

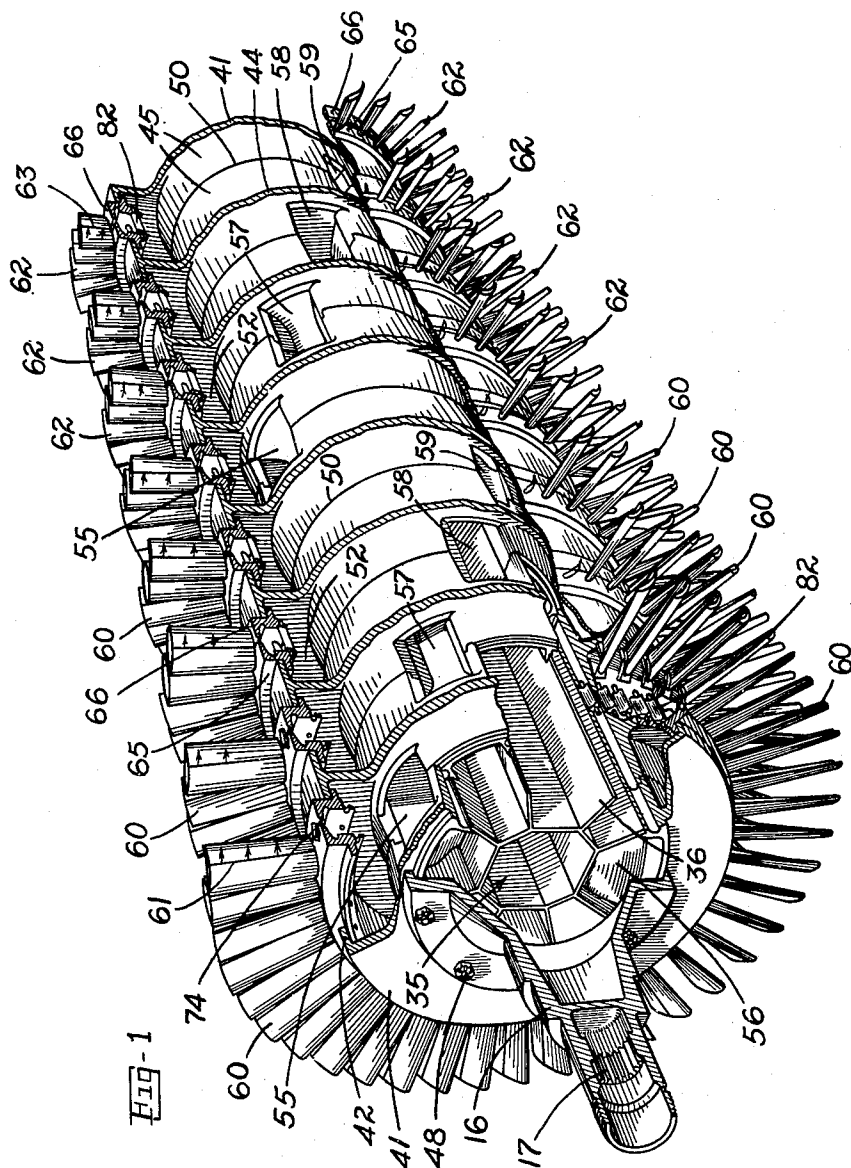
Aug. 3, 1954

E. A. STALKER  
AXIAL FLOW COMPRESSOR

2,685,405

Filed May 3, 1948

6 Sheets-Sheet 1



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# AXIAL FLOW COMPRESSOR

6 Sheets-Sheet 2



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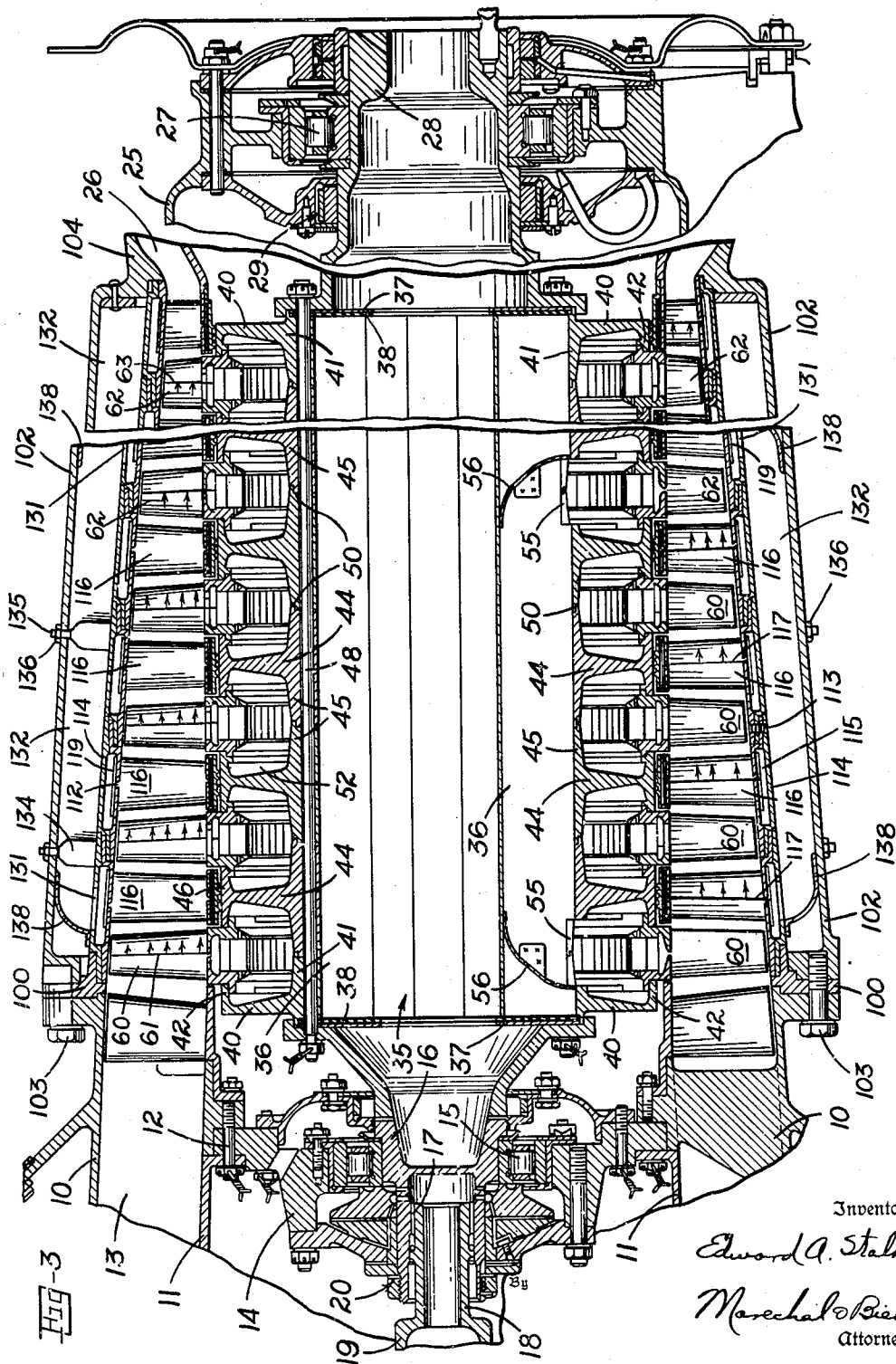
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6 Sheets-Sheet 3



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# AXIAL FLOW COMPRESSOR

6 Sheets-Sheet 5



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Fig-11

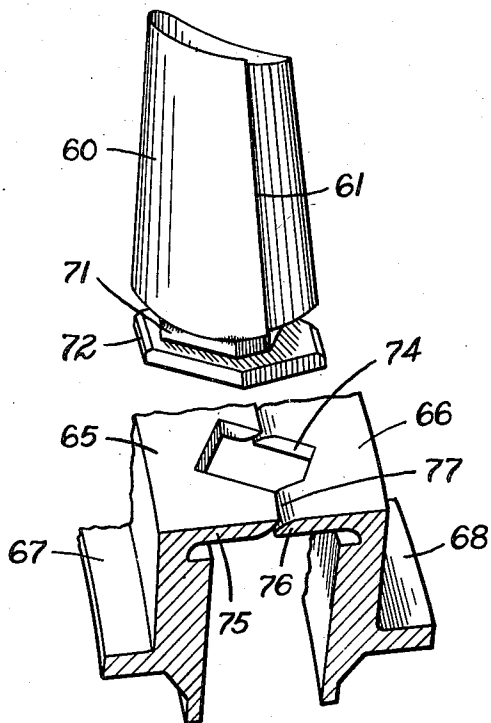


Fig-14

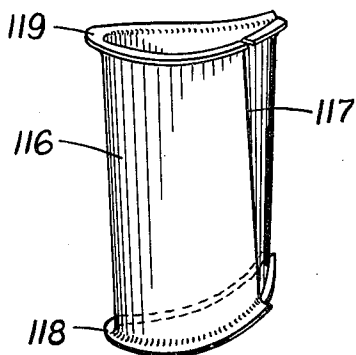


Fig-13

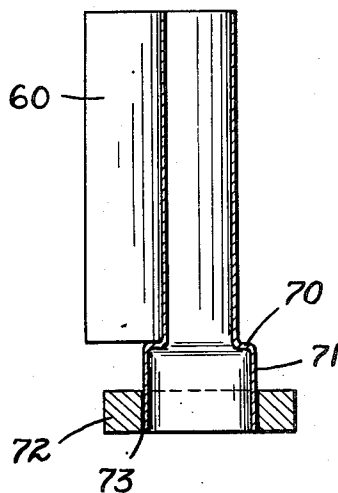
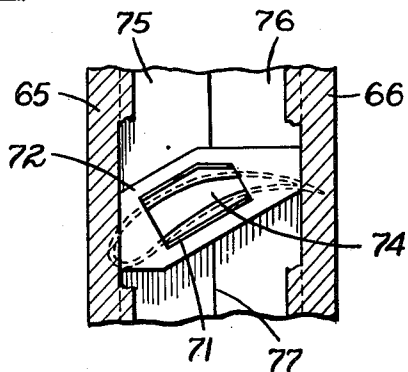


Fig-12



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## UNITED STATES PATENT OFFICE

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## AXIAL FLOW COMPRESSOR

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Application May 3, 1948, Serial No. 24,906

26 Claims. (Cl. 230-122)

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This invention relates to compressors and particularly to compressors of the axial flow type.

It is a principal object of the invention to provide an axial flow compressor which is simple in construction, relatively light in weight, which has a high compression ratio, and which is highly efficient in operation.

It is also an object to provide a compressor of this type which can be assembled by the stacking and assembly of a series of parts in proper interfitting relation with respect to each other.

It is a further object to provide such a compressor in which the parts may be readily and quickly assembled in sub-assemblies, with such sub-assemblies then being arranged or stacked in cooperative relation with each other to form the completed device.

It is another object to provide a compressor of the axial flow type having blades provided with slots, and arranged in a series of stages, the blades of the upstream stages having blowing or discharge slots and the blades of the downstream stages having suction slots.

It is a further object to provide such an axial flow compressor having manifolds and flow directing baffles for the supplying of a flow of fluid from a high pressure stage to the blades of a lower pressure stage.

It is also an object to provide such a compressor in which both the rotor and stator are assembled by the stacking of a series of pre-assembled units in axial engaging and interfitting relation.

Other objects and advantages will be apparent from the following description, the accompanying drawings, and the appended claims.

In the drawings:

Fig. 1 is a view in perspective of the rotor construction in accordance with the present invention with one side thereof being broken away in order to show the manifold and internal hub construction;

Fig. 2 is a view in perspective of the stator or casing of the compressor with one side being broken out to show the details of the manifold and blade supporting construction;

Fig. 3 is a vertical sectional view through the assembled compressor with certain parts being broken out;

Fig. 4 is an exploded view on an enlarged scale in vertical section through the compressor showing in the manner in which the units or sub-assemblies of the rotor and stator are stacked and assembled into the completed compressor;

Fig. 5 is a perspective view through the outer

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casing showing the manifold and portions of two stages of the stator blades;

Fig. 6 is a broken view in perspective through the hub showing portions of two stages of rotor blades with an intervening set of stator blades;

Fig. 7 is a sectional view through a typical blade, either a rotor or a stator blade, located in a relatively upstream position and having a discharge slot on its camber face;

Fig. 8 is a similar view through a typical blade, either a rotor or a stator blade, located in a relatively downstream position and having an induction slot on its camber face;

Fig. 9 is a detailed perspective view of one of the deflecting vanes which are arranged to deflect the flow of fluid from the manifold on the interior into the base of the rotor blade;

Fig. 10 is a view in perspective of the skeleton framework which serves to supply the fuel to the manifold on the stator, with only one section being shown as completely developed;

Fig. 11 is a view in perspective showing one of the rotor blades spaced above its support;

Fig. 12 is a bottom view looking radially outwardly toward the base of the blade showing the blade in position between the support rings;

Fig. 13 is a sectional view through the blade on the line 13-13 of Fig. 7; and

Fig. 14 is a view in perspective of a typical form of stator blade.

The present invention provides an axial flow compressor in which the blades, and preferably the mountings for the blades where exposed in the compressor chamber, are provided with slots through which a flow of fluid is caused to take place. Such flow may serve to protect the surface against damaging contact with highly heated gases which are handled by the compressor, and likewise is advantageous from an aerodynamic standpoint in developing a greater lift coefficient or compression effect in each succeeding stage. Where the compressor is provided with such slot flows, it is possible to obtain a materially increased compression ratio while requiring a lesser number of blower stages, and a corresponding reduction in both the size and the weight of the overall compressor.

The present invention provides a compressor of this type in which the entire rotor and stator may be assembled from units or sub-assemblies by the proper stacking thereof in interfitting relation to each other, thus enabling the blades and other parts of the device to be constructed in a simple and economical manner as separate units or sub-assemblies, and with such units being then

readily stacked and assembled into the final construction.

In order to provide the slot flows desired, a manifold means is provided, the manifold of an upstream series of blades being connected by a duct or fluid flow passage with a manifold of a downstream series of blades in order to provide for a flow of the fluid therebetween. That is, because of a great pressure at the downstream or discharge end of the compressor, a relatively small portion of the compressed fluid enters the induction slots of the blades which are open at their hub end, on both the rotor and stator, and this fluid flows through the duct to the discharge manifold at the upstream location, from which it is, because of a greater pressure at the downstream from the slots thereof. A similar arrangement of slots on the blade supporting rings is also preferably provided to improve the characteristics of the main flow thereover.

Thus the blades of an upstream group are provided with discharge slots while those of a downstream group are provided with induction slots. Blades having induction slots are generally more efficient in turning or controlling the flow than those having discharge slots, it having been found that the former are capable of deflecting the flow through a greater angle for a given volume of slot flow and for a given difference in pressure between the interior and exterior of the blade, than the latter. Since the power expended in producing the slot flow varies generally as the product of the volume per second and the pressure difference, the blade with the induction slot is usually more effective and satisfactory. Accordingly, in accordance with the present invention, the pressure ratio of the several stages is preferably so arranged that the amount of compression per stage is increased progressively toward the high pressure or discharge end of the device, the blades of the downstream stages being more highly cambered for this purpose. In this way the less efficient discharge slots are used where the efficiency is less important, and the highly efficient induction slots are employed where the greater part of the work of compressing is performed.

By way of example the drawings illustrate a typical embodiment of the invention in the form of an axial flow compressor incorporating eight stages, with the four upstream stages being so arranged that the slots are discharge slots, on both the rotor and stator, and with the four downstream stages operating with induction slots on both rotor and stator, the flow induced through the induction slots being supplied respectively to the corresponding stage upstream, thus providing substantially uniform pressure differences between the induction slots and the discharge slots of each pair of stages.

Referring to the drawing, and more particularly to Figs. 1 and 3 thereof, an outer housing is shown at 10 with an inner housing member 11 being bolted thereto by means of bolts 12 defining an inlet passage 13 which forms the fluid inlet to the compressor. A front bearing bracket 14 is supported from the housing members and is provided with bearings 15 for rotatably mounting a front flange member 16. Such flange is provided with an internal spline 17 within which there is received the forwardly projecting end 18 of a hollow tubular drive shaft 19 by means of which the operating power is delivered to the compressor. Suitable running seals and lubricating means are indicated generally at 20.

At the discharge end of the machine there is an air discharge housing indicated at 25 which forms one wall of the discharge outlet 26 of the compressor and which also provides a support for the bearing 27 within which is rotatably mounted rear flange member 28. Suitable seals and lubricating means are indicated generally at 29.

Between the end brackets 16 and 28 there is received the rotor spider shown generally at 35. This spider has a central hollow portion to decrease the weight thereof and projecting radially from such central portion are a series of eight vanes or ribs 36 which extend the entire axial length of the spider. These vanes define a series of eight axial flow passages extending along the rotor and are the means by which the fluid is transferred from a downstream manifold to an upstream manifold. Both ends of the passages so defined are closed by metal disks 37 and by sealing disks 38 of rubber or the like, such disks being generally annular and of sufficient radial extent to overlie and thus effectively seal the entire end of the passage.

In order to define the manifolds and to provide for support of the rotor blades, a series of disks or rings are arranged on the outer periphery of the spider. This construction is shown in Figs. 3, 4, and 6, where the end rings 40 are of generally channel shape having a base 41 and an outer turned flange 42. The intermediate rings indicated generally at 44 are substantially I-shaped in cross section and have base flanges 45 and outer heads 46. In the embodiment shown these rings are assembled over the spider, to provide eight different stages, and are mounted in place by means of a series of tie rods 43 which pass through the respective peripheries of brackets 16 and 28 respectively, and which also extend through apertures in the bases 41 and 45 of each of the rings. Also as shown in Fig. 3 the adjacent faces of the inner flanges 41 and 45 of the rings are grooved as shown at 50 to interfit with each other and thus key together to secure interlocking relation with each other. It will thus be seen that each pair of adjacent rings defines a chamber or manifold space 52 which serves to supply or receive a flow of fluid from the adjacent series of blades.

In order to provide for the passage of such fluid flows from a downstream to a corresponding upstream stage, the inner flanges 41, 45 of the rings of each stage are broken out or apertured in two diametrically opposite positions, as indicated at 55 in order to provide two parallel paths of communication between the blades of that stage and two oppositely located axial passages defined by vanes 36. In order to confine and guide the flow to the proper location, baffle plates 56 may be suitably positioned in the passage between vanes 36, two such baffles being indicated in Fig. 3, one beneath the aperture 55 in the first stage, and one beneath the corresponding aperture 55 in the fifth stage of the rotor. It will be understood that a similar construction is provided in the passage opposite that shown so that the rotor thus is provided with two diametrically opposite flow passages communicating between the manifold at the first stage and that at the fifth stage.

Similarly, pairs of apertures 57, 58, and 59 are provided in corresponding relation on diametrically opposite sides of the rotor beneath the manifolds of the second and sixth stages, the third and seventh stages, and the fourth and eighth stages, respectively.

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From the above description it will be understood that provision is made for the flow of fluid from each of the downstream stages, i. e., the fifth through the eighth stages, to the corresponding upstream stage, i. e., the first through the fourth stages, respectively, and that such flow passages are arranged in duplicate, on opposite sides of the rotor spider, so that the flow inducted in each of the downstream stages, after being delivered radially inwardly and through its respective manifold, is caused to flow upstream under the pressure differential provided, where it is delivered radially outwardly through the corresponding manifolds, and into the respective pressure chambers 52 where it is available for discharge through the proper desired stage of rotor blades.

The blades themselves as shown in Figs. 7, 8 and 11 have a generally airfoil shape, those of the upstream series being shown in Fig. 7 at 60 and having discharge slots 61 located on their camber or upper surface. The blades of the downstream series of stages as shown in Fig. 8 are indicated at 62 and are shown as provided with induction slots 63 on their camber or upper surfaces. The blades are hollow and the flow in each case travels radially through the hollow base of the blade to or from the respective chambers 52.

The rotor blades as shown in Figs. 3 and 4 are assembled into stages by means of a pair of rings 65, 66 which are formed with outwardly extending flanges 67, 68, respectively, that are adapted to engage beneath the flanges 42 and 46 of the series of rotor rings 40, 44. The rotor blades are each provided at their lower end with an offset shoulder portion 70 leading into a hollow shank 71 which is fastened in place in an opening in a base plate 72 by means such as silver solder 73 (Fig. 13). The shape of the portion 71 is generally rectangular but one corner is cut off, and a correspondingly shaped aperture 74 (Fig. 11) is formed in the adjacent flanges 75, 76 of rings 65, 66 so that the blade can be assembled in only one position. This aperture 74 is of the proper size to receive and clamp the portion 71 of the base of the blade while the plate 72 extends beneath and locks within the assembled flanges 75, 76 when the blade assembly is made. Thus the blade is held securely in proper angular position and the centrifugal force is adequately taken by the ring structure.

Likewise the adjacent surfaces of the flanges 75, 76 are so formed that they define a slot 77 therebetween, such slot serving to allow the passage of a fluid flow therethrough in the same manner and for the same purpose as the flows which take place through the blade slots themselves, the slots of the rings of the first through the fourth or upstream series of stages being discharge slots, and those of the fifth through the eighth or downstream series of stages being induction slots. Also as indicated in Fig. 4, the rings 65, 66 of all of the stages except the first and the fifth stages, the flanges 67, and 68 of which cooperate with flanges 78 on the rotor disks 44 to provide for additional guiding and sealing engagement.

Likewise the rings 65, 66 are provided with a series of apertures 80 which are located opposite each other and which provide for receiving a series of deflector vanes 82 (Fig. 9) which serve to direct the passage of the fluid flows between the flow passages through the chamber 52, to or from the manifolds, in order to facilitate the

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delivery of the flow thereto with minimum turbulence and loss of energy. The rings 65, 66 are preferably assembled separately with the series of blades 60, 62 and the vanes 82 therein, which may be done quickly and accurately in a suitable fixture, and the sub-assembly is then secured together with suitable means such as rivets 83, the rivet heads being staked to prevent turning.

As shown in Figs. 3 and 4, a series of such sub-assemblies or rotor stages may be then put together by stacking the series of rings 44 between the end disks 40, and with the rings 65, 66 and the assembled stage of rotor blades between each adjacent pair of rings. This may be conveniently accomplished on rods similar to the tie rods 48 but of longer extent to permit the stacking action, following which the rods 48 may be inserted and bolted in place to thus provide the completely assembled rotor. It will be understood that in the final assembly of the compressor, this stacking operation of the rotor takes place concurrently and in alternating relation with the stacking of the corresponding stages of the stator, the entire compressor thus being assembled at one time by the stacking of the several sub-assemblies thereof.

Referring now to the construction of the stator, the housing member 10 is provided with a ring 100 to which is bolted a compressor housing shell or casing 102 by means of a series of bolts 103. The shell 102 is of generally frusto-conical shape and at its discharge end is formed with a member 104 defining the outer wall of outlet 26 for the compressed fluid, the member 104 terminating in an attaching flange 105. Ring 100 also serves to support a series of interfitting structural members which provide for holding the stator blades and define the inner surface of the compressor chamber. As shown in Fig. 4 these members comprise two rings or ring-like members 110 and 111 which are spaced apart leaving a slot 112 therebetween which thus extends circumferentially around the casing. Each of rings 110 and 111 is riveted as shown at 113 to an upper annular ring 114 with a space 115 therebetween adapted to serve as an annular manifold for all the blades of that stage. The stator blades are shown at 116, Fig. 14. The blades of the four upstream stages have discharge slots 117 on their camber faces, while the blades of the four downstream stages have induction slots, the blade slots in section being similar to those shown in Figs. 7 and 8. Both the inner and outer ends of the stator blades have turned over flanges 118, and 119 respectively, by means of which the blades are secured in place. It will be understood that the blades of the stator are assembled between the two rings 110, 111, which are suitably notched to receive the outer ends thereof. Adjacent such sub-assemblies are then stacked in abutting relation, keys 120 being provided which fit into grooves 121 to prevent relative axial rotation of adjacent rings.

At the inner ends of the stator blades, there is provided another sub-assembly comprising a ring 122 having sealing ribs 123 thereon which are adapted to ride in sealed relation against the upper surface of flange 46 of the rotor. Additional rings 125, 126 are secured in position on ring 122 and spaced therefrom to provide a communicating chamber or manifold 127 with the rings being suitably apertured as indicated at 128 to receive the end of the blade therebetween and with a slot 129 formed between the adjacent edges thereof. The rings 122, 125 and 126 may

be secured together by means of rivets 130 (Figs. 4 and 5), this sub-assembly being accomplished before the stacking of the stages in the housing. The provision of the communicating manifold chambers 115 and 127 at the inner and outer ends of the stator blades thus provides for supply of the flows equally to all of the blades of each respective stage.

In order to provide for delivery of fluid from a higher pressure downstream stage to a corresponding lower pressure upstream stage, a series of stator vanes are provided, the arrangement in skeleton form being illustrated in Fig. 10. As there shown, and referring for purposes of illustration to a description of the construction for supplying fluid from the fifth to the first stage as typical of the remaining construction, the outer periphery of rings 114 of the first and fifth stages is apertured as shown at 131 (Figs. 3, 5 and 10) and communication is thus established into the passage between the outer surface of the rings 114 and the inner circumference of the casing 102. This space is divided into a series of axially extending passages by means of a series of vanes 132, the adjacent pair of which as shown in Fig. 10 extends to define a passage 133 between such apertures 131. Similar passages 133 are provided around the entire circumference between each adjacent pair of vanes 132, although Fig. 10 shows the complete development of only one section of the entire circumference. The vanes 132 are formed with attaching brackets 134, the brackets being welded to the faces of the vanes (Fig. 2) and carrying bolts 135 that extend outwardly through the casing 102 and are fixed in position therein by nuts 136. While the vanes are not attached to the surface of the rings 114, the arrangement is such that they extend in contact therewith and thus define effectively closed passages for the transfer of the fluid flow in the manner desired.

Reflecting vanes 138 (Figs. 3 and 5) are located immediately opposite the corresponding apertures 131 and thus guide the flow of fluid properly to and from the passage 133 and through the opening 131 into the manifold chambers 115 for discharge from or induction into the slots previously described.

By reference to Fig. 10 it will be seen that there are 12 sets of vanes, each defining four separate passages between successive pairs of stages so that there are a total of 12 parallel passages for supplying the fluid from the blades of each downstream stage to the blades of each corresponding upstream stage. This assures proper flow of fluid axially and in the reverse direction to the main flow of fluid, from the induction slots of the four downstream stages to the discharge slots of the corresponding four upstream stages.

It will also be evident that the stator, like the rotor, is adapted to be assembled in a series of sub-assemblies, each of which can be made separately and in a simple and effective manner, with the blades of each stage being secured in position in such sub-assembly before stacking in the compressor itself. In the final stacking and assembly of the compressor, it will be understood that the vanes 132 are first secured in position in the stator casing or housing, following which the sub-assemblies may be stacked adjacent each other, suitably interlocked to prevent relative rotation, such stacking operation proceeding in a step-by-step manner, with a stage of rotor sub-assemblies alternating with a stage of stator sub-assemblies.

The invention thus provides a simple and highly effective compressor construction which provides for efficiently developing a high compression and with a limited size and weight of material, by reason of the large compression ratios which are accomplished and the high efficiency to which the device operates. Moreover, the provision of the slot flows on both the blades of the rotor and stator, as well as on the surfaces of the hub and the internal compressor surface itself, further provides for desirable aerodynamic characteristics, making possible the utilization of higher compression ratios in the later stages where the more efficient induction slots are utilized as distinguished from the somewhat less efficient discharge slots provided in the earlier stages.

Further, the invention provides a device of this character which can be simply and readily constructed, and if necessary disassembled for repair or replacement of the individual parts thereof, such assembly taking place conveniently and economically in the form of sub-assemblies which are made in advance of the final assembly, and with such sub-assembled units being then stacked and secured together in the final operation to provide the finished compressor.

While the form of apparatus herein described constitutes a preferred embodiment of the invention, it is to be understood that the invention is not limited to this precise form of apparatus, and that changes may be made therein without departing from the scope of the invention which is defined in the appended claims.

What is claimed is:

1. In an axial flow compressor, a rotor comprising a central spider, means on said spider defining a plurality of circumferentially spaced fluid flow passages, blades arranged in a plurality of separately assembled stages, said blades having slots on their surfaces providing for a flow of said fluid therethrough, a plurality of pairs of cooperating rings mounted on said spider and engaging and supporting said blades, means establishing communication through said rings between the blades of a downstream stage and said flow passage, and means establishing communication through said rings between said flow passage and the blades of an upstream stage.

2. In an axial flow compressor, a rotor comprising a plurality of spaced supporting hub rings, a plurality of blade supporting rings engageable with said hub rings respectively and adapted to be stacked thereon, a plurality of individual blades arranged in stages between each adjacent pair of said blade supporting rings, and means on said hub rings for securing said blades supporting rings with said blades therebetween in said assembled stacked relation.

3. In an axial flow compressor, a supporting structure, means defining an axially extending flow passage in said supporting structure, blades mounted on said structure and arranged in a plurality of stages, said blades being formed with slots adapted to carry a flow of fluid therethrough, means defining a manifold chamber in direct communication with the plurality of blades of each respective stage, and means establishing communication between the manifold chamber of a downstream stage and that of an upstream stage through said flow passage for the induction of a fluid flow through said blade slots of said downstream stage and the discharge of a fluid flow through said blade slots of said upstream stage.

4. In an axial flow compressor, a supporting structure, means defining a plurality of axially extending flow passages circumferentially spaced around said supporting structure, blades mounted on said structure and arranged in a plurality of stages, said blades being formed with slots adapted to carry a flow of fluid therethrough, means defining a manifold chamber in direct communication with the plurality of blades of each respective stage, means establishing communication between the manifold chamber of a downstream stage and that of an upstream stage through a selected one of said flow passages for the induction of a fluid flow through said blade slots of said downstream stage and the discharge of a fluid flow through said blade slots of said upstream stage, and baffle means for directing the passage of said flows between said flow passages and said manifold chambers.

5. In an axial flow compressor, a supporting structure, blades mounted on said structure and arranged in a plurality of stages, said blades being formed with slots adapted to carry a flow of fluid therethrough, means for discharging a flow through the slots of each of the blades of a plurality of adjacent upstream stages, means for inducting a flow through the slots of each of the blades of a plurality of downstream stages all axially spaced from said upstream stages, and means for establishing a substantially greater compression ratio per stage toward the discharge end of the compressor.

6. In an axial flow compressor, a supporting structure, blades mounted on said structure and arranged in a plurality of stages, means dividing the blades into a plurality of upstream stages and a plurality of downstream stages all axially spaced from said upstream stages, means for inducting a flow through the slots of the blades of each downstream stage, and means for supplying said inducted flow to the blades of the corresponding upstream stages for discharge through the slots thereof.

7. In an axial flow compressor, a rotor comprising a hollow hub, means defining a plurality of axially extending flow passages circumferentially spaced around said hub, a plurality of blade supporting rings outwardly of said passages and extending adjacent each other, blades arranged in stages and supported between adjacent pairs of said rings, means forming a manifold common to a plurality of said blades of a single stage and communicating with one of said flow passages, and means defining apertures in predetermined portions of said rings establishing communication between selected ones of said stages through said respective manifolds and passages.

8. In an axial flow compressor, a supporting structure, vanes defining a plurality of axially extending flow passages circumferentially spaced around said supporting structure, a plurality of blade supporting rings extending adjacent each other, blades arranged in stages, means for supporting the blades at each stage between adjacent pairs of said rings, and means defining apertures in predetermined portions of said rings establishing communication between selected ones of said stages through said passages respectively.

9. In an axial flow compressor, a supporting structure, vanes defining a plurality of axially extending flow passages circumferentially spaced around said supporting structure, a plurality of blade supporting rings extending adjacent each other, blades arranged in stages, means for supporting the blades of each stage between adja-

cent pairs of said rings, means defining apertures in predetermined portions of said rings establishing communication between selected ones of said stages through said passages respectively, and deflecting baffles in said passages adjacent said apertures for directing the flow thereinto.

10. In an axial flow compressor, a supporting structure, vanes defining a plurality of axially extending flow passages circumferentially spaced around said supporting structure, a plurality of blade supporting rings extending adjacent each other, blades arranged in stages, means for supporting the blades of each stage between adjacent pairs of said rings, said blades having slots therein, means defining apertures in predetermined portions of said rings establishing communication between the blades of selected ones of said stages through said passages respectively, and means forming a manifold at the inner ends of the blades of each said stage and deflecting baffles in said passages adjacent said apertures for directing the flow thereinto.

11. In an axial flow compressor, a supporting structure, means defining a plurality of axially extending flow passages circumferentially spaced around said supporting structure, a plurality of blade supporting rings extending adjacent each other, blades arranged in stages, means for supporting the blades of each stage between adjacent pairs of said rings, said blades being formed with slots adapted to carry a flow of fluid therethrough, and means defining apertures in predetermined portions of said rings establishing communication between the blades of a downstream stage and those of an upstream stage through a selected one of said passages for the flow of a fluid therethrough for delivery through said slots.

12. In an axial flow compressor, a supporting structure, means defining a plurality of axially extending flow passages circumferentially spaced around said supporting structure, a plurality of blade supporting rings extending adjacent each other, blades arranged in stages, means for supporting the blades of each stage between adjacent pairs of said rings, said blades being formed with slots adapted to carry a flow of fluid therethrough, and means defining apertures in predetermined portions of said rings establishing communication between the blades of a downstream stage and those of an upstream stage through a selected one of said passages for the flow of a fluid therethrough for delivery through said slots, and means forming a manifold adjacent the ends of the blades of each said stage.

13. In an axial flow compressor, a supporting structure, means defining a plurality of axially extending flow passages circumferentially spaced around said supporting structure, a plurality of blade supporting rings extending adjacent each other and supported by said structure, blades arranged in stages, means for supporting the blades of each stage between adjacent pairs of said rings, said rings being formed with slots adapted to carry a flow of fluid therethrough, means including apertures in predetermined portions of said rings establishing communication between a downstream stage and an upstream stage through a selected one of said passages for the flow of a fluid therethrough, and vanes arranged circumferentially of said rings to direct the fluid flow toward said slots.

14. In an axial flow compressor, a rotor com-

prising a central hub, a plurality of ring-shaped members having overhanging flanges on their outer faces and adapted to be assembled in adjacent stacked relation on said hub, both said flanges being apertured in cooperating opposite portions a blade assembly adapted to be received on said hub between corresponding apertures of adjacent rings and having flanges engageable beneath said overhanging flanges of adjacent said rings, means for securing said rings and said blade assemblies in alternating stacked relation on said hub, means on said hub forming axially extending flow passages, and means including said passages providing communication between the plurality of blades of one stage and those of another stage.

15. In an axial flow compressor, a rotor comprising a central hub, a plurality of ring-shaped members having overhanging flanges on their outer faces and adapted to be assembled in adjacent stacked relation on said hub, a blade assembly adapted to be received on said hub between adjacent rings and having flanges engageable beneath said overhanging flanges of adjacent said rings, means for securing said rings and said blade assemblies in alternating stacked relation on said hub, said blade assembly including a pair of rings having flanges extending toward each other, and a plurality of separate blades mounted on and supported between said flanges.

16. In an axial flow compressor, a blade assembly for a single stage thereof comprising a pair of rings having flanges extending toward each other, said flanges having complementary openings spaced around the circumference thereof, a hollow slotted blade received in each pair of said openings and secured in position by engagement with said flanges, means for fastening said rings together with said blades in position therein, and means forming flow passages extending through said rings for supplying a cooling flow to said blades.

17. In an axial flow compressor, a blade assembly for a single stage thereof comprising a pair of rings having flanges extending toward each other, said flanges having complementary openings spaced around the circumference thereof, a hollow blade received in each pair of said openings and secured in position by engagement with said flanges, means for fastening said rings together with said blades in position therein, said flanges of said rings being spaced from each other to form a slot for the flow of a fluid therethrough, and means forming a manifold chamber communicating with a plurality of said blades.

18. In an axial flow compressor, a blade assembly for a single stage thereof comprising a pair of rings having flanges extending toward each other, said flanges having complementary openings spaced around the circumference thereof, a blade received in each pair of said openings and secured in position by engagement with said flanges, means for fastening said rings together with said blades in position therein, said flanges of said rings being spaced from each other to form a slot for the flow of a fluid therethrough, and a plurality of vanes supported by said rings on the opposite side from said blades for guiding the flow through said slot.

19. In an axial flow compressor, a stator comprising a casing, means in said casing defining a plurality of circumferentially spaced fluid flow passages, blades supported from said casing and arranged in a plurality of separately assembled

stages, said blades having slots on their surfaces providing for a flow of said fluid therethrough, means providing communication between a plurality of the blades of a downstream stage and said flow passage, and means providing communication between said flow passage and a plurality of the blades of an upstream stage.

20. In an axial flow compressor, a stator comprising an outer casing, a plurality of blade supporting rings supported from said casing and adapted to be stacked thereon, a plurality of individual blades arranged in stages between each adjacent pair of said rings, and means for securing said rings with each of said stages of blades therebetween in said assembled stacked relation.

21. In an axial flow compressor, a stator comprising an outer casing, a plurality of vanes defining axially extending passages circumferentially arranged inwardly of said casing, a plurality of blade supporting rings, blades on said rings extending inwardly therefrom and arranged in a plurality of stages, apertures in said rings establishing communication between a plurality of the blades of a downstream stage and one of said passages, and means defining apertures in another said ring establishing communication between a plurality of the blades of an upstream stage and the same said passage.

22. In an axial flow compressor, a stator comprising an outer casing, a plurality of vanes defining axially extending passages circumferentially arranged inwardly of said casing, a plurality of rings, blades on said rings extending inwardly therefrom and arranged in a plurality of stages, means forming apertures in said rings establishing communication between the blades of a downstream stage and one of said passages, means defining apertures in another said ring establishing communication between the blades of an upstream stage and the same said passage, and deflecting means mounted in said passage adjacent said apertures to direct a flow therethrough.

23. In an axial flow compressor, a stator, a plurality of ring-shaped members supported from said stator, a plurality of blades supported by each pair of said members forming a stage of blades for said compressor, means for stacking said members with said blades therebetween in adjacent relation to each other, means defining a plurality of axially extending flow passages outwardly of said members, and means defining apertures through said members for establishing communication through said respective passages between the blades of one stage and those of a different stage.

24. In an axial flow compressor, a plurality of stator blade assemblies for a plurality of stages including a pair of ring-shaped members for engaging a plurality of blades to form each stage, a plurality of rotor blade assemblies for a plurality of stages including a pair of ring-shaped members for engaging a plurality of blades to form each stage, a casing structure for receiving said ring-shaped members of said stator blade assemblies therein, a hub for receiving said ring-shaped members of said rotor blade assemblies thereon, means for stacking said stator blade assemblies in said casing and for stacking said rotor blade assemblies on said hub in alternating relation with said stator blade assemblies, means for securing said stacked stator blade assemblies in said casing, and means for securing said stacked rotor blade assemblies on said hub.

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25. In an axial flow compressor, a supporting structure including a plurality of separable hub members adapted to be assembled in side by side relation, a plurality of separable ring-shaped members mounted on said supporting structure between adjacent pairs of said hub members, each of said ring members having overhanging flanges extending toward each other, both said flanges being apertured in and cooperating at a plurality of points around their circumferences providing for receiving blades therebetween, hollow blades having flow passages therein, means at the base of each blade overlapping both the adjacent flanges, means for securing said ring members in adjacent relation on said structure to retain said plurality of blades in assembled relation, and means forming a passage through said ring-shaped members between said flanges for establishing a flow therethrough.

26. In an axial flow compressor, a stator, a plurality of hollow ring-shaped members supported from said stator, a plurality of hollow stator blades supported by each said member forming a stage of blades for said compressor, each said blade having an apertured surface for the passage of fluid therethrough, a plurality of

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blades of the same stage having their interiors in communication with the interior of a said member thereof, means defining a plurality of axially extending flow passages outwardly of said members, said members having apertures leading into their hollow interiors for communication through their respective passages between the interiors of a plurality of blades of one stage and the interiors of a plurality of the blades of a different stage.

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