United States Patent [19]

Hornschuch

[11] **3,861,820**

[45] **Jan. 21, 1975**

[54] **CENTRIFUGAL GAS COMPRESSOR UNIT**

[75] Inventor: **Hanns Hornschuch,** Easton, Pa.

[73] Assignee: **Ingersoll-Rand Company,** Woodcliffe, N.J.

[22] Filed: **Feb. 22, 1974**

[21] Appl. No.: **444,739**

Related U.S. Application Data

[62] Division of Ser. No. 349,656, April 10, 1973, Pat. No. 3,826,587.

[52] **U.S. Cl.** ..... **415/64,** 415/219 C, 403/383, 415/199 A

[51] **Int. Cl.** **F01d 13/02,** F04d 17/12

[58] **Field of Search** .. 415/64, 122 R, 219 C, 199 A, 415/179; 416/244, 201, 199 A; 403/383, 359

[56] **References Cited**

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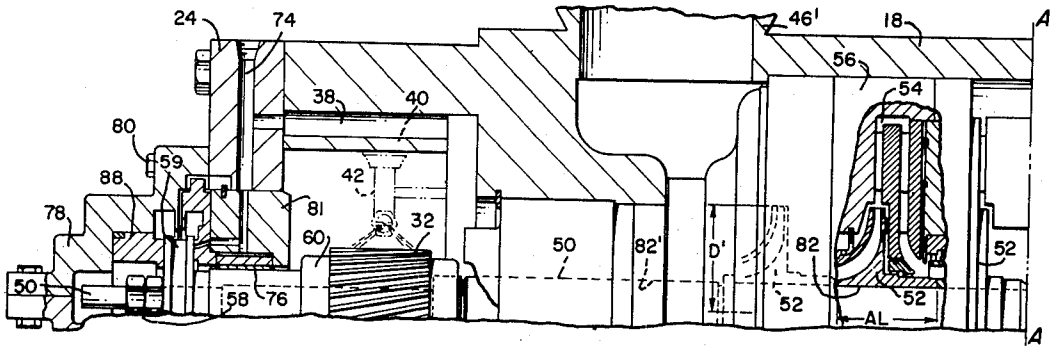
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Primary Examiner—Henry F. Raduazo
Attorney, Agent, or Firm—Bernard J. Murphy

[57] **ABSTRACT**

A multi-housing compressor having a plurality of gas compressing stages in each of parallel housings, the housings being integral with and extending perpendicularly from a gear housing. Rotor assemblies and associated diffusors are slidably replaceable from the respective housings, obviating any requirement to dismantle the gear housings. While the housings each receive gas, sequentially, for further compression, impellers and shafts in a plurality of the compressor housings are of identical weight, with the impellers thereof of identical axial length albeit of differing diameters.

3 Claims, 8 Drawing Figures



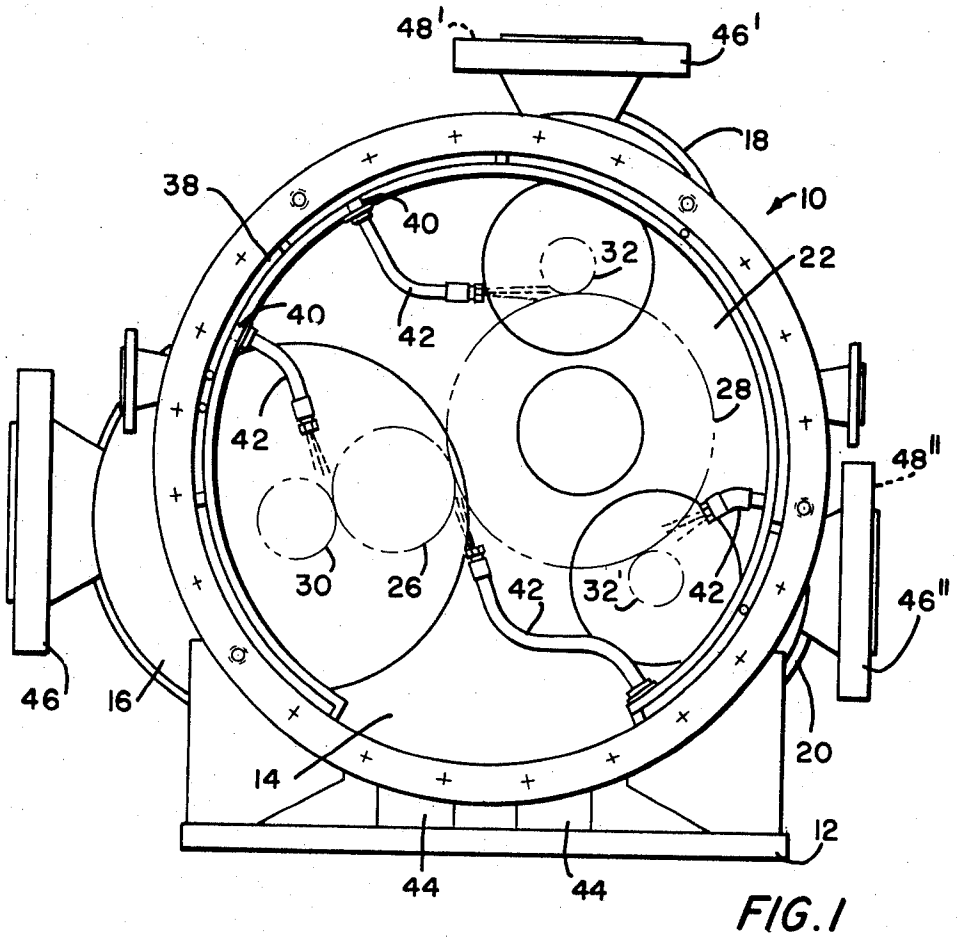
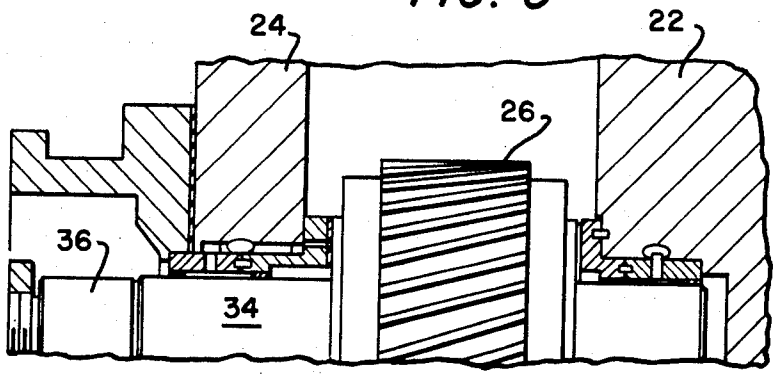

48'
46'
18
10
38
40
32
22
40
42
28
42
48"
30
26
42
32'
42
46"
46
16
14
20
12
44
44

FIG. 1

FIG. 3


24
22
26
36
34

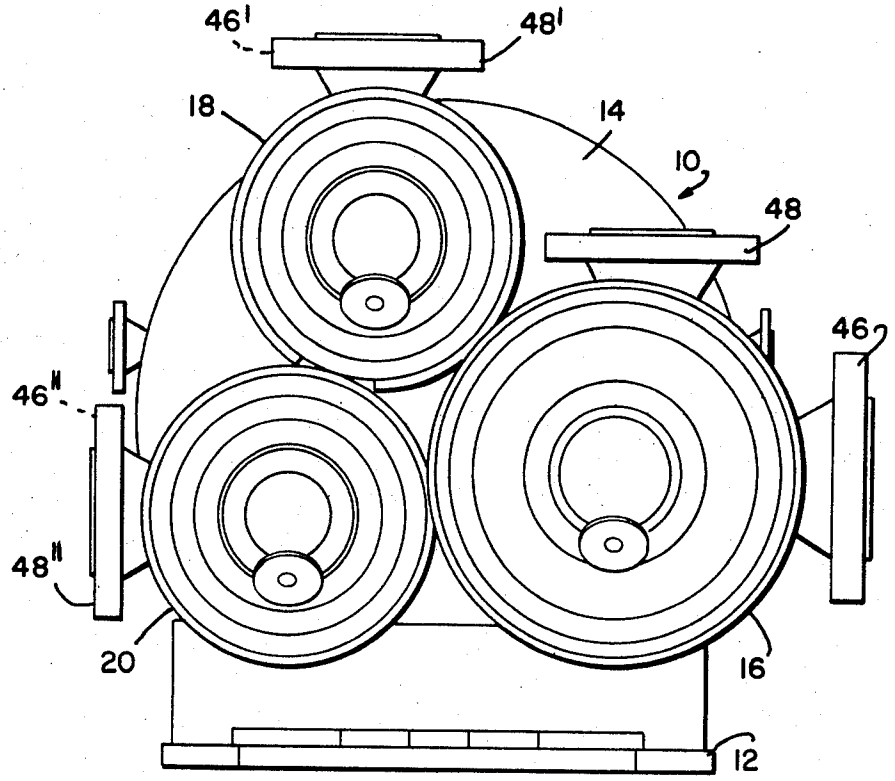


FIG. 2

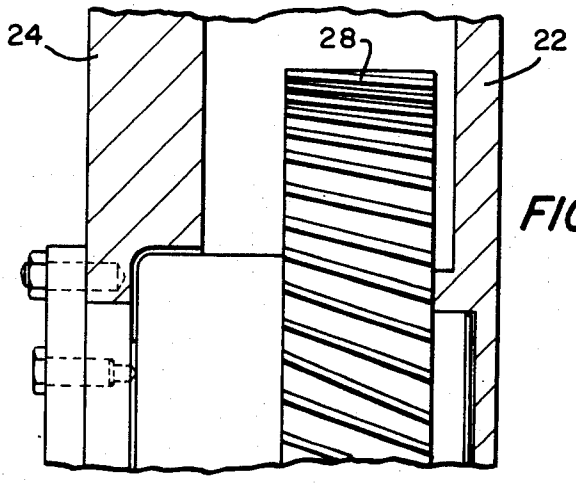


FIG. 4

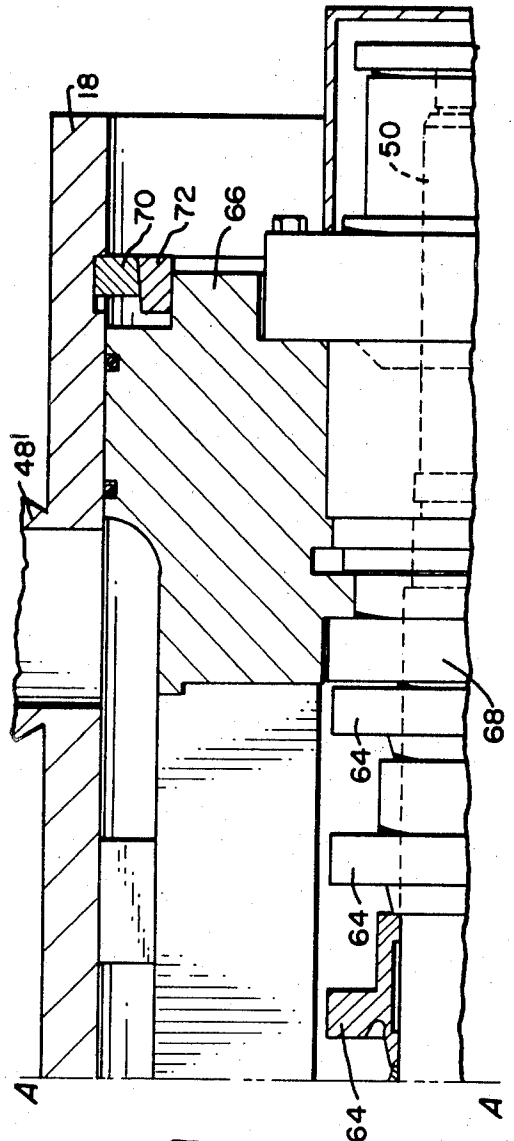

18
70
72
66
50
48'
68
64
64
64
A
A

FIG. 5A

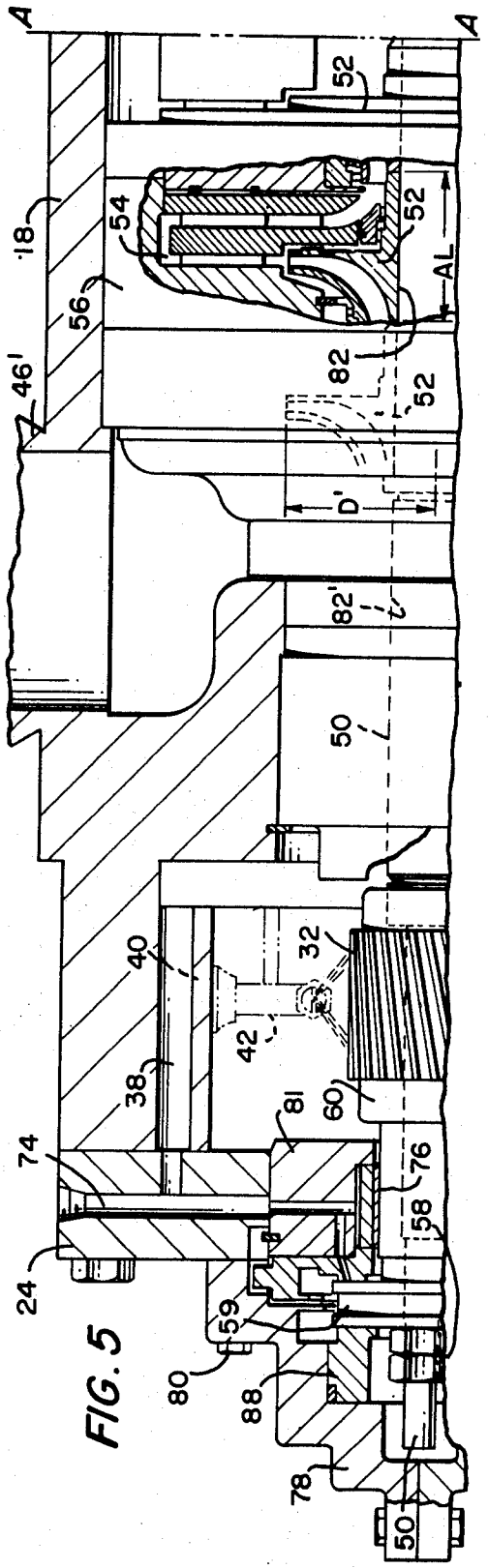

A
A
52
18
54
52
AL
56
46'
82
52
D'
82'
50
40
32
42
38
81
60
74
76
58
24
59
80
88
78
50

FIG. 5

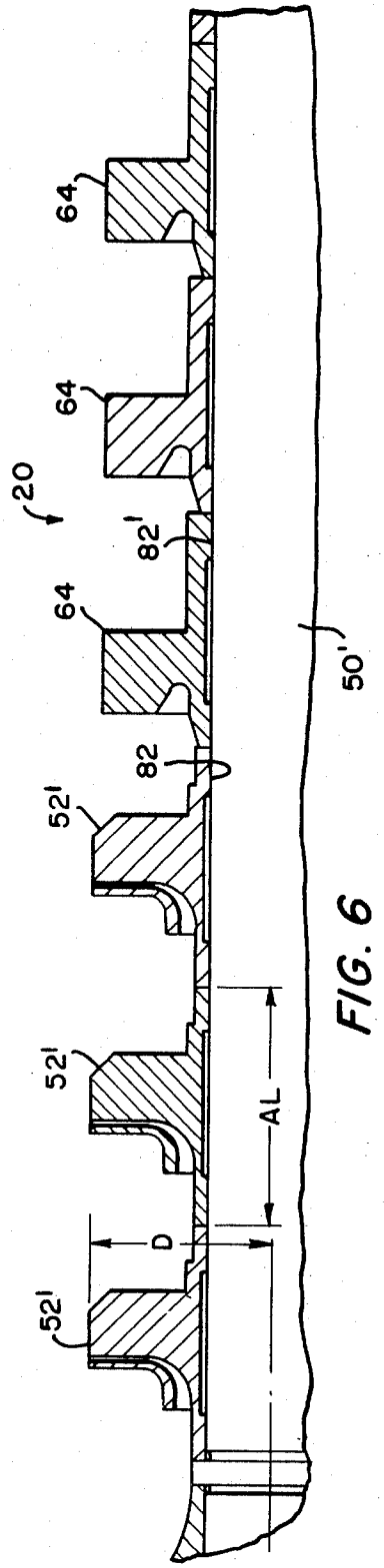


FIG. 6

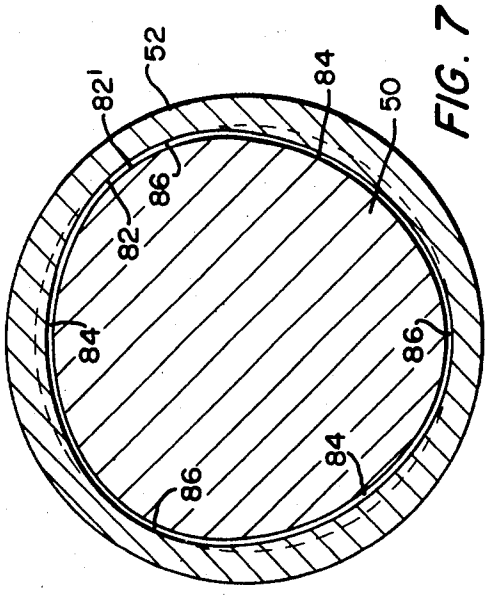


FIG. 7

CENTRIFUGAL GAS COMPRESSOR UNIT

This is a division, of application Ser. No. 349,656 filed Apr. 10, 1973, now U.S. Pat. No. 3,826,587.

This invention pertains to gas compressors, and in particular to a high speed multi-housing, multi-stage centrifugal gas compressor unit, for high compression ratios, having as its primary application natural gas service such as gathering, pipeline feed, gas injection and gas lift.

Present day centrifugal compressors used for natural gas service employ two, or three multi-stage centrifugal compressor units arranged "in line," driven through a step-up gear, and coupled through high-speed couplings. This results in a very lengthy machinery arrangement which is difficult to line up and keep in alignment. Such arrangements are very susceptible to vibration, when the alignment becomes distorted. The individual compressor units are vibration-sensitive because of the long shaft overhangs, particularly on the thrust bearing end. Compressor unit maintenance and servicing are time consuming, because the housings or casings of some of the machines, and usually portions of their associated piping, must be completely removed from a baseplate to gain access. So also, the "in line" arrangement requires a very elongate baseplate, which is space consuming, and therefore costly, particularly wherein the machinery is mounted on an off-shore platform.

It is, therefore an object of this invention to set forth an improved centrifugal gas compressor unit which avoids the aforenoted limitations in the prior art.

Another object of the invention is to teach a centrifugal gas compressor unit comprising a plurality of separate, elongate, gas compressor housings; a plurality of successive gas compressing stages within each of said housings; means for admitting gas to a first of said housings; means for discharging compressed gas from a last of said housings; means for communicating gas between each of said housings for successive gas compression; said stages each comprising a bladed gas compressor impeller and vaned diffusor; a shaft confined within each of said housings, rotatably supporting said impellers; bearing means interposed between each of said shafts and housings for supporting said shafts for rotation; a gear housing, having parallel spaced apart walls, integral with said compressor housings; said compressor housings extending in parallel axes from, and perpendicular to, one of said walls of said gear housing; each of said shafts extending through both of said walls, and having a hollow gear shaft concentrically engaged therewith; each of said gear shafts carries gear means intermediate said walls; an idler gear, rotatably supported by and between said walls, drivingly engaged with a plurality of said gear means; a driving gear, rotatably supported by an between said walls, drivingly engaged with said idler gear at at least one of said gear means; and means replaceably coupled to said compressor housings for retaining said stages and impeller shafts in said compressor housings; wherein said stages and impeller shafts are slidably removable from said compressor housings, and from said gear housing, via ends of said compressor housings opposite said one wall, upon removal of said retaining means.

A feature of this invention comprises a multi-housing compressor having a plurality of gas compressing stages in each of parallel housings, the housings being integral with and extending perpendicularly from a gear housing. Rotor assemblies and associated diffusors are slidably replaceable from the respective housings, obviating any requirement to dismantle the gear housings. While the housings each receive gas, sequentially, for further compression, impellers and shafts in a plurality of the compressor housings are of identical weight, with the impellers thereof of identical axial length albeit of differing diameters.

Further objects and features of this invention will become more apparent by reference to the following description taken in conjunction with the accompanying figures, in which:

FIG. **1** is a front, elevational view of an embodiment of the novel centrifugal gas compressor, according to the invention, with the cover plate removed for purposes of clarity;

FIG. **2** is a rear elevational view of the embodiment of FIG. **1**;

FIG. **3** is a fragmentary and half axial illustration of the driving gear within the gear housing;

FIG. **4** is a fragmentary view of the idler gear within the gear housing;

FIG. **5** and **5A** are broken, half axial views partly in cross-section, of the second compressor housing. Views **5** and **5A** are broken on section lines A—A and are to be understood to be substantially symmetrical about the axial centerline thereof.

FIG. **6** is an axial illustration of the impeller shaft of the third compressor housing, with but halves of the impellers thereof shown in cross-section; and

FIG. **7** is a simple diagrammatic illustration representative of the novel arrangement set forth herein for coupling the impellers to the impeller shafts.

As shown in FIGS. **1** and **2** the compressor **10**, according to one embodiment, comprises a base plate **12** which supports a gear housing **14**. A plurality of three barrels or compressor housings **16, 18** and **20**, are integral with the gear housing, and, extend therefrom, perpendicularly, in parallel axes. The gear housing **14** is defined by an inner wall **22** and an outer wall or cover plate **24**. Within these walls a driving gear **26** and an idler gear **28** are rotatably mounted as shown in FIGS. **3** and **4**. Driving gear **26** (FIG. **1**) is in mesh with gear **30** of the first compressor housing **16**, and with the idler gear **28**. In turn, idler gear **28** is in mesh with gears **32** and **32'** of the second and third compressor housings **18** and **20**, respectively. Driving gear **26** is mounted on a shaft **34** which has a coupling end **36** projecting from the outer wall or cover plate **24**, whereat a prime mover can be coupled to impart driving torque to the gear train.

The gear housing **14** confines therewithin a reservoir **38**, shown in FIGS. **1** and **5**. Reservoir **38** has a plurality of outlet ports **40** which receive conduits **42**. The conduits **42** are flexible and are conformed to open onto those locations within the gear housing **14** whereat the gears of the gear train mesh. A pair of limbs **44** disposed between the baseplate **12** and gear housing **14** have conduits or passageways (not shown) formed therein, and lubricant discharged by conduits **42** is scavaged therethrough for collection in a sump (not shown) mounted therebelow.

The several housings have inlet and outlet flanged ducts for admitting gas, sequentially to each of the housings in turn. Accordingly, inlet flanged duct **46** admits gas to the first housing **16**, this housing having an

outlet flanged duct **48.** The latter duct, by means of piping (not shown) communicates with the inlet flanged duct **46'** of the second compressor housing **18,** and gas discharged therefrom is passed through its outlet flanged duct **48'** to compressor housing **20.** The latter also has both an inlet flanged duct **46''** and an outlet flanged duct **48''** for discharging the final, totally compressed gas product to a using end item (or to storage).

In FIGS. **5** and **5A**, only one compressor housing, specifically the second compressor housing **18,** is shown.

However, the parts emplacement and cooperation are sufficiently similar, in housing **16** and **20,** so illustration of housing **18** only, is deemed to be adequate.

An impeller shaft **50** is rotatably carried within the housing **18** and mounts impellers **52** for rotation in cooperative adjacency to diffusors **54.** Diffusors **54** are supported within a diffusor housing **56** according to a method well known in the prior art. Locking nuts **58** threadedly fastened to the gear housing end of the shaft **50** secure the shaft within the gear housing **14,** against a thrust collar **59.** A hollow gear-shaft **60** is rotatably engaged with shaft **50** (by conventional means) and has formed thereon the gear **32** which derives rotary power from the driving gear **26.** A number of impeller dummies **64** are carried on the other end of the impeller shaft **50.** The dummies **64** are of the same axial length as each of the impellers **52** so that when it is desired to increase or decrease the compressor housing capability it remains only to substitute impellers for one or more of the dummies **64,** or vice versa. The rotor assembly, comprising the impeller shaft **50,** the impellers **52** and the dummies **64,** together with the diffusors **54** and housing **56,** are slidably removable, as a unit, from the end of housing **18,** which is most remote from the gear housing **14,** upon removal of retainer **66** whereupon bench dismantling of the unit can follow. Retainer **66** is engaged with an end seal **68** for securing the removable unit in the housing **18.** Retainer **66,** in turn, is held within the housing by a split ring **70** and an retaining ring **72.** Both rings have surfaces which define a tapered wedge interface. Mounting and tensioning hardware (not shown) secures ring **72** to the retainer **66.**

A lubricant passageway **74** is formed within the housing wall or cover plate **24** for admitting lubricant into the reservoir **38,** and also for conducting lubricant to shaft bearing **76.** It is to be noted that reservoir **38,** in addition to serving as a lubricant manifold, also serves to suppress the emission of gear noise from the gear housing **14.** As FIGS. **1** and **5** evidence, the reservoir extends fully across the housing **14,** and substantially envelops the gear train. In defining a hollow, walled structure, which is substantially closed, it presents a sound buffer intermediate the gear train and the external periphery of the housing **14.**

The locked end of shaft **50** is enclosed within a cover **78** secured by means of bolts **80** to the gear housing **14,** cover **78** being replaceable for service of the rotor assembly,

To replace the slidably removable unit (rotor assembly, diffusors, diffusor housing) from the housing **18** it remains only to remove cover **78,** unfasten the lock nuts **58** and, using a gear puller or the like on thrust collar **59,** withdraw the hollow gear shaft **60** from the impeller shaft **50.** Cover plate **24** carries bearing **76** within a bearing housing **81** in an aperture, and both are removed therethrough with gear shaft **60.** Then by removing rings **70** and **72,** and the retainer **66,** the whole unit can be withdrawn without having to disassemble the gear housing **14.**

It is the teaching of this invention to secure the impeller **52** to the impeller shaft **60** without any requirement for keying, bolting, or heating. With reference to FIG. **7** it will be noted that the nominal inside diameter **82** of the impellers corresponds substantially with the nominal outside diameter **82'** of the impeller shaft. However, the impeller mounting bores as well as the outside diameter of the shaft are formed as something other than true circles. That is, as shown in FIG. **7,** a true circular surface if formed about the shaft, and within the impellers, would be represented by the dashed lines and the solid lines contiguous therewith. However, the impeller bores and the shaft outside diameter or periphery are formed with eccentric surfaces **84** which, therebetween, define three lobes **86.** With the impeller bores and the shaft surface aligned, lobe-for-lobe, the impellers are freely, slidably mountable onto the shaft. Then, by forcefully torquing the impellers on the shaft, the priorly aligned lobes separate, rotationally, and effect a binding, circumferential-wedging relationship with adjacent surfaces **84.** It is a teaching of this invention to torque these lobes **86** into such a bound engagement with the adjacent eccentric surfaces **84,** as will be greater than any contrary torquing force experienced by the impellers while compressing gas. When necessary to remove an impeller it remains only to reverse the torque lock-up rotation to again slidably align the lobes of both the impellers and the shaft, whereupon the impellers can be slid off the shaft.

This teaching, of circumferentially wedging the impellers **52** (and **52'**) onto the impeller shaft **50** (and **50°**) is, of course, particularly useful in the disclosed gas compressor unit **10.** However, it has a universal applicability whenever and wherever it is desired to couple a first element to a second element. Thus, all broad practices wherein one element is secured to another, by the torqued coupling arrangement, and the method of its execution, as disclosed herein, is considered to be within the ambit of my teaching.

The gear train, as is evidenced in FIGS. **3, 4,** and **5,** comprises helical gears which are so oriented as to counter the thrust normally developed by the rotor assembly. Therefore, the thrust bearing **88** (FIG. **5**) need not be so large as ordinarily would be necessary. This offers no small economies in machine-space requirements and costs.

Housings **18** and **20** contain shafts **50** nd **50°**, respectively (FIGS. **5, 5A,** and **6**) which are identical in length, weight and configuration. So also, the impellers **52** are identical in weight and axial length AL with impellers **52'**. This is true, notwithstanding the fact that impellers **52** and **52'** have different diameters D' and D. This is arranged by having impellers **52'** with weighting metal downstream of the blade surface. The common weight and length of these rotor assemblies, and the standard axial length of the impellers, greatly simplifies the fabrication, balancing, and alignment of the compressor unit **10.**

While I have described my invention in connection with a specific embodiment thereof, it is to be clearly understood that this is done only by way of example, and not as a limitation to the scope of the invention, as

set forth in the objects thereof and in the appended claims.

I claim:

1. A centrifugal gas compressor unit, comprising:

a plurality of separate, gas compressor housings;

a plurality of successive gas compressing stages within each of said housings;

means for admitting gas to a first of said housings;

means for discharging compressed gas from a last of said housings;

means for communicating gas between each of said housings for successive gas compression;

said stages each comprising a bladed gas compressor impeller and vaned diffusor;

a shaft confined within each of said housings rotatably supporting said impellers; and

bearing means interposed between each of said shafts and housings for supporting said shafts for rotation; wherein

at least one of said impeller shafts is substantially circular in cross-section, having a central locus and at least one portion on the circumferential surface thereof which is eccentric, defining of said circumferential surface a first segment located a first radial distance from said locus, and a second segment located a second radial distance from said locus:

at least one of said impellers of said one shaft has a substantially circular shaft mounting hole formed therein, said mounting hole having a radial center and at least one portion on the circumferential surface of said mounting hole which is eccentric, defining of said latter circumferential surface a first arcuate portion located a first radial distance from said center; and a second arcuate portion located a second radial distance from said center; and

said shaft circumferential surface and said impeller mounting hole dimensionally define a mutual, slidable engagement and interface, upon one of said first and second segments being disposed in common, radial alignment and juxtaposition with one of said first and second arcuate portions, and define a torqued, interference fit, upon a portion of said second segment being disposed in common, radial alignment and juxtaposition with a portion of said first arcuate portion.

2. A gas compressor unit, according to claim **1**, wherein:

said at least one impeller shaft, in cross-section, is of plural lobe shape defining a plurality of eccentric portions on the circumferential shaft surface;

said shaft mounting hole of said one impeller is of plural lobe shape defining a plurality of eccentric portions on the circumferential hole surface; and

said lobes lie intermediate said eccentric portions formed on each of said shaft and impeller mounting hole and circumferential surfaces.

3. A gas compressor unit, according to claim **2**, wherein:

said lobes of said shaft and impeller, respectively, are torqued into an interference fit with said eccentric portions of said impeller and shaft.

* * * * *