

DOCKET NO: 470515US

**IN THE UNITED STATES PATENT AND TRADEMARK OFFICE  
PATENT TRIAL & APPEAL BOARD**

PATENT: 8,573,374

INVENTOR: HEIKO MAGERKURTH et al.

TITLE: HYDRODYNAMIC TORQUE CONVERTER

TRIAL NO.: IPR2017-00442

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**DECLARATION OF DR. STEVEN SHAW**

1. I, Dr. Steven Shaw, make this declaration in connection with this petition for *inter partes* review of U.S. Patent No. 8,573,374 (“the ’374 patent,” attached as Exhibit 1101 to the petition). I am over 21 years of age and otherwise competent to make this declaration.

Although I am being compensated for my time in preparing this declaration, the opinions herein are my own, and I have no stake in the outcome of the *inter partes* review proceeding.

**I. QUALIFICATIONS**

2. A detailed record of my professional qualifications, including a list of publications, awards, and professional activities, can be found

in my *curriculum vitae*, which is attached as Appendix A to this declaration. I have provided testimony by deposition within the last five years in IPR2016-00502, filed against U.S. Patent No. 8,161,740.

3. I am currently the Harris Professor of Mechanical and Aerospace Engineering at Florida Institute of Technology. I am on leave from Michigan State University (“MSU”), where I serve as a University Distinguished Professor of Mechanical Engineering and an Adjunct Professor of Physics and Astronomy. Additionally, I am involved in a small family business that makes hand and specialty tools for Snap-On, etc. as 49% owner, Vice President, and Board Member, although I am not involved in day-to-day operations.

4. Before joining the faculty at MSU in 1984, I was an Assistant Professor in the School of Engineering at Oakland University. I also served as an Associate Professor in the Department of Mechanical Engineering at the University of Michigan during 1991-93, and have held visiting professor appointments at Cornell University, the University of Minnesota, Caltech, the University of Michigan, the University of California-Santa Barbara, and McGill University.

5. During the past 32 years, I have performed research relevant to the subject matter of the '374 patent, including on dampers, rotor systems, and centrifugal pendulum vibration absorbers. I have also worked on these topics with several companies, including Ford Motor Company off and on since 1984, with Teledyne Continental Motors in 1994, with Chrysler (in its various incarnations) continually since 2006, with Honda in 2013, with Valeo starting in 2015, and with Achates Power in 2016.

6. My work on this topic has included various types of fundamental studies, design assistance, and the development of experimental methods for system characterization. This work been funded by the companies noted above and by the U.S. National Science Foundation. I have also published extensively, with over 150 technical publications. Of these, approximately 25 archival journal papers and numerous conference papers relate to this topic. I have also given professional presentations on the subject at many conferences and university seminars. I have graduated 7 Ph.D. students and 8 M.S. students working in this area, and currently have one Ph.D. student in progress on this subject. My 1997 SAE Arch T. Colwell Merit Award

and my 2013 ASME N. O. Myklestad Award, which is “presented in recognition of a major innovative contribution to vibration engineering,” were based on my technical contributions to this topic.

7. In addition, I have consultation experience with torque converters, and regularly use torque converters as an example in my classes when I teach system dynamics and vibrations.

8. I hold an A.B. degree in Physics and an M.S.E. in Applied Mechanics from the University of Michigan and a Ph.D. in Theoretical and Applied Mechanics from Cornell University.

9. I have used my education and experience working in the mechanical engineering field, and my understanding of the knowledge, creativity, and experience of a person having ordinary skill in the art in forming the opinions expressed in this report, as well as any other materials discussed herein.

## **II. MATERIALS CONSIDERED**

10. In forming my opinions, I read and considered the '374 patent and its prosecution history, the exhibits listed in the Exhibit List filed with the petition for *inter partes* review of the '374 patent, as well as any other material referenced herein.

### **III. LEGAL PRINCIPLES**

11. For the purposes of this declaration, I have been informed about certain aspects of patent law that are relevant to my analysis and opinions, as set forth in this section of my declaration.

#### **A. A Person Having Ordinary Skill in the Art**

12. I understand that the disclosure of patents and prior art references are to be viewed from the perspective of a person having ordinary skill in the art at the time of the alleged invention (“PHOSITA”). Unless I state otherwise, I provide my opinion herein from the viewpoint of a PHOSITA at the earliest alleged priority date for the ’374 patent, which I have been informed is July 4, 2008.

13. The ’374 patent relates to the field of hydrodynamic torque converter designs. The particular technical issue that the ’374 patent purports to address is the arrangement of components within the torque converter to decrease the assembly space while maintaining functionality. I understand from my own work experience and conversations with engineers who work in the field of hydrodynamic torque converter design that torque converter design involves three main considerations: (1) efficient transfer of torque, (2) packaging of the torque converter parts so that the torque converter fits in the space

specified by the customer, and (3) reduction of noise, vibration, and harshness (called “NVH” in the industry) to meet or exceed customer requirements. A PHOSITA in the field of hydrodynamic torque converter design would be skilled in each of those three areas, although practically speaking, torque converters are designed by teams of engineers.

14. The references that I discuss below are informative of the level of skill of a PHOSITA and are of the type that are reasonably relied upon by experts in my field to form opinions on the subject of vibration absorbers, including vibration absorbers used in hydrodynamic torque converters.

15. Long before the '374 patent application was filed, various components used to dampen and absorb vibrations in hydrodynamic torque converters were well-known.

16. The '374 patent acknowledges that combining (i) torsional vibration dampers positioned between the lock-up clutch and the output hub with (ii) turbine dampers positioned between the turbine and the output hub to damp the torsional vibrations of an internal combustion engine was known prior to the filing date. (Ex. 1101, 1:23–42.)

17. Torsional vibration absorbers were also well-known. (*See, e.g.,* Ex. 1110, 2:15–20 (describing cancellers known in the art). The prior art also demonstrates that companies such as DaimlerChrysler, Mannesmann Sachs/ZF Sachs, and Carl Freudenberg were already seeking patent protection on compact torque converter designs with different damper and absorber arrangements. (Ex. 1110, Figs. 1–8, 2:15–20; Ex. 1111; Ex. 1112; Ex. 1113.)

18. It was also well-known in the art to arrange these components so as to reduce assembly space as much as possible. (*See, e.g.,* Ex. 1109, 5:3–34 (teaching sharing components and benefits of reducing space); Ex. 1110, 3:9–16 (describing benefits of using existing space to decrease assembly space.)

19. Based on these factors, I have concluded that a PHOSITA was sufficiently skilled in the general design of hydrodynamic torque converters and experienced in arranging their layouts to most efficiently use available space in view of the numerous ways to connect torque converter components described in the prior art.

## **B. Claim Construction**

20. I understand that “claim construction” is the process of determining a patent claim’s meaning. I also have been informed and understand that the proper construction of a claim term is the meaning that a PHOSITA would have given to that term.

21. I understand that claims in *inter partes* review proceedings are to be given their broadest reasonable interpretation in light of the specification, which is what I have done when performing my analysis in this declaration. I provide comments on specific terms below.

22. Torsional Vibration Absorber: Under its broadest reasonable interpretation in light of the specification, “torsional vibration absorber” means a component or device designed to absorb torsional vibrations. As described in the ’374 patent, this includes movable masses disposed on mounting parts. (Ex. 1101, 1:43–45.) Some examples of movable masses disposed on mounting parts are compensation flywheels, frequency-tuned mass-spring devices and centrifugal-force pendulums.

23. Parallel: Under its broadest reasonable interpretation in light of the specification, “parallel” means “does not transfer torque generated by the engine along the power path but rotates with” the



other components in the power path. This is consistent with the description of parallel components in the '374 specification and in Haller. (Ex. 1101, 5:12–16; Ex. 1110, 3:1–3.) Both documents describe absorbers that are parallel to the drivetrain such that they don't transfer engine torque, but they do rotate with the other components in the drivetrain.

24. In a pocket: Under its broadest reasonable interpretation in light of the specification, wherein the lock-up clutch is axially mounted, “in a pocket” in claim 10 means “*partially* in a pocket.” Claim 11 specifies that the lock-up clutch is formed out of a piston, and the piston in the '374 patent extends partially out of the pocket. Thus, in the embodiment shown, the lock-up clutch is *partially* in the pocket. (Ex. 1101, Fig. 1.)

### **C. Anticipation**

25. I understand that a patent claim is unpatentable as anticipated if a PHOSITA during the relevant timeframe would have understood a single prior art reference to teach every limitation contained in the claim. The disclosure in a reference does not have to be in the same words as the claim, but all of the requirements of the

claim must be described in enough detail, or necessarily implied by or inherent in the reference, to enable a POSITA looking at the reference to make and use at least one embodiment of the claimed invention.

#### **IV. THE '374 PATENT**

26. The '374 patent was filed as the national stage entry of PCT/DE2009/000819 on June 12, 2009 and issued November 5, 2013.

27. The '374 patent describes a torque converter that purportedly dampens vibrations well while taking up little assembly space. More particularly, the '374 patent describes disposing multiple damper stages in series between a lock-up clutch and an output hub, with a torsional vibration damper between them. (Ex. 1101, 1:63–2:5.)

28. By integrating “both damper stages in a single damper that concurrently features a torsional vibration absorber assigned to both damper stages,” the '374 patent explains that multiple components can be shared, providing a lighter and narrower torque converter. (Ex. 1101, 2:5–18.)

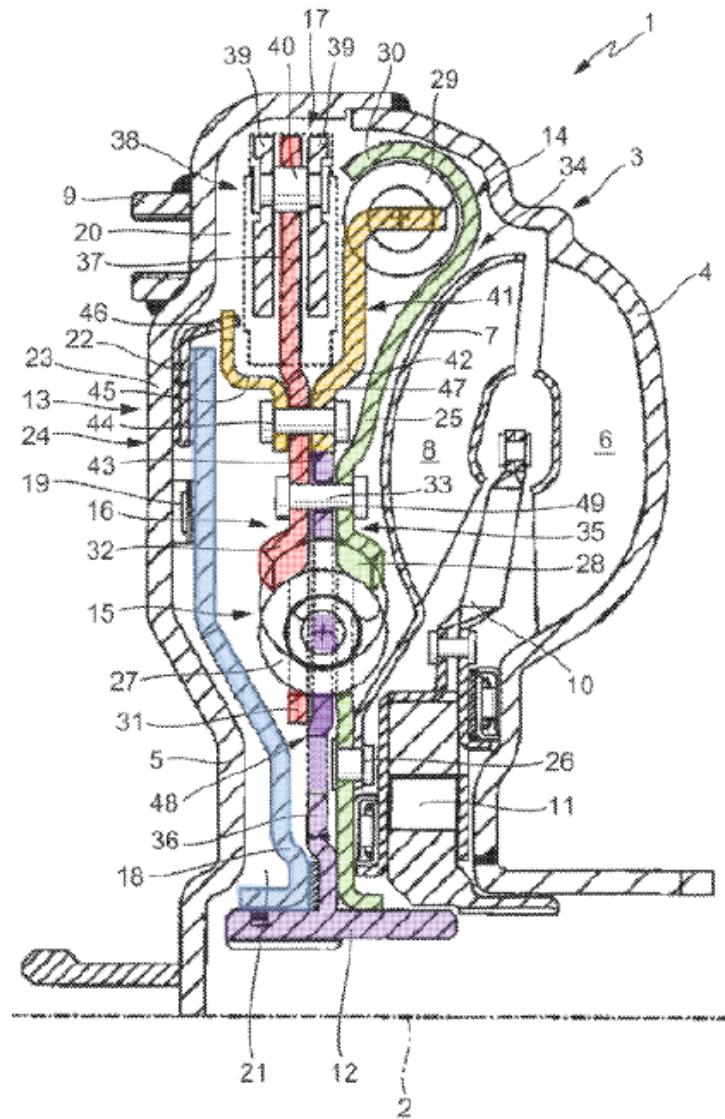
29. The '374 patent acknowledges that combining (i) torsional vibration dampers positioned between the lock-up clutch and the output hub and (ii) turbine dampers positioned between the turbine and the

output hub to damp the torsional vibrations of an internal combustion engine was known prior to the filing date. (Ex. 1101, 1:23–42.)

30. The '374 patent also acknowledges that it was known to use vibration absorbers such as centrifugal force pendulums to reduce torsional vibrations. (Ex. 1101, 1:43–50.)

31. But the '374 patent alleges that, due to restrictive assembly space specifications in motor vehicles, a torque converter that took up less assembly space while still providing sufficient vibration damping was needed. (Ex. 1101, 1:51–59.)

32. The only drawing figure in the '374 patent, reproduced below with colored annotations, depicts a hydrodynamic torque converter 1 having a housing 3, an impeller 6, and a turbine 7 inside the housing 3. (Ex. 1101, 3:56–4:8.)



**'374 Patent Figure**

33. Additionally, Fig. 1 shows a lock-up clutch 13 (including piston 18 in blue) mounted on the housing 3.

34. When the lock-up clutch is closed, it transmits torque from an internal combustion engine to the output hub 12 (purple) via first and second damper stages 14, 15, as follows: the input 41 (yellow) to the first damper stage receives torque from the lock-up clutch. The *output* of

the first damper stage is a disk part 25 (green) that also forms a portion of the *input* of the second damper stage. (Ex. 1101, 4:38–40.)

35. The input of the second damper stage is completed by disk part 31 (red), which also forms the mounting part for the torsional vibration absorber 17. (Ex. 1101, 5:3–5.) The output (purple) of the second damper stage is part of the output hub (purple).

36. When the lock-up clutch is open, torque flows via impeller 6 to the turbine 7 which is fastened to disk part 25 (green). Because disk part 25 is the input of the second damper stage, torque is transmitted through the second damper stage 15 to the output hub (purple). (Ex. 1101, 4:8–16.)

37. The two damper stages 14, 15 are connected by a single disk part 25 (green). (Ex. 1101, 4:38–40.) The disk part 25 forms the complete output part 34 of damper stage 14 and part of the input part 35 of damper stage 15, completed by a second disk part 31 (red). (Ex. 1101, 4:53–58.) The two disk parts 25 (green) and 41 (yellow) are axially spaced relative to one another by rivets 33 and accommodate flange part 36 (purple), welded to the output hub 12. (Ex. 1101, 4:58–62.)

38. Disk part 31 (together with 32 and 37, red) forms the mounting part 37 of the torsional vibration absorber 17, shown in Fig. 1 as a centrifugal force pendulum 38. (Ex. 1101, 5:3–5.)

## **V. Summary of Select Prior Art**

39. All the components of the '374 claims were well-known in the art, as detailed below. Moreover, these components were arranged in the prior art in the same space-saving fashion taught by the '374 patent.

### **1. Degler**

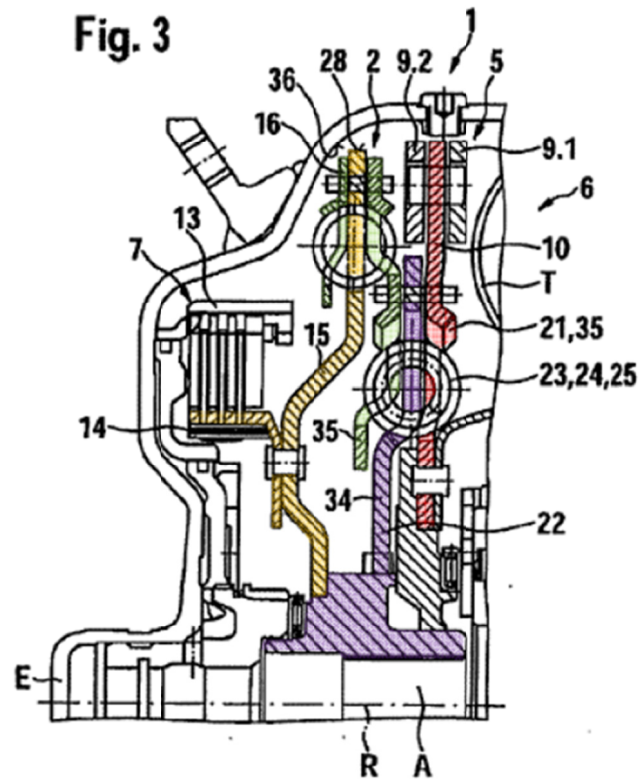
40. Degler describes a force transmission device optimized to reduce or cancel rotational irregularities over the entire operating range of the engine. (Ex. 1103, 3.<sup>1</sup>) Degler's devices include hydrodynamic torque converters with at least two dampers connectable in series and a rotational-speed-adaptive vibration absorber, preferably arranged between the dampers. (Ex. 1103, 3.)

41. Degler's torque converter includes many of the same components as the '374 patent, highlighted below. In Fig. 3 (below), rotational-speed-adaptive vibration absorber 5 is integral with primary

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<sup>1</sup> All citations in my declaration are to the internal page numbers of the references.

part 21 of second damper 4. (Ex. 1103, 14.) The rotational-speed-adaptive vibration absorber can be a centrifugal pendulum and “does not transmit any torque but is suitable for absorbing excitations over a very broad range.” (Ex. 1103, 3.)

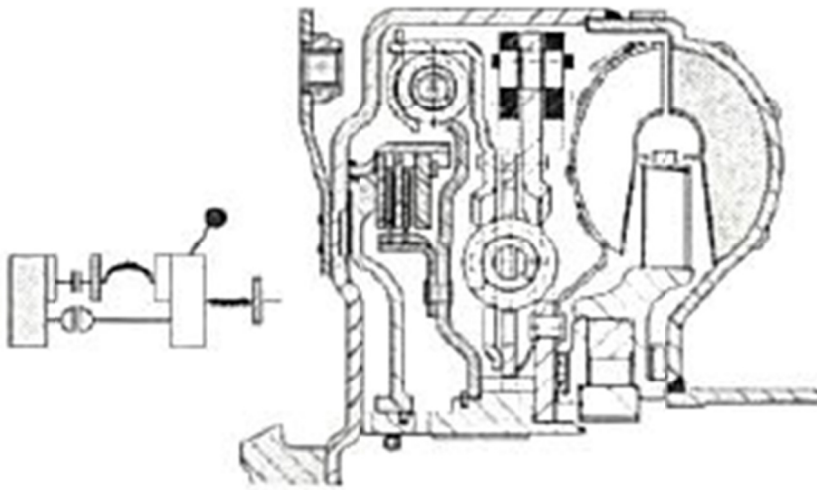


**Degler Fig. 3**

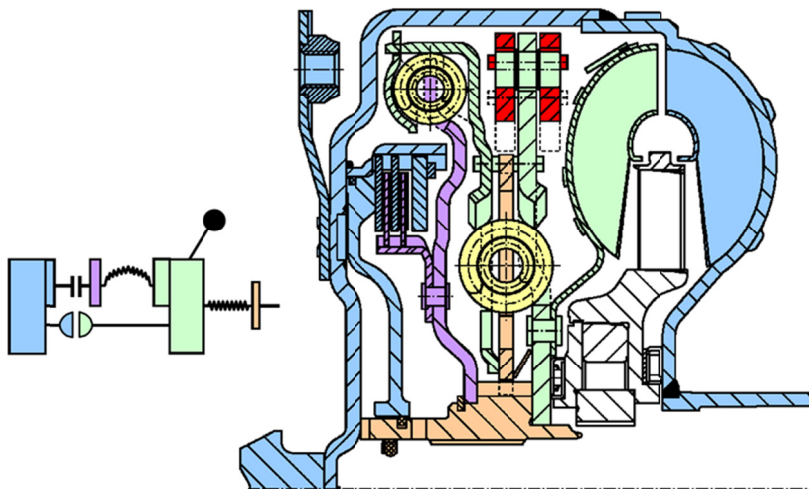
## **2. Reik**

42. Reik is a paper and presentation distributed at the CTI Symposium in Berlin, German in December, 2008. (Ex. 1106; Ex. 1107.) The paper includes a schematic drawing of a hydrodynamic torque converter including the same components and orientations as discussed

and claimed in the '374 patent.



(Ex. 1106, 512.) A color version of this figure from the presentation (Ex. 1115) rather than the black and white version from the book (Ex. 1106) is provided for ease:



As is apparent, the figures in Ex. 1106 and 1115 are identical. I use the colored figure from Ex. 1115 for reference in my declaration for ease.



## VI. ANALYSIS

43. It is my opinion that claims 1, 3–5, 8, 10, and 14–16 of the '374 patent are anticipated over the prior art, as detailed below. At the request of counsel, I have divided the claims into elements denoted as [a], [b], [c], etc. to correspond to the discussion of the same elements in the petition for *inter partes* review, as follows:

Claim 1:

**[a]** A hydrodynamic torque converter (1)

**[b]** with a turbine (7) driven by an impeller (6) as well as housing (3)

**[c]** in which a torsional vibration damper (16) with multiple of damper stages (14, 15),

**[d]** a torsional vibration absorber (17) and

**[e]** a lock-up clutch (13) are additionally installed,

**[f]** wherein a first damper stage (14) and a second damper stage (15) are disposed between the lock-up clutch (13) and an output hub (12),

**[g]** the second damper stage (15) is disposed between the turbine (7) and the output hub (12)

**[h]** and the torsional vibration absorber (17) is parallel to both damper stages (14, 15).

Claim 2:

The hydrodynamic torque converter (1) according to claim 1, wherein an input part (41) of the first damper stage (14) and an output part (48) of the second damper stage (15) are centered on one another.

Claim 3:

The hydrodynamic torque converter (1) according to claim 1, wherein a disk part (25) is allocated to two damper stages (14, 15) as one piece.

Claim 4:

**[a]** The hydrodynamic torque converter (1) according to claim 1, wherein the torsional vibration absorber (17) comprises a plurality of absorber masses (39), and

**[b]** a mounting part (37) of the torsional vibration absorber (17) forms a disk part (31) of an input part (35) of the second damper stage (15).

Claim 5:

The hydrodynamic torque converter (1) according to claim 1, wherein absorber masses (39) of the torsional vibration absorber (17) and energy accumulators (29) of the first damper stage (14) disposed over the circumference are radially at the same height but axially spaced apart.

Claim 6:

The hydrodynamic torque converter (1) according to claim 5, wherein a middle mounting diameter of the energy accumulators (29) is disposed radially outside the turbine (7).

Claim 7:

The hydrodynamic torque converter (1) according to claim 5, wherein the energy accumulators (29) overlap the turbine (7) at least partially and axially.

Claim 8:

The hydrodynamic torque converter (1) according to claim 1, wherein energy accumulators (27) are distributed over the circumference of the second damper stage (15) based on a middle mounting diameter radially within turbine blades (8) of the turbine (7).

Claim 9:

The hydrodynamic torque converter (1) according to claim 8, wherein the energy accumulators (27) of the second damper stage (15) and the turbine (7) at least partially and axially overlap.

Claim 10:

The hydrodynamic torque converter (1) according to claim 1, wherein the lock-up clutch (13) in a closed state is axially mounted in a pocket (24) formed in a housing wall (23) radially inward of

fastening means (9) provided on external part of the torque converter (1).

Claim 11:

**[a]** The hydrodynamic torque converter (1) according to claim 10, wherein the lock-up clutch (13) is formed out of a piston (18) centered on the output hub (12) and

**[b]** mounted non-rotatably and axially displaceably on the housing (3), and axially pressurizes a friction plate (22) that can be clamped between said piston and said housing (3) to develop a frictional engagement.

Claim 12:

The hydrodynamic torque converter (1) according to claim 11, wherein a mounting part (37) of the torsional vibration absorber (17) is disposed axially between lock-up clutch (13) and the first damper stage (14).

Claim 13:

The hydrodynamic torque converter (1) according to claim 12, wherein between the friction plate (22) and an input part (41) of the first damper stage (14) transition connections (44) are formed, which reach through circular segment-shaped openings (47) of the mounting part (37).

Claim 14:

The hydrodynamic torque converter according to claim 1, wherein in the closed state of the lock-up clutch (13) the torsional vibration absorber (17) acts between both damper stages (14, 15).

Claim 15:

The hydrodynamic torque converter according to claim 1, wherein the torsional vibration absorber (17) is connected non-rotatably with the turbine (7).

Claim 16:

The hydrodynamic torque converter according to claim 15, wherein in the opened state of the lock-up clutch (13) the torsional vibration absorber (17) is connected non-rotatably with the turbine (7).

**A. Ground 1: Claims 1, 3–5, 8, 10, and 14–16 Are Anticipated By Degler**

44. I have been asked to assume that Degler constitutes prior art against the '374 patent. With that assumption, it is my opinion that Degler anticipates claims 1, 3–5, 8, 10, and 14–16.

**Claim 1[a]: A hydrodynamic torque converter (1):**

45. Degler discloses hydrodynamic torque converters. (Ex. 1103, 9 (“Hydrodynamic component 6 can be constructed as a hydrodynamic clutch...in a particularly advantageous embodiment, as a hydrodynamic

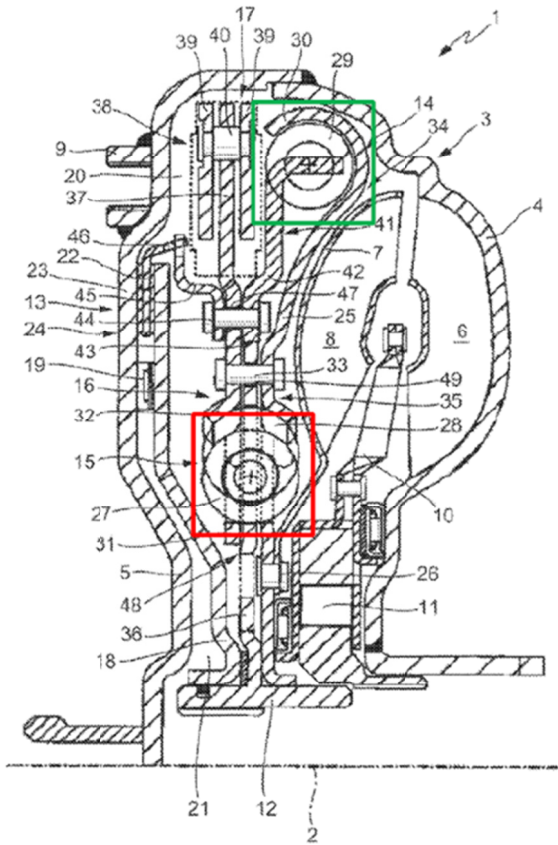
rotational-speed/torque converter...”).) Thus, it is my opinion that Degler anticipates element 1[a].

**Claim 1[b]: with a turbine (7) driven by an impeller (6) as well as housing (3)**

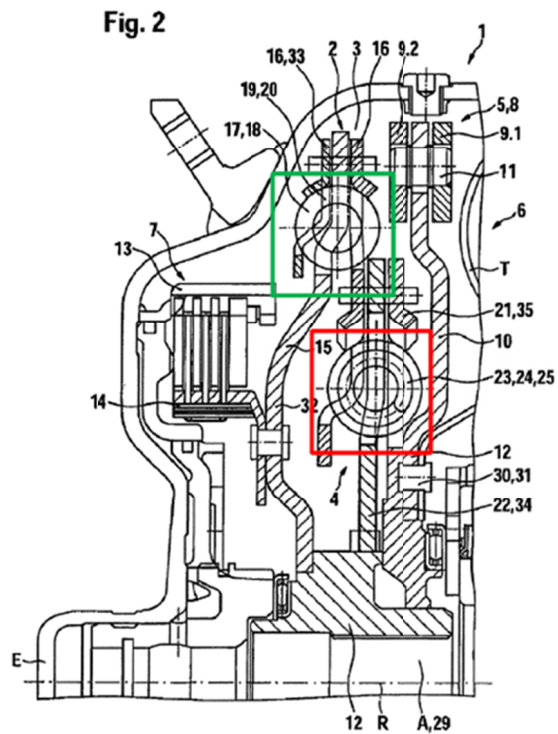
46. The hydrodynamic torque converter in Degler includes a turbine driven by an impeller in a housing. (Ex. 1103, 9 (“Hydrodynamic component 6 comprises at least one primary wheel functioning as pump impeller P...and one secondary wheel functioning as turbine wheel T...”).) The housing is visible in the drawing figures. (Ex. 1103, Fig. 2.) Thus, it is my opinion that Degler anticipates element 1[b].

**Claim 1[c]: in which a torsional vibration damper (16) with multiple of damper stages (14, 15)**

47. Degler discloses several examples of torsional vibration dampers with multiple stages. Degler’s two damper stages (first damper 3 (green) and second damper 4 (red) in Fig. 2 or Fig. 3 correspond with the first 14 and second 15 damper stages of the ’374 patent (Fig. 2 shown below):



**'374 Patent**



**Degler Fig. 2**

48. Thus, it is my opinion that Degler anticipates element 1[c].

**Claim 1[d]: a torsional vibration absorber (17)**

49. Degler teaches rotational-speed-adaptive vibration absorbers such as the centrifugal pendulum absorber shown in Fig. 4. (Ex. 1103, 3 (“A force-transmission device constructed according to the invention...comprising...a rotational-speed-adaptive vibration absorber”); Fig. 4.) Thus, it is my opinion that Degler anticipates element 1[d].

**Claim 1[e]: and a lock-up clutch (13) are additionally installed**

50. Degler's torque converters include a lock-up clutch. (Ex. 1103, 9 ("Device 7 for bypassing hydrodynamic component 6 preferably has the form of a so-called lockup clutch...").) Thus, it is my opinion that Degler anticipates element 1[e].

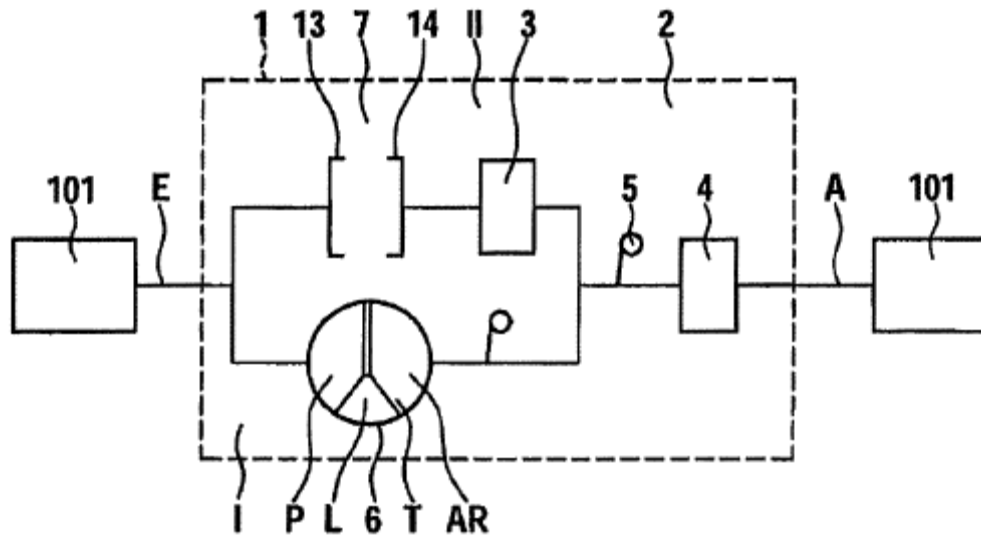
**Claim 1[f]: wherein a first damper stage (14) and a second damper stage (15) are disposed between the lock-up clutch (14) and an output hub (12),**

51. The '374 patent describes two torque paths. Claim 1[f] describes the first torque path, *i.e.*, where torque passes through both damper stages when transferred from the lock-up clutch 14 to the output hub 12.

52. Degler Figs. 1c and 2 embody torque paths similar to those described in the '374 patent. In Figs. 1c and 2, the first damper 3 acts as a standard damper and the second damper 4 acts as a turbine damper, as in the '374 patent. (Ex. 1103, 10 ("According to figure 1c, this arrangement of the two dampers 3 and 4 connected in series in the force flow in the force flow direction as viewed between input E and output A is always connected downstream from mechanical power branch II"; Figs. 1c and 2).) This arrangement is depicted below in Fig. 1c:



**Fig. 1c**



53. Thus, it is my opinion that Degler anticipates element 1[f].

**Claim 1[g]: the second damper stage (15) is disposed between the turbine (7) and the output hub (12) and**

54. As noted above, the '374 patent describes two torque paths.

Claim 1[g] describes the second torque path, *i.e.*, where torque passes through the second damper stage 15 when transferred from the turbine 7 to the output hub 12.

55. Degler Figs. 1c and 2 embody torque paths similar to those described in the '374 patent. In Figs. 1c and 2, the second damper is active when the torque path is through the impeller/turbine, as in the '374 patent. (Ex. 1103, 10 ("The tie-in of hydrodynamic component 6,

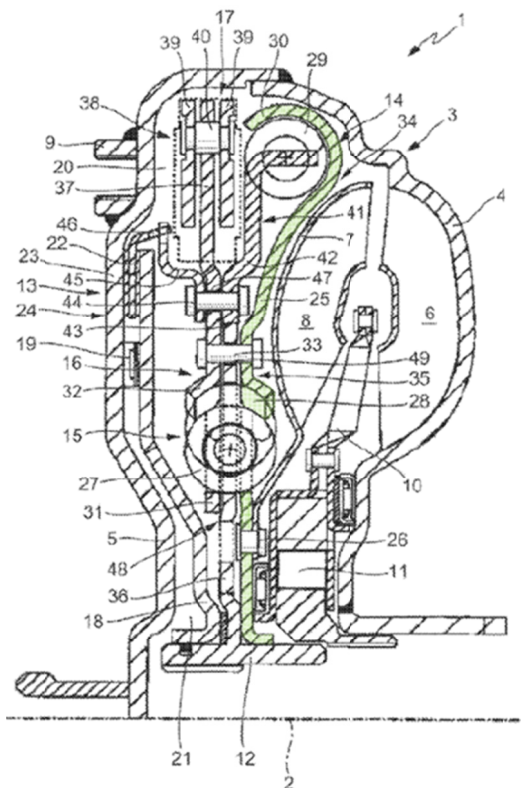
especially with turbine wheel T, takes place here between the two dampers 3 and 4"; Figs. 1c and 2).) Thus, it is my opinion that Degler anticipates element 1[g].

**Claim 1[h]: the torsional vibration absorber (17) is parallel to both damper stages (14, 15).**

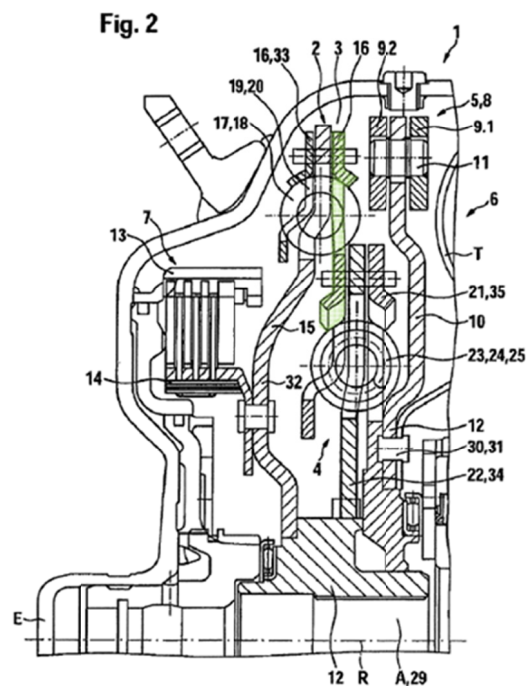
56. In Degler Figs. 1c and 2, the vibration absorber 5 is parallel to both damper stages because it is connected to second damper stage 4 and does not transmit torque. (Ex. 1103, Fig. 2.) Thus, it is my opinion that Degler anticipates claim element 1[h].

**Claim 3: The hydrodynamic torque converter (1) according to claim 1, wherein a disk part (25) is allocated to two damper stages (14, 15) as one piece.**

57. Claim 3 requires that a single disk part is shared between the first and second damper stages. As shown in '374 Fig.1, disk part 25 (green) is a single component shared between both damper stages. The same relationship is depicted in Degler Fig. 2:



**'374 Patent Fig. 1**



**Degler Fig. 2**

58. Moreover, Degler specifically teaches that “integral construction between primary part 21 and secondary part 16 is also possible.” (Ex. 1103, 13.) Thus, it is my opinion that Degler anticipates claim 3.

**Claim 4[a]: The hydrodynamic torque converter (1) according to claim 1, wherein the torsional vibration absorber (17) comprises a plurality of absorber masses (39), and**

59. Degler describes torsional vibration absorbers with a plurality of absorber masses. (Ex. 1103, 6 (“inertial masses are

pendulum-mounted on the inertial-mass support device”); Fig. 4.) Thus, it is my opinion that Degler anticipates claim element 4[a].

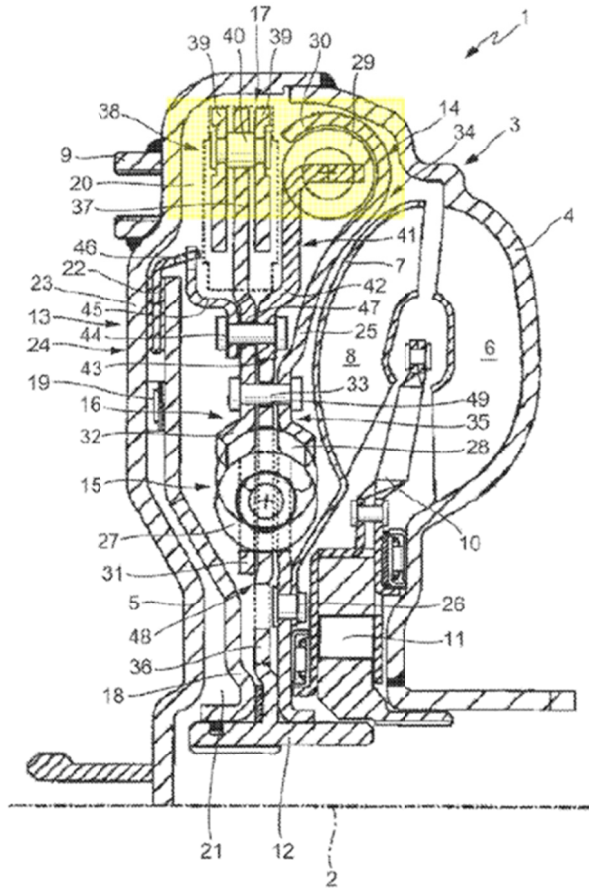
**Claim 4[b]: a mounting part (37) of the torsional vibration absorber (17) forms a disk part (31) of an input part (35) of the second damper stage (15).**

60. Claim 4[b] specifies that the mounting part of the torsional vibration absorber forms an input part of the second damper stage. In Degler Fig. 3 the torsional vibration absorber is mounted on the disk input 21 of the second damper stage. (Ex. 1103, Fig. 3.) Thus, it is my opinion that Degler anticipates claim element 4[b].

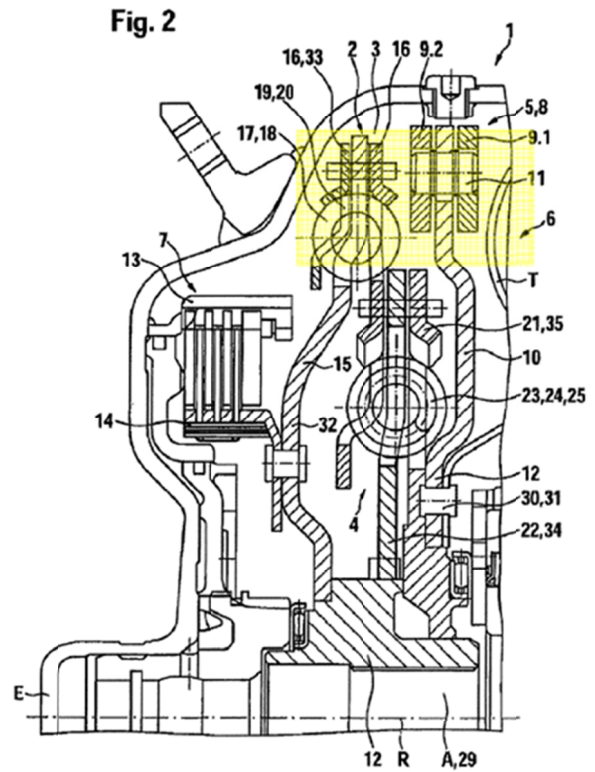
**Claim 5: The hydrodynamic torque converter (1) according to claim 4, wherein absorber masses (39) of the torsional vibration absorber (17) and energy accumulators (29) of the first damper stage (14) disposed over the circumference are radially at the same height but axially spaced apart.**

61. Claim 5 specifies that the absorber masses and the springs of the first damper stage be axially spaced apart but radially at the same height, as illustrated in Fig. 1 of the '374 patent.

62. Under the broadest reasonable interpretation, this includes instances where there is overlap between the radial height of the absorber masses and the springs of the first damper stage, as shown in Degler Fig. 2:



'374 Patent Fig. 1



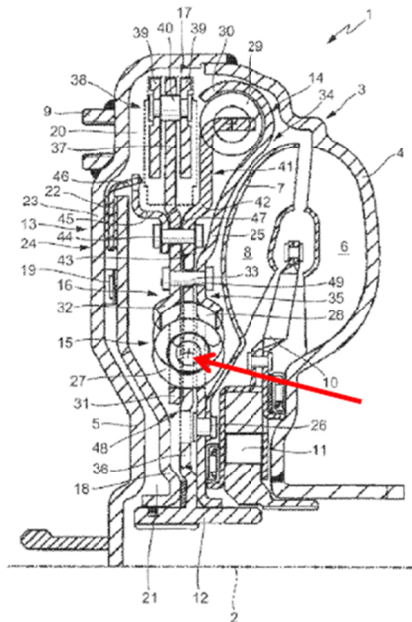
Degler Fig. 2

63. Thus, it is my opinion that Degler anticipates claim 5.

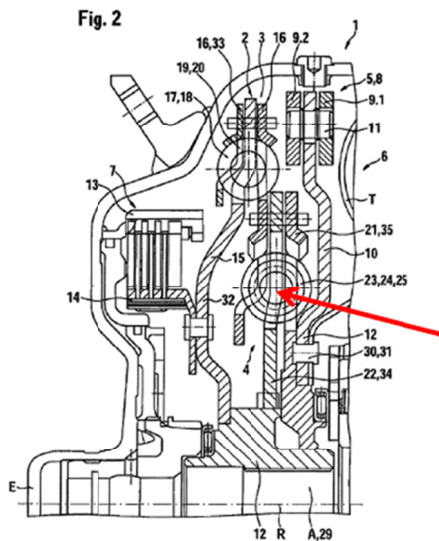
**Claim 8: The hydrodynamic torque converter (1) according to claim 1, wherein energy accumulators (27) are distributed over the circumference of the second damper stage (15) based on a middle mounting diameter radially within turbine blades (8) of the turbine (7).**

64. Claim 8 requires that the middle mounting diameter, *i.e.*, center of the springs of the second damper, be radially within (below) the turbine.

65. As shown in '374 Fig. 1, the central portion of the springs of the second damper are mounted below the turbine. The same relationship can be seen in Degler (although the turbine is largely not shown), annotated with red arrows illustrating the center of the springs of the second damper located below the turbine:



'374 Patent Fig. 1



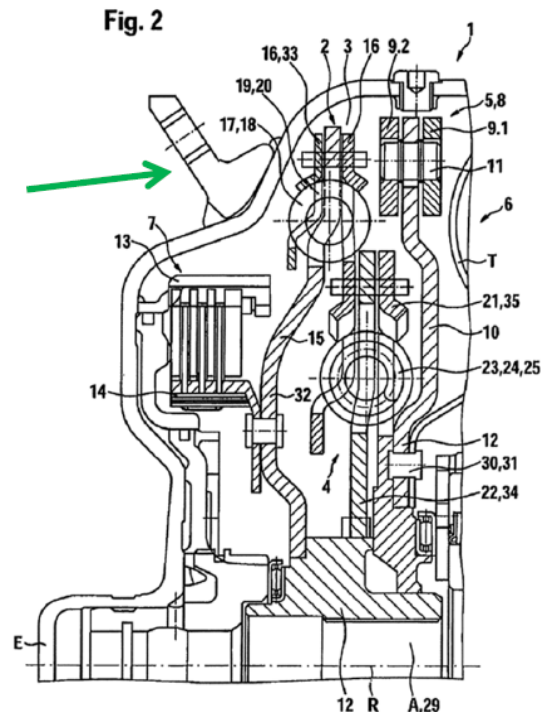
Degler Fig. 2

66. Thus, it is my opinion that Degler anticipates claim 8.

**Claim 10: The hydrodynamic torque converter (1) according to claim 1, wherein the lock-up clutch (13) in a closed state is axially mounted in a pocket (24) formed in a housing wall (23) radially inward of fastening means (9) provided on external part of the torque converter (1).**

67. Claim 10 specifies that, when closed, at least the mounting portion of the lock-up clutch is axially mounted in a pocket in the housing wall radially inward of the fastening means on the housing.

68. The hydrodynamic torque converter in Degler Fig. 2 has a fastening bracket (indicated by green arrow) on the housing of the torque converter for attaching the housing to a drive. (Ex. 1103, Fig. 2.)



And, as shown in Fig. 2, when closed, the clutch 7 is axially mounted in a pocket formed in the housing wall radially inside of the fastening bracket. Thus, it is my opinion that Degler anticipates claim 10.

**Claim 14: The hydrodynamic torque converter (1) according to claim 1, wherein in the closed state of the**

**lock-up clutch (13) the torsional vibration absorber (17) acts between both damper stages (14, 15).**

69. Claim 14 requires that the torsional vibration absorber act between both damper stages when the lock-up clutch is closed.

70. Degler states that its embodiments are “characterized in that the rotational-speed-adaptive vibration absorber is disposed between the dampers at least in one force-flow direction over the damper arrangement.” (Ex. 1103, 3.) Thus, it is my opinion that Degler anticipates claim 14.

**Claim 15: The hydrodynamic torque converter (1) according to claim 1, wherein the torsional vibration absorber (17) is connected non-rotatably with the turbine (7).**

71. In Degler Fig. 2 the mounting part of the rotational-speed-adaptive vibration absorber is connected indirectly to rotate with the turbine. (Ex. 1103, Fig. 6, *see also* 4 (“rotational-speed-adaptive vibration absorber is connected at least indirectly to rotate with the secondary wheel. By the association of the rotational-speed-adaptive vibration absorber with the turbine wheel, this can preferably be active in all operating conditions...”).) Thus, it is my opinion that Degler anticipates claim 15.



**Claim 16: The hydrodynamic torque converter (1) according to claim 1, wherein in the opened state of the lock-up clutch (13) the torsional vibration absorber (17) is connected non-rotatably with the turbine (7).**

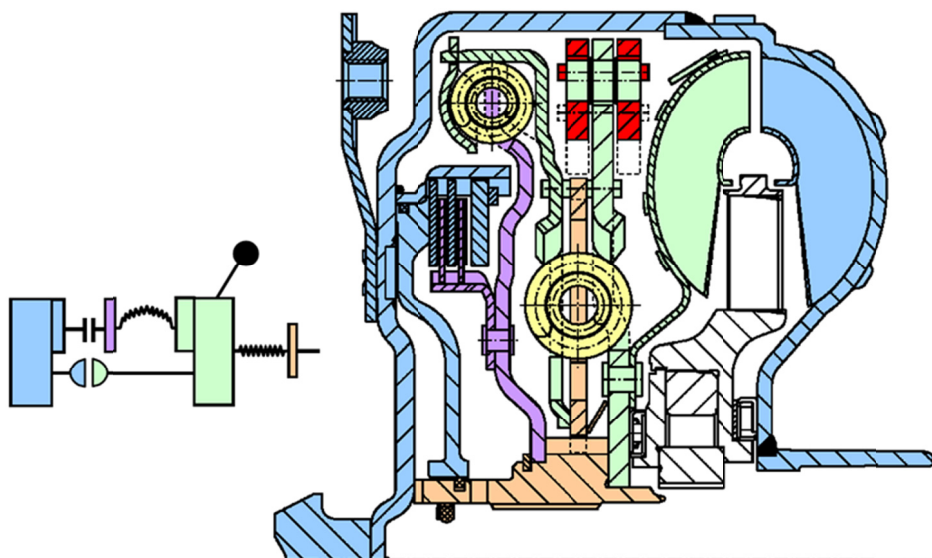
72. In Degler Fig. 2 the mounting part of the rotational-speed-adaptive vibration absorber is connected indirectly to rotate with the turbine when the lock-up clutch is open. (Ex. 1103, Fig. 6, *see also* 4 (“rotational-speed-adaptive vibration absorber is connected at least indirectly to rotate with the secondary wheel...By the association of the rotational-speed-adaptive vibration absorber with the turbine wheel, this can preferably be active in all operating conditions...”).) Thus, it is my opinion that Degler anticipates claim 16.

**B. Ground 2: Claims 1, 3–5, 8, 10, and 14–16 Are Anticipated By Reik**

73. I have been asked to assume that Reik constitutes prior art against the '374 patent. With that assumption, it is my opinion that Reik anticipates claims 1, 3–5, 8, 10, and 14–16.

**Claim 1[a]: A hydrodynamic torque converter (1):**

74. Reik discloses hydrodynamic torque converters. (Ex. 1106, 512; Ex. 1115, 35.)



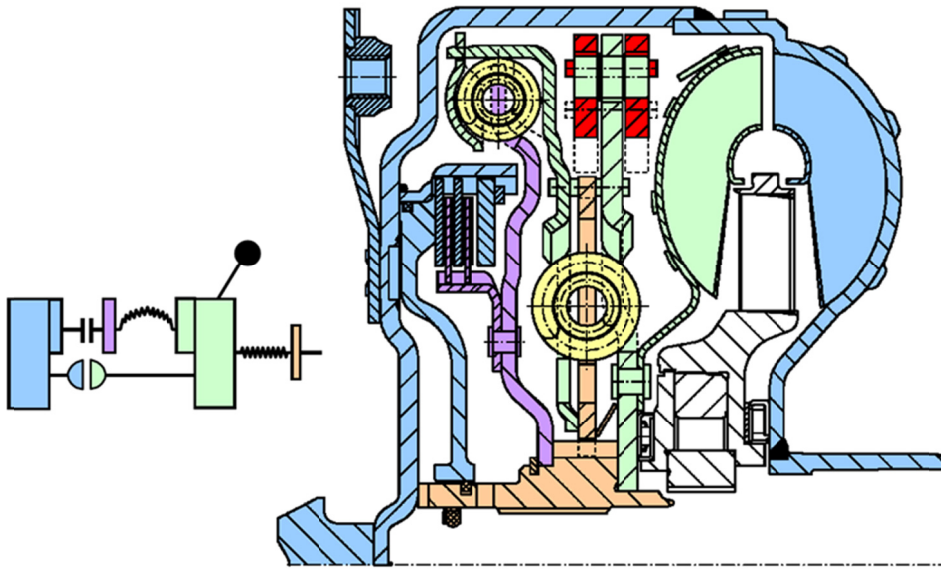
75. Thus, it is my opinion that Reik anticipates element 1[a].

**Claim 1[b]: with a turbine (7) driven by an impeller (6) as well as housing (3)**

76. The hydrodynamic torque converter in Reik includes a turbine (green) driven by an impeller (blue) in a housing. (Ex. 1106, 512; Ex. 1115, 35.) Thus, it is my opinion that Reik anticipates element 1[b].

**Claim 1[c]: in which a torsional vibration damper (16) with multiple of damper stages (14, 15)**

77. Reik discloses a torsional vibration damper with multiple stages. (Ex. 1106, 512; Ex. 1115, 35.) Reik's two damper stages (shown in yellow) correspond with the first 14 and second 15 damper stages of the '374 patent:



78. Thus, it is my opinion that Reik anticipates element 1[c].

**Claim 1[d]: a torsional vibration absorber (17)**

79. Reik teaches rotational-speed-adaptive vibration absorbers such as a centrifugal pendulum absorber. (Ex. 1106, 512; Ex. 1115, 34.)

Thus, it is my opinion that Reik anticipates element 1[d].

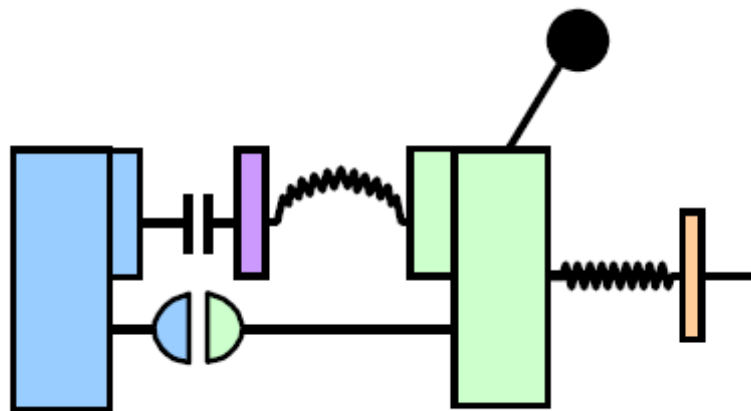
**Claim 1[e]: and a lock-up clutch (13) are additionally installed**

80. Reik's torque converter includes a lock-up clutch. (Ex. 1106, 512; Ex. 1115, 35.) Thus, it is my opinion that Reik anticipates element 1[e].

**Claim 1[f]: wherein a first damper stage (14) and a second damper stage (15) are disposed between the lock-up clutch (14) and an output hub (12),**

81. As discussed above, the '374 patent describes two torque paths. Claim 1(f) describes the first torque path, *i.e.*, where torque passes through both damper stages when transferred from the lock-up clutch 14 to the output hub 12.

82. Reik embodies torque paths similar to those described in the '374 patent. In Reik, the first damper acts as a standard damper and the second damper acts as a turbine damper, as in the '374 patent:



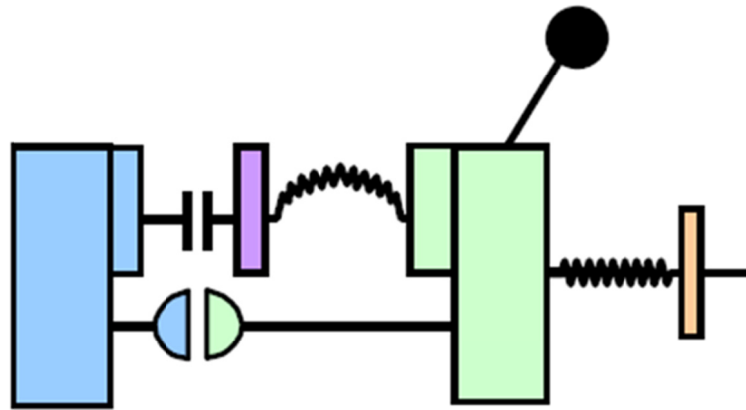
83. As shown along the top of Reik's circuit diagram, torque goes through the lockup clutch (blue) to the purple input of the first damper, then through the green disk components to the second damper and out the output (orange). (Ex. 1106, 512; Ex. 1115, 35.) Thus, it is my opinion that Reik anticipates element 1[f].

**Claim 1[g]: the second damper stage (15) is disposed between the turbine (7) and the output hub (12) and**

84. As noted above, the '374 patent describes two torque paths.

Claim 1(g) describes the second torque path, *i.e.*, where torque passes through the second damper stage 15 when transferred from the turbine 7 to the output hub 12

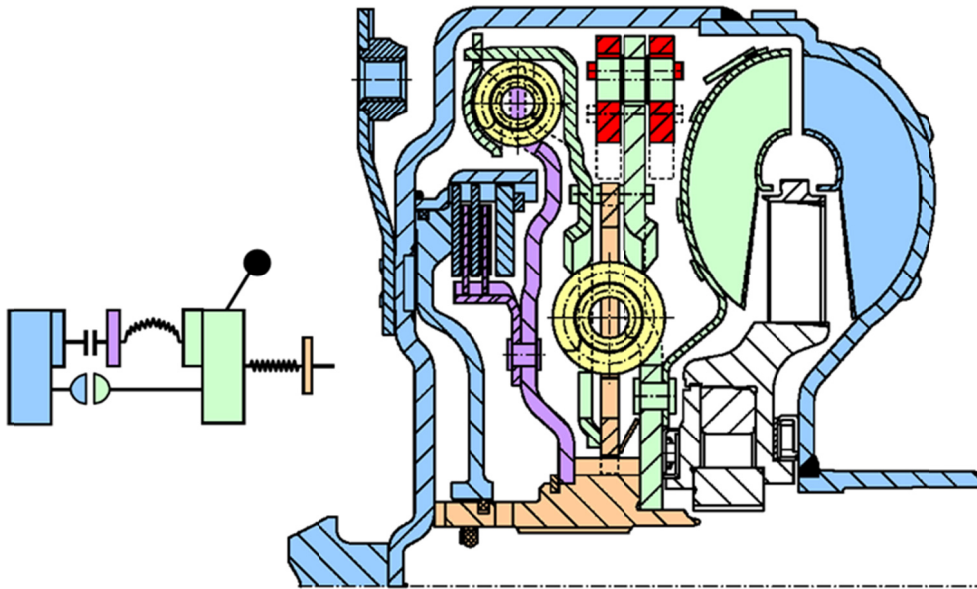
85. Reik embodies torque paths similar to those described in the '374 patent. (Ex. 1106, 512; Ex. 1115, 35.)



86. As shown along the bottom of Reik's circuit diagram (*see* above), torque goes through the turbine and impeller (blue and green semi-circles), then to the green disk components and through the turbine damper and out the output (orange). Thus, it is my opinion that Reik anticipates element 1[g].

**Claim 1[h]: the torsional vibration absorber (17) is parallel to both damper stages (14, 15).**

87. In Reik, the vibration absorber (masses in red) is parallel to both damper stages because it is connected to the second damper stage and does not transmit torque:



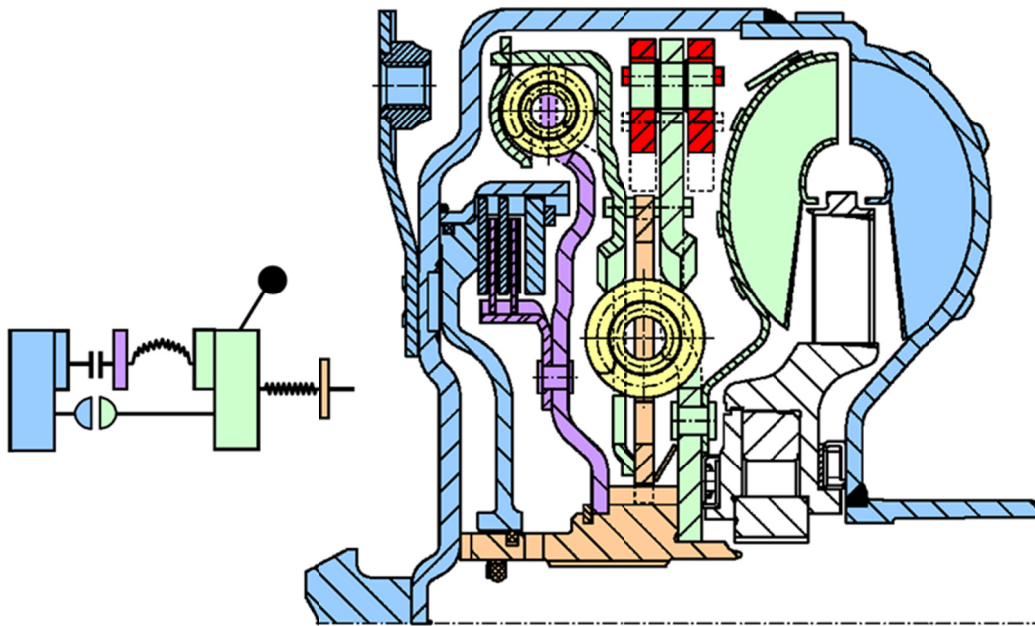
(Ex. 1106, 512; Ex. 1115, 35.)

88. Reik's circuit diagram illustrates this arrangement, with the absorber (black circle) mounted between the two damper stages, which are schematically represented by springs. Thus, it is my opinion that Reik anticipates element 1[h].

**Claim 3: The hydrodynamic torque converter (1) according to claim 1, wherein a disk part (25) is allocated to two damper stages (14, 15) as one piece.**

89. Claim 3 requires that a single disk part is shared between the first and second damper stages.

90. The same relationship is depicted in Reik, with the green component shared between the first and second damper stages:



91. The green component forms the output of the first damper stage and part of the input of the second damper stage. Thus, it is my opinion that Reik anticipates claim 3.

**Claim 4[a]: The hydrodynamic torque converter (1) according to claim 1, wherein the torsional vibration absorber (17) comprises a plurality of absorber masses (39), and**

92. Reik teaches rotational-speed-adaptive vibration absorbers with multiple masses. Indeed, the description of Fig. 19 on page 512 of

Ex. 1106 refers to the “centrifugal pendulum absorber” with “pendulums,” *i.e.*, multiple masses.

93. Thus, it is my opinion that Reik anticipates element 4[a].

**Claim 4[b]: a mounting part (37) of the torsional vibration absorber (17) forms a disk part (31) of an input part (35) of the second damper stage (15).**

94. Claim 4[b] specifies that the mounting part of the torsional vibration absorber forms an input part of the second damper stage.

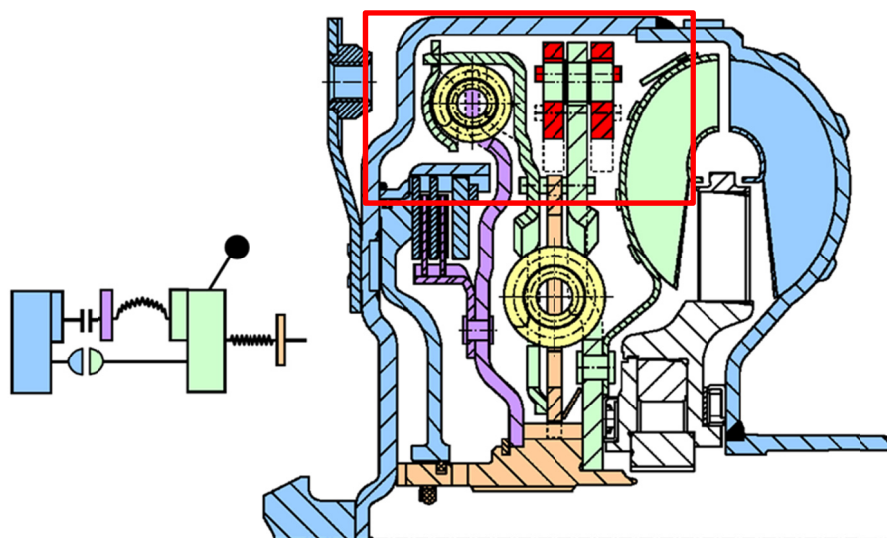
95. In Reik the torsional vibration absorber is mounted on the disk input of the second damper stage (shown in green). (Ex. 1106, 512; Ex. 1115, 35.) Thus, it is my opinion that Reik anticipates element 4[b].

**Claim 5: The hydrodynamic torque converter (1) according to claim 4, wherein absorber masses (39) of the torsional vibration absorber (17) and energy accumulators (29) of the first damper stage (14) disposed over the circumference are radially at the same height but axially spaced apart.**

96. Claim 5 specifies that the absorber masses and the springs of the first damper stage be axially spaced apart but radially at the same height, as illustrated in Fig. 1 of the '374 patent.

97. This orientation is met by Reik, shown in the red box:



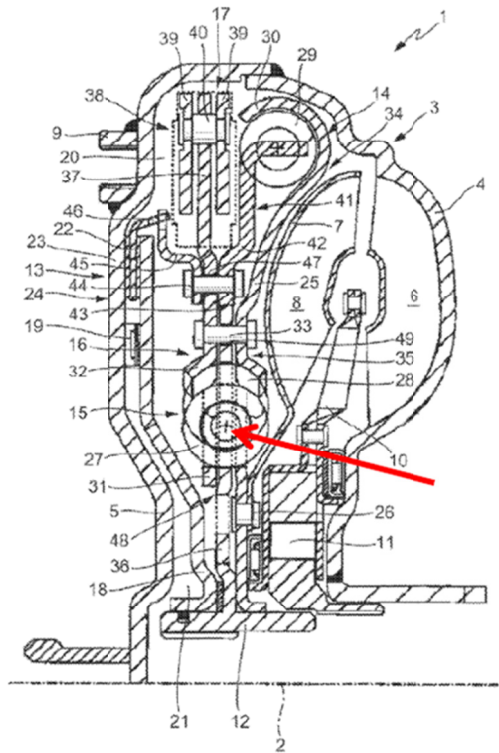


98. Thus, it is my opinion that Reik anticipates claim 5.

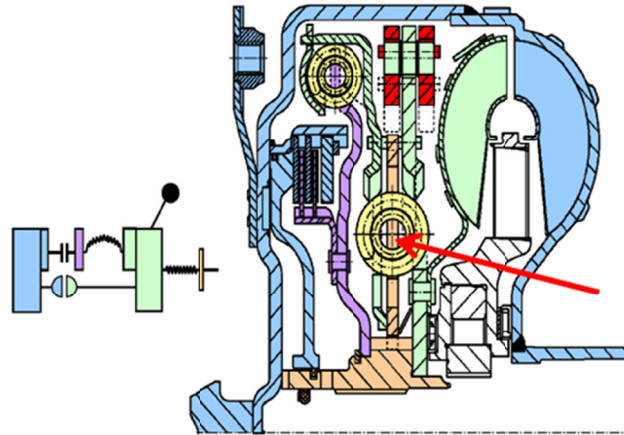
**Claim 8: The hydrodynamic torque converter (1) according to claim 1, wherein energy accumulators (27) are distributed over the circumference of the second damper stage (15) based on a middle mounting diameter radially within turbine blades (8) of the turbine (7).**

99. Claim 8 requires that the middle mounting diameter, *i.e.*, center of the springs of the second damper, be radially within (*i.e.*, radially inside) the turbine.

100. As shown in '374 Fig. 1, the central portion of the springs of the second damper are mounted below the turbine. The same relationship is depicted in Reik, annotated with red arrows illustrating the center of the springs of the second damper below the turbine:



**'374 Patent**



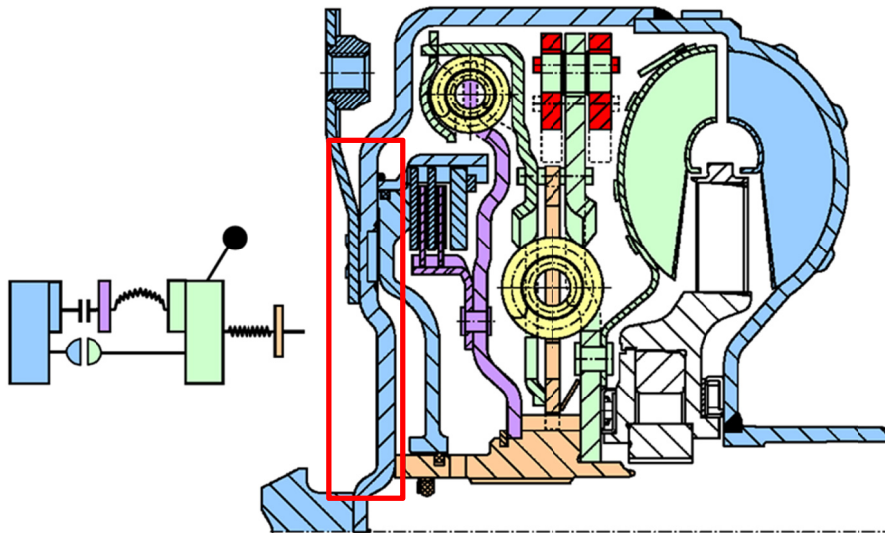
**Reik**

101. Thus, it is my opinion that Reik anticipates claim 8.

**Claim 10: The hydrodynamic torque converter (1) according to claim 1, wherein the lock-up clutch (13) in a closed state is axially mounted in a pocket (24) formed in a housing wall (23) radially inward of fastening means (9) provided on external part of the torque converter (1).**

102. Claim 10 specifies that, when closed, mounting portion of the lock-up clutch is in a pocket in the housing wall below fastening means on the housing.

103. The hydrodynamic torque converter in Reik shows part of the piston of the lock-up clutch is axially mounted in a pocket formed in the housing wall radially inside of the fastening bracket:



104. Thus, it is my opinion that Reik anticipates claim 10.

**Claim 14: The hydrodynamic torque converter (1) according to claim 1, wherein in the closed state of the lock-up clutch (13) the torsional vibration absorber (17) acts between both damper stages (14, 15).**

105. Claim 14 requires that the torsional vibration absorber act between both damper stages when the lock-up clutch is closed.

106. As shown above, in Reik, the torsional vibration absorber is disposed between the dampers at least in one force-flow direction over the damper arrangement. (Ex. 1106, 512; Ex. 1115, 35.) Reik depicts this arrangement in the circuit diagram where the absorber is

schematically shown connected between the two springs representative of the dampers. Thus, it is my opinion that Reik anticipates claim 14.

**Claim 15: The hydrodynamic torque converter (1) according to claim 1, wherein the torsional vibration absorber (17) is connected non-rotatably with the turbine (7).**

107. In Reik the mounting part of the rotational-speed-adaptive vibration absorber is connected indirectly to rotate with the turbine. (Ex. 1106, 512; Ex. 1115, 35.) Reik depicts this arrangement by coloring the mount for the absorber and the turbine shell in green. Thus, it is my opinion that Reik anticipates claim 15.

**Claim 16: The hydrodynamic torque converter (1) according to claim 1, wherein in the opened state of the lock-up clutch (13) the torsional vibration absorber (17) is connected non-rotatably with the turbine (7).**

108. In Reik the mounting part of the torsional vibration absorber is connected indirectly to rotate with the turbine when the lock-up clutch is open. (Ex. 1106, 512; Ex. 1115, 35.) Reik's circuit diagram depicts this arrangement by showing the absorber connected to a component that is the same color as the turbine. Thus, it is my opinion that Reik anticipates claim 16.

## VII. CONCLUDING STATEMENTS

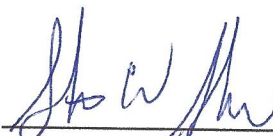
109. In signing this declaration, I understand that the declaration will be filed as evidence in a contested case before the Patent Trial and Appeal Board of the United States Patent and Trademark Office. I acknowledge that I may be subject to cross-examination in the case and that cross-examination will take place within the United States. If cross-examination is required of me, I will appear for cross-examination within the United States during the time allotted for cross-examination.

110. I declare that all statements made herein of my knowledge are true and that all statements made on information and belief are believed to be true; and further, that these statements were made with knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under 18 U.S.C. § 1101.

111. I declare under penalty of perjury under the laws of the United States of America that the foregoing is true and correct.

Executed on

12/5/2016



Steven Shaw

# APPENDIX A

Mechanical and Aerospace Engineering Department  
Florida Institute of Technology  
150 W. University Blvd.  
Melbourne, FL 32901

Phone: (321) 674-8698  
E-mail: sshaw@fit.edu

**EDUCATION**

Ph.D., Theoretical and Applied Mechanics, Cornell U., Ithaca, NY, 1983, Advisor: P. J. Holmes  
M.S.E., Applied Mechanics, U. of Michigan, Ann Arbor, MI, 1979  
A.B., Physics, U. of Michigan, Flint, MI, 1978

**PROFESSIONAL EXPERIENCE***Academic Employment*

Jan. 2016-present, Harris Professor, Department of Aerospace and Mechanical Engineering,  
Florida Institute of Technology (Florida Tech), Melbourne, FL  
2011-present, University Distinguished Professor, Department of Mechanical Engineering,  
Michigan State University (MSU), East Lansing, MI (on leave in 2016)  
2014-present, Adjunct Professor of Physics and Astronomy, MSU  
1994-2011, Professor, Department of Mechanical Engineering, MSU  
1991-93, Associate Professor, Department of Mechanical Engineering, University of Michigan  
1987-1991, Associate Professor, Department of Mechanical Engineering, MSU  
1990, Acting Associate Chairperson, Department of Mechanical Engineering, MSU  
1984-1987, Assistant Professor, Department of Mechanical Engineering, MSU  
1983-1984, Assistant Professor, School of Engineering, Oakland University, Rochester, MI

*Visiting Positions*

July-August 2008, Visiting Professor, Department of Mechanical Engineering, McGill  
University, Montreal, QC, Canada  
January-June 2004, Visiting Professor, Department of Mechanical Engineering, University of  
California-Santa Barbara, CA  
Summers 2000, 2002-05, Visiting Research Scientist, Department of Mechanical Engineering,  
University of Michigan, Ann Arbor, MI  
January-June, 1989, Visiting Associate Professor, Applied Mechanics, California Institute of  
Technology, Pasadena, CA  
July 1984, Visiting Assistant Professor, Department of Aerospace Engineering and Mechanics,  
University of Minnesota, Minneapolis, MN  
June 1983, Visiting Assistant Professor, Department of Theoretical and Applied Mechanics,  
Cornell University, Ithaca, NY

*Other Positions*

August 2015-January 2016, Research Professor, Florida Tech, Melbourne, FL  
1992-present, Vice-President and Board Member, SE Tools, Lapeer, MI (family business)  
1991-present, President, Steven W. Shaw and Associates, Inc. (consulting company)

*Consulting* (through Steven W. Shaw and Associates, Inc., unless otherwise indicated)

2016, pendulum vibration absorbers, for Valeo through Florida Tech Consulting

2015-present, technical expert, IP issues for vibration absorbers

2013, technical expert, NineSigma, machine design brainstorming

2003-2008, technical expert for legal firms on design IP issues

1984-1986, 1993-2002, consultant, Ford Motor Company, assist with the design of dynamic vibration absorbers, and analytical support for noise and vibration issues

*Teaching Experience*

dynamics, vibrations, controls, dynamical systems, design projects, engineering analysis, statics, machine design, strength of materials

*Research Interest Areas*

Fundamental: nonlinear dynamics and vibrations, exploitation of nonlinear behavior in the design of mechanical systems, nonlinear resonances, effects of noise in nonlinear oscillations

Applications: resonant micro/nano-electromechanical systems for sensing and signal processing, vibration absorbers for rotating machinery, nonlinear normal modes, mode localization, structural vibration and control, chaotic motions in mechanical systems, vibro-impact dynamics, mechanism dynamics, vehicle dynamics and stability

**HONORS AND AWARDS**

N. O. Myklestad Award, ASME Design Division, "Presented in recognition of a major innovative contribution to vibration engineering," 2013

Promoted to University Distinguished Professor, MSU, 2011

University Distinguished Faculty Award, MSU, 2008

Withrow Distinguished Senior Scholar Award, College of Engineering, MSU, 2002

Certificate of Appreciation, "Rattle Severity Detection Using Spectral Data," Intellectual Property Group, Visteon Corporation, 2000

Arch T. Colwell Merit Award, SAE, 1997, for the paper marked + in the publication list below.

Fellow, ASME, elected 1995

Westinghouse Distinguished Lecturer, Department of Mechanical Engineering and Applied Mechanics, University of Michigan, Ann Arbor, MI, September, 1990

Henry Ford Customer Satisfaction Award, Ford Motor Company, with 5 others, for

"Development of CAE Tools for Squeak and Rattle Prevention," 1986

Henry Hess Award, ASME, for the two -part paper marked \* in the publication list below, for best paper by an author under 31 years of age, 1986

James B. Angell Scholar, College of Literature Science & Arts, U. of Michigan, 1976, 1978

**SPECIAL LECTURES**

Advanced School, 6 lectures for The Art of Modeling Mechanical Systems, International Centre for Mechanical Sciences (CISM), Udine, Italy, 2015

Invited Tutorial, "Nonlinear Modal Interactions," IMAC XXXIII and XXXIV, Orlando, FL, 2015, 2016

N. O. Myklestad Award Keynote Lecture, 25th ASME Conference on Vibration and Noise, IDETC,



Portland, OR, 2013  
 Keynote Lecture, 1st Annual Review Meeting for EPSRC Project: Engineering Nonlinearity, Jesus College, Cambridge University, UK, 2013  
 Keynote Lecture, AUTOMATION 2012, Chang Gung University, Taiwan, 2012  
 Keynote Lecture, 24th ASME Conference on Vibration and Noise, IDETC, Chicago, IL, 2012  
 Keynote Lecture, 4th International Conference on Localization, Energy Transfer and Nonlinear Normal Modes in Mechanics and Physics, Haifa, Israel, 2012  
 Advanced School, 6 lectures for Modal Analysis of Nonlinear Mechanical Systems, International Centre for Mechanical Sciences (CISM), Udine, Italy, 2012  
 Plenary Lecture, International Modal Analysis Conference XXVIII, Jacksonville, FL, 2010  
 Advanced School, 6 lectures for Exploiting Nonlinear Behaviour in Structural Dynamics, CISM, Udine, Italy, 2010  
 Keynote Lecture, First ASME Dynamic Systems and Control Conference, Ann Arbor, MI, 2008  
 Symposium Invited Speaker, First ASME Conference on Smart Materials, Adaptive Structures, and Intelligent Systems, Symposium on Nonlinear Dynamics and Passive/Adaptive Controls, Ellicott City, MD, 2008  
 Symposium Invited Speaker, 42<sup>nd</sup> Meeting, Society of Engineering Science, Symposium on Nonlinear Localization and Targeted Energy Transfer Phenomena in Dynamical Systems, Champaign-Urbana, IL, 2008  
 Plenary Lecture, Advanced Problems in Mechanics – APM2008, St. Petersburg, Russia, 2008  
 Engineer's Edge Learning Series, Chrysler Technology Center, Auburn Hills, MI, joint with A. G. Haddow and B. Geist, 2007  
 Keynote Lecture, 2nd International Conference on Nonlinear Normal Modes and Localization in Vibrating Systems, Samos, Greece, 2006  
 Symposium Invited Speaker, Minisymposium on Reduced-Order Modeling, Fifth Euromech Nonlinear Dynamics Conference, ENOC2005, Eindhoven, 2005  
 Keynote Lecture, JSME Minisymposium on Nonlinear Dynamics and Chaos in Mechanical Systems, Tokyo, Japan, 2001  
 Keynote Lecture, IUTAM Symposium on Nonlinear Dynamics and Chaos in Mechanics, Ithaca, NY, 1997  
 Inaugural Sethna Lecture, Department of Aerospace Engineering and Mechanics, University of Minnesota, Minneapolis, MN, 1994  
 Westinghouse Distinguished Lectures, Department of Mechanical Engineering and Applied Mechanics, two lectures, University of Michigan, Ann Arbor, MI, September, 1990  
 Chaos: Applications in Engineering and Science, one of six invited speakers for a one-day Workshop at University College London, 1990

## **PROFESSIONAL AFFILIATIONS AND ACTIVITIES**

### *Society Memberships*

The American Society of Mechanical Engineers (ASME), 1982-present  
 The Society for Experimental Mechanics, 2011-present  
 The Society for Industrial and Applied Mathematics (SIAM), 1983-2000, 2009-2013  
 The Society of Automotive Engineers (SAE), 1995-2010  
 The American Academy of Mechanics (AAM), 1983-2002

### *Professional Committee Activities*

Member, Steering Committee, EPSRC Engineering Nonlinearity Grant; oversight of a £4.5M grant  
Involving five universities and eight companies in the UK, 2013-2017  
Member, Technical Committee on Vibration and Sound, Design Division, ASME, 2006-2012  
Vice Chair, SIAM Dynamical Systems Activity Group, 2010-2011

### *Editorial Service*

Associate Editor, *SIAM Journal on Applied Dynamical Systems*, 2012-present  
Contributing Editor, *Nonlinear Dynamics*, Springer, 1990-present  
Associate Technical Editor, *Journal of Vibration and Acoustics*, 2008-2014  
Editorial Board, *Communications in Nonlinear Science and Numerical Simulation*, Elsevier  
Science, 2001-2009  
Editorial Board, *Journal of Sound and Vibration*, Academic Press, 1995-2007  
Editorial Board, *Archive of Applied Mechanics*, Springer-Verlag, 1997-2003  
Editorial Advisory Board, *Encyclopedia of Vibration*, Academic Press, appeared in 2001  
Editorial Board, *Dynamics and Stability of Systems*, Carfax, 1995-2000  
Editorial Board, *International Journal of Bifurcation and Chaos*, World Scientific, 1992-98  
Associate Technical Editor, *Journal of Applied Mechanics*, ASME, 1994-97

### *Paper Refereeing*

*Journal of Applied Physics; IEEE Transactions on Mechatronics; SIAM Journal on Applied Dynamical Systems; Experimental Mechanics; Journal of Engineering Mathematics; Mechanics Research Communications; Sensors and Actuators A: Physical; Electron Device Letters; Journal of Physics A: Mathematical and Theoretical; Journal of Physics: Condensed Matter; Journal of Microelectromechanical Systems (JMEMS); Journal of Micromechanics and Microengineering (JMM); ASME Journal of Vibration and Acoustics; ASME Journal of Computational and Nonlinear Dynamics; International Journal of Bifurcation and Chaos; Journal of Guidance, Control, and Dynamics; Journal of Nonlinear Science; Nonlinear Dynamics; Physica D; Journal of Sound and Vibration (JSV); ASME Journal of Dynamic Systems, Measurement and Control; ASME Journal of Applied Mechanics; Physics of Fluids; International Journal of Solids and Structures; Journal of Fluids and Structures; Meccanica; IEEE Transactions on Circuits and Systems; SIAM Journal on Applied Mathematics; Dynamics and Stability of Systems; International Journal of Mechanical Sciences; Journal of Vibration and Control; Proceedings of the Royal Society; Mechanism and Machine Theory; ASME Journal of Engineering for Gas Turbines and Power; Journal of Ship Research; several ASME Conferences.*

### *Proposal Reviewing*

National Science Foundation (regularly), Army Research Office, Michigan Sea Grant Program, Science and Engineering Research Council-UK, US National Research Council, AFOSR, Australian Research Council, Ohio Board of Regents

### *Outreach*

High School Engineering Institute, Organizer/ Lecturer, Mechanical Engineering Section, 2005, 2007-09, 2012-15  
Spartan Engineering Teens, Organizer/Lecturer, Mechanical Engineering Section, 2011, 2016  
High School Engineering Exploration, Organizer/Lecturer, Mechanical Engineering Section, 2010

### *University Service*

Chairperson's Advisory Committee, MSU, 1988-91, 1994-97, 2003-07, 2010-15  
Departmental/College Rating Committees, MSU, 1989-91, 1994-2002, 2004-15  
College Rating Committee (for P&T), Chair, 2014  
Departmental Chairperson Search Committee, Chair, 2009-10  
Undergraduate Curriculum Committee, MSU, 1986-87, 1989, 1999-2001, 2008-09 (Chair)  
Faculty Search Committees, MSU, chair of successful search for 4 new faculty members, 2007  
Graduate Studies Committee, MSU, 1985-1991, 1996-98; chair, 1987-88, 1998-2002  
Chair, Individual Reappointment/Promotion Committees; UM, 1991-93; MSU, 1994-2005  
Co-Organizer, Mechanical Engineering Seminar Series, MSU, 1985-86, 1999-2002  
Departmental Graduate Advisor, MSU, 1996-98  
Chairperson's Advisory Committee, UM, 1993  
Search Committee for Vice President of Research and Graduate Studies, MSU, 1987-90  
Graduate Council, Oakland University, 1983-84

### *Professional Service*

Co-organizer, with L. Rensen, Minisymposium, "Nonlinear Modes and Modal Interactions," IMAC XXXIV A Conference and Exposition on Structural Dynamics, Orlando, 2016  
Scientific Committee Member, Sixth International Conference on Nonlinear Vibrations, Localization and Energy Transfer. Liège, Belgium, 2016  
Panel Member, "Present and Future Challenges in Nonlinear Dynamics and Vibrations: From Theory to Design," IDETC, Boston, 2015  
Member, NSF Committee on *Research Needs & Open Questions in Vibration Energy Transport & Dissipation*, A. Akay, Chair, 2015-16  
Co-organizer, with K. Spak, Minisymposium, "Nonlinear Modal Interactions," IMAC XXXIII A Conference and Exposition on Structural Dynamics, Orlando, 2015  
Co-organizer, with Jeff Rhoads, Minisymposium, "Applications of Resonance," USNCTAM, East Lansing, MI, 2014  
Co-organizer, with Jeff Rhoads and Mohammad Younis, Minisymposium on "Micro- and Nano-Electro-Mechanical Systems," European Conference on Nonlinear Oscillations, Vienna, 2014  
Co-Organizer, with J. Moehlis and W. Lacarbona, Symposium on Design of Dynamic Structures, Devices, and Systems, 1st ASME Dynamics for Design Conference (DFD), 2012  
Organizing Committee, SIAM Conference on Applications of Dynamical Systems, 2011  
Co-Organizer and Co-Chair, Funding Panel Session, SIAM Conference on Applications of Dynamical Systems, 2011  
Program Committee, ASME Dynamic Systems and Control Conference, 2008, 2009  
Scientific Committee, Symposium on Mechanics of Slender Structures (MoSS), University of Maryland, Baltimore County 2008  
Co-Organizer, with O. Gottlieb, Min-symposium on "Nonlinear dynamics in nano- and micro-electromechanical systems," Sixth Euromech Conference on Nonlinear Vibrations, St. Petersburg, Russia, 2008  
Organizing Committee, ASME International Conference on Micro and Nanosystems, 2007  
ASME IDETC, September, Las Vegas, NV  
Scientific Committee, The 2nd International Conference on Nonlinear Dynamics: KhPI 2007, in

honor of Alexander Lyapunov 150th Anniversary. National Technical University, Polytechnical Institute, Kharkov, Ukraine, 2007

Scientific Committee, International Conference on Material Theory and Nonlinear Dynamics, Hanoi, Vietnam, 2007

Organizing Committee, International Workshop on Applied Dynamical Systems – Mechanics, Turbulence, Knots, Cockroaches, and Chaos, Montreal, 2005

Co-Organizer, with O. Gottlieb, Min-symposium on “Nonlinear dynamics in nano- and micro-electromechanical systems,” Fifth Euromech Conference on Nonlinear Vibrations, Eindhoven, 2005

Co-Organizer, with K. Turner and J. Moehlis, Mini-Symposium on “Nonlinear Dynamics of MEMS,” SIAM Conference on Dynamical Systems, Snowbird, UT, 2005

Co-Organizer, with O. Gottlieb and K. Turner, Symposium on “Nonlinear dynamics, bifurcations and chaos in nano- and micro-electromechanical systems,” 19th Biennial ASME Conference on Mechanical Vibration and Noise, Chicago, 2003

Co-Organizer, with C. Pierre, Symposium on “Nonlinear Normal Modes and Localization,” 18th Biennial ASME Conference on Mechanical Vibration and Noise, Pittsburgh, 2001

Co-Organizer, with C. Pierre, Symposium on “Nonlinear Normal Modes and Localization,” 17th Biennial ASME Conference on Mechanical Vibration and Noise, Las Vegas, 1999

Scientific Organizing Committee, IUTAM Symposium on Unilateral Multi-body Dynamics, Munich, August, 1998

Co-Organizer, with C. Pierre, Symposium on “Mode Localization and Nonlinear Normal Modes,” 16th biennial ASME Conference on Mechanical Vibration and Noise, Sacramento, CA, 1997

Organizing Committee, Asia-Pacific Vibration Conference, held in Kitakyushu, Japan, November 14-18, 1993

Scientific Organizing Committee, IUTAM Symposium on Nonlinearity and Chaos in Engineering Dynamics, London, July 19-23, 1993

Co-Organizer and Chair, Invited Symposium on Nonlinear Dynamics, ASME Summer Meeting, Columbus, OH 1991

Session Chair, International Conference on Bifurcation and Chaos, Wurzburg, Germany, 1990

Organizer and Chair, Invited Mini-symposium on Nonlinear Mechanical Systems, SIAM Conference on Dynamical Systems, Orlando, FL 1990

Session Chair, Dynamics, Society of Engineering Science Meeting, Ann Arbor, MI, 1989.

Session Co-Chair, Chaotic Dynamics, IUTAM Symposium on Nonlinear Dynamics in Engineering Systems, Stuttgart, West Germany, 1989

Organizer, with F. Moon (Cornell) and R. Miller (USC), Symposium on Nonlinear Dynamics and Chaos, ASME/ASCE Mechanics Conference, San Diego, CA, 1989

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C. Cassella, S. Strachan, S. W. Shaw, and G. Piazza, "Phase Noise Suppression through Parametric Filtering," submitted to *Applied Physics Letters*.

L. L. Li, P. M. Polunin, S. Dou, O. Shoshani, B. S. Strachan, J. S. Jensen, S. W. Shaw, and K. L. Turner, "Tailoring the Nonlinear Response of MEMS Resonators Using Shape Optimization," submitted to *Applied Physics Letters*

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S. W. Shaw, M. A. Acar, B. F. Feeny, B. K. Geist, "Vibration Modes and Resonances for Flexible Rotating Shafts with Centrifugal Pendulum Vibration Absorbers," 15th International Symposium on Transport Phenomena and Dynamics of Rotating Machinery, ISROMAC-15, Honolulu, 2014

C. Shi, R. G. Parker, S. W. Shaw, "Vibration Response of Rotor Systems with Centrifugal Pendulum Vibration Absorbers Under Gravitational Loading," extended abstract, 15th International Symposium on Transport Phenomena and Dynamics of Rotating Machinery, ISROMAC-15, Honolulu, 2014

S. W. Shaw, M. A. Acar, B. F. Feeny, B. K. Geist, "Vibration Modes and Resonances for Flexible Rotating Shafts with Centrifugal Pendulum Vibration Absorbers," extended abstract, IMAC XXXII A Conference & Exposition On Structural Dynamics, Orlando, FL, 2014

B. Vidmar, S. Shaw, and B. Feeny, "Experimental Investigation of Multiple Order Centrifugal Pendulum Vibration Absorbers," paper DETC2013-12688, *Proceedings of the ASME 2013 International Design Engineering Technical Conferences & Computers and Information in Engineering Conference*, Portland, OR, 2013

C. Shi, R. Parker, and S. Shaw, "Optimal Tuning of Centrifugal Pendulum Vibration Absorbers," paper DETC2013-12449, *Proceedings of the ASME 2013 International Design Engineering Technical Conferences & Computers and Information in Engineering Conference*, Portland, OR, 2013

S. W. Shaw and B. S. Strachan, "Exploiting Nonlinear Modal Interactions in MEMS," paper #359, extended abstract, *International Modal Analysis Conference*, Garden Grove, CA, 2013

S. W. Shaw, "Designing Nonlinear Torsional Vibration Absorbers," Chapter 4 in *Exploiting Nonlinear Behavior in Structural Dynamics*, pages 135-169, CISM International Centre for Mechanical Sciences, Vol. 536, D. Wagg and L. Virgin (Eds.), 2012

N. J. Miller, P. Polunin, M. I. Dykman, and S. W. Shaw, "The Balanced Dynamical Bridge: Detection and Sensitivity to Parameter Shifts and Non-Gaussian Noise," paper DETC2012-70318, *Proceedings of the ASME 2012 International Design Engineering Technical Conferences & Computers and Information in Engineering Conference*, Chicago, IL, 2012

B. J. Vidmar, S. W. Shaw, B. F. Feeny, and B. K. Geist, "Analysis and Design of Multiple Order Centrifugal Pendulum Vibration Absorbers," paper DETC2012-71074, *Proceedings of the ASME 2012 International Design Engineering Technical Conferences & Computers and Information in Engineering Conference*, Chicago, IL, 2012

B. J. Vidmar, S. W. Shaw and B. F. Feeny, "Nonlinear Interactions in Systems of Multi-Order Torsional Vibration Absorbers," *Proceedings of the 14<sup>th</sup> International Symposium on Transport and Dynamics of Rotating Machinery*, Honolulu, HA, 2012

S. W. Shaw, N. J. Miller, M. I. Dykman, C. Burgner and K. L. Turner, "Dynamic Bifurcations with Loss of Local Stability in the Presence of Noise," Abstract, *SIAM Conference on Applications of Dynamical Systems*, Snowbird, UT, 2011

B. S. Strachan and S. W. Shaw, "Subharmonic Resonance Cascades in a Class of Coupled Resonators," paper DETC2011-48599, *Proceedings of the ASME 2011 International Design Engineering Technical Conferences & Computers and Information in Engineering Conference*, Washington, DC, 2011

R. J. Monroe and S. W. Shaw, "Nonlinear Transient Dynamics of Pendulum Torsional Vibration Absorbers," paper DETC2011-48353, *Proceedings of the ASME 2011 International Design Engineering Technical Conferences & Computers and Information in Engineering Conference*, Washington, DC, 2011

C. Burgner, K. Turner, N. Miller and Steven Shaw, "Noise Squeezing Control for Bifurcation Detection Sensing in MEMS," paper DETC2011/MNS-47461, *Proceedings of the ASME 2011 International Design Engineering Technical Conferences & Computers and Information in Engineering Conference*, Washington, DC, 2011



K. L. Turner, C. Burgner, Z. Yie, S. W. Shaw, N. J. Miller, "Nonlinear dynamics of MEMS systems," proceedings of the INTERNATIONAL CONFERENCE ON APPLICATIONS IN NONLINEAR DYNAMICS (ICAND 2010); doi:10.1063/1.3574849, American Institute of Physics Conference Series, Volume 1339, pp.111-113, 2011

C. Burgner, K. Turner, N. Miller, Steven Shaw, and M. Dykman, "Parameter Sweep Strategies for Sensing Using Bifurcations in MEMS," Paper 201, *Hilton Head, 2010: A Solid State Sensor, Actuator, and Microsystems Workshop*; Hilton Head, SC, 2010

Z. Yie, K.L. Turner, N.J. Miller, and S. W. Shaw, "Sensitivity Enhancement Using Parametric Amplification in Resonant Sensing Array," Paper 95, *Hilton Head, 2010: A Solid State Sensor, Actuator, and Microsystems Workshop*; Hilton Head, SC, 2010

N. Miller, C. Burgner, M. Dykman, S. Shaw, and K. Turner, "Fast estimation of Bifurcation Conditions using Noisy Response Data," Proceedings of *the SPIE*, Vol. 7647, 7647-23, 2010

J. Portman, M. Khasin, S. W. Shaw, M. I. Dykman, "The spectrum of an oscillator with fluctuating mass and nanomechanical mass sensing," Abstract: V14.00010, APS March Meeting, 2010

S. Gozin, B. J. Olson, C. Pierre, and S. W. Shaw, "Resonance Suppression in Multi-DOF Cyclic Systems Using Order-Tuned Absorbers," *The 2009 ASME International Design Engineering Technical Conferences, DETC2009-86287, 22<sup>nd</sup> Biennial Conference on Mechanical Vibration and Noise*, San Diego, CA, 2009

R. Monroe, S. W. Shaw, B. Geist, and A. G. Haddow, "Accounting for Roller Dynamics in the Design of Bifilar Torsional Vibration Absorbers" *The 2009 ASME International Design Engineering Technical Conferences*, Paper DETC2009-87431, *22<sup>nd</sup> Biennial Conference on Mechanical Vibration and Noise*, San Diego, CA, 2009.

J. F. Rhoads, S. W. Shaw, and K. L. Turner, "Nonlinear Dynamics and its Applications in Micro- and Nano-resonators," invited keynote paper, Paper DSC2008-254, *Proceedings of the ASME Dynamic Systems and Controls Conference*, Ann Arbor, 2008.

J. Issa, R. Mukherjee, and S. W. Shaw, "Control of Space Structures Using Cable Actuators," Paper DSC2008-009, *Proceedings of the ASME Dynamic Systems and Controls Conference*, Ann Arbor, 2008.

N. J. Miller and S. W. Shaw, "Frequency Sweeping with Concurrent Parametric Amplification," Paper DSC2008-118, *Proceedings of the ASME Dynamic Systems and Controls Conference*, Ann Arbor, 2008.

B. E. DeMartini, M. A. Zielke, K. G. Owen, K. L. Turner, J. F. Rhoads, and S. W. Shaw, "Detection and Identification of Multiple Chemicals Using a Single Input-Single Output Coupled Microresonator Array," Extended Abstract, *International Workshop on Nanomechanical Cantilever Sensors*, Max Planck Institute for Polymer Research, Mainz, Germany, 2008.

J. F. Rhoads and S. W. Shaw, "Effects of Nonlinearity on Parametric Amplifiers," *Proceedings of the 2008 ASME IDETC*, Paper DETC2008-49594, Brooklyn, NY, 2008.

B. J. Olson and S. W. Shaw, "Vibration Absorbers for Cyclic Rotating Flexible Structures: Linear and Nonlinear Tuning," Paper SMASIS08-632, *Proceedings of the ASME 2008 Conference on Smart Materials, Adaptive Structures, and Intelligent Systems*, Baltimore, 2008.

N. J. Miller, S. W. Shaw, L. A. Oropeza-Ramos, and K. L. Turner, "Analysis of a Novel MEMS Gyroscope Actuated by Parametric Resonance," *Proceedings of the Sixth EUROMECH Nonlinear Dynamics Conference* (ENOC 2008), St. Petersburg, Russia, 2008.

N. Miller, S. Shaw, L. Oropeza-Ramos, and K. Turner, "A MEMS-Based Rate Gyroscope Based on Parametric Resonance," Paper ESDA08-59567, *Proceedings of the 9th Biennial ASME Conference on Design and Analysis*, Haifa, Israel, 2008.

S. W. Shaw, M. Orlowski, A. Haddow, and B. Geist "Transient Dynamics of Centrifugal Pendulum Vibration Absorbers," Paper 2008-20119, *Twelfth International Symposium on Transport Phenomena and Dynamics of Rotating Machinery* (ISROMAC-12), Honolulu, Hawaii, February, 2008.

J. F. Rhoads, N. J. Miller, S. W. Shaw, and B. F. Feeny. "Mechanical Domain Parametric Amplification," Paper DETC2007-35426, *IDETC/CIE 2007: The 2007 ASME International Design Engineering Technical Conferences, 6th International Conference on Multibody Systems, Nonlinear Dynamics, and Control*. Las Vegas, Nevada, 2007.

B. DeMartini, J. Rhoads, S. Shaw, K. Turner, "A Resonant SISO Sensor Based on a Coupled Array of Micromechanical Oscillators," *Hilton Head, 2006: A Solid State Sensor, Actuator, and Microsystems Workshop*; Hilton Head, SC, 2006.

J. Rhoads, B. DeMartini, S. Shaw, K. Turner, "A SISO, Multi-Analyte Sensor Based on a Coupled Micromechanical Array," *Proceedings of the 2006 ASME IMECE*, Chicago, 2006.

S. W. Shaw, B.J. Olson, and C. Pierre, "Order-Tuned and Impact Vibration Absorbers for Rotating Flexible Structures," *Eleventh International Symposium on Transport Phenomena and Dynamics of Rotating Machinery* (ISROMAC-11), Honolulu, Hawaii, March, 2006.

B. E. DeMartini, J. Moehlis, K. L. Turner, J. F. Rhoads, S. W. Shaw, and W. Zhang, "Modeling of Parametrically Excited Microelectromechanical Oscillator Dynamics with Application to Filtering," Paper PID134530, *IEEE Sensors 2005, 4<sup>th</sup> IEEE Conference on Sensors*, Irvine, CA, 2005.

B. J. Olson, S. W. Shaw, and C. Pierre, "Order-Tuned Vibration Absorbers for Cyclic Rotating Flexible Structures," Paper DETC2005-84641, *Proceedings of the 20th Biennial Conference on Mechanical Vibration and Noise*, Long Beach, California, 2005.

J. F. Rhoads, S. W. Shaw, K. L. Turner, J. Moehlis, B. E. DeMartini, and W. Zhang. "Nonlinear Response of Parametrically-Excited MEMS," Paper DETC2005-84603, *Proceedings of the 20th Biennial Conference on Mechanical Vibration and Noise*. Long Beach, California, 2005.

S. S. Nudehi, R. Mukherjee, and S. W. Shaw, "Vibration Control in a Flexible Beam Using a Conservative Force," Paper IMECE2004-60783, *Proceedings of the 2004 ASME International Mechanical Engineering Conference*. Anaheim, California, 2004

B. J. Olson, S. W. Shaw, and G. Stépán, "Nonlinear Dynamics of Longitudinal Vehicle Traction," *Proceedings of the 9<sup>th</sup> Mini-Conference on Vehicle System Dynamics, Identifications and Anomalies* (Budapest, Hungary), 2004.

S. W. Shaw, T. Nester, A. Haddow, and P. Schmitz, "Experimental Observations of Centrifugal Pendulum Vibration Absorbers," *Tenth International Symposium on Transport Phenomena and Dynamics of Rotating Machinery* (ISROMAC-10), Honolulu, Hawaii, March, 2004.

S. W. Shaw, K. L. Turner, J. F. Rhoads, and R. Baskaran, "Parametrically Excited MEMS-Based Filters," *Proceedings of the IUTAM Symposium on Chaotic Dynamics and Control of Systems and Processes in Mechanics*, 137-146. Rome, Italy: Springer. 2003.

T.M. Nester, A. G. Haddow, and S. W. Shaw. "Experimental Investigation of a System of Nearly-Identical Centrifugal Pendulum Vibration Absorbers," *Proceedings of the 19<sup>th</sup> Biennial Conference on Mechanical Vibration and Noise*, Paper DETC/2003-48410, Chicago, September 2003.

D. Jiang, C. Pierre, and S. W. Shaw. "Nonlinear Normal Modes for Vibratory Systems Under Periodic Excitation," *Proceedings of the 19<sup>th</sup> Biennial Conference on Mechanical Vibration and Noise*, Paper DETC/2003-48443, Chicago, September 2003.

P. Apiwattanalungarn, S. W. Shaw, and C. Pierre. "Component Mode Synthesis Using Nonlinear Normal Modes," *Proceedings of the 19<sup>th</sup> Biennial Conference on Mechanical Vibration and Noise*, Paper DETC/2003-48441, Chicago, September 2003.

T.M. Nester, A. G. Haddow, S. W. Shaw, J.E. Brevick, and V.J. Borowski. "Vibration Reduction in Variable Displacement Engines Using Pendulum Absorbers," Paper 2003-01-1484 *Proceedings of the SAE Noise and Vibration Conference and Exhibition*, Traverse City, MI, 2003.

T.M. Nester, S. W. Shaw, A. G. Haddow, and J.E. Brevick. "Centrifugal Pendulum Vibration Absorbers in Variable Displacement Engines." Abstract, *Ninth Conference on Nonlinear Vibrations, Stability, and Dynamics of Structures*. Blacksburg, VA, July 28-August 1, 2002.

D. Jiang, C. Pierre, and S. W. Shaw, "The Construction of Nonlinear Normal Modes for Systems with Internal Resonance: Application to Rotating Beams," Abstract, *Ninth Conference on Nonlinear Vibrations, Stability, and Dynamics of Structures*. Blacksburg, VA, July 28-August 1, 2002.

M. Legrand, D. Jiang, C. Pierre, and S. W. Shaw, "Nonlinear Normal Modes of a Rotating Shaft Based on the Invariant Manifold Method," *Ninth International Symposium on Transport Phenomena and Dynamics of Rotating Machinery* (ISROMAC-9), Honolulu, Hawaii, February 10-14, 2002.

A. Haddow and S. W. Shaw, "An Experimental Study of Torsional Vibration Absorbers," *Proceedings of the 18<sup>th</sup> Biennial Conference on Mechanical Vibration and Noise*, ASME Paper DETC2001/VIB-21754,

Pittsburgh, Pennsylvania, September 9-12, 2001.

D. Jiang, V. Soumier, C. Pierre, and S. W. Shaw. "Large amplitude nonlinear normal modes of piecewise linear systems," *Proceedings of the 18<sup>th</sup> Biennial Conference on Mechanical Vibration and Noise*, ASME Paper DETC2001/VIB-21734, Pittsburgh, Pennsylvania, September 9-12, 2001.

A. Haddow and S. W. Shaw, "Torsional Vibration Absorbers: A Testing and Evaluation Apparatus," *Proceedings of SAE Noise and Vibration Conference*, SAE Paper 2001-01-1577, 2001.

S. W. Shaw, "Perturbation Techniques for Nonlinear Systems," *Encyclopedia of Vibration*, Academic Press, pp. 1009-1011, 2001.

S. W. Shaw, Questions for Structural Dynamics 2000, *Structural Dynamics 2000: current status and future directions*, pp. 469-470, D.J. Ewins and D.J. Inman, eds., Research Studies Press, Ltd., 2001.

B. J. Olson, S. W. Shaw, and G. Stépán, "A Nonlinear Model for Vehicle Braking," in the *Eighth Conference on Nonlinear Vibrations, Stability, and Dynamics of Structures*, (Blacksburg, VA), Jul 23-27, 2000.

S. W. Shaw and A. Alsuwaiyan, "Torsional Vibration Reduction Using Passive Nonlinear Absorbers," *Proceedings of the SPIE Conference on Smart Structures*, Newport Beach, CA, March, 2000.

F. Salam, H. Khalil, C. Radcliffe, and S. Shaw, "Development of a Course Sequence in Sensing and Control for Automotive Systems," *Proceedings of the Conference on Decision and Control*, 1999.

H. Khalil and S. W. Shaw, "Classical Stability Theory: Nonlinear," *Wiley Encyclopedia of Electrical and Electronics Engineering*, Volume 20, 390-398, 1999.

S. W. Shaw and C. Pierre, "Invariant Manifolds and Model Reduction in Nonlinear Systems," *Applied Mechanics in the Americas*, Volume 8, Dynamics, 1597-1600, 1999.

E. Pesheck, C. Pierre and S. W. Shaw, "Model Reduction of a Nonlinear Rotating Beam Through Nonlinear Normal Modes," paper DETC99/VIB-8074, Proceedings 1999 ASME Design Engineering Technical Conferences (to appear on CD-ROM).

C. P. Chao and S. W. Shaw, "Dynamically Stable Non-Linear Modes of Multiple Subharmonic Torsional Vibration Absorbers," paper DETC99/VIB-8073, Proceedings 1999 ASME Design Engineering Technical Conferences (to appear on CD-ROM).

A. Alsuwaiyan and S. W. Shaw, "Steady-State Synchronous and Localized Responses of Tuned Pendulum Vibration Absorbers," paper DETC99/VIB-8014, Proceedings 1999 ASME Design Engineering Technical Conferences.

A. Alsuwaiyan and S. W. Shaw, "Stability Limitations for Multiple Centrifugal Pendulum Vibration Absorbers," paper DETC99/VIB-8055, Proceedings 1999 ASME Design Engineering Technical Conferences.

S. W. Shaw, C.P. Chao and C.T. Lee, "Nonlinear Dynamics and the Design of Tuned Pendulum Vibration

Absorbers," *Proceedings of the IUTAM Symposium on Applications of Nonlinear and Chaotic Dynamics in Mechanics*, 223-234, edited by F. C. Moon. Kluwer, 1998.

S. W. Shaw and B. F. Feeny, "Nonlinear Dynamics with Impacts and Friction," *Dynamics and Chaos in Manufacturing Processes*, Chapter 9, 241-264, edited by F.C. Moon. Wiley Interscience, 1998,

Y. Wang, C.P. Chao, and S. W. Shaw, "Design of Pendulum Vibration Absorbers for the Attenuation of Transverse Vibrations in Rotating Beams," with, paper DETC97/VIB-4182, Proceedings 1997 ASME Design Engineering Technical Conferences, 1997.

S. R. Hsieh, S. W. Shaw, J. Her and V. Borowski "Rattle Reduction of Automotive Components - An FEM Approach," paper DETC97/VIB-3928, Proceedings 1997 ASME Design Engineering Technical Conferences 1997.

C. P. Chao and S. W. Shaw, "On the Effects of Imperfections and Mistuning on the Performance of Subharmonic Vibration Absorbers," with C.P. Chao, paper DETC97/VIB-4104, Proceedings 1997 ASME Design Engineering Technical Conferences, 1997.

C.P. Chao and S. W. Shaw, "Nonlinear Localization in Systems of Tautochronic Pendulum Vibration Absorbers," paper DETC97/VIB-3956, Proceedings 1997 ASME Design Engineering Technical Conferences, 1997.

S. L. Chen and S. W. Shaw, "Phase Space Transport in a Class of Multi-Degree of Freedom Systems," paper DETC97/VIB-4105, Proceedings 1997 ASME Design Engineering Technical Conferences, 1997.

+ "Attenuation of Engine Torsional Vibrations Using Tuned Pendulum Absorbers," with V. Garg and C.P. Chao, Paper 971961, Proceedings of the 1997 *SAE Noise and Vibration Conference and Exposition*, 1997.

"A CAE Methodology for Reducing Rattle in Structural Components," S. R. Hsieh, V. J. Borowski, J. Y. Her, S. W. Shaw, Paper 972057, Proceedings of the 1997 *SAE Noise and Vibration Conference and Exposition*, 1997.

"On the dynamics of systems with multiple centrifugal pendulum vibration absorbers - stability and bifurcation of the unison response," invited paper, with C.P. Chao, 2nd European Nonlinear Oscillations Conference, Prague, September, 1996.

"Robust Stabilization of Large Amplitude Ship Rolling in Regular Beam Seas," with S.L. Chen, H. K. Khalil and A. W. Troesch. Symposium Volume on *Nonlinear Dynamics and Control*, 1996 International Mechanical Engineering Conference and Exposition, Atlanta.

"Nonlinear Modal Analysis of the Forced Response of Structural Systems," Paper 96-1250, with N. Boivin and C. Pierre, *Proceedings of the AIAA Dynamics Specialists Conference*, Salt Lake City, UT, April 1996.

"Torsional Vibration Reduction in Internal Combustion Engines Using Centrifugal Pendulums," ASME Design Engineering Technical Conference, Volume DE-84-1, 487-492, with C.T. Lee, 1995.

"A Comparative Study of Nonlinear Centrifugal Pendulum Vibration Absorbers," *Nonlinear and Stochastic Dynamics*, ASME Volume AMD-Vol.192/DE-Vol. 78,91-98, with C.T. Lee, 1994.

"Nonlinear Dynamics and Capsizing of Small Fishing Vessels," *Proceedings of the Fifth International Conference on Stability of Ships and Ocean Vehicles*, Volume 3, with C. Jiang and A. W. Troesch, 1994.

"On the Nonlinear Dynamics of Centrifugal Pendulum Vibration Absorbers," *Proceedings of the Conference on Asymptotics in Mechanics*, with C.T. Lee, St. Petersburg, Russia, 1994.

"On the Nonlinear Dynamics of Centrifugal Pendulum Vibration Absorbers," *Smart Structures, Nonlinear Vibration and Control*, Volume 1, 247-309, A. Guran and D. J. Inman, eds., Prentice Hall, with C.T. Lee, 1995.

"Non-Linear Modal Analysis of Structural Systems Using Multi-Mode Invariant Manifolds," Paper 94-1672, with N. Boivin and C. Pierre, *Proceedings of the AIAA Dynamics Specialists Conference*, Hilton Head, SC, April 1994.

"A Predictive Method for Vessel Capsize in Random Seas," *Nonlinear Dynamics of Marine Vehicles*, ASME Volume, with S. R. Hsieh and A. W. Troesch, 1993.

Forward for Volume 4 (6) of *Nonlinear Dynamics*, pp. 527-530, in honor of the 70th birthday of Professor P. R. Sethna, with A.K. Bajaj, 1993.

"Normal Modes and Modal Analysis Techniques for Nonlinear Structural Systems," with C. Pierre, to appear in the volume, *Stochastic Modelling and Nonlinear Dynamics: Applications to Mechanical Systems*, CRC Press, N. Sri Namachchivaya and W. Klieman, eds., 1992.

"On Nonlinear Normal Modes," *Nonlinear Vibrations*, ASME Volume DE-50 (and AMD-144), pp. 1-5, R.A. Ibrahim, N.S. Namachchivaya and A.K. Bajaj (eds.), with C. Pierre, 1992, invited.

"Reducing Vibration of Reciprocating Engines with Crankshaft Pendulum Absorbers," 1991 SAE Technical Paper 911876, V. J. Borowski, H.H. Denman, D. L. Cronin, J. P. Hanisko, L. T. Brooks, D.A. Mikulec, W. B. Crum, and M.P. Anderson, 1991. Also appeared in the SAE Transactions.

"The Local Stability of Inactive Modes in Chaotic Multi-Degree-of-Freedom Systems," *International Series of Numerical Mathematics* 97, 333-342, (from the Proceedings of the Conference: Bifurcation and Chaos: Analysis, Algorithms, and Applications, Wurzburg, 1990), with S. R. Hsieh, 1991, invited.

"On Domains of Convergence in Eigenvalue Optimization Problems," *Proceedings of the Third Air Force/NASA Symposium on Recent Advances in Multidisciplinary Analysis and Optimization*, 198-203, with A. Diaz and J. Pan, 1990.

"On Domains of Convergence in Eigenvalue Optimization Problems," *Proceedings of the Second World Congress on Computational Mechanics*, Extended Abstract, International Association of Computational Mechanics, with A. Diaz, 1990.

"The Stability of Modes at Rest in a Chaotic System," Abstract, Third Conference on Nonlinear Vibrations, Stability, and Dynamics of Structures and Mechanisms, Blacksburg, VA, 1990.

"Nonlinear Interactions in Rotordynamics," Abstract, Third Conference on Nonlinear Vibrations, Stability, and Dynamics of Structures and Mechanisms, Blacksburg, VA, 1990.

"Nonlinear Interactions Between Resonance and Instability in a Symmetric Rotor," *Proceedings of the Third International Symposium on Transport Phenomena and Dynamics of Rotating Machinery*, Volume 2, 198-212, with J. Shaw, 1990, invited.

"The Suppression of Chaos in Periodically Forced Oscillators," *Nonlinear Dynamics in Engineering Systems*, W. Schielen (Ed.), 289-296 (from the IUTAM Symposium, Stuttgart), 1990, invited.

"Nonlinear Dynamics of a Rotating Shaft," *Trends in the Applications of Mathematics to Mechanics*, W. Schneider, H. Troger, and F. Ziegler (eds.), 62-70, with J. Shaw, 1991, invited.

"Nonlinear Interactions in Rotordynamics," Abstract, 26th Meeting of the Society of Engineering Science, 1989, invited.

"Chaotic Dynamics in a Class of Multi-Degree of Freedom Systems," Abstract, Applied Mechanics and Engineering Sciences Conference, 89, 1988.

"Extensions and New Applications of Melnikov's Method for Predicting the Onset of Chaos," Abstract, Second Workshop on Non-linear Vibrations, Stability and Dynamics of Structures and Mechanisms, 1988.

"The Performance of an Impact Print Hammer," *Developments in Mechanics* 14b, 826-831, with P.C. Tung, 1987.

"Experimental Response of a Single Degree of Freedom Impacting System," *Developments in Mechanics* 14b, 839-844, with D. Moore, 1987.

"The Dynamic Analysis of the Centrifugal Pendulum Vibration Absorber with Motion Limiting Stops," *Developments in Mechanics* 14b, 845-850, with M. Sharif-Bakhtiar, 1987.

"On the Effects of Asymmetries on a System Near a Codimension Two Point," *Dynamical Systems Approaches to Nonlinear Problems in Circuits and Systems*, 317-332, SIAM Publication, F. Salam and M. Levi (eds.), with P. R. Sethna.

"Chaotic Dynamics of a Rotating Beam," Abstract, AFOSR/ARO Workshop on Nonlinear Dynamics, Stability, and Dynamics at Structures and Mechanisms, 1987.

"Chaotic Motions of a Torsional Vibration Absorber," Abstract, 23rd Annual Meeting of the Society of Engineering Science, S-16 #2, 1986, invited.

S. W. Shaw, "Arnold Tongues and Subharmonics in the Forced Oscillations of a Mechanical Clock," *Proceedings 1985 IEEE Conference on Decision and Control*, 976-981, 1985, invited.

S. W. Shaw, "Forced Oscillations of the Inverted Pendulum with Constraints," Abstract, 22nd Annual Meeting of the Society of Engineering Science, 321, 1985, invited.

P. R. Sethna and S. W. Shaw, "Bifurcations of Articulated Tubes Conveying a Fluid," Abstract, 1985 Summer Conference on Multiparameter Bifurcation Theory, American Mathematical Society, 1985.

S. W. Shaw, "The Dynamic Response of a Single Degree of Freedom System with Dry Friction," *Developments in Mechanics* 13, 434-435, 1985.

S. W. Shaw and P. J. Holmes, "Piecewise Linear Forced Oscillations," Abstract, Ninth U.S. National Congress of Applied Mechanics, 149, 1982.

## **PRESENTATIONS**

### *Invited External Seminars*

Department of Mechanical Engineering, University of Washington, Seattle, WA, 2016  
Valeo Research and Development Center, Amiens, France, 2015  
Center for Applied Mathematics, Cornell University, Ithaca, NY, 2014  
Department of Mechanical and Aerospace Engineering, Florida Institute of Technology, Melbourne, FL, 2014  
Ocean and Mechanical Engineering Department, Florida Atlantic University, Boca Raton, FL, 2013  
Department of Power Engineering, National Tsing Hua University, Hsinchu, Taiwan, 2012  
Mechanical Engineering Department, McGill University, Montreal, 2005, 2011  
Dynamics Interest Group, UIUC, 2010  
Department of Mechanical Engineering, Purdue University, 1985, 1992, 2010  
Dynamics and Controls Group, Department of Mechanical Engineering, TU/Eindhoven, 2009  
Research and Innovation Center, Ford Motor Company, Dearborn, MI, 2009  
Department of Mechanical Engineering, Rice University, Houston, TX, 2009  
Department of Mechanical Engineering, University of Maryland-Baltimore County, 2008  
Department of Mechanical Engineering, University of Rhode Island, 2008  
Department of Mechanical Engineering, Tel Aviv University, 2008  
Department of Mechanical Engineering, Southern Methodist University, Dallas, 2008  
Department of Mechanical Engineering, Duke University, 1992, 2008  
Control Engineering Seminar, University of Michigan, 2004, 2007  
Department of Engineering Mathematics, University of Bristol, Bristol, UK, 2007  
Boeing Integrated Defense Systems, El Segundo, CA, 2007  
Department of Mechanical Engineering, UCLA, 2007  
Department of Mechanical Engineering, Technion, Haifa, Israel, 2006.  
Center for Control Engineering and Computing, UC-Santa Barbara, 2000, 2004.  
Mechanical Engineering Seminar, Oakland University, March, 2002.  
Mathematics Department Seminar, Calvin College, April, 2001.  
Mechanical Engineering Department Seminar, University of Akron, April, 2001.  
Department of Dynamical Systems and Control, Caltech, 2000.  
NASA Langley, Structural Dynamics Branch, Hampton, VA, (with C. Pierre), 1999  
Department of Aeronautical and Astronautical Engineering, University of Illinois, Urbana,



1992, 1995

Department of Aerospace Engineering and Mechanics, University of Minnesota, 1994.  
Center for Nonlinear and Complex Systems, Duke University, 1992  
Department of Mechanical Engineering, Case Western Reserve University, 1992  
Department of Mechanical and Aerospace Engineering, Arizona State University, 1990, 1992  
Department of Mathematics, University of Missouri-Rolla, 1992  
Department of Mechanical Engineering, University of Missouri-Rolla, 1992  
Department of Theoretical and Applied Mechanics, Cornell University, 1991  
Department of Mechanical Engineering, University of Washington, 1991  
Department of Mechanical Engineering, Washington State University, 1991  
Engineering Research, Ford Motor Company, Dearborn, 1984, 1988, 1991.  
Power Systems Department, General Motors Research Laboratories, 1990  
Department of Mechanical Engineering, University of Michigan, Ann Arbor, 1983, 1987  
Scientific Laboratories, Ford Motor Company, Dearborn, 1990  
Physics Department, Oberlin College, 1989  
Applied Mechanics/Mechanical Engineering, Caltech, 1989  
Applied Mathematics, University of Michigan, Ann Arbor, 1988  
Physics Department, University of Michigan, Flint, 1988  
Department of Mechanical Engineering, Wayne State University, 1987  
Department of Mechanical Engineering, University of California, Berkeley, 1986  
Physics Department, Wayne State University, 1984

#### *In-House Seminars*

ASME Student Chapter, Florida Tech, 2016  
Mechanical and Aerospace Engineering Department, Florida Tech, 2016  
Condensed Matter Group, Physics and Astronomy, MSU, 2012  
Electrical and Computer Engineering Department, MSU, 2012  
Mechanical Engineering Department, MSU, 1986, 1987 (fluids group), 1991, 1994, 2003, 2007  
Applied Math Seminar, Department of Mathematics, MSU, 1984, 1987(2), 1991, 2006  
School of Engineering, Oakland University, 1983  
Department of Theoretical and Applied Mechanics, Cornell University, 1983

#### *Conferences (presentations without associated papers; keynote and other special lectures listed above)*

IDEAS (Investigating Dynamics in Engineering and Applied Science), A workshop celebrating  
Gábor Stépán's 60th birthday, 2014, Budapest, Hungary, invited  
USNCTAM, minisymposium in honor of F. C. Moon, East Lansing, MI, 2014, invited  
Symposium on Advances in Nonlinear Dynamics, in honor of A. K. Bajaj, West Lafayette, IN,  
2012, invited  
IUTAM Symposium on Nonlinear Dynamics in Advanced Technologies and Engineering Design,  
Aberdeen, Scotland, 2010  
Nonlinear Vibrations Workshop, Duke University, Durham, NC, 2008, 2010  
SPIE Smart Structures/NDE Conference, San Diego, CA, 2010  
Non-linear Vibrations, Stability, and Dynamics of Structures and Mechanisms, Blacksburg, VA,  
1988, 1990, 1992, 1994, 1996, 2000, 2010  
22<sup>nd</sup> Biennial Conference on Mechanical Vibration and Noise, ASME International Design

Engineering Technical Conference, San Diego, CA, 2009  
 CMMI Grantees Conference, Honolulu, 2 posters, 2009  
 Ninth Biennial ASME Conference on Design and Analysis, Haifa, Israel, 2008  
 Sixth EUROMECH Conference on Nonlinear Dynamics, St. Petersburg, Russia, 2008  
 Twelfth International Symposium on Transport Phenomena and Dynamics of Rotating Machinery (ISROMAC-12), Honolulu, Hawaii, 2008  
 2007 ASME Design Engineering Technical Conferences, Las Vegas  
 Applied Nonlinear Dynamics: Making it Real, University of Bristol, Bristol, UK, invited, 2007  
 Workshop on Coupled Oscillators and Applications to Nanosystems, Santa Barbara, CA, 2007  
 DARPA Workshop on Nonlinear Dynamics in Nano-mechanical Systems, San Francisco, CA, invited, 2007  
 Eleventh International Symposium on Transport Phenomena and Dynamics of Rotating Machinery (ISROMAC-11), Honolulu, Hawaii, March, 2006  
 2005 ASME Design Engineering Technical Conferences (2 papers), Long Beach  
 International Workshop on Applied Dynamical Systems – Mechanics, Turbulence, Knots, Cockroaches, and Chaos, Montreal, October, 2005, invited  
 Fifth EUROMECH Conference on Nonlinear Dynamics, Eindhoven, 2005, two presentations, including one invited sectional lecture  
 SIAM Conference on Dynamical Systems, Snowbird, UT, 2005, invited  
 IUTAM Symposium on Chaotic Dynamics and Control of Systems and Processes in Mechanics, Rome, 2003  
 Tenth International Symposium on Transport Phenomena and Dynamics of Rotating Machinery (ISROMAC-10), Honolulu, Hawaii, March, 2004  
 2003 ASME Design Engineering Technical Conferences (3 papers), Chicago  
 SAE Noise and Vibration Conference and Exhibition, Traverse City, MI, 2003  
 JSME Minisymposium on Nonlinear Dynamics and Chaos in Mechanical Systems, Tokyo, 2001  
 SPIE Conference on Smart Structures, Newport Beach, 2000  
 Symmetry and Stability in Nonlinear Mechanics, Budapest, 2000, invited  
 1999 ASME Design Engineering Technical Conferences (4 papers), Las Vegas  
 1999 ASME Mechanics and Materials Conference (2 papers), Blacksburg, VA  
 NASA Ames, Rotorcraft Dynamics Branch, Moffett Field, CA, 1998  
 1997 ASME Design Engineering Technical Conferences (5 papers), Sacramento, CA  
 IUTAM Symposium on Applications of Nonlinear and Chaotic Dynamics in Mechanics, Ithaca, NY, invited keynote speaker, 1997  
 1997 SAE Noise and Vibration Conference and Exposition, Traverse City, MI  
 1996 Winter Annual Meeting, Atlanta, GA  
 Second European Non-Linear Oscillations Conference, Prague, 1996, invited sectional lecture  
 The Panther CAE Experience, Ford Motor Co., Dearborn, MI, 1995, invited  
 Advanced Research Workshop on Nonlinear Dynamics, Aberdeen, Scotland, 1995, invited  
 NSF Workshop on Nonlinear Dynamics in Manufacturing, La Jolla, CA, 1995, invited  
 1994 ASME Winter Annual Meeting, Chicago, invited  
 31st Annual Meeting of the Society of Engineering Science, College Station, TX, 1994  
 International Symposium on Asymptotics in Mechanics, St. Petersburg, Russia, 1994  
 Twelfth U.S. National Congress of Applied Mechanics, Seattle, 1994  
 1992 ASME Winter Annual Meeting, Anaheim, CA, invited  
 XVIIIth International Congress of Theoretical and Applied Mechanics, Haifa, Israel, 1992

ASME Summer Applied Mechanics Conference, Scottsdale, AZ, 1992  
 Fourth ARO Workshop on Rotorcraft Dynamics, College Park, MD, 1991, invited  
 Bifurcation and Chaos: Analysis, Algorithms, and Applications, Wurzburg, Germany, 1990,  
 invited  
 26th Annual Meeting of the Society of Engineering Science, Ann Arbor, 1989, invited  
 IUTAM Symposium on Nonlinear Dynamics in Engineering Systems, Stuttgart, FRG, 1989,  
 invited  
 8th Symposium on Trends in the Application of Mathematics to Mechanics, Hollabrunn,  
 Austria, 1989, invited  
 ASME/ASCE Mechanics Conference, San Diego, 1989, invited  
 SIAM Conference on Control in the 90's, San Francisco, 1989, invited  
 Applied Mechanics and Engineering Sciences Conference, Berkeley, 1988  
 AFOSR/ARO Workshop on Nonlinear Vibrations, Stability, and Dynamics of Structures and  
 Mechanisms, Blacksburg, VA, 1987  
 Engineering Foundation Workshop on Nonlinear Dynamics, Henniker, NH, 1986, invited  
 23rd Annual Meeting of the Society of Engineering Science, Buffalo, 1986, invited  
 IEEE Conference on Decision and Control, Ft. Lauderdale, 1985, invited  
 22nd Annual Meeting of the Society of Engineering Science, State College, PA, 1985, invited.  
 19th Midwest Mechanics Conference, Columbus, 1985  
 American Mathematical Society Summer Conference on Multiparameter Bifurcation Theory,  
 Arcata, CA, 1985  
 ASME/ASCE Mechanics Conference, Albuquerque, 1985, 2 papers  
 XVIth International Congress of Theoretical and Applied Mechanics, Lyngby, Denmark, 1984  
 ASME Winter Annual Meeting, Boston, 1983

*Other Meetings Attended (without presentation):*

DARPA MTO MESO Program Review, Washington, DC, 2013  
 DARPA MTO MESO Program Review, Jykell Island, GA, 2011  
 Hilton Head: A Solid State Sensors, Actuator, and Microsystems Workshop; Hilton Head, SC,  
 2008, 2012, 2014, 2016  
 SIAM Conference on Dynamical Systems, Snowbird, UT, 2009  
 Structural Dynamics 2000, Workshop on the future of structural dynamics, invited participant,  
 Los Alamos, 1999  
 SAE Noise and Vibration Conference and Exposition, Traverse City, MI, 1995  
 ASME Summer Conference, Columbus, OH, 1991  
 SIAM Conference on Dynamical Systems, Orlando, FL, 1990  
 Twentieth Midwestern Mechanics Conference, West Lafayette, IN, 1987  
 ASME Winter Annual Meeting, Anaheim, CA, 1986  
 NSF Workshop on Research Needs in Theoretical Dynamics, Buffalo, NY, 1986, invited  
 participant  
 First IBM/University Symposium on Impact Printing, Yorktown Heights, NY, 1985 invited  
 participant  
 Army Research Office Workshop on Chaos in Nonlinear Dynamical Systems, Research Triangle  
 Park, NC, 1983  
 Chaos in Dynamical Systems, College Park, MD, 1983

**GRADUATE STUDENTS** (at MSU unless otherwise indicated)

*Current:*     Joey Fisher, M.S. (thesis), FIT  
                  B. Scott Strachan, dual Ph.D. in ME and ECE, joint with P. Chahal, ECE  
                  Pavel Polunin, dual Ph.D. in ME and Physics, joint with M. Dykman, Physics  
                  Mustafa Acar, Ph.D., joint with B. Feeny

*Past:*        Ming Mu, M.S., 2015, joint with B. Feeny  
                  S. Tran, M.S., 2014 (project), joint with B. Feeny  
                  Abhisek Jain, M.S. 2013 (thesis), joint with B. Feeny  
                  Pavel Polunin, M.S., 2013 (thesis)  
                  Brendan Vidmar, Ph.D., 2012, joint with B. Feeny  
                  Nicholas Miller, dual Ph.D. in ME and Physics, 2012, joint with M. Dykman, Physics  
                  Thomas Theisen M.S., 2011 (thesis) joint with B. Feeny  
                  Ryan Monroe, Ph.D., 2011  
                  Brendan Vidmar, M.S., 2009 (thesis), joint with B. Feeny  
                  Jeffrey Rhoads, Ph.D., 2007  
                  Nicholas Miller, M.S., 2007 (thesis)  
                  Mark Orlowski, M.S., 2007 (thesis)  
                  Brian Olson, Ph.D., 2006  
                  Jeffrey Rhoads, M.S. 2003 (thesis)  
                  Dongying Jiang, Ph.D., UM, 2003, joint with C. Pierre  
                  Polarit Apiwattanalungarn, Ph.D., 2003, joint with C. Pierre  
                  Tyler Nester, M.S. 2002 (thesis)  
                  Brian Olson, M.S., 2001 (thesis)  
                  Abdallah Alsuwaiyan, Ph.D., 1999  
                  Eric Pesheck, Ph.D., UM, 1999, joint with C. Pierre  
                  Chang-Po Chao, Ph.D., 1997  
                  Vishal Garg, M.S., 1996 (thesis)  
                  Shyh-Leh Chen, Ph.D., 1996  
                  Cheng-Tang Lee, Ph.D., UM, 1994  
                  Nicholas Boivin, Ph.D., UM, 1995, joint with C. Pierre  
                  Changben Jiang, Ph.D., UM, 1995, joint with A. Troesch  
                  L. Steven Gunsore, M.S., 1995, (project)  
                  Haider Arafat, M.S.E., UM, 1993 (project)  
                  Anthony Boardman, M.S.E., UM, 1993 (project)  
                  Rosamond Dolid, M.S.E., UM, 1993 (project)  
                  Charisse Russell, M.S.E., UM, 1993 (project), joint with N. Perkins  
                  John Miller, M.S.E., UM, 1992 (project), joint with C. Pierre  
                  Famarz Farahanchi, M.S., 1991 (thesis)  
                  Shang-Rou Hsieh, Ph.D., 1991  
                  Jinsiang Shaw, Ph.D., 1989  
                  Mehrnam Sharif-Bakhtiar, Ph.D., 1989  
                  Doug Moore, M.S., 1987 (thesis)  
                  Pi-Cheng Tung, Ph.D., 1987

*Visiting:* Johannes Mayet, 2014, from TU-Munich, advisor: H. Ulbrich  
Suguang Duo, 2014, from TU-Denmark, advisor: J. Jensen  
Guangming Zhao, 2012, from Wuhan University of Technology, advisor: J. Zhengfeng  
Hein van Beek, 2010, from TU-Eindhoven, advisor: H. Nijmeijer  
Gábor Csernák, 1999, from TU-Budapest, advisor: G. Stépán

#### **UNDERGRADUATE STUDENT SUPERVISION (since 2007)**

Previous: Michael Thelen, Jessica O'Brien, James Miller, Cody Little, Bara Aldasouqi, Kyle Justus, Brian Rockwell, J. T. Whitman, Brian Wagonecht, Thomas Theisen, Ashley Kulczycki, Brian Rockwell, Jelena Paripovic

#### **EXTERNAL FUNDING (\* indicates active and approved projects)**

- \* "Pendulum Vibration Absorbers," Achates Power Inc., through Florida Tech Consulting (FTC)
- \* "Collaborative Research: Tailoring the Nonlinear Response of MEMS," NSF. PIs: S. W. Shaw and K. L. Turner (UCSB), May 2016-May 2019. \$600K total, FIT portion \$300k.
- \* "GOALI: Vibration Absorbers for Multi-Frequency Excitation," NSF. PIs: S. W. Shaw, B. F. Feeny, and B. Geist, (FCA, Chrysler), June 2011-June 2017 (including two years no cost extension), \$350k (plus a \$6k RUE supplement in 2009).

"Pendulum Absorber Software," Valeo, through FTC, \$45k, 2016.

"Nonlinear Elasticity of Doped Semiconductors," DARPA MTO, PIs: M. I. Dykman and S. W. Shaw, Nov. 2015-Nov. 2016, \$134k.

"Collaborative Research: MEMS Frequency Converters Based on Nonlinear Resonances," NSF. PIs: S. W. Shaw, P. Chahal, and K. Turner (UCSB), Sept. 2012-Aug. 2016 (including two years no cost extension). \$550K total, MSU portion \$225k.

"Pendulum Absorber for Axle Whine," FCA (Chrysler), PIs: S. W. Shaw and B. F. Feeny, June 2015-July 2016, \$50k.

"Studying Electron Transport in Nanowires Using Fluctuations of Nanomechanical Vibrations," ARO. PIs: M. I. Dykman and S. W. Shaw, July 2012-June 2016 (including one year no cost extension), \$450k.

"DEFYS: Practical Nonlinearities," subcontract from Stanford, DARPA MTO prime, MSU PIs: M. I. Dykman, S. W. Shaw. T. Kenny (Stanford); Jan. 2014-Dec. 2015, MSU portion: \$550k.

"Pendulum Vibration Absorber Analysis," Valeo, 10/1/2015-1/15/2016, \$45k.

"Pendulum Absorber Simulation Software Integration," PIs: S. W. Shaw and B. Feeny, Ford Motor Company; 2014-15, \$27k.

"DEFYS: Dynamics Enabled NEMS Oscillators," subcontract from Caltech, DARPA MTO prime, MSU PI: M. I. Dykman, co-PI: S. W. Shaw; Caltech PI: M. Roukes; Phase I: July 1, 2010-Dec 13, 2013; MSU portion: \$490K.

"Collaborative Research: Noisy Nonlinear Microscale Oscillators for Novel Applications," NSF. PIs: S. W. Shaw, M. I. Dykman, and H. B. Chan (U. of Florida/Hong Kong U. of Science and Technology), July 1, 2009-June 30, 2013 (including a one-year no-cost extension), \$424k total (MSU portion \$295k, plus a \$6k RUE supplement in 2009).

"Crankshaft Pendulum Absorber," Honda R & D Americas, Inc. PIs: S. W. Shaw and B. F. Feeny, Feb. 14 - Aug. 14, 2013. \$30k.

"Development of CAE Tools for Pendulum Absorber Design," Ford Motor Co. PIs: S. W. Shaw and B. F. Feeny, Jan.-Dec., 2012, \$55k.

"Collaborative Research: Novel Microscale Resonant Sensors for Chemical and Biological Detection," NSF PIs: S. W. Shaw and K. L. Turner (UCSB), Aug 16, 2008-Aug. 15, 2012 (including a one-year, no-cost extension), \$436k (MSU portion \$180k, plus a \$6k RUE supplement in 2009).

"GOALI: Transient Dynamics of Torsional Vibration Absorbers," NSF. PIs: S. W. Shaw, A. G. Haddow, B. F. Feeny (MSU), and B. Geist, (Chrysler Group, LLC), Sept. 2007-Aug. 2011 (including a one-year, no-cost extension), \$350k, plus a \$6k RUE supplement in 2009, and a \$3k travel supplement in 2009.

"Pendulum Vibration Absorber to Expand MDS Operating Range," Chrysler Challenge Fund. PIs: S. W. Shaw and B. F. Feeny, July 2010-June 2011, \$50k.

"Pendulum Vibration Absorber to Expand MDS Operating Range," Chrysler Challenge Fund. PIs: A. G. Haddow and S. W. Shaw, July 2008-June 2009, \$50k.

"Pendulum Vibration Absorber to Expand MDS Operating Range," Chrysler Challenge Fund. PIs: A. G. Haddow and S. W. Shaw, July 2007-June 2008, \$50k.

"Vibration Absorbers for Systems with Cyclic Symmetry," NSF, Collaborative Grant. PIs: S. W. Shaw and A. G. Haddow (MSU), C. Pierre (McGill University), Aug. 2004-July 2008 (including a one-year, no-cost extension), \$300k total (MSU portion \$170k).

"Dynamics of Microbeam Sensor Arrays," NSF SST (Small Sensors Team). PIs: K. Turner (UCSB), S. W. Shaw, J. Moehlis (UCSB), Sept. 2004-Aug. 2007, \$400k total (MSU portion \$110k).

"Improved Control Authority in Flexible Structures Using Stiffness Variation," AFOSR, PIs: R. Mukherjee (MSU) and S. W. Shaw, Feb. 2004-Aug. 2007, \$271k.

"Pendulum Vibration Absorber to Expand MDS Operating Range," Chrysler Challenge Fund. PIs: A. G. Haddow and S. W. Shaw, Jan. 2006-Jan. 2007, \$50k.

"Improved Performance for MEMS-based Filters," AFOSR, PIs: K. Turner (UCSB) and S. W. Shaw, Jan. 2002-June 2005, \$289k.

"Model Reduction Techniques for Large-Amplitude Vibrations of Complex Nonlinear Structures," ARO, PIs: S. W. Shaw and C. Pierre (U. of Michigan), May 2001-Dec. 2004, \$210k.

"The Dynamic Performance of Nonlinear Vibration Absorbers," NSF, Dynamic Systems and Control Program. PIs: S. W. Shaw and A. Haddow (MSU), Sept. 2000-Aug. 2004, \$235k.

"Improved Control Authority Using Variable Stiffness," AFOSR, PIs: R. Mukherjee and S. W. Shaw, March 2003-Feb. 2004, \$47k.

"The Dynamics of Systems with Tuned Substructures," NSF, with A. Haddow, Aug. 1997-Aug. 2001, \$240k.

"Nonlinear Modal Analysis and Component-Mode Synthesis of Large-Scale Structural Systems," Army Research Office, with C. Pierre, Jan. 1997-Dec. 2000, \$257k.

"Real-Time Automotive Sensing and Control," NSF, PI: F. Salam, Co-PIs: S. Shaw, H. Khalil, C. Radcliffe, L. Tummala, Aug. 1997-Aug. 2000, \$420k.

"Risk Analysis of Commercial Fishing Vessels Operating in Extreme Seas," Michigan Sea Grant College Program, with A. Troesch, Sept. 1997-Aug. 2000, \$180k.

"A Nonlinear Probabilistic Approach to the Problem of Fishing Vessel Capsize," Michigan Sea Grant Program, with A. Troesch, Sept. 1993-Aug. 1996, \$180k.

"Modal Analysis Techniques for Nonlinear, Large-Scale Systems," Army Research Office, with C. Pierre, Jan. 1993-Dec. 1996, \$257k.

"An Invariant Manifold Approach to Modal Analysis of Nonlinear Structural Systems," NSF, Grant MSS-9201815 (at UM) and MSS-9496271 (at MSU), with C. Pierre, Sept. 1992-Jan. 1997, \$283k.

"A Nonlinear Probabilistic Approach to the Problem of Fishing Vessel Capsize," Michigan Sea Grant Program, with A. Troesch, Sept. 1991-Aug. 1993, \$120k.

"Nonlinear Dynamics of Mechanical Systems," NSF, Grant MSS-8915453, Feb. 1990-July 1993, \$181k.

"Dynamic Signal Analyzer," NSF Engineering Research Equipment Grant, Co-PI, P.I.: A. G. Haddow, 1988, \$40k (with \$37k MSU matching funds).

"Nonlinear Dynamics," DARPA, with S. N. Chow, A. Novick-Cohen, B. Drachman, S. Dragosh, L. Ni and K. Mischaikow. Jan. 1988-Dec. 1990, \$1,306k. (moved to Georgia Tech with S. N. Chow in Sept., 1988).

"Dynamics of Nonlinear Mechanical Systems," NSF, Grant MSM-8613294, Jan. 1987- Dec. 1989, \$152k.

"National Intelligence Mathematics and Multiprocessing Project," DARPA, 1985-87, with S. N. Chow, B. Drachman, T.Y. Li, L.M. Ni and L.S. Young, \$741k.

"Forced Vibrations of Mechanical Systems Having Amplitude Constraints," NSF Research Initiation Grant, MEA-8421248, 1984-86, \$48k.