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Flatt et al.

[11] **3,904,324**

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[54] **TIP TURBINE INFLATING DEVICE**

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[52] **U.S. Cl.** **417/355**; 9/315; 137/527

[51] **Int. Cl.** **F04b 17/00**; F04b 35/00; B63c 7/16

[58] **Field of Search** ..... 417/355, 348; 9/11 A, 315, 9/316; 415/202

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[57] **ABSTRACT**

An inflating device having the character of a tip turbine type fan particularly adapted to enable a substantially instantaneous inflation of emergency life saving devices such as escape slides and life rafts. It features an improved nozzle configuration for receiving and delivering a small amount of high pressure air to a rotor assembly, in the operation of which the high pressure air is expanded and delivered as a high volume inflating medium, amplified by an ingested portion of ambient air. The rotor housing is distinguished by an inlet the form of which produces a smooth inflow of the ingested air and an outlet characterized by stator blades the mount of which avoids the problems normally anticipated where the device is subjected to extreme changes in temperature. The rotor outlet features a diffuser extension which contributes to its performance and increases its pumping efficiency.

12 Claims, 8 Drawing Figures

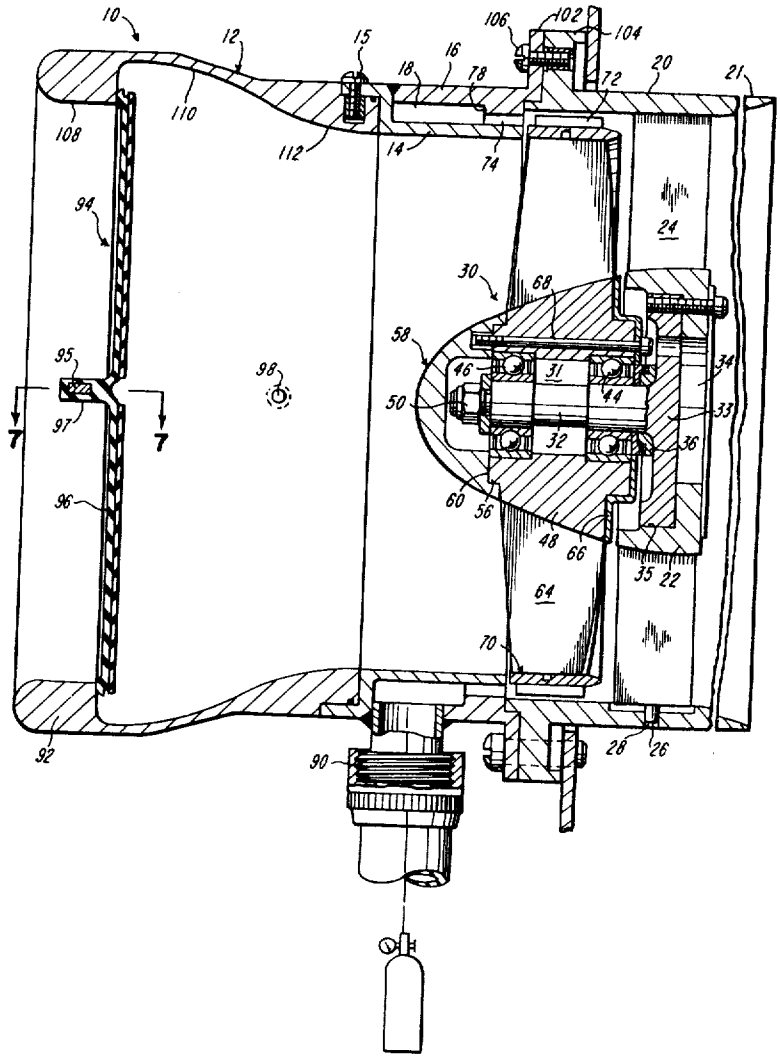


FIG-1

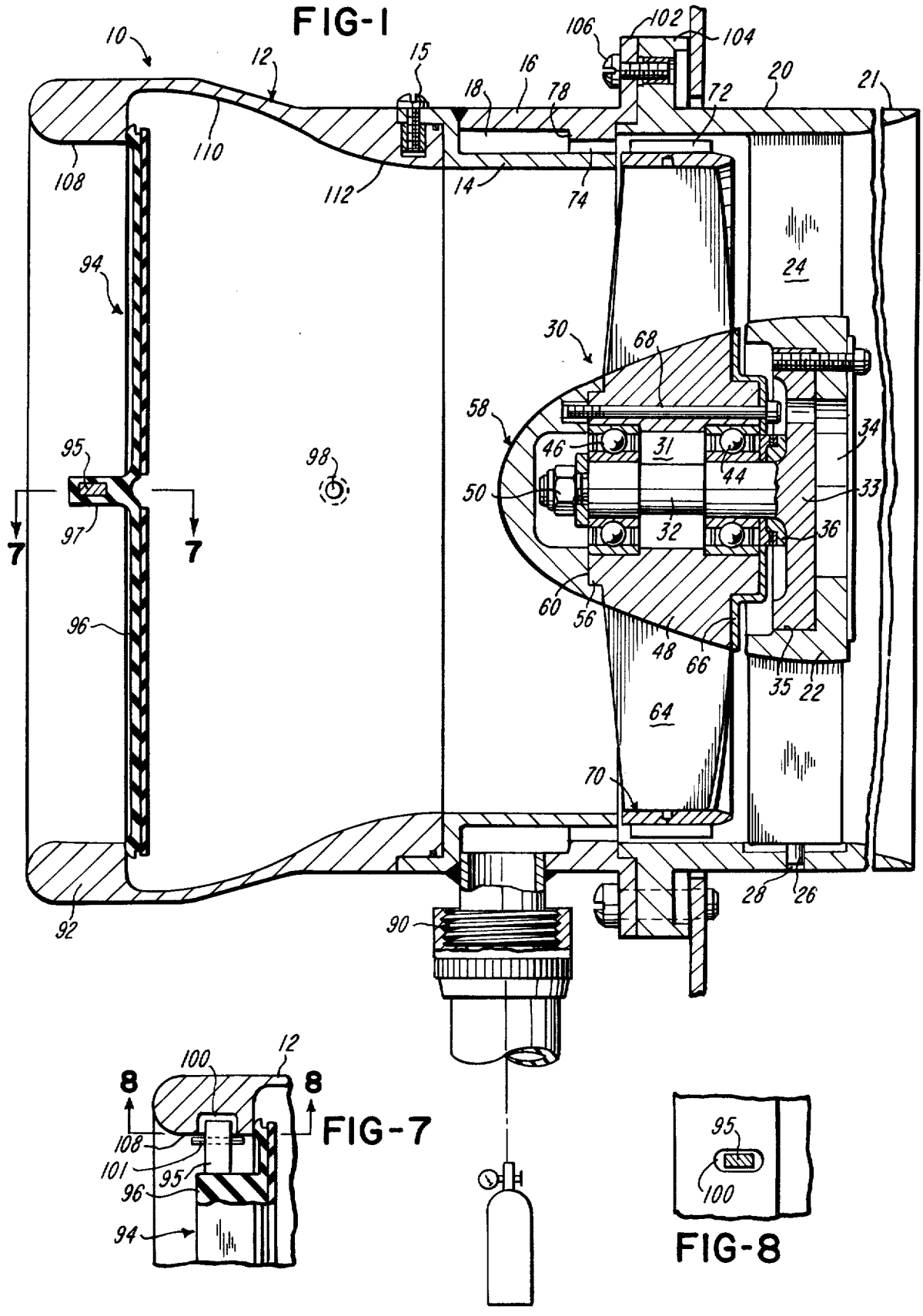


FIG-7

FIG-8

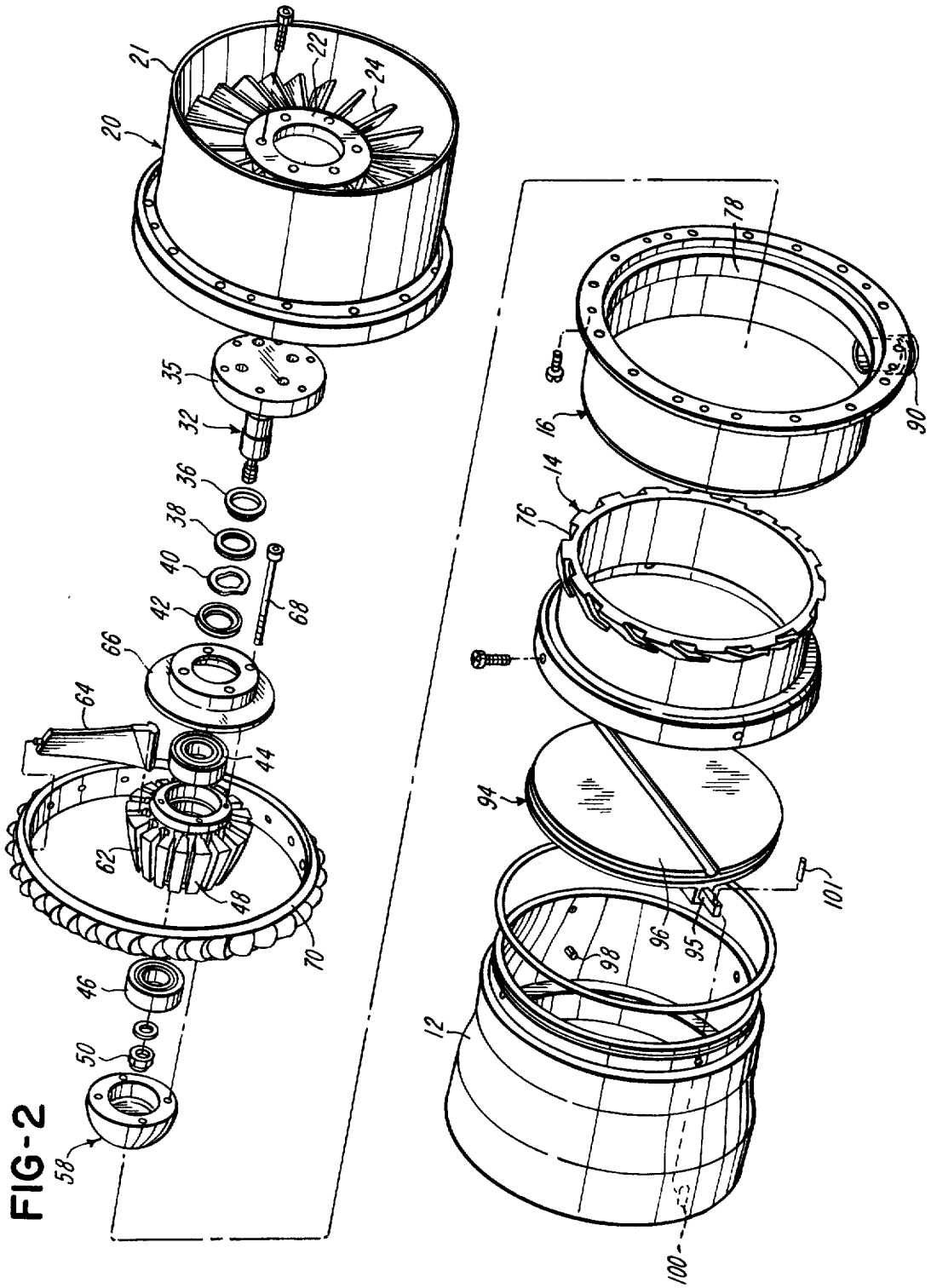

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FIG-2

FIG-4

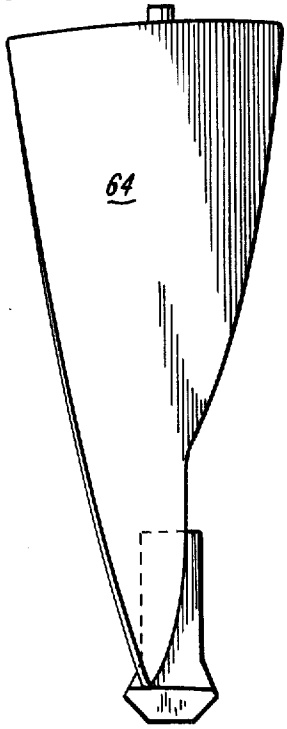


FIG-5

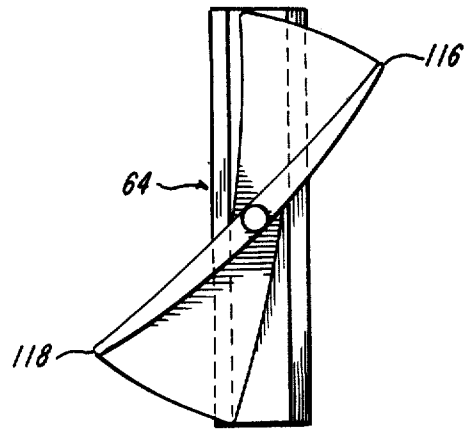


FIG-3

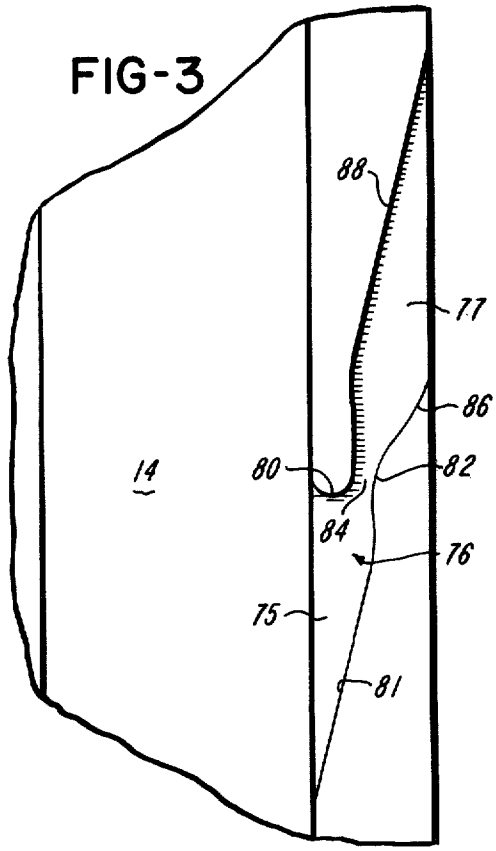
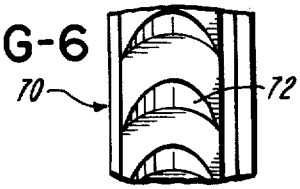


FIG-6



TIP TURBINE INFLATING DEVICE

BACKGROUND OF THE INVENTION

This invention relates to a unique embodiment of a tip turbine type fan, providing an inflating device featuring improvements producing a relatively quiet and substantially instantaneously operating unit. The invention embodiments are so designed as to eliminate undesirable noise, to increase safety, and otherwise reduce existing problems in operating emergency inflatable life saving devices. It will be particularly described in reference to its application to the inflation of escape slides and life rafts used in conjunction with aircraft. It will be apparent, however, that the invention units have a considerable range of application, and advantage for other purposes.

With the advent of large passenger aircraft and extended foreign travel, the aircraft industry had to consider better, safer and faster means for de-embarking passengers in the event of emergency. This led to the incorporation of inflatable slides which are extensible from an aircraft. With the introduction of this concept, there had to be developed a means for their quick inflation. To date the best means provided for such purpose has been a bomb-type device the triggering of which causes a release of compressed air which is injected in the inflatable apparatus. While such means have shown a capability to serve the intended purpose, they have inherent disadvantage in use. The bomb type device is heavy, relatively expensive and, when used, discharges an objectionable, dirty, hard to remove effluent. It is also costly to recharge. Further, the speed, degree and character of inflation of which it is capable appears to leave much to be desired. With a bomb type inflating medium there is also a safety problem. Even if this last is remote, there could be serious consequences on malfunction, particularly when used in a large passenger aircraft. It is for such reasons as this that there has been a continuing search for a special type inflating means to overcome the noted problems. The present invention provides the answer.

SUMMARY OF THE INVENTION

The invention provides inflating apparatus which is uniquely applicable to inflating large inflatable objects with high speed and efficiency, and in a quiet and safe manner. It not only does this but also provides a concept of an improved turbine type fan which has a high degree of versatility in its embodiment and use. It is to be understood, of course, that the invention is intended to and does comprehend basic improvements in tip turbine type fans as well as a new and improved inflating apparatus.

As an inflating apparatus, embodiments of the invention are characterized by a tubular housing defining a flow passage the inlet end of which is open to and provides a particularly advantageous contoured flow path for ingestion of surrounding air. At its opposite or discharge end the housing may be coupled in a sleeve or other adapter forming an opening to a device to be inflated, when applied to such purpose. The housing embodies a rotor assembly followed by a stator unit and its discharge end is formed as a diffuser, such elements being each constructed to lend economy and efficiency of the invention apparatus for its intended application. The stator blades are mounted in an improved manner so as to accommodate the effects of extremes in temperature without dangerous stress factors resulting. The rotor assembly is simply constructed so as to be rugged yet more economical to fabricate than would normally be anticipated and more highly efficient in operation. As a prime factor of the invention embodiment, the tubular housing incorporates turbine nozzles each of which have a particularly contoured inlet and outlet enabling full admission of air and reducing windage drag. This nozzle assembly, when the invention apparatus is applied for inflating purposes, is suitably coupled by tubing or flexible conduit to a bottle or tank of compressed air. The latter will be conventionally controlled by valve means which may be manually opened or remotely operated. In any event, the nozzle assembly is here arranged to produce a smooth inflow of a relatively small amount of compressed air to drive the rotor assembly through the buckets peripherally of the rotor blades and to be passed thereby to and through the stator unit which directs the same to the device to be inflated. Simultaneously the driven rotor blades will influence a smoothly ingested flow of surrounding air to substantially amplify the available compressed air and together therewith afford a substantially instantaneous inflation of the coupled device, which may be in the illustrative instance an aircraft escape slide.

The whole operation as enabled with the application of the invention apparatus for inflation purposes is quiet, smooth, efficient and extremely rapid in function.

It is accordingly a primary object of the invention to provide improvements in tip turbine type fans enabling embodiments which are more efficient and satisfactory in use, more versatile and adaptable in application and unlikely to malfunction.

It is a further primary object of the invention to provide improved inflating apparatus having particular application for emergency usage and to function in a manner which is safe and simple in operation.

An additional object of the invention is to provide improved means for emergency inflation of de-embarking apparatus in transportation vehicles, including large aircraft.

An additional object of the invention is to simplify and improve the construction of tip turbine type fan units in a manner to enable them to function more quietly and with higher efficiency.

Another object of the invention is to provide improved inflating apparatus and improvements in tip turbine type fan embodiments possessing the advantageous structural features, the inherent meritorious characteristics and the means and mode of use herein described.

With the above and other incidental objects in view as will more fully appear in the specification, the invention intended to be protected by Letters Patent consists of the features of construction, the parts and combinations thereof, and the mode of operation as hereinafter described or illustrated in the accompanying drawings or their equivalents.

Referring to the drawings, wherein is illustrated one but not necessarily the only form of embodiment of the invention,

FIG. 1 is a cross section of an improved tip turbine type fan unit adapted for use as an inflating device;

FIG. 2 is an exploded view of the apparatus of FIG. 1;

FIG. 3 is a fragmentary view of the improved turbine nozzle units featured in the invention apparatus;

FIG. 4 is a detail of the rotor blades, the tip end view being illustrated in FIG. 5; and

FIG. 6 is a fragmentary detail illustrating the buckets incorporated in the turbine portion of the illustrated rotor assembly shown in FIG. 1;

FIG. 7 is a fragmentary sectional view taken on line 7—7 of FIG. 1; and

FIG. 8 is a sectional view taken on line 8-8 of FIG. 7.

Like parts are indicated by similar characters of reference throughout the several views.

As shown, a tubular structure **10** is composed of a series of end abutted ring like sections, including an inlet section **12**, a nozzle section **14**, having a housing **16** which defines therewith an annular chamber **18**, and a stator section **20**, the latter being axially extended by an integrated diffuser section **21** forming the discharge end of the structure **10**.

The stator ring section **20** has incorporated therein a stator blade assembly. The latter includes a centrally concentrically positioned hub **22** to which are fixed a plurality of radially projected, circumferentially spaced stator blades **24**. Fixed centrally of and projected radially from the outer flatted ends of each blade **24** is a pin **26**. The stator ring section **20** has a plurality of circumferentially spaced apertures **28**, each aligning with and accommodating one of the pins **26**. The arrangement is such to normally provide a clearance at the joint between the stator ring and the adjacent end of each blade. This enables a floating relation therebetween which accommodates the relative expansion and contraction of the related parts. This construction prevents damage from stresses induced one to the other. Such stresses normally occur from extremes in temperature to which these parts or associated parts are subjected in use. This pinned stator concept is particularly advantageous where the unit in which it is incorporated is required to be run for relatively long periods of time.

Positioned within the tubular structure **10**, in immediately preceding relation to the stator blades, is a rotor assembly **30**. The assembly **30** mounts on a spindle **32** which has an expanded disc-like base **33**.

The stator hub **22** has a central aperture **34** and a complementary recess **35** in its innermost face which accommodates and nests the spindle base. The arrangement is such to position the axis of the spindle **32** in a line commonly shared by the central longitudinal axis of the tubular structure **10**.

Positioned about the spindle **32**, in succession, in a direction towards its projected extremity, starting from a point at its base **33**, are a spacing washer **36**, a shim member **38**, a ring shaped wave spring **40**, a pre-load washer **42**, and a ball bearing **44**. The items **36**, **38**, **40** and **42** afford an assembly providing a load and limit on the inner race portion of bearing **44**, at one face thereof. Longitudinally spaced from the bearing **44** on the spindle **32** is an identical ball bearing **46**. The shaft diameter of the spindle **32** is reduced in dimension between the bearings **44** and **46**.

The bearings **44** and **46** serve to mount thereon the hub **48** of a bladed rotor. As seen in FIG. **1**, these bearings nest their outer races in enlarged bore portions of the rotor hub to either end thereof. Accordingly, on applying a washer and a threadedly engaged nut **50** to the projected end of the spindle **32**, beyond the bearing **46**, the inner races of bearings **44** and **46** are positively preloaded and contained on the spindle. As seen from the drawings, the enlarged ends of the bore of the rotor hub produce oppositely facing shoulders which serve as abutments for the adjacent faces of the outer races of the bearings **44** and **46**.

The rotor hub **48** is shaped to a generally conical form at its outermost surface and gently curved in a longitudinal sense as shown in FIG. **1**. As a matter of fact, in the preferred embodiment shown, the outer surface of stator hub **22** is curved similarly to extend the longitudinal line of the rotor hub. The latter, however, has a cylindrical extension of reduced outer diameter to either end thereof.

A spinner **58** is positioned over the rotor hub extension **56**, to the end of the rotor which is remote from the spindle base. The spinner is a cap-like shell formed to nest the extension **56**, to cap the rotor bore, accommodate the projected end of spindle **32**, and to provide thereon a recessed shoulder **60**. The inner peripheral edge of shoulder **60** is positioned to confine the outer face of the outer race of the ball bearing **46**.

The outer surface of spinner **58** is conically formed and longitudinally curved to a blunt nose of arcuate form the line of which provides an extension of that of the rotor hub **48**. As seen in FIG. **1**, looking from the inlet to the discharge end of the illustrated tube structure **10**, the configuration of spinner **58**, rotor hub **48**, and stator hub **22** is to provide an aerodynamic shape to the blade mounting structure.

The rotor hub **48** is provided with dovetailed circumferentially spaced slots **62** on its outer periphery, which receive complementary shaped portions on the roots of rotor blades **64**.

As the blades are applied, their root portions are abutted by the capping end surface of spinner **58** at one end and they are capped at their other ends and fixed against axial movement by a centrally apertured cap shaped retainer plate **66**. The latter coextensively covers and abuts the adjacent end of the rotor hub **48** and its inner peripheral portion caps and confines the outer race of ball bearing **44**, at the face thereof adjacent the stator unit. The assembly of the rotor unit to the spindle **32** is very simple to effect and requires no special skills. Bolts **68** are directed through aligned apertures in the blade retainer plate **66** and the rotor hub to have their projected extremities threadedly engaged in the spinner **58**. In this manner there is completed a most secure and integrated mounting of the rotor assembly here provided. The base of spindle **32** is suitably apertured to facilitate proper application of the bolts **68**.

A ring-like turbine portion **70** extends circumferentially at the outer ends of the rotor blades **64**. In this case also a pin-slot connection is provided between the ring and the central portion of the outer end of each blade **64**. This connection avoids a rigid relation between these parts which obviates accidental buckling or distortion by reason of transmitted stress to which the parts might be subjected. As seen in FIG. **6** turbine buckets **72** are fixed in connection with and projected at the outer periphery of ring **70**. In operation the entrances to the buckets **72** move in a plane parallel to, and immediately adjacent, and in alignment with turbine nozzles **74** defined by nozzle section **14** and the housing section **16**.

The nozzles **74** provide discharge openings from the chamber **18**. As shown in the drawings, these nozzles

are basically provided by **16** convergent-divergent grooves **76** of a particular configuration which are formed in a ringlike peripheral projection on the one end of the nozzle ring section **14** which is immediately adjacent the rotor assembly. The grooves **76** are capped by an internal projection **78** on the housing **16** to complete the nozzle wall structure. The nozzles have contoured entrance and exit portions **75** and **77**, respectively, the contour being provided by the form of the side wall portions of groove **76**. The entrance to each groove is substantially and laterally expanded and the leading side thereof commences in a short side wall portion **80** formed on a uniform curve of approximately 180° and a relatively small radius. The opposite side wall has an entrance portion **81** which in contrast is longitudinally extended at a relatively flat angle in the neighborhood of 15°–19° to the plane defined by the wall surface of the chamber **18** at the entrance to the nozzles. The side wall **81** continues in this flat angle to a point immediately preceding its discharge end where it is diverted inwardly towards the wall portion **80** in a smooth curved segment **82** which closely approaches the inner end of the approximately 180° arc of the side wall portion **80** to form therewith a nozzle throat **84** of reduced width, from which point the side wall portion **82** is extended in a reversely directed gentle curve to produce a short flatly angled exit portion **86**. By contrast the wall portion **80** is extended by an elongated wall segment which departs from the side wall portion **82**, in a gentle curve progressively flatted to produce an elongated exit side wall portion **88**, providing the nozzle with an exit angle of approximately 13°. Thus each nozzle has a form that one side wall at the entrance portion thereof has an extended length and is flatly angled to an opposite side wall entrance portion of arc form to define therewith a narrow throat in the nozzle which is near its inlet. Immediately beyond this throat the side walls uniformly diverge to produce a modified hour glass configuration. The wall **80**, which is extended at its exit portion **88**, is flatly angled to form a wide mouth discharge area and a discharge angle for the nozzle which is optimally in the range of 11°–15°.

The convergent-divergent nozzles **74** so provided are such that they have a short rounded nozzle inlet at their leading surface and an unusually flat discharge angle of a nature to result in smoother flow of air from chamber **18** to, through and from the nozzle in a relatively guiet manner and with significantly improved flow efficiency.

It is noted in the use of the described embodiment for inflating purposes, there is provided in connection with the housing **16** a tubular inlet adapter **90** to which is coupled, by appropriate flexible conduit, the valved outlet of a small cylinder of compressed air. On opening of such valve, the chamber **18** receives a small amount of compressed air, which air exits by way of the turbine nozzles **74**. As noted, there is a substantially expanded inlet area for each nozzle by reason of the shape of the entrance portions of its side walls, the short rounded entrance surface of the wall section **80** being significant in providing increase in flow efficiency to and through the nozzle throat. At the exit ends of the nozzles the discharge angle has been lowered to substantially depart from conventional turbine practice, increasing and smoothing discharge and yielding, in delivery, a higher turbine efficiency as compared to conventional practice, and with a minimal number of nozzles. It is of course obvious that there is substantial saving in manufacturing inherent in this high efficiency turbine apparatus whether used for inflating purposes or otherwise, suitably modified.

It is an important advantage that the air flow deriving from a small amount of compressed air, as handled by the improved nozzles, reduces turbine windage drag.

The inlet end of the tubular housing **10** has an internal flange **92**, the outermost end surface of which is aerodynamically rounded, which is normally bridged at its flat inner side by a flapper type valve assembly **94**. As seen in FIGS. **1** and **7**, the latter includes a bar **95** of rectangular cross-section which is extended diametrally across the inlet of the housing **10**. The bar **95** is embedded in a diametral projection **97** integrated with a disc-formed section of rubber-like sheet material, half segments **96** of which are formed to hinge inwardly of the housing **10**, towards each other. Each half segment **96** mounts a metal plate coextensive with its inner face and means biasing it to closed position. As the half segments swing in, in an obvious manner, they are limited in travel by a rod **98** which is fixed in transversely bridging relation to the inlet section **12** of the housing **10**, intermediate its ends.

Noting FIGS. **7** and **8** of the drawings, the valve assembly **94** has a floating mount in the inlet of the housing **10**. This is achieved by the provision of diametrally opposite recesses **100** formed in the inner wall of flange **92**, which recesses receive, in slip fit relation thereto, the respective ends of the bar **95** which are projected relative the periphery of the half segments **96** of the valve assembly **94**. The recesses **100** are elongated in a sense axially of the inlet section **12** so as to accommodate the insertion therein of the respective ends of the bar **95**. Note that the cross-section of the ends of the bar **94** is generally complementary in configuration to the cross-section of the accommodating recesses **100** but of smaller dimension to enable an axial and slght rotative movement of the bar within the inlet flange **92**. The bar **95** has an aperture spaced inwardly of each of its respective ends. Once the bar is in place across the inlet, each of these apertures in the bar will have thrust therein a friction fit retaining pin **101** to project from opposite sides of the bar. Upon application of the pins **101**, the removal of the valve assembly **94** will obviously be precluded until removal of the pins. Thus, by virtue of the mount of this valve assembly, one provides that once the housing **10** has induced therein a back pressure, for example due to inflation of a connected article, this pressure will cause the half segments **96** of the valve assembly to be forced into a bridging sealing relation to the flat innerside of the flange **92**. Peripheral portions of the half segments **96**, as may be seen from the drawings, are extended to overlap the inner side of the flange and thereby form a seal of the inlet to the housing **10** as back pressure grows within the housing. The fact that the valve assembly **94** has a floating mount insures its self adjustment so that there will be a complete seal of the inlet so as to preclude any leakage from the article to which the tip turbine type fan or inflating unit is connected. As will be obvious, the device to be inflated will have an adapter defining an opening into which the sections **21** and **20** of the housing **10** may be thrust until the portions of the object to be inflated rimming such opening are brought into contact with the flange **104**. As will be obvious, any desired or required connecting elements may be applied

to the object to be inflated through the flanges **102** and **104** and the invention unit thereby suitably secured in coupled relation to the object.

Of particular fabricating and assembly importance is the simple telescoping relation of parts of tubular housing structure **10.** As seen, the inlet end of nozzle ring **14** is in effect expanded to produce a cup form nesting the abutted end of inlet section **12,** fasteners **15** being applicable through the cup wall to engage and fix the same to section **12.** The housing **16** for the nozzle section is welded thereto and positioned to extend the cup wall. The projected end of housing **16** is externally flanged at **102** and slightly cupped to have a female-male connection with the stator ring, the latter of which is externally flanged at **104.** The flanges **102** and **104** mate and securely abut to receive therethrough the connecting bolts **106.**

Thus the time and effort for assembly of both housing and internal operating components is reduced to a minimum and can be readily achieved by people unversed in the art.

Another significant point influencing the smooth and quiet operation of the unit in delivering a gaseous flow, for inflating purposes or otherwise, is the interior wall configuration of the inlet section **12** and the diffuser section **21.**

As seen, in FIG. **1,** at the inlet to the section **12** the receiving wall surface **108** which defines the entrance to the flow path through the valve assembly **94** is first rounded aerodynamically, then straight. The interior wall surface of section **12** is then expanded to produce, in a longitudinal sense, a smoothly concave portion **110** gradually reducing in cross section. This concave portion is followed by a curve in the wall surface which tends to produce a convex portion **112** reducing the cross section of the interior of section **12** to less than that defined at its inlet. Beyond the section **12** this cross-sectional area is maintained by the inner wall of nozzle section **16** and turbine ring **70.** At and beyond the ring **70** there is, as seen, an expansion of the interior cross-sectional area of housing **10,** in its discharge area which accommodates the stator unit.

A further graduated expansion of the cross-sectional area of housing **10** is defined by the inner wall surface of the diffuser section **21.** This last expansion commences immediately following the stator, at which point in operation of the unit there is produced a pressure which is reduced with respect to the ambient pressure. This last results in a reduction in back pressure and has proven to introduce an unexpectedly significant factor in the operation of the invention unit. It results in an increase in its performance and pumping efficiency, making this unit extremely effective for a fast inflation of an inflatable object to which it is connected. Attention is further directed to the rotor assembly wherein parts are reduced to a minimum, a spinner yoke such as would normally be used is here eliminated and a single set of bolts **68** does the whole job of fixing the spinner, rotor hub and blades together, utilizing the retainer plate **66.** Again there is enabled a minimal cost in construction and ease in assembly and maintenance.

Further improvements lie in the design of both the rotor and the stator blades.

The floating stator blades as here proposed are to be formed with radii of 0.010 inch at their leading and trailing edges. This is in contrast to conventional practice which would dictate radii of 0.004 inch. While 0.010 inch is preferred the radius can range in the neighborhood of 0.008 to 0.012 inch. Also there is no use of backward curvature at the trailing edges of the stator blades. Thus in accordance with the invention practice it has been found the blade form requirements are not as rigid as would be anticipated and the elimination of complex design requirements in this respect enables more cheaply fabricated stator blades.

Similarly by reason of the inventive concept the radii at the leading and trailing edges **116** and **118** of the rotor blades has been enlarged preferably to 0.012 inches, while conventional design practice would dictate 0.005 inch radius. Again the radius can range, from 0.010 to 0.014 inch with similar advantageous results in use. This has improved rotor efficiency in partially stalled condition, particularly important when the fan is used in an inflating apparatus.

As noted previously the invention improvements in tip turbine type units producing a uniquely improved inflating apparatus are equally and variously advantageous where the basic improved tip turbine fan structure is applied to other and more conventional purposes. Where applied to other purposes one need only modify, for example, the passage or inlet to the uniquely designed chamber **18** wherein the nozzles are actually formed in one wall thereof. Such modifications will, of course, have no material effect on nor create a departure from the invention concept.

Where dimensions have been noted, they are in each case referenced to a 5½ inch tip turbine unit. They will be scaled up or down proportionally as the basic 5½ inches dimension of the tip turbine unit is increased or decreased.

In function of the illustrated unit, the invention concept provides that, when used in connection with a large inflatable object, as shown, as compressed air is released from a bottle or tank and delivered to the annular chamber **18** embodied in the wall of housing **10,** the air will issue, under its own pressure, by way of nozzles **74** to the interior of housing **10,** in the expanded area thereof containing the turbine buckets **72.** As the compressed air moves through the nozzles **74,** its entrance is smooth and expedited by the leading surface portion **80** of the nozzle wall configuration and the discharge is made intense and positive by the relatively flat angle induced by the nozzle form. As the compressed air issues to the housing **10,** it will impinge on and drive the buckets **72** and thereby the rotor unit **30.** The compressed air will continue its movement through the expanded discharge end of housing **10,** influenced by the nature and form of the stator blades **24.** The drive of the rotor **30** will influence an ingestion of surrounding air, the same being smoothly introduced to the housing **10** by reason of the form of the entrance surface **108.** Insuction will draw the valve segments **96** inwardly of the housing **10** to accommodate the inflow of the ingested air. The ingested air is immediately expanded within the entrance portion of the housing and then accelerated in flow to move smoothly to and through the rotor blades **64,** and, under the influence thereof, be driven thereby past the stator blades **24** to be entrained with the expanding compressed air which is the source of its movement to and through the housing **10.** In the area of the diffuser section the reduced pressure influence of the construction will influence an increased air flow over and above what would normally anticipated for the size of the rotor unit here employed,

as previously described. The operation is highly effective and enables utilization of a minimal amount of compressed air to achieve a substantially instantaneous inflation of the inflatable article to which the invention apparatus is coupled. Note that the aerodynamic form of the rotor hub, the cap **58** and the related stator hub **22** insures an extremely rapid discharge of ingested air in a smooth flowing quiet movement. The floating relation of the stator blades in respect to the ring **20** prevents the extremely cold temperatures which can develop at the outlet from the housing in certain instances from inducing distortion or buckling or the parts. Moreover, when the invention apparatus is suitably coupled to an article to be inflated and its inflation is achieved, there is produced in the housing **10** a back pressure which effectively seals the valve assembly **94** across the inlet to the housing **10** as previously described.

Thus, the invention has very simply provided an answer to serious problems in the related art while affording a unit having considerable versatility in application.

From the above description it will be apparent that there is thus provided a device of the character described possessing the particular features of advantage before enumerated as desirable, but which obviously is susceptible of modification in its form, proportions, detail construction and arrangement of parts without departing from the principle involved or sacrificing any of its advantages.

While in order to comply with the statute the invention has been described in language more or less specific as to structural features, it is to be understood that the invention is not limited to the specific features shown, but that the means and construction herein disclosed comprise but one of several modes of putting the invention into effect and the invention is therefore claimed in any of its forms or modifications within the legitimate and valid scope of the appended claims.

Having thus described our invention, we claim:

1. A tip turbine type unit having particular advantage for inflation purposes including a tubular housing comprised of connected ring-like segments one of which enbodies therein a double walled portion forming a chamber for gaseous fluid in at least one wall portion of which are embodied passages forming turbine nozzles within said tubular housing, a rotor unit bridging said tubular housing to provide outer bladed portions thereof in the path of discharge from said nozzles, means bridging said tubular housing providing a base for mounting said rotor unit within said housing, a spindle unit, said base and said spindle unit having a male-female connection to mount said spindle unit, said spindle unit mounting bearing means having mounted thereabout a hub portion of said rotor unit, said hub portion having peripherally projected blade means and means mounting to either end of said rotor hub portion and interconnected therewith to contain said bearing means and said spindle and mount said rotor unit to said base.

2. Apparatus as set forth in claim **1** characterized by said means to contain the said hub portion of said rotor unit including a cap for said spindle and bearing means, to one end thereof, and a retainer forming a cap for said bearing means to the other end thereof, and bolt means extended through one of said caps and said hub portion to the other said caps for a simple releasable assembly of said rotor unit to its base.

3. A tip turbine type unit having particular advantage for inflation purposes including a tubular housing comprised of connected ring-like segments one of which embodies therein a double walled portion forming a chamber for gaseous fluid in at least one wall portion of which are embodied passages forming turbine nozzles within said tubular housing, a rotor unit bridging said tubular housing to provide outer bladed portions thereof in the path of discharge from said nozzles, a stator unit bridging said tubular housing in a following relation to said rotor unit and providing a base for mounting said rotor unit within said housing, said stator unit positioning at one end of said housing constituting its discharge end and including blade means having a floating connection with the said one end of said housing, a portion of said one end of said housing forming a periphery of said stator unit, a spindle one end of which has a cupped mount to said base, bearing means provided in end spaced relation on said spindle, a hub portion of said rotor unit mounting on said bearing means, the latter being cupped in enlarged portions of a bore in the rotor hub portion to either end thereof, and cap means to either end of and releasably secured to said hub portion to mount the same on said spindle, and means containing said bearing means to said spindle.

4. Inflating apparatus comprising a housing having a through passage, one end of which defines an inlet to and the other an outlet from said housing, a wall portion of said housing, intermediate its ends, incorporating a chamber and providing means for coupling thereto a source of gaseous fluid under pressure, a rotor in said housing, said rotor being mounted to bridge said passage in following relation to the portion of said housing including said chamber, wall portions of said chamber embodying further passages forming turbine nozzles, said nozzles being formed to provide through passages the discharge ends of which are relatively expanded and oriented to produce a pressured flow of gaseous fluid from said chamber and against adjacent portions of said rotor, whereby to drive said rotor and to cause said rotor, in turn, to ingest air and cause the flow thereof to and through said first mentioned passage to mingle with the gaseous fluid driving said rotor and move therewith, on disc harge thereof to the interior of a coupled inflatable object, to produce a substantially instantaneous inflation thereof, said first mentioned passage being expanded in cross sectional area at a location immediately following said inlet and thereafter being smoothly reduced in cross sectional area immediately upstream of said rotor.

5. Inflating apparatus including a housing forming a through passage one end of which is an inlet to and the other an outlet from said housing, a wall portion of said housing, intermediate its ends, incorporating a chamber and providing means for coupling thereto a source of gaseous fluid under pressure, a rotor in said housing, said rotor being mounted to bridge said passage in following relation to the portion of said housing including said chamber, wall portions of said chamber embodying further passages forming turbine nozzles, said nozzles being formed to provide through passages the discharge ends of which are positioned immediately adjacent outer peripheral portions of said rotor which include blade-like configurations, and said housing through passage having an interior wall surface which lends a configuration to said through passage wherein

the cross sectional area thereof is expanded immediately following and adjacent to said inlet and thereafter uniformly reduced to a location immediately in advance of said rotor and then expanded about and beyond said rotor.

6. Inflating apparatus as in claim **5** characterized by said housing having a tubular form and being comprised of telescopically nested ring segments including an inlet segment, a nozzle segment and a stator segment, said nozzle segment including a double walled structure formed by concentrically positioned portions of ring segments creating said chamber in an annular configuration, mating portions of said ring segments defining one end wall of said annular chamber which includes said nozzles.

7. Inflating apparatus as in claim **5** wherein a shoulder is provided in said passage by the expansion thereof immediately following said inlet, which shoulder is in facing relation to the downstream portion of said passage, said shoulder having in abutted relation thereto a valve unit adapted to bridge said shoulder, at least a portion of said valve unit being displaceable from said shoulder to accommodate a flow of gaseous fluid thereby to the downstream portion of said passage under the influence of said rotor, and said valve unit having means providing therefor a floating mount in said passage to provide that said valve unit may shift in an axial sense to insure a seal of said passage by said unit in the event back pressure should develop in the downstream portion of said passage.

8. Apparatus as set forth in claim **7** characterized by the wall of said passage at said inlet having therein recesses which are elongated in a direction downstream of said passage and there being projecting means mounting said valve unit which are freely received in said recesses to provide that said unit may float in said passage to the extent permitted by said recesses and there being means precluding the displacement of said projecting means from said recesses.

9. Inflating apparatus comprising a housing having a through passage, one end of which defines an inlet to and the other an outlet from said housing, a wall portion of said housing, intermediate its ends, incorporating a chamber and providing means for coupling thereto a source of gaseous fluid under pressure, a rotor in said housing, said rotor being mounted to bridge said passage in following relation to the portion of said housing including said chamber, wall portions of said chamber embodying further passages forming turbine nozzles, said nozzles being formed to provide through passages the discharge ends of which are relatively expanded and oriented to produce a pressured flow of gaseous fluid from said chamber and against adjacent portions of said rotor, said nozzle through passages including opposite side wall portions the major extent of the length at which are flatly angled to approximately the same degree and in the same sense while the entrance portion of one of which and an exit portion of the other of which are formed on a curve for a rapid and smooth entrance to said nozzle passages of gaseous fluid exiting from said chamber and a smooth pressured exit of fluid from said nozzle passages to drive said rotor and cause said rotor, in turn, to ingest air into said housing to mingle with the fluid delivered by way of said nozzles and to discharge therewith from said housing through passage by way of said outlet for introduction into a coupled inflatable object.

10. Apparatus as in claim **9** wherein said entrance portion of said one side wall portion of said nozzle through passages has an arcuate configuration including an arcuate portion of approximately 180°.

11. Apparatus as in claim **10** wherein said arc of approximately 180° is continued in generally the same sense in a gently flatted curve to merge into the long flatly angled portion of said one side wall portion.

12. Apparatus as in claim **11** wherein adjacent and spaced from its discharge end the flatly angled portion of the other side wall portion of a nozzle through passage is extended in an arcuate configuration which together with the arcuate formation on the opposite side wall portion forms a narrow throat in said passage, beyond which throat the opposite side wall portions of the nozzle passage diverge.

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UNITED STATES PATENT AND TRADEMARK OFFICE

CERTIFICATE OF CORRECTION

PATENT NO. : 3,904,324

DATED : September 9, 1975

INVENTOR(S) : Joseph Flatt, Robert C. LoPiccolo, Eugene Linsker

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

Col. 1, line 6, "guiet" is corrected to read -- quiet --.

Col. 1, line 63, a comma is substituted for a period following "diffuser".

Col. 4, line 38, "cap" is corrected to read -- cup --.

Col. 5, line 47, "guiet" is corrected to read -- quiet --.

Col. 6, line 36, "94" is corrected to read -- 95 --.

Col. 6, line 38, "slght" is corrected to read -- slight --.

Claim 9, Col, 12, line 14, "at" is corrected to read -- of --.

Signed and Sealed this

seventeenth Day of *February 1976*

[SEAL]

Attest:

RUTH C. MASON
Attesting Officer

C. MARSHALL DANN
Commissioner of Patents and Trademarks