

## New Way Air Bearings Offers Bently Balance Bearings for Improved Rotor Balancing Operations

New Way Air Bearings now offers externally pressurized air bearings for non-contact support of rotors during balancing operations. The non-contact air bearings eliminate damage to the rotor from hard rollers and the mess of oil film bearings in vacuum chambers. Most importantly the air bearings provide a more precise axis of rotation with a cleaner signal for higher resolution in balancing.

Both audible and electrical noise in balancing operations is reduced by supporting the rotor being balanced on air bearings. In “soft bearing” balance machines the unbalance force from a rotating rotor is transmitted through hard rollers, to a flexibly mounted yoke, and it is the resulting motion of the yoke that is measured and indicates the balance error. The “soft bearing” term refers to balance machine designs where displacement of the shaft is measured along an intentionally soft axis. But since the rotor is still supported in rotation by hard rollers, (Illustration 1) it is not just the rotor that is turning, there are other motions that cause rotor motions and mask out of balance force.

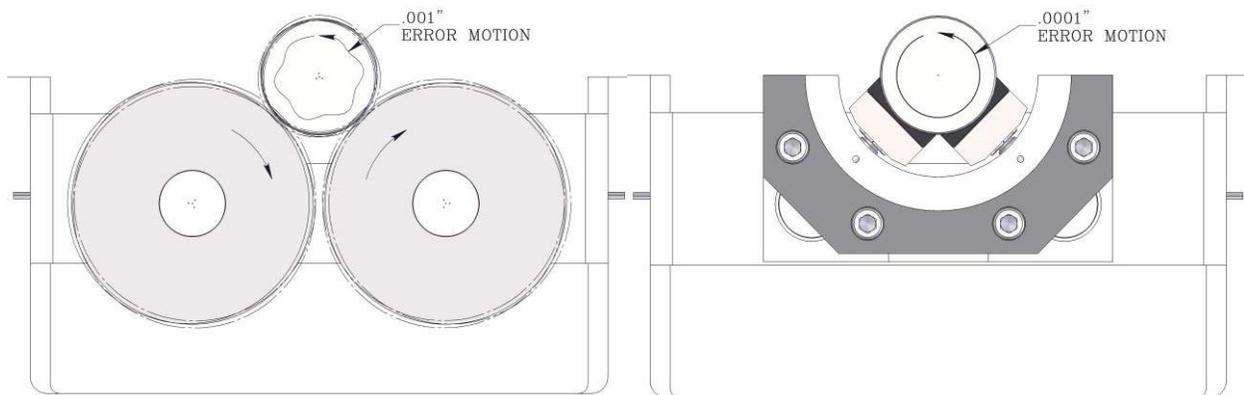


Illustration 1

Illustration 2

For instance, errors from run out of the 4 supporting rollers combine, and being a different diameter than the rotor, cause asynchronous motion errors of the supported rotor that often exceeds .001 of an inch. Alternatively, with the rotor supported on air bearings, (Illustration 2 and photo 1) the roundness of the journal (often .0001 of an inch or better) is the only rotating reference surface and so the motion errors will be synchronous and averaged so there will be less than a tenth of amplitude of the hard roller motion errors. This results in a clean signal that is exactly the same each revolution, allowing for a finer resolution in balancing.

A rotor supported on rollers will also see some axial forces from miss-alignments of the rollers. Changes in this axial force, say from changes in unbalance force, are likely to be almost synchronous, but out of phase enough to obscure balance resolution. Air bearings impart zero axial force on the rotor, avoiding this error source. The radial

friction is also near zero and so the heavy spot finds the low point of rotation when you turn on the air pressure on to the bearings. This improves the resolution in static balancing by an order of magnitude because the static, “break a way” co-efficient of friction of air bearings is 10 times lower than rolling elements in a typical roller stand or horizontal way static balancing set up.

An additional and very practical benefit of replacing the hard rollers with air bearings is that the rotor can be supported on its bearing journals without fear of damage to the bearing surface from point contact with a hard roller or from contamination between the rolling surfaces at speed. The Bently Balance Bearing faces are from graphite, presenting a relatively soft, large contact area and non-scoring bearing surface should contact occur.

In high speed or “at speed” balancing the stiffness and damping function of the support bearings becomes critical for good balancing (Photo 2). At least partly for this reason, large rotors are often balanced on their operational hydrodynamic oil bearings, although, hydrodynamic oil bearings can make an oily mess of the rotor in vacuum environments. This is especially an issue for motors and generators with electrical windings, but oil is still a mess for any bladed roller. The air bearings eliminate the need to flood, contain and collect oil in vacuum, yet use so little air that vacuum pressure in the bunker is not affected.

Air bearings can be made to closely match the stiffness and damping of oil bearings. This is a challenge because the stiffness and damping of oil bearings is dependent on rotor speed and so will be different progressing through critical speeds. When looking for the axial unbalance distribution and how it aligns with the mode shapes the rotor needs to traverse in operation it is useful to support the rotor on adjustable stiffness balance bearings. Although speed has little effect on stiffness and damping in externally pressurized air bearings, input pressure is a first order effect and can be used to adjust bearing stiffness at speed. We call these bearings “Bently Balance Bearings” because Don Bently frequently advocated for varying the input pressure of externally pressurized support bearings as a means of dynamically tuning machines. This adjustability helps in getting the right stiffness and damping at different speeds and in testing for sensitivities to changes in stiffness when confirming rotor dynamic models. (See video

[https://www.youtube.com/watch?v=xsLck\\_iKGpw](https://www.youtube.com/watch?v=xsLck_iKGpw) )

### **Technical Specifications**

Unit loading of air bearings have been demonstrated at over 400 psi with 600 psi input pressure. With normal shop pressure of 100psi the air bearings will carry 60 psi unit loading. Such a bearing with 10 square inches of face would

flow about 20 SCFH. Maximum surface speeds at the bearing face are a function of gap, which is adjustable by varying input pressure. Even small gaps allow for high surface speeds with relatively low heat generation as has been demonstrated by DGS. But with Externally Pressurized Bearings small gaps may be adjusted as the gap will increase proportionally with increasing pressure but shear in the gap will drop on a cube function of the gap. Bently Balance Bearings are available for rotors from 2mm up to 2m in diameter.

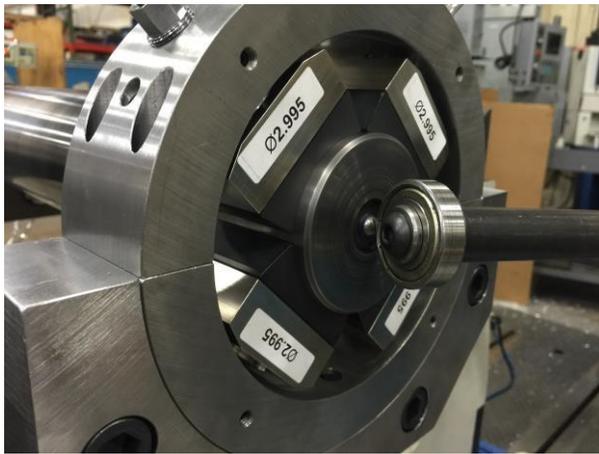


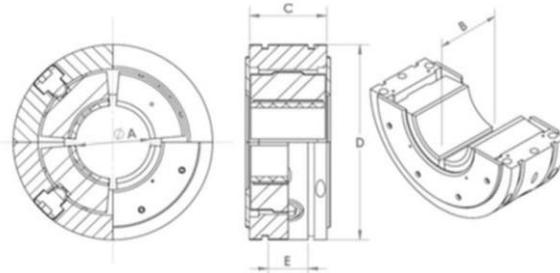
Photo 1



Photo 2

Bearing Dia "A" (mm)	Pad Width "B" (mm)	Cartridge OD "D" (mm)	Load Capab @4 bar input	Load Capab @8 bar input	Load Capab @80 bar input
25	25	65	188N (42 lbf)	377N (85 lbf)	3,77kN (848 lbf)
40	40	105	483N (108 lbf)	965N (217 lbf)	9,7kN (2.17 klbf)
50	50	135	754N (170 lbf)	1.51kN (339 lbf)	15.1kN (3.39 klbf)
75	75	200	1.7kN (381 lbf)	3.4kN (763 lbf)	33.9kN (7.63 klbf)
100	100	285	3kN (678 lbf)	6kN (1.36 klbf)	60.3kN (13.56 klbf)
125	125	335	4.7kN (1.06 klbf)	9.4kN (2.12 klbf)	94.3 kN (21.19 klbf)
150	150	380	6.8kN (1.53 klbf)	13.6kN (3.05 klbf)	135.7kN (30.51 klbf)
200	200	450	12.1 kN (2.71 klbf)	24.1kN (5.42 klbf)	241.3kN (54.24 klbf)
300	300	600	27.1kN (6.10 klbf)	54.3kN (12.20 klbf)	542.9kN (122 klbf)
400	400	800	48.3kN (10.85 klbf)	96.5kN (21.70 klbf)	965.1kN (217 klbf)
500	500	1000	75.4kN (16.96 klbf)	150.8kN (33.9 klbf)	1,508kN (339 klbf)

Table



Drawing

### Mounting

New Way provides “bolt-on” adaptive hardware for implementing air bearings into existing low speed balance machines (Illustration 3). The adaptive hardware, in turn, accommodates New Way’s gas bearing hardware, which is easily assembled to the adaptive hardware. In the image shown below, the balancing machine’s yoke is shown on the right-hand side, and New Way’s adaptive hardware and gas bearings are shown on the left-hand side. The adaptive hardware uses the same mounting features as the original hard rollers.

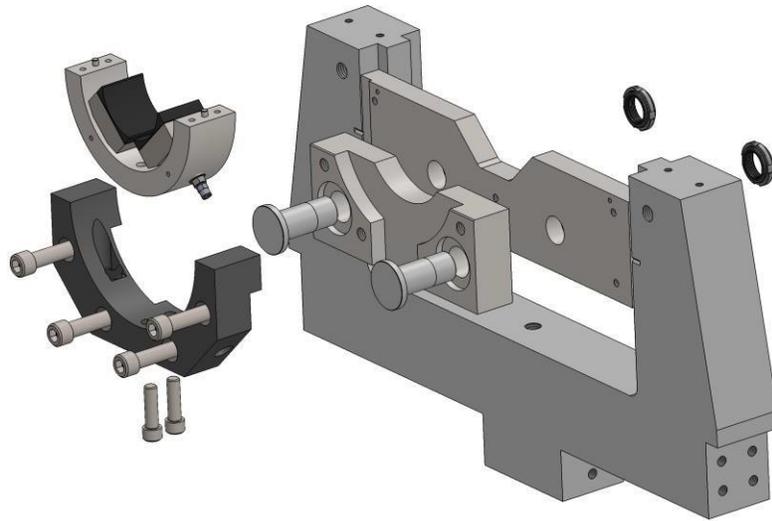


Illustration 3

To further simplify air bearings for balance machine applications, New Way has designed the bearing pads to “snap on/snap off”, as shown in the image below (Illustration 4). This feature allows for several varying sizes of bearing pads to be easily switched out, allowing the balance machine operator to easily balance rotors with different journal sizes without having to adjust or plumb air into bearings.

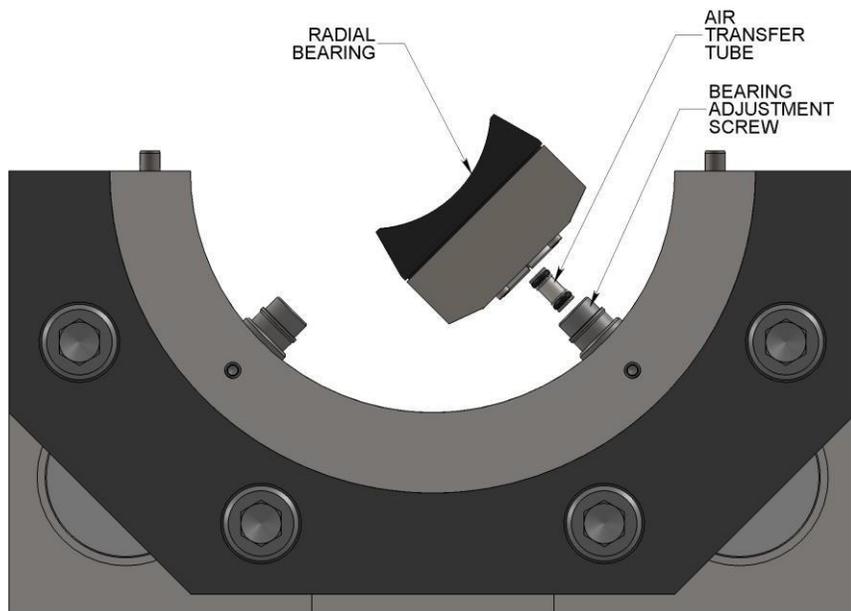


Illustration 4

A final assembly configuration for a balancing operation is shown in the image below. (Illustration 5)

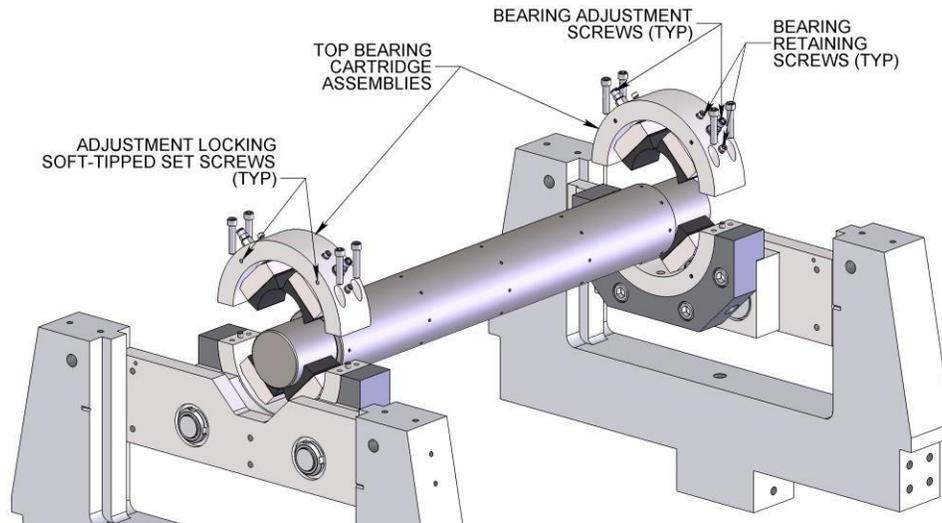


Illustration 5 – Patent Pending

### About New Way

Founded in 1991, New Way Air Bearings has been manufacturing externally pressurized air bearings for the machine tool, semiconductor and medical industries. Offering a full line of standard off-the-shelf air bushings and pads, the company also supplies original equipment manufacturers with custom products including heavy-duty spindles, high-speed bearings and air bearing support for rotating diagnostic X-ray equipment. Don Bently did die in Oct. 2012 and New Way did acquire assets of Don Bently's Bently Pressurized Bearing Company including rights to use the name.

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