March 18, 1947. W. B. JUTTE 2,417,600

MULTI-STAGE RADIAL FLOW TURBINE

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FIG. 1.

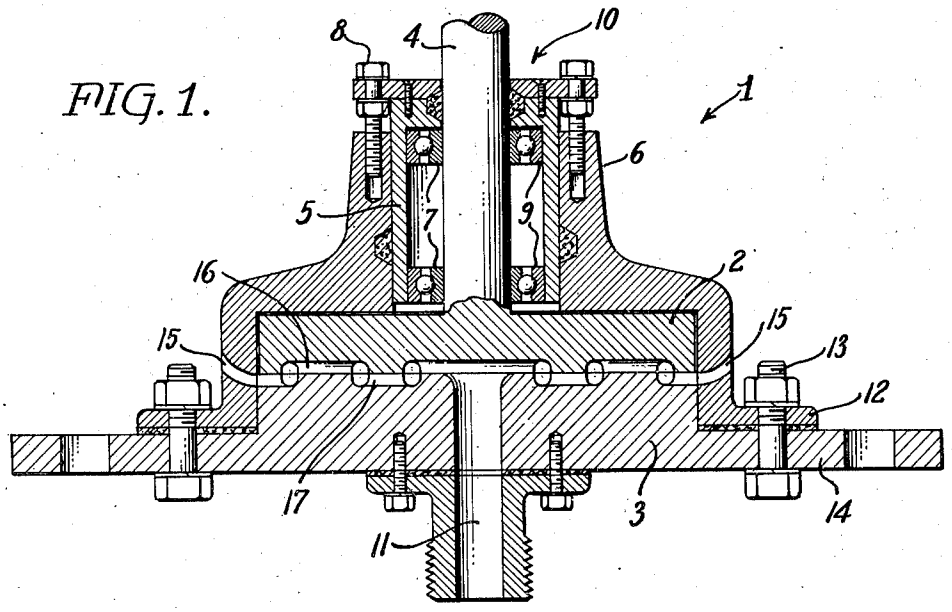
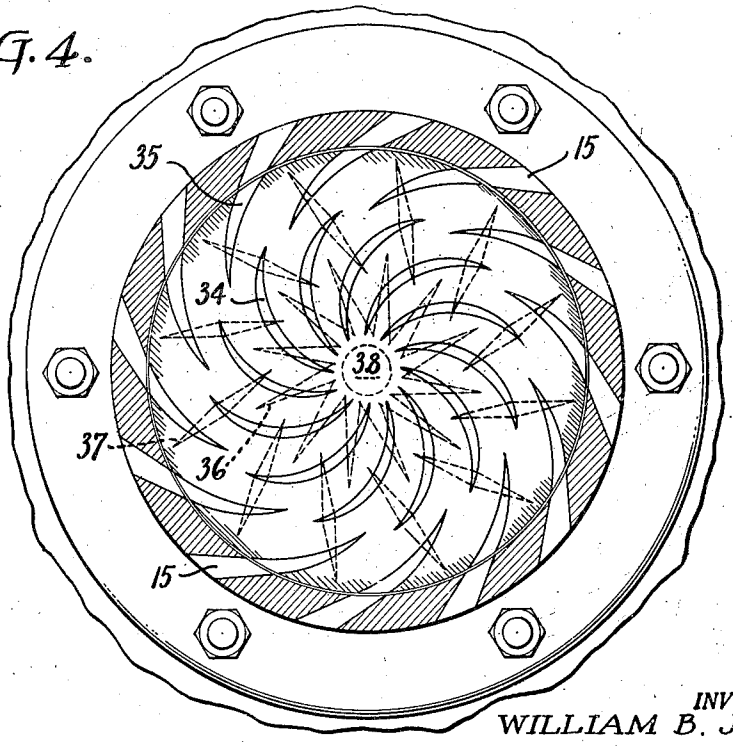


FIG. 4.



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FIG. 3.

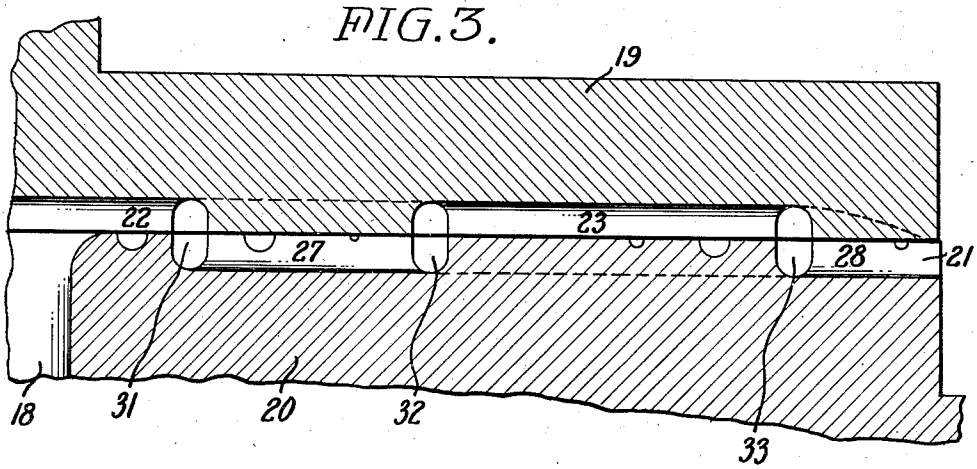
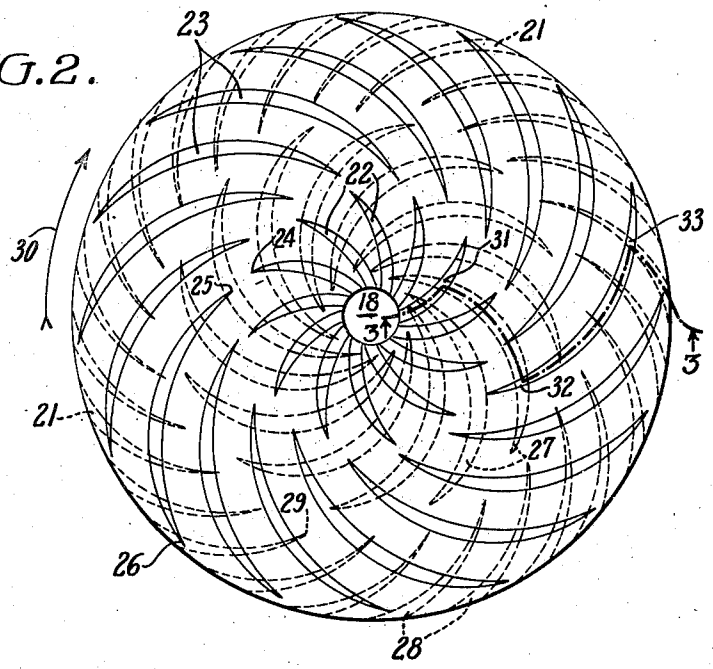


FIG. 2.



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MULTI-STAGE RADIAL FLOW TURBINE

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FIG. 6.

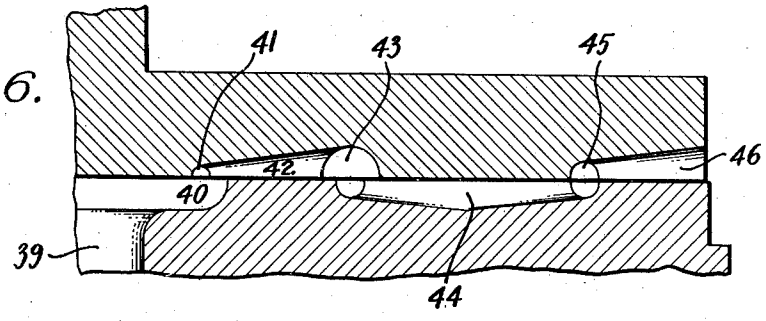
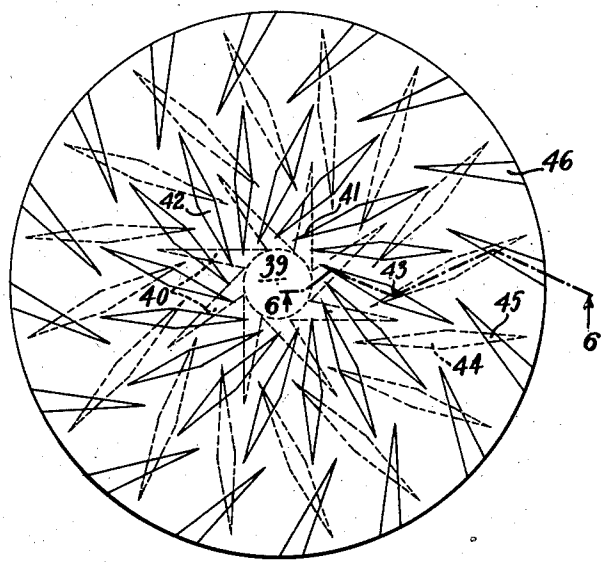


FIG. 5.



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MULTISTAGE RADIAL FLOW TURBINE

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8 Claims. (Cl. 253—79)

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The invention relates to an improvement in a multi-stage radial flow turbine actuated by steam or other fluid. The invention also relates to a multi-stage turbine which is reversible, and to a rotary machine which may be employed as a blower or compressor.

In my co-pending application, S. N. 575,163, filed January 29, 1945, for Turbine, there is disclosed and claimed a turbine or compressor wherein the stator and rotor are each provided with a set of dead end fluid channels closed at one end with provisions for transferring the fluid from a channel in one set to a channel in the other set at the crossing point thereof.

An object of the present invention is to make use of the channel arrangement disclosed and claimed in the former application and extend it to multi-stage operation. This is accomplished by employing in one of the stator or rotor members an additional set of dead end channels which are closed at both ends as a connecting link between two sets of dead end channels in the other stator or rotor member, the fluid path between the inlet and the exhaust extending partly through a channel in one member, partly through a link channel in the other member, and partly through a channel of another set in the first member, the transfer or shift from one to the other occurring at the crossing points of the first and second, also second and third arrays of channels, with an impulse thrust occurring at each crossing point and reaction thrust occurring along the rotor channel at one side of the crossing point.

As in the former application, the invention provides a turbine which employs both reaction and impulse principles. An impulse-reaction type of turbine is, of course, already known. The present type of turbine is rather complicated and costly in that it employs rings of moving blades interspersed with rings of fixed blades, the moving blades being arranged on the circumference of a drum along the periphery of which the steam progresses as it expands, the drum increasing in diameter for multi-stage operation.

The present invention provides a multi-stage turbine having low speed with high velocity of fluid, having low weight and low cost per H. P., good efficiency at a wide range of speeds and reversibility by reversing the direction of flow. While some efficiency is lost in reverse operation, this is not of particular moment as in marine work for example, operation in reverse is not maintained for protracted periods of time. Also, the single turbine of the present invention which

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can be reversed by reversing the direction of flow, has obvious advantages in cost and space over the usual arrangement where the turbine cannot be thus reversed, necessitating a separate turbine for reverse operation.

By way of example, the invention is illustrated as applied to a disk-type rotor and stator, although other surfaces of revolution such as concentric cylinders could be used. While it has been proposed heretofore to provide a disk-type rotor and stator having intersecting channels, such channels have heretofore been provided with an inlet at the inner end of both arrays of channels and with an outlet at the outer ends of both arrays of channels. The present invention is an improvement on that arrangement in that by providing a part only of the path in one channel, and other parts in other channels, the crossing point determines the locus of shift from one to the other, the steam or the like being deflected or caused to change its direction on leaving one channel and entering another at the crossing point. As a result of this, an impulse is imparted, and, in fact, this impulse operates through a radius arm which gradually increases as the crossing point progresses outwardly, while an additional amount of energy is abstracted from the elastic fluid according to the reaction principle, over that part of the rearwardly discharging channel path in the rotor and the force of such reaction increases as the crossing point progresses outwardly, while the impulse force, likewise, increases.

The thrust is substantially continuous because the construction above-described provides a composite channel, having one or more parts in the rotor and the remainder in the stator, which makes possible a period of substantially continuous, uninterrupted expansion of the fluid, which is impossible in other known types of radial-flow turbines because they provide continuous flow through unstopped grooves in both rotor and stator, the flow being impeded, confused, or pulsated at the crossing points of the open channels. In the present invention the only way in which the fluid can travel from the inlet to the exhaust is to (*a*) shift from a channel in one member to a channel in the other at the crossing point, giving one stage of expansion and (*b*) shift from the channel in the other to a channel in the first member, at the crossing point, giving a second stage of operation, and in so doing the fluid is caused to produce multi-stage work both by impulse and reaction.

According to the present invention there is

provided a construction which is far simpler than heretofore by employing relatively rotatable disk-like members, either of which may be a rotor and the other a stator, or both may be rotors, wherein provision is made for multi-stage radial flow, instead of axial peripheral flow while employing both reaction and impulse principles. Preferably, the outlet channels increase in size towards the exhaust, in accordance with the increase in volume of the expanding steam or fluid.

Preferably a sufficient number of inlet and outlet channels are provided so that each inlet channel crosses a plurality of link channels, and each link channel crosses a plurality of outlet channels, whereby an impulse thrust is provided at each of the various crossing points.

Another object of the invention is to float the rotor and the thrust imposed on it by its work on the fluid pressure between the rotor and stator.

While in the above description and hereafter reference is specifically made to a turbine, it is understood that such description is intended to apply in an analogous manner to a pump, compressor, or blower because the apparatus of this invention may be employed as one or the other.

For further details of the invention, reference may be made to the drawings, wherein

Fig. 1 is a vertical sectional view of a turbine or compressor according to the present invention, schematically showing a typical arrangement of channels in the stator and rotor.

Fig. 2 is a schematic plan view of a preferred arrangement of channels.

Fig. 3 is an enlarged sectional view on the broken line 3—3 in Fig. 2.

Fig. 4 is a schematic plan view partly in section of a modified channel arrangement.

Fig. 5 is a schematic plan view of a further modification.

Fig. 6 is an enlarged sectional view on line 6—6 in Fig. 5.

The feature of dead end channels to provide a part of the fluid path in the rotor, and the remainder in the stator, is disclosed and claimed in co-pending application S. N. 575,163, filed January 29, 1945, for "Turbine." Generally speaking, the present case is an improvement thereon in obtaining multi-stage operation by the use of link channels closed at both ends. Copending application S. N. 622,521, filed October 16, 1945, for Radial flow turbine discloses and claims a turbine or compressor wherein one or more of the channels are straight instead of curved, a feature disclosed herein and later described.

Referring in detail to the drawings, the turbine or compressor herein described is illustrated in a simplified form in order to more clearly illustrate the working principle. The turbine or compressor 1 comprises a rotor disk 2 and a stator disk 3 having adjacent surfaces in close face to face relation and separated from each other by a very thin film of steam or vapor or other fluid, on which the rotor 2 is adapted to float. The rotor 2 has a coaxial shaft 4 supported by a bearing 10 in the housing 6. Bearing 10 is preferably both a radial and thrust bearing and, for example, may have a sleeve 5 which is adjustable longitudinally on the shaft 4 by means of adjusting nuts or bolts 8. The bearing 10 has spaced ball bearings of which one race 7 is fixed to shaft 4 and a complementary race 9 secured to the sleeve 5. By adjusting the nuts or bolts 8, a desired clearance

may be obtained between the under face of rotor 2 and the top face of stator 3. The stator 3 has a coaxial inlet 11 for the steam or vapor, or other fluid. Inlet 11 extends through the surface in which stator channels 17 are arranged to communicate with the center portion of the rotor channels 16. The housing 6 is provided with a flange 12 so that bolts such as 13 may secure this flange to the flange 14 on the stator 3. The housing 6 is provided with a number of spaced outlets 15. The fluid pressure in inlet 11 produces rotation of rotor 2, the fluid passing through the cooperating rotor channels 16 and stator channels 17 to the exhaust 15.

The rotor channels 16 and stator channels 17 may be arranged as shown in Figs. 2 to 6. Figs. 2 and 3 show a preferred form wherein fluid under pressure enters inlet 18 and passes through certain channels, later described, in rotor 19 and stator 20 to a number of spaced outlets such as shown at 21 in the stator 20. In Fig. 2 the rotor channels are shown in full lines and comprise (*a*) an inner array 22, open at their inner ends to stator inlet 18, and closed at their outer ends, and (*b*) an outer array 23 of link channels closed at their opposite ends. As each of the rotor channels in the array 22 is closed at its outer ends, as indicated at 24, and as each rotor link channel in the array 23 is closed at its inner end as is indicated at 25 and also at its outer end 26, the rotor channels 22, 23 provide only a part of the path from inlet 18 to the outlets 21, the remainder of that path being in the stator as follows: The stator grooves in Fig. 2 are shown in dotted lines and comprise (*a*) an inner array 27 of link channels closed at both ends, and (*b*) an outer array 28 of channels closed at their inner ends as indicated at 29 and open at their outer ends and serving as outlets 21, in communication with outlets such as 15 in Fig. 1, the housing 6 of Fig. 1 being omitted in Fig. 3.

The rotor channels 22 are curved in one direction, being convex in the direction of rotation which is clockwise as indicated by the arrow 30, and they cross a plurality, here shown as four, of the inner stator link channels 27 which are curved in the opposite direction. Stator link channels are each crossed by a plurality of the outer rotor link channels 23 which are convex in the direction of rotation and arranged at a greater angle to the radius than the inner rotor channels 22. Each of the outer rotor link channels 23 crosses a plurality of the outer stator channels 28 which are curved oppositely to rotor channels 23.

The fluid path branches from a channel in array 22 to a plurality of channels in the array 27, at the crossing points thereof, such as indicated at 31, the path further branching from each channel in the array 27 to a plurality of channels in the array 23, at the crossing points thereof, such as indicated at 32, and from each channel in array 23 to a plurality of channels in array 28, at the crossing points thereof, such as indicated at 33. All such crossing points 31, 32, 33 progress radially outward as rotor 19 rotates when passage 18 is an inlet. They progress radially inward when 21 is an inlet for reverse rotation of rotor 19. Also the wide spread branchings make possible a high velocity of fluid for a low speed of rotation of the rotor as well as multistage expansion.

The fluid from inlet 18 changes direction at each of the crossing points such as 31, 32, 33,

producing at each crossing point an impulse thrust in the direction of rotation. The fluid between inlet 18 and a crossing point such as 31, and between crossing points 32 and 33, in the rotor channels produces reaction thrust additive to the impulse thrusts at the crossing points.

To take care of the expansion of fluid as it approaches the outlet 21, the various rotor and stator channels may increase in number or size or both as the outlet 21 is approached. Fig. 2 shows 12 channels in each of the arrays 22 and 27, 16 channels in array 23, and 24 channels in array 28.

The broken line 3—3 in Fig. 2 and Fig. 3 show one of the various paths for fluid from inlet 18 to outlets such as 21.

There will be a slight amount of leakage of the fluid due to the fact that rotor 19 is floating on an extremely thin film of the fluid and such leakage will, in general, do useful work on the rotor 19 because if such leakage as indicated finds its way into a stator groove, such as 27 or 28, all elastic fluid, including the leakage, expands in that groove, performing work on each of the rotor grooves, 22, 23 as they communicate therewith.

The composite channel provided partly by the separated rotor grooves, 22, 23, and the remainder by the separated stator grooves, 27, 28, effects a substantially continuous, uninterrupted expansion of elastic fluid such as steam.

The fluid pressure on the under side of rotor 19 may serve to float the rotor and the thrust imposed on it by its work whereby the rotor 2 serves as a thrust bearing.

Instead of having all of the arrays of channels curved, one or more of such arrays may be straight, to cheapen the cost of manufacture as it is cheaper to machine a straight groove than a curved groove. In the modification shown in Fig. 4, the stator channels 36, 37 are straight while the rotor channels 34, 35 are curved. The inner rotor link channels 34 are closed at their opposite ends while the outer rotor channels 35 are closed at their inner ends and open at their outer ends to exhaust into the outlets 15. The channels 34 and 35 are convex in the direction of rotation, which is counterclockwise, and cooperating therewith is an inner array 36 and an outer array 37 of stator channels, both of which are straight, that is, their central line is straight whereas the sides thereof may taper as indicated. The channels 36 are closed at their outer ends and their inner ends open into inlet 38. The channels 37 are link channels closed at both ends. The channels 36 are here shown as tangential to the inlet 38, although these channels may be radial. The array 36 crosses a plurality of channels in the array 34; each channel in array 34 crosses a plurality of channels in the array 37; and each channel 37 is crossed, at times, by a plurality of the outlet channels 35. The operation is substantially as described in connection with Fig. 2, the fluid in inlet 38 passing to the various stator channels 36 to the points where they cross the rotor channels 34, thence, along channels 34 to the points where the latter cross the stator channels 37 and along them to the points where they cross the outlet channels 35 and, thence, out the channels 35 to the outlets 15.

In the modification shown in Fig. 5 all channels are illustrated as being straight, that is their median line is straight, the stator channels being shown in dotted lines, the rotor channels in full lines, as in other figures. One of the paths for fluid is shown by the broken lines 6—6 and by

Figure 6, wherein fluid in inlet 39 passes into a stator groove 40 to a crossing point 41 then along a rotor groove 42 to a crossing point 43 then along a stator groove 44 to a crossing point 45 then along a rotor groove 46 to one of the outlets 15 shown in Fig. 1. The operation is substantially the same as that described in connection with Fig. 2.

I claim:

1. A multi-stage radial flow machine comprising a rotor member and a stator member having opposed surfaces in close face to face relation, the said surface of one of said members having two spaced sets of channels each set being out of direct communication with the other set, one set being closed at one end and the other set being closed at the other end, the said surface of the other of said members having a cooperating set of link channels closed at both ends crossing and opening into each of said separated sets at points which progress radially as said rotor member rotates to provide fluid communication from one of said two spaced sets to the other through said link channels at the crossing points of said link channels with said separated sets of channels.

2. A machine for fluids and having two relatively rotatable coaxial adjacent members having opposed surfaces in close face to face relation, the said surface of one of said members having inner and outer spaced arrays of channels, and the said adjacent opposed surface of the other of said members having a cooperating array of link channels, said link channels of one of said members intersecting the channels of both arrays of the other member at points progressing radially during relative rotation of said members, a fluid passage, the channels of the inner one of said spaced arrays being closed at their outer ends and communicating with said fluid passage at their inner ends, the channels of the outer spaced array being closed at their inner ends and having fluid passages at their outer ends, and said link channels being closed at both ends, whereby the path for fluid between said first mentioned fluid passage and the outer ends of said outer array of channels shifts from said inner array of channels to said link channels and from said link channels to said outer array of channels at the progressive crossing points thereof.

3. A machine according to claim 2 wherein the channels of said outer array are closed at their outer ends, said other member having an outer array of channels closed at their inner ends and crossing at points progressing radially along outer portion of said last mentioned outer array of channels.

4. A multi-stage turbine comprising relatively rotatable coaxial stator and rotor members having adjacent surfaces in close face to face relation, said surface of one of said members having a set of link channels closed at both ends, the said surface of said other member having (*a*) an inner array of channels closed at their outer ends and crossing inner portions of said link channels and (*b*) an outer array of channels closed at their inner ends and crossing outer portions of said link channels, said crossings progressing radially as said rotor rotates.

5. A machine comprising a rotor member and a stator member having surface in close face to face relation, an inlet and an outlet therefor, said rotor and stator surfaces having more than two angularly related radially spaced arrays of dead

end channels, said arrays crossing each other to provide a fluid path from said inlet to said outlet, a part only of the path from said inlet to said outlet being in the channels of one of said members and at least two radially separated portions of that path being in the channels of the other member.

6. A machine according to claim 5 wherein said rotor channels extend in directions to provide a reaction thrust radially outward of said channel crossings, and said crossings change the direction of fluid flow to provide impulse thrusts, said impulse and reaction thrusts being additive.

7. A machine according to claim 5 wherein said crossings and said impulse thrusts thereat progress radially outward as said rotor rotates.

8. A machine according to claim 5 wherein each of the channels in one of said surfaces branches into a plurality of channels in the other of said surfaces and each of the channels in said

other surface branches into another of said arrays of channels in said one surface at their respective crossings.

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