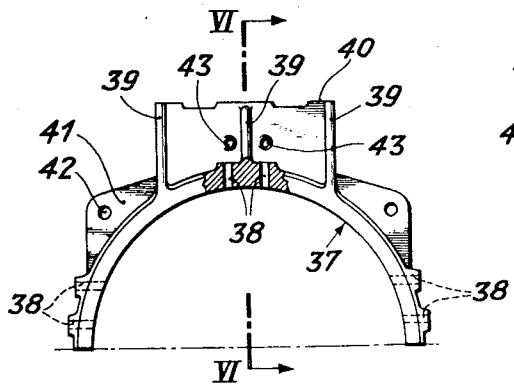


Fig. 6

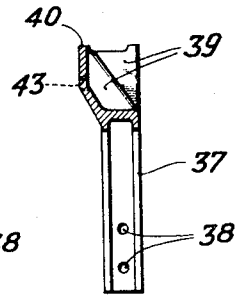


Fig. 8

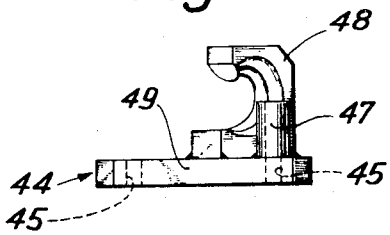
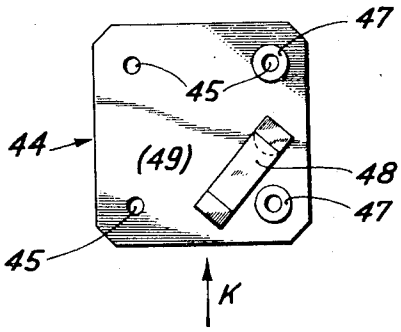


Fig. 7



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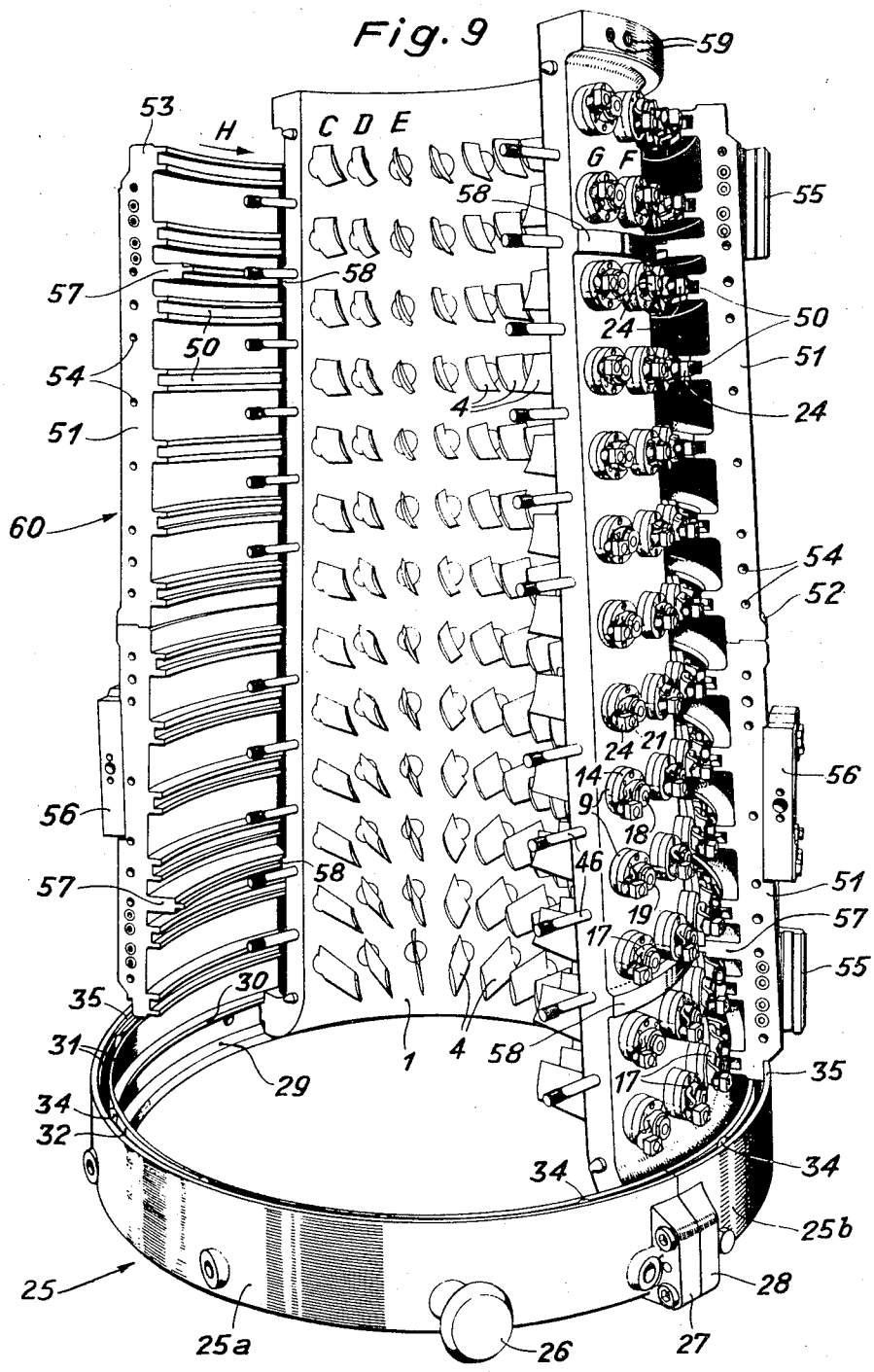
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Fig. 9



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METHOD OF ASSEMBLING A PLURALSTAGE AXIAL COMPRESSOR

This application is a division of my application Ser. No. 700,191, now U.S. Pat. No. 3,538,579, filed Jan. 24, 1968.

BACKGROUND OF THE INVENTION

Field of the Invention

The present invention pertains to a method of assembling a plural-stage axial compressor in which a blade carrier of annular shape, divided into plural parts along an axial plane and supporting a plurality of rotatable guide blades, is coupled to an adjusting sheath of annular shape for the blades, which sheath is similarly divided into plural parts along an axial plane or planes, the pitch adjusting levers of the blades being provided with pegs or pins which are inserted into circular grooves distributed lengthwise of the inner circumference of the sheath.

In plural-stage axial compressors whose guide blades are disposed on a blade carrier and are adjusted in pitch by means of an axially movable sheath, the assembly of the blade carrier to the sheath is difficult and time consuming since the pitch adjusting levers of the individual blades must all be inserted into a circular grooves of the sheath. The method according to the invention makes it possible to simplify the assembly of these parts. In accordance with the invention, one-half of the blade carrier and one-half of the sheath are first supported opposite each other on different diameters of the mounting ring but with their axis coaxial and vertical. These two halves are each of approximately semicylindrical shape, and will for convenience hereinafter sometimes be referred to as shells. Thereafter, the adjusting levers of successive axial rows of guide blades are positioned opposite the corresponding grooves. The cranks or pins of the pitch adjusting levers for each axial row of blades are then inserted into the grooves of the sheath by relative rotation of the two shells with respect to each other about their common axis, and finally the two shells are temporarily fastened together by suitable means for insertion into the compressor housing.

Advantageously, one of the two halves or shells may be fixed to the mounting ring while the other is movable with respect thereto, it being advantageous to rotate the sheath half about the blade carrier half.

The mounting ring of the invention is split along a diameter into two detachable half rings but which when fastened together form a ring possessing an inner annular support or bearing surface for the blade carrier and a circular centering surface by means of which the blade carrier is centered in the mounting ring. It also includes an exterior annular support surface for support of the sheath, concentric to the inner support surface, and a flange by means of which the adjusting sheath is centered in the mounting ring. At least one of the two supports surfaces takes the form of a race and may be provided with rollers.

In order to facilitate laying down of the two shells after assembly together with their axes vertical, one of the two halves of the split mounting ring may be provided with a straight edge on its exterior.

BRIEF DESCRIPTION OF THE DRAWINGS

The invention will now be further described in terms of a nonlimitative example of the practice of the method thereof and in terms of a nonlimitative exemplary embodiment of the apparatus thereof and by reference to the accompanying drawings, in which:

FIG. 1 illustrates the support of the adjustable pitch guide blades in the blade carrier, FIG. 1 taking the form of a fragmentary section along a plane perpendicular to the axis of the machine;

FIG. 2 and 3 are respectively plan and side elevational views of the mounting or assembly ring of the invention, FIG. 3 being taken in the direction indicated by the arrow A in FIG. 2 and FIG. 3 moreover being shown partly in section along the section line III—III of FIG. 2;

FIG. 4 shows at an enlarged scale the portion of FIG. 3 within the dash line box B in FIG. 3;

FIG. 5 is a view partly in section and partly in plan of a suspension ring for the blade carrier, affixed thereto at the end of the blade carrier opposite the mounting ring of FIGS. 2 and 3;

FIG. 6 is a section taken along the line VI—VI of FIG. 5;

FIGS. 7 and 8 are plan and side elevational views, FIG. 8 being taken in the direction indicated by the arrow K in FIG. 7, of one means for temporarily fastening to each other a blade carrier half and a sheath half assembled together, preliminary to insertion thereof into the compressor; and

FIG. 9 is a fragmentary perspective view of a plural stage axial compressor in which the assembly of one blade carrier half and of one sheath half is nearly completed.

In FIG. 1, reference character 3 identifies the annular streaming channel provided between the guide blade carrier I and the rotor II of the axial compressor. The blade carrier is made up of two substantially semicylindrical halves or shells, one of which is identified at reference character 1 in FIG. 9. The guide blades 4 of adjustable pitch extend into this channel. One of these blades is illustrated at reference character 4. It is supported in a bore 5 of the carrier I and is provided with an O -ring disposed in a circular groove in order to seal the flow channel 3 off from the exterior. The O-ring simultaneously serves to protect the bearing of the blade 4 from fouling.

A sleeve 9 is disposed in the bore 5, supported at a shoulder 7 of the bore and fastened to the carrier 1 by screws not shown. Between the shoulder 7 of the bore 5 and the sleeve 9 there is inserted a washer 6 which can vary in thickness from blade to blade. Its function is to permit control of the depth to which the sleeve 9 penetrates into the bore 5 and hence of the depth to which the blade 4 penetrates into the space 3, and thereby of the approach of the blade tip to the rotor II.

An axial bearing ring 8 together with bushings 10 and 11 at its cylindrical shaft 16. A cover 14 is supported on the sleeve 9 by means of a further axial bearing ring 13, this cover being fastened to the sleeve 9 by means of screw 15. By means of the cover 14 and the screws 15, the rings 8 and 13 and the bushings 10 and 11 and spacer 12 are fastened to the sleeve 9.

Rotation of the blade 4 for variation of pitch is effected by means of the adjusting lever 17 which is supported on a reduced extension 18 of the shaft 16 and which is held thereon be means of a nut 19. The nut is locked by means of a locking wafer 20. At its other end the adjusting lever 17 is provided with a crankpin 21 held in position by means of a locking pin 22. A slide 24 is rotatably engaged about pin 21 with a spacing washer 23 between the slide and the lever. The slide 24 fits into a corresponding groove 50 of the adjustment sheath, as illustrated in FIG. 9.

The mounting ring of the invention is illustrated in FIGS. 2, 3 and 4. It comprises two half rings 25*a* and 25*b* which can be fastened to each other to make up a ring generally indicated at 25, for example by means of screws, at flangelike extensions 27 and 28. Each half ring may be cast integrally or made up of a number of parts welded together. The half rings 25*a* and 25*b* possess together an inner plane annular support surface 29 for the blade carrier shell 1, spaced from the cylindrical centering surface 30 by means of which the blade carrier shell 1 is centered on the mounting ring 25 in the assembly process.

The outer plane annular support surface 31, 96 is radially outwardly disposed with respect to the inner surface 29 and with respect to the centering surface 30, serves to support one of the two halves or shells 60 of the adjustment sheath, as shown in FIG. 9. The surfaces 29 and 31 are parallel and coaxial. As is 101 particularly illustrated in FIG. 4, the surface 31 has cut therein a circular groove 32 concentric therewith. Bearing rollers 34 supported on pins 33 are distributed around this groove, as illustrated in FIG. 2, and the sheath shell 60 rests thereon. The rollers 34 facilitate shift of the shell 60 with respect to the blade carrier shell 1. At its outer limit the support surface 31 is provided with a flange 35 having a cylindrical inner surface 35*a* coaxial with the cylindrical surface 30

and with the plane surface **29** and **31**, by means of which the sheath shell **60** is held in coaxial position in the mounting ring **25** and with respect to the blade carrier **1**.

In order to facilitate laying down into horizontal position of the shells **1** and **60** after their assembly into interengaging relationship while vertical, the half ring **25***b* is provided at its exterior with a straight edge or foot **36**. The other half ring **25***a* is provided on its exterior with studs **26**, as indicated in FIG. **9**, by means of which the mounting ring **25** can be handles and transported.

The extension **36** additionally serves to permit disposition horizontally, before assembly into the housing of the compressor, of the halves of the blade carrier and sleeve assembled together in accordance with the invention.

A second positioning or support foot, at the other end of the blade carrier **1**, is formed by the supporting and adjusting half ring **37** illustrated in FIGS. **5** and **6**. This ring, which may also be cast, is provided with bores **38** through which it may be fastened to the blade carrier shell **1** by means of bolts, not shown. The ring **37** additionally includes at the exterior thereof an abutment or supporting surface **40**, reinforced by means of three ribs **39**. The abutment edge **40** cooperates with the extension **36** on the ring **25** to support the assembly in horizontal position. Additionally, eyes **42** are provided at two flat extensions **41** on the exterior of the ring **37**. Through these eyes, the ring **37** and consequently the shells **1** and **60** fastened thereto may be suspended for insertion into the housing of the compressor. The eyes **42** may however be replaced with studs similar to the studs **26** already referred to. Additionally, the ring **37** is provided to the left and to the right of the middle rib **39** with bores **43** through which the upper half of the adjustment sheath can, after assembly to its half of the blade carrier, be clamped between the rings **25***b* and **37** by means of screws, not shown, for insertion into the compressor housing. The phrase "upper half" here is used to refer to the fact that preferably the first pair of shells (one shell I and one shell **60**) are assembled together and then inserted into the compressor housing with their concave sides upward, in the lower half of the cavity provided for the blade carrier and sheath in the compressor housing. The second pair of semicylindrical shells, including one shell **1** and one shell **60**, may thus be referred to as the "upper" shells.

The fastening elements **44** shown in FIGS. **7** and **8**, by means of which the "first" or lower sheath half or shell **60** and the appurtenant half **1** of the blade carrier are temporarily fastened to each other for insertion into the compressor housing, comprise in substance a substantially rectangular baseplate **49** provided with four holes **45**. Through these holes the elements **44** are fastened to the blade carrier half **1** by means of threaded studs **46** and similarly to the adjustment sheath half **60**, near the axial ends thereof (i.e., at the top and bottom thereof in FIG. **9**). This is done after the blade carrier half and sheath half have been assembled together and rotated about their common axis so that their limiting axial planes substantially coincide. In this position, two of the holes **45** of each plate **44** accommodate studs **46** of the blade carrier half, and two accommodate bolts which thread into bores **54** of the sheath half. In this way, the lower halves of the blade carrier **1** and sheath **60** are fastened with respect to each other before they are assembled into the housing.

In addition, sleeves or washers **47** are affixed to each plate **49** about the two holes **45** provide for studs **46** from the blade carrier half **1**. These sleeves are fitted to the length of the threaded bolts **46** which subsequently serve to fasten together the two halves of the blade carrier. That is, the sleeves **47** are of such length that nuts run down over the threaded parts of studs **46** will serve to hold the plates **49** against the parting plane surface of the blade carrier half **1**. In addition, each of the plates **49** is provided with a hook **48** at the free side thereof, i.e., on the same side as the sleeves **47**. The hooks **48** serve to permit the fastening of cords by means of which the blade carrier and sheath halves may be suspended during assembly. The hooks **48** are so disposed on the plates **49** that the cords contact each other above the center of gravity of the combined halves **1** and **60**. At this contact point the assembled shells **1** and **60** are suspended for transport. The fastening elements **44** may be cast or made of separate elements welded together.

The adjustment sheath, which is axially split just as is the blade carrier **1** and which is indicated in FIG. **9** may moreover in large machines be divided perpendicularly to its axis as well, is made up of thin sheets or plates reinforced at their ends by means of a ring **53** and by means of flanges **51** and **52** along the parting surfaces thereof. Bores **54** are provided in the flanges **51** which receive fastening bolts upon assembly of the two semicylindrical halves together. In addition, guide rails **55** are fastened to the flanges **51** in order to permit the sheath to move axially of the compressor so as to effect changes in pitch of the guide blades. Motion of the sheath **60** is effected by means of a device such as a servomotor through a linkage, not shown, which engages the blocks **56** fastened to the flanges **51**.

The groove-bearing rings **50** are welded or otherwise fastened to the inner surface of the sheath. These grooves receive the pins **21** and slides **24** of the pitch changing levers **17** illustrated in FIG. **1**. In addition, two collars **57** are fastened to the inner surface of the sheath **60**. These collars can rest against corresponding surfaces **58** on the outside of the blade carrier. The collars **57** and the cooperating surfaces **58** serve to support the sheath half **60** and carrier half **1** with respect to each other during assembly so as to prevent stressing of the pins **21** on the levers **17**. During operation of the completed compressor a small clearance of the order of 2 mm. exists between the collars **57** and the surfaces **58**.

The blade carrier halves are provided with a number of threaded bores **59** at their upper reinforced edges. These bores receive screws for fastening of the supporting and adjusting ring **37** of FIG. **5**.

In the embodiment illustrated, assembly of the blade carrier and adjusting sheath is carried out according to the invention in the following manner.

One blade carrier half **1** is first so fastened to the semiring **25***b* that when the assembly thereof with one sheath half is later set upright, the blade carrier half will rest on the supporting surface **29** and be centered at the surface **30**. Then, the mounting ring **25** is completed by screwing on the second half **25***a* and the blade supporting half **1** is set upright, with its axis vertical, with the aid of the ring **25**. One half **60** of adjustment sheath is then set on the rollers **34** of the other half ring **25***a* and centered against the surface **35***a*. In the next step the adjustment levers **17** of the blades **4** in one vertical row C (FIG. **9**) are so disposed that the slides **24** thereof stand opposite the corresponding grooves **50** of the sheath, as is illustrated for the rows F and G in FIG. **9**.

The sheath half **60**, which can be readily moved on the rollers **34**, is then rotated in the direction of the arrow H in FIG. **9** past the first row C of blades **4**. The rows D, E, etc., are then successively set up with insertion of the slides **24** of those rows successively into the grooves **50** upon further rotation of the sheath half **60**. Insertion successively of the vertical rows of blade adjustment levers into the grooves **50** continues until the rows F and G are thus inserted. Thereupon the ring **37** is fastened to the blade carrier half **1** by means of screws entering the tapped holes **59**.

Although the process hereinabove described, for assembly of the lower half of the blade carrier **1** to the lower half of the sheath **60** is the same as that employed in assembling together their upper halves, the fastening of the two halves together occurs differently in the two cases in view of the difference in conditions obtaining in the two cases.

In the case of the lower halves, the fastening takes place by means of the elements **44** illustrated in FIGS. **7** and **8**. As hereinabove already briefly stated, the fastening elements **44** are affixed to the planes **51** of the flanges on the sheath half **60** and to the corresponding surfaces along the parting plane of the blade carrier half **1**, these surfaces being coplanar with the

planes **51** when the lower half of the sheath and lower half of the blade carrier have been fully assembled together. The half ring **25***a* is then removed. The "lower half" assembly, comprising a semicylindrical half of the blade carrier and a semicylindrical half of the sheath, is then set down on the supports **36** and **40** of the half rings **25***b* and **37**, this operation being carried out with the aid of a suitable handling fixture which connects to the ring **37**.

After the fixture is connected to the hooks **48** of the fastening means **44**, the two half rings **25***b* and **37** are removed and the lower half of the assembly comprising a blade carrier half **1** and a sheath half **60** is inserted into the compressor housing. The temporary fastening plates **44** may then be removed.

The other two halves, one of the blade carrier and the other of sheath, are then assembled together in substantially the same way, to form the upper half of the complete assembly which when completed will comprise an annular blade carrier inside an annular sheath. Since however the fastening elements **44** would prevent setting of the upper half of the assembly onto the lower half already inserted into the compressor housing, affixation of the upper half of the sheath **60** to the upper half of the carrier **1** is effected by means of the support ring **37**, fastened at **38** to the upper half of the carrier whereby the upper half of the sheath **60** is clamped between the rings **25***b* and **37** by means of screws passing through the threaded bores **43** (FIG. **5**). After loosening of the semiring **25***a*, the assembled upper half of the blade carrier **1** and of the sheath **60** are then set onto the lower half of the assembly in the compressor housing, with the aid of the fixture which connects to the eyes **42** of ring **37** and to the studs **26** of the half ring **25***b*, whereafter the half rings **25***b* and **37** may be removed. The two halves **1** of the blade carrier are then assembled together by means of screws **46** and nuts, not shown. To fasten the nuts and screws together the upper half of the sheath **60** is provided with slotted holes, not shown, through which a wrench can be passed. Finally the two halves of the sheath **60** are then fastened together by screws, not shown, passing through the bores **54**.

While the present invention has been described herein in terms of a presently preferred embodiment of the apparatus thereof and in terms of the presently preferred practice of the method thereof, the invention itself is not limited thereto but, rather, comprises all modifications on and departures from that embodiment and preferred practice properly falling within the spirit and scope of the appended claims.

I claim :

1. A method of assembling a plural stage axial compressor in which an annular blade carrier divided into plural parts along an axial plane and provided with a plurality of variable pitch blades is to be assembled to an annular pitch adjusting sheath, likewise divided into plural parts along an axial plane, with pins on adjusting levers of the blades being engaged in grooves on the inside of the sheath, which method comprises supporting a separate part of the carrier and separate part of the sheath coaxially, rotating said separate parts with respect to each other about their common axis to engage the pins on said separate carrier part in the grooves of said separate sheath part, and fastening said separate parts together.

2. A method according to claim **1** including the further step of supporting said separate parts on coaxial circular guide surfaces.

3. A method according to claim **2** including the further step of fastening one of said separate parts with respect to said guide surfaces.

4. A method according to claim **3** wherein said separate carrier part is fastened with respect to said guide surfaces and said separate sheath part is rotated therearound.

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