United States Patent [19]

Corrigan et al.

[11] **3,841,789**

[45] **Oct. 15, 1974**

[54] **VARIABLE DIFFUSER**

[75] Inventors: **Leo A. Corrigan; Esten W. Spears, Jr.,** both of Indianapolis, Ind.

[73] Assignee: **General Motors Corportion,** Detroit, Mich.

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[52] **U.S. Cl.** **415/148,** 415/150

[51] **Int. Cl.** **F04d 29/46**

[58] **Field of Search** 415/148, 149, 150, 151, 415/163, 126, 146, 164, 165

[56] **References Cited**

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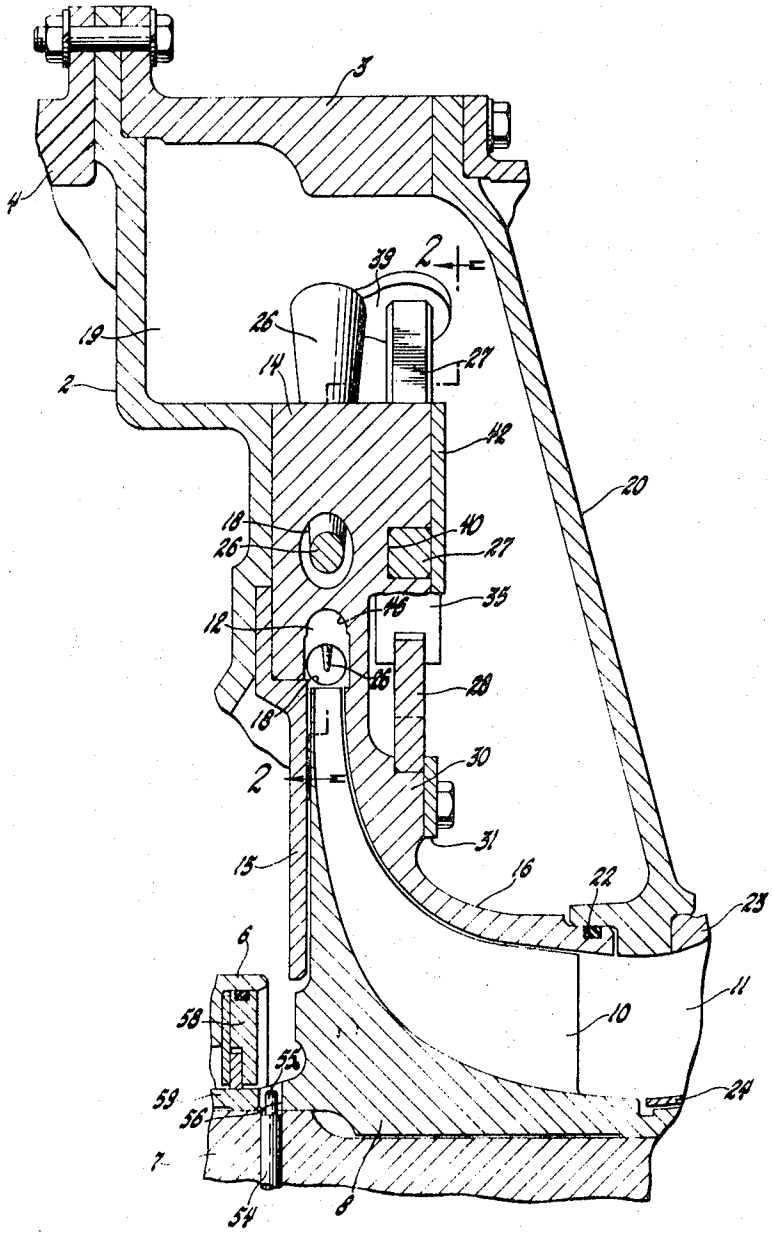
Primary Examiner—Henry F. Raduazo

Attorney, Agent, or Firm—Paul Fitzpatrick

[57] **ABSTRACT**

A centrifugal compressor has a diffuser in the form of a ring with diverging passages extending through the ring generally tangentially to the periphery of the compressor rotor. The relation of area to distance along each passage is varied by a tapered centerbody, each centerbody being mounted on a plunger reciprocably guided on the diffuser body. The centerbodies are concurrently adjusted longitudinally of the passages by an actuating ring rotatable about the axis of the compressor engaging the plungers.

4 Claims, 4 Drawing Figures



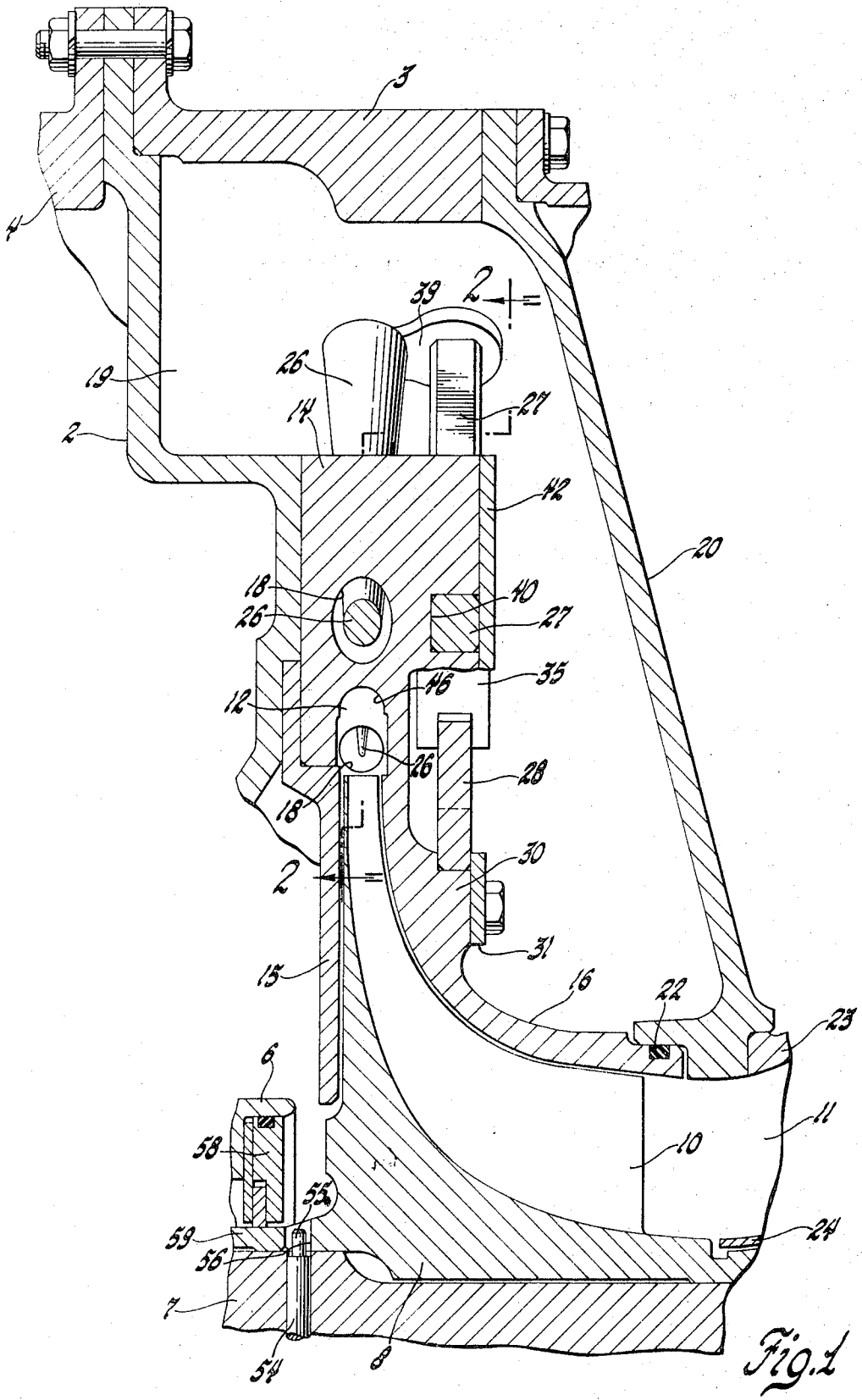

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Fig. 1

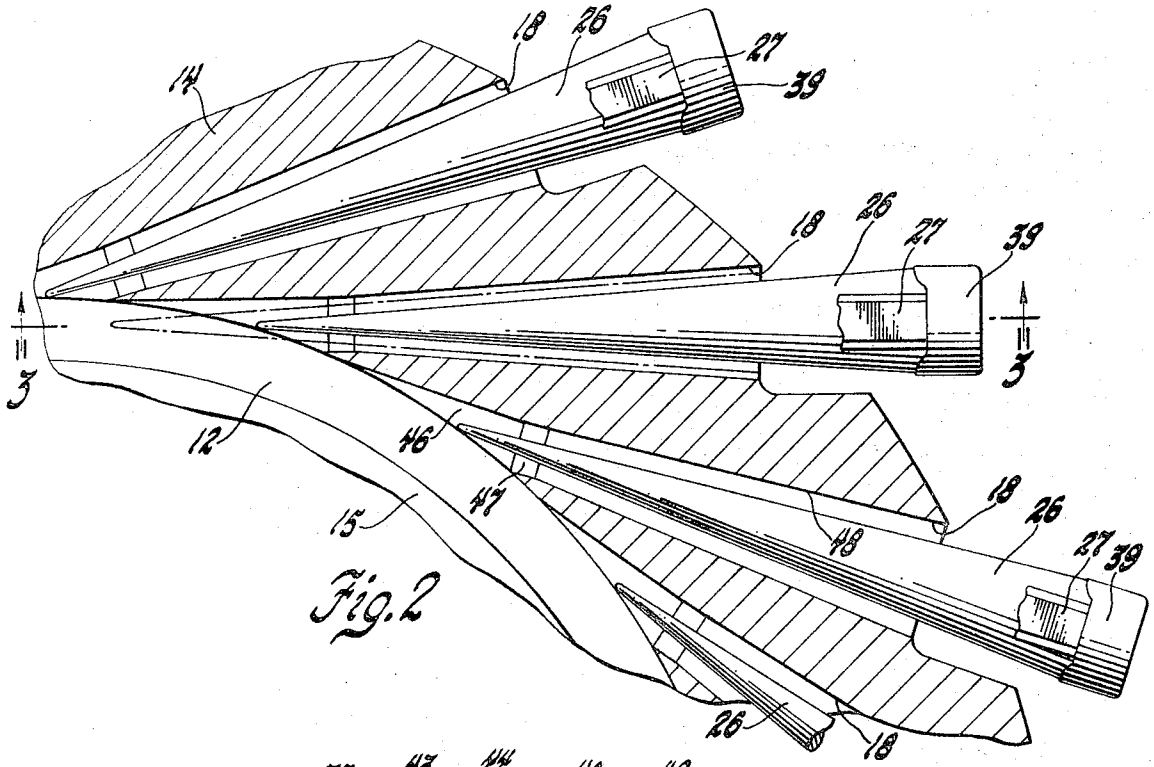


Fig. 2

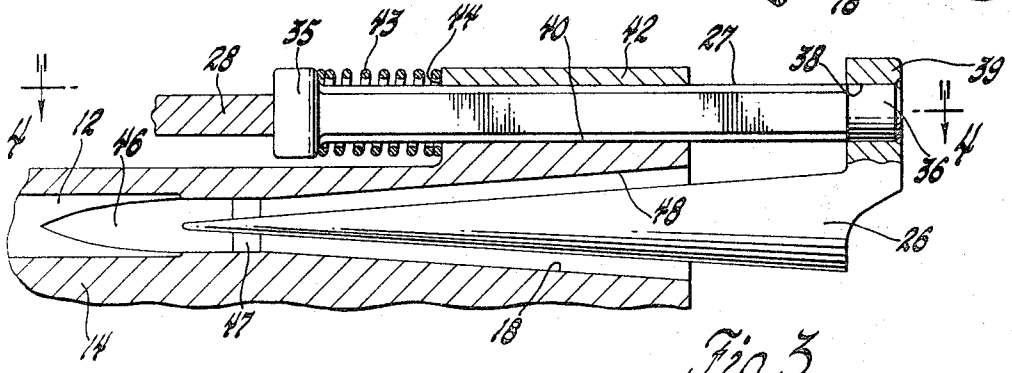


Fig. 3

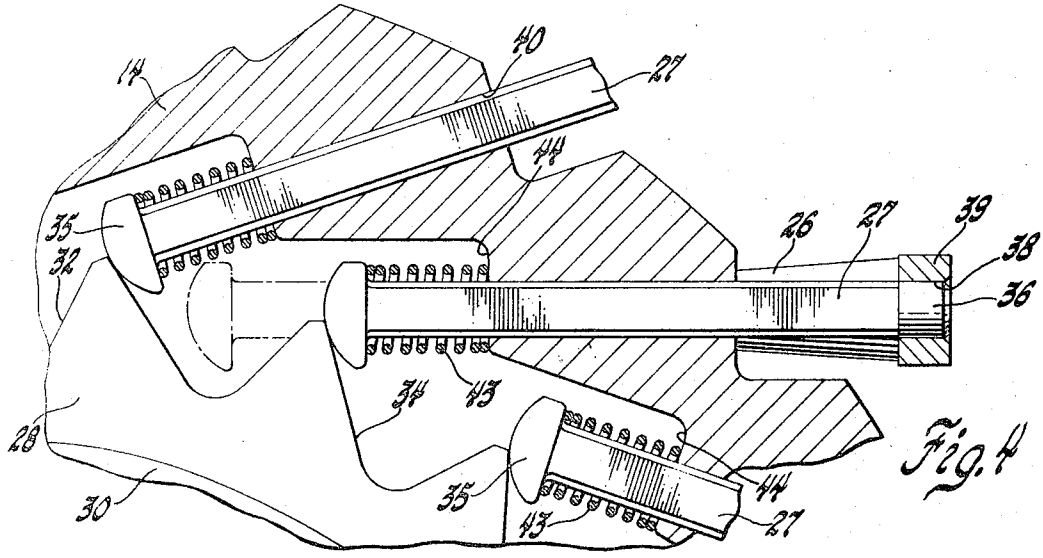


Fig. 4

VARIABLE DIFFUSER

Our invention is directed to variable diffuser structures for dynamic air compressors and other machines of this general type. Its most significant application, as it appears at present, is in a radial-flow compressor for service in which a considerable variation in flow from the compressor is desired, as may be in the case in a gas turbine engine for automotive service.

A centrifugal compressor in which the dimensions of all the flow paths are fixed has certain fixed relations between the significant parameters of operation of the compressor. The parameters of significance from the present point of view are as follows: First, the ratio of discharge pressure to inlet pressure of the machine. Second, the rate of flow, which may be expressed as weight per unit time. Third, the speed of rotation of the compressor rotor. Fourth, the power required to drive the compressor. These are interrelated, and although the relations between them will be varied by changes in ambient (or inlet) conditions, there is no great flexibility of operation of the machine. For example, at any given speed, no great variation of flow is available. Flexibility of operation is quite desirable in certain applications of compressors, among which is use in a gas turbine which should have efficient part throttle and idling operation. A gas turbine engine for an automotive passenger vehicle will ordinarily operate at relatively low power or idling conditions a large part of the time.

The compressor may be adapted to operate efficiently under small flow conditions, with small power input, by varying the physical configuration of the compressor. Our invention is directed to improved means for varying the compressor characteristic by varying the configuration of the diffuser of the compressor. Such variation may be employed in conjunction with means for varying the conditions in the inlet to the compressor, such as the inlet area or the swirl of air entering the compressor, and with means for varying the characteristics of the turbine to which the compressed air flows. Our invention, however, is directed specifically to the variable diffuser, and not to other variable geometry which might be employed in an engine having a compressor embodying our invention.

Our invention is specifically directed to a preferred arrangement for varying the relation of area to distance along the diffusing passages of a centrifugal compressor diffuser or the like. The compressor, apart from the variable geometry diffuser mechanism of our invention, may be of conventional known type.

Variable diffusers for centrifugal compressors and the like have been proposed hitherto, but we believe that our preferred structure is significantly different from and superior to those of which we are aware. We are aware of Jassniker U.S. Pat. NO. 2,996,996, Aug. 22, 1961, Jekat U.S. Pat. No. 3,138,317, June 23, 1964, and Buchi French Pat. No. 952,053, Apr. 25, 1947. The last-named is a turbine exhaust diffuser.

The nature of our invention and its advantages will be clear to those skilled in the art from the succeeding detailed description and accompanying drawings of the preferred embodiment.

FIG. 1 is a partial sectional view of a centrifugal compressor taken in a plane containing the axis of rotation of the compressor rotor.

FIG. 2 is a partial cross sectional view, taken in the plane indicated by the line 2—2 in FIG. 1.

FIG. 3 is a partial cross sectional view taken in the plane indicated by the line 3—3 in FIG 2.

FIG. 4 is a partial cross sectional view taken in the plane indicated by the line 4—4 in FIG. 3.

Referring first to FIG. 1 for a general description of the centrifugal compressor in which our invention is embodied, an engine frame member 2 is bolted at its margin to a housing member 3 and a casing 4, the latter of which may enclose the combustion apparatus and turbine (not shown) of a gas turbine engine. The frame member 2 includes a central portion 6 which supports a shaft 7 by a suitable bearing (not shown). A compressor rotor or impeller 8 is fixed to the shaft 7 so that it may be driven by the turbine. The rotor 8 bears radially extending vanes 10 to impel air which enters through an annular air entry 11 and discharge it at the periphery of the impeller into a vaneless space 12 immediately surrounding the rotor. The vaneless space is defined by a recess on the inner surface of an annular diffuser body 14. The diffuser body is suitably fixed to the forward surface of frame member 12, and an annular rear plate 15 extends inwardly along the rear face of the impeller from the inner surface of diffuser body 14. A shroud 16 which, in this structure, is integral with the body 14, defines the outer boundary of the fluid flow path through the rotor 8.

In operation, the rotor 8 is rotated at high speed by shaft 7 and delivers the air with radial and tangential components of velocity into space 12, from which it flows through an annular array of diffusing passages 18 which, as is most clearly apparent from FIG. 2, extend approximately tangentially from the space 12 to the radially outer surface of the diffuser body 14. The air discharged by the impeller is decelerated in its passage through the diverging passages 18 and flows at reduced velocity and increased static pressure into a plenum or chamber 19 defined generally between diffuser body 14 and housing member 3. This plenum space is closed by a front cover 20 bolted to member 3 and overlapping the forward end of shroud 16, with a seal 22 at the overlap.

The air entry 11 to the rotor is defined by an outer wall 23 and an inner wall 24 of an air entrance structure which is indicated fragmentarily in FIG. 1, this being mounted on the front cover 20.

Our invention lies in means for varying the area to length relationship of the diffuser passages 18, which comprises the following major elements: A tapering center-body 26 reciprocable along the axis of each passage 18, a reciprocably mounted plunger 27 fixed to and supporting each centerbody, and an actuating ring 28 journaled on the shroud 16 for rotation about the axis of the compressor. The actuating ring 28 is rotatably mounted on the cylindrical outer surface of a boss 30 extending from the shroud 16 and is held in place by a retainer ring 31 bolted to the front surface of boss 30. The ring 28 has teeth 32 so as to define a generally radial actuating surface 34 for each plunger 27. The actuating surfaces 34 engage heads 35 integral with the plungers 27 both the heads and plungers being approximately of square cross section. The outermost end of each plunger 27 is turned to provide a cylindrical dowel 36 which fits a bore 38 in a bracket 39 integral with and extending laterally from the outer end of the corresponding centerbody 26. These parts may be simply press fitted, or the dowel 36 may be brazed in the bore

38. The center line of the centerbody should parallel the center line of the plunger.

Each plunger 27 is reciprocable, being guided in a slot 40 milled in the forward face of the diffuser body 14 parallel to one of the passages 18. The plungers are retained in place by a ring 42 suitably fixed to the diffuser body.

The plunger heads 35 are biased into contact with the actuating surfaces 34 by compression springs 43 disposed between the heads 35 and abutments 44 defined on the diffuser body at the inner ends of slots 40. Thus, if ring 28 is rotated counterclockwise as viewed in FIG. 4, the springs 43 move the plungers inwardly and thus move the centerbodies 26 into the diffusing passages 18. If the ring is rotated clockwise, the centerbodies are moved outwardly in the diffusing passages.

A positive connection between the plungers 27 and actuating ring 28 could be provided, but the arrangement shown is preferred.

Passing to a more detailed description of the diffusing passages 18, each includes an entrance portion 46 extending from the outer boundary of the vaneless space 12 to a throat 47, from which the passage diverges and may be of conical configuration. So far as the cross section of the throat 47 and diverging portion 48 of the passages are concerned, they are preferably circular in cross section, but may be oval or even rectangular. The centerbody 26 should correspond in cross section to the passage and therefore preferably is of circular cross section. The centerbody extends from the throat to the passage outlet.

As will be apparent, movement of the centerbody 26 into the diffusing passage decreases the flow area at all points along the length of the passage, with the structure illustrated. The relative amount of decrease is a function of the tapers of the diverging portion 48 of the passage and the centerbody. With straight tapers of both, these may be so related that the ratio of inlet area to outlet area of the passage is the same at both extreme positions of the centerbody, but the area at all points along the passage varies as the centerbody moves to accommodate to varying rates of flow of air. On the other hand, it may be desirable to have the ratio of the throat and discharge areas of the disputing passage vary as the area varies. This may be accomplished, depending upon the relative divergence of the passage and centerbody. For example, if the angle of divergence of the passage is sufficiently greater than that of the centerbody, the passage will be constricted relatively more at the throat than at the outlet. On the other hand, if the centerbody has the same angle of divergence as the passage, the ratio of outlet to inlet will decrease as the passage area is reduced.

In any event, a smooth variation in area of the diffusing passage from throat to outlet may be maintained over a relatively wide range of effective area and capacity for properly handling varying air flow. It will be realized that greater flexibility can be achieved by use of nonconical taper of passage, centerbody, or both. For example, with exponential variation of both, the relative change in area at all points along the passage can be kept equal as the centerbody moves.

Our variable diffuser may be employed in diffusing passages having arcuate centerlines if the centerbodies are correspondingly curved and the plungers 27 move in curved tracks. However, the additional complication and difficulty of manufacture seem undesirable.

It may be in order to mention a few visible structural details irrelevant to the present invention. The rotor 8 is located with respect to shaft 7 by a radial pin 54 having reduced end portions 55 received in notches 56 in the rear face of the hub of impeller 8. A sealing structure 58 is provided between the inner portion 6 of frame member 2 and a collar 59 on shaft 7.

It should be apparent to those skilled in the art from the foregoing detailed description that our invention provides a very simple and practicable arrangement for varying the effective flow area of a compressor diffuser or similar structure, and that the structure is adaptable by changes in dimensions to a variety of desired operating characteristics of the compressor. The centerbodies are supported by means external to the diffusing passages which do not interfere with free flow through the passages.

The detailed description of the preferred embodiment of the invention for the purpose of explaining the principles thereof is not to be considered as limiting or restricting the invention, since many modifications may be made by the exercise of skill in the art.

We claim:

1. A centrifugal machine comprising a rotor adapted to impel a fluid and a stator adapted to receive and diffuse the fluid impelled by the rotor; the stator comprising a body defining an annular array of diffusing passages extending generally tangentially outward from adjacent the periphery of the rotor; the machine being characterized by means for concurrently varying the relation of cross-sectional area to distance from the entrance to the passage throughout a substantial portion of the length of each diffusing passage comprising, in combination, a tapering centerbody extending axially of each passage; a reciprocably mounted plunger fixed to and supporting each centerbody; guide means on the body guiding each plunger for reciprocating movement; and actuating means on the body coupled to the centerbodies for concurrent movement of the centerbodies.

2. A centrifugal machine comprising a rotor adapted to impel a fluid and a stator adapted to receive and diffuse the fluid impelled by the rotor; the stator comprising a body defining an annular array of diffusing passages extending generally tangentially outward from adjacent the periphery of the rotor; the machine being characterized by means for concurrently varying the relation of cross-sectional area to distance from the entrance to the passage throughout a substantial portion of the length of each diffusing passage comprising, in combination, a tapering centerbody extending axially of each passage; a reciprocably mounted plunger fixed to and supporting each centerbody; guide means on the body guiding each plunger for reciprocating movement; and actuating ring means mounted on the body rotatable about the axis of rotation of the rotor and engaging the plungers for concurrent movement of the centerbodies.

3. A centrifugal machine comprising a rotor adapted to impel a fluid and a stator adapted to receive and diffuse the fluid impelled by the rotor; the stator comprising a body defining an annular array of diffusing passages extending generally tangentially outward from adjacent the periphery of the rotor and diverging outwardly from a throat to an outlet; the machine being characterized by means for concurrently varying the relation of cross-sectional area to distance from the en-

trance to the passage throughout the portion of each diffusing passage from the throat to the outlet comprising, in combination, a tapering centerbody extending from the throat to the outlet in each passage; a reciprocably mounted plunger fixed to and supporting each centerbody; guide means on the body guiding each plunger for reciprocating movement; and actuating means on the body coupled to the plungers for concurrent movement of the centerbodies.

4. A centrifugal machine comprising a rotor adapted to impel a fluid and a stator adapted to receive and diffuse the fluid impelled by the rotor; the stator comprising a body defining an annular array of diffusing passages extending generally tangentially outward from adjacent the periphery of the rotor and diverging outwardly from a throat to an outlet; the machine being characterized by means for concurrently varying the relation of cross-sectional area to distance from the entrance to the passage throughout the portion of each diffusing passage from the throat to the outlet comprising, in combination, a tapering centerbody in each passage extending from the throat to the outlet; a reciprocably mounted plunger fixed to and supporting each centerbody; guide means on the body guiding each plunger for reciprocating movement; and actuating ring means mounted on the body rotatable about the axis of rotation of the rotor and engaging the plungers for concurrent movement of the centerbodies.

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