Bruce L. Campbell, P.C., OSB No. 925377
bruce.campbell@millernash.com
MILLER NASH GRAHAM & DUNN LLP
3400 U.S. Bancorp Tower
111 S.W. Fifth Avenue
Portland, Oregon 97204
Telephone: 503.224.5858
Facsimile: 503.224.0155

Attorneys for Plaintiffs

UNITED STATES DISTRICT COURT

DISTRICT OF OREGON

Portland Division

SAWSTOP, LLC, an Oregon limited liability company, and **SD3, LLC**, an Oregon limited liability company,

Plaintiffs,

v.

ROBERT BOSCH TOOL CORPORATION, a Delaware corporation, and **ROBERT BOSCH GMBH**, a German company,

Defendants.

CV No. 3:15-cv-1320

COMPLAINT FOR PATENT INFRINGEMENT

DEMAND FOR JURY TRIAL

Plaintiffs SawStop, LLC ("SawStop") and SD3, LLC ("SD3") (collectively, "Plaintiffs"), bring this Complaint for patent infringement against Defendants Robert Bosch Tool Corporation

("Bosch Tool") and Robert Bosch GmbH ("Bosch GmbH") (collectively, "Defendants"), and allege as follows:

PARTIES

1. Plaintiff SawStop is a limited liability company organized and existing under the laws of Oregon. SawStop has a principal place of business at 9564 SW Tualatin Road, Tualatin, Oregon.

2. Plaintiff SD3 is a limited liability company organized and existing under the laws of Oregon. SD3 has a principal place of business at 9564 SW Tualatin Road, Tualatin, Oregon.

3. On information and belief, Defendant Bosch Tool is a Delaware corporation with a principal place of business at 1800 West Central Road, Mount Prospect, Illinois, 60056.

4. On information and belief, Defendant Bosch GmbH is a company organized under the laws of Germany with a principal place of business at Robert-Bosch-Platz 1, 70839 Gerlingen-Schillerhöhe, Baden-Wuerttemberg, Germany.

JURISDICTION AND VENUE

5. This is an action for patent infringement under 35 U.S.C. §§ 271 and 281. The Court has subject matter jurisdiction under 28 U.S.C. §§ 1331 and 1338(a).

6. The Court has personal jurisdiction over the Defendants under ORCP 4 A(4), 4 C and 4 D(1) and (2), among other provisions. On information and belief, Defendants have engaged in substantial, continuous, and systematic business within this District. On information and belief, Defendants regularly and deliberately engage in activities that result in using, selling, offering for sale, or importing alleged infringing products in or into this District. On information and belief, Defendants and their retailers maintain Internet websites available to consumers nationwide, including within this District, on which alleged infringing products are advertised and offered for sale in and shipping to this District. On information and

MILLER NASH GRAHAM & DUNN LLP
ATTORNEYS AT LAW
TELEPHONE: 503.224.5858
3400 U.S. BANCORP TOWER
111 S.W. FIFTH AVENUE
PORTLAND, OREGON 97204

belief, Defendants maintain sales and distribution operations in this District and have marketed and offered for sale alleged infringing products through these operations.

7. Venue is proper in this District under 28 U.S.C. §§ 1391 (b) & (c) and 1400(b).

BACKGROUND

8. In August 2000, Dr. Stephen F. Gass and his colleagues formed SawStop to develop and commercialize safety systems for woodworking machines such as table saws.

9. The safety systems that Dr. Gass and his colleagues developed are able to detect contact between a saw blade and an operator of the saw, and react to mitigate injury to the operator from the saw blade.

10. In August 2000, Dr. Gass and his colleagues formed SD3 to own intellectual property associated with the safety systems they had developed.

11. Since late 2004, SawStop has sold woodworking machines equipped with these safety systems.

12. On information and belief, in March 2015, Defendants announced the impending release of the Bosch GTS1041A REAXX, a bench top table saw equipped with a system that detects contact between a saw blade and an operator of the saw and retracts the saw blade in response to detected contact.

13. On information and belief, Defendants have shown and demonstrated the Bosch GTS1041A REAXX at trade shows in the United States.

14. On information and belief, Defendants have offered for sale the Bosch GTS1041A REAXX throughout the United States, including in this District.

15. On information and belief, Defendants have marketed the Bosch GTS1041A REAXX throughout the United States, including in this District.

MILLER NASH GRAHAM & DUNN LLP
ATTORNEYS AT LAW
TELEPHONE: 503.224.5858
3400 U.S. BANCORP TOWER
111 S.W. FIFTH AVENUE
PORTLAND, OREGON 97204

COUNT I: INFRINGEMENT OF U.S. PATENT NO. 7,225,712

16. Plaintiffs repeat and re-allege each and every allegation of the foregoing paragraphs as though fully set forth herein.

17. On June 5, 2007, the United States Patent & Trademark Office duly issued U.S. Patent No. 7,225,712 (the '712 Patent), titled "Motion Detecting System for Use in A Safety System for Power Equipment." A true and correct copy of the '712 Patent is attached as Exhibit A.

18. Plaintiff SD3 is the owner of all rights, title, and interest in the '712 Patent.

19. Plaintiff SawStop is the sole licensee of the '712 Patent.

20. Plaintiff SawStop marks, and has continuously marked, its products with the '712 Patent pursuant to 35 U.S.C. § 287.

21. Defendants have cited the '712 Patent during prosecution of their own United States Patent or Patents.

22. On information and belief, Defendants have been on notice of the '712 Patent, including by way of Plaintiff SawStop's marking of its products and Defendants' citation of the '712 Patent during prosecution of their own United States Patent or Patents.

23. In violation of 35 U.S.C. § 271, Defendants have infringed, and are continuing to infringe literally and/or under the doctrine of equivalents, the '712 Patent by practicing one or more claims of the '712 Patent in the manufacture, use, offer for sale, sale, or importation of products including, but not limited to, the Bosch GTS1041A REAXX saw.

24. As a result of Defendants' infringement of the '712 Patent, Plaintiffs have suffered and will continue to suffer damages and irreparable harm.

25. Plaintiffs are entitled to recover from Defendants the damages they have sustained as a result of Defendants' infringement of the '712 Patent in an amount subject to proof at trial, but in no event less than a reasonable royalty, together with interest and costs as fixed by the Court.

MILLER NASH GRAHAM & DUNN LLP
ATTORNEYS AT LAW
TELEPHONE: 503.224.5858
3400 U.S. BANCORP TOWER
111 S.W. FIFTH AVENUE
PORTLAND, OREGON 97204

26. Having been on notice of the '712 Patent, Defendants' infringement of the '712 Patent was and continues to be willful, and therefore warrants an increase of damages pursuant to 35 U.S.C. § 284 and an award of attorney fees pursuant to 35 U.S.C. § 285.

27. Unless Defendants are enjoined from continuing their infringement of the '712 Patent, Plaintiffs will suffer additional irreparable harm, and are therefore entitled to a permanent injunction against further infringement.

COUNT II: INFRINGEMENT OF U.S. PATENT NO. 7,600,455

28. Plaintiffs repeat and re-allege each and every allegation of the foregoing paragraphs as though fully set forth herein.

29. On October 13, 2009, the United States Patent & Trademark Office duly issued U.S. Patent No. 7,600,455 (the '455 Patent), titled "Logic Control for Fast-Acting Safety System." A true and correct copy of the '455 Patent is attached as Exhibit B.

30. Plaintiff SD3 is the owner of all rights, title, and interest in the '455 Patent.

31. Plaintiff SawStop is the sole licensee of the '455 Patent.

32. Plaintiff SawStop marks, and has continuously marked, its products with the '455 Patent pursuant to 35 U.S.C. § 287.

33. Defendants have cited the '455 Patent during prosecution of their own United States Patent or Patents.

34. On information and belief, Defendants have been on notice of the '455 Patent, including by way of Plaintiff SawStop's marking of its products and Defendants' citation of the '455 Patent during prosecution of their own United States Patent or Patents.

35. In violation of 35 U.S.C. § 271, Defendants have infringed, and are continuing to infringe literally and/or under the doctrine of equivalents, the '455 Patent by practicing one or more claims of the '455 Patent in the manufacture, use, offer for sale, sale, or importation of products including, but not limited to, the Bosch GTS1041A REAXX saw.

MILLER NASH GRAHAM & DUNN LLP
ATTORNEYS AT LAW
TELEPHONE: 503.224.5858
3400 U.S. BANCORP TOWER
111 S.W. FIFTH AVENUE
PORTLAND, OREGON 97204

36. As a result of Defendants' infringement of the '455 Patent, Plaintiffs have suffered and will continue to suffer damages and irreparable harm.

37. Plaintiffs are entitled to recover from Defendants the damages they have sustained as a result of Defendants' infringement of the '455 Patent in an amount subject to proof at trial, but in no event less than a reasonable royalty, together with interest and costs as fixed by the Court.

38. Having been on notice of the '455 Patent, Defendants' infringement of the '455 Patent was and continues to be willful, and therefore warrants an increase of damages pursuant to 35 U.S.C. § 284 and an award of attorney fees pursuant to 35 U.S.C. § 285.

39. Unless Defendants are enjoined from continuing their infringement of the '455 Patent, Plaintiffs will suffer additional irreparable harm, and are therefore entitled to a permanent injunction against further infringement.

COUNT III: INFRINGEMENT OF U.S. PATENT NO. 7,610,836

40. Plaintiffs repeat and re-allege each and every allegation of the foregoing paragraphs as though fully set forth herein.

41. On November 3, 2009, the United States Patent & Trademark Office duly issued U.S. Patent No. 7,610,836 (the '836 Patent), titled "Replaceable Brake Mechanism for Power Equipment." A true and correct copy of the '836 Patent is attached as Exhibit C.

42. Plaintiff SD3 is the owner of all rights, title, and interest in the '836 Patent.

43. Plaintiff SawStop is the sole licensee of the '836 Patent.

44. Plaintiff SawStop marks, and has continuously marked, its products with the '836 Patent pursuant to 35 U.S.C. § 287.

45. On information and belief, Defendants have been on notice of the '836 Patent, including by way of Plaintiff SawStop's marking of its products.

46. In violation of 35 U.S.C. § 271, Defendants have infringed, and are continuing to infringe literally and/or under the doctrine of equivalents, the '836 Patent by

MILLER NASH GRAHAM & DUNN LLP
ATTORNEYS AT LAW
TELEPHONE: 503.224.5858
3400 U.S. BANCORP TOWER
111 S.W. FIFTH AVENUE
PORTLAND, OREGON 97204

practicing one or more claims of the '836 Patent in the manufacture, use, offer for sale, sale, or importation of products including, but not limited to, the Bosch GTS1041A REAXX saw.

47. As a result of Defendants' infringement of the '836 Patent, Plaintiffs have suffered and will continue to suffer damages and irreparable harm.

48. Plaintiffs are entitled to recover from Defendants the damages they have sustained as a result of Defendants' infringement of the '836 Patent in an amount subject to proof at trial, but in no event less than a reasonable royalty, together with interest and costs as fixed by the Court.

49. Having been on notice of the '836 Patent, Defendants' infringement of the '836 Patent was and continues to be willful, and therefore warrants an increase of damages pursuant to 35 U.S.C. § 284 and an award of attorney fees pursuant to 35 U.S.C. § 285.

50. Unless Defendants are enjoined from continuing their infringement of the '836 Patent, Plaintiffs will suffer additional irreparable harm, and are therefore entitled to a permanent injunction against further infringement.

COUNT IV: INFRINGEMENT OF U.S. PATENT NO. 7,895,927

51. Plaintiffs repeat and re-allege each and every allegation of the foregoing paragraphs as though fully set forth herein.

52. On March 1, 2011, the United States Patent & Trademark Office duly issued U.S. Patent No. 7,895,927 (the '927 Patent), titled "Power Equipment with Detection and Reaction Systems." A true and correct copy of the '927 Patent is attached as Exhibit D.

53. Plaintiff SD3 is the owner of all rights, title, and interest in the '927 Patent.

54. Plaintiff SawStop is the sole licensee of the '927 Patent.

55. Plaintiff SawStop marks, and has continuously marked, its products with the '927 Patent pursuant to 35 U.S.C. § 287.

56. Defendants have cited the '927 Patent during prosecution of their own United States Patent or Patents.

MILLER NASH GRAHAM & DUNN LLP
ATTORNEYS AT LAW
TELEPHONE: 503.224.5858
3400 U.S. BANCORP TOWER
111 S.W. FIFTH AVENUE
PORTLAND, OREGON 97204

57. On information and belief, Defendants have been on notice of the '927 Patent, including by way of Plaintiff SawStop's marking of its products and Defendants' citation of the '927 Patent during prosecution of their own United States Patent or Patents.

58. In violation of 35 U.S.C. § 271, Defendants have infringed, and are continuing to infringe literally and/or under the doctrine of equivalents, the '927 Patent by practicing one or more claims of the '927 Patent in the manufacture, use, offer for sale, sale, or importation of products including, but not limited to, the Bosch GTS1041A REAXX saw.

59. Defendants have actively induced, and are continuing to actively induce infringement of the '927 Patent, by causing others to act in a manner that directly infringes one or more claims of the '927 Patent, knowing that these acts would lead to infringement.

60. As a result of Defendants' infringement of the '927 Patent, Plaintiffs have suffered and will continue to suffer damages and irreparable harm.

61. Plaintiffs are entitled to recover from Defendants the damages they have sustained as a result of Defendants' infringement of the '927 Patent in an amount subject to proof at trial, but in no event less than a reasonable royalty, together with interest and costs as fixed by the Court.

62. Having been on notice of the '927 Patent, Defendants' infringement of the '927 Patent was and continues to be willful, and therefore warrants an increase of damages pursuant to 35 U.S.C. § 284 and an award of attorney fees pursuant to 35 U.S.C. § 285.

63. Unless Defendants are enjoined from continuing their infringement of the '927 Patent, Plaintiffs will suffer additional irreparable harm, and are therefore entitled to a permanent injunction against further infringement.

COUNT V: INFRINGEMENT OF U.S. PATENT NO. 8,011,279

64. Plaintiffs repeat and re-allege each and every allegation of the foregoing paragraphs as though fully set forth herein.

MILLER NASH GRAHAM & DUNN LLP
ATTORNEYS AT LAW
TELEPHONE: 503.224.5858
3400 U.S. BANCORP TOWER
111 S.W. FIFTH AVENUE
PORTLAND, OREGON 97204

65. On September 6, 2011, the United States Patent & Trademark Office duly issued U.S. Patent No. 8,011,279 (the '279 Patent), titled "Power Equipment with Systems to Mitigate or Prevent Injury." A true and correct copy of the '279 Patent is attached as Exhibit E.

66. Plaintiff SD3 is the owner of all rights, title, and interest in the '279 Patent.

67. Plaintiff SawStop is the sole licensee of the '279 Patent.

68. Plaintiff SawStop marks, and has continuously marked, its products with the '279 Patent pursuant to 35 U.S.C. § 287.

69. On information and belief, Defendants have been on notice of the '279 Patent, including by way of Plaintiff SawStop's marking of its products.

70. In violation of 35 U.S.C. § 271, Defendants have infringed, and are continuing to infringe literally and/or under the doctrine of equivalents, the '279 Patent by practicing one or more claims of the '279 Patent in the manufacture, use, offer for sale, sale, or importation of products including, but not limited to, the Bosch GTS1041A REAXX saw.

71. As a result of Defendants' infringement of the '279 Patent, Plaintiffs have suffered and will continue to suffer damages and irreparable harm.

72. Plaintiffs are entitled to recover from Defendants the damages they have sustained as a result of Defendants' infringement of the '279 Patent in an amount subject to proof at trial, but in no event less than a reasonable royalty, together with interest and costs as fixed by the Court.

73. Having been on notice of the '279 Patent, Defendants' infringement of the '279 Patent was and continues to be willful, and therefore warrants an increase of damages pursuant to 35 U.S.C. § 284 and an award of attorney fees pursuant to 35 U.S.C. § 285.

74. Unless Defendants are enjoined from continuing their infringement of the '279 Patent, Plaintiffs will suffer additional irreparable harm, and are therefore entitled to a permanent injunction against further infringement.

MILLER NASH GRAHAM & DUNN LLP
ATTORNEYS AT LAW
TELEPHONE: 503.224.5858
3400 U.S. BANCORP TOWER
111 S.W. FIFTH AVENUE
PORTLAND, OREGON 97204

COUNT VI: INFRINGEMENT OF U.S. PATENT NO. 8,191,450

75. Plaintiffs repeat and re-allege each and every allegation of the foregoing paragraphs as though fully set forth herein.

76. On June 5, 2012, the United States Patent & Trademark Office duly issued U.S. Patent No. 8,191,450 (the '450 Patent), titled "Power Equipment with Detection and Reaction Systems." A true and correct copy of the '450 Patent is attached as Exhibit F.

77. Plaintiff SD3 is the owner of all rights, title, and interest in the '450 Patent.

78. Plaintiff SawStop is the sole licensee of the '450 Patent.

79. Plaintiff SawStop marks, and has continuously marked, its products with the '450 Patent pursuant to 35 U.S.C. § 287.

80. Defendants have cited the '450 Patent during prosecution of their own United States Patent or Patents.

81. On information and belief, Defendants have been on notice of the '450 Patent, including by way of Plaintiff SawStop's marking of its products and Defendants' citation of the '450 Patent during prosecution of their own United States Patent or Patents.

82. In violation of 35 U.S.C. § 271, Defendants have infringed, and are continuing to infringe literally and/or under the doctrine of equivalents, the '450 Patent by practicing one or more claims of the '450 Patent in the manufacture, use, offer for sale, sale, or importation of products including, but not limited to, the Bosch GTS1041A REAXX saw.

83. As a result of Defendants' infringement of the '450 Patent, Plaintiffs have suffered and will continue to suffer damages and irreparable harm.

84. Plaintiffs are entitled to recover from Defendants the damages they have sustained as a result of Defendants' infringement of the '450 Patent in an amount subject to proof at trial, but in no event less than a reasonable royalty, together with interest and costs as fixed by the Court.

MILLER NASH GRAHAM & DUNN LLP
ATTORNEYS AT LAW
TELEPHONE: 503.224.5858
3400 U.S. BANCORP TOWER
111 S.W. FIFTH AVENUE
PORTLAND, OREGON 97204

85. Having been on notice of the '450 Patent, Defendants' infringement of the '450 Patent was and continues to be willful, and therefore warrants an increase of damages pursuant to 35 U.S.C. § 284 and an award of attorney fees pursuant to 35 U.S.C. § 285.

86. Unless Defendants are enjoined by this Court from continuing their infringement of the '450 Patent, Plaintiffs will suffer additional irreparable harm, and are therefore entitled to a permanent injunction against further infringement.

PRAYER FOR RELIEF

WHEREFORE, Plaintiffs pray for judgment as follows:

A. An entry of judgment that Defendants infringe the '712, '455, '836, '927, '279, and '450 Patents under 35 U.S.C. § 271;

B. An entry of judgment that Defendants willfully infringe the '712, '455, '836, '927, '279, and '450 Patents;

C. An award of damages adequate to compensate Plaintiffs for Defendants' infringement, in an amount no less than a reasonable royalty, together with interest and costs as fixed by the Court pursuant to 35 U.S.C. § 284.

D. Enhancement of the award of damages pursuant to 35 U.S.C. § 284, based on Defendants' willful infringement;

E. An award of attorney fees pursuant to 35 U.S.C § 285;

F. A permanent injunction against further infringement of the '712, '455, '836, '927, '279, and '450 Patents by Defendants and all persons in active concert or participation with Defendants pursuant to 35 U.S.C. § 283; and

G. Such other and further relief as the Court or a jury may deem just and proper.

MILLER NASH GRAHAM & DUNN LLP
ATTORNEYS AT LAW
TELEPHONE: 503.224.5858
3400 U.S. BANCORP TOWER
111 S.W. FIFTH AVENUE
PORTLAND, OREGON 97204

DEMAND FOR JURY TRIAL

Pursuant to Fed. R. Civ. P. 38(b), Plaintiffs respectfully request a trial by jury of all issues so triable.

DATED this 16th day of July, 2015.

MILLER NASH GRAHAM & DUNN LLP

s/ *Bruce L. Campbell*

Bruce L. Campbell, P.C.
OSB No. 925377
bruce.campbell@millernash.com
Phone: 503.224.5858
Fax: 503.224.0155

Attorneys for Plaintiff

EXHIBIT A

US007225712B2

(12) **United States Patent**
Gass et al.

(10) **Patent No.: US 7,225,712 B2**
(45) **Date of Patent: Jun. 5, 2007**

(54) **MOTION DETECTING SYSTEM FOR USE IN A SAFETY SYSTEM FOR POWER EQUIPMENT**

(75) Inventors: **Stephen F. Gass**, Wilsonville, OR (US); **Robert L. Chamberlain**, Raleigh, NC (US); **J. David Fulmer**, Tualatin, OR (US); **Joel F. Jensen**, Redwood City, CA (US); **Benjamin B. Schramm**, Los Gatos, CA (US)

(73) Assignee: **SD3, LLC**, Wilsonville, OR (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 896 days.

(21) Appl. No.: **09/929,234**

(22) Filed: **Aug. 13, 2001**

(65) **Prior Publication Data**

US 2002/0017178 A1 Feb. 14, 2002

Related U.S. Application Data

(60) Provisional application No. 60/225,056, filed on Aug. 14, 2000, provisional application No. 60/225,057, filed on Aug. 14, 2000, provisional application No. 60/225,058, filed on Aug. 14, 2000, provisional application No. 60/225,059, filed on Aug. 14, 2000, provisional application No. 60/225,089, filed on Aug. 14, 2000, provisional application No. 60/225,094, filed on Aug. 14, 2000, provisional application No. 60/225,169, filed on Aug. 14, 2000, provisional application No. 60/225,170, filed on Aug. 14, 2000, provisional application No. 60/225,200, filed on Aug. 14, 2000, provisional application No. 60/225,201, filed on Aug. 14, 2000, provisional application No. 60/225,206, filed on Aug. 14, 2000, provisional application No. 60/225,210, filed on Aug. 14, 2000, provisional application No. 60/225,211, filed on Aug. 14, 2000, provisional application No. 60/225,212, filed on Aug. 14, 2000.

(51) **Int. Cl.**
B26D 1/14 (2006.01)
B27B 5/00 (2006.01)

(52) **U.S. Cl.** **83/62.1**; 83/471.3; 83/477.1; 83/DIG. 1

(58) **Field of Classification Search** 83/DIG. 1, 83/62.1, 478, 76.7, 472, 397.1, 398, 932, 83/971.3, 473, 501, 477.1, 526, 491, 58, 83/471.3; 144/427, 391, 356, 384
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

146,886 A 1/1874 Doane et al.

(Continued)

FOREIGN PATENT DOCUMENTS

CH 297525 6/1954

(Continued)

OTHER PUBLICATIONS

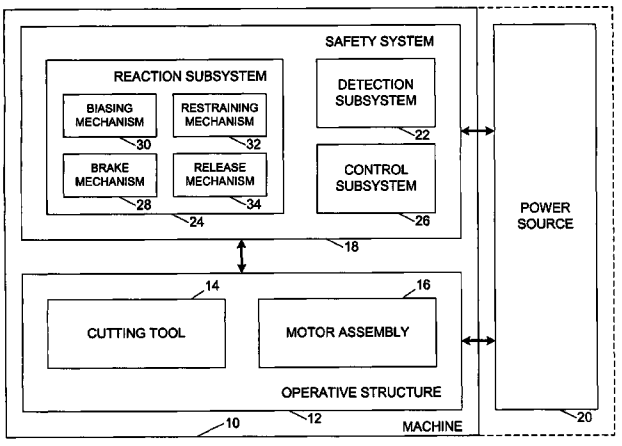
Analog Devices, Inc., 3-Axis Capacitive Sensor—Preliminary Technical Data AD7103, pp. 1-40, © 1998.

Primary Examiner—Boyer D. Ashley
Assistant Examiner—Ghassem Alie

(57) **ABSTRACT**

A woodworking machine including a detection system adapted to detect a dangerous condition between a person and a working portion of the machine is disclosed. The machine includes a reaction system associated with the detection system to cause a predetermined action to take place relative to the working portion upon detection of the dangerous condition. A motion detection system is adapted to detect motion of the working portion and to disable the reaction system when the working portion is not moving. The motion detection system may include a sensor, such as a Hall effect sensor, an electromagnetic field sensor, an optical sensor, or an electrical sensor. The woodworking machine may take the form of a saw, the working portion may be a blade adapted to cut when spinning, and the dangerous condition may be a person contacting the blade.

20 Claims, 6 Drawing Sheets



U.S. PATENT DOCUMENTS

162,814	A	5/1875	Graves et al.
261,090	A	7/1882	Grill
264,412	A	9/1882	Kuhlmann
299,480	A	5/1884	Kuhlmann et al.
302,041	A	7/1884	Sill
307,112	A	10/1884	Groff
509,253	A	11/1893	Shields
545,504	A	9/1895	Hoover
869,513	A	10/1907	Pfeil
941,726	A	11/1909	Pfalzgraf
997,720	A	7/1911	Troupenat
1,037,843	A	9/1912	Ackley
1,050,649	A	1/1913	Harrold et al.
1,054,558	A	2/1913	Jones
1,074,198	A	9/1913	Phillips
1,082,870	A	12/1913	Humason
1,101,515	A	6/1914	Adam
1,126,970	A	2/1915	Folmer
1,132,129	A	3/1915	Stevens
1,148,169	A	7/1915	Howe
1,154,209	A	9/1915	Rushton
1,205,246	A	11/1916	Mowry
1,228,047	A	5/1917	Reinhold
1,240,430	A	9/1917	Erickson
1,244,187	A	10/1917	Frisbie
1,255,886	A	2/1918	Jones
1,258,961	A	3/1918	Tattersall
1,311,508	A	7/1919	Harrold
1,324,136	A	12/1919	Turner
1,381,612	A	6/1921	Anderson
1,397,606	A	11/1921	Smith
1,427,005	A	8/1922	McMichael
1,430,983	A	10/1922	Granberg
1,464,924	A	8/1923	Drummond
1,465,224	A	8/1923	Lantz
1,496,212	A	6/1924	French
1,511,797	A	10/1924	Berghold
1,526,128	A	2/1925	Flohr
1,527,587	A	2/1925	Hutchinson
1,551,900	A	9/1925	Morrow
1,553,996	A	9/1925	Federer
1,582,483	A	4/1926	Runyan
1,600,604	A	9/1926	Sorlien
1,616,478	A	2/1927	Watson
1,640,517	A	8/1927	Procknow
1,662,372	A	3/1928	Ward
1,701,948	A	2/1929	Crowe
1,711,490	A	5/1929	Drummond
1,712,828	A	5/1929	Klehm
1,774,521	A	9/1930	Neighbour
1,807,120	A	5/1931	Lewis
1,811,066	A	6/1931	Tannewitz
1,879,280	A	9/1932	James
1,896,924	A	2/1933	Ulrich
1,902,270	A	3/1933	Tate
1,904,005	A	4/1933	Masset
1,910,651	A	5/1933	Tautz
1,938,548	A	12/1933	Tautz
1,938,549	A	12/1933	Tautz
1,963,688	A	6/1934	Tautz
1,988,102	A	1/1935	Woodward
1,993,219	A	3/1935	Merrigan
2,007,887	A	7/1935	Tautz
2,010,851	A	8/1935	Drummond
2,020,222	A	11/1935	Tautz
2,038,810	A	4/1936	Tautz
2,075,282	A	3/1937	Hedgpeth
2,095,330	A	10/1937	Hedgpeth
2,106,288	A	1/1938	Tautz
2,106,321	A	1/1938	Guertin
2,121,069	A	6/1938	Collins
2,131,492	A	9/1938	Ocenasek
2,163,320	A	6/1939	Hammond
2,168,282	A	8/1939	Tautz
2,241,556	A	5/1941	MacMillin et al.
2,261,696	A	11/1941	Ocenasek
2,265,407	A	12/1941	Tautz
2,286,589	A	6/1942	Tannewitz
2,292,872	A	8/1942	Eastman
2,299,262	A	10/1942	Uremovich
2,312,118	A	2/1943	Neisewander
2,313,686	A	3/1943	Uremovich
2,328,244	A	8/1943	Woodward
2,352,235	A	6/1944	Tautz
2,377,265	A	3/1945	Rady
2,402,232	A	6/1946	Baker
2,425,331	A	8/1947	Kramer
2,434,174	A	1/1948	Morgan
2,452,589	A	11/1948	McWhirter et al.
2,466,325	A	4/1949	Ocenasek
2,496,613	A	2/1950	Woodward
2,509,813	A	5/1950	Dineen
2,517,649	A	8/1950	Frechtmann
2,518,684	A	8/1950	Harris
2,530,290	A	11/1950	Collins
2,554,124	A	5/1951	Salmont
2,562,396	A	7/1951	Schutz
2,572,326	A	10/1951	Evans
2,590,035	A	3/1952	Pollak
2,593,596	A	4/1952	Olson
2,601,878	A	7/1952	Anderson
2,623,555	A	12/1952	Eschenburg
2,625,966	A	1/1953	Copp
2,626,639	A	1/1953	Hess
2,661,777	A	12/1953	Hitchcock
2,661,780	A	12/1953	Morgan
2,675,707	A	4/1954	Brown
2,678,071	A	5/1954	Odlum et al.
2,690,084	A	9/1954	Van Dam
2,695,638	A	11/1954	Gaskell
2,704,560	A	3/1955	Woessner
2,711,762	A	6/1955	Gaskell
2,722,246	A	11/1955	Arnoldy
2,731,049	A	1/1956	Akin
2,736,348	A	2/1956	Nelson
2,737,213	A	3/1956	Richards et al.
2,758,615	A	8/1956	Mastriforte
2,785,710	A	3/1957	Mowery, Jr.
2,786,496	A	3/1957	Eschenburg
2,810,408	A	10/1957	Boice et al.
2,844,173	A	7/1958	Gaskell
2,850,054	A	9/1958	Eschenburg
2,852,047	A	9/1958	Odlum et al.
2,873,773	A	2/1959	Gaskell
2,883,486	A	4/1959	Mason
2,894,546	A	7/1959	Eschenburg
2,913,025	A	11/1959	Richards
2,913,581	A	11/1959	Simonton et al.
2,945,516	A	7/1960	Edgemond, Jr. et al.
2,954,118	A	9/1960	Anderson
2,957,166	A	10/1960	Gluck
2,978,084	A	4/1961	Vilkaitis
2,984,268	A	5/1961	Vuichard
2,991,593	A	7/1961	Cohen
3,005,477	A	10/1961	Sherwen
3,011,529	A	12/1961	Copp
3,011,610	A	12/1961	Stiebel et al.
3,013,592	A	12/1961	Ambrosio et al.
3,021,881	A	2/1962	Edgemond, Jr. et al.
3,035,995	A	5/1962	Seeley et al.
3,047,116	A	7/1962	Stiebel et al.
3,085,602	A	4/1963	Gaskell
3,105,530	A	10/1963	Peterson
3,129,731	A	4/1964	Tyrrell

3,163,732	A		12/1964	Abbott			
3,184,001	A		5/1965	Reinsch et al.			
3,186,256	A		6/1965	Reznick			
3,207,273	A		9/1965	Jurin			
3,213,731	A		10/1965	Renard			
3,224,474	A		12/1965	Bloom			
3,232,326	A		2/1966	Speer et al.			
3,246,205	A		4/1966	Miller			
3,249,134	A		5/1966	Vogl et al.			
3,306,149	A		2/1967	John			
3,313,185	A		4/1967	Drake et al.			
3,315,715	A		4/1967	Mytinger			
3,323,814	A		6/1967	Phillips			
3,337,008	A		8/1967	Trachte			
3,356,111	A		12/1967	Mitchell			
3,386,322	A		6/1968	Stone et al.			
3,439,183	A		4/1969	Hurst, Jr.			
3,445,835	A		5/1969	Fudaley			
3,454,286	A		7/1969	Anderson et al.			
3,456,696	A		7/1969	Gregory et al.			
3,512,440	A		5/1970	Frydmann			
3,538,964	A		11/1970	Warrick et al.			
3,540,338	A		11/1970	McEwan et al.			
3,554,067	A		1/1971	Scutella			
3,566,996	A		3/1971	Crossman			
3,580,376	A		5/1971	Loshbough			
3,581,784	A		6/1971	Warrick			
3,613,748	A		10/1971	De Pue			
3,670,788	A		6/1972	Pollak et al.			
3,675,444	A		7/1972	Whipple			
3,680,609	A		8/1972	Menge			
3,688,815	A		9/1972	Ridenour			
3,695,116	A		10/1972	Baur			
3,696,844	A		10/1972	Bernatschek			
3,745,546	A		7/1973	Struger et al.			
3,749,933	A		7/1973	Davidson			
3,754,493	A		8/1973	Niehaus et al.			
3,772,590	A		11/1973	Mikulecky et al.			
3,785,230	A		1/1974	Lokey			
3,805,639	A	*	4/1974	Peter	74/616		
3,805,658	A	*	4/1974	Scott et al.	83/545		
3,808,932	A		5/1974	Russell			
3,829,850	A		8/1974	Guetersloh			
3,858,095	A		12/1974	Friemann et al.			
3,861,016	A		1/1975	Johnson et al.			
3,863,208	A		1/1975	Balban			
3,880,032	A		4/1975	Green			
3,882,744	A		5/1975	McCarroll			
3,886,413	A		5/1975	Dow et al.			
3,889,567	A	*	6/1975	Sato et al.	83/818		
3,922,785	A		12/1975	Fushiya			
3,924,688	A		12/1975	Cooper et al.			
3,931,727	A		1/1976	Luenser			
3,935,777	A		2/1976	Bassett			
3,945,286	A		3/1976	Smith			
3,946,631	A		3/1976	Malm			
3,947,734	A		3/1976	Fyler			
3,949,636	A		4/1976	Ball et al.			
3,953,770	A		4/1976	Hayashi			
3,960,310	A		6/1976	Nussbaum			
3,967,161	A		6/1976	Lichtblau			
3,974,565	A		8/1976	Ellis			
3,975,600	A		8/1976	Marston			
3,978,624	A		9/1976	Merkel et al.			
3,994,192	A		11/1976	Faig			
4,007,679	A		2/1977	Edwards			
4,016,490	A		4/1977	Weckenmann et al.			
4,026,174	A		5/1977	Fierro			
4,026,177	A		5/1977	Lokey			
4,029,159	A	*	6/1977	Nymann	173/217		
4,047,156	A		9/1977	Atkins			
4,048,886	A	*	9/1977	Zettler	83/58		
4,060,160	A		11/1977	Lieber			
4,070,940	A		1/1978	McDaniel et al.			
4,075,961	A		2/1978	Harris			
4,077,161	A		3/1978	Wyle et al.			
4,085,303	A		4/1978	McIntyre et al.			
4,090,345	A		5/1978	Harkness			
4,091,698	A		5/1978	Obear et al.			
4,106,378	A		8/1978	Kaiser			
4,117,752	A		10/1978	Yoneda			
4,145,940	A		3/1979	Woloveke et al.			
4,152,833	A		5/1979	Phillips			
4,161,649	A		7/1979	Klos et al.			
4,175,452	A		11/1979	Idel			
4,190,000	A		2/1980	Shaull et al.			
4,195,722	A		4/1980	Anderson et al.			
4,199,930	A		4/1980	Lebet et al.			
4,249,117	A		2/1981	Leukhardt et al.			
4,249,442	A		2/1981	Fittery			
4,262,278	A		4/1981	Howard et al.			
4,267,914	A		5/1981	Saar			
4,270,427	A		6/1981	Colberg et al.			
4,276,799	A		7/1981	Muehling			
4,291,794	A		9/1981	Bauer			
4,305,442	A		12/1981	Currie			
4,321,841	A		3/1982	Felix			
4,372,202	A		2/1983	Cameron			
4,391,358	A		7/1983	Haeger			
4,418,597	A		12/1983	Krusemark et al.			
4,466,233	A		8/1984	Thesman			
4,470,046	A		9/1984	Betsill			
4,510,489	A		4/1985	Anderson, III et al.			
4,512,224	A		4/1985	Terauchi			
4,518,043	A		5/1985	Anderson et al.			
4,532,501	A		7/1985	Hoffman			
4,532,844	A		8/1985	Chang et al.			
4,557,168	A	*	12/1985	Tokiwa	83/56		
4,560,033	A		12/1985	DeWoody et al.			
4,566,512	A		1/1986	Wilson			
4,573,556	A		3/1986	Andreasson			
4,576,073	A		3/1986	Stinson			
4,589,047	A		5/1986	Gaus et al.			
4,589,860	A		5/1986	Brandenstein et al.			
4,599,597	A		7/1986	Rotbart			
4,599,927	A		7/1986	Eccardt et al.			
4,606,251	A		8/1986	Boileau			
4,615,247	A		10/1986	Berkeley			
4,621,300	A		11/1986	Summerer			
4,625,604	A		12/1986	Handler et al.			
4,637,188	A		1/1987	Crothers			
4,637,289	A		1/1987	Ramsden			
4,644,832	A	*	2/1987	Smith	83/72		
4,653,189	A	*	3/1987	Andreasson	30/382		
4,657,428	A		4/1987	Wiley			
4,672,500	A		6/1987	Tholome et al.			
4,675,664	A		6/1987	Cloutier et al.			
4,679,719	A		7/1987	Kramer			
4,722,021	A		1/1988	Hornung et al.			
4,751,603	A		6/1988	Kwan			
4,756,220	A		7/1988	Olsen et al.			
4,757,881	A		7/1988	Jonsson et al.			
4,792,965	A		12/1988	Morgan			
4,805,504	A		2/1989	Fushiya			
4,840,135	A		6/1989	Yamauchi			
4,845,476	A		7/1989	Rangeard et al.			
4,864,455	A		9/1989	Shimomura et al.			
4,875,398	A		10/1989	Taylor et al.			
4,896,607	A		1/1990	Hall et al.			
4,906,962	A		3/1990	Duimstra			
4,934,233	A		6/1990	Brundage et al.			
4,936,876	A		6/1990	Reyes			
4,937,554	A		6/1990	Herman			
4,965,909	A		10/1990	McCullough et al.			
4,975,798	A		12/1990	Edwards et al.			
5,020,406	A		6/1991	Sasaki et al.			

5,025,175	A		6/1991	Dubois, III			
5,046,426	A		9/1991	Julien et al.			
5,052,255	A		10/1991	Gaines			
5,074,047	A		12/1991	King			
5,081,406	A		1/1992	Hughes et al.			
5,082,316	A		1/1992	Wardlaw			
5,083,973	A		1/1992	Townsend			
5,086,890	A		2/1992	Turczyn et al.			
5,094,000	A	*	3/1992	Becht et al.	30/475		
5,119,555	A		6/1992	Johnson			
5,122,091	A		6/1992	Townsend			
5,174,349	A		12/1992	Svetlik et al.			
5,184,534	A		2/1993	Lee			
5,198,702	A		3/1993	McCullough et al.			
5,199,343	A		4/1993	OBanion			
5,201,684	A		4/1993	DeBois, III			
5,207,253	A		5/1993	Hoshino et al.			
5,212,621	A		5/1993	Panter			
5,218,189	A		6/1993	Hutchison			
5,231,359	A		7/1993	Masuda et al.			
5,231,906	A		8/1993	Kogej			
5,239,978	A		8/1993	Plangetis			
5,245,879	A		9/1993	McKeon			
5,257,570	A		11/1993	Shiotani et al.			
5,265,510	A		11/1993	Hoyer-Ellefsen			
5,272,946	A		12/1993	McCullough et al.			
5,276,431	A		1/1994	Piccoli et al.			
5,285,708	A		2/1994	Bosten et al.			
5,320,382	A		6/1994	Goldstein et al.			
5,321,230	A		6/1994	Shanklin et al.			
5,331,875	A		7/1994	Mayfield			
5,353,670	A		10/1994	Metzger, Jr.			
5,377,554	A		1/1995	Reulein et al.			
5,377,571	A		1/1995	Josephs			
5,392,568	A		2/1995	Howard, Jr. et al.			
5,392,678	A		2/1995	Sasaki et al.			
5,401,928	A	*	3/1995	Kelley	200/510		
5,411,221	A		5/1995	Collins et al.			
5,436,613	A		7/1995	Ghosh et al.			
5,451,750	A		9/1995	An			
5,453,903	A		9/1995	Chow			
5,471,888	A		12/1995	McCormick			
5,480,009	A	*	1/1996	Wieland et al.	188/77 W		
5,503,059	A		4/1996	Pacholok			
5,510,685	A		4/1996	Grasselli			
5,513,548	A		5/1996	Garuglieri			
5,534,836	A		7/1996	Schenkel et al.			
5,572,916	A	*	11/1996	Takano	83/74		
5,587,618	A		12/1996	Hathaway			
5,592,353	A		1/1997	Shinohara et al.			
5,606,889	A		3/1997	Bielinski et al.			
5,623,860	A		4/1997	Schoene et al.			
5,648,644	A		7/1997	Nagel			
5,659,454	A		8/1997	Vermesse			
5,667,152	A		9/1997	Mooring			
5,671,633	A		9/1997	Wagner			
5,695,306	A		12/1997	Nygren, Jr.			
5,700,165	A		12/1997	Harris et al.			
5,724,875	A		3/1998	Meredith et al.			
5,730,165	A		3/1998	Philipp			
5,741,048	A		4/1998	Eccleston			
5,755,148	A		5/1998	Stumpf et al.			
5,771,742	A		6/1998	Bokaie et al.			
5,782,001	A		7/1998	Gray			
5,787,779	A		8/1998	Garuglieri			
5,791,057	A		8/1998	Nakamura et al.			
5,791,223	A		8/1998	Lanzer			
5,791,224	A		8/1998	Suzuki et al.			
5,791,441	A		8/1998	Matos et al.			
5,819,619	A		10/1998	Miller et al.			
5,852,951	A		12/1998	Santi			
5,861,809	A		1/1999	Eckstein et al.			
5,875,698	A		3/1999	Ceroll et al.			
5,921,367	A		7/1999	Kashioka et al.			
5,930,096	A		7/1999	Kim			
5,937,720	A		8/1999	Itzov			
5,942,975	A		8/1999	Sorensen			
5,943,932	A		8/1999	Sberveglieri			
5,950,514	A		9/1999	Benedict et al.			
5,963,173	A		10/1999	Lian et al.			
5,974,927	A		11/1999	Tsune			
5,989,116	A	*	11/1999	Johnson et al.	452/150		
6,018,284	A		1/2000	Rival et al.			
6,037,729	A		3/2000	Woods et al.			
6,052,884	A		4/2000	Steckler et al.			
6,095,092	A		8/2000	Chou			
6,119,984	A		9/2000	Devine			
6,133,818	A		10/2000	Hsieh et al.			
6,141,192	A		10/2000	Garzon			
6,148,504	A		11/2000	Schmidt et al.			
6,150,826	A		11/2000	Hokodate et al.			
6,170,370	B1		1/2001	Sommerville			
6,244,149	B1		6/2001	Ceroll et al.			
6,257,061	B1		7/2001	Nonoyama et al.			
6,330,848	B1		12/2001	Nishio et al.			
6,352,137	B1		3/2002	Stegall et al.			
6,366,099	B1		4/2002	Reddi			
6,376,939	B1		4/2002	Suzuki et al.			
6,404,098	B1		6/2002	Kayama et al.			
6,405,624	B2		6/2002	Sutton			
6,418,829	B1		7/2002	Pilchowski			
6,420,814	B1		7/2002	Bobbio			
6,427,570	B1		8/2002	Miller et al.			
6,430,007	B1		8/2002	Jabbari			
6,431,425	B1		8/2002	Moorman et al.			
6,450,077	B1		9/2002	Ceroll et al.			
6,453,786	B1		9/2002	Ceroll et al.			
6,460,442	B2		10/2002	Talesky et al.			
6,471,106	B1		10/2002	Reining			
6,479,958	B1		11/2002	Thompson et al.			
D466,913	S		12/2002	Ceroll et al.			
6,492,802	B1		12/2002	Bielski			
D469,354	S		1/2003	Curtsinger			
6,502,493	B1		1/2003	Eccardt et al.			
6,536,536	B1		3/2003	Gass et al.			
6,543,324	B2		4/2003	Dils			
6,546,835	B2		4/2003	Wang			
6,575,067	B2		6/2003	Parks et al.			
6,578,460	B2		6/2003	Sartori			
6,578,856	B2		6/2003	Kahle			
6,595,096	B2		7/2003	Ceroll et al.			
D478,917	S		8/2003	Ceroll et al.			
6,601,493	B1		8/2003	Crofutt			
6,607,015	B1		8/2003	Chen			
D479,538	S		9/2003	Welsh et al.			
6,617,720	B1		9/2003	Egan, III et al.			
6,619,348	B2		9/2003	Wang			
6,640,683	B2		11/2003	Lee			
6,644,157	B2		11/2003	Huang			
6,647,847	B2		11/2003	Hewitt et al.			
6,659,233	B2		12/2003	DeVlieg			
6,736,042	B2		5/2004	Behne et al.			
6,742,430	B2		6/2004	Chen			
6,796,208	B1		9/2004	Jorgensen			
6,826,988	B2		12/2004	Gass et al.			
6,857,345	B2		2/2005	Gass et al.			
6,874,397	B2		4/2005	Chang			
6,874,399	B2		4/2005	Lee			
6,920,814	B2		7/2005	Gass et al.			
6,945,148	B2		9/2005	Gass et al.			
6,945,149	B2		9/2005	Gass et al.			
2001/0032534	A1		10/2001	Cerroll et al.			
2002/0096030	A1		7/2002	Wang			
2002/0109036	A1		8/2002	Denen et al.			
2003/0037655	A1		2/2003	Chin-Chin			
2003/0074873	A1		4/2003	Freiberg et al.			

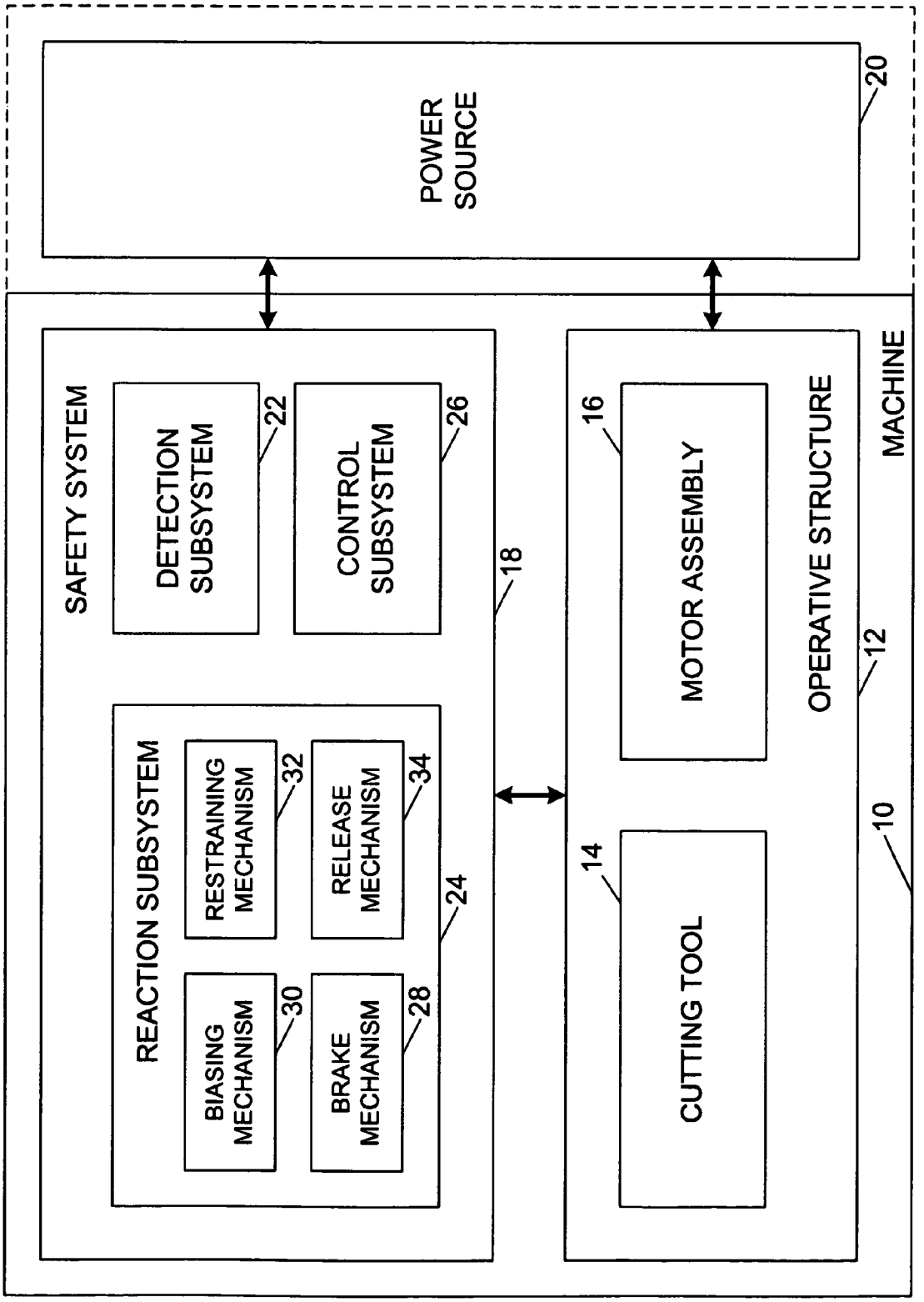
2003/0089212	A1	5/2003	Parks et al.
2003/0101857	A1	6/2003	Chuang
2003/0109798	A1	6/2003	Kermani
2004/0011177	A1	1/2004	Huang
2004/0060404	A1	4/2004	Metzger, Jr.
2004/0104085	A1	6/2004	Lang et al.
2004/0159198	A1	8/2004	Peot et al.
2004/0194594	A1	10/2004	Dils et al.
2004/0200329	A1	10/2004	Sako
2004/0226424	A1	11/2004	O'Banion et al.
2004/0226800	A1	11/2004	Pierga et al.
2005/0057206	A1	3/2005	Uneyama
2005/0092149	A1	5/2005	Hartmann
2005/0139051	A1	6/2005	Gass et al.
2005/0139056	A1	6/2005	Gass et al.
2005/0139057	A1	6/2005	Gass et al.
2005/0139058	A1	6/2005	Gass et al.
2005/0139459	A1	6/2005	Gass et al.
2005/0155473	A1	7/2005	Gass
2005/0166736	A1	8/2005	Gass et al.
2005/0178259	A1	8/2005	Gass et al.
2005/0204885	A1	9/2005	Gass et al.

FOREIGN PATENT DOCUMENTS

DE	76186		8/1921
DE	2800403		7/1979
DE	3427733		1/1986
DE	4235161	A1	5/1993
DE	4326313		2/1995
DE	19609771		6/1998
EP	146460		11/1988
EP	0362937	A2	4/1990
ES	2152184		1/2001
FR	2556643		6/1985
FR	2570017		3/1986
GB	598204		2/1948
GB	1132708		11/1968
GB	2096844		10/1982
GB	2142571		1/1985

* cited by examiner

Fig. 1


POWER SOURCE
20
SAFETY SYSTEM
DETECTION SUBSYSTEM
22
CONTROL SUBSYSTEM
26
18
REACTION SUBSYSTEM
RESTRAINING MECHANISM
32
RELEASE MECHANISM
34
24
BIASING MECHANISM
30
BRAKE MECHANISM
28
MACHINE
OPERATIVE STRUCTURE
12
16
MOTOR ASSEMBLY
14
CUTTING TOOL
10

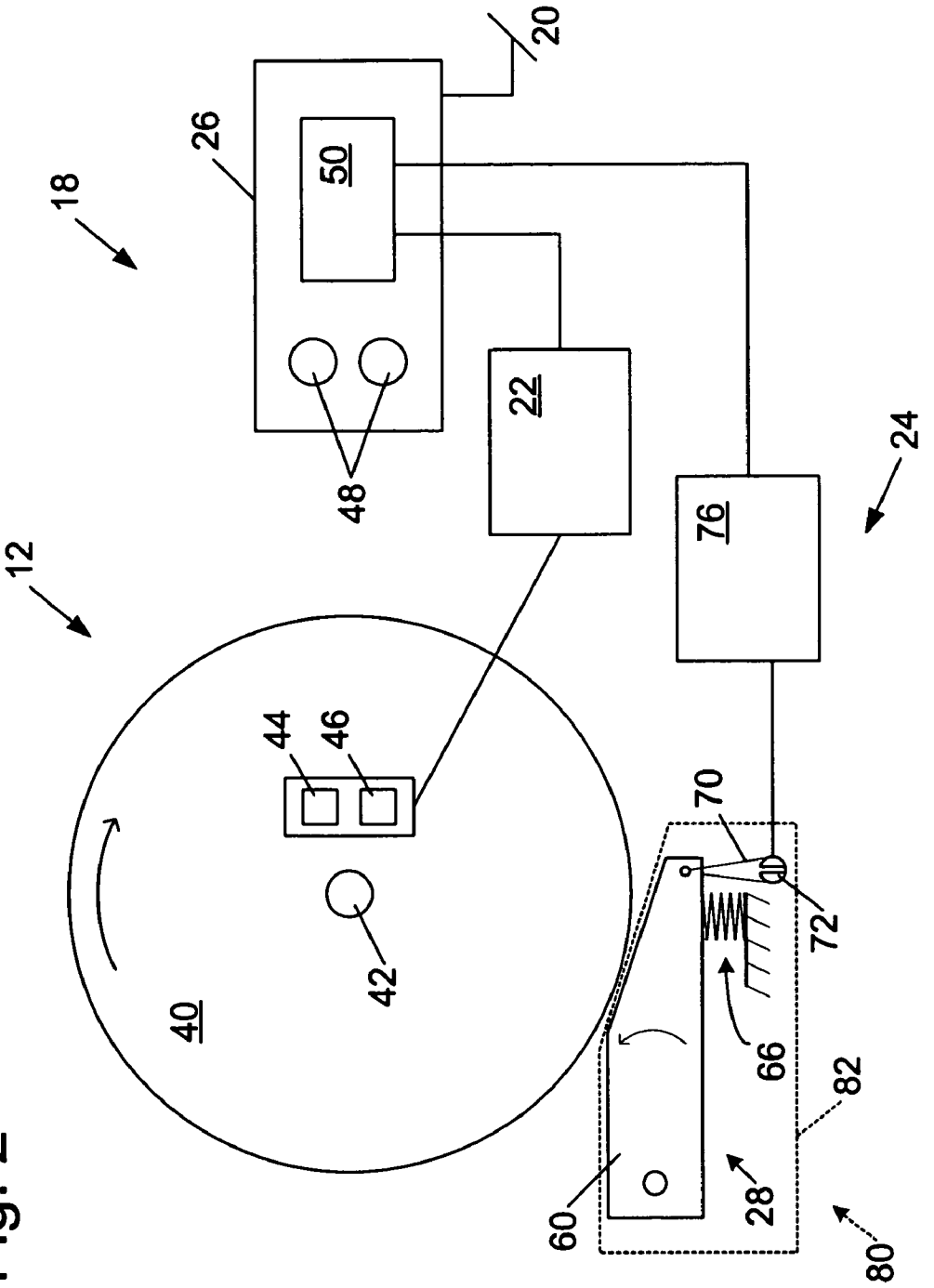


Fig. 2

Fig. 3

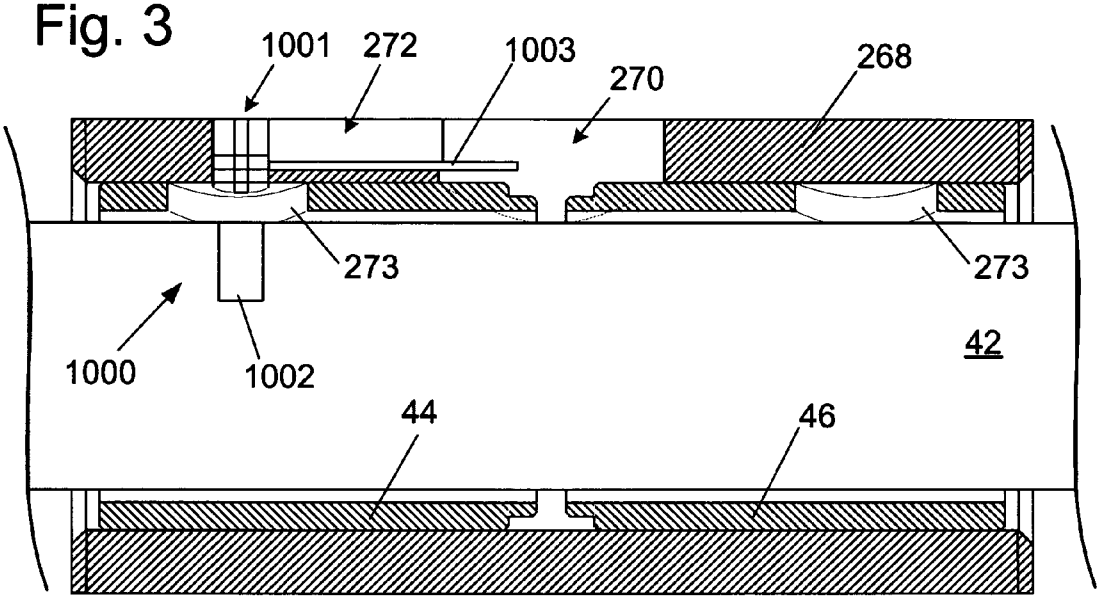

1001
272
1003
270
268
273
273
1000
1002
42
44
46

Fig. 4

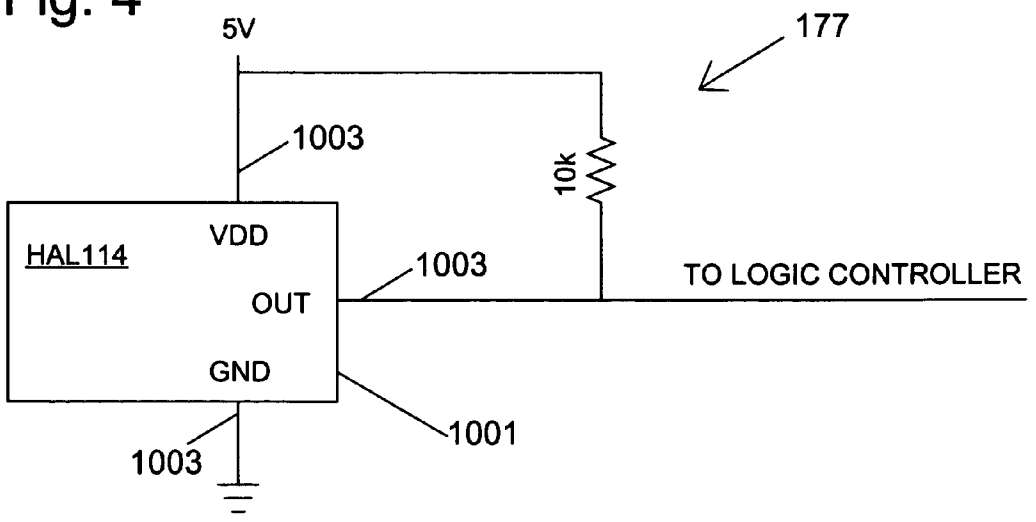

5V
177
1003
10k
HAL114
VDD
OUT
GND
1003
TO LOGIC CONTROLLER
1001
1003

Fig. 5

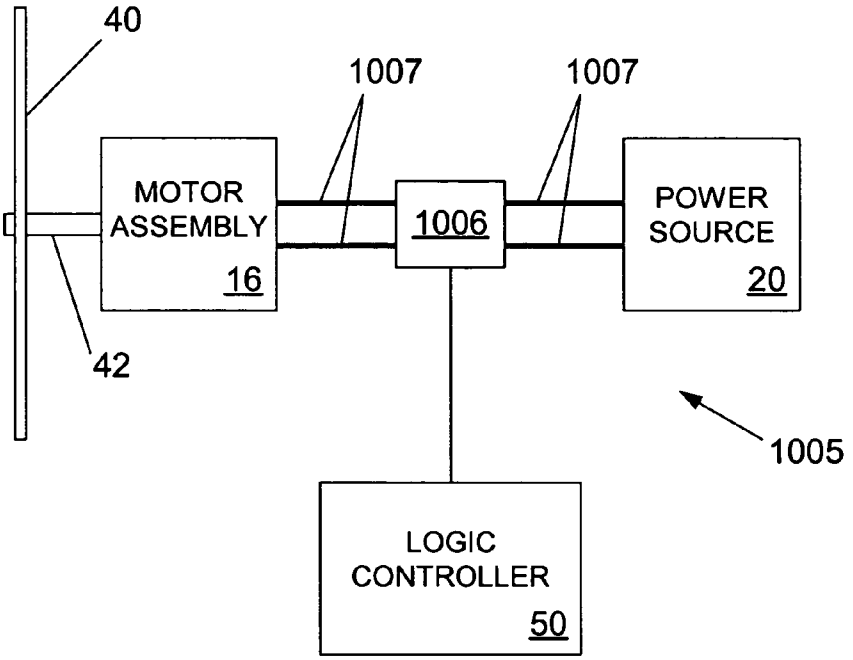

40
1007
1007
MOTOR ASSEMBLY
16
1006
POWER SOURCE
20
42
1005
LOGIC CONTROLLER
50

Fig. 6

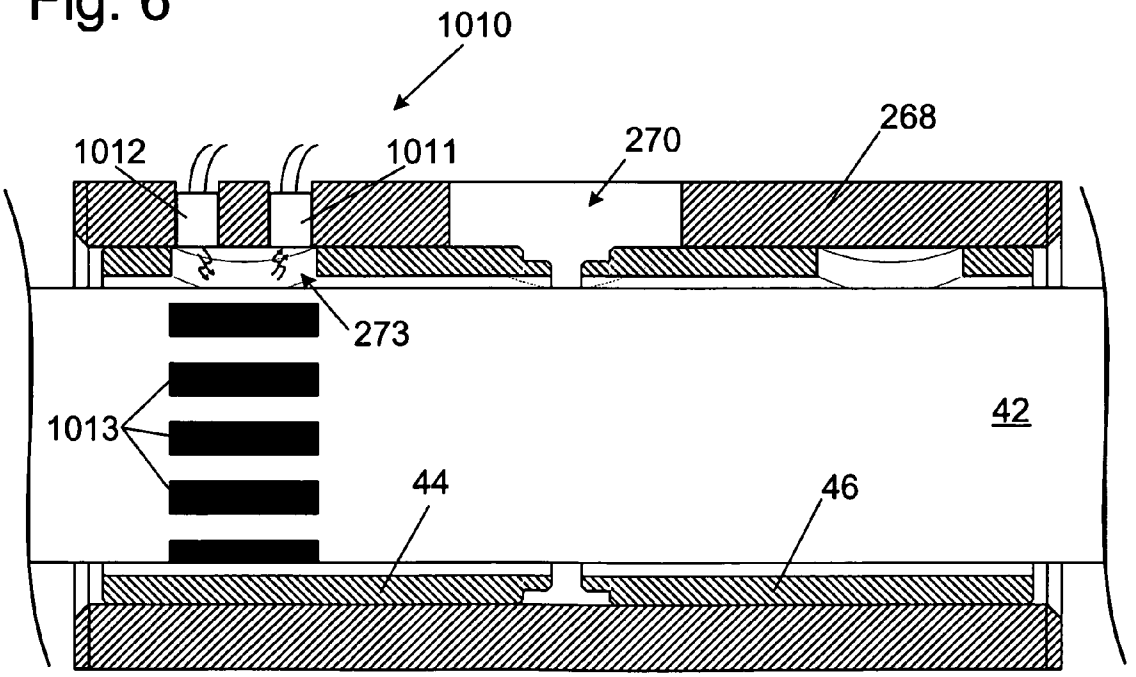

1010
1012
1011
270
268
273
1013
42
44
46

Fig. 7

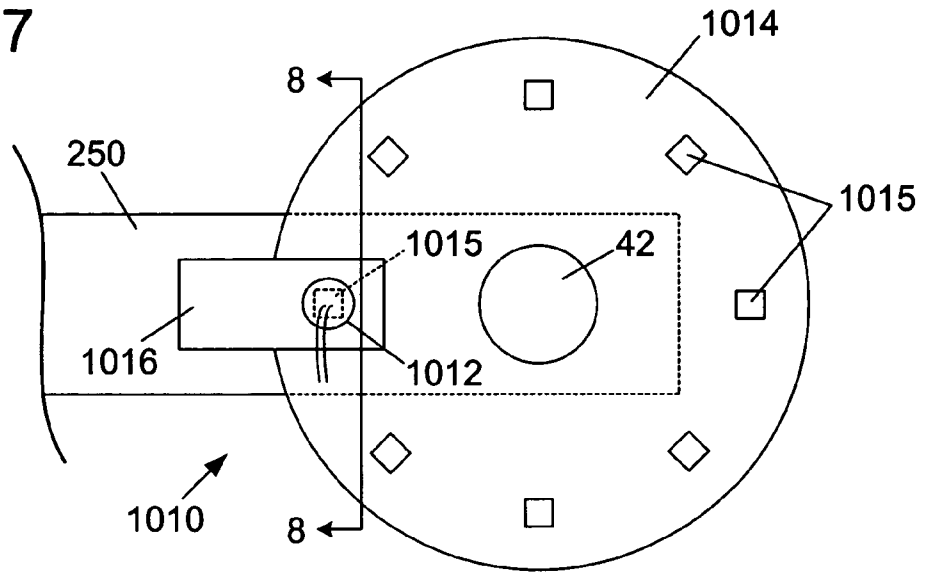


Fig. 8

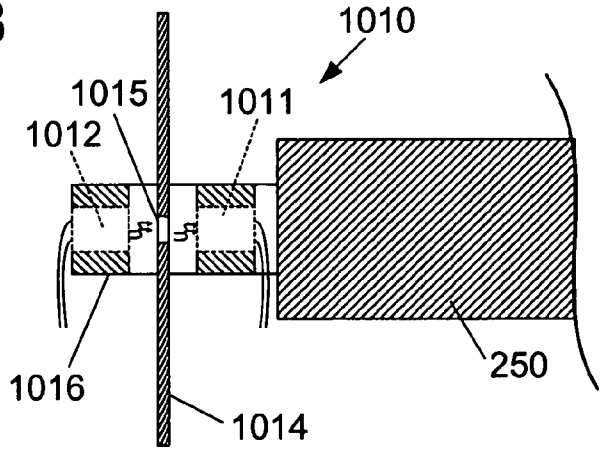


Fig. 9

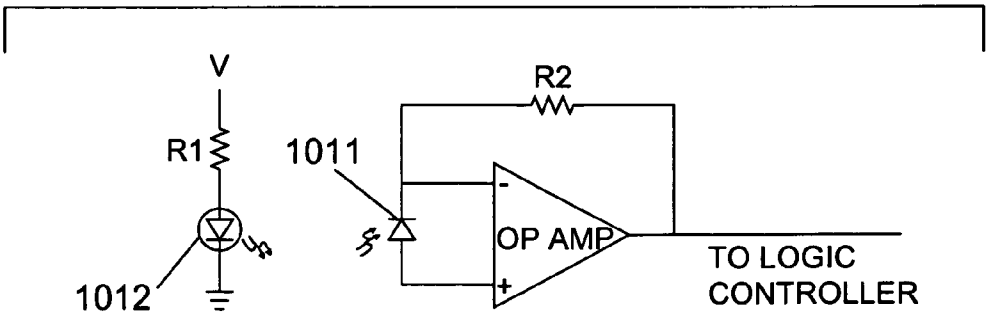


Fig. 10

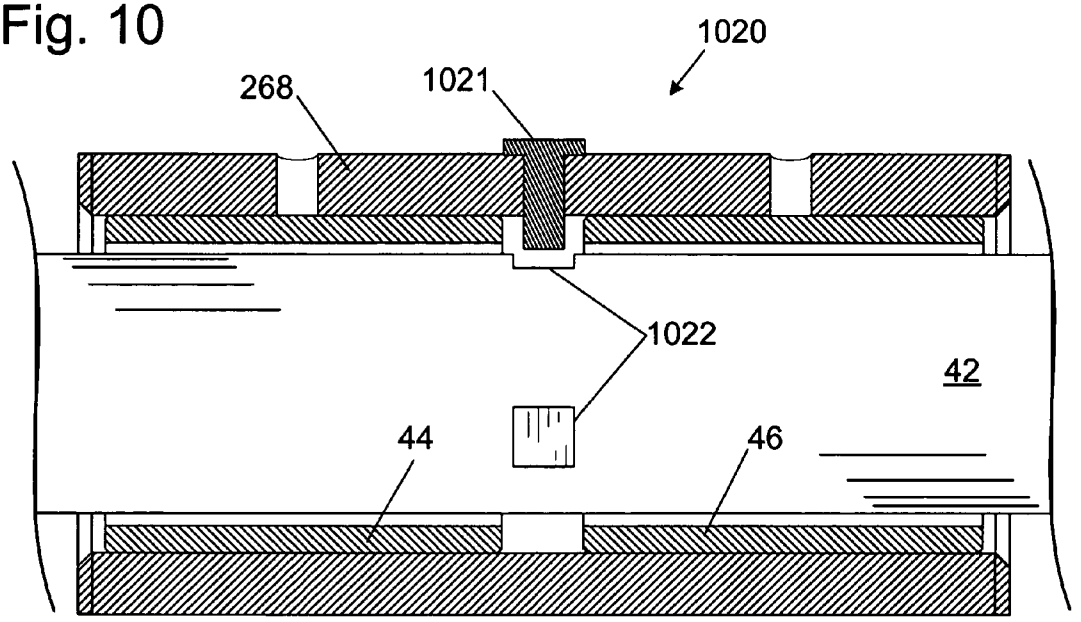
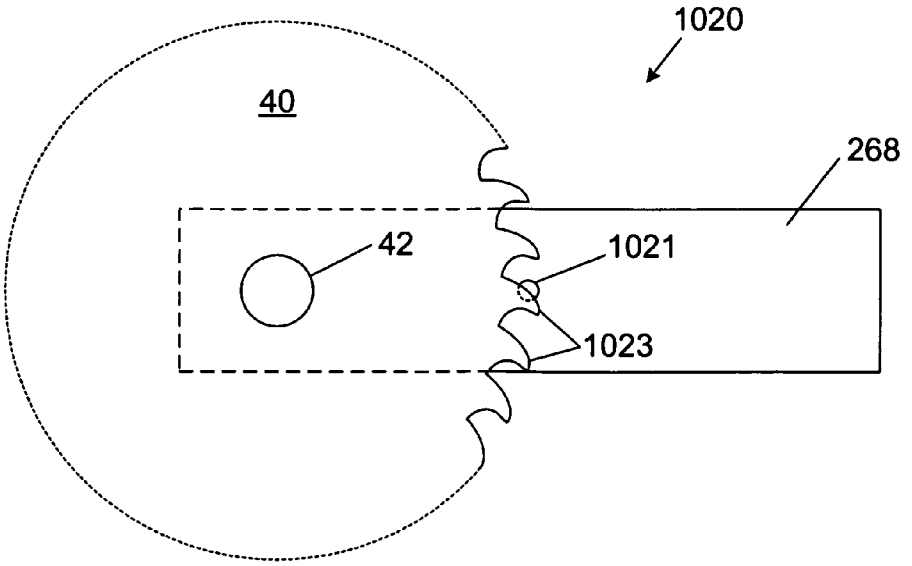


Fig. 11



MOTION DETECTING SYSTEM FOR USE IN A SAFETY SYSTEM FOR POWER EQUIPMENT

CROSS-REFERENCE TO RELATED APPLICATIONS

This application claims the benefit of and priority from the following U.S. Provisional Patent Applications: Ser. No. 60/225,056, filed Aug. 14, 2000, Ser. No. 60/225,057, filed Aug. 14, 2000, Ser. No. 60/225,058, filed Aug. 14, 2000, Ser. No. 60/225,059, filed Aug. 14, 2000, Ser. No. 60/225,089, filed Aug. 14, 2000, Ser. No. 60/225,094, filed Aug. 14, 2000, Ser. No. 60/225,169, filed Aug. 14, 2000, Ser. No. 60/225,170, filed Aug. 14, 2000, Ser. No. 60/225,200, filed Aug. 14, 2000, Ser. No. 60/225,201, filed Aug. 14 , 2000, Ser. No. 60/225,206, filed Aug. 14 , 2000, Ser. No. 60/225,210, filed Aug. 14, 2000, Ser. No. 60/225,211, filed Aug. 14, 2000, and Ser. No. 60/225,212, filed Aug. 14, 2000.

FIELD

The present invention relates to safety systems, and more particularly to a high-speed safety system for use on power equipment.

BACKGROUND

Beginning with the industrial revolution and continuing to the present, mechanized equipment has allowed workers to produce goods with greater speed and less effort than possible with manually-powered tools. Unfortunately, the power and high operating speeds of mechanized equipment creates a risk for those operating such machinery. Each year thousands of people are maimed or killed by accidents involving power equipment.

As might be expected, many systems have been developed to minimize the risk of injury when using power equipment. Probably the most common safety feature is a guard that physically blocks an operator from making contact with dangerous components of machinery, such as belts, shafts or blades. In many cases, guards are effective to reduce the risk of injury, however, there are many instances where the nature of the operations to be performed precludes using a guard that completely blocks access to hazardous machine parts.

Various systems have been proposed to prevent accidental injury where guards cannot effectively be employed. For instance, U.S. Pat. Nos. 941,726, 2,978,084, 3,011,610, 3,047,116, 4,195,722 and 4,321,841, the disclosures of which are incorporated herein by reference, all disclose safety systems for use with power presses. These systems utilize cables attached to the wrists of the operator that either pull back a user's hands from the work zone upon operation or prevent operation until the user's hands are outside the danger zone. U.S. Pat. Nos. 3,953,770, 4,075,961, 4,470,046, 4,532,501 and 5,212,621, the disclosures of which are incorporated herein by reference, disclose radio-frequency safety systems which utilize radio-frequency signals to detect the presence of a user's hand in a dangerous area of the machine and thereupon prevent or interrupt operation of the machine.

U.S. Pat. Nos. 4,959,909, 5,025,175, 5,122,091, 5,198,702, 5,201,684, 5,272,946, and 5,510,685 disclose safety systems for use with meat-skinning equipment, and are incorporated herein by reference. These systems interrupt or reverse power to the motor, or disengage a clutch, upon

contact with a user's hand by any dangerous portion of the machine. Typically, contact between the user and the machine is detected by monitoring for electrical contact between a fine wire mesh in a glove worn by the user and some metal component in the dangerous area of the machine.

U.S. Pat. Nos. 3,785,230 and 4,026,177, the disclosures of which are herein incorporated by reference, disclose a safety system for use on circular saws to stop the blade when a user's hand approaches the blade. The system uses the blade as an antenna in an electromagnetic proximity detector to detect the approach of a user's hand prior to actual contact with the blade. Upon detection of a user's hand, the system engages a brake using a standard solenoid. U.S. Pat. No. 4,117,752, which is herein incorporated by reference, discloses a similar braking system for use with a band saw, where the brake is triggered by actual contact between the user's hand and the blade.

It is often necessary for an equipment operator to touch the blade or other cutting device of power equipment when the blade or device is not moving (e.g., to adjust the blade, perform equipment maintenance, etc.). Thus, it would be desirable to disable the safety system when the blade is not moving since there is no danger to the user from contact with the blade.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a schematic block diagram of a machine with a fast-acting safety system according to the present invention.

FIG. **2** is a schematic diagram of an exemplary safety system in the context of a machine having a circular blade.

FIG. **3** is a partial cross-section view of an exemplary magnetic sensor assembly according to the present invention, where the arbor is not in cross-sectional view.

FIG. **4** is a schematic diagram of an exemplary circuit according to the present invention for use with a magnetic sensor assembly.

FIG. **5** is a schematic view of an exemplary EMF sensor assembly according to the present invention.

FIG. **6** is a partial cross-section view of an exemplary optical sensor assembly according to the present invention, where the arbor is not in cross-sectional view.

FIG. **7** is a side elevation of an alternative optical sensor assembly according to the present invention.

FIG. **8** is a cross-section view of the alternative optical sensor assembly of FIG. **7**, taken generally along the line **8**—**8**.

FIG. **9**. is a schematic diagram of an exemplary circuit according to the present invention for use with an optical sensor assembly.

FIG. **10** is a partial cross-section view of an exemplary electrical sensor assembly according to the present invention, where the arbor is not in cross-sectional view.

FIG. **11** is a schematic side elevation of an alternative electrical sensor assembly according to the present invention.

DETAILED DESCRIPTION

A machine is shown schematically in FIG. **1** and indicated generally at **10**. Machine **10** may be any of a variety of different machines adapted for cutting workpieces, such as wood, including a table saw, miter saw (chop saw), radial arm saw, circular saw, band saw, jointer, planer, etc. Machine **10** includes an operative structure **12** having a cutting tool **14** and a motor assembly **16** adapted to drive the

cutting tool. Machine **10** also includes a safety system **18** configured to minimize the potential of a serious injury to a person using machine **10**. Safety system **18** is adapted to detect the occurrence of one or more dangerous conditions during use of machine **10**. If such a dangerous condition is detected, safety system **18** is adapted to engage operative structure **12** to limit any injury to the user caused by the dangerous condition.

Machine **10** also includes a suitable power source **20** to provide power to operative structure **12** and safety system **18**. Power source **20** may be an external power source such as line current, or an internal power source such as a battery. Alternatively, power source **20** may include a combination of both external and internal power sources. Furthermore, power source **20** may include two or more separate power sources, each adapted to power different portions of machine **10**.

It will be appreciated that operative structure **12** may take any one of many different forms, depending on the type of machine **10**. For example, operative structure **12** may include a stationary housing configured to support motor assembly **16** in driving engagement with cutting tool **14**. Alternatively, operative structure **12** may include a movable structure configured to carry cutting tool **14** between multiple operating positions. As a further alternative, operative structure **12** may include one or more transport mechanisms adapted to convey a workpiece toward and/or away from cutting tool **14**.

Motor assembly **16** includes one or more motors adapted to drive cutting tool **14**. The motors may be either directly or indirectly coupled to the cutting tool, and may also be adapted to drive workpiece transport mechanisms. Cutting tool **14** typically includes one or more blades or other suitable cutting implements that are adapted to cut or remove portions from the workpieces. The particular form of cutting tool **14** will vary depending upon the various embodiments of machine **10**. For example, in table saws, miter saws, circular saws and radial arm saws, cutting tool **14** will typically include one or more circular rotating blades having a plurality of teeth disposed along the perimetrical edge of the blade. For a jointer or planer, the cutting tool typically includes a plurality of radially spaced-apart blades. For a band saw, the cutting tool includes an elongate, circuitous tooth-edged band.

Safety system **18** includes a detection subsystem **22**, a reaction subsystem **24** and a control subsystem **26**. Control subsystem **26** may be adapted to receive inputs from a variety of sources including detection subsystem **22**, reaction subsystem **24**, operative structure **12** and motor assembly **16**. The control subsystem may also include one or more sensors adapted to monitor selected parameters of machine **10**. In addition, control subsystem **26** typically includes one or more instruments operable by a user to control the machine. The control subsystem is configured to control machine **10** in response to the inputs it receives.

Detection subsystem **22** is configured to detect one or more dangerous, or triggering, conditions during use of machine **10**. For example, the detection subsystem may be configured to detect that a portion of the user's body is dangerously close to, or in contact with, a portion of cutting tool **14**. As another example, the detection subsystem may be configured to detect the rapid movement of a workpiece due to kickback by the cutting tool, as is described in U.S. Provisional Patent Application Ser. No. 60/182,866, the disclosure of which is herein incorporated by reference. In some embodiments, detection subsystem **22** may inform control subsystem **26** of the dangerous condition, which then activates reaction subsystem **24**. In other embodiments, the detection subsystem may be adapted to activate the reaction subsystem directly.

Once activated in response to a dangerous condition, reaction subsystem **24** is configured to engage operative structure **12** quickly to prevent serious injury to the user. It will be appreciated that the particular action to be taken by reaction subsystem **24** will vary depending on the type of machine **10** and/or the dangerous condition that is detected. For example, reaction subsystem **24** may be configured to do one or more of the following: stop the movement of cutting tool **14**, disconnect motor assembly **16** from power source **20**, place a barrier between the cutting tool and the user, or retract the cutting tool from its operating position, etc. The reaction subsystem may be configured to take a combination of steps to protect the user from serious injury. Placement of a barrier between the cutting tool and teeth is described in more detail in U.S. Provisional Patent Application Ser. No. 60/225,206, entitled "Cutting Tool Safety System," filed Aug. 14, 2000 by SD3, LLC, the disclosure of which is herein incorporated by reference. Retraction of the cutting tool from its operating position is described in more detail in U.S. Provisional Patent Application Ser. No. 60/225,089, entitled "Retraction System For Use In Power Equipment," filed Aug. 14, 2000 by SD3, LLC, the disclosure of which is herein incorporated by reference.

The configuration of reaction subsystem **24** typically will vary depending on which action(s) are taken. In the exemplary embodiment depicted in FIG. **1**, reaction subsystem **24** is configured to stop the movement of cutting tool **14** and includes a brake mechanism **28**, a biasing mechanism **30**, a restraining mechanism **32**, and a release mechanism **34**. Brake mechanism **28** is adapted to engage operative structure **12** under the urging of biasing mechanism **30**. During normal operation of machine **10**, restraining mechanism **32** holds the brake mechanism out of engagement with the operative structure. However, upon receipt of an activation signal by reaction subsystem **24**, the brake mechanism is released from the restraining mechanism by release mechanism **34**, whereupon, the brake mechanism quickly engages at least a portion of the operative structure to bring the cutting tool to a stop.

It will be appreciated by those of skill in the art that the exemplary embodiment depicted in FIG. **1** and described above may be implemented in a variety of ways depending on the type and configuration of operative structure **12**. Turning attention to FIG. **2**, one example of the many possible implementations of safety system **18** is shown. System **18** is configured to engage an operative structure having a cutting tool in the form of a circular blade **40** mounted on a rotating shaft or arbor **42**. Blade **40** includes a plurality of cutting teeth (not shown) disposed around the outer edge of the blade. As described in more detail below, braking mechanism **28** is adapted to engage the teeth of blade **40** and stop the rotation of the blade. U.S. Provisional Patent Application Ser. No. 60/225,210, entitled "Translation Stop For Use In Power Equipment," filed Aug. 14, 2000 by SD3, LLC, the disclosure of which is herein incorporated by reference, describes other systems for stopping the movement of the cutting tool. U.S. Provisional Patent Application Ser. No. 60/225,058, entitled "Table Saw With Improved Safety System," filed Aug. 14, 2000 by SD3, LLC, and U.S. Provisional Patent Application Ser. No. 60/225,057, entitled "Miter Saw With Improved Safety System," filed Aug. 14, 2000 by SD3, LLC, the disclosures of which are herein incorporated by reference, describe safety system **18** in the context of particular types of machines **10**.

In the exemplary implementation, detection subsystem **22** is adapted to detect the dangerous condition of the user coming into contact with blade **40**. The detection subsystem includes a sensor assembly, such as contact detection plates **44** and **46**, capacitively coupled to blade **40** to detect any contact between the user's body and the blade. Typically, the blade, or some larger portion of cutting tool **14** is electrically isolated from the remainder of machine **10**. Alternatively, detection subsystem **22** may include a different sensor assembly configured to detect contact in other ways, such as optically, resistively, etc. In any event, the detection subsystem is adapted to transmit a signal to control subsystem **26** when contact between the user and the blade is detected. Various exemplary embodiments and implementations of detection subsystem **22** are described in more detail in U.S. Provisional Patent Application Ser. No. 60/225,200, entitled "Contact Detection System For Power Equipment," filed Aug. 14, 2000 by SD3, LLC, and U.S. Provisional Patent Application Ser. No. 60/225,211, entitled "Apparatus And Method For Detecting Dangerous Conditions In Power Equipment," filed Aug. 14, 2000 by SD3, LLC, the disclosures of which are herein incorporated by reference.

Control subsystem **26** includes one or more instruments **48** that are operable by a user to control the motion of blade **40**. Instruments **48** may include start/stop switches, speed controls, direction controls, etc. Control subsystem **26** also includes a logic controller **50** connected to receive the user's inputs via instruments **48**. Logic controller **50** is also connected to receive a contact detection signal from detection subsystem **22**. Further, the logic controller may be configured to receive inputs from other sources (not shown) such as blade motion sensors, workpiece sensors, etc. In any event, the logic controller is configured to control operative structure **12** in response to the user's inputs through instruments **48**. However, upon receipt of a contact detection signal from detection subsystem **22**, the logic controller overrides the control inputs from the user and activates reaction subsystem **24** to stop the motion of the blade. Various exemplary embodiments and implementations of control subsystem **26** are described in more detail in U.S. Provisional Patent Application Ser. No. 60/225,059, entitled "Logic Control For Fast Acting Safety System," filed Aug. 14, 2000 by SD3, LLC, the disclosure of which is herein incorporated by reference.

In the exemplary implementation, brake mechanism **28** includes a pawl **60** mounted adjacent the edge of blade **40** and selectively moveable to engage and grip the teeth of the blade. Pawl **60** may be constructed of any suitable material adapted to engage and stop the blade. As one example, the pawl may be constructed of a relatively high strength thermoplastic material such as polycarbonate, ultrahigh molecular weight polyethylene (UHMW) or Acrylonitrile Butadiene Styrene (ABS), etc., or a metal such as aluminum, etc. It will be appreciated that the construction of pawl **60** will vary depending on the configuration of blade **40**. In any event, the pawl is urged into the blade by a biasing mechanism in the form of a spring **66**. In the illustrative embodiment shown in FIG. **2**, pawl **60** is pivoted into the teeth of blade **40**. It should be understood that sliding or rotary movement of pawl **60** may also be used. The spring is adapted to urge pawl **60** into the teeth of the blade with sufficient force to grip the blade and quickly bring it to a stop.

The pawl is held away from the edge of the blade by a restraining mechanism in the form of a fusible member **70**. The fusible member is constructed of a suitable material adapted to restrain the pawl against the bias of spring **66**, and also adapted to melt under a determined electrical current density. Examples of suitable materials for fusible member **70** include NiChrome wire, stainless steel wire, etc. The fusible member is connected between the pawl and a contact mount **72**. Preferably, fusible member **70** holds the pawl relatively close to the edge of the blade to reduce the distance the pawl must travel to engage the blade. Positioning the pawl relatively close to the edge of the blade reduces the time required for the pawl to engage and stop the blade. Typically, the pawl is held approximately 1/32-inch to 1/4-inch from the edge of the blade by fusible member **70**, however other pawl-to-blade spacings may also be used within the scope of the invention.

Pawl **60** is released from its unactuated, or cocked, position to engage blade **40** by a release mechanism in the form of a firing subsystem **76**. The firing subsystem is coupled to contact mount **72**, and is configured to melt fusible member **70** by passing a surge of electrical current through the fusible member. Firing subsystem **76** is coupled to logic controller **50** and activated by a signal from the logic controller. When the logic controller receives a contact detection signal from detection subsystem **22**, the logic controller sends an activation signal to firing subsystem **76**, which melts fusible member **70**, thereby releasing the pawl to stop the blade. Various exemplary embodiments and implementations of reaction subsystem **24** are described in more detail in U.S. Provisional Patent Application Ser. No. 60/225,056, entitled "Firing Subsystem For Use In Fast Acting Safety System," filed Aug. 14, 2000 by SD3, LLC, U.S. Provisional Patent Application Ser. No. 60/225,170, entitled "Spring-Biased Brake Mechanism for Power Equipment," filed Aug. 14, 2000 by SD3, LLC, and U.S. Provisional Patent Application Ser. No. 60/225,169, entitled "Brake Mechanism For Power Equipment," filed Aug. 14, 2000 by SD3, LLC, the disclosures of which are herein incorporated by reference.

It will be appreciated that activation of the brake mechanism will require the replacement of one or more portions of safety system **18**. For example, pawl **60** and fusible member **70** typically must be replaced before the safety system is ready to be used again. Thus, it may be desirable to construct one or more portions of safety system **18** in a cartridge that can be easily replaced. For example, in the exemplary implementation depicted in FIG. **2**, safety system **18** includes a replaceable cartridge **80** having a housing **82**. Pawl **60**, spring **66**, fusible member **70** and contact mount **72** are all mounted within housing **82**. Alternatively, other portions of safety system **18** may be mounted within the housing. In any event, after the reaction system has been activated, the safety system can be reset by replacing cartridge **80**. The portions of safety system **18** not mounted within the cartridge may be replaced separately or reused as appropriate. Various exemplary embodiments and implementations of a safety system using a replaceable cartridge are described in more detail in U.S. Provisional Patent Application Ser. No. 60/225,201, entitled "Replaceable Brake Mechanism For Power Equipment," filed Aug. 14, 2000 by SD3, LLC, and U.S. Provisional Patent Application Ser. No. 60/225,212, entitled "Brake Positioning System," filed Aug. 14, 2000 by SD3, LLC, the disclosures of which are herein incorporated by reference.

While one particular implementation of safety system **18** has been described, it will be appreciated that many variations and modifications are possible within the scope of the invention. Many such variations and modifications are described in U.S. Provisional Patent Application Ser. No. 60/182,866, filed Feb. 16, 2000 and U.S. Provisional Patent

Application Ser. No. 60/157,340, filed Oct. 1, 1999, the disclosures of which are herein incorporated by reference.

As mentioned above, safety system **18** may include a sensor or sensor assembly for detecting motion of the blade or cutting tool. The sensor assembly typically is coupled to send a signal to logic controller **50** indicating whether the blade is in motion. The logic controller may be configured to respond differently to the detection of a dangerous condition based on whether the blade is moving. For example, it is often necessary for a user of machine **10** to touch blade **40** when preparing the machine for use, and when installing or removing the blade. Usually, the user would disconnect all power from machine **10** while performing such operations. However, in the event that the user neglects to disconnect the machine from power source **20** before touching the blade, logic controller **50** would receive a contact detection signal from detection subsystem **22**. If safety system **18** includes a blade motion sensor, then logic controller **50** may be configured not to actuate firing subsystem **76** when the blade is not moving. Instead, the logic controller may be configured to take one or more other actions such as disabling motor assembly **16**, sounding an alarm, displaying an error, etc. Alternatively, the logic controller may be configured to take no action if contact is detected while the blade is not moving.

In addition to detecting whether the blade is moving, safety system **18** may also be configured to determine the speed at which the blade is moving. This allows the logic controller to distinguish between rapid blade movement which could cause injury to the user, and slow blade movement which generally would not cause injury to the user. Thus, for example, a user could move the blade by hand without actuating firing subsystem **76**. In some embodiments, the blade motion sensor may be configured to determine relative blade speed. In alternative embodiments, logic controller **50** may be configured to analyze the signal from the blade motion sensor to determine relative blade speed.

It will be appreciated that the speed at which a blade is considered likely to cause injury will vary depending on the type of machine **10** and blade **40**. For example, a 14-inch carbide tooth blade on a table saw will cause serious injury at a lower speed than a 5⅜-inch plywood blade on a cordless trim saw. Thus, an embodiment of safety system **18** for use on the table saw may be configured to actuate the firing subsystem only at blade speeds above approximately 10, 25, 60, or 90 rpm, while an alternative embodiment of safety system **18** for use on the trim saw may be configured to actuate the firing subsystem only at blade speeds above approximately 40, 100, or 240 rpm.

Alternatively or additionally, the logic controller may be configured to interpret blade motion as being dangerous only when detected during or soon after motor assembly **16** was in operation. In other words, the blade motion detection would only be active while the blade was being moved by the motor assembly and during a relatively brief period afterward while the blade was coasting to a stop. Any blade motion detected at other times would be ignored.

Safety system **18** may include any of a wide variety of sensor assemblies to detect blade movement. Furthermore, each sensor assembly may be adapted as necessary depending on the particular type of blade **40** and/or the configuration of machine **10**. While several exemplary sensor assemblies are described herein, it will be understood that all methods and mechanisms suitable for automatically detecting the motion of a blade are within the scope of the invention.

One exemplary embodiment of safety system **18** includes a magnetic sensor assembly **1000** configured to detect movement of the blade. It will be appreciated that the blade movement may be detected by monitoring the blade or any other portion of the safety system that moves with the blade, including the arbor, bearings, motor assembly, arbor pulley, etc. In the exemplary implementation depicted in FIG. **3**, magnetic sensor assembly **1000** includes a Hall effect sensor **1001** and one or more magnets **1002**. A coil could also be used to detect magnetic field fluctuations from rotation. The magnets are mounted on arbor **42**. Sensor **1001** is mounted and configured to detect blade motion by detecting the movement of the magnets on the arbor. Sensor **1001** may be any suitable Hall effect sensor such as, for example, the sensor available from Micronas Intermetall of San Jose, Calif., under the part no. HAL114.

Hall effect sensor **1001** may be mounted adjacent the arbor by any suitable method. In the exemplary implementation, the sensor is mounted in a recessed region **272** of an insulating tube **268**. The insulating tube also supports charge plates **44** and **46**, as is described in more detail in U.S. Provisional Application Ser. No. 60/225,211, entitled "Apparatus and Method for Detecting Dangerous Conditions in Power Equipment," filed Aug. 14, 2000, by SD3, LLC. The recessed region is disposed at least partially over a hole **273** in charge plate **44**. Alternatively the recessed region may be disposed over a hole **273** in charge plate **46**. In any event, magnet **1002** is disposed on arbor **42** to pass beneath or adjacent hole **273** as the arbor rotates within the insulating tube. Hole **273** allows sensor **1001** to detect the field created by magnet **1002** as it passes. Sensor **1001** includes one or more connector leads **1003** connectable to receive power from, and transmit signals to, logic controller **50**.

Magnets **1002** may be mounted on the arbor in any suitable fashion. Typically, the magnets are mounted so as not to extend above the surface of the arbor. For example, the magnets may be press-fit and/or glued in a recess formed on the arbor. Alternatively, one or more of the magnets may be mounted to extend above the surface of the arbor. The size and number of magnets **1002** may be varied to control the signal produced by sensor **1001**. In alternative embodiments, magnets **1002** may be mounted at other locations such as an end of arbor **42**, on blade **40**, etc.

Sensor **1001** may be connected to send signals to logic controller **50** via any suitable circuitry. For example, FIG. **4** illustrates one exemplary rotation sense circuit **177** adapted to couple the signals from sensor **1001** to logic controller **50**. Those of skill in the art will appreciate that circuit **177** may be modified as needed for a particular application.

Another example of a suitable method for detecting blade motion is through electromagnetic field (EMF) measurements. As is known to those of skill in the art, when power to an electric motor is shut off, the motor will produce EMF pulses on the input power cables as the motor spins down. Thus, where blade **40** is driven by an electric motor assembly **16**, the blade may be assumed to be in motion whenever an EMF pulse is detected on the power supply cables, as well as whenever power is being supplied to the motor assembly.

Thus, in another exemplary embodiment depicted in FIG. **5**, safety system **18** includes an EMF sensor assembly **1005** configured to detect motion of blade **40**. Sensor assembly **1005** includes an EMF detection circuit **1006** disposed in the power supply path between motor assembly **16** and power source **20**. Circuit **1006** is adapted to monitor power cables **1007** which extend between the power source and the motor assembly, and to detect the presence of EMF pulses on the

cables. Alternatively, circuit **1006** may be disposed at any other location suitable for detecting EMF pulses from motor assembly **16**. Circuit **1006** may be any circuit or mechanism adapted to detect EMF pulses, such as are known to those of skill in the art. Circuit **1006** is also coupled to logic controller **50**, and adapted to convey a signal to the logic controller indicating the presence and/or absence of EMF pulses on cables **1007**. Optionally, circuit **1006** and/or logic controller **50** may be adapted to analyze the detected EMF emissions, and evaluate the speed of blade **40**. In such case, the logic controller may be configured not to actuate firing subsystem **76** when the speed of the blade is unlikely to cause serious injury to the user.

In another exemplary embodiment, safety system **18** includes an optical sensor assembly adapted to optically detect movement of blade **40**. Safety system **18** may be configured to optically detect blade motion in a variety of ways. For example, a rotary optical encoder may be coupled to the arbor to detect rotation of the arbor. Any rotary encoder may be used, such as those available from Omron Electronics Inc., of Schaumburg, Ill. Alternatively, other optical sensor assemblies may be used as described below.

Typically, the optical sensor assembly will be at least partially enclosed to prevent saw dust or other debris from interfering with the detection. One exemplary implementation of an optical sensor assembly is indicated generally at **1010** in FIG. **6**. Sensor assembly **1010** includes an optical detector **1011** adapted to detect light from an optical source **1012**. Alternatively, plural optical sources and/or plural optical detectors may be used. It will be appreciated that any of a variety of different optical sources may be used which are known to those of skill in the art, including an incandescent or fluorescent bulb, light emitting diode (LED), laser diode, etc. Similarly, any of a variety of different optical detectors may be used which are known to those of skill in the art, including a photodiode, phototransistor, etc.

In any event, the optical source is arranged so that the signal received at the optical detector when the blade is moving is different than the signal received when the blade is stationary. For example, the source and detector may be arranged so that a signal is received only when the blade is moving, or only when the blade is stationary. Alternatively, source **1012** and detector **1011** may be arranged so that the amount of emitted light that reaches the detector varies when the blade is in motion.

The implementation depicted in FIG. **6** uses this latter arrangement. Sensor assembly **1010** includes an LED **1012** mounted in insulating tube **268** to emit light through hole **273** in charge plate **44** or **46**. The light reflects off arbor **42** and is detected by a photodiode **1011** which is also mounted in insulating tube **268** adjacent hole **273**. The arbor includes one or more reduced-reflection regions **1013** adapted to reduce the amount of light reflected to photodiode **1011**. Regions **1013** may be formed by coating the arbor with a light-absorbing coating, roughening the arbor to cause random scattering of the light, etc. In any event, the reduced reflecting regions create a varying signal at the photodiode when the arbor is rotating. In contrast, a constant signal is produced at the photodiode when the arbor is stationary.

The minimal clearance between arbor **42** and charge plates **44**, **46** tends to maintain the space between the arbor and the photodiode/LED relatively free of debris which could block the signal. Alternatively, the insulating tube assembly may be sealed in a protective housing (not shown).

In another alternative implementation depicted in FIGS. **7** and **8**, optical sensor assembly **1010** includes a barrier member **1014** mounted on the arbor and disposed between photodiode **1011** and LED **1012**. Alternatively, the barrier member may be mounted on any other portion of cutting tool **14** or motor assembly **16** adapted to move with the blade. Barrier member **1014** includes one or more light-transmitting regions or holes **1015**, which may take any desired shape or size. The photodiode and LED are mounted in a support member **1016** attached to an arbor block **250**, and disposed on either side of barrier member **1014**. The photodiode is aligned so that emitted light will pass through holes **1015**. Likewise, the LED is aligned to detect the light which passes through the holes. Thus, as arbor **42** rotates, light from the LED is alternately blocked and transmitted by the barrier member, thereby creating a varying signal at the photodiode.

Photodiode **1011** and LED **1012** may be connected to any suitable driving circuitry such as are known to those of skill in the art. FIG. **9** shows one exemplary circuitry for producing an optical signal at LED **1012** and detecting the signal at photodiode **1011**. The particular values of the circuit components and voltage supplies may be selected as desired for a specific application. In any event, the photodiode is coupled to transmit a signal to logic controller **50** to indicate whether blade **40** is moving.

In another exemplary embodiment, safety system **18** includes an electrical sensor assembly adapted to electrically detect movement of blade **40**. There are numerous methods and mechanisms for electrically detecting blade movement within the scope of the invention. The particular method and/or mechanism selected will typically depend on the specific type and configuration of machine **10**. For example, where charge plate **46** is configured to capacitively detect a signal induced in the blade, any incidental eccentricity in the blade or the blade rotation will cause the capacitance between the blade and charge plate **46** to vary as the blade rotates. As a result, charge plate **46** will detect a varying signal amplitude when the blade is rotating. Thus, a single sensor may be configured to detect both contact with the user and rotation of the blade. Preferably, the incidental variation fluctuation is insufficient in magnitude and/or rate of change to trigger reaction subsystem **24**.

Rather than rely on incidental eccentricities, safety system **18** may include an exemplary electrical sensor assembly adapted to detect a signal variation caused by a designed eccentricity or non-uniformity in the blade. Alternatively, the sensor assembly may be adapted to detect the signal from an eccentricity in some portion of cutting tool **14** that moves with the blade and is electrically coupled to the blade. One exemplary implementation of such a sensor assembly is indicated generally at **1020** in FIG. **10**. Sensor assembly **1020** includes a detection electrode **1021** capacitively coupled to detect an electrical signal on arbor **42**. Electrode **1021** may be mounted in any suitable fashion to provide electrical insulation from arbor **42** as well as the remainder of cutting tool **14** and machine **10**. In the exemplary implementation, electrode **1021** is mounted in insulating tube **268** and arranged to extend to a point closely adjacent the arbor between charge plates **44** and **46**. Sensor assembly **1020** also includes one or more eccentricities **1022** disposed on the arbor and substantially aligned with electrode **1021** so as to pass by the electrode as the arbor rotates.

It will be appreciated that eccentricities **1022** may be configured in any desired quantity, size, shape or form adapted to cause a variation in the capacitance between the arbor and the electrode as the arbor rotates. In the exemplary implementation, eccentricities **1022** take the form of beveled regions formed on the surface of arbor **42**. Thus, the space between the electrode and the arbor is greater (and therefore

the capacitance is less) when an eccentricity is positioned beneath the electrode than when an eccentricity is not positioned beneath the electrode. Alternatively, eccentricities **1022** may take other forms adapted to vary the capacitance between the arbor and electrode, including raised regions, dielectric pads, etc. In any event, if an electrical signal is induced in the arbor (e.g., by charge plate **44** of contact detection subsystem **22**), then electrode **1021** will detect variations in that signal if the arbor is rotating. Conversely, the electrode will detect no variations in the signal if the arbor is stationary.

Turning attention now to FIG. **11**, another exemplary implementation of electrical sensor assembly **1020** is shown in which electrode **1021** is disposed adjacent the teeth **1023** of blade **40**. Electrode **1021** may be mounted on arbor block **250** or any other suitable portion of machine **10**. Additionally, the electrode may be positioned at the side of the blade (as shown in FIG. **11**) or at the perimeter of the blade facing in toward the arbor. The size, shape and position of the electrode may vary depending on the position and size of teeth **1023**. In any event, as teeth **1023** pass by electrode **1021**, the capacitance between the blade and the electrode varies, thereby varying the amplitude of the signal detected by the electrode. Alternatively, a plurality of electrodes may be positioned at various points adjacent the teeth so that blade motion would be detected by modulations in the relative signal amplitudes at the electrodes. Such an alternative detection mechanism may also be used with other implementations of sensor assembly **1020**.

While a few exemplary magnetic, EMF, optical and electrical sensor assemblies have been described for detecting blade motion, it will be appreciated that many modifications and variations to such sensor assemblies are included within the scope of the invention. Furthermore, safety system **18** may include other types of motion detection sensors such as mechanical sensors, sonic and ultra-sonic sensors, etc. In any event, the invention provides effective and reliable means for discriminating between conditions which are, and are not, likely to cause injury to a user of power machinery.

It is believed that the disclosure set forth above encompasses multiple distinct inventions with independent utility. While each of these inventions has been disclosed in its preferred form, the specific embodiments thereof as disclosed and illustrated herein are not to be considered in a limiting sense as numerous variations are possible. The subject matter of the inventions includes all novel and non-obvious combinations and subcombinations of the various elements, features, functions and/or properties disclosed herein. No single feature, function, element or property of the disclosed embodiments is essential to all of the disclosed inventions. Similarly, where the claims recite "a" or "a first" element or the equivalent thereof, such claims should be understood to include incorporation of one or more such elements, neither requiring nor excluding two or more such elements.

It is believed that the following claims particularly point out certain combinations and subcombinations that are directed to one of the disclosed inventions and are novel and non-obvious. Inventions embodied in other combinations and subcombinations of features, functions, elements and/or properties may be claimed through amendment of the present claims or presentation of new claims in this or a related application. Such amended or new claims, whether they are directed to a different invention or directed to the same invention, whether different, broader, narrower or equal in scope to the original claims, are also regarded as included within the subject matter of the inventions of the present disclosure.

The invention claimed is:

1. A woodworking machine comprising:
a support;
a movable blade coupled to the support;
a control system configured to detect a dangerous condition between a person and the blade by imparting an electric signal to the blade and monitoring the electric signal for at least one change indicative of the dangerous condition; and
a brake mechanism triggerable by the control system to stop movement of the blade upon detection of the dangerous condition by the control system;
where the control system is further configured to determine if the blade is moving, and configured not to trigger the brake mechanism if the blade is not moving.

2. The woodworking machine of claim **1**, where the blade is coupled to the support by a rotatable arbor, and where the control system is configured to determine if the blade is moving by detecting whether the arbor is rotating.

3. The woodworking machine of claim **1**, where the control system includes a magnetic sensor adapted to determine if the blade is moving.

4. The woodworking machine of claim **3**, where the magnetic sensor includes a Hall effect sensor.

5. The woodworking machine of claim **1**, where the control system includes an electronic sensor adapted to determine if the blade is moving.

6. The woodworking machine of claim **5**, where the electronic sensor includes a capacitive sensor.

7. The woodworking machine of claim **1**, where the control system includes an optical sensor adapted to determine if the blade is moving.

8. A woodworking machine comprising:
a working portion adapted to work when moving;
a detection system adapted to detect a dangerous condition between a person and the working portion by imparting an electric signal to the working portion and monitoring the electric signal for at least one change indicative of the dangerous condition;
a reaction system associated with the detection system to cause a predetermined action to take place relative to the working portion upon detection of the dangerous condition; and
a motion detection system adapted to detect motion of the working portion and to disable the reaction system when the working portion is not moving.

9. The woodworking machine of claim **8**, where the working portion is a spinning blade and where the motion detection system detects whether the blade is spinning.

10. The woodworking machine of claim **8**, where the motion detection system detects the speed of the motion and considers the working portion to be not moving if the working portion is moving below a threshold speed.

11. The woodworking machine of claim **8**, where the motion detection system includes a sensor.

12. The woodworking machine of claim **11**, where the sensor is a Hall effect sensor.

13. The woodworking machine of claim **11**, where the sensor is an electromagnetic field sensor.

14. The woodworking machine of claim **11**, where the sensor is an optical sensor.

15. The woodworking machine of claim **11**, where the sensor is an electrical sensor.

16. The woodworking machine of claim 8, where the working portion is a cutter, where the reaction system is a brake system, and where the predetermined action is to engage and stop the cutter.

17. A woodworking machine comprising:

a working portion adapted to work when moving;

a motor to move the working portion;

a detection system adapted to detect a dangerous condition between a person and the working portion by imparting an electric signal to the working portion and monitoring the electric signal for at least one change indicative of the dangerous condition; and

a reaction system associated with the detection system to cause a predetermined action to take place relative to the working portion upon detection of the dangerous condition;

where the detection system and reaction system are configured to function when the motor is moving the working portion and for a defined period of time after the motor has been turned off, and where the reaction system is configured not to cause the predetermined action to take place after the defined period of time has past until the motor starts moving the working portion.

18. A woodworking machine comprising:

a cutting tool;

a motor to spin the cutting tool;

a detection system adapted to detect a dangerous condition between a person and the cutting tool by imparting an electric signal to the cutting tool and monitoring the electric signal for at least one change indicative of the dangerous condition;

a reaction system associated with the detection system to cause a predetermined action to take place relative to the working portion upon detection of the dangerous condition; and

a control system adapted to monitor the detection system and control actuation of the reaction system, where the control system is adapted to trigger the reaction system if the dangerous condition is detected when the motor is spinning the cutting tool or during coast-down of the cutting tool after the motor is turned off and to deactivate the reaction system after coast-down.

19. The woodworking machine of claim 18, where the reaction system is a brake system, and where the predetermined action is to engage and stop the culling tool.

20. The woodworking machine of claim 18, where the control system is adapted to re-activate the reaction system when the motor starts spinning the cutting tool after deactivation of the reaction system.

* * * * *

EXHIBIT B

US007600455B2

(12) **United States Patent**
Gass et al.

(10) **Patent No.: US 7,600,455 B2**
(45) **Date of Patent: Oct. 13, 2009**

(54) **LOGIC CONTROL FOR FAST-ACTING SAFETY SYSTEM**

(75) Inventors: **Stephen F. Gass**, Wilsonville, OR (US); **J. David Fulmer**, Tualatin, OR (US); **Joel F. Jensen**, Redwood City, CA (US); **Benjamin B. Schramm**, Los Gatos, CA (US); **Robert L. Chamberlain**, Raleigh, NC (US)

(73) Assignee: **SD3, LLC**, Tualatin, OR (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 998 days.

(21) Appl. No.: **09/929,237**

(22) Filed: **Aug. 13, 2001**

(65) **Prior Publication Data**

US 2002/0020262 A1 Feb. 21, 2002

Related U.S. Application Data

(60) Provisional application No. 60/225,056, filed on Aug. 14, 2000, provisional application No. 60/225,057, filed on Aug. 14, 2000, provisional application No. 60/225,058, filed on Aug. 14, 2000, provisional application No. 60/225,059, filed on Aug. 14, 2000, provisional application No. 60/225,089, filed on Aug. 14, 2000, provisional application No. 60/225,094, filed on Aug. 14, 2000, provisional application No. 60/225,169, filed on Aug. 14, 2000, provisional application No. 60/225,170, filed on Aug. 14, 2000, provisional application No. 60/225,200, filed on Aug. 14, 2000, provisional application No. 60/225,201, filed on Aug. 14, 2000, provisional application No. 60/225,206, filed on Aug. 14, 2000, provisional application No. 60/225,210, filed on Aug. 14, 2000, provisional application No. 60/225,211, filed on Aug. 14, 2000, provisional application No. 60/225,212, filed on Aug. 14, 2000.

(51) **Int. Cl.**
B26D 5/00 (2006.01)
B27B 13/14 (2006.01)
B26D 1/14 (2006.01)

(52) **U.S. Cl.** **83/58**; 83/62.1; 83/DIG. 1; 83/477.1; 83/477.2; 83/490; 83/788

(58) **Field of Classification Search** ..... 83/DIG. 1, 83/58, 62.1, 62, 13, 490, 471, 581, 477.1, 83/477.2, 471.3, 589, 397, 397.1, 630, 292, 83/644, 788; 72/1, 20.1, 21.3; 192/144, 192/130; 340/258 C, 411; 307/117
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

0,146,886 A 1/1874 Doane et al.

(Continued)

FOREIGN PATENT DOCUMENTS

CA 2140991 1/1995

(Continued)

OTHER PUBLICATIONS

Gordon Engineering Corp., Product Catalog, Oct. 1997, pp. cover, 1, 3 and back, Brookfield, Connecticut, US.

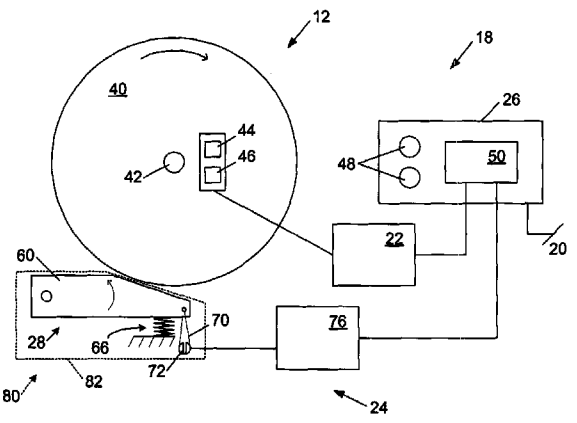
(Continued)

Primary Examiner—Ghassem Alie

(57) **ABSTRACT**

Woodworking machines including cutting tools and motors adapted to drive the cutting tools are disclosed. The machines also include a detection system adapted to detect a dangerous condition between the cutting tool and a person, and a reaction system adapted to perform a specified action upon detection of the dangerous condition. The machines further include a control system adapted to test the operability of at least a portion of the detection system and/or the reaction system. The control system is adapted to disable the motor if the tested portion is inoperable.

21 Claims, 11 Drawing Sheets



U.S. PATENT DOCUMENTS

0,162,814	A	5/1875	Graves et al.
0,261,090	A	7/1882	Grill
0,264,412	A	9/1882	Kuhlmann
0,299,480	A	5/1884	Kuhlmann et al.
0,302,041	A	7/1884	Sill
0,307,112	A	10/1884	Groff
0,509,253	A	11/1893	Shields
0,545,504	A	9/1895	Hoover
0,869,513	A	10/1907	Pfeil
0,941,726	A	11/1909	Pfalzgraf
0,982,312	A	1/1911	Swafford
0,997,720	A	7/1911	Troupenat
1,037,843	A	9/1912	Ackley
1,050,649	A	1/1913	Harrold et al.
1,054,558	A	2/1913	Jones
1,074,198	A	9/1913	Phillips
1,082,870	A	12/1913	Humason
1,101,515	A	6/1914	Adam
1,126,970	A	2/1915	Folmer
1,132,129	A	3/1915	Stevens
1,148,169	A	7/1915	Howe
1,154,209	A	9/1915	Rushton
1,205,246	A	11/1916	Mowry
1,228,047	A	5/1917	Reinhold
1,240,430	A	9/1917	Erickson
1,244,187	A	10/1917	Frisbie
1,255,886	A	2/1918	Jones
1,258,961	A	3/1918	Tattersall
1,311,508	A	7/1919	Harrold
1,324,136	A	12/1919	Turner
1,381,612	A	6/1921	Anderson
1,397,606	A	11/1921	Smith
1,427,005	A	8/1922	McMichael
1,430,983	A	10/1922	Granberg
1,450,906	A	4/1923	Anderson
1,464,924	A	8/1923	Drummond
1,465,224	A	8/1923	Lantz
1,492,145	A	4/1924	Talley
1,496,212	A	6/1924	French
1,511,797	A	10/1924	Berghold
1,526,128	A	2/1925	Flohr
1,527,587	A	2/1925	Hutchinson
1,551,900	A	9/1925	Morrow
1,553,996	A	9/1925	Federer
1,582,483	A	4/1926	Runyan
1,590,988	A	6/1926	Campbell
1,600,604	A	9/1926	Sorlien
1,616,478	A	2/1927	Watson
1,640,517	A	8/1927	Procknow
1,662,372	A	3/1928	Ward
1,668,061	A	5/1928	Falkins
1,701,948	A	2/1929	Crowe
1,711,490	A	5/1929	Drummond
1,712,828	A	5/1929	Klehm
1,774,521	A	9/1930	Neighbour
1,807,120	A	5/1931	Lewis
1,811,066	A	6/1931	Tannewitz
1,879,280	A	9/1932	James
1,896,924	A	2/1933	Ulrich
1,902,270	A	3/1933	Tate
1,904,005	A	4/1933	Masset
1,910,651	A	5/1933	Tautz
1,938,548	A	12/1933	Tautz
1,938,549	A	12/1933	Tautz
1,963,688	A	6/1934	Tautz
1,988,102	A	1/1935	Woodward
1,993,219	A	3/1935	Merrigan
2,007,887	A	7/1935	Tautz
2,010,851	A	8/1935	Drummond
2,020,222	A	11/1935	Tautz
2,038,810	A	4/1936	Tautz
2,075,282	A	3/1937	Hedgpeth
2,095,330	A	10/1937	Hedgpeth
2,106,288	A	1/1938	Tautz
2,106,321	A	1/1938	Guertin
2,121,069	A	6/1938	Collins
2,131,492	A	9/1938	Ocenasek
2,163,320	A	6/1939	Hammond
2,168,282	A	8/1939	Tautz
2,241,556	A	5/1941	MacMillin et al.
2,261,696	A	11/1941	Ocenasek
2,265,407	A	12/1941	Tautz
2,286,589	A	6/1942	Tannewitz
2,292,872	A	8/1942	Eastman
2,299,262	A	10/1942	Uremovich
2,312,118	A	2/1943	Neisewander
2,313,686	A	3/1943	Uremovich
2,328,244	A	8/1943	Woodward
2,352,235	A	6/1944	Tautz
2,377,265	A	3/1945	Rady
2,392,486	A	1/1946	Larsen
2,402,232	A	6/1946	Baker
2,425,331	A	8/1947	Kramer
2,434,174	A	1/1948	Morgan
2,452,589	A	11/1948	McWhirter et al.
2,466,325	A	4/1949	Ocenasek
2,496,613	A	2/1950	Woodward
2,501,134	A	3/1950	Meckoski et al.
2,509,813	A	5/1950	Dineen
2,517,649	A	8/1950	Frechtmann
2,518,684	A	8/1950	Harris
2,530,290	A	11/1950	Collins
2,554,124	A	5/1951	Salmont
2,562,396	A	7/1951	Schutz
2,572,326	A	10/1951	Evans
2,590,035	A	3/1952	Pollak
2,593,596	A	4/1952	Olson
2,601,878	A	7/1952	Anderson
2,623,555	A	12/1952	Eschenburg
2,625,966	A	1/1953	Copp
2,626,639	A	1/1953	Hess
2,661,777	A	12/1953	Hitchcock
2,661,780	A	12/1953	Morgan
2,675,707	A	4/1954	Brown
2,678,071	A	5/1954	Odlum et al.
2,690,084	A	9/1954	Van Dam
2,695,638	A	11/1954	Gaskell
2,704,560	A	3/1955	Woessner
2,711,762	A	6/1955	Gaskell
2,719,547	A	10/1955	Gjerde
2,722,246	A	11/1955	Arnoldy
2,731,049	A	1/1956	Akin
2,736,348	A	2/1956	Nelson
2,737,213	A	3/1956	Richards et al.
2,758,615	A	8/1956	Mastriforte
2,785,710	A	3/1957	Mowery, Jr.
2,786,496	A	3/1957	Eschenburg
2,804,890	A	9/1957	Fink
2,810,408	A	10/1957	Boice et al.
2,839,943	A	6/1958	Caldwell et al.
2,844,173	A	7/1958	Gaskell
2,850,054	A	9/1958	Eschenburg
2,852,047	A	9/1958	Odlum et al.
2,873,773	A	2/1959	Gaskell
2,876,809	A	3/1959	Rentsch et al.
2,883,486	A	4/1959	Mason
2,894,546	A	7/1959	Eschenburg
2,913,025	A	11/1959	Richards
2,913,581	A	11/1959	Simonton et al.
2,937,672	A	5/1960	Gjerde
2,945,516	A	7/1960	Edgemond, Jr. et al.
2,954,118	A	9/1960	Anderson
2,957,166	A	10/1960	Gluck
2,978,084	A	4/1961	Vilkaitis

2,984,268	A		5/1961	Vuichard			
2,991,593	A		7/1961	Cohen			
3,005,477	A		10/1961	Sherwen			
3,011,529	A		12/1961	Copp			
3,011,610	A		12/1961	Stiebel et al.			
3,013,592	A		12/1961	Ambrosio et al.			
3,021,881	A		2/1962	Edgemond, Jr. et al.			
3,035,995	A	*	5/1962	Seeley et al.	376/215		
3,047,116	A		7/1962	Stiebel et al.			
3,085,602	A		4/1963	Gaskell			
3,105,530	A		10/1963	Peterson			
3,129,731	A		4/1964	Tyrrell			
3,163,732	A		12/1964	Abbott			
3,184,001	A		5/1965	Reinsch et al.			
3,186,256	A		6/1965	Reznick			
3,207,273	A		9/1965	Jurin			
3,213,731	A		10/1965	Renard			
3,224,474	A		12/1965	Bloom			
3,232,326	A		2/1966	Speer et al.			
3,246,205	A	*	4/1966	Miller	361/15		
3,249,134	A		5/1966	Vogl et al.			
3,274,876	A		9/1966	Debus			
3,276,497	A		10/1966	Heer			
3,306,149	A		2/1967	John			
3,313,185	A		4/1967	Drake et al.			
3,315,715	A		4/1967	Mytinger			
3,323,814	A		6/1967	Phillips			
3,337,008	A		8/1967	Trachte			
3,356,111	A		12/1967	Mitchell			
3,368,596	A		2/1968	Comer			
3,386,322	A		6/1968	Stone et al.			
3,439,183	A	*	4/1969	Hurst, Jr.	307/132 R		
3,445,835	A		5/1969	Fudaley			
3,454,286	A		7/1969	Anderson et al.			
3,456,696	A		7/1969	Gregory et al.			
3,512,440	A		5/1970	Frydmann			
3,538,964	A		11/1970	Warrick et al.			
3,540,338	A		11/1970	McEwan et al.			
3,554,067	A		1/1971	Scutella			
3,566,996	A		3/1971	Crossman			
3,580,376	A	*	5/1971	Loshbough	198/323		
3,581,784	A		6/1971	Warrick			
3,593,266	A	*	7/1971	Van Sickle	340/454		
3,613,748	A		10/1971	De Pue			
3,621,894	A		11/1971	Niksich			
3,670,788	A		6/1972	Pollak et al.			
3,675,444	A		7/1972	Whipple			
3,680,609	A		8/1972	Menge			
3,688,815	A		9/1972	Ridenour			
3,695,116	A		10/1972	Baur			
3,696,844	A		10/1972	Bernatschek			
3,716,113	A	*	2/1973	Kobayashi et al.	188/1.11 R		
3,719,103	A		3/1973	Streander			
3,740,000	A		6/1973	Takada			
3,745,546	A		7/1973	Struger et al.			
3,749,933	A		7/1973	Davidson			
3,754,493	A		8/1973	Niehaus et al.			
3,772,590	A		11/1973	Mikulecky et al.			
3,785,230	A		1/1974	Lokey			
3,793,915	A		2/1974	Hujer			
3,805,639	A		4/1974	Peter			
3,805,658	A		4/1974	Scott et al.			
3,808,932	A		5/1974	Russell			
3,829,850	A		8/1974	Guetersloh			
3,829,970	A		8/1974	Anderson			
3,858,095	A		12/1974	Friemann et al.			
3,861,016	A		1/1975	Johnson et al.			
3,863,208	A	*	1/1975	Balban	280/735		
3,874,747	A		4/1975	Case et al.			
3,880,032	A		4/1975	Green			
3,882,744	A		5/1975	McCarroll			
3,886,413	A	*	5/1975	Dow et al.	361/181		
3,889,567	A		6/1975	Sato et al.			
3,905,263	A		9/1975	Smith			
3,922,785	A		12/1975	Fushiya			
3,924,688	A		12/1975	Cooper et al.			
3,931,727	A	*	1/1976	Luenser	72/21.3		
3,935,777	A		2/1976	Bassett			
3,945,286	A		3/1976	Smith			
3,946,631	A		3/1976	Malm			
3,947,734	A		3/1976	Fyler			
3,949,636	A		4/1976	Ball et al.			
3,953,770	A		4/1976	Hayashi			
3,960,310	A		6/1976	Nussbaum			
3,967,161	A		6/1976	Lichtblau			
3,974,565	A		8/1976	Ellis			
3,975,600	A		8/1976	Marston			
3,978,624	A		9/1976	Merkel et al.			
3,994,192	A		11/1976	Faig			
4,007,679	A		2/1977	Edwards			
4,016,490	A		4/1977	Weckenmann et al.			
4,026,174	A		5/1977	Fierro			
4,026,177	A		5/1977	Lokey			
4,029,159	A	*	6/1977	Nymann	173/217		
4,047,156	A		9/1977	Atkins			
4,048,886	A	*	9/1977	Zettler	83/58		
4,060,160	A		11/1977	Lieber			
4,070,940	A		1/1978	McDaniel et al.			
4,075,961	A		2/1978	Harris			
4,077,161	A		3/1978	Wyle et al.			
4,085,303	A		4/1978	McIntyre et al.			
4,090,345	A		5/1978	Harkness			
4,091,698	A		5/1978	Obear et al.			
4,106,378	A		8/1978	Kaiser			
4,117,752	A		10/1978	Yoneda			
4,145,940	A		3/1979	Woloveke et al.			
4,152,833	A	*	5/1979	Phillips	30/382		
4,161,649	A	*	7/1979	Klos et al.	192/144		
4,175,452	A		11/1979	Idel			
4,184,394	A		1/1980	Gjerde			
4,190,000	A		2/1980	Shaull et al.			
4,195,722	A		4/1980	Anderson et al.			
4,199,930	A		4/1980	Lebet et al.			
4,206,666	A		6/1980	Ashton			
4,206,910	A		6/1980	Biesemeyer			
4,249,117	A		2/1981	Leukhardt et al.			
4,249,442	A		2/1981	Fittery			
4,262,278	A	*	4/1981	Howard et al.	340/452		
4,267,914	A		5/1981	Saar			
4,270,427	A		6/1981	Colberg et al.			
4,276,459	A		6/1981	Willett et al.			
4,276,799	A		7/1981	Muehling			
4,291,794	A		9/1981	Bauer			
4,305,442	A		12/1981	Currie			
4,319,146	A		3/1982	Wires, Sr.			
4,321,841	A		3/1982	Felix			
4,334,450	A		6/1982	Benuzzi			
4,372,202	A		2/1983	Cameron			
4,374,552	A		2/1983	Dayen			
4,385,539	A		5/1983	Meyerhoefer et al.			
4,391,358	A		7/1983	Haeger			
4,418,597	A		12/1983	Krusemark et al.			
4,427,042	A		1/1984	Mitchell et al.			
4,466,170	A		8/1984	Davis			
4,466,233	A		8/1984	Thesman			
4,470,046	A		9/1984	Betsill			
4,503,739	A		3/1985	Konieczka			
4,510,489	A		4/1985	Anderson, III et al.			
4,512,224	A		4/1985	Terauchi			
4,518,043	A		5/1985	Anderson et al.			
4,532,501	A		7/1985	Hoffman			
4,532,844	A		8/1985	Chang et al.			
4,557,168	A		12/1985	Tokiwa			
4,559,858	A		12/1985	Laskowski			
4,560,033	A		12/1985	DeWoody et al.			
4,566,512	A		1/1986	Wilson			

4,573,556	A		3/1986	Andreasson	5,265,510	A		11/1993	Hoyer-Ellefsen
4,576,073	A		3/1986	Stinson	5,272,946	A		12/1993	McCullough et al.
4,589,047	A		5/1986	Gaus et al.	5,276,431	A		1/1994	Piccoli et al.
4,589,860	A		5/1986	Brandenstein et al.	5,285,708	A		2/1994	Bosten et al.
4,599,597	A		7/1986	Rotbart	5,293,802	A		3/1994	Shiotani et al.
4,599,927	A		7/1986	Eccardt et al.	5,320,382	A		6/1994	Goldstein et al.
4,606,251	A		8/1986	Boileau	5,321,230	A		6/1994	Shanklin et al.
4,615,247	A		10/1986	Berkeley	5,331,875	A		7/1994	Mayfield
4,621,300	A		11/1986	Summerer	5,353,670	A		10/1994	Metzger, Jr.
4,625,604	A		12/1986	Handler et al.	5,377,554	A		1/1995	Reulein et al.
4,637,188	A		1/1987	Crothers	5,377,571	A		1/1995	Josephs
4,637,289	A		1/1987	Ramsden	5,392,568	A		2/1995	Howard, Jr. et al.
4,644,832	A		2/1987	Smith	5,392,678	A		2/1995	Sasaki et al.
4,653,189	A		3/1987	Andreasson	5,401,928	A		3/1995	Kelley
4,657,428	A		4/1987	Wiley	5,411,221	A		5/1995	Collins et al.
4,661,797	A		4/1987	Schmall	5,423,232	A		6/1995	Miller et al.
4,672,500	A	*	6/1987	Tholome et al. 361/93.7	5,436,613	A		7/1995	Ghosh et al.
4,675,664	A		6/1987	Cloutier et al.	5,447,085	A		9/1995	Gochnauer
4,679,719	A		7/1987	Kramer	5,451,750	A		9/1995	An
4,718,229	A		1/1988	Riley	5,453,903	A		9/1995	Chow
4,722,021	A		1/1988	Hornung et al.	5,471,888	A		12/1995	McCormick
4,751,603	A		6/1988	Kwan	5,480,009	A		1/1996	Wieland et al.
4,756,220	A		7/1988	Olsen et al.	5,503,059	A	*	4/1996	Pacholok 89/1.11
4,757,881	A		7/1988	Jonsson et al.	5,510,587	A		4/1996	Reiter
4,774,866	A		10/1988	Dehari et al.	5,510,685	A		4/1996	Grasselli
4,792,965	A		12/1988	Morgan	5,513,548	A		5/1996	Garuglieri
4,805,504	A		2/1989	Fushiya et al.	5,531,147	A		7/1996	Serban
4,831,279	A		5/1989	Ingraham	5,534,836	A		7/1996	Schenkel et al.
4,840,135	A		6/1989	Yamauchi	5,572,916	A		11/1996	Takano
4,845,476	A		7/1989	Rangeard et al.	5,587,618	A		12/1996	Hathaway
4,864,455	A		9/1989	Shimomura et al.	5,592,353	A		1/1997	Shinohara et al.
4,875,398	A		10/1989	Taylor et al.	5,606,889	A		3/1997	Bielinski et al.
4,888,869	A		12/1989	Leatherman	5,619,896	A		4/1997	Chen
4,896,607	A		1/1990	Hall et al.	5,623,860	A		4/1997	Schoene et al.
4,906,962	A		3/1990	Duimstra	5,647,258	A		7/1997	Brazell et al.
4,907,679	A		3/1990	Menke	5,648,644	A	*	7/1997	Nagel 187/288
4,934,233	A		6/1990	Brundage et al.	5,659,454	A		8/1997	Vermesse
4,936,876	A		6/1990	Reyes	5,667,152	A		9/1997	Mooring
4,937,554	A	*	6/1990	Herman 340/453	5,671,633	A		9/1997	Wagner
4,962,685	A		10/1990	Hagstrom	5,695,306	A		12/1997	Nygren, Jr.
4,964,450	A		10/1990	Hughes et al.	5,700,165	A		12/1997	Harris et al.
4,965,909	A		10/1990	McCullough et al.	5,720,213	A		2/1998	Sberveglieri
4,975,798	A		12/1990	Edwards et al.	5,722,308	A		3/1998	Ceroll et al.
5,020,406	A		6/1991	Sasaki et al.	5,724,875	A		3/1998	Meredith et al.
5,025,175	A		6/1991	Dubois, III	5,730,165	A		3/1998	Philipp
5,042,348	A		8/1991	Brundage et al.	5,741,048	A	*	4/1998	Eccleston 303/7
5,046,426	A		9/1991	Julien et al.	5,755,148	A		5/1998	Stumpf et al.
5,052,255	A		10/1991	Gaines	5,771,742	A		6/1998	Bokaie et al.
5,074,047	A		12/1991	King	5,782,001	A		7/1998	Gray
5,081,406	A		1/1992	Hughes et al.	5,787,779	A		8/1998	Garuglieri
5,082,316	A		1/1992	Wardlaw	5,791,057	A		8/1998	Nakamura et al.
5,083,973	A		1/1992	Townsend	5,791,223	A		8/1998	Lanzer
5,086,890	A		2/1992	Turczyn et al.	5,791,224	A		8/1998	Suzuki et al.
5,094,000	A		3/1992	Becht et al.	5,791,441	A	*	8/1998	Matos et al. ..... 188/1.11 L
5,116,249	A		5/1992	Shiotani et al.	5,797,307	A		8/1998	Horton
5,119,555	A		6/1992	Johnson	5,819,619	A		10/1998	Miller et al.
5,122,091	A		6/1992	Townsend	5,819,625	A		10/1998	Sberveglieri
5,146,714	A		9/1992	Liiber	5,852,951	A		12/1998	Santi
5,174,349	A		12/1992	Svetlik et al.	5,857,507	A		1/1999	Puzio et al.
5,184,534	A		2/1993	Lee	5,861,809	A		1/1999	Eckstein et al.
5,198,702	A		3/1993	McCullough et al.	5,875,698	A		3/1999	Ceroll et al.
5,199,343	A		4/1993	OBanion	5,880,954	A		3/1999	Thomson et al.
5,201,110	A		4/1993	Bane	5,921,367	A		7/1999	Kashioka et al.
5,201,684	A		4/1993	DeBois, III	5,927,857	A		7/1999	Ceroll et al.
5,206,625	A	*	4/1993	Davis 340/454	5,930,096	A		7/1999	Kim
5,207,253	A		5/1993	Hoshino et al.	5,937,720	A		8/1999	Itzov
5,212,621	A		5/1993	Panter	5,942,975	A		8/1999	S.o slashed.rensen
5,218,189	A		6/1993	Hutchison	5,943,932	A		8/1999	Sberveglieri
5,231,359	A		7/1993	Masuda et al.	5,950,514	A		9/1999	Benedict et al.
5,231,906	A		8/1993	Kogej	5,963,173	A		10/1999	Lian et al.
5,239,978	A		8/1993	Plangetis	5,974,927	A		11/1999	Tsune
5,245,879	A		9/1993	McKeon	5,989,116	A		11/1999	Johnson et al.
5,257,570	A		11/1993	Shiotani et al.	6,009,782	A		1/2000	Tajima et al.

6,018,284	A	1/2000	Rival et al.	
6,037,729	A	3/2000	Woods et al.	
6,052,884	A	4/2000	Steckler et al.	
6,062,121	A	5/2000	Ceroll et al.	
6,070,484	A	6/2000	Sakamaki	
6,095,092	A	8/2000	Chou	
6,112,785	A	9/2000	Yu	
6,119,984	A	9/2000	Devine	
6,133,818	A	10/2000	Hsieh et al.	
6,141,192	A	10/2000	Garzon	
6,148,504	A	11/2000	Schmidt et al.	
6,148,703	A	11/2000	Ceroll et al.	
6,150,826	A	11/2000	Hokodate et al.	
6,161,459	A	12/2000	Ceroll et al.	
6,170,370	B1	1/2001	Sommerville	
6,244,149	B1	6/2001	Ceroll et al.	
6,250,190	B1	6/2001	Ceroll et al.	
6,257,061	B1	7/2001	Nonoyama et al.	
6,283,002	B1	9/2001	Chiang	
6,295,910	B1	10/2001	Childs et al.	
6,325,195	B1 *	12/2001	Doherty	192/133
6,330,848	B1	12/2001	Nishio et al.	
6,336,273	B1	1/2002	Nilsson et al.	
6,352,137	B1	3/2002	Stegall et al.	
6,357,328	B1	3/2002	Ceroll et al.	
6,366,099	B1	4/2002	Reddi	
6,376,939	B1	4/2002	Suzuki et al.	
6,404,098	B1	6/2002	Kayama et al.	
6,405,624	B2	6/2002	Sutton	
6,418,829	B1	7/2002	Pilchowski	
6,420,814	B1	7/2002	Bobbio	
6,427,570	B1	8/2002	Miller et al.	
6,430,007	B1	8/2002	Jabbari	
6,431,425	B1	8/2002	Moorman et al.	
6,450,077	B1	9/2002	Ceroll et al.	
6,453,786	B1	9/2002	Ceroll et al.	
6,460,442	B2	10/2002	Talesky et al.	
6,471,106	B1	10/2002	Reining	
6,479,958	B1	11/2002	Thompson et al.	
6,484,614	B1	11/2002	Huang	
D466,913	S	12/2002	Ceroll et al.	
6,492,802	B1	12/2002	Bielski	
D469,354	S	1/2003	Curtsinger	
6,502,493	B1	1/2003	Eccardt et al.	
6,543,324	B2	4/2003	Dils	
6,546,835	B2	4/2003	Wang	
6,564,909	B1 *	5/2003	Razzano	188/1.11 L
6,575,067	B2	6/2003	Parks et al.	
6,578,460	B2	6/2003	Sartori	
6,578,856	B2	6/2003	Kahle	
6,581,655	B2	6/2003	Huang	
6,595,096	B2	7/2003	Ceroll et al.	
D478,917	S	8/2003	Ceroll et al.	
6,601,493	B1	8/2003	Crofutt	
6,607,015	B1	8/2003	Chen	
D479,538	S	9/2003	Welsh et al.	
6,617,720	B1	9/2003	Egan, III et al.	
6,619,348	B2	9/2003	Wang	
6,640,683	B2	11/2003	Lee	
6,644,157	B2	11/2003	Huang	
6,647,847	B2	11/2003	Hewitt et al.	
6,659,233	B2	12/2003	DeVlieg	
6,684,750	B2	2/2004	Yu	
6,722,242	B2	4/2004	Chuang	
6,734,581	B1	5/2004	Griffis	
6,736,042	B2	5/2004	Behne et al.	
6,742,430	B2	6/2004	Chen	
6,796,208	B1	9/2004	Jorgensen	
6,800,819	B2	10/2004	Sato et al.	
6,826,988	B2	12/2004	Gass et al.	
6,826,992	B1	12/2004	Huang	
6,840,144	B2	1/2005	Huang	
6,854,371	B2	2/2005	Yu	
6,857,345	B2	2/2005	Gass et al.	
6,874,397	B2	4/2005	Chang	
6,874,399	B2	4/2005	Lee	
6,880,440	B2	4/2005	Gass et al.	
6,889,585	B1	5/2005	Harris et al.	
6,920,814	B2	7/2005	Gass et al.	
6,922,153	B2	7/2005	Pierga et al.	
6,945,148	B2	9/2005	Gass et al.	
6,945,149	B2	9/2005	Gass et al.	
6,968,767	B2	11/2005	Yu	
6,986,370	B1	1/2006	Schoene et al.	
7,024,975	B2	4/2006	Gass et al.	
2001/0032534	A1	10/2001	Cerroll et al.	
2002/0043776	A1	4/2002	Chuang	
2002/0050201	A1	5/2002	Lane et al.	
2002/0088325	A1	7/2002	Talesky et al.	
2002/0096030	A1	7/2002	Wang	
2002/0096591	A1	7/2002	Tanji	
2002/0109036	A1	8/2002	Denen et al.	
2002/0134212	A1	9/2002	Ceroll et al.	
2002/0174755	A1	11/2002	Behne et al.	
2003/0000359	A1	1/2003	Eccardt et al.	
2003/0037655	A1	2/2003	Chin-Chin	
2003/0074873	A1	4/2003	Freiberg et al.	
2003/0089212	A1	5/2003	Parks et al.	
2003/0101857	A1	6/2003	Chuang	
2003/0109798	A1	6/2003	Kermani	
2003/0213349	A1	11/2003	Chang	
2004/0011177	A1	1/2004	Huang	
2004/0060404	A1	4/2004	Metzger, Jr.	
2004/0104085	A1	6/2004	Lang et al.	
2004/0159198	A1	8/2004	Peot et al.	
2004/0194594	A1	10/2004	Dils et al.	
2004/0200329	A1	10/2004	Sako	
2004/0226424	A1	11/2004	OBanion et al.	
2004/0226800	A1	11/2004	Pierga et al.	
2004/0255745	A1	12/2004	Peot et al.	
2005/0057206	A1	3/2005	Uneyama	
2005/0092149	A1	5/2005	Hartmann	
2005/0139051	A1	6/2005	Gass et al.	
2005/0139056	A1	6/2005	Gass et al.	
2005/0139057	A1	6/2005	Gass et al.	
2005/0139058	A1	6/2005	Gass et al.	
2005/0139459	A1	6/2005	Gass et al.	
2005/0155473	A1	7/2005	Gass	
2005/0166736	A1	8/2005	Gass et al.	
2005/0178259	A1	8/2005	Gass et al.	
2005/0204885	A1	9/2005	Gass et al.	
2005/0211034	A1	9/2005	Sasaki et al.	
2005/0235793	A1	10/2005	O'Banion et al.	
2005/0274432	A1	12/2005	Gass et al.	
2006/0000337	A1	1/2006	Gass	
2006/0032352	A1	2/2006	Gass et al.	
2006/0123960	A1	6/2006	Gass et al.	
2006/0123964	A1	6/2006	Gass et al.	

FOREIGN PATENT DOCUMENTS

CH	297525		6/1954
DE	76186		8/1921
DE	2917497		4/1979
DE	2800403		7/1979
DE	3427733		1/1986
DE	4235161	A1	5/1993
DE	4326313		2/1995
DE	19609771		6/1998
EP	146460		11/1988
EP	0362937	A2	4/1990
ES	2152184		1/2001
FR	2556643		6/1985
FR	2570017		3/1986
GB	598204		2/1948
GB	1132708		11/1968

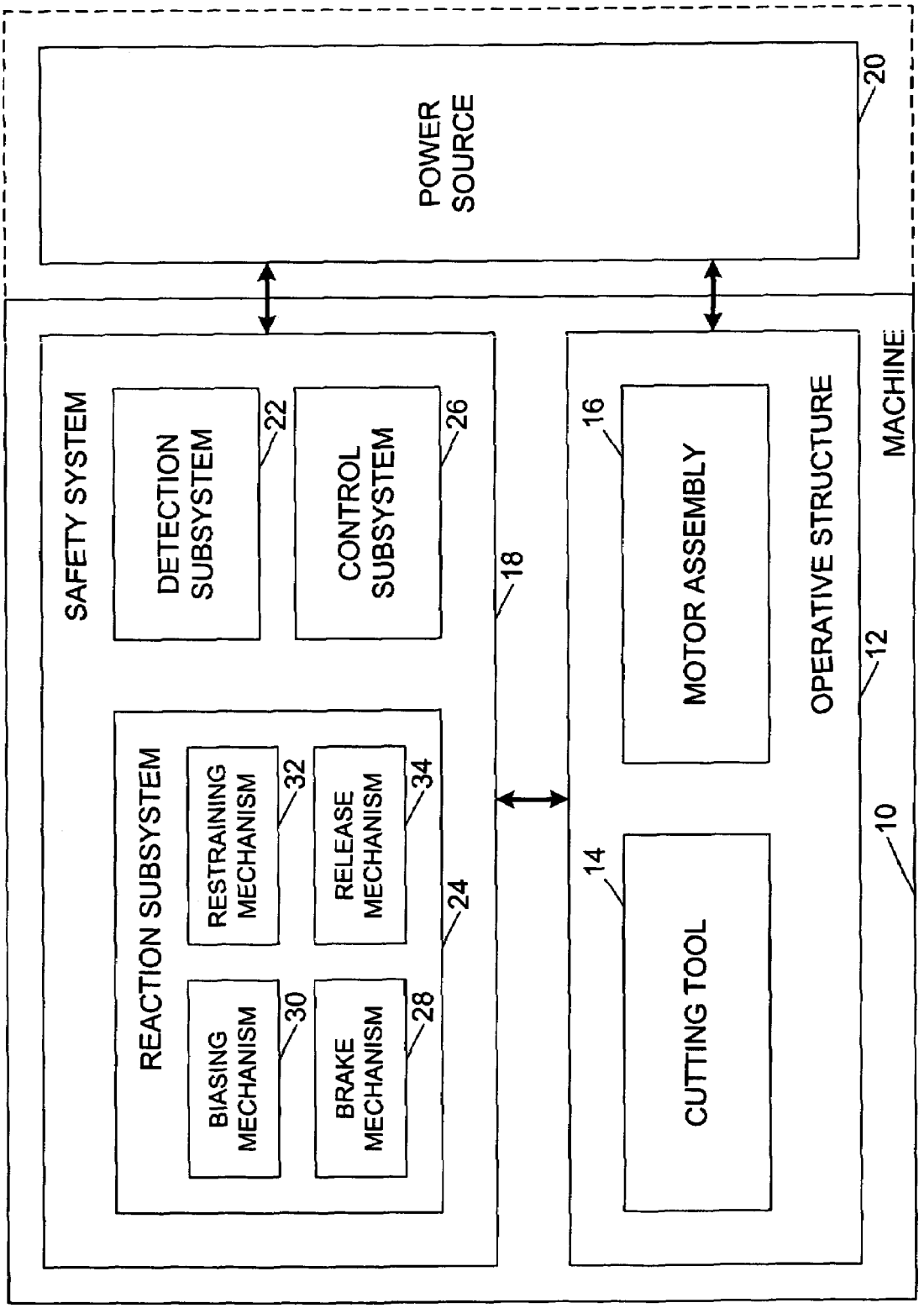
GB 2096844 10/1982
GB 2142571 1/1985

OTHER PUBLICATIONS

You Should Have Invented It, French television show video.
Analog Devices, Inc., 3-Axis Capacitive Sensor—Preliminary Technical Data AD7103, pp. 1-40, © 1998.
Tablesaw Splitters and Blade Covers, *Fine Woodworking*, pp. 77-81, Dec. 2001.
Young Inventor: Teen's Device Earns Her Trip to Science Fair, *The Arizona Republic*, May 5, 2006.
Operator Injury Mitigation Using Electronic Sensing and Mechanical Braking and Decoupling Devices in Handheld Circular Saws, Erin F. Eppard, date unknown.
Skil Model 3400-Type 1 10" Table Saw Parts List and Technical Bulletin, S-B Power Tool Company, Jun. 1993.
Shop Fox® Fence Operating Manual, Woodstock International, Inc., 1996, revised May 1997.
Analog Devices, Inc., 3-Axis Capacitive Sensor—Preliminary Technical Data AD7103, pp. 1-40, © 1998.
Excaliber T-Slot Precision Saw Fence Model TT45 Owner's Manual, Sommerville Design & Manufacturing, Inc., May 2000.
Bosch Model 4000 Worksite Table Saw Operating/Safety Instructions, S-B Power Tool Company, Jul. 2000.
XACTA Fence II™ Homeshop 30/52 Owner's Manual, JET Equipment & Tools, Mar. 2001.
XACTA Fence II™ Commercial 30/50 Owner's Manual, JET Equipment & Tools, Mar. 2001.
Bosch 10" Table Saw Model 0601476139 Parts List and Technical Bulletin, S-B Power Tool Company, Apr. 2001.
Biesemeyer® T-Square® Universal Home Shop Fence system Instruction Manual, Delta Machinery, Jun. 1, 2001.
Powermatic 10" Tilting Arbor Saw Model 66 Instruction Manual & Parts List, JET Equipment & Tools, Jun. 2001.
Skil Model 3400 Table Saw Operating/Safety Instructions, S-B Power Tool Company, Sep. 2001.
The Merlin Splitter by Excalibur a Sommerville Design Product Overview & Generic Installation Notes, Sommerville Design & Manufacturing Inc., at least as early as 2002.
INCRA Incremental Micro Precision Table Saw Fence Owner's Manual, Taylor Design Group, Inc., 2003.
Shop Fox® Models W2005, W2006, W2007 Classic Fence Instruction Manual, Woodstock International, Jan. 2000, revised Mar. 2004.
ACCU-FENCE® 64A Fence and Rail System Owner's Manual, WMH Tool Group, Sep. 2004.
Unifence™ Saw Guide Instruction Manual, Delta Machinery, Feb. 22, 2005.
Biesemeyer® T-Square® Commercial Fence System Instruction Manual, Delta Machinery, May 2, 2005.
Laguna Tools table saw owner's manual, date unknown.

* cited by examiner

Fig. 1


POWER SOURCE
20
MACHINE
10
SAFETY SYSTEM
DETECTION SUBSYSTEM
22
CONTROL SUBSYSTEM
26
18
REACTION SUBSYSTEM
RESTRAINING MECHANISM
32
RELEASE MECHANISM
34
24
BIASING MECHANISM
30
BRAKE MECHANISM
28
OPERATIVE STRUCTURE
12
MOTOR ASSEMBLY
16
CUTTING TOOL
14

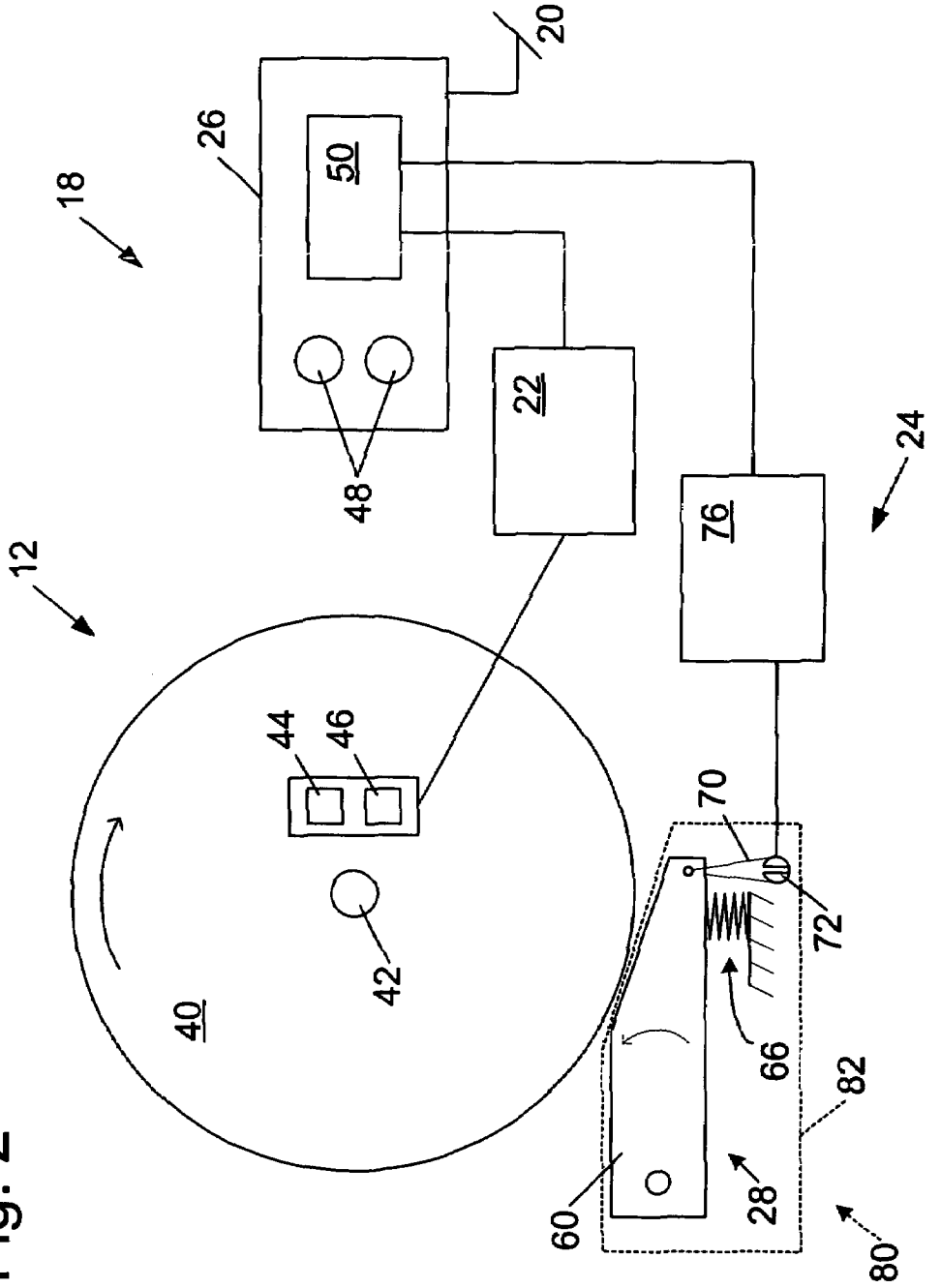


Fig. 2

Fig. 3

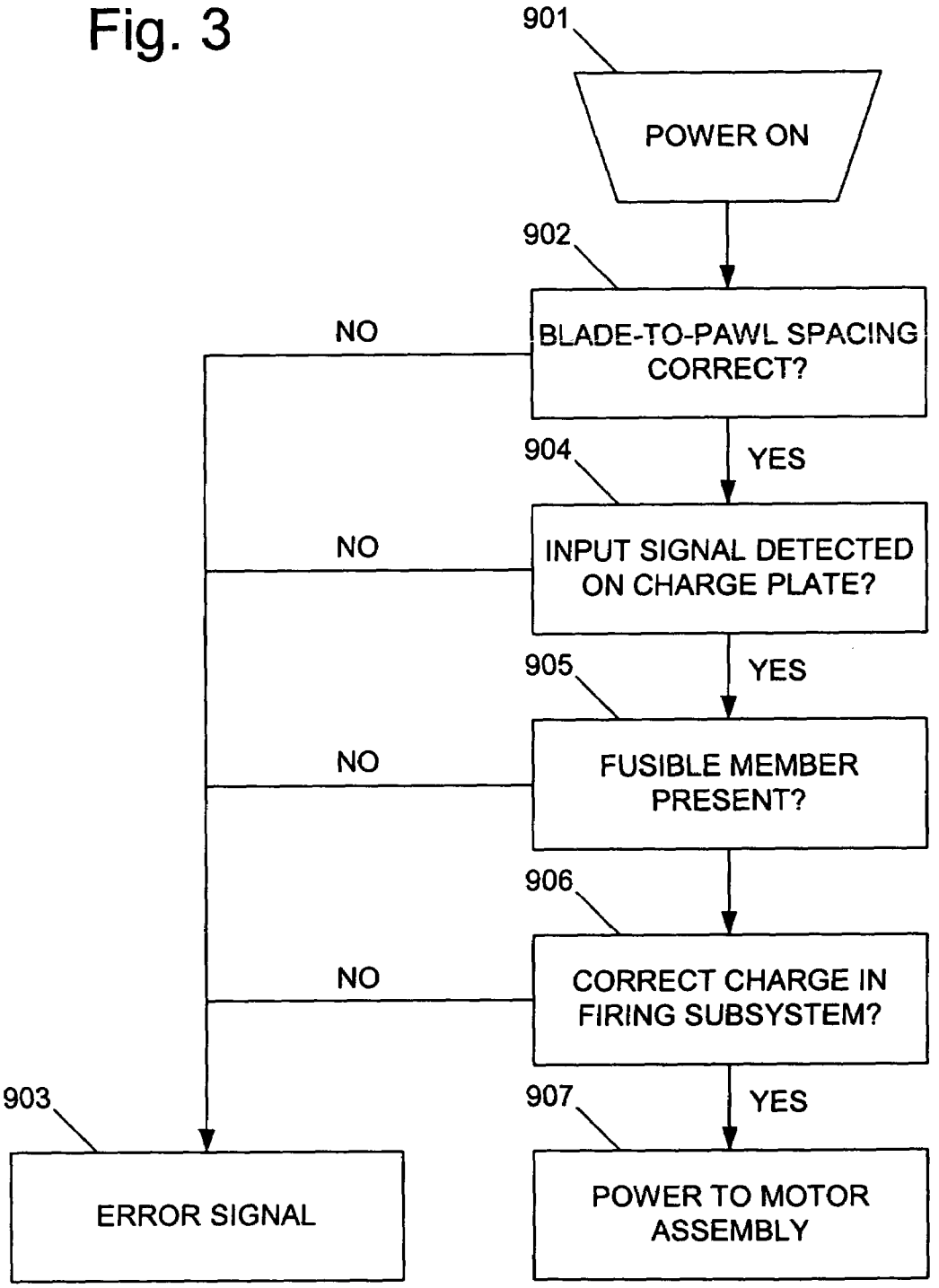

901
POWER ON
902
BLADE-TO-PAWL SPACING CORRECT?
NO
YES
904
INPUT SIGNAL DETECTED ON CHARGE PLATE?
NO
YES
905
FUSIBLE MEMBER PRESENT?
NO
906
CORRECT CHARGE IN FIRING SUBSYSTEM?
NO
YES
907
903
ERROR SIGNAL
POWER TO MOTOR ASSEMBLY

Fig. 4A

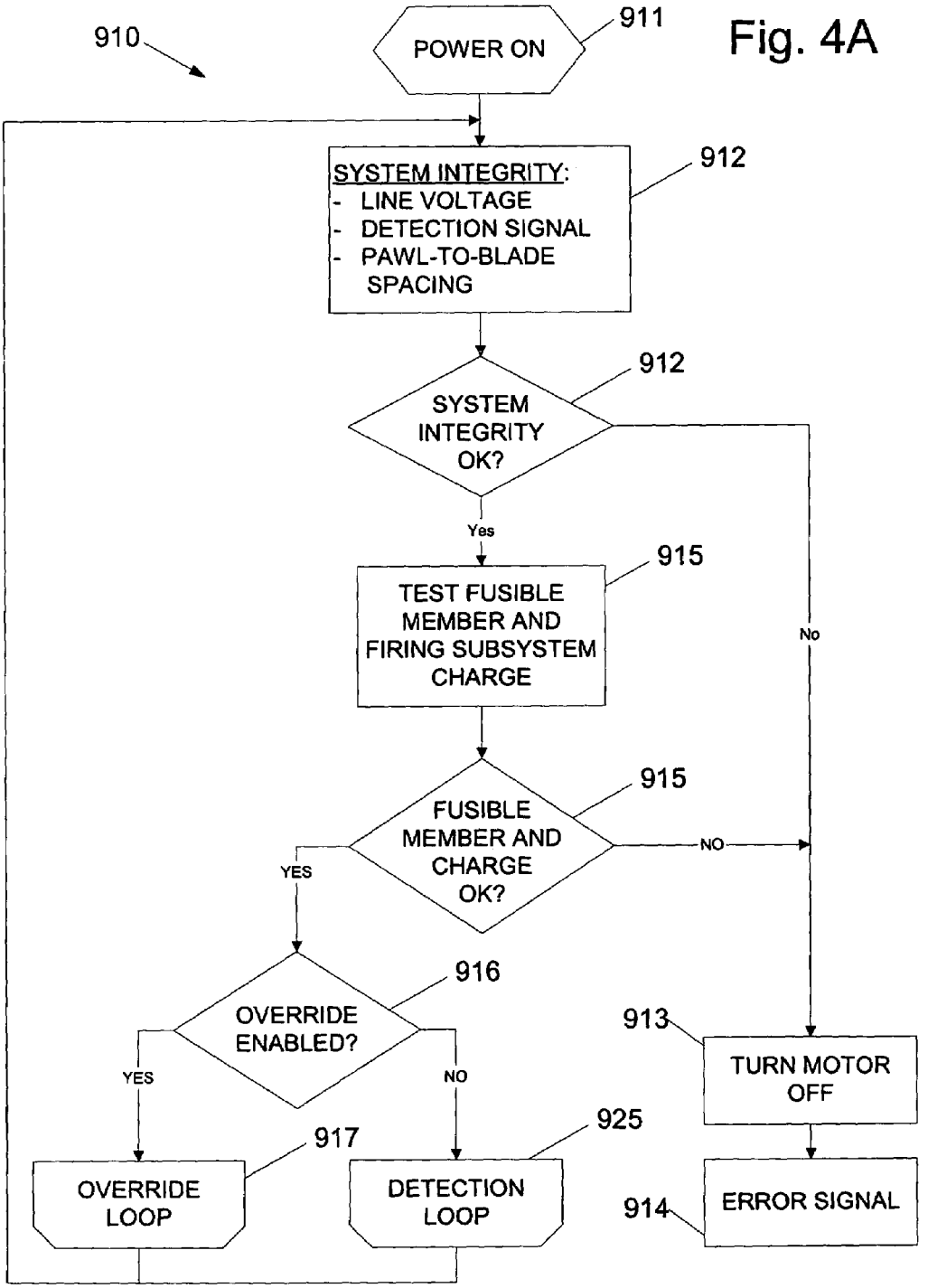

910
911
POWER ON
912
SYSTEM INTEGRITY:
- LINE VOLTAGE
- DETECTION SIGNAL
- PAWL-TO-BLADE SPACING
912
SYSTEM INTEGRITY OK?
Yes
No
915
TEST FUSIBLE MEMBER AND FIRING SUBSYSTEM CHARGE
915
FUSIBLE MEMBER AND CHARGE OK?
YES
NO
916
OVERRIDE ENABLED?
YES
NO
913
TURN MOTOR OFF
917
OVERRIDE LOOP
925
DETECTION LOOP
914
ERROR SIGNAL

Fig. 4B

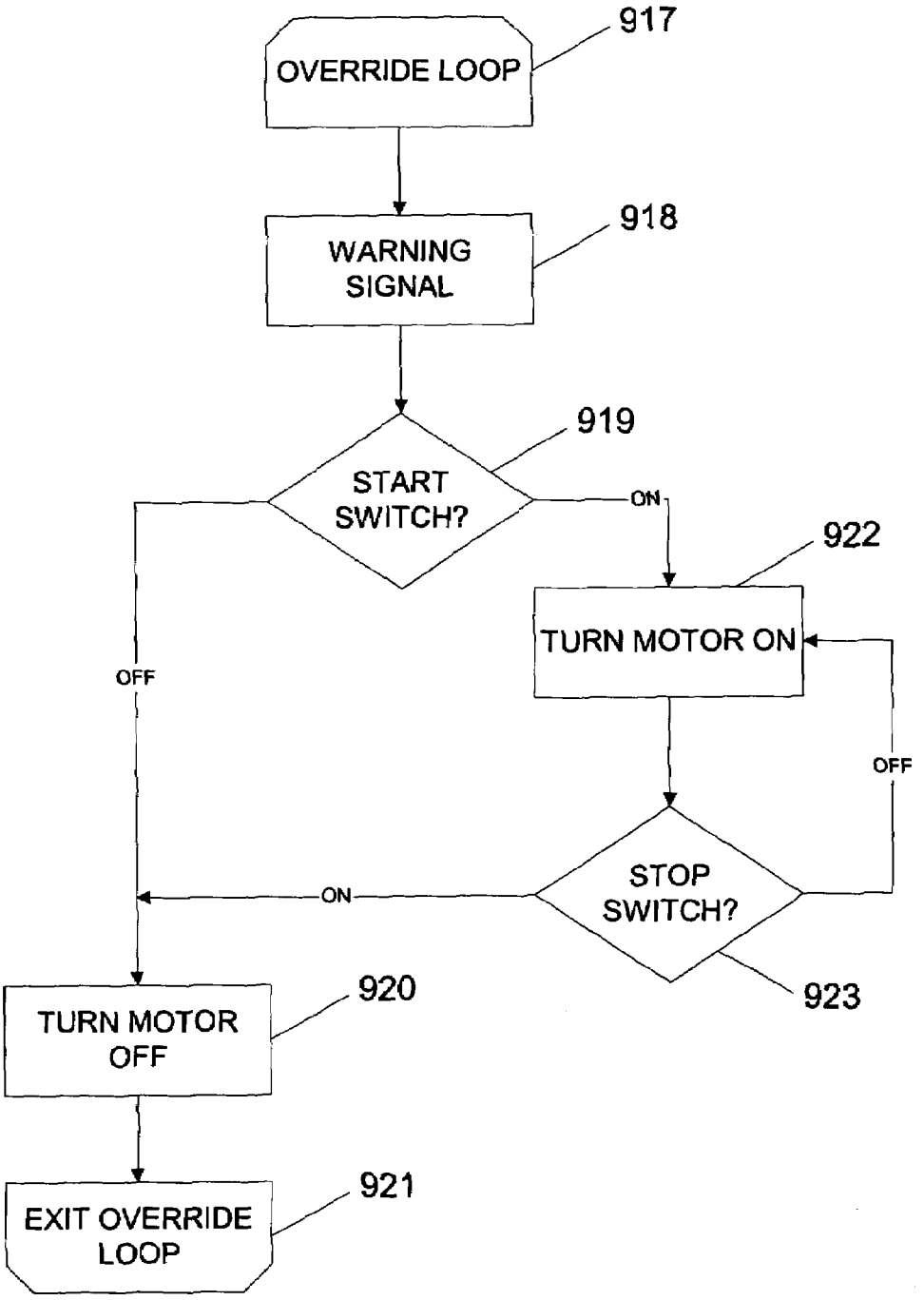
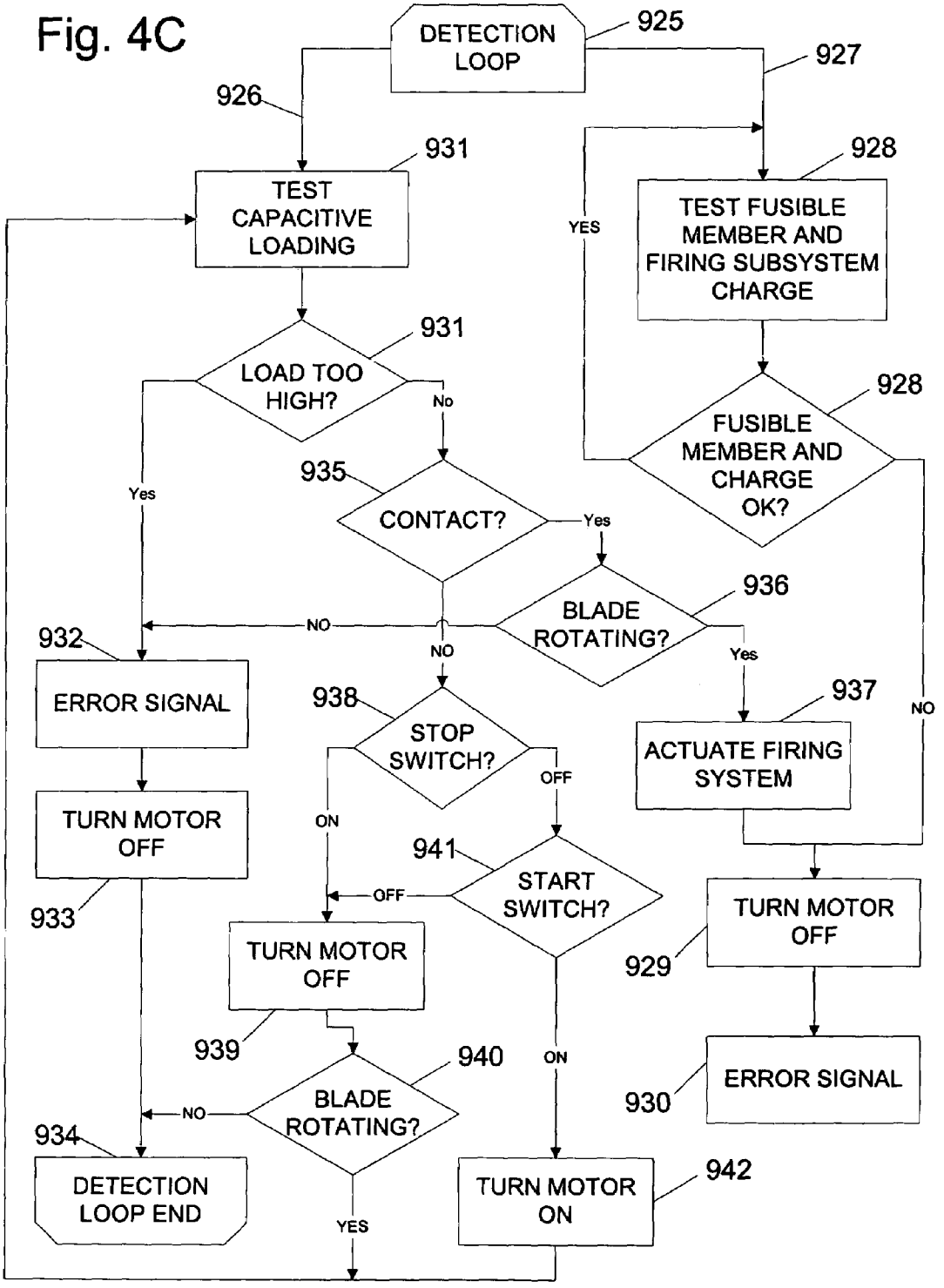

OVERRIDE LOOP
917
WARNING SIGNAL
918
START SWITCH?
919
ON
OFF
TURN MOTOR ON
922
OFF
STOP SWITCH?
ON
923
TURN MOTOR OFF
920
EXIT OVERRIDE LOOP
921

Fig. 4C


DETECTION LOOP
925
926
927
931
TEST CAPACITIVE LOADING
928
TEST FUSIBLE MEMBER AND FIRING SUBSYSTEM CHARGE
YES
931
LOAD TOO HIGH?
No
928
FUSIBLE MEMBER AND CHARGE OK?
935
CONTACT?
Yes
Yes
936
BLADE ROTATING?
NO
NO
Yes
932
ERROR SIGNAL
938
STOP SWITCH?
937
ACTUATE FIRING SYSTEM
NO
TURN MOTOR OFF
ON
OFF
941
START SWITCH?
933
OFF
TURN MOTOR OFF
TURN MOTOR OFF
929
939
940
ON
ERROR SIGNAL
930
NO
BLADE ROTATING?
934
942
DETECTION LOOP END
YES
TURN MOTOR ON

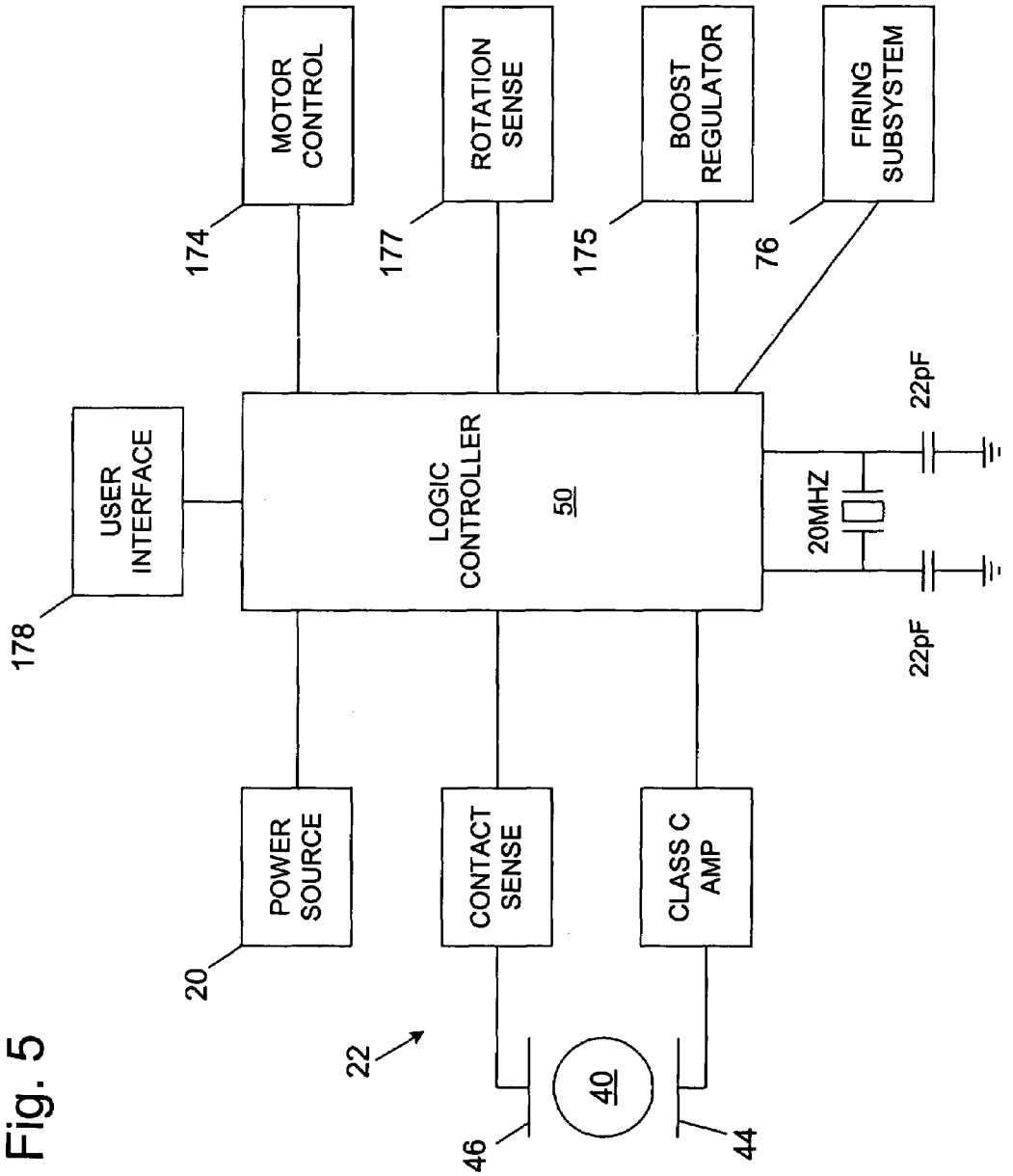

MOTOR CONTROL
174
ROTATION SENSE
177
BOOST REGULATOR
175
FIRING SUBSYSTEM
76
USER INTERFACE
178
LOGIC CONTROLLER
50
22pF
20MHZ
22pF
POWER SOURCE
20
CONTACT SENSE
CLASS C AMP
22
40
46
44

Fig. 5

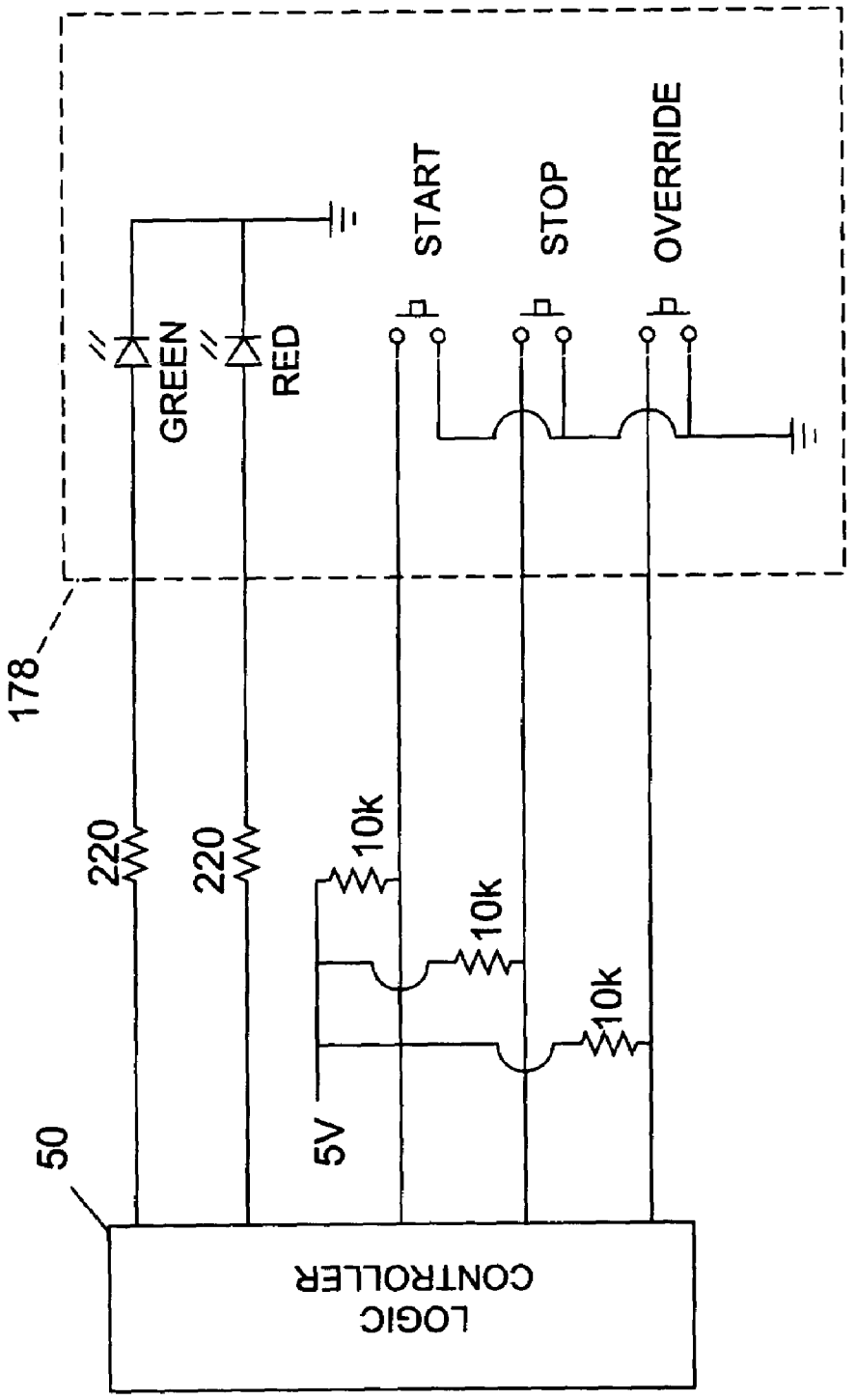

START
STOP
OVERRIDE
GREEN
RED
178
220
220
10k
10k
10k
5V
50
CONTROLLER
LOGIC

Fig. 6

Fig. 7

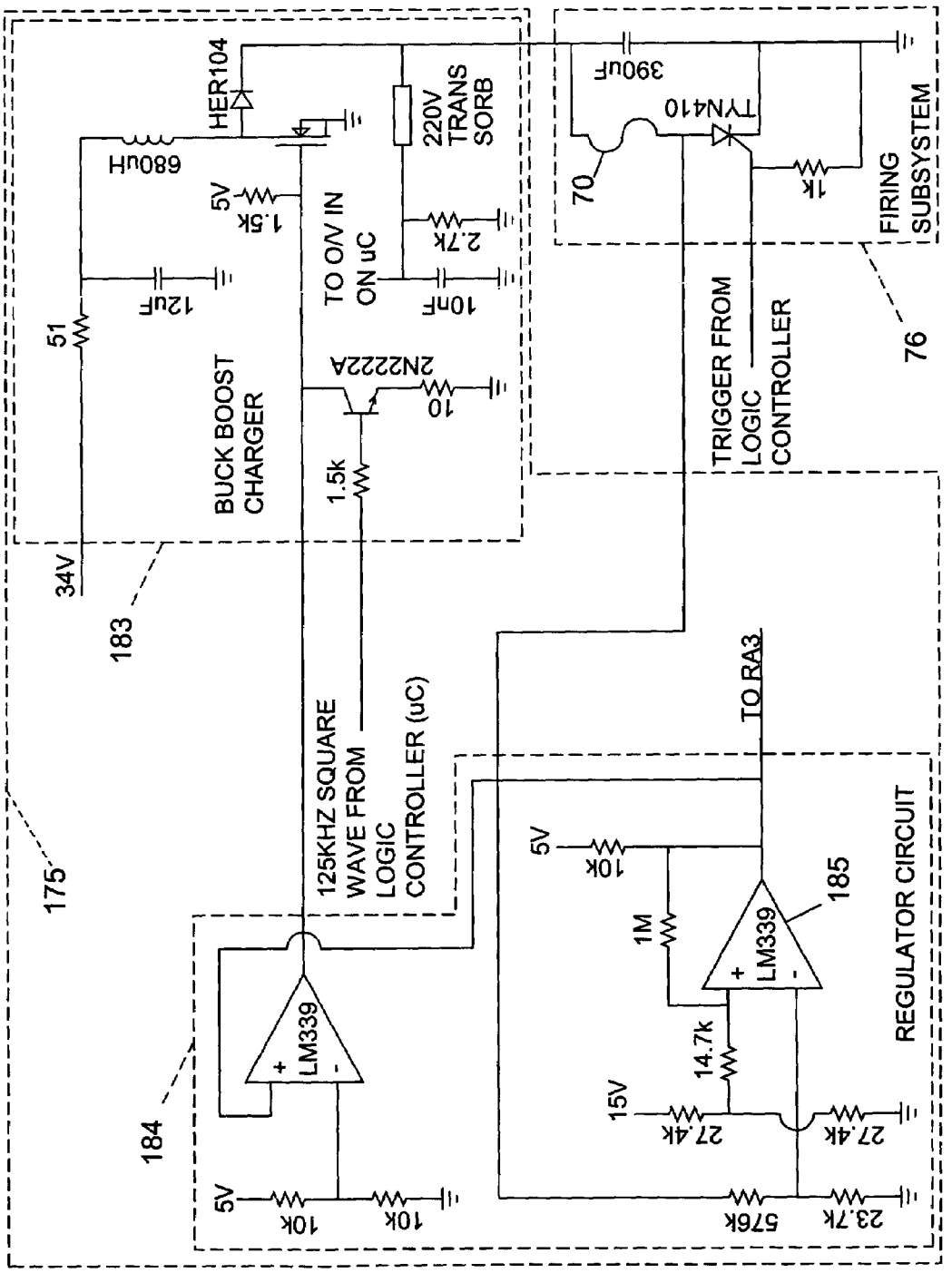

HER104
680uH
220V TRANS SORB
5V
1.5K
2.7K
TO O/V IN ON uC
12uF
10nF
51
2N2222A
10
1.5k
BUCK BOOST CHARGER
34V
183
390UF
TYN410
70
1K
FIRING SUBSYSTEM
76
TRIGGER FROM LOGIC CONTROLLER
175
125KHZ SQUARE WAVE FROM LOGIC CONTROLLER (uC)
TO RA3
5V
10K
1M
LM339
185
14.7k
15V
27.4K
27.4K
REGULATOR CIRCUIT
184
5V
10K
10K
576K
23.7K

Fig. 8

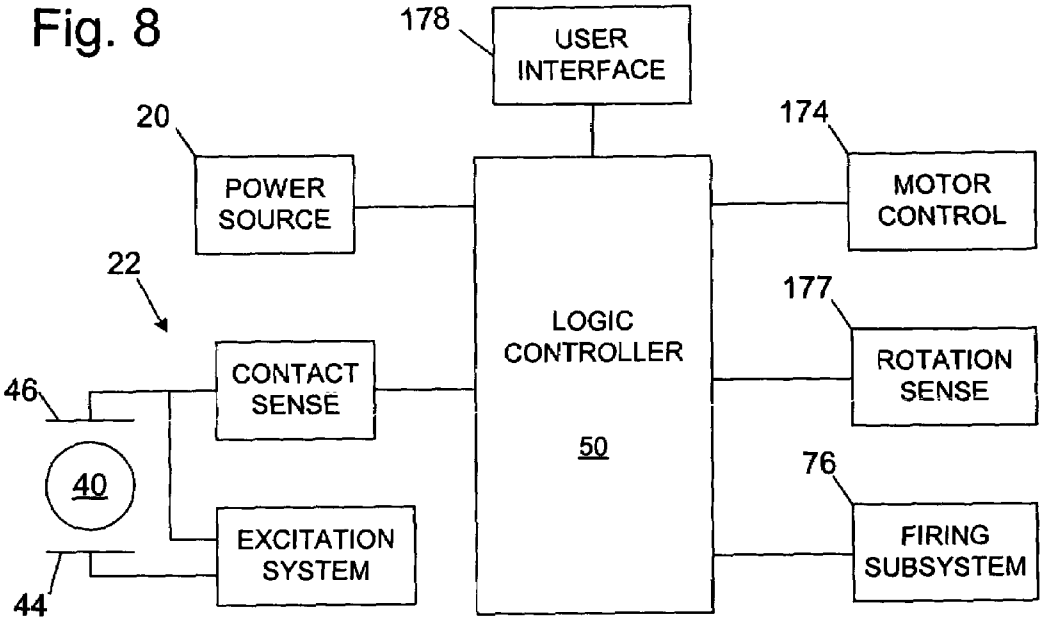

178
USER INTERFACE
20
POWER SOURCE
174
MOTOR CONTROL
22
LOGIC CONTROLLER
50
177
ROTATION SENSE
CONTACT SENSE
46
40
76
FIRING SUBSYSTEM
EXCITATION SYSTEM
44

Fig. 9

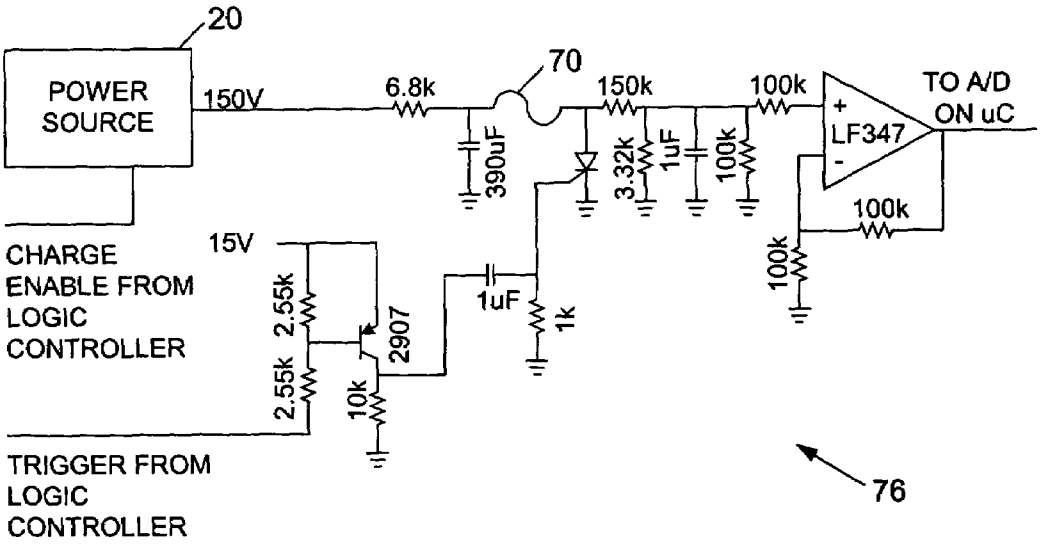

20
POWER SOURCE
150V
6.8k
70
150k
100k
TO A/D ON uC
LF347
390uF
3.32k
1uF
100k
100k
100k
CHARGE ENABLE FROM LOGIC CONTROLLER
15V
2.55k
2.55k
2907
1uF
1k
10k
TRIGGER FROM LOGIC CONTROLLER
76

Fig. 10

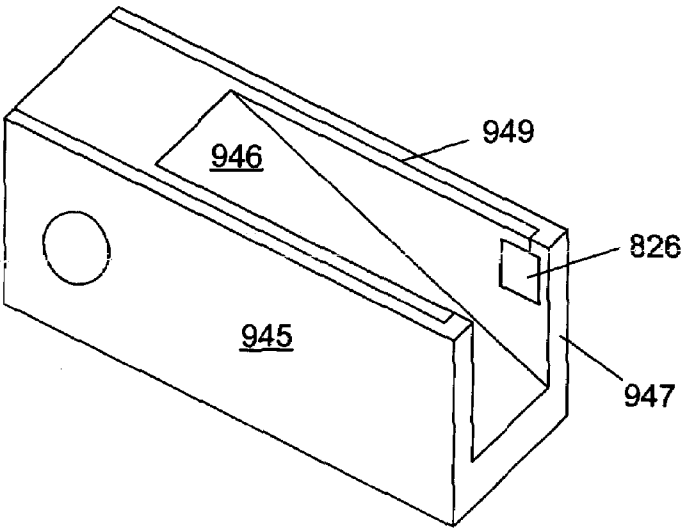
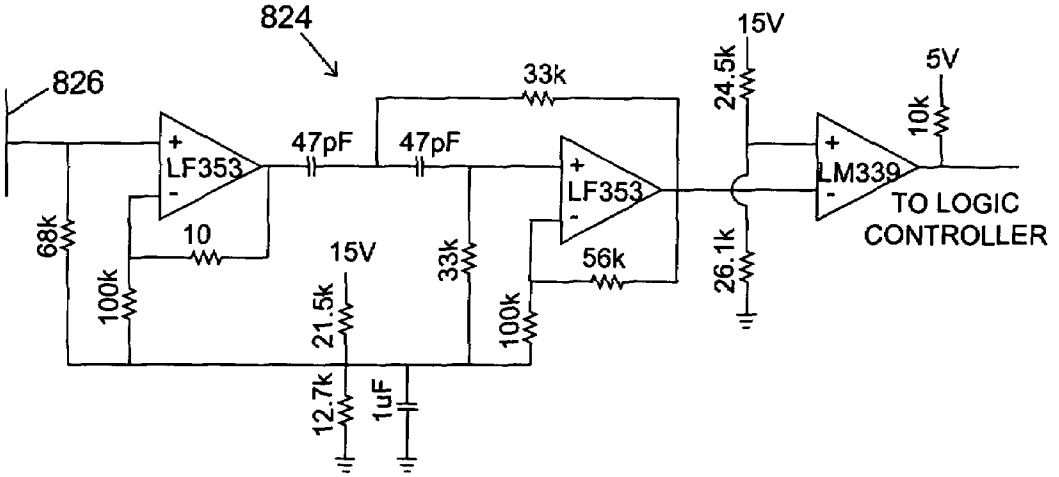

949
946
826
945
947

Fig. 11


824
826
33k
15V
24.5k
5V
10k
47pF
47pF
LF353
LF353
LM339
TO LOGIC
CONTROLLER
68k
10
15V
33k
56k
26.1k
100k
21.5k
100k
12.7k
1uF

LOGIC CONTROL FOR FAST-ACTING SAFETY SYSTEM

CROSS-REFERENCE TO RELATED APPLICATIONS

This application claims the benefit of and priority from the following U.S. Provisional Patent Applications: Ser. No. 60/225,056, filed Aug. 14, 2000, Ser. No. 60/225,057, filed Aug. 14, 2000, Ser. No. 60/225,058, filed Aug. 14, 2000, Ser. No. 60/225,059, filed Aug. 14, 2000, Ser. No. 60/225,089, filed Aug. 14, 2000, Ser. No. 60/225,094, filed Aug. 14, 2000, Ser. No. 60/225,169, filed Aug. 14, 2000, Ser. No. 60/225,170, filed Aug. 14, 2000, Ser. No. 60/225,200, filed Aug. 14, 2000, Ser. No. 60/225,201, filed Aug. 14, 2000, Ser. No. 60/225,206, filed Aug. 14, 2000, Ser. No. 60/225,210, filed Aug. 14, 2000, Ser. No. 60/225,211, filed Aug. 14, 2000, and Ser. No. 60/225,212, filed Aug. 14, 2000.

FIELD

The present invention relates to safety systems, and more particularly to a high-speed safety system for use on power equipment.

BACKGROUND

Beginning with the industrial revolution and continuing to the present, mechanized equipment has allowed workers to produce goods with greater speed and less effort than possible with manually-powered tools. Unfortunately, the power and high operating speeds of mechanized equipment creates a risk for those operating such machinery. Each year thousands of people are maimed or killed by accidents involving power equipment.

As might be expected, many systems have been developed to minimize the risk of injury when using power equipment. Probably the most common safety feature is a guard that physically blocks an operator from making contact with dangerous components of machinery, such as belts, shafts or blades. In many cases, guards are effective to reduce the risk of injury, however, there are many instances where the nature of the operations to be performed precludes using a guard that completely blocks access to hazardous machine parts.

Various systems have been proposed to prevent accidental injury where guards cannot effectively be employed. For instance, U.S. Pat. Nos. 941,726, 2,978,084, 3,011,610, 3,047,116, 4,195,722 and 4,321,841, the disclosures of which are incorporated herein by reference, all disclose safety systems for use with power presses. These systems utilize cables attached to the wrists of the operator that either pull back a user's hands from the work zone upon operation or prevent operation until the user's hands are outside the danger zone. U.S. Pat. Nos. 3,953,770, 4,075,961, 4,470,046, 4,532,501 and 5,212,621, the disclosures of which are incorporated herein by reference, disclose radio-frequency safety systems which utilize radio-frequency signals to detect the presence of a user's hand in a dangerous area of the machine and thereupon prevent or interrupt operation of the machine.

U.S. Pat. Nos. 4,959,909, 5,025,175, 5,122,091, 5,198,702, 5,201,684, 5,272,946, and 5,510,685 disclose safety systems for use with meat-skinning equipment, and are incorporated herein by reference. These systems interrupt or reverse power to the motor, or disengage a clutch, upon contact with a user's hand by any dangerous portion of the machine. Typically, contact between the user and the machine is detected by monitoring for electrical contact between a fine wire mesh in a glove worn by the user and some metal component in the dangerous area of the machine. Although such systems are suitable for use with meat skinning machines, they are relatively slow to stop the motion of the cutting element because they rely on the operation of solenoids or must overcome the inertia of the motor. However, because these systems operate at relatively low speeds, the blade does not need to be stopped rapidly to prevent serious injury to the user.

U.S. Pat. Nos. 3,785,230 and 4,026,177, the disclosures of which are herein incorporated by reference, disclose a safety system for use on circular saws to stop the blade when a user's hand approaches the blade. The system uses the blade as an antenna in an electromagnetic proximity detector to detect the approach of a user's hand prior to actual contact with the blade. Upon detection of a user's hand, the system engages a brake using a standard solenoid. Unfortunately, such a system is prone to false triggers and is relatively slow acting because of the solenoid. U.S. Pat. No. 4,117,752, which is herein incorporated by reference, discloses a similar braking system for use with a band saw, where the brake is triggered by actual contact between the user's hand and the blade. However, the system described for detecting blade contact does not appear to be functional to accurately and reliably detect contact. Furthermore, the system relies on standard electromagnetic brakes operating off of line voltage to stop the blade and pulleys of the band saw. It is believed that such brakes would take 58 ms-1s to stop the blade. Therefore, the system is too slow to stop the blade quickly enough to avoid serious injury.

None of the safety systems mentioned above disclose any method or mechanism for ensuring that the system is operational before setting the blade or other dangerous portion of the machine in motion. In addition, none of the systems mentioned above disclose any method or mechanism for preventing false triggers during initial startup or for monitoring the operating status of the machinery to prevent triggering the safety system when the blade is stationary. Further, none of the above-mentioned systems disclose any method or mechanism for allowing a user to disable the safety system under certain conditions.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a schematic block diagram of a machine with a fast-acting safety system according to the present invention.

FIG. **2** is a schematic diagram of an exemplary safety system in the context of a machine having a circular blade.

FIG. **3** is a flowchart diagram of an exemplary self-test logic sequence according to the present invention.

FIGS. **4**A-C are flowchart diagrams of an exemplary self-test and operational sequence according to the present invention.

FIG. **5** is a schematic block diagram of a logic controller according to a first exemplary implementation of the present invention.

FIG. **6** is a schematic diagram of a user interface according to the present invention.

FIG. **7** is a schematic diagram of a firing capacitor charge and test circuit according to the first exemplary implementation of the present invention.

FIG. **8** is a schematic block diagram of a logic controller according to a second exemplary implementation of the present invention.

FIG. **9** is a schematic diagram of a firing capacitor charge and test circuit according to the second exemplary implementation of the present invention.

FIG. **10** is an isometric view of an exemplary pawl adapted for measuring pawl-to-blade spacing according to the present invention.

FIG. **11** is a schematic diagram of an exemplary circuit for detecting blade-to-pawl spacing according to the present invention.

DETAILED DESCRIPTION

A machine according to the present invention is shown schematically in FIG. **1** and indicated generally at **10**. Machine **10** may be any of a variety of different machines adapted for cutting workpieces, such as wood, including a table saw, miter saw (chop saw), radial arm saw, circular saw, band saw, jointer, planer, etc. Machine **10** includes an operative structure **12** having a cutting tool **14** and a motor assembly **16** adapted to drive the cutting tool. Machine **10** also includes a safety system **18** configured to minimize the potential of a serious injury to a person using machine **10**. Safety system **18** is adapted to detect the occurrence of one or more dangerous conditions during use of machine **10**. If such a dangerous condition is detected, safety system **18** is adapted to engage operative structure **12** to limit any injury to the user caused by the dangerous condition.

Machine **10** also includes a suitable power source **20** to provide power to operative structure **12** and safety system **18**. Power source **20** may be an external power source such as line current, or an internal power source such as a battery. Alternatively, power source **20** may include a combination of both external and internal power sources. Furthermore, power source **20** may include two or more separate power sources, each adapted to power different portions of machine **10**.

It will be appreciated that operative structure **12** may take any one of many different forms, depending on the type of machine **10**. For example, operative structure **12** may include a stationary housing configured to support motor assembly **16** in driving engagement with cutting tool **14**. Alternatively, operative structure **12** may include a movable structure configured to carry cutting tool **14** between multiple operating positions. As a further alternative, operative structure **12** may include one or more transport mechanisms adapted to convey a workpiece toward and/or away from cutting tool **14**.

Motor assembly **16** includes one or more motors adapted to drive cutting tool **14**. The motors may be either directly or indirectly coupled to the cutting tool, and may also be adapted to drive workpiece transport mechanisms. Cutting tool **14** typically includes one or more blades or other suitable cutting implements that are adapted to cut or remove portions from the workpieces. The particular form of cutting tool **14** will vary depending upon the various embodiments of machine **10**. For example, in table saws, miter saws, circular saws and radial arm saws, cutting tool **14** will typically include one or more circular rotating blades having a plurality of teeth disposed along the perimetrical edge of the blade. For a jointer or planer, the cutting tool typically includes a plurality of radially spaced-apart blades. For a band saw, the cutting tool includes an elongate, circuitous tooth-edged band.

Safety system **18** includes a detection subsystem **22**, a reaction subsystem **24** and a control subsystem **26**. Control subsystem **26** may be adapted to receive inputs from a variety of sources including detection subsystem **22**, reaction subsystem **24**, operative structure **12** and motor assembly **16**. The control subsystem may also include one or more sensors adapted to monitor selected parameters of machine **10**. In addition, control subsystem **26** typically includes one or more instruments operable by a user to control the machine. The control subsystem is configured to control machine **10** in response to the inputs it receives.

Detection subsystem **22** is configured to detect one or more dangerous, or triggering, conditions during use of machine **10**. For example, the detection subsystem may be configured to detect that a portion of the user's body is dangerously close to, or in contact with, a portion of cutting tool **14**. As another example, the detection subsystem may be configured to detect the rapid movement of a workpiece due to kickback by the cutting tool, as is described in U.S. Provisional Patent Application Ser. No. 60/182,866, the disclosure of which is herein incorporated by reference. In some embodiments, detection subsystem **22** may inform control subsystem **26** of the dangerous condition, which then activates reaction subsystem **24**. In other embodiments, the detection subsystem may be adapted to activate the reaction subsystem directly.

Once activated in response to a dangerous condition, reaction subsystem **24** is configured to engage operative structure **12** quickly to prevent serious injury to the user. It will be appreciated that the particular action to be taken by reaction subsystem **24** will vary depending on the type of machine **10** and/or the dangerous condition that is detected. For example, reaction subsystem **24** may be configured to do one or more of the following: stop the movement of cutting tool **14**, disconnect motor assembly **16** from power source **20**, place a barrier between the cutting tool and the user, or retract the cutting tool from its operating position, etc. The reaction subsystem may be configured to take a combination of steps to protect the user from serious injury. Placement of a barrier between the cutting tool and teeth is described in more detail in U.S. Provisional Patent Application Ser. No. 60/225,206, entitled "Cutting Tool Safety System," filed Aug. 14, 2000 by SD3, LLC, the disclosure of which is herein incorporated by reference. Retraction of the cutting tool from its operating position is described in more detail in U.S. Provisional Patent Application Ser. No. 60/225,089, entitled "Retraction System For Use In Power Equipment," filed Aug. 14, 2000 by SD3, LLC, the disclosure of which is herein incorporated by reference.

The configuration of reaction subsystem **24** typically will vary depending on which action(s) are taken. In the exemplary embodiment depicted in FIG. **1**, reaction subsystem **24** is configured to stop the movement of cutting tool **14** and includes a brake mechanism **28**, a biasing mechanism **30**, a restraining mechanism **32**, and a release mechanism **34**. Brake mechanism **28** is adapted to engage operative structure **12** under the urging of biasing mechanism **30**. During normal operation of machine **10**, restraining mechanism **32** holds the brake mechanism out of engagement with the operative structure. However, upon receipt of an activation signal by reaction subsystem **24**, the brake mechanism is released from the restraining mechanism by release mechanism **34**, whereupon, the brake mechanism quickly engages at least a portion of the operative structure to bring the cutting tool to a stop.

It will be appreciated by those of skill in the art that the exemplary embodiment depicted in FIG. **1** and described above may be implemented in a variety of ways depending on the type and configuration of operative structure **12**. Turning attention to FIG. **2**, one example of the many possible implementations of safety system **18** is shown. System **18** is configured to engage an operative structure having a cutting tool in the form of a circular blade **40** mounted on a rotating shaft or arbor **42**. Blade **40** includes a plurality of cutting teeth (not shown) disposed around the outer edge of the blade. As described in more detail below, braking mechanism **28** is adapted to engage the teeth of blade **40** and stop the rotation of the blade. U.S. Provisional Patent Application Ser. No. 60/225,210, entitled "Translation Stop For Use In Power

Equipment," filed Aug. 14, 2000 by SD3, LLC, the disclosure of which is herein incorporated by reference, describes other systems for stopping the movement of the cutting tool. U.S. Provisional Patent Application Ser. No. 60/225,058, entitled "Table Saw With Improved Safety System," filed Aug. 14, 2000 by SD3, LLC, and U.S. Provisional Patent Application Ser. No. 60/225,057, entitled "Miter Saw With Improved Safety System," filed Aug. 14, 2000 by SD3, LLC, the disclosures of which are herein incorporated by reference, describe safety system **18** in the context of particular types of machines **10**.

In the exemplary implementation, detection subsystem **22** is adapted to detect the dangerous condition of the user coming into contact with blade **40**. The detection subsystem includes a sensor assembly, such as contact detection plates **44** and **46**, capacitively coupled to blade **40** to detect any contact between the user's body and the blade. Typically, the blade, or some larger portion of cutting tool **14** is electrically isolated from the remainder of machine **10**. Alternatively, detection subsystem **22** may include a different sensor assembly configured to detect contact in other ways, such as optically, resistively, etc. In any event, the detection subsystem is adapted to transmit a signal to control subsystem **26** when contact between the user and the blade is detected. Various exemplary embodiments and implementations of detection subsystem **22** are described in more detail in U.S. Provisional Patent Application Ser. No. 60/225,200, entitled "Contact Detection System For Power Equipment," filed Aug. 14, 2000 by SD3, LLC, and U.S. Provisional Patent Application Ser. No. 60/225,211, entitled "Apparatus And Method For Detecting Dangerous Conditions In Power Equipment," filed Aug. 14, 2000 by SD3, LLC, the disclosures of which are herein incorporated by reference.

Control subsystem **26** includes one or more instruments **48** that are operable by a user to control the motion of blade **40**. Instruments **48** may include start/stop switches, speed controls, direction controls, etc. Control subsystem **26** also includes a logic controller **50** connected to receive the user's inputs via instruments **48**. Logic controller **50** is also connected to receive a contact detection signal from detection subsystem **22**. Further, the logic controller may be configured to receive inputs from other sources (not shown) such as blade motion sensors, workpiece sensors, etc. In any event, the logic controller is configured to control operative structure **12** in response to the user's inputs through instruments **48**. However, upon receipt of a contact detection signal from detection subsystem **22**, the logic controller overrides the control inputs from the user and activates reaction subsystem **24** to stop the motion of the blade. Various exemplary embodiments and implementations of logic controller **50** will be described below. Various exemplary embodiments and implementations of a blade motion detection system are described in U.S. Provisional Patent Application Ser. No. 60/225,094, entitled "Motion Detecting System For Use In Safety System For Power Equipment," filed Aug. 14, 2000 by SD3, LLC, the disclosure of which is herein incorporated by reference.

In the exemplary implementation, brake mechanism **28** includes a pawl **60** mounted adjacent the edge of blade **40** and selectively moveable to engage and grip the teeth of the blade. Pawl **60** may be constructed of any suitable material adapted to engage and stop the blade. As one example, the pawl may be constructed of a relatively high strength thermoplastic material such as polycarbonate, ultrahigh molecular weight polyethylene (UHMW) or Acrylonitrile Butadiene Styrene (ABS), etc., or a metal such as aluminum, etc. It will be appreciated that the construction of pawl **60** will vary depending on the configuration of blade **40**. In any event, the pawl is urged into the blade by a biasing mechanism in the form of a spring **66**. In the illustrative embodiment shown in FIG. **2**, pawl **60** is pivoted into the teeth of blade **40**. It should be understood that sliding or rotary movement of pawl **60** may also be used. The spring is adapted to urge pawl **60** into the teeth of the blade with sufficient force to grip the blade and quickly bring it to a stop.

The pawl is held away from the edge of the blade by a restraining mechanism in the form of a fusible member **70**. The fusible member is constructed of a suitable material adapted to restrain the pawl against the bias of spring **66**, and also adapted to melt under a determined electrical current density. Examples of suitable materials for fusible member **70** include NiChrome wire, stainless steel wire, etc. The fusible member is connected between the pawl and a contact mount **72**. Preferably, fusible member **70** holds the pawl relatively close to the edge of the blade to reduce the distance the pawl must travel to engage the blade. Positioning the pawl relatively close to the edge of the blade reduces the time required for the pawl to engage and stop the blade. Typically, the pawl is held approximately 1/32-inch to 1/4-inch from the edge of the blade by fusible member **70**, however other pawl-to-blade spacings may also be used within the scope of the invention.

Pawl **60** is released from its unactuated, or cocked, position to engage blade **40** by a release mechanism in the form of a firing subsystem **76**. The firing subsystem is coupled to contact mount **72**, and is configured to melt fusible member **70** by passing a surge of electrical current through the fusible member. Firing subsystem **76** is coupled to logic controller **50** and activated by a signal from the logic controller. When the logic controller receives a contact detection signal from detection subsystem **22**, the logic controller sends an activation signal to firing subsystem **76**, which melts fusible member **70**, thereby releasing the pawl to stop the blade. Various exemplary embodiments and implementations of reaction subsystem **24** are described in more detail in U.S. Provisional Patent Application Ser. No. 60/225,056, entitled "Firing Subsystem For Use In Fast Acting Safety System," filed Aug. 14, 2000 by SD3, LLC, U.S. Provisional Patent Application Ser. No. 60/225,170, entitled "Spring-Biased Brake Mechanism for Power Equipment," filed Aug. 14, 2000 by SD3, LLC, and U.S. Provisional Patent Application Ser. No. 60/225,169, entitled "Brake Mechanism For Power Equipment," filed Aug. 14, 2000 by SD3, LLC, the disclosures of which are herein incorporated by reference.

It will be appreciated that activation of the brake mechanism will require the replacement of one or more portions of safety system **18**. For example, pawl **60** and fusible member **70** typically must be replaced before the safety system is ready to be used again. Thus, it may be desirable to construct one or more portions of safety system **18** in a cartridge that can be easily replaced. For example, in the exemplary implementation depicted in FIG. **2**, safety system **18** includes a replaceable cartridge **80** having a housing **82**. Pawl **60**, spring **66**, fusible member **70** and contact mount **72** are all mounted within housing **82**. Alternatively, other portions of safety system **18** may be mounted within the housing. In any event, after the reaction system has been activated, the safety system can be reset by replacing cartridge **80**. The portions of safety system **18** not mounted within the cartridge may be replaced separately or reused as appropriate. Various exemplary embodiments and implementations of a safety system using a replaceable cartridge are described in more detail in U.S. Provisional Patent Application Ser. No. 60/225,201, entitled "Replaceable Brake Mechanism For Power Equipment," filed Aug. 14, 2000 by SD3, LLC, and U.S. Provisional Patent Application Ser. No. 60/225,212, entitled "Brake Positioning

System," filed Aug. 14, 2000 by SD3, LLC, the disclosures of which are herein incorporated by reference.

While one particular implementation of safety system **18** has been described, it will be appreciated that many variations and modifications are possible within the scope of the invention. Many such variations and modifications are described in U.S. Provisional Patent Application Ser. Nos. 60/182,866 and 60/157,340, the disclosures of which are herein incorporated by reference.

Considering logic controller **50** now in more detail, it will be appreciated that the logic controller may be configured to perform a variety of functions depending on the particular type of machine **10** and/or the application. For example, logic controller **50** may be configured to conduct various self-test safety checks when the machine is switched on or off and during use, to ensure that detection subsystem **22** is operating properly and to prevent inadvertent triggering of reaction subsystem **24**. Additionally, the logic controller may be configured to control one or more display devices to inform a user of the status of machine **10** and safety system **18**. Furthermore, logic controller **50** may be implemented in a variety of ways including using one or more custom application specific integrated circuits (ASICs), microprocessors, micro-controllers, digital logic circuits, and/or analog circuits, etc.

In one exemplary embodiment, logic controller **50** is configured to perform the self-check logic sequence shown in FIG. **3**. The exemplary sequence begins when the user initially supplies power to the system, indicated at **901**. The logic system first checks to determine whether the spacing between the blade and pawl is correct, as indicated at **902**. The blade-to-pawl spacing may be measured by any suitable mechanism such as described in more detail below. If the spacing is outside acceptable limits, the system responds with an error signal, indicated at **903**. The error signal may be an audible and/or visible signal, etc. In one embodiment described in more detail below, control subsystem includes a user interface adapted to indicate the status of the machine and annunciate any error conditions. Preferably, the logic system remains in the error state and prevents further operation of the machine until the correct blade-to-pawl spacing is detected.

If the blade-to-pawl spacing is acceptable, the logic system determines whether the input signal produced on charge plate **44** by detection subsystem **22** is being detected at a sufficient amplitude on charge plate **46**, as indicated at **904**. This step ensures that the reaction subsystem will not be triggered accidentally upon start-up due to a fault in the detection subsystem, a grounded blade, incorrectly placed charge plates, etc. If the proper input signal is not detected, logic controller **50** responds with an error signal **903**. It will be appreciated that either the same or a different error signal may be produced for each fault condition.

If the proper input signal is detected, the logic controller proceeds to determine whether a fusible member is present, as indicated at step **905**. The presence of a fusible member may be determined by any suitable means such as described in more detail below. If no fusible member is present, logic controller **50** returns an error signal **903**. If a fusible member is detected, the logic controller then checks the electrical charge stored by firing subsystem **76**, as indicated at **906**. This step ensures that sufficient charge is present to melt the fusible member if the dangerous condition is detected. Exemplary circuitry for detecting sufficient charge is described in more detail below. If sufficient charge is not detected within a determined time period, the logic controller responds with an error signal **903**.

In the sequence depicted in FIG. **3**, after the predetermined checks are completed, logic controller **50** allows power to be sent to motor assembly **16**, as indicated at **907**. It will be appreciated that the electrical sequence described above typically is completed within no more than a few seconds if no faults are detected. In addition to an initial power-up sequence, logic controller **50** may be configured to perform any of a variety of checks during operation. For example, the rotation of the blade may be monitored by known mechanisms and the firing system may be disabled when the blade is not moving. This would allow the user to touch the blade when it is stopped without engaging brake mechanism **28**. Various exemplary embodiments and implementations of a blade motion detection system are described in U.S. Provisional Application Ser. No. 60/225,094, entitled "Motion Detection System for Use in Safety System for Power Equipment," filed Aug. 14, 2000, by SD3, LLC.

It will appreciated that many variations on the logic sequence described above may be implemented within the scope of the invention. For example, some embodiments of logic controller **50** may include a battery, a capacitor or other charge storage device to ensure the detection and reaction subsystems will continue to function at least temporarily after power to the machine is turned off. As another example, power to the motor assembly may be shut off if an error occurs other than contact detection such as incorrect blade-to-charge plate spacing, insufficient charge on the charge storage devices, etc. Thus, logic controller **50** may be implemented to provide any of a variety of safety and/or operational functions as desired.

Additionally, since reaction subsystem **24** is configured to stop cutting tool **14** upon contact with a user's body, it may also be desirable to stop motor assembly **16**, or at least the portion of the motor assembly adapted to drive the cutting tool, to prevent damage to the motor as it tries to drive the stalled cutting tool. However, since machine **10** typically is designed with the expectation that the cutting tool may stop due to binding, etc., it will usually be sufficient to turn off the motor assembly within a few seconds. This can be accomplished simply by cutting power to the motor. For example, when machine **10** includes a magnetic contactor switch **48**, the logic controller may be adapted to interrupt the circuit holding the magnetic contactor closed so that power to the motor is interrupted. It should be understood that this step is optional, in that interrupting power to the machine's motor assembly is neither necessary nor sufficient to prevent serious injury to the user when the user touches the machine's cutting tool. Therefore, the principal benefit of this step is to reduce the likelihood of damaging the motor assembly or drive system while the brake system is preventing rotation or other movement of the cutting tool. It will be appreciated that there are many other suitable ways of stopping motor assembly **12** which are within the scope of the invention. As one example, power to the motor assembly may be controlled directly by safety stop **30** (e.g., through solid state on/off switches, etc.). This embodiment is described in more detail in U.S. Provisional Application Ser. No. 60/225,200, entitled "Contact Detection System for Power Equipment," filed Aug. 14, 2000, by SD3, LLC. Also, it is possible to simply allow existing overload circuitry to trip in and turn off the stalled motor.

Since the contact detection subsystem described above relies on certain electrical properties of the human body, the use of safety system **18** while cutting some materials, such as foil-coated insulation, may cause the detection circuitry to falsely register contact with a user. In addition, as described in U.S. Provisional Application Ser. No. 60/225,200, entitled "Contact Detection System for Power Equipment," filed Aug.

14, 2000, by SD3, LLC, extremely green wood may cause false triggers in some types of detection subsystems due to the relatively high dielectric constant of green wood. Therefore, it may be desirable to provide a manual bypass or override control that prevents the brake from operating for a particular cutting operation. A suitable override control may include a mechanical switch between fusible member **70** and firing system **76**. Alternatively, the switch may be a single-use switch configured to reset itself after each use. As a further alternative, safety system **18** may include sensors adjacent the workpiece to detect the presence of foil, green wood, etc., and disable the reaction subsystem automatically. This latter alternative relieves the user of having to remember to disable and re-enable the brake system.

In any event, the override control may be configured in a variety of ways depending on the application and the level of safety desired. For example, the override control may be configured to time-out (i.e., turn off) if the user does not switch the machine on within a predetermined time (e.g., 3, 5 or 10 seconds, etc.). This would prevent the user from actuating the override control and then becoming distracted before proceeding to cut the workpiece and forgetting the safety system had been disabled. In some embodiments, it may be desirable to allow a user to override the error caused by a failed self-test (e.g., no fusible member, insufficient stored charged, missing or incorrectly installed cartridge **80**, etc.). In other embodiments, logic controller **50** may be configured to require that the detection and reaction subsystems are operational before allowing the user to engage the override.

Typically, the override control is configured to reduce the likelihood that it will be actuated accidentally by the user. For example, the override control switch may be located away from the remaining operator switches and away from an area on machine **10** where the user is likely to accidentally bump against while using the machine. Alternatively or additionally, override control switch **48** may include a cover or similar barrier which the user must remove or overcome before the switch can be actuated. Such covered switches are known to those of skill in the art. As an additional safety measure, logic controller **50** may be configured to produce a visual and/or audible alarm or warning when the override is actuated. Furthermore, where logic controller **50** is adapted to control the supply of power to motor assembly **16**, the logic controller may be configured to "pulse" the motor one or more times to alert the user that the blade is about to begin moving with the safety system disabled. This would alert a user, who accidentally actuated the override while in contact with the blade, to quickly move away from the blade.

In view of the above considerations, an alternative embodiment of logic controller **50** may be configured to perform the self-test and detection logic shown schematically in FIGS. **4**A-C. The main logic sequence, indicated generally at **910** in FIG. **4**A, begins when machine **10** is first connected to power source **20**, as indicated at **911**. Logic controller **50** begins sequence **910** by performing a system integrity check, as indicated at **912**. The system integrity check may include any one or more of a variety of checks which typically will vary depending on the particular type and configuration of machine **10**. In the exemplary embodiment, system integrity check **912** includes testing the sufficiency of power source **20** (here, standard line current) by any suitable means which are known to those of skill in the art. The system integrity check may also include driving the detection signal onto charge plate **44** and attempting to detect the signal at charge plate **46**. Failure to detect the detection signal at charge plate **46** may indicate a number of problems such as an electronic failure in detection subsystem **22**, a mis-positioned or grounded charge plate, grounded blade, etc. Exemplary system integrity check **912** also includes a pawl-to-blade spacing test to ensure that pawl **60** is properly positioned adjacent blade **40** so that the pawl will engage and stop the blade if released. Exemplary mechanisms for detecting correct blade-to-pawl spacing are described in more detail below. If any of the tests performed during system integrity check **912** is negative, logic controller **50** turns motor assembly **16** off (if on), as indicated at **913**, and outputs an error signal to the user, as indicated at **914**. Once the user corrects the error and resets the logic controller (e.g., by disconnecting and then reconnecting the power to machine **10**), the system integrity check is repeated.

If system integrity check **912** is successful, logic controller **50** proceeds to check fusible member **70** as well as the stored charge in firing subsystem **76**, as indicated at **915**. If either the fusible member test or the stored charge test is negative, the logic controller turns off the motor assembly, indicated at **913**, and then outputs an error signal, indicated at **914**. It may be desirable to repeat step **915** one or more times, or provide a delay between steps **912** and **915** to ensure that firing subsystem **76** has sufficient time to build up the electrical charge.

If both the fusible member and firing subsystem tests are successful, the logic controller then proceeds to one of two operational loops depending on whether the user-operable override switch has been activated, as indicated at **916**. It will be appreciated that testing for a user override signal after performing the fusible member/charge storage test prevents a user from overriding safety system **18** unless the safety system is functional. Thus, for example, if a contact detection occurs and the brake is triggered, the user cannot proceed to operate the system until the fusible member, and/or pawl, and/or firing subsystem, etc., is replaced (typically by replacing cartridge **80**). Alternatively, step **915** may be eliminated from the main operational loop. This would allow machine **10** to be operated regardless of whether safety system **18** was completely functional by engaging the override.

In any event, if the override has been actuated, logic controller **50** proceeds to operate in an override loop, as indicated at **917** and detailed in FIG. **4**B. Typically, logic controller **50** first outputs a warning signal, as indicated at **918** and described above. Next, at step **919**, the logic controller checks the status of START switch **48**, which is operable by a user to turn on motor assembly **16**. As described above, logic controller **50** may be configured to read START switch **48** as being "on" only if it is actuated within a predetermined period after the override is enabled. If the START switch is "off," logic controller **50** turns off the motor assembly (if on), as indicated at **920**, and exits the override loop as indicated at **921**. As shown in FIG. **4**A, the logic controller returns to the system integrity check at the end of the override loop. Thus, the logic controller will continue to perform the system integrity check and the fusible member/stored charge tests until the START switch is actuated. This ensures that if a user engages the override and then delays actuating the START switch, the system will not turn on the motor assembly if a failure occurs between the time the override is enabled and the time the START switch is actuated.

If, at step **919**, the START switch is on, logic controller proceeds to turn on motor assembly **16**, as indicated at **922**. The motor assembly remains on until STOP switch **48** is actuated by the user, as indicated at **923**. Once the STOP switch is actuated, logic controller **50** turns off the motor assembly, as indicated at **920**, and exits the override loop at **921**. As mentioned above, the logic controller returns to step **912** after exiting the override loop.

If, at step **916**, the override has not been engaged by the user, logic controller **50** proceeds to the detection loop **925**, which is shown in detail in FIG. **4**C. In the exemplary embodiment, detection loop **925** is depicted with two logic paths which are executed simultaneously. In a first path **926** the logic controller monitors detection subsystem **22**, while in a second path **927** the logic controller continually rechecks the fusible member and stored charge in firing subsystem **76**. This dual-path operation ensures that machine **10** will be shut down if a failure occurs while the blade is in motion. It will be appreciated by those of skill in the art that the dual-path operation may be implemented in a variety of ways including the use of interrupts, state machines, etc. Alternatively, the two paths may be implemented in a single sequential loop. However, since testing of the stored charge consumes several milliseconds or even several seconds in some embodiments, it is typically desirable, in those embodiments, to execute both paths simultaneously so that several milliseconds or more do not pass between successive contact detection measurements.

Path **927** includes testing fusible member **70** and the charge stored by firing subsystem **76**, as indicated at **928**. This test is continuously repeated unless and until either the fusible member test or the stored charge test fails, at which point logic controller **50** turns the motor assembly off, as indicated at **929**, and outputs an error message, as indicated at **930**. The logic controller also stops executing test **928** when it exits the detection loop or when an error in path **926** occurs, as described below. The tests of fusible member **70** and firing subsystem **76** at step **928** may be the same as, or different than, the tests that are used in the main loop at step **915**. In any event, the logic controller must be reset from step **930**, as described above.

Path **926** is the contact detection path and includes testing for excessive impedance loading on the blade, as indicated at **931**. Step **931** ensures that power will not be supplied to the motor assembly if the capacitive load on the blade is so high that the detection subsystem might not be able to detect a contact between the blade and the user. This might occur for a variety of reasons. For example, if the blade is cutting highly dielectric materials (e.g., green wood), the capacitive load on the blade will increase. This issue is described in more detail in the incorporated references.

As another example, the user might accidentally actuate the START switch while in contact with the blade. Since some exemplary detection subsystems rely on a sudden change (rather than an absolute level) in the signal detected at charge plate **46**, step **931** ensures that the safety system will not allow the blade to begin rotating if the user is touching the blade when the START switch is actuated. In this embodiment, the logic controller is configured to set the value for excessive capacitive loading at approximately at least that amount of loading caused when a user contacts the blade. However, it will be appreciated that logic controller **50** may be configured to recognize any desired amount of capacitive loading as being excessive.

If the capacitive load on the blade is too high, logic controller **50** outputs an error signal, at **932**, and turns off motor assembly **16** (if on), as indicated at step **933**. The logic controller then exits the detection loop, at **934**, and returns to system integrity check **912** in the main operational loop shown in FIG. **4**A. It will be appreciated that safety system **18** will not be enabled during the several seconds it takes the blade to spin down. This is because the capacitive loading is too high to accurately detect contact with the user, and is likely to trigger even though no contact has occurred. In alternative embodiments, the logic controller may continue to monitor for contact detection while the blade is rotating and actuate the firing system if contact is detected. Alternatively, the logic controller may be configured to actuate the firing system if the loading becomes too high.

Once the logic controller returns to the main loop after detecting a high capacitive loading error, the user may nevertheless operate machine **10** by engaging the override. If the user does not actuate the override, safety system **18** will not supply power to motor assembly **16** until the capacitive loading problem is corrected.

If, at step **931**, the capacitive loading on the blade is within defined limits, the logic controller proceeds to test the contact detection signal from detection subsystem **22**, as indicated at **935**. If contact is detected, the logic controller determines whether the blade is rotating, as indicated at **936**. If the blade is rotating, the logic controller actuates the firing subsystem, at **937**, turns off motor assembly **16**, at **929**, and outputs an error, at **930**. The logic controller must then be reset as described above.

However, if the blade is not rotating at step **936**, then the logic controller outputs an error signal, at step **932**, turns off the motor assembly (if on), at **933**, and exits the detection loop, at **934**. Thus, if a user touches the blade when it is not rotating, the safety system will detect the contact but will not actuate the firing subsystem. This allows a user to change or adjust the blade without actuating the brake. However, the user would typically remove power from machine **10** before adjusting or replacing the blade, in which case, neither safety system **18** nor motor assembly **16** would be operable.

If no contact is detected at step **935**, logic controller **50** checks the status of STOP switch **48**, as indicated at **938**. If the STOP switch is actuated, the logic controller turns off the motor assembly (if on), as indicated at **939**, and checks for blade rotation, as indicated at **940**. If the blade is rotating, the logic controller loops back to step **931** so that the contact detection is active as long as the blade continues to rotate. Thus, if a user actuates the STOP switch and then contacts the blade before it spins down, safety system **18** will react to stop the blade. Once the blade ceases to rotate, the logic controller exits the detection loop, as indicated at **934**.

If the STOP switch has not been actuated at step **938**, the logic controller checks the status of START switch **48**, as indicated at **941**. If the START switch has been actuated, the logic controller turns the motor assembly on (if off), and loops back to repeat the contact detection, as indicated at **942**. If the START switch has not been actuated, the logic controller turns off the motor assembly (if on), as indicated at **939**, and checks for blade rotation, at **940**. The logic controller continues to execute the detection loop until the blade stops, at which point the logic controller exits the detection loop, as indicated at **934**. Thus, the logic controller is configured to continuously monitor for contact detection whenever the blade is rotating and the user has not engaged the override.

Those of skill in the art will appreciate that control subsystem **26** and logic controller **50** may be implemented using many different components and many different configurations. Therefore, while two exemplary implementations are described below, it should be understood that any other suitable implementation may be used.

A first exemplary implementation is illustrated schematically in FIG. **5**. Logic controller **50** takes the form of a PIC16C63A-20/SO controller available from Microchip Technology, Inc., of Chandler, Ariz. The logic controller is coupled to power source **20**, contact detection subsystem **22**, and a user interface **178**. The user interface may include any suitable mechanism adapted to display signals to a user and to allow a user to input signals to the logic controller. Examples of suitable user interface mechanisms which are known to

those of skill in the art include lights, display screens, buzzers, sirens, switches, buttons, knobs, etc. In one exemplary embodiment depicted in FIG. **6**, user interface **178** includes START, STOP, and OVERRIDE switches to allow the user to input control commands, and a pair of LED lights which indicate the system status. The LED lights may indicate system status in a variety of ways such as color, blinking, etc.

The logic controller is also connected to control motor assembly **16** via a suitable motor control circuit **174**, such as is described in more detail in U.S. Provisional Application Ser. No. 60/225,200, entitled "Contact Detection System for Power Equipment," filed Aug. 14, 2000, by SD3, LLC, and to firing subsystem **76**. When the logic controller receives a signal from detection subsystem **22** that contact between the user and blade has occurred, the logic controller actuates firing subsystem **76** and stops motor assembly **16**. The operation and testing sequences are implemented by software instructions stored within, and executable by, the logic controller. It will be appreciated that the software instructions may take a variety of forms.

The logic controller of the exemplary implementation depicted in FIG. **5** is configured to conduct a variety of self-tests before enabling power to motor control **174**, as well as whenever the blade is moving. For example, the logic controller is configured to evaluate the line voltage supplied by power source **20**, and to shut off the motor if the voltage drops below a minimum value sufficient to operate the safety system. The logic controller is also adapted to test the contact sense signal received from the detection subsystem to ensure the charge plates are correctly positioned, that the detection signal is properly coupled across the blade, and that the capacitive load on the blade is within defined limits. Further, the logic controller is also coupled to a blade rotation sense component **177**. Examples of suitable mechanisms for detecting blade rotation are described in U.S. Provisional Application Ser. No. 60/225,094, entitled "Motion Detection System for Use in Safety System for Power Equipment," filed Aug. 14, 2000, by SD3, LLC.

In addition, logic controller **50** is also adapted to detect whether firing subsystem **76** has sufficient stored charge to melt fusible member **70**. It will be appreciated that detection of sufficient stored charge in the firing subsystem may be carried out in a variety of ways depending on the configuration of the firing system. In each of the exemplary implementations described herein, firing subsystem **76** includes a single 390 μF firing capacitor **620** configured to discharge through fusible member **70** via a suitable SCR **621** connected to ground. Exemplary firing subsystems **76** are described in greater detail in U.S. Provisional Application Ser. No. 60/225,056, entitled "Firing Subsystem for Use in a Fast-Acting Safety System," filed Aug. 14, 2000, by SD3, LLC.

In the implementation depicted in FIG. **5**, the firing capacitor is both charged and tested by a buck-boost regulator **175**, which is shown in greater detail in FIG. **7**. Buck-boost regulator **175** includes a buck-boost charger **183** that steps up an 32-volt supply input to 180 volts for charging the firing capacitor. Logic controller **50** provides a 125 khz input to control the buck-boost cycle of the charger. A regulator circuit **184** monitors the voltage on the firing capacitor and turns charger **183** on or off as necessary to maintain the charge near 180 volts. Regulator circuit **184** is constructed with a predetermined amount of hysteresis so that the charger will go on when the firing circuit voltage falls below 175 volts and turn off when the voltage reaches 180 volts, as set by the voltage divider inputs and feedback to comparator **185**.

The output of comparator **185** is fed to logic controller **50**. The logic controller monitors both the time required to charge and to discharge the firing capacitor based on the state of the output of comparator **185**. Thus, the controller can verify that the firing capacitor is operating properly and storing adequate charge. If the firing capacitor cannot reach 180 volts quickly enough or discharges too rapidly, the logic controller determines that the firing capacitor or charging system has failed and takes appropriate action based on its programming.

It should be noted that regulator circuit **184** measures the voltage across the firing capacitor through fusible member **70**. As a result, the regulator circuit is also testing the integrity of the fusible member since a missing or failed fusible member would prevent the regulator circuit from detecting the voltage on the firing capacitor. While testing both the firing capacitor charge and fusible member with a single mechanism or test provides obvious savings of both processor cycle time and component costs, the fusible member may alternatively be tested separately from the firing capacitor charge.

A second exemplary implementation of logic controller **50** is illustrated schematically in FIG. **8**. Logic controller **50** is implemented by a 87C752 controller available from Philips Semiconductor of Sunnyvale, Calif. As in the first exemplary implementation described above, the logic controller of the second implementation is coupled to power source **20**, contact detection subsystem **22**, firing subsystem **76**, user interface **178**, motor control **174**, and blade rotation sense **177**. Suitable examples of power source **20**, contact detection subsystem **22**, and motor control **174** are described in more detail in U.S. Provisional Application Ser. No. 60/225,200, entitled "Contact Detection System for Power Equipment," filed Aug. 14, 2000, by SD3, LLC. Exemplary firing subsystems **76** are described in more detail in U.S. Provisional Application Ser. No. 60/225,056, entitled "Firing Subsystem for Use in a Fast-Acting Safety System," filed Aug. 14, 2000, by SD3, LLC. Exemplary circuitry and mechanisms for sensing blade rotations are described in more detail in U.S. Provisional Application Ser. No. 60/225,094, entitled "Motion Detection System for Use in Safety System for Power Equipment," filed Aug. 14, 2000, by SD3, LLC.

As shown in FIG. **9**, the firing capacitor charging circuit for the second implementation is regulated by an enable line from logic controller **50**. By deactivating the charging circuit, the logic controller can monitor the capacitor voltage through an output to an analog-to-digital converter (A/D) line on the logic controller. When the capacitor is not being charged, it will normally discharge at a relatively known rate through the various paths to ground. By monitoring the discharge rate, the controller can insure that the capacitance of the capacitor is sufficient to burn the fusible member. Optionally, the logic controller may be configured to measure the voltage on the firing capacitor at a plurality of discharge intervals to evaluate the integrity of the capacitor. In one embodiment, the logic controller measures the capacitor voltage at three defined intervals during a discharge cycle, which should correspond to 3%, 5% and 7% of the full charge voltage. The logic controller may be configured to interpret a low voltage at any of the discharge intervals as a failure, or may require a low voltage at two or more discharge intervals to indicate a failure.

As with the first exemplary implementation described above, the logic controller is configured to test the firing capacitor through fusible member **70**, thereby simultaneously testing the fusible member. Alternatively or additionally, the logic controller may test the fusible member independently of the capacitor by monitoring the capacitor voltage during charging.

As mentioned above, logic controller **50** may also be configured to monitor the pawl-to-blade spacing. It is well known in the art that many cutting tools such as saw blades do not

have precisely uniform dimensions. As a result, when a new blade is installed on a saw, the pawl may no longer be correctly spaced from the blade. An incorrectly positioned pawl may slow the stopping speed of the pawl or prevent the pawl from stopping the blade. Therefore, to ensure the blade is stopped with uniform braking speed, it may be necessary to adjust the position of the pawl whenever a blade is replaced. Exemplary mechanisms and methods for automatically positioning the pawl are described in U.S. Provisional Application Ser. No. 60/225,212 entitled "Brake Positioning System," filed Aug. 14, 2000, by SD3, LLC. However, regardless of whether the pawl is automatically positioned, configuring logic controller **50** to detect incorrect blade-to-pawl spacing provides an additional level of assurance that a user is protected against accidental contact with the blade.

It will be appreciated that there are many ways in which incorrect spacing between blade **40** and pawl **60** may be detected. As one example, FIG. **10** illustrates a pawl **945** having a capacitive system for detecting correct pawl spacing. Similar to pawl **40** shown in FIG. **2**, pawl **945** may include a portion **946** that is beveled or otherwise shaped to quickly and completely engage the teeth of a cutting tool. In addition, pawl **945** includes a pair of generally parallel, spaced-apart arms **947** which extend beyond portion **946**. Arms **947** are disposed to extend on either side of the blade, without touching the blade, when the pawl is in place adjacent the blade. Each arm includes a capacitor plate **826** disposed on the inside surface of the arm adjacent the blade. Conductive leads **949** run from each capacitor plate **826** to suitable blade detector circuitry (not shown).

Capacitor plates **826** are positioned on arms **947** such that, when the pawl spacing is within a desired range, the blade extends between the two capacitor plates. It will be appreciated that the capacitance across plates **826** will vary depending on whether the blade is positioned between the plates. The blade detector circuitry is configured to drive an electrical signal through conductive leads **949** and detect changes in the capacitance across the plates.

Suitable circuitry that may be used with pawl **945** is well known to those of skill in the art. One exemplary pawl-to-blade spacing detection circuit is indicated generally at **824** in FIG. **11**. As described above and in U.S. Provisional Application Ser. No. 60/225,200, entitled "Contact Detection System for Power Equipment," filed Aug. 14, 2000, by SD3, LLC, and U.S. Provisional Application Ser. No. 60/225,211, entitled "Apparatus and Method for Detecting Dangerous Conditions in Power Equipment," filed Aug. 14, 2000, by SD3, LLC, one exemplary contact detection system suitable for use with the present invention applies an electrical signal to the blade via a drive plate (not shown). This signal can be picked up by either or both of plates **826** and monitored to insure that it has an amplitude in a predetermined range. In particular, the amplitude detected by plates **826** will fall off rapidly with distance from the blade. Therefore, by monitoring the detected amplitude, proper spacing can be verified. If the proper signal is not detected, circuit **824** conveys an error signal to logic controller **50**, which prevents operation of machine **10** until proper pawl-to-blade spacing is detected. Other examples include circuits similar to the exemplary contact detection circuits described in U.S. Provisional Application Ser. No. 60/225,200, entitled "Contact Detection System for Power Equipment," filed Aug. 14, 2000, by SD3, LLC.

Capacitor plates **826** can optionally be shaped to detect when the pawl is too close to the blade as well as not close enough. Alternatively, two pairs of capacitor plates may be positioned on the pawl: one pair to detect if the pawl is too close to the blade, and the other pair to detect if the pawl is too far from the blade. In any event, the detector circuitry is configured to transmit an error signal to logic controller **50**, which then takes appropriate action.

While one exemplary automatic pawl spacing detection system has been described above, it will be appreciated that there are many possible variations within the scope of the invention. For example, both capacitor plates may be positioned on the same side of the blade rather than on opposite sides. The capacitor plates and/or blade detection circuitry may be separate from the pawl. In the latter case, for example, the capacitor plates and detection circuitry may be mounted on a separate electronics board associated with the pawl. Alternatively, the capacitor plates may be replaced with one or more light-emitting diodes and detectors such that, when the pawl is properly positioned, the blade obstructs the optical path between the diodes and detectors. Other methods of detecting the proximity of the blade to the pawl are also possible. As a further option, capacitor plates **826** may function as charge plates **44**, **46** as well as pawl-spacing detectors. In addition, a detection plate may be mounted on beveled face **946** of the pawl. This plate can be used to detect the drive input signal used for contact detection. The amplitude of the signal detected at the plate will be inversely proportional to the space between the plate and the teeth of the blade. If this signal does not have an amplitude over a given threshold, the system would interpret this as indicating that the pawl face is not close enough to the blade.

In embodiments where portions of safety system **18** are mounted in a replaceable cartridge **80**, logic controller **50** may also be configured to detect whether the cartridge is properly connected to the remainder of the safety system. One exemplary method of testing for an operable connection with the cartridge is by testing a component mounted in the cartridge (e.g., the fusible link, charge stored by firing system, etc.). Alternatively, a cable (not shown) connecting cartridge **80** to logic controller **50** may include a separate signal line which is grounded or otherwise biased when the cartridge is connected. In addition to detecting an operable connection to the cartridge, the correct blade-to-pawl spacing may be detected by measuring the blade-to-cartridge spacing. For example, capacitor plates **826** may be placed on cartridge housing **82** rather than on the pawl itself. Furthermore, failure of the blade-to-cartridge spacing test could also be used to detect an inoperable connection to the cartridge.

As described above, the present invention provides a reliable, effective and fast-acting system for preventing serious injuries to operators of power cutting machinery. While a few specific embodiments of safety system **18** and particularly control subsystem **26** have been described, those of skill in the art will appreciate that the present invention may be adapted in numerous ways for use in a wide variety of applications. Therefore, it will be understood that all such adaptations and applications are within the scope of the invention.

It is believed that the disclosure set forth above encompasses multiple distinct inventions with independent utility. While each of these inventions has been disclosed in its preferred form, the specific embodiments thereof as disclosed and illustrated herein are not to be considered in a limiting sense as numerous variations are possible. The subject matter of the inventions includes all novel and non-obvious combinations and subcombinations of the various elements, features, functions and/or properties disclosed herein. No single feature, function, element or property of the disclosed embodiments is essential to all of the disclosed inventions. Similarly, where the claims recite "a" or "a first" element or the equivalent thereof, such claims should be understood to include incorporation of one or more such elements, neither requiring nor excluding two or more such elements.

It is believed that the following claims particularly point out certain combinations and subcombinations that are directed to one of the disclosed inventions and are novel and

non-obvious. Inventions embodied in other combinations and subcombinations of features, functions, elements and/or properties may be claimed through amendment of the present claims or presentation of new claims in this or a related application. Such amended or new claims, whether they are directed to a different invention or directed to the same invention, whether different, broader, narrower or equal in scope to the original claims, are also regarded as included within the subject matter of the inventions of the present disclosure.

The invention claimed is:

1. A woodworking machine comprising:
- a cutting tool for cutting workpieces;
- a motor configured to drive the cutting tool;
- a detection system configured to detect a dangerous condition between a person and the cutting tool;
- a reaction system controllable to disable the cutting tool if the dangerous condition is detected; and
- a control system configured to determine the operability of the reaction system without having to operate the reaction system and to disable the motor if the reaction system is inoperable.

2. The machine of claim **1**, where the reaction system includes a capacitor adapted to store electrical charge and to trigger the disabling of the cutting tool upon discharge of at least part of the electrical charge, and where the control system is configured to determine the capacitance of the capacitor.

3. The machine of claim **1**, where the reaction system includes a capacitor adapted to store electrical charge and to trigger the disabling of the cutting tool upon discharge of at least part of the electrical charge, and where the control system is configured to determine the electrical charge stored on the capacitor.

4. The machine of claim **1**, where the reaction system includes a brake mechanism adjacent to and spaced from the cutting tool, and further comprising a spacing detection system adapted to detect whether the spacing between the cutting tool and a selected portion of the brake mechanism is within a predetermined range, and where the control system is configured to disable the motor if the spacing detected by the spacing detection system is out of the predetermined range.

5. The machine of claim **1**, where the reaction system includes at least one replaceable single-use component, and where the control system is configured to detect whether the single-use component has been used, and if so, to disable the motor until the single-use component has been replaced.

6. The machine of claim **5**, where the reaction system includes a fusible member.

7. The machine of claim **1**, further comprising a user interface controllable by the control system to indicate whether the reaction system is operable.

8. The machine of claim **1**, further comprising a user-actuatable override switch coupled to the control system, and where the control system is configured not to disable the motor if the override switch is actuated.

9. The machine of claim **8**, where the control system is configured to at least temporarily disable the reaction system if the override switch is actuated.

10. The machine of claim **1**, where the reaction system is adapted to be electrically coupled to the control system, and where the control system is configured to disable the motor if the reaction system is not coupled to the control system.

11. The machine of claim **1**, where the reaction system includes a fusible member and where the control system is configured to determine the condition of the fusible member.

12. The machine of claim **1**, where the reaction system is controllable to disable the cutting tool by stopping the cutting tool.

13. The machine of claim **1**, where the reaction system is controllable to disable the cutting tool by retracting the cutting tool.

14. A woodworking machine comprising:
- a cutting tool for cutting workpieces;
- a detection system adapted to detect a dangerous condition between a user and the cutting tool;
- a reaction system adapted to disable the cutting tool when the detection system detects the dangerous condition; and
- a control system adapted to monitor the detection system and control actuation of the reaction system;
- where the control system is adapted to test at least a portion of the reaction system to verify that the portion of the reaction system is operational without having to operate the reaction system.

15. The machine of claim **14**, further including a motor controllable by the control system to drive the cutting tool, and where the control system is adapted to test the portion of the reaction system prior to actuation of the motor, and where the control system is adapted not to actuate the motor unless the portion of the reaction system is operational.

16. The machine of claim **15**, where the control system is adapted to test the portion of the reaction system while the motor is running, and to shut off the motor if the control system determines the portion of the reaction system is not operational while the motor is running.

17. The machine of claim **14**, where the reaction system is adapted to disable the cutting tool by stopping the cutting tool.

18. The machine of claim **14**, where the reaction system is adapted to disable the cutting tool by retracting the cutting tool.

19. A woodworking machine comprising:
- a support structure;
- a cutting tool adapted to move to cut a workpiece, where the cutting tool is supported by the support structure;
- a motor adapted to drive the cutting tool;
- a detection system adapted to detect a dangerous condition between the cutting tool and a person;
- a reaction system adapted to perform a specified action upon detection of the dangerous condition; and
- a self-test system adapted to test the operability of at least a portion of the reaction system without having to perform the specified action and to disable the motor if the tested portion of the reaction system is inoperable.

20. The woodworking machine of claim **19**, where the self-test system tests the operability of the reaction system while the cutting tool is moving.

21. A woodworking machine comprising:
- a cutting tool for cutting workpieces;
- a motor configured to drive the cutting tool;
- detection means for detecting a dangerous condition between a person and the cutting tool;
- reaction means for disabling the cutting tool if the dangerous condition is detected; and
- control means for determining the operability of the reaction means without having to operate the reaction means and for disabling the motor if the reaction means is inoperable.

* * * * *

EXHIBIT C

US007610836B2

(12) **United States Patent**
Gass et al.

(10) **Patent No.: US 7,610,836 B2**
(45) **Date of Patent: Nov. 3, 2009**

(54) **REPLACEABLE BRAKE MECHANISM FOR POWER EQUIPMENT**

(75) Inventors: **Stephen F. Gass**, Wlsonville, OR (US); **David S. D'Ascenzo**, Portland, OR (US); **Andrew L. Johnston**, Redwood City, CA (US); **Joel F. Jensen**, Redwood City, CA (US); **Sung H. Kim**, Palo Alto, CA (US); **Anwyl M. McDonald**, Palo Alto, CA (US)

(73) Assignee: **SD3, LLC**, Tualatin, OR (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 622 days.

(21) Appl. No.: **09/929,236**

(22) Filed: **Aug. 13, 2001**

(65) **Prior Publication Data**

US 2002/0020261 A1 Feb. 21, 2002

Related U.S. Application Data

(60) Provisional application No. 60/225,056, filed on Aug. 14, 2000, provisional application No. 60/225,057, filed on Aug. 14, 2000, provisional application No. 60/225,058, filed on Aug. 14, 2000, provisional application No. 60/225,059, filed on Aug. 14, 2000, provisional application No. 60/225,089, filed on Aug. 14, 2000, provisional application No. 60/225,094, filed on Aug. 14, 2000, provisional application No. 60/225,169, filed on Aug. 14, 2000, provisional application No. 60/225,170, filed on Aug. 14, 2000, provisional application No. 60/225,200, filed on Aug. 14, 2000, provisional application No. 60/225,201, filed on Aug. 14, 2000, provisional application No. 60/225,206, filed on Aug. 14, 2000, provisional application No. 60/225,210, filed on Aug. 14, 2000, provisional application No. 60/225,211, filed on Aug. 14, 2000, provisional application No. 60/225,212, filed on Aug. 14, 2000.

(51) **Int. Cl.**
B23D 45/04 (2006.01)
B27B 3/28 (2006.01)

(52) **U.S. Cl.** **83/58**; 83/62.1; 83/397.1; 83/471.2; 83/471.3; 83/478; 83/490; 83/581

(58) **Field of Classification Search** ..... 83/58, 83/62.1, 490, 471, 477, 471.1, 471.2, 581, 83/DIG. 1, 397.1, 471.3, 478, 666, 72, 67, 83/473, 76.7, 481, 485, 487, 489, 574, 821, 83/823, 827, 526, 76.8, 477.1, 491, 522.12, 83/544, 546, 564, 590, 665, 397; 144/384, 144/391, 927, 154.5, 356, 154, 365, 117.1, 144/118; 337/1, 5, 10, 17, 70, 140, 148, 337/170, 190, 237, 239; 403/2, 28; 335/142; 74/2; 292/290, DIG. 66; 307/116, 142, 131; 192/179 R, 133, 148, 144, 142 R, 138, 137; 30/382, 351; 361/1, 124; 340/530, 590, 340/680

See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

941,726 A 11/1909 Pfalzgraf

(Continued)

FOREIGN PATENT DOCUMENTS

CA 2140991 1/1995

(Continued)

OTHER PUBLICATIONS

Gordon Engineering Corp., Product Catalog, Oct. 1997, pp. cover, 1, 3 and back, Brookfield, Connecticut, US.
Sink Drain Plug Lifter, circa 1974.

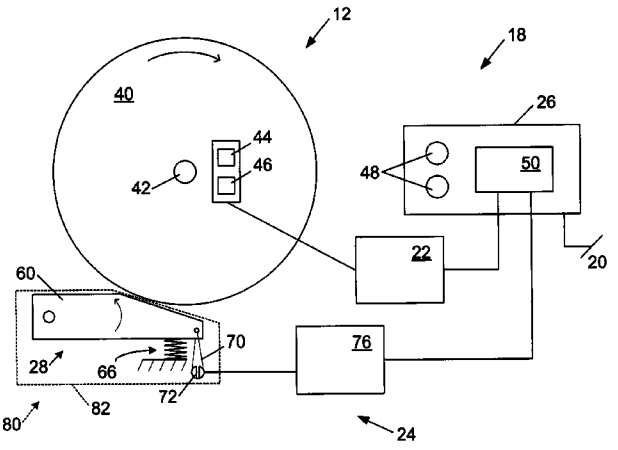
(Continued)

Primary Examiner—Ghassem Alie

(57) **ABSTRACT**

Woodworking machines are disclosed having cutting tools adapted to cut workpieces. The machines include a safety system adapted to detect one or more dangerous conditions between a person and the cutting tool, and to stop movement of the cutting tool upon detection of the dangerous condition. At least part of the safety system is housed in a removable cartridge.

18 Claims, 9 Drawing Sheets



U.S. PATENT DOCUMENTS

982,312	A		1/1911	Swafford			
1,205,246	A		11/1916	Mowry			
RE15,262	E		1/1922	Gurgel			
1,450,906	A		4/1923	Anderson			
1,492,145	A		4/1924	Talley			
1,551,900	A		9/1925	Morrow			
1,582,483	A		4/1926	Runyan			
1,590,988	A		6/1926	Campbell			
1,668,061	A		5/1928	Falkins			
1,807,120	A		5/1931	Lewis			
1,811,066	A		6/1931	Tannewitz			
1,896,924	A		2/1933	Ulrich			
1,902,270	A		3/1933	Tate			
1,910,651	A		5/1933	Tautz			
1,938,548	A		12/1933	Tautz			
1,938,549	A		12/1933	Tautz			
1,963,688	A		6/1934	Tautz			
2,007,887	A		7/1935	Tautz			
2,020,222	A		11/1935	Tautz			
2,038,810	A		4/1936	Tautz			
2,044,481	A		6/1936	Manley et al.			
2,106,288	A		1/1938	Tautz			
2,121,069	A		6/1938	Collins			
2,163,320	A		6/1939	Hammond			
2,241,556	A		5/1941	MacMillin et al.			
2,286,589	A		6/1942	Tannewitz			
2,313,686	A		3/1943	Uremovich			
2,328,244	A		8/1943	Woodward			
2,352,235	A		6/1944	Tautz			
2,377,265	A	*	5/1945	Rady	200/302.1		
2,392,486	A		1/1946	Larsen			
2,402,232	A		6/1946	Baker			
2,425,331	A		8/1947	Kramer			
2,434,174	A		1/1948	Morgan			
2,452,589	A		11/1948	McWhirter et al.			
2,466,325	A		4/1949	Ocenasek			
2,496,613	A		2/1950	Woodward			
2,501,134	A		3/1950	Meckoski et al.			
2,509,813	A	*	5/1950	Dineen	192/101		
2,517,649	A		8/1950	Frechtmann			
2,562,396	A		7/1951	Schutz			
2,572,326	A		10/1951	Evans			
2,593,596	A		4/1952	Olson			
2,601,878	A		7/1952	Anderson			
2,623,555	A		12/1952	Eschenburg			
2,661,780	A		12/1953	Morgan			
2,675,707	A	*	4/1954	Brown	74/2		
2,690,084	A		9/1954	Van Dam			
2,719,547	A		10/1955	Gjerde			
2,722,246	A		11/1955	Arnoldy			
2,731,049	A		1/1956	Akin			
2,736,348	A		2/1956	Nelson			
2,737,213	A		3/1956	Richards et al.			
2,785,710	A		3/1957	Mowery, Jr.			
2,786,496	A		3/1957	Eschenburg			
2,804,890	A		9/1957	Fink			
2,839,943	A		6/1958	Caldwell et al.			
2,844,173	A		7/1958	Gaskell			
2,852,047	A		9/1958	Odlum et al.			
2,876,809	A		3/1959	Rentsch et al.			
2,883,486	A		4/1959	Mason			
2,913,581	A		11/1959	Simonton et al.			
2,937,672	A		5/1960	Gjerde			
2,954,118	A		9/1960	Anderson			
2,957,166	A		10/1960	Gluck			
2,978,084	A		4/1961	Vilkaitis			
2,984,268	A		5/1961	Vuichard			
2,991,593	A		7/1961	Cohen			
3,005,477	A		10/1961	Sherwen			
3,007,501	A		11/1961	Mundell et al.			
3,011,610	A		12/1961	Stiebel et al.			
3,035,995	A		5/1962	Seeley et al			
3,047,116	A		7/1962	Stiebel et al.			
3,129,731	A		4/1964	Tyrrell			
3,163,732	A	*	12/1964	Abbott et al.	337/128		
3,184,001	A		5/1965	Reinsch et al.			
3,186,256	A		6/1965	Reznick			
3,207,273	A	*	9/1965	Jurin	49/7		
3,213,731	A		10/1965	Renard			
3,224,474	A		12/1965	Bloom			
3,246,205	A		4/1966	Miller			
3,274,876	A		9/1966	Debus			
3,276,497	A		10/1966	Heer			
3,313,185	A		4/1967	Drake et al			
3,323,814	A	*	6/1967	Phillips	403/11		
3,337,008	A		8/1967	Trachte			
3,368,596	A		2/1968	Comer			
3,386,322	A		6/1968	Stone et al.			
3,439,183	A		4/1969	Hurst, Jr			
3,445,835	A		5/1969	Fudaley			
3,454,286	A		7/1969	Anderson et al.			
3,456,696	A		7/1969	Gregory et al.			
3,512,440	A		5/1970	Frydmann			
3,540,338	A		11/1970	McEwan et al.			
3,554,067	A		1/1971	Scutella			
3,566,934	A		3/1971	Thrasher			
3,566,996	A		3/1971	Crossman			
3,580,376	A		5/1971	Loshbough			
3,581,784	A		6/1971	Warrick			
3,593,266	A		7/1971	Van Sickle			
3,613,748	A		10/1971	De Pue			
3,621,894	A		11/1971	Niksich			
3,648,126	A		3/1972	Boos et al.			
3,675,444	A	*	7/1972	Whipple	464/160		
3,680,609	A		8/1972	Menge			
3,688,815	A		9/1972	Ridenour			
3,695,116	A		10/1972	Baur			
3,696,844	A		10/1972	Bernatschek			
3,716,113	A		2/1973	Kobayashi et al.			
3,719,103	A		3/1973	Streander			
3,740,000	A		6/1973	Takada			
3,745,546	A		7/1973	Struger et al.			
3,749,933	A		7/1973	Davidson			
3,772,590	A		11/1973	Mikulecky et al.			
3,785,230	A		1/1974	Lokey			
3,793,915	A		2/1974	Hujer			
3,829,850	A		8/1974	Guetersloh			
3,829,970	A		8/1974	Anderson			
3,858,095	A		12/1974	Friemann et al.			
3,861,016	A		1/1975	Johnson et al.			
3,863,208	A		1/1975	Balban			
3,874,747	A		4/1975	Case et al.			
3,882,744	A		5/1975	McCarroll			
3,886,413	A		5/1975	Dow et al.			
3,905,263	A		9/1975	Smith			
3,922,785	A		12/1975	Fushiya			
3,924,688	A		12/1975	Cooper et al.			
3,931,727	A		1/1976	Luenser			
3,935,777	A		2/1976	Bassett			
3,945,286	A		3/1976	Smith			
3,946,631	A		3/1976	Malm			
3,947,734	A		3/1976	Fyler			
3,953,770	A		4/1976	Hayashi			
3,960,310	A		6/1976	Nussbaum			
3,967,161	A		6/1976	Lichtblau			
3,970,178	A		7/1976	Densow			
3,974,565	A		8/1976	Ellis			
3,975,600	A		8/1976	Marston			
3,978,624	A		9/1976	Merkel et al.			
3,994,192	A		11/1976	Faig			
4,007,679	A		2/1977	Edwards			
4,016,490	A		4/1977	Weckenmann et al.			
4,026,177	A		5/1977	Lokey			
4,029,159	A		6/1977	Nymann			

4,047,156	A		9/1977	Atkins			
4,060,160	A		11/1977	Lieber			
4,063,777	A		12/1977	Takada			
4,070,940	A		1/1978	McDaniel et al.			
4,075,961	A		2/1978	Harris			
4,077,161	A		3/1978	Wyle et al.			
4,085,303	A		4/1978	McIntyre et al.			
4,090,345	A		5/1978	Harkness			
4,091,698	A		5/1978	Obear et al.			
4,106,378	A		8/1978	Kaiser			
4,117,752	A		10/1978	Yoneda			
4,138,905	A		2/1979	Konishi			
4,145,940	A		3/1979	Woloveke et al.			
4,152,833	A		5/1979	Phillips			
4,161,649	A		7/1979	Klos et al.			
4,175,452	A		11/1979	Idel			
4,184,394	A		1/1980	Gjerde			
4,190,000	A		2/1980	Shaull et al.			
4,195,722	A		4/1980	Anderson et al.			
4,199,930	A		4/1980	Lebet et al.			
4,200,002	A		4/1980	Takahashi			
4,206,666	A		6/1980	Ashton			
4,206,910	A		6/1980	Biesemeyer			
4,249,117	A		2/1981	Leukhardt et al.			
4,249,442	A		2/1981	Fittery			
4,251,599	A		2/1981	McCormick			
4,255,995	A		3/1981	Connor			
4,262,278	A		4/1981	Howard et al.			
4,267,914	A		5/1981	Saar			
4,270,427	A		6/1981	Colberg et al.			
4,276,459	A		6/1981	Willett et al.			
4,276,799	A		7/1981	Muehling			
4,288,048	A		9/1981	Sieben			
4,291,794	A		9/1981	Bauer			
4,302,879	A		12/1981	Murray			
4,305,442	A		12/1981	Currie			
4,319,146	A		3/1982	Wires, Sr.			
4,321,841	A		3/1982	Felix			
4,334,450	A		6/1982	Benuzzi			
4,370,810	A		2/1983	Schurr et al.			
4,372,202	A		2/1983	Cameron			
4,374,552	A		2/1983	Dayen			
4,385,539	A		5/1983	Meyerhoefer et al.			
4,391,358	A		7/1983	Haeger			
4,427,042	A		1/1984	Mitchell et al.			
4,466,170	A		8/1984	Davis			
4,466,233	A		8/1984	Thesman			
4,470,046	A		9/1984	Betsill			
4,492,291	A		1/1985	Chometon et al.			
4,503,739	A		3/1985	Konieczka			
4,510,489	A		4/1985	Anderson, III et al.			
4,512,224	A		4/1985	Terauchi			
4,518,043	A		5/1985	Anderson et al.			
4,532,501	A		7/1985	Hoffman			
4,532,844	A		8/1985	Chang et al.			
4,559,858	A		12/1985	Laskowski et al.			
4,560,033	A		12/1985	DeWoody et al.			
4,566,512	A		1/1986	Wilson			
4,573,556	A		3/1986	Andreasson			
4,589,047	A		5/1986	Gaus et al.			
4,589,860	A		5/1986	Brandenstein et al.			
4,599,597	A	*	7/1986	Rotbart	337/206		
4,599,927	A		7/1986	Eccardt et al.			
4,606,251	A		8/1986	Boileau			
4,617,544	A		10/1986	Mooz et al.			
4,621,300	A		11/1986	Summerer			
4,625,406	A		12/1986	Fushiya et al.			
4,635,364	A		1/1987	Noll et al.			
4,637,188	A		1/1987	Crothers			
4,637,289	A		1/1987	Ramsden			
4,638,393	A		1/1987	Oishi et al.			
4,653,189	A	*	3/1987	Andreasson	30/382		
4,657,428	A		4/1987	Wiley			
4,661,797	A		4/1987	Schmall			
4,672,500	A		6/1987	Tholome et al.			
4,675,664	A		6/1987	Cloutier et al.			
4,679,719	A		7/1987	Kramer			
4,683,660	A		8/1987	Schurr			
4,694,721	A		9/1987	Brickner, Jr.			
4,718,229	A		1/1988	Riley			
4,721,023	A		1/1988	Bartlett et al.			
4,722,021	A		1/1988	Hornung et al.			
4,751,603	A		6/1988	Kwan			
4,756,220	A		7/1988	Olsen et al.			
4,757,881	A		7/1988	Jonsson et al.			
4,774,866	A		10/1988	Dehari et al.			
4,792,965	A		12/1988	Morgan			
4,805,504	A		2/1989	Fushiya et al.			
4,805,505	A		2/1989	Cantlin			
4,819,501	A		4/1989	Kraus et al.			
4,831,279	A		5/1989	Ingraham			
4,840,135	A		6/1989	Yamauchi			
4,845,476	A		7/1989	Rangeard et al.			
4,864,455	A		9/1989	Shimomura et al.			
4,888,869	A		12/1989	Leatherman			
4,896,607	A		1/1990	Hall et al.			
4,906,962	A		3/1990	Duimstra			
4,907,679	A		3/1990	Menke			
4,934,233	A		6/1990	Brundage et al.			
4,936,876	A		6/1990	Reyes			
4,937,554	A		6/1990	Herman			
4,962,685	A		10/1990	Hagstrom			
4,964,450	A		10/1990	Hughes et al.			
4,965,909	A		10/1990	McCullough et al.			
4,969,063	A		11/1990	Scott et al.			
4,975,798	A		12/1990	Edwards et al.			
5,020,406	A		6/1991	Sasaki et al.			
5,025,175	A		6/1991	Dubois, III			
5,042,348	A		8/1991	Brundage et al.			
5,046,426	A		9/1991	Julien et al.			
5,052,255	A		10/1991	Gaines			
5,067,366	A		11/1991	Gandiglio			
5,074,047	A		12/1991	King			
5,081,406	A		1/1992	Hughes et al.			
5,082,316	A	*	1/1992	Wardlaw	292/201		
5,083,973	A		1/1992	Townsend			
5,086,890	A		2/1992	Turczyn et al.			
5,094,000	A		3/1992	Becht et al.			
5,116,249	A		5/1992	Shiotani et al.			
5,119,555	A		6/1992	Johnson			
5,122,091	A		6/1992	Townsend			
5,123,317	A		6/1992	Barnes, Jr. et al.			
5,125,160	A		6/1992	Gassen			
5,146,714	A		9/1992	Liiber			
5,156,508	A		10/1992	Grisley			
5,184,403	A		2/1993	Schliemann			
5,184,534	A		2/1993	Lee			
5,198,702	A		3/1993	McCullough et al.			
5,199,343	A		4/1993	OBanion			
5,201,110	A		4/1993	Bane			
5,201,684	A		4/1993	DeBois, III			
5,201,863	A		4/1993	Peot			
5,206,625	A		4/1993	Davis			
5,207,253	A		5/1993	Hoshino et al.			
5,212,621	A		5/1993	Panter			
5,218,189	A		6/1993	Hutchison			
5,230,269	A		7/1993	Shiotani et al.			
5,231,359	A		7/1993	Masuda et al.			
5,231,906	A		8/1993	Kogej			
5,239,978	A		8/1993	Plangetis			
5,245,879	A	*	9/1993	McKeon	74/2		
5,257,570	A		11/1993	Shiotani et al.			
5,265,510	A		11/1993	Hoyer-Ellefsen			
5,272,946	A		12/1993	McCullough et al.			
5,276,431	A		1/1994	Piccoli et al.			
5,285,708	A		2/1994	Bosten et al.			

5,293,802 A	3/1994	Shiotani et al.	
5,320,382 A	6/1994	Goldstein et al.	
5,321,230 A	6/1994	Shanklin et al.	
5,331,875 A	7/1994	Mayfield	
5,353,670 A	10/1994	Metzger, Jr.	
5,377,554 A	1/1995	Reulein et al.	
5,377,571 A	1/1995	Josephs	
5,392,568 A	2/1995	Howard, Jr. et al.	
5,392,678 A	2/1995	Sasaki et al.	
5,401,928 A	3/1995	Kelley	
5,411,221 A	5/1995	Collins et al.	
5,423,232 A	6/1995	Miller et al.	
5,436,613 A	7/1995	Ghosh et al.	
5,447,085 A	9/1995	Gochnauer	
5,451,750 A	9/1995	An	
5,453,903 A	9/1995	Chow	
5,471,888 A	12/1995	McCormick	
5,480,009 A	1/1996	Wieland et al.	
5,503,059 A	4/1996	Pacholok	
5,510,587 A	4/1996	Reiter	
5,510,685 A	4/1996	Grasselli	
5,531,147 A	7/1996	Serban	
5,534,836 A	7/1996	Schenkel et al.	
5,592,353 A	1/1997	Shinohara et al.	
5,606,889 A	3/1997	Bielinski et al.	
5,619,896 A	4/1997	Chen	
5,623,860 A	4/1997	Schoene et al.	
5,647,258 A	7/1997	Brazell et al.	
5,648,644 A	7/1997	Nagel	
5,659,454 A	8/1997	Vermesse	
5,667,152 A	9/1997	Mooring	
5,671,633 A	9/1997	Wagner	
5,695,306 A	12/1997	Nygren, Jr.	
5,700,165 A	12/1997	Harris et al.	
5,720,213 A	2/1998	Sberveglieri	
5,722,308 A	3/1998	Ceroll et al.	
5,724,875 A	3/1998	Meredith et al.	
5,730,165 A	3/1998	Philipp	
5,741,048 A	4/1998	Eccleston	
5,755,148 A	5/1998	Stumpf et al.	
5,768,786 A	6/1998	Kane et al.	
5,771,742 A	6/1998	Bokaie et al.	
5,782,001 A	7/1998	Gray	
5,787,779 A	8/1998	Garuglieri	
5,791,057 A	8/1998	Nakamura et al.	
5,791,223 A	8/1998	Lanzer	
5,791,224 A	8/1998	Suzuki et al.	
5,791,441 A	8/1998	Matos et al.	
5,797,307 A	8/1998	Horton	
5,819,619 A	10/1998	Miller et al.	
5,819,625 A	10/1998	Sberveglieri	
5,852,951 A	12/1998	Santi	
5,857,507 A	1/1999	Puzio et al.	
5,861,809 A	1/1999	Eckstein et al.	
5,875,698 A	3/1999	Ceroll et al.	
5,880,954 A	3/1999	Thomson et al.	
5,921,367 A	7/1999	Kashioka et al.	
5,927,857 A	7/1999	Ceroll et al.	
5,930,096 A	7/1999	Kim	
5,937,720 A	8/1999	Itzov	
5,942,975 A	8/1999	Sorensen	
5,943,932 A	8/1999	Sberveglieri	
5,950,514 A	9/1999	Benedict et al.	
5,963,173 A	10/1999	Lian et al.	
5,974,927 A	11/1999	Tsune	
6,009,782 A	1/2000	Tajima et al.	
6,018,284 A	1/2000	Rival et al.	
6,037,729 A	3/2000	Woods et al.	
6,052,884 A	4/2000	Steckler et al.	
6,062,121 A	5/2000	Ceroll et al.	
6,070,484 A	6/2000	Sakamaki	
6,095,092 A	8/2000	Chou	
6,109,157 A	8/2000	Talesky	
6,112,785 A	9/2000	Yu	
6,119,984 A	9/2000	Devine	
6,133,818 A	10/2000	Hsieh et al.	
6,141,192 A	10/2000	Garzon	
6,148,504 A	11/2000	Schmidt et al.	
6,148,526 A	11/2000	Kirn et al.	
6,148,703 A	11/2000	Ceroll et al.	
6,150,826 A	11/2000	Hokodate et al.	
6,161,459 A	12/2000	Ceroll et al.	
6,244,149 B1	6/2001	Ceroll et al.	
6,250,190 B1	6/2001	Ceroll et al.	
6,257,061 B1	7/2001	Nonoyama et al.	
6,283,002 B1	9/2001	Chiang	
6,295,910 B1	10/2001	Childs et al.	
6,312,028 B1	11/2001	Wilkosz	
6,325,195 B1	12/2001	Doherty	
6,330,848 B1	12/2001	Nishio et al.	
6,336,273 B1	1/2002	Nilsson et al.	
6,352,137 B1	3/2002	Stegall et al.	
6,357,328 B1	3/2002	Ceroll et al.	
6,361,092 B1	3/2002	Eagle et al.	
6,366,099 B1	4/2002	Reddi	
6,376,939 B1	4/2002	Suzuki et al.	
6,404,098 B1	6/2002	Kayama et al.	
6,418,829 B1	7/2002	Pilchowski	
6,420,814 B1	7/2002	Bobbio	
6,427,570 B1	8/2002	Miller et al.	
6,430,007 B1	8/2002	Jabbari	
6,431,425 B1	8/2002	Moorman et al.	
6,450,077 B1	9/2002	Ceroll et al.	
6,453,786 B1	9/2002	Ceroll et al.	
6,460,442 B2	10/2002	Talesky et al.	
6,471,106 B1	10/2002	Reining	
6,479,958 B1	11/2002	Thompson et al.	
6,484,614 B1	11/2002	Huang	
D466,913 S	12/2002	Ceroll et al.	
6,492,802 B1	12/2002	Bielski	
D469,354 S	1/2003	Curtsinger	
6,530,303 B1	3/2003	Parks et al.	
6,536,536 B1 *	3/2003	Gass et al.	173/2
6,543,324 B2	4/2003	Dils	
6,546,835 B2	4/2003	Wang	
6,564,909 B1	5/2003	Razzano	
6,575,067 B2	6/2003	Parks et al.	
6,578,856 B2	6/2003	Kahle	
6,581,655 B2	6/2003	Huang	
6,595,096 B2	7/2003	Ceroll et al.	
D478,917 S	8/2003	Ceroll et al.	
6,601,493 B1	8/2003	Crofutt	
6,607,015 B1	8/2003	Chen	
D479,538 S	9/2003	Welsh et al.	
6,617,720 B1	9/2003	Egan, III et al.	
6,619,348 B2	9/2003	Wang	
6,640,683 B2	11/2003	Lee	
6,644,157 B2	11/2003	Huang	
6,647,847 B2	11/2003	Hewitt et al.	
6,659,233 B2	12/2003	DeVlieg	
6,684,750 B2	2/2004	Yu	
6,722,242 B2	4/2004	Chuang	
6,734,581 B1	5/2004	Griffis	
6,736,042 B2	5/2004	Behne et al.	
6,742,430 B2	6/2004	Chen	
6,796,208 B1	9/2004	Jorgensen	
6,800,819 B2	10/2004	Sato et al.	
6,826,988 B2	12/2004	Gass et al.	
6,826,992 B1	12/2004	Huang	
6,840,144 B2	1/2005	Huang	
6,854,371 B2	2/2005	Yu	
6,857,345 B2	2/2005	Gass et al.	
6,874,397 B2	4/2005	Chang	
6,874,399 B2	4/2005	Lee	
6,880,440 B2	4/2005	Gass et al.	
6,889,585 B1	5/2005	Harris et al.	

6,920,814	B2	7/2005	Gass et al.	
6,922,153	B2	7/2005	Pierga et al.	
6,945,148	B2	9/2005	Gass et al.	
6,945,149	B2	9/2005	Gass et al.	
6,957,601	B2	10/2005	Gass et al.	
6,968,767	B2	11/2005	Yu	
6,986,370	B1	1/2006	Schoene et al.	
6,994,004	B2	2/2006	Gass et al.	
6,997,090	B2	2/2006	Gass et al.	
7,000,514	B2	2/2006	Gass et al.	
7,024,975	B2	4/2006	Gass et al.	
7,098,800	B2	8/2006	Gass	
7,137,326	B2	11/2006	Gass et al.	
7,171,879	B2	2/2007	Gass et al.	
7,197,969	B2	4/2007	Gass et al.	
7,210,383	B2	5/2007	Gass et al	
7,225,712	B2	6/2007	Gass et al.	
7,228,772	B2	6/2007	Gass	
7,231,856	B2	6/2007	Gass et al.	
2001/0032534	A1	10/2001	Cerroll et al.	
2002/0020262	A1*	2/2002	Gass et al.	83/58
2002/0020263	A1*	2/2002	Gass et al.	83/58
2002/0043776	A1	4/2002	Chuang	
2002/0050201	A1	5/2002	Lane et al.	
2002/0050714	A1	5/2002	Imai et al.	
2002/0096591	A1	7/2002	Tanji	
2002/0109036	A1	8/2002	Denen et al.	
2002/0170400	A1*	11/2002	Gass	83/62.1
2003/0000359	A1	1/2003	Eccardt et al.	
2003/0037651	A1*	2/2003	Gass et al.	83/62.1
2003/0037655	A1	2/2003	Chin-Chin	
2003/0074873	A1	4/2003	Freiberg et al.	
2003/0089212	A1	5/2003	Parks et al.	
2003/0109798	A1	6/2003	Kermani	
2004/0011177	A1	1/2004	Huang	
2004/0060404	A1	4/2004	Metzger, Jr.	
2004/0103544	A1	6/2004	Hartmann	
2004/0104085	A1	6/2004	Lang et al.	
2004/0118261	A1	6/2004	Garcia et al.	
2004/0159198	A1	8/2004	Peot et al.	
2004/0194594	A1	10/2004	Dils et al.	
2004/0200329	A1	10/2004	Sako	
2004/0226424	A1	11/2004	O'Banion et al.	
2004/0226800	A1	11/2004	Pierga et al.	
2004/0255745	A1	12/2004	Peot et al.	
2005/0057206	A1	3/2005	Uneyama	
2005/0087049	A1	4/2005	Miller	
2005/0092149	A1	5/2005	Hartmann	
2005/0139051	A1	6/2005	Gass et al.	
2005/0139056	A1	6/2005	Gass et al.	
2005/0139057	A1	6/2005	Gass et al.	
2005/0139058	A1	6/2005	Gass et al.	
2005/0139459	A1	6/2005	Gass et al.	
2005/0145080	A1	7/2005	Voigtlaender	
2005/0155473	A1	7/2005	Gass	
2005/0166736	A1	8/2005	Gass et al.	
2005/0178259	A1	8/2005	Gass et al.	
2005/0204885	A1	9/2005	Gass et al.	
2005/0211034	A1	9/2005	Sasaki et al.	
2005/0235793	A1	10/2005	O'Banion et al.	
2005/0268767	A1	12/2005	Pierga et al.	
2005/0274432	A1	12/2005	Gass et al.	
2006/0000337	A1	1/2006	Gass	
2006/0032352	A1	2/2006	Gass et al.	
2006/0123960	A1	6/2006	Gass et al.	
2006/0123964	A1	6/2006	Gass et al.	
2006/0179983	A1	8/2006	Gass et al.	
2006/0219076	A1	10/2006	Gass et al.	
2006/0225551	A1	10/2006	Gass	
2006/0230896	A1	10/2006	Gass	
2006/0247795	A1	11/2006	Gass et al.	
2006/0254401	A1	11/2006	Gass et al.	
2006/0272463	A1	12/2006	Gass	
2007/0028733	A1	2/2007	Gass	
2007/0101842	A1	5/2007	Gass	
2007/0131071	A1	6/2007	Gass et al.	

FOREIGN PATENT DOCUMENTS

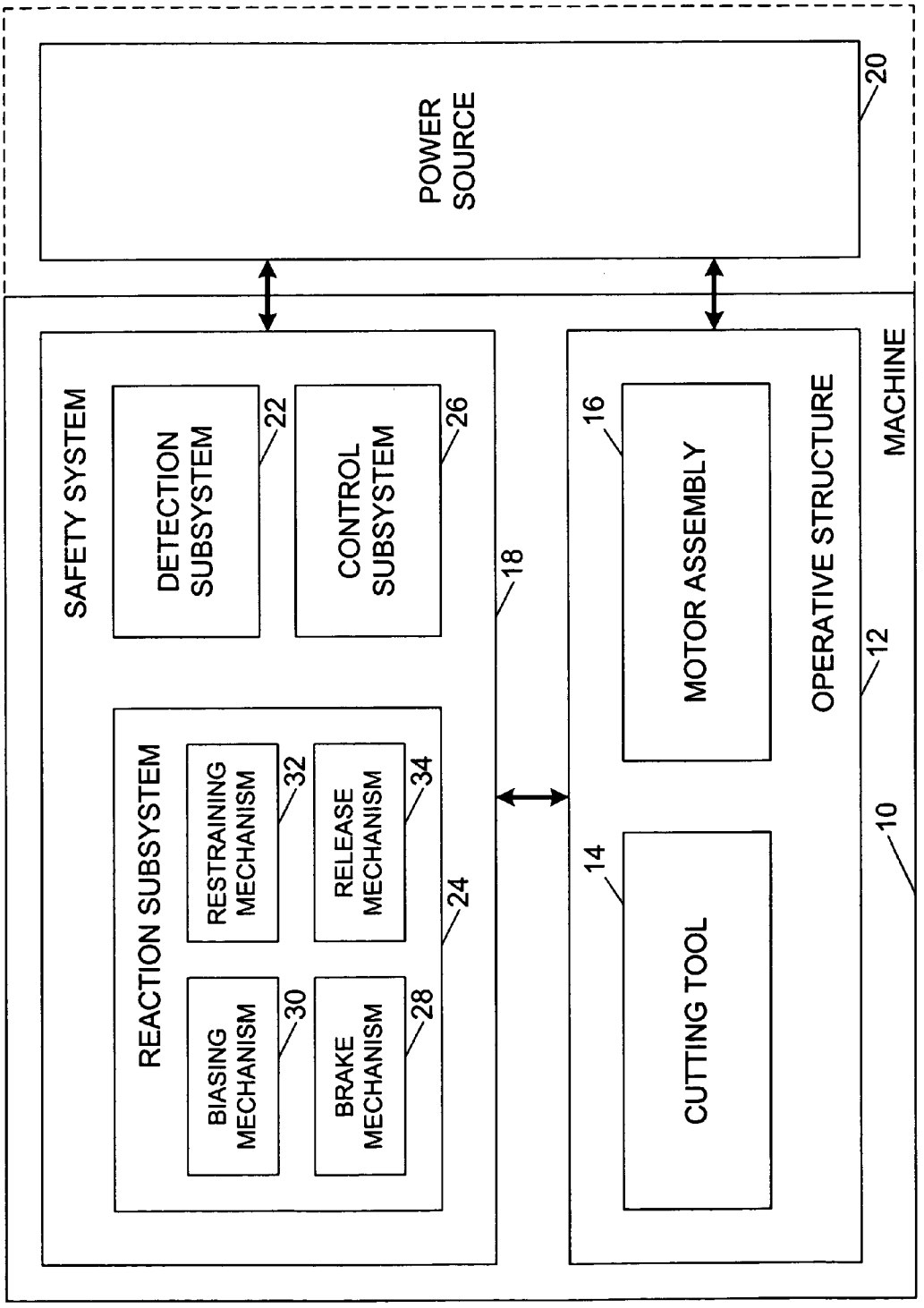
CH	297525	6/1954
DE	76186	8/1921
DE	2917497	4/1979
DE	2800403	7/1979
DE	3427733	1/1986
DE	4205965 C1	2/1992
DE	4235161 A1	5/1993
DE	4326313	2/1995
DE	19609771	6/1998
DE	20102704	2/2001
EP	146460	11/1988
EP	0362937 A2	4/1990
ES	2152184	1/2001
FR	2556643	6/1985
FR	2570017	3/1986
GB	598204	2/1948
GB	1132708	11/1968
GB	2096844	10/1982
GB	2142571	1/1985
JP	06328359	11/1994

OTHER PUBLICATIONS

Craftsman® Power and Hand Tools, pp. 142-143, 2003.
Young Inventor: Teen's Device Earns Her Trip to Science Fair, *The Arizona Republic*, May 5, 2006.
Grizzly Industrial, Inc. Model G0605X/G0606X Extreme Series 12" Table Saw Owner's Manual, Grizzly Industrial, Inc., Oct. 2006.
Operator Injury Mitigation Using Electronic Sensing and Mechanical Braking and Decoupling Devices in Handheld Circular Saws, Erin F. Eppard, date unknown.
Skil Model 3400-Type 1 10" Table Saw Parts List and Technical Bulletin, S-B Power Tool Company, Jun. 1993.
Shop Fox® Fence Operating Manual, Woodstock International, Inc., 1996, revised May 1997.
Excaliber T-Slot Precision Saw Fence Model TT45 Owner's Manual, Sommerville Design & Manufacturing, Inc., May 2000.
Bosch Model 4000 Worksite Table Saw Operating/Safety Instructions, S-B Power Tool Company, Jul. 2000.
XACTA Fence II™ Homeshop 30/52 Owner's Manual, JET Equipment & Tools, Mar. 2001.
XACTA Fence II™ Commercial 30/50 Owner's Manual, JET Equipment & Tools, Mar. 2001.
Bosch 10" Table Saw Model 0601476139 Parts List and Technical Bulletin, S-B Power Tool Company, Apr. 2001.
Biesemeyer® T-Square® Universal Home Shop Fence system Instruction Manual, Delta Machinery, Jun. 1, 2001.
Powermatic 10" Tilting Arbor Saw Model 66 Instruction Manual & Parts List, JET Equipment & Tools, Jun. 2001.
Ski Model 3400 Table Saw Operating/Safety Instructions, S-B Power Tool Company, Sep. 2001.
The Merlin Splitter by Excalibur a Sommerville Design Product Overview & Generic Installation Notes, Sommerville Design & Manufacturing Inc., at least as early as 2002.
INCRA Incremental Micro Precision Table Saw Fence Owner's Manual, Taylor Design Group, Inc., 2003.
Shop Fox® Models W2005, W2006, W2007 Classic Fence Instruction Manual, Woodstock International, Jan. 2000, revised Mar. 2004.
ACCU-FENCE® 64A Fence and Rail System Owner's Manual, WMH Tool Group, Sep. 2004.
Unifence™ Saw Guide Instruction Manual, Delta Machinery, Feb. 22, 2005.
Biesemeyer® T-Square® Commercial Fence System Instruction Manual, Delta Machinery, May 2, 2005.
Laguna Tools table saw owner's manual, date unknown.
Analog Devices, Inc., 3-Axis Capacitive Sensor—Preliminary Technical Data AD7103, pp. 1-40, © 1998.

* cited by examiner

Fig. 1


POWER SOURCE
20
SAFETY SYSTEM
DETECTION SUBSYSTEM
22
CONTROL SUBSYSTEM
26
18
REACTION SUBSYSTEM
RESTRAINING MECHANISM
32
RELEASE MECHANISM
34
24
BIASING MECHANISM
30
BRAKE MECHANISM
28
MACHINE
OPERATIVE STRUCTURE
12
16
MOTOR ASSEMBLY
14
CUTTING TOOL
10

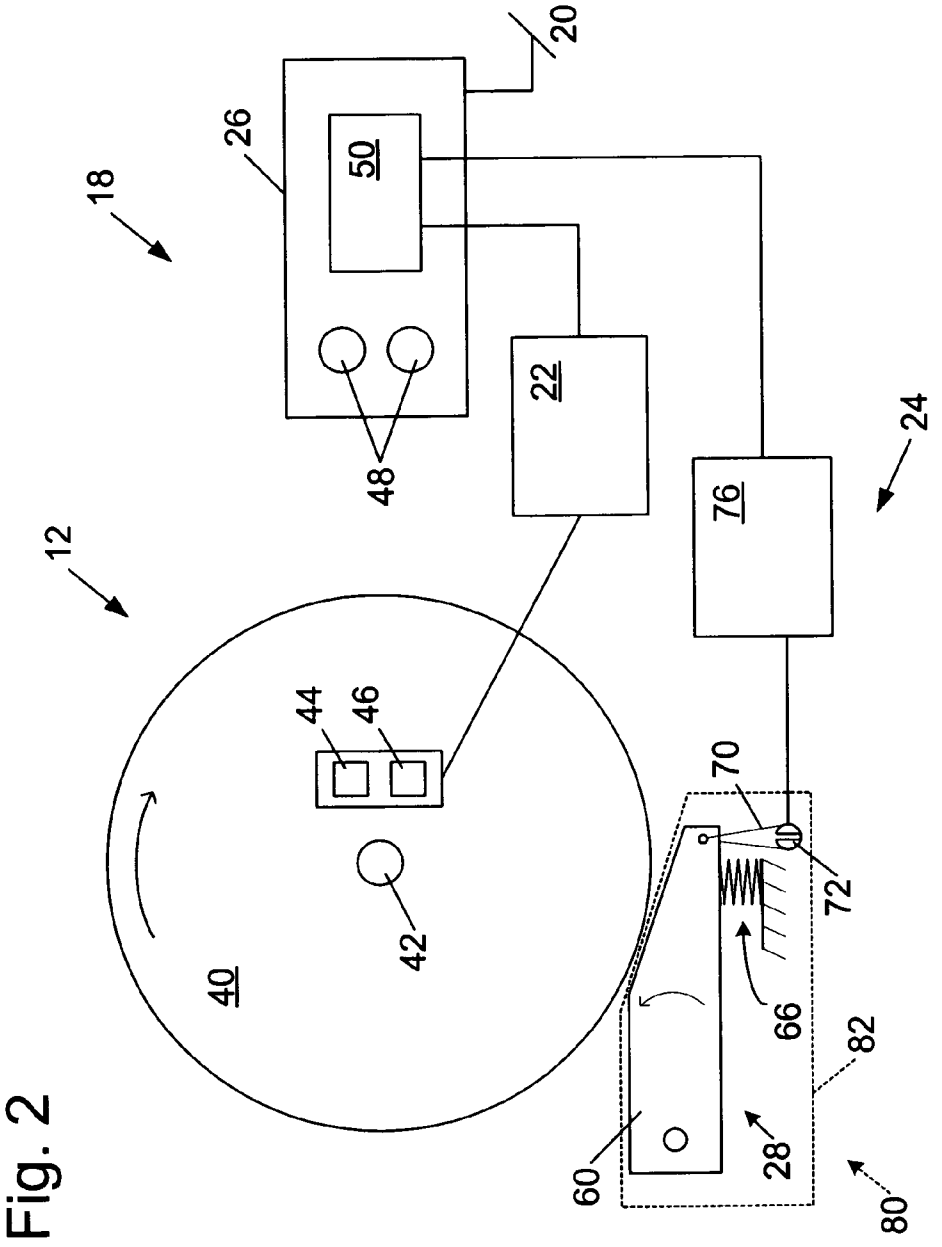


Fig. 2

Fig. 10

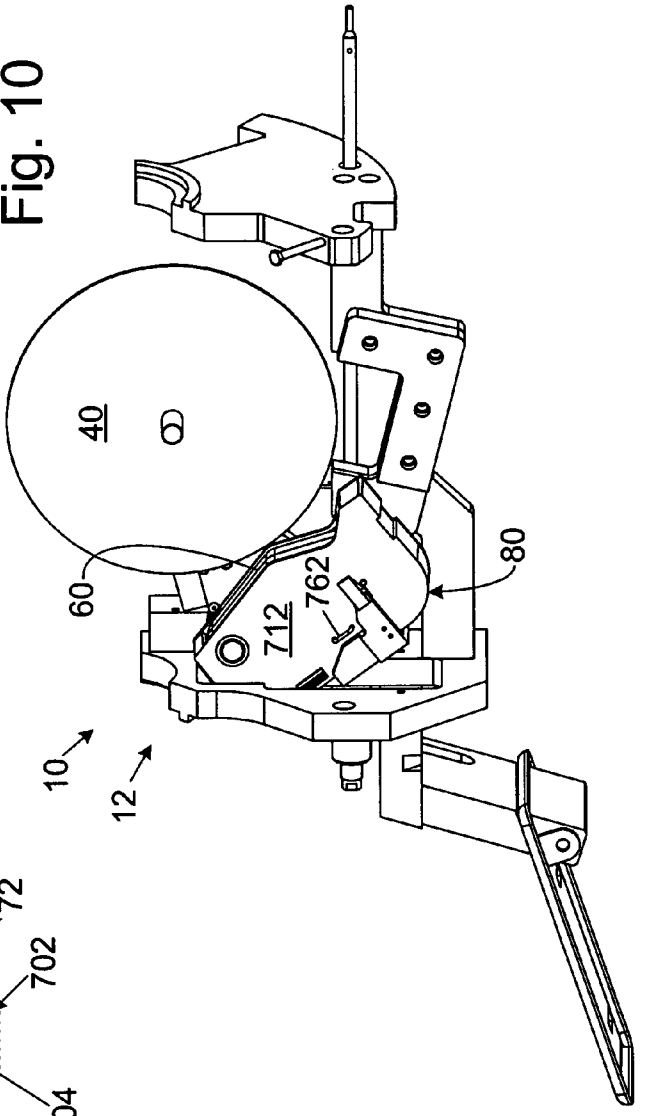

40
60
762
712
80
10
12

Fig. 3

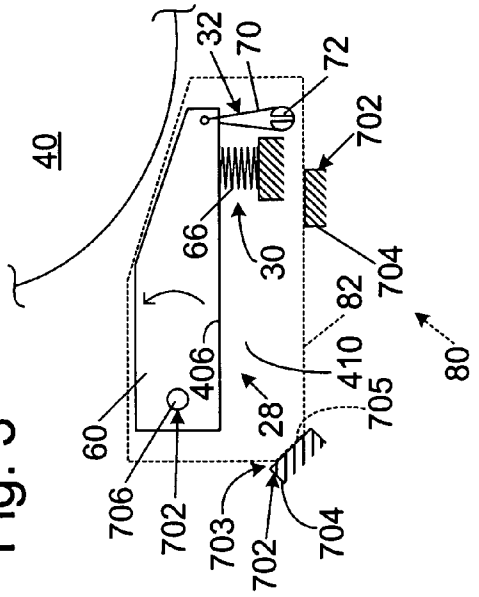

40
32
70
72
702
66
30
704
82
80
406
410
705
28
60
706
702
703
702
704

Fig. 4

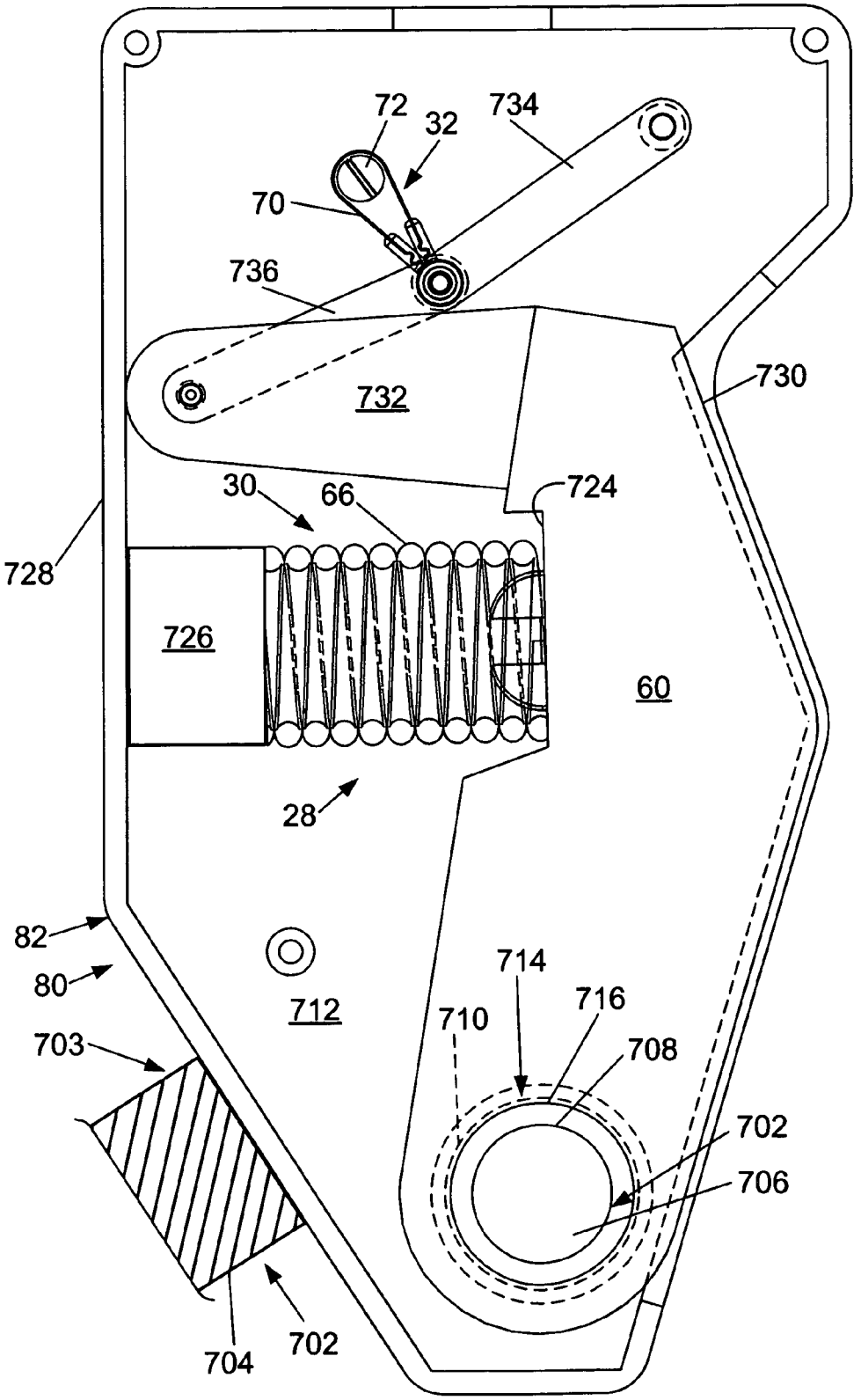

72
32
734
70
736
732
730
724
30
66
728
726
60
28
82
80
712
714
716
710
708
703
702
706
704
702

Fig. 5

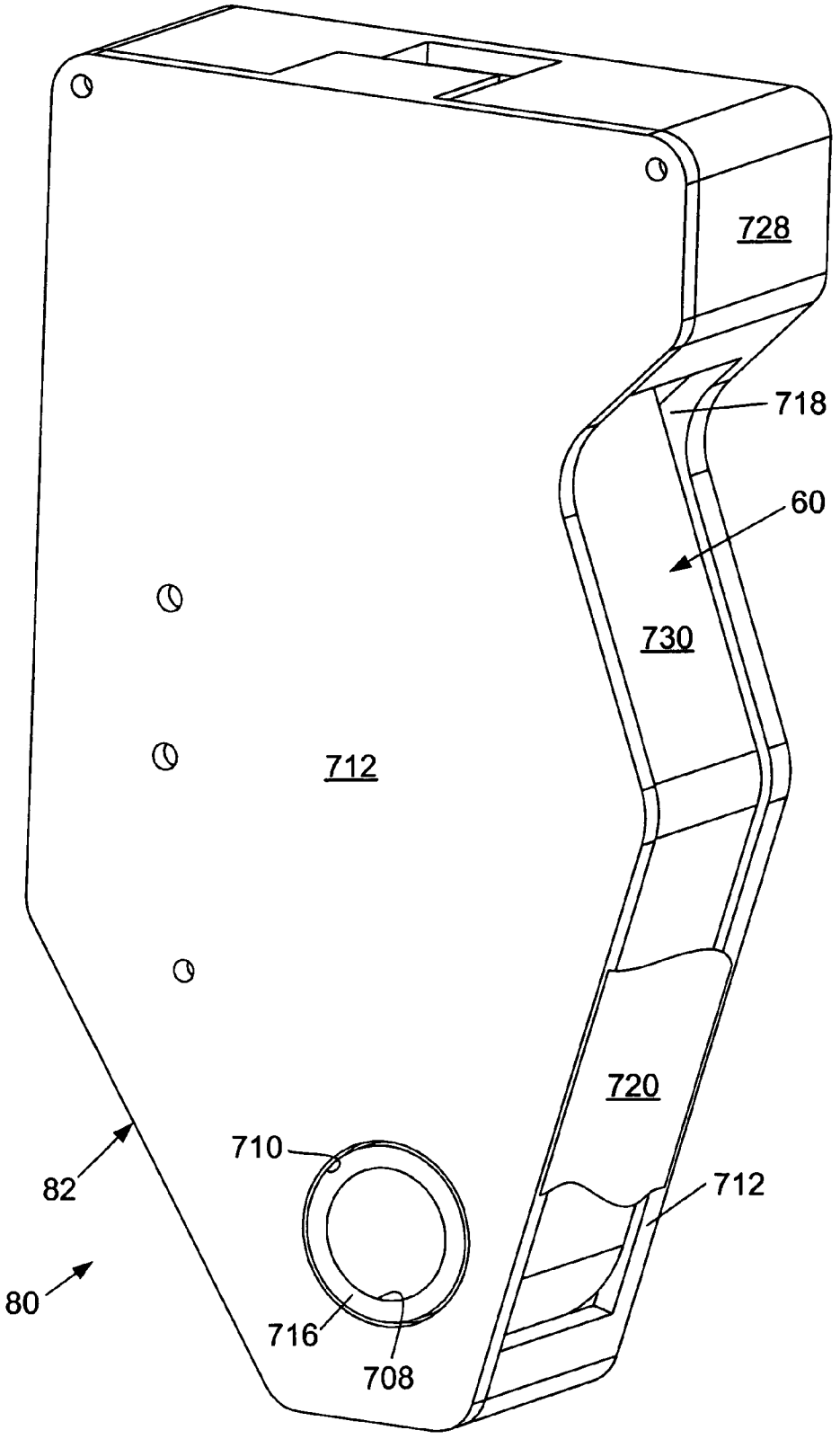


Fig. 6

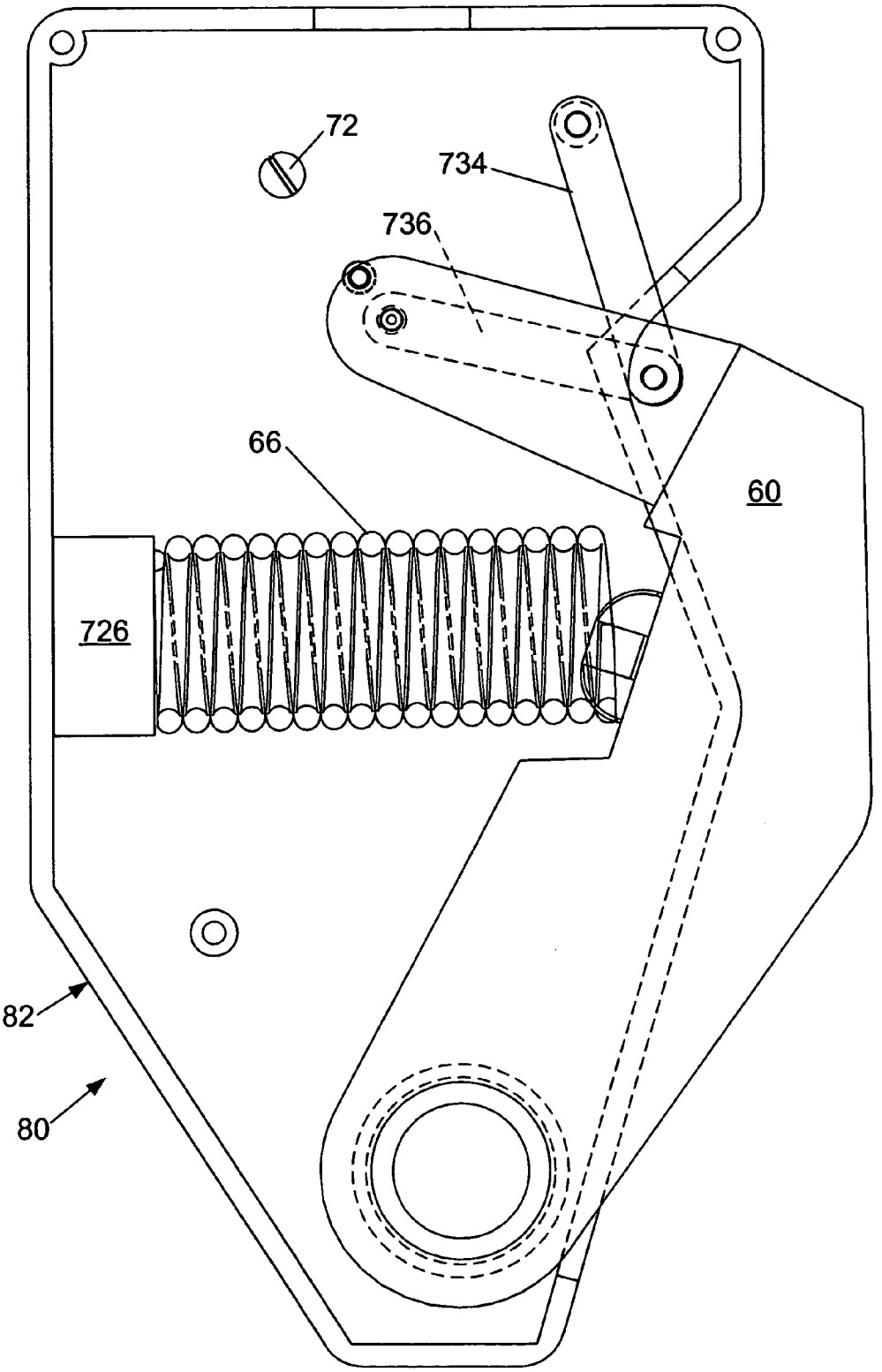


Fig. 7

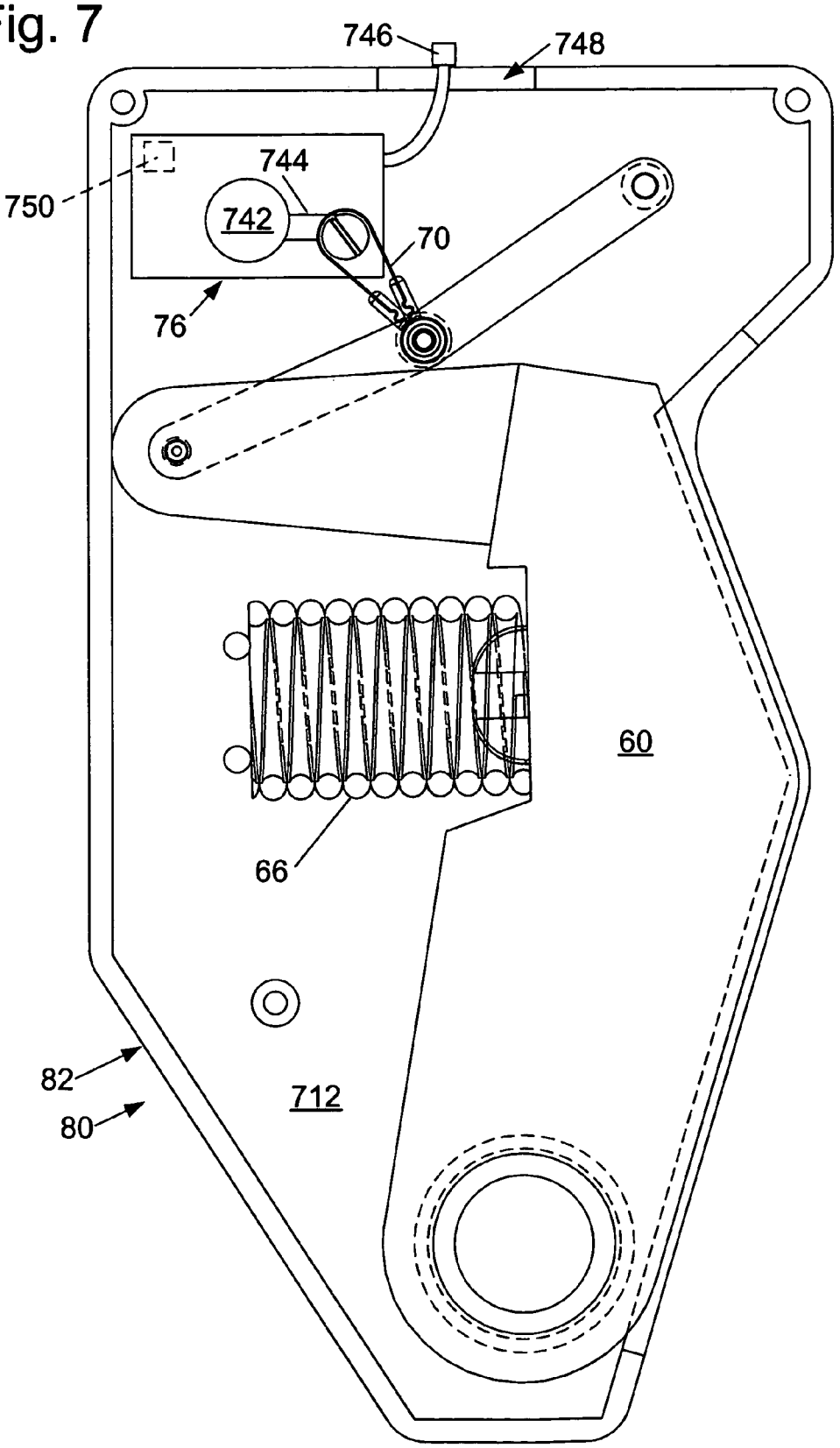


Fig. 9

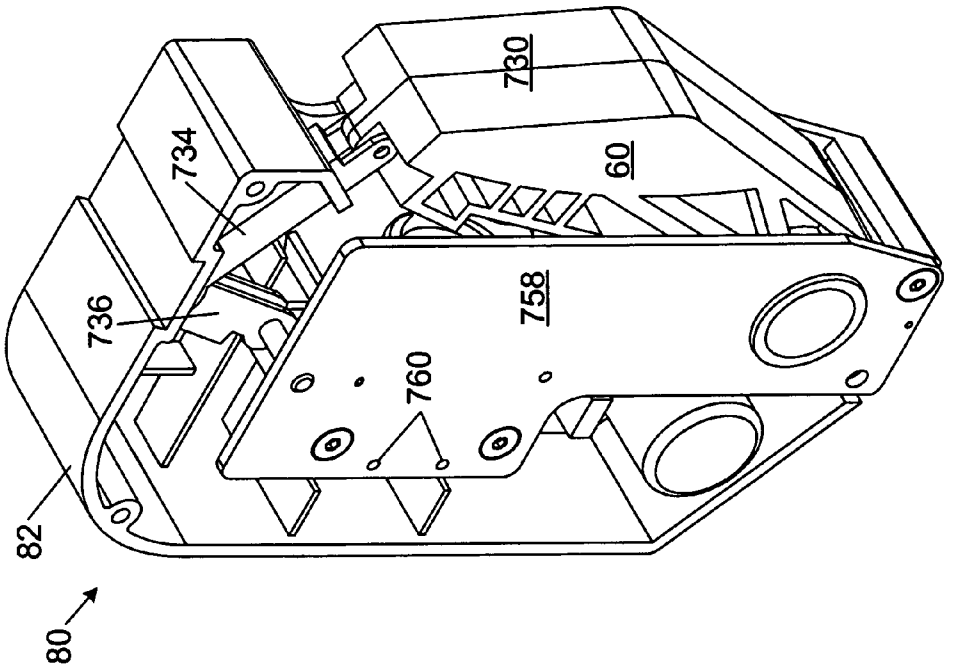

730
734
60
736
758
760
82
80

Fig. 8

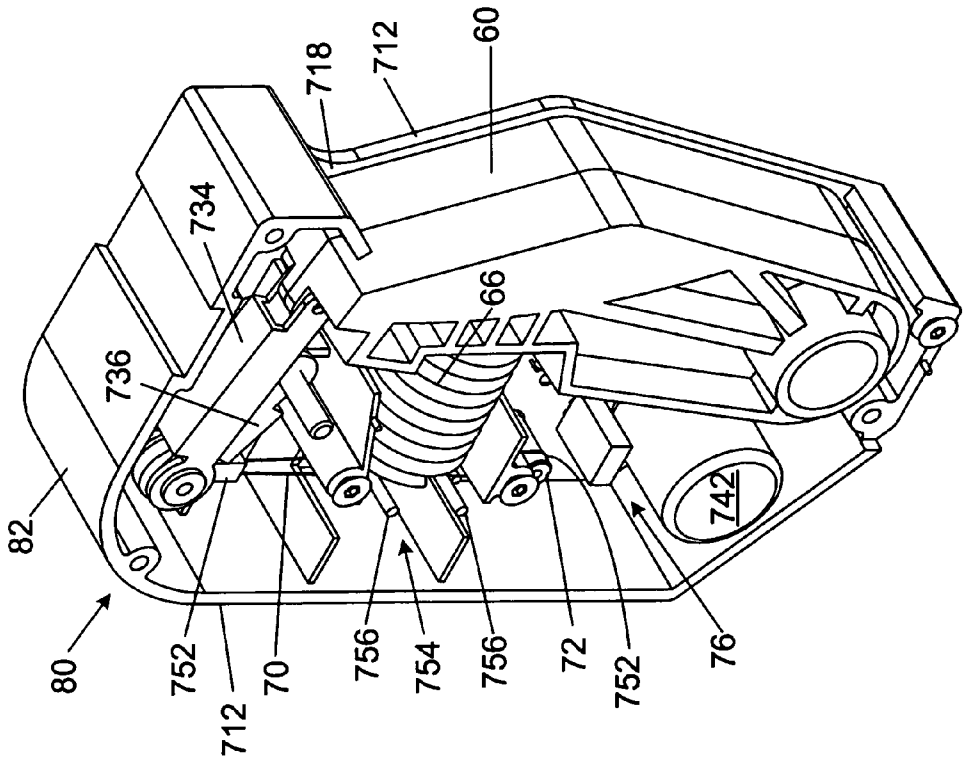

718
712
60
734
66
736
742
82
80
752
712
70
756
754
756
72
752
76

Fig. 11

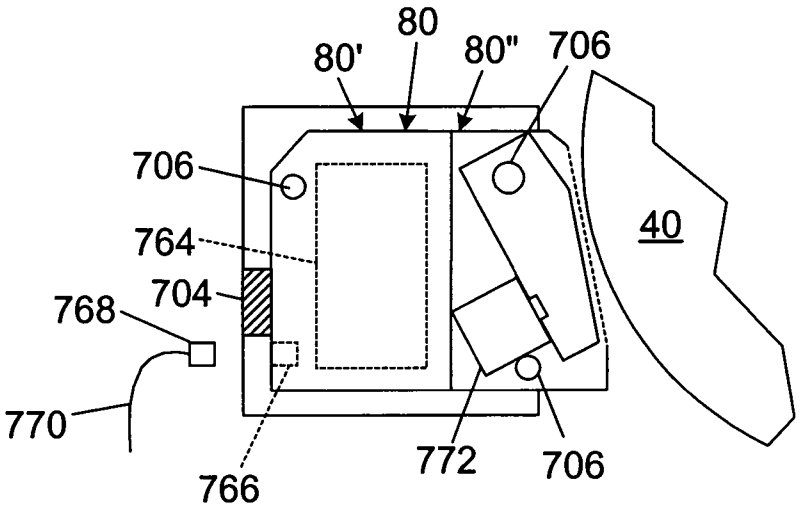
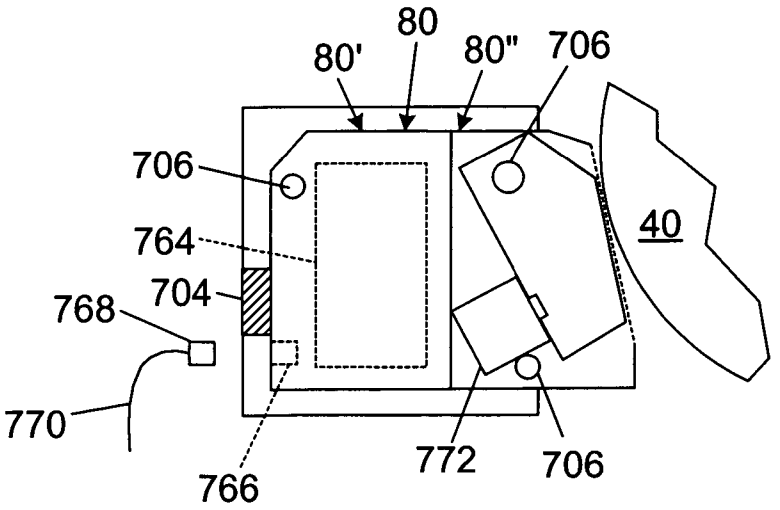

80
80'
80"
706
706
764
704
768
770
766
772
706
40

Fig. 12


80
80'
80"
706
706
764
704
768
770
766
772
706
40

REPLACEABLE BRAKE MECHANISM FOR POWER EQUIPMENT

CROSS-REFERENCE TO RELATED APPLICATIONS

This application claims the benefit of and priority from the following U.S. Provisional Patent Applications: Ser. No. 60/225,056, filed Aug. 14, 2000, Ser. No. 60/225,057, filed Aug. 14, 2000, Ser. No. 60/225,058, filed Aug. 14, 2000, Ser. No. 60/225,059, filed Aug. 14, 2000, Ser. No. 60/225,089, filed Aug. 14, 2000, Ser. No. 60/225,094, filed Aug. 14, 2000, Ser. No. 60/225,169, filed Aug. 14, 2000, Ser. No. 60/225,170, filed Aug. 14, 2000, Ser. No. 60/225,200, filed Aug. 14, 2000, Ser. No. 60/225,201, filed Aug. 14, 2000, Ser. No. 60/225,206, filed Aug. 14, 2000, Ser. No. 60/225,210, filed Aug. 14, 2000, Ser. No. 60/225,211, filed Aug. 14, 2000, and Ser. No. 60/225,212, filed Aug. 14, 2000.

FIELD

The present invention relates to safety systems for power equipment, and more particularly to a replaceable brake mechanism for use in woodworking equipment and other power equipment.

BACKGROUND

Safety systems are often employed with power equipment such as table saws, miter saws, band saws, jointers, shapers, circular saws and other woodworking machinery, to minimize the risk of injury when using the equipment. Probably the most common safety feature is a guard that physically blocks an operator from making contact with dangerous components of machinery, such as belts, shafts or blades. In many cases, guards effectively reduce the risk of injury, however, there are many instances where the nature of the operations to be performed precludes using a guard that completely blocks access to hazardous machine parts.

The present invention discloses safety systems for use on power equipment. The disclosed safety systems include a replaceable brake mechanism adapted to engage a blade or other cutting tool to protect the user against serious injury if a dangerous, or triggering, condition occurs. The brake mechanism includes a one or more cartridges that may be selectively removed and replaced from the power equipment, such as after use and/or to adapt the brake mechanism for a particular use.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a schematic block diagram of a machine with a fast-acting safety system according to the present invention.

FIG. **2** is a schematic diagram of an exemplary safety system in the context of a machine having a circular blade.

FIG. **3** is a fragmentary side elevation view of a safety system having a replaceable brake mechanism housed in a cartridge.

FIG. **4** is a side elevation view of the interior of another cartridge according to the present invention.

FIG. **5** is an isometric view of the cartridge of FIG. **4**.

FIG. **6** is a side elevation view of the cartridge of FIG. **4** with the pawl in its blade-engaging position.

FIG. **7** is a side-elevation view of another cartridge according to the present invention.

FIG. **8** is an isometric view of the interior of another cartridge according to the present invention.

FIG. **9** is an isometric view of a variation of the cartridge of FIG. **8**.

FIG. **10** is an isometric view showing the cartridge of FIG. **9** installed in a machine.

FIG. **11** is a fragmentary side elevation view of another cartridge according to the present invention.

FIG. **12** is a fragmentary side elevation view of another cartridge according to the present invention.

DETAILED DESCRIPTION

A machine is shown schematically in FIG. **1** and indicated generally at **10**. Machine **10** may be any of a variety of different machines adapted for cutting workpieces, such as wood, including a table saw, miter saw (chop saw), radial arm saw, circular saw, band saw, jointer, planer, etc. Machine **10** includes an operative structure **12** having a cutting tool **14** and a motor assembly **16** adapted to drive the cutting tool. Machine **10** also includes a safety system **18** configured to minimize the potential of a serious injury to a person using machine **10**. Safety system **18** is adapted to detect the occurrence of one or more dangerous, or triggering, conditions during use of machine **10**. If such a dangerous condition is detected, safety system **18** is adapted to engage operative structure **12** to limit any injury to the user caused by the dangerous condition.

Machine **10** also includes a suitable power source **20** to provide power to operative structure **12** and safety system **18**. Power source **20** may be an external power source such as line current, or an internal power source such as a battery. Alternatively, power source **20** may include a combination of both external and internal power sources. Furthermore, power source **20** may include two or more separate power sources, each adapted to power different portions of machine **10**.

It will be appreciated that operative structure **12** may take any one of many different forms, depending on the type of machine **10**. For example, operative structure **12** may include a stationary housing configured to support motor assembly **16** in driving engagement with cutting tool **14**. Alternatively, operative structure **12** may include a movable structure configured to carry cutting tool **14** between multiple operating positions. As a further alternative, operative structure **12** may include one or more transport mechanisms adapted to convey a workpiece toward and/or away from cutting tool **14**.

Motor assembly **16** includes one or more motors adapted to drive cutting tool **14**. The motors may be either directly or indirectly coupled to the cutting tool, and may also be adapted to drive workpiece transport mechanisms. Cutting tool **14** typically includes one or more blades or other suitable cutting implements that are adapted to cut or remove portions from the workpieces. The particular form of cutting tool **14** will vary depending upon the various embodiments of machine **10**. For example, in table saws, miter saws, circular saws and radial arm saws, cutting tool **14** will typically include one or more circular rotating blades having a plurality of teeth disposed along the perimetrical edge of the blade. For a jointer or planer, the cutting tool typically includes a plurality of radially spaced-apart blades. For a band saw, the cutting tool includes an elongate, circuitous tooth-edged band.

Safety system **18** includes a detection subsystem **22**, a reaction subsystem **24** and a control subsystem **26**. Control subsystem **26** may be adapted to receive inputs from a variety of sources including detection subsystem **22**, reaction subsystem **24**, operative structure **12** and motor assembly **16**. The control subsystem may also include one or more sensors adapted to monitor selected parameters of machine **10**. In addition, control subsystem **26** typically includes one or more

instruments operable by a user to control the machine. The control subsystem is configured to control machine **10** in response to the inputs it receives.

Detection subsystem **22** is configured to detect one or more dangerous, or triggering, conditions during use of machine **10**. For example, the detection subsystem may be configured to detect that a portion of the user's body is dangerously close to, or in contact with, a portion of cutting tool **14**. As another example, the detection subsystem may be configured to detect the rapid movement of a workpiece due to kickback by the cutting tool, as is described in U.S. Provisional Patent Application Ser. No. 60/182,866, the disclosure of which is herein incorporated by reference. In some embodiments, detection subsystem **22** may inform control subsystem **26** of the dangerous condition, which then activates reaction subsystem **24**. In other embodiments, the detection subsystem may be adapted to activate the reaction subsystem directly.

Once activated in response to a dangerous condition, reaction subsystem **24** is configured to engage operative structure **12** quickly to prevent serious injury to the user. It will be appreciated that the particular action to be taken by reaction subsystem **24** will vary depending on the type of machine **10** and/or the dangerous condition that is detected. For example, reaction subsystem **24** may be configured to do one or more of the following: stop the movement of cutting tool **14**, disconnect motor assembly **16** from power source **20**, place a barrier between the cutting tool and the user, or retract the cutting tool from its operating position, etc. The reaction subsystem may be configured to take a combination of steps to protect the user from serious injury. Placement of a barrier between the cutting tool and teeth is described in more detail in U.S. Provisional Patent Application Ser. No. 60/225,206, entitled "Cutting Tool Safety System," filed Aug. 14, 2000 by SD3, LLC, the disclosure of which is herein incorporated by reference. Retraction of the cutting tool from its operating position is described in more detail in U.S. Provisional Patent Application Ser. No. 60/225,089, entitled "Retraction System For Use In Power Equipment," filed Aug. 14, 2000 by SD3, LLC, the disclosure of which is herein incorporated by reference.

The configuration of reaction subsystem **24** typically will vary depending on which action(s) are taken. In the exemplary embodiment depicted in FIG. **1**, reaction subsystem **24** is configured to stop the movement of cutting tool **14** and includes a brake mechanism **28**, a biasing mechanism **30**, a restraining mechanism **32**, and a release mechanism **34**. Brake mechanism **28** is adapted to engage operative structure **12** under the urging of biasing mechanism **30**. During normal operation of machine **10**, restraining mechanism **32** holds the brake mechanism out of engagement with the operative structure. However, upon receipt of an activation signal by reaction subsystem **24**, the brake mechanism is released from the restraining mechanism by release mechanism **34**, whereupon, the brake mechanism quickly engages at least a portion of the operative structure to bring the cutting tool to a stop.

It will be appreciated by those of skill in the art that the exemplary embodiment depicted in FIG. **1** and described above may be implemented in a variety of ways depending on the type and configuration of operative structure **12**. Turning attention to FIG. **2**, one example of the many possible implementations of safety system **18** is shown. System **18** is configured to engage an operative structure having a cutting tool in the form of a circular blade **40** mounted on a rotating shaft or arbor **42**. Blade **40** includes a plurality of cutting teeth (not shown) disposed around the outer edge of the blade. As described in more detail below, braking mechanism **28** is adapted to engage the teeth of blade **40** and stop the rotation of the blade. U.S. Provisional Patent Application Ser. No. 60/225,210, entitled "Translation Stop For Use In Power Equipment," filed Aug. 14, 2000 by SD3, LLC, the disclosure of which is herein incorporated by reference, describes other systems for stopping the movement of the cutting tool. U.S. Provisional Patent Application Ser. No. 60/225,058, entitled "Table Saw With Improved Safety System," filed Aug. 14, 2000 by SD3, LLC and U.S. Provisional Patent Application Ser. No. 60/225,057, entitled "Miter Saw With Improved Safety System," filed Aug. 14, 2000 by SD3, LLC, the disclosures of which are herein incorporated by reference, describe safety system **18** in the context of particular types of machines **10**.

In the exemplary implementation, detection subsystem **22** is adapted to detect the dangerous condition of the user coming into contact with blade **40**. The detection subsystem includes a sensor assembly, such as contact detection plates **44** and **46**, capacitively coupled to blade **40** to detect any contact between the user's body and the blade. Typically, the blade, or some larger portion of cutting tool **14** is electrically isolated from the remainder of machine **10**. Alternatively, detection subsystem **22** may include a different sensor assembly configured to detect contact in other ways, such as optically, resistively, etc. In any event, the detection subsystem is adapted to transmit a signal to control subsystem **26** when contact between the user and the blade is detected. Various exemplary embodiments and implementations of detection subsystem **22** are described in more detail in U.S. Provisional Patent Application Ser. No. 60/225,200, entitled "Contact Detection System For Power Equipment," filed Aug. 14, 2000 by SD3, LLC and U.S. Provisional Patent Application Ser. No. 60/225,211, entitled "Apparatus And Method For Detecting Dangerous Conditions In Power Equipment," filed Aug. 14, 2000 by SD3, LLC, the disclosures of which are herein incorporated by reference.

Control subsystem **26** includes one or more instruments **48** that are operable by a user to control the motion of blade **40**. Instruments **48** may include start/stop switches, speed controls, direction controls, etc. Control subsystem **26** also includes a logic controller **50** connected to receive the user's inputs via instruments **48**. Logic controller **50** is also connected to receive a contact detection signal from detection subsystem **22**. Further, the logic controller may be configured to receive inputs from other sources (not shown) such as blade motion sensors, workpiece sensors, etc. In any event, the logic controller is configured to control operative structure **12** in response to the user's inputs through instruments **48**. However, upon receipt of a contact detection signal from detection subsystem **22**, the logic controller overrides the control inputs from the user and activates reaction subsystem **24** to stop the motion of the blade. Various exemplary embodiments and implementations of control subsystem **26** are described in more detail in U.S. Provisional Patent Application Ser. No. 60/225,059, entitled "Logic Control For Fast Acting Safety System," filed Aug. 14, 2000 by SD3, LLC and U.S. Provisional Patent Application Ser. No. 60/225,094, entitled "Motion Detecting System For Use In Safety System For Power Equipment," filed Aug. 14, 2000 by SD3, LLC, the disclosures of which are herein incorporated by reference.

In the exemplary implementation, brake mechanism **28** includes a pawl **60** mounted adjacent the edge of blade **40** and selectively moveable to engage and grip the teeth of the blade. Pawl **60** may be constructed of any suitable material adapted to engage and stop the blade. As one example, the pawl may be constructed of a relatively high strength thermoplastic material such as polycarbonate, ultrahigh molecular weight polyethylene (UHMW) or Acrylonitrile Butadiene Styrene (ABS), etc., or a metal such as aluminum, etc. It will be

appreciated that the construction of pawl **60** will vary depending on the configuration of blade **40**. In any event, the pawl is urged into the blade by a biasing mechanism in the form of a spring **66**. In the illustrative embodiment shown in FIG. **2**, pawl **60** is pivoted into the teeth of blade **40**. It should be understood that sliding or rotary movement of pawl **60** may also be used. The spring is adapted to urge pawl **60** into the teeth of the blade with sufficient force to grip the blade and quickly bring it to a stop.

The pawl is held away from the edge of the blade by a restraining mechanism in the form of a fusible member **70**. The fusible member is constructed of a suitable material adapted to restrain the pawl against the bias of spring **66**, and also adapted to melt under a determined electrical current density. Examples of suitable materials for fusible member **70** include NiChrome wire, stainless steel wire, etc. The fusible member is connected between the pawl and a contact mount **72**. Preferably, fusible member **70** holds the pawl relatively close to the edge of the blade to reduce the distance the pawl must travel to engage the blade. Positioning the pawl relatively close to the edge of the blade reduces the time required for the pawl to engage and stop the blade. Typically, the pawl is held approximately 1/32-inch to 1/4-inch from the edge of the blade by fusible member **70**, however other pawl-to-blade spacings may also be used within the scope of the invention.

Pawl **60** is released from its unactuated, or cocked, position to engage blade **40** by a release mechanism in the form of a firing subsystem **76**. The firing subsystem is coupled to contact mount **72**, and is configured to melt fusible member **70** by passing a surge of electrical current through the fusible member. Firing subsystem **76** is coupled to logic controller **50** and activated by a signal from the logic controller. When the logic controller receives a contact detection signal from detection subsystem **22**, the logic controller sends an activation signal to firing subsystem **76**, which melts fusible member **70**, thereby releasing the pawl to stop the blade. Various exemplary embodiments and implementations of reaction subsystem **24** are described in more detail in U.S. Provisional Patent Application Ser. No. 60/225,056, entitled "Firing Subsystem For Use In Fast Acting Safety System," filed Aug. 14, 2000 by SD3, LLC, U.S. Provisional Patent Application Ser. No. 60/225,170, entitled "Spring-Biased Brake Mechanism for Power Equipment," filed Aug. 14, 2000 by SD3, LLC, and U.S. Provisional Patent Application Ser. No. 60/225,169, entitled "Brake Mechanism For Power Equipment," filed Aug. 14, 2000 by SD3, LLC, the disclosures of which are herein incorporated by reference.

It will be appreciated that activation of the brake mechanism will typically require the replacement of one or more portions of safety system **18**. For example, pawl **60** and fusible member **70** typically must be replaced before the safety system is ready to be used again. Thus, it may be desirable to construct one or more portions of safety system **18** in a cartridge that can be easily replaced. For example, in the exemplary implementation depicted in FIG. **2**, safety system **18** includes a replaceable cartridge **80** having a housing **82**. Housing **82** may be formed of any suitable material or combination of materials, such as plastic, fiber-reinforced plastic, metal, etc. Pawl **60**, spring **66**, fusible member **70** and contact mount **72** are all mounted within housing **82**. Alternatively, other portions of safety system **18** may be mounted within the housing. In any event, after the reaction system has been activated, the safety system can be reset by replacing cartridge **80**.

In FIG. **2** and the subsequent figures, various embodiments of cartridges **80** are shown and described and include various elements, subelements and possible variations. It should be understood that cartridges according to the present invention may include any one or more of these elements, subelements and variations, regardless of whether those elements, subelements and variations are shown in the same or different figures or descriptions.

Examples of suitable brake mechanisms **28** and biasing mechanisms **30**, including suitable pawls **60** that may be used with the cartridges described herein are disclosed in U.S. Provisional Patent Application Ser. No. 60/225,169, entitled "Brake Mechanism For Power Equipment," filed Aug. 14, 2000 by SD3, LLC and U.S. Provisional Patent Application Ser. No. 60/225,170, entitled "Spring-Biased Brake Mechanism for Power Equipment," filed Aug. 14, 2000 by SD3, LLC. The disclosures of these provisional applications are hereby incorporated by reference.

Cartridge **80** should include or be in communication with the operative portions of release mechanism **34** that are required to cause restraining mechanism **32** to release pawl **60** to engage the blade or other cutting tool of the machine. For example, in FIG. **2**, it can be seen the mounts **72** are in electrical communication with firing subsystem **76**. Upon activation of detection subsystem **22**, such as upon detection of a dangerous or triggering condition, firing subsystem **76** actuates release mechanism **32**, such as by melting fusible member **70** with a surge of current stored by subsystem **76**. Examples of suitable restraining mechanisms **32** and firing subsystems **76** for use in cartridges **80** are disclosed in U.S. Provisional Patent Application Ser. No. 60/225,056, entitled "Firing Subsystem for Use in a Fast-Acting Safety System," filed Aug. 14, 2000 by SD3, LLC, the disclosure of which is herein incorporated by reference. The communication between the firing subsystem and mounts **72** may be by any suitable electrical linkage. Preferably, the electrical connection between mounts **72** and subsystem **76** is automatically established when cartridge **80** is installed within machine **10**. For example, housing **82** may include contacts that engage corresponding contacts associated with the firing subsystem when the cartridge is installed in its mounting position within the machine. Alternatively, a plug and socket assembly may be used to electrically interconnect the mounts **72** and firing subsystem **76**.

Cartridge **80** is removably installed in machine **10** so that brake mechanism **28**, and more particularly pawl **60**, is positioned near the blade or other cutting tool of the machine. Cartridge **80** may include a brake positioning system or other suitable mechanism for selectively adjusting the position of the pawl and/or cartridge relative to blade **40**. For example, the position of the cartridge relative to the blade or other cutting tool may be adjustable such as by pivoting or sliding the cartridge relative to one or more mounting bolts. In which case, pawl-to-blade spacing may be determined indirectly by measuring the blade-to-cartridge spacing if desired. Alternatively, the cartridge may be stationary and the pawl may be adjustable within the cartridge. As a further alternative, both the cartridge and pawl are adjustable. Examples of suitable brake positioning system are disclosed in U.S. Provisional Patent Application Ser. No. 60/225,212, entitled "Brake Positioning System," filed Aug. 14, 2000 by SD3, LLC, the disclosure of which is herein incorporated by reference.

As shown in FIG. **3**, machine **10** includes a support structure **702** adapted to receive cartridge **80** and operatively position the cartridge for use in safety system **18**. Support structure **702** may extend from or be mounted on any suitable structure forming part of machine **10**. When the position of blade **40** is adjustable, it may be preferable for cartridge **80** and/or support structure **702** to move with the blade so that the desired positioning of pawl **60** relative to blade **40** is main-

tained. Alternatively the cartridge may include a pawl **60** sized to accommodate adjustments to the position of the blade without requiring corresponding adjustments to the cartridge and/or mounting structure.

Examples of suitable support structures include one or more mounting brackets **704** to which the cartridge is attached by any suitable releasable fastening mechanism, such as bolts, pins or screws. Support structure **702** may additionally, or alternatively, include one or more axles **706** upon which the cartridge is mounted. For example, pawl **60** is shown in FIG. **3** pivotally mounted on an axle **706** that passes through pawl **60** and at least a portion of cartridge **80**. Also shown in FIG. **3**, is mounting bracket **704** that supports and positions cartridge **80** relative to blade **40**. Another example of a suitable support structure is a socket or other receiver within machine **10**. Typically, cartridge **80** will be supported in sufficient directions and/or positions to retain the cartridge in its intended mounting position and orientation. Cartridge **80** and support structure **702** preferably include key structure **703** that prevents the cartridge from being installed within machine **10** other than in its intended mounting position. An example of a suitable key structure **703** is shown in FIG. **3**, in which housing **82** of cartridge **80** includes a bevel **705** that mates with mounting bracket **704**. It should be understood that key structure **703** may include any suitable mechanism, including the relative size, shape and positioning of cartridge **80** and support structure **702**, that prevents the cartridge from being installed in a position other than its intended mounting position.

Another cartridge according to the present invention is shown in FIG. **4**. Similar to the cartridge shown in FIGS. **2** and **3**, the cartridge shown in FIG. **4** includes a housing **82**, a brake mechanism **28** having a pawl **60**, a biasing mechanism **30** such as spring **66**, and a restraining mechanism **32** such as fusible member **70**. Also shown is another example of a suitable key structure **703**, namely, the irregular shape of housing **82** and mounting bracket **704** against which the housing is supported.

As shown, pawl **60** includes an aperture, or bore, **708** through which an axle or pin **706** may extend to support the pawl and cartridge within machine **10**. Also shown is an aperture **710** in one or more of the cartridge's side walls **712** through which axle **706** extends. Alternatively, cartridge **80** may be supported by a support structure **702** that does not directly support pawl **60**. For example, pawl **60** may pivot about an axle forming part of cartridge **80**, which in turn is supported by support structure **702**, such as pins, mounting brackets or the like. However, it may be preferable to support pawl **60** with at least one of support structures **702** to increase the supporting force provided other than by cartridge **80**. Similarly, this reduces the strength required for cartridge **80** because support structures **702** absorb much of the force imparted on pawl **60** as the pawl engages the blade or other cutting tool of the machine.

Pawl **60** should be retained in its mounting position within cartridge **80** when the cartridge is not installed within the machine. An example of a suitable coupling **714** between the pawl and cartridge is shown in FIG. **5**, in which the aperture **710** through cartridge **80** is larger than the corresponding aperture **708** through pawl **60**. Pawl **60** includes an outwardly extending bushing, or carrier, **716** that extends at least partially through the sidewalls of the cartridge to position the pawl relative to the cartridge. It should be understood that it is within the scope of the invention that this configuration could be reversed, with pawl **60** having a larger aperture than cartridge **80** and with the cartridge having an inwardly extending bushing or carrier that passes at least partially through the aperture in pawl **60**.

Also shown in more detail in FIG. **5** is the cartridge's opening **718** through which at least a portion of pawl **60** projects upon release of restraining mechanism **32**. Although pawl **60** is shown completely within housing **82** in FIG. **5**, it should be understood that at least a portion of pawl **60** may project from housing **82** when the pawl is in its cocked, or restrained, position. Opening **718** may include a cover **720** that seals the opening and thereby prevents contaminants such as dust, particulate, water, grease and the like from entering the cartridge and possibly interfering with the operation thereof. Although only a portion of cover **720** is shown in FIG. **5**, it should be understood that the cover preferably covers the entire opening **718**. Cover **720** may be formed of any suitable material to prevent contaminants from entering the cartridge through opening **718**, while not interfering with the operation of brake mechanism **28**. Examples of suitable materials for cover **720** include tape and thin metal, paper or plastic films. When a cover **720** is used that completely closes opening **718**, the entire cartridge is preferably, but not necessarily, sealed against the entry of contaminants. Cover **720** may be attached to cartridge **80** through any suitable mechanism, such as with an adhesive. In embodiments of the cartridge in which the pawl is not prevented from pivoting or otherwise moving by restraining mechanism **32**, cover **720** may also function as a pawl-restraining mechanism that prevents the pawl from extending through opening **718** until release of biasing mechanism **30** by the restraining mechanism.

Returning briefly to FIG. **4**, it can be seen that biasing mechanism **30** includes spring **66**, which is compressed between a spring-receiving portion **724** of the pawl and a support **726** forming part of cartridge **80**. As shown, support **726** extends from the housing of the cartridge, although any suitable support may be used, including the end wall **728** of the cartridge, a support that extends from the end wall, and a support that extends from at least one of the cartridge's side walls **712**.

In the embodiment of pawl **60** shown in FIG. **4**, the pawl includes a blade-engaging surface **730** and a distal portion **732** that is coupled to linkages **734** and **736**. Linkage **734** is pivotally coupled to housing **82**, and linkage **736** interconnects distal portion **732** of pawl **60** to linkage **734**. As shown, both linkages are in compression when pawl **60** is in its cocked, or restrained, position. It should be understood, however, that any suitable number and type of linkages may be used. Alternatively, restraining mechanism **32** may restrain the pawl directly, such as shown in FIGS. **2** and **3**. As a further alternative, restraining mechanism **32** may restrain a support positioned intermediate spring **66** and pawl **60** and upon which restraining mechanism **32** acts, thereby leaving pawl completely or relatively free from the bias of spring **66** until the release of restraining mechanism **32**.

Fusible member **70** extends around contact mount **72** and at least a portion of one of the linkages to prevent pawl **60** from pivoting under the force of biasing mechanism **30**. As shown, the ends of fusible member **70** are coupled to the linkages. Upon release of restraining mechanism **32**, such as when a sufficient current is passed through fusible member **70** via contact mount **72**, the fusible member no longer retains the linkages and pawl in the position shown, and the pawl pivots to its blade-engaging position, which is shown in FIG. **6**.

Firing subsystem **76** may alternatively be located within housing **80**, such as schematically illustrated in FIG. **7**. An advantage of locating firing subsystem **76** within cartridge **80**

is that the firing subsystem may be replaced with the rest of the cartridge. It also enables the capacitor or other current-storing or current-generating device **742** used to release fusible member **70** to be housed near contact mounts **72** and connected thereto by a direct linkage **744**, instead of by wires. Also shown in FIG. **7** is plug **746** that extends through a port **748** in housing **82** and which is adapted to electrically connect firing subsystem **76** with controller **50** or another suitable portion of control subsystem **26**. Alternatively, contacts **750** are shown extending from or forming a portion of housing **82**.

Another exemplary cartridge is shown in FIG. **8**. As shown, cartridge **80** includes firing subsystem **76** of release mechanism **34**. Also shown in FIG. **8** is another version of linkages **734** and **736**, in which linkage **734** is in tension instead of compression. The linkage assemblies shown in FIGS. **4** and **8** may both be referred to as over-center linkages. In FIG. **8**, fusible member **70** is shown having a fixed length defined by end portions **752** that are adapted to be coupled to contact mount **72** and linkages **734** and **736**, respectively. An advantage of a fixed length fusible member is that it facilitates easier assembly of cartridges with uniform pawl positions.

Unlike support **726**, which is shown in FIG. **4** supporting the end of spring **66** distal pawl **60**, in FIG. **8**, cartridge **80** includes a removable support **754**. Support **754** may be selectively removed from cartridge **80** to release, or at least substantially reduce, the biasing force exerted by spring **66** upon pawl **60**. For example, support **754** may be removed after actuation of brake mechanism **28** to remove the spring force so that it is easier to remove and replace the cartridge. An example of a suitable support **754** is a clip **756** that extends through at least one of the cartridge's side walls **712**. Clip **756** may be supported between both of the cartridges side walls. Alternatively, cartridge **80** may include an internal support **758** adapted to support the ends **760** of clip **756**, such as shown in FIG. **9**, in which the pawl is shown in its blade-engaging positions. Preferably clip **756** or other support **754** may be removed from the cartridge without having to first remove the cartridge from machine **10**. For example, clip **756** may include a portion **762** that extends external to cartridge **80** and which may be grasped by a tool to withdraw the clip from the cartridge, such as shown in FIG. **10**. A benefit of the embodiment shown in FIG. **9** is that pulling clip **756** releases spring **66**, which in turn breaks fusible member **70**. The safety system's controller may be configured to detect this break in fusible member **70**, and respond accordingly to the fault in the system.

In FIGS. **7-9**, firing subsystem **76** is shown housed within cartridge **80**. It should be understood that other components of the safety system's electronics may also be housed within cartridge **80**. For example, the cartridge may include a sensing assembly to determine if the cartridge is properly installed within machine **10**, with operation of the machine being prevented until the safety system receives a signal that the cartridge is properly installed.

Placing most of safety system **18** in the cartridge allows manufacturers to develop improved electronics, additional functions, etc., without requiring significant, if any, changes to the machine. As a further alternative, safety system **18** may include a plurality of cartridges, including at least one cartridge that contains pawl **60** and at least one cartridge that contains electronics, such as firing subsystem **76** and/or other electronic portions of the safety system. An example of such a cartridge assembly is shown in FIG. **11**. As shown, a pair of cartridges **80** are shown and indicated generally at **80'** and **80"**. Cartridges **80'** and **80"** may also be described as subcartridges or modules that are united to form cartridge **80**. Cartridge **80'** includes an electronics unit **764**, such as firing subsystem **76** or control subsystem **26**, and an electrical connector **766** configured to operably engage plug **768**, attached to cable **770**. The cable includes conductors for supplying electrical power to the electronics unit. The cable may also conduct output signals from the electronics unit, such as a cutoff signal to stop motor assembly **16**, or a signal to control subsystem **26**, depending upon the particular electronics housed in cartridge **80'**. Although plug **768** and cable **770** are shown as being freely movable, it will be appreciated that plug **768** may be rigidly mounted to the support surface upon which cartridge **80** is mounted. Further, plug **768** may be rigidly positioned to ensure that the cartridge is properly aligned and oriented when the connector is engaged with the plug. Cartridge **80"**, on the other hand, includes pawl **60** and the biasing and restraining mechanisms, which are collectively indicated as module **772** to indicate that the biasing and restraining mechanisms may also form a cartridge or module that may be selectively removed and replaced. Preferably, the cartridges are in communication with each other, such as to release the restraining mechanism responsive to a signal from electronics unit **764**.

Optionally, cartridge **80"**, or any of the previously described cartridges, may be provided in different sizes or configurations to accommodate different blade sizes. For example, a longer version of the cartridge, such as shown in FIG. **12**, may be used for a smaller diameter blade **40**. Furthermore, different cartridges may be provided for different applications that use different types of blades (e.g., dado, cross-cutting, ripping, plywood, etc.). For example, a first cartridge having a first type pawl may be provided for a first type blade, while a second cartridge having a second, different pawl may be provided for a second, different blade. Alternatively, the electronics of one cartridge may be different from those of another cartridge to allow for different applications (e.g., cutting plastic rather than wood). Additionally, plural cartridges may be used simultaneously to ensure the safety system responds optimally for each material.

While one particular implementation of safety system **18** has been described, it will be appreciated that many variations and modifications are possible within the scope of the invention. Many such variations and modifications are described in U.S. Provisional Patent Application Ser. Nos. 60/182,866 and 60/157,340, the disclosures of which are herein incorporated by reference. For example, while portions of safety system **18** have been described herein as being incorporated into a replaceable cartridge **80**, other components of the safety system may also be included in the cartridge.

It is believed that the disclosure set forth above encompasses multiple distinct inventions with independent utility. While each of these inventions has been disclosed in its preferred form, the specific embodiments thereof as disclosed and illustrated herein are not to be considered in a limiting sense as numerous variations are possible. The subject matter of the inventions includes all novel and non-obvious combinations and subcombinations of the various elements, features, functions and/or properties disclosed herein. No single feature, function, element or property of the disclosed embodiments is essential to all of the disclosed inventions. Similarly, where the claims recite "a" or "a first" element or the equivalent thereof, such claims should be understood to include incorporation of one or more such elements, neither requiring nor excluding two or more such elements.

It is believed that the following claims particularly point out certain combinations and subcombinations that are directed to one of the disclosed inventions and are novel and non-obvious. Inventions embodied in other combinations and subcombinations of features, functions, elements and/or

properties may be claimed through amendment of the present claims or presentation of new claims in this or a related application. Such amended or new claims, whether they are directed to a different invention or directed to the same invention, whether different, broader, narrower or equal in scope to the original claims, are also regarded as included within the subject matter of the inventions of the present disclosure.

The invention claimed is:

1. A woodworking machine comprising:

a support frame including a work surface for supporting workpieces;

a cutting tool supported by the frame and movable relative to the work surface to cut the workpieces supported by the work surface; and

a safety system configured to detect a dangerous condition between a person and the cutting tool and to perform a predetermined action upon detection of the dangerous condition to mitigate the dangerous condition, wherein the safety system includes a cartridge removably coupled to the support frame, wherein the cartridge is adapted to perform the predetermined action a single time and then to be replaced, and wherein the cartridge has one or more single-use components configured to be expended when the cartridge performs the predetermined action.

2. The machine of claim **1**, where the one or more single-use components include a brake pawl selectively movable to engage the cutting tool upon detection of the dangerous condition.

3. The machine of claim **2**, where the safety system includes a spring mounted in the cartridge and arranged to urge the brake pawl into contact with the cutting tool.

4. The machine of claim **2**, wherein the brake pawl and the cartridge include concentric bores adapted to couple the cartridge and the brake pawl to the support frame for pivotal movement relative to each other after the dangerous condition is detected.

5. The machine of claim **1**, further comprising at least one motor configured to drive the cutting tool, and a control system configured to determine if at least one of the single-use components has been used, end where the control system is configured to prevent operation of the at least one motor if one of the single-use components has been used.

6. The machine of claim **1**, where the cartridge includes key structure, and where the support frame includes corresponding key structure configured to engage the cartridge key structure to prevent incorrect installation of the cartridge.

7. The machine of claim **1**, wherein the cartridge includes at least two single-use components.

8. The machine of claim **7**, wherein at least one of the single-use components is an electrical component.

9. The machine of claim **7**, wherein at least one of the single-use components is adapted to engage and stop the cutting tool after detection of the dangerous condition.

10. The machine of claim **1**, wherein the cutting tool includes a cutting surface and at least one single-use components is adapted to engage the cutting surface of the cutting tool to stop the cutting tool after detection of the dangerous condition.

11. The machine of claim **1**, wherein the cartridge includes a brake pawl and a housing defining an internal compartment having an opening, and further wherein the cartridge includes a biasing mechanism within the compartment and adapted to urge the brake pawl in a direction generally away from the opening.

12. The machine of claim **11**, wherein the biasing mechanism is a spring positioned to extend at least partially through the opening when urging the brake pawl in a direction generally away from the opening.

13. The machine of claim **11**, wherein the brake pawl is adapted to move relative to the cartridge upon detection of the dangerous condition and urging of the brake pawl in the direction generally away from the opening.

14. The machine of claim **1**, where the predetermined action is moving a brake into contact with the cutting tool.

15. The machine of claim **1**, where the predetermined action is stopping the cutting tool.

16. The machine of claim **1**, where the dangerous condition is contact between a person and the cutting tool.

17. The machine of claim **1**, where the dangerous condition is proximity between a person and the cutting tool.

18. A woodworking machine comprising:

a support frame including a work surface for supporting workpieces;

a cutting tool supported by the frame and movable relative to the work surface to cut the workpieces supported by the work surface; and

a safety brake means for detecting a dangerous condition between a person and the cutting tool, and for stopping the movement of the cutting tool upon detection of the dangerous condition, wherein the safety brake means comprises a cartridge removably coupled to the support frame and one or more single-use components associated with the cartridge and adapted to be used upon detection of the dangerous condition.

* * * * *

UNITED STATES PATENT AND TRADEMARK OFFICE

CERTIFICATE OF CORRECTION

PATENT NO. : 7,610,836 B2
APPLICATION NO. : 09/929236
DATED : November 3, 2009
INVENTOR(S) : Gass et al.

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

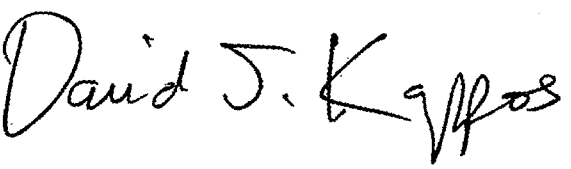
On the Title Page:

The first or sole Notice should read --

Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 802 days.

Signed and Sealed this

Fourth Day of January, 2011



David J. Kappos
Director of the United States Patent and Trademark Office

EXHIBIT D

US007895927B2

(12) **United States Patent**
Gass

(10) **Patent No.: US 7,895,927 B2**
(45) **Date of Patent: Mar. 1, 2011**

(54) **POWER EQUIPMENT WITH DETECTION AND REACTION SYSTEMS**

(75) Inventor: **Stephen F. Gass**, West Linn, OR (US)

(73) Assignee: **SD3, LLC**, Tualatin, OR (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

(21) Appl. No.: **12/800,607**

(22) Filed: **May 19, 2010**

(65) **Prior Publication Data**

US 2010/0236663 A1 Sep. 23, 2010

Related U.S. Application Data

(63) Continuation of application No. 11/796,819, filed on Apr. 30, 2007, which is a continuation of application

(Continued)

(60) Provisional application No. 60/225,200, filed on Aug. 14, 2000, provisional application No. 60/225,211,

(Continued)

(51) **Int. Cl.**
B26D 5/00 (2006.01)

(52) **U.S. Cl.** ..... **83/62.1**; 192/129 R; 83/522.12; 83/DIG. 1

(58) **Field of Classification Search** ..... 83/DIG. 1, 83/58, 62, 62.1, 72, 76.7, 788, 581, 471.2, 83/477.1, 477.2, 522.12, 526, 397.1, 522.121; 144/154.5, 356, 384, 391, 427, 286.5; 29/708, 29/254, 413; 324/550, 424; 408/5; 56/10.9, 56/11.3; 192/192 A, 129 R, 130; 102/202.7; 89/1.56; 137/68.12, 72, 76; 188/5, 6, 110, 188/189; 169/57, 59, 42, DIG. 3; 74/2; 403/2, 28; 411/2, 39, 390; 335/1, 242, 132; 318/362; 241/32.5; 337/239, 148, 1, 5, 10, 17, 140, 170, 190, 237, 401, 290, 404, 405; 218/2, 154; 307/639, 328, 115, 326, 142, 117, 126, 131; 451/409; 280/806; 297/480; 187/69, 77, 89, 189, 216, 166, 72.3

See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

146,886 A 1/1874 Doane et al.

(Continued)

FOREIGN PATENT DOCUMENTS

CA 2140991 1/1995

(Continued)

OTHER PUBLICATIONS

Sink Drain Plug Lifter, circa 1974.

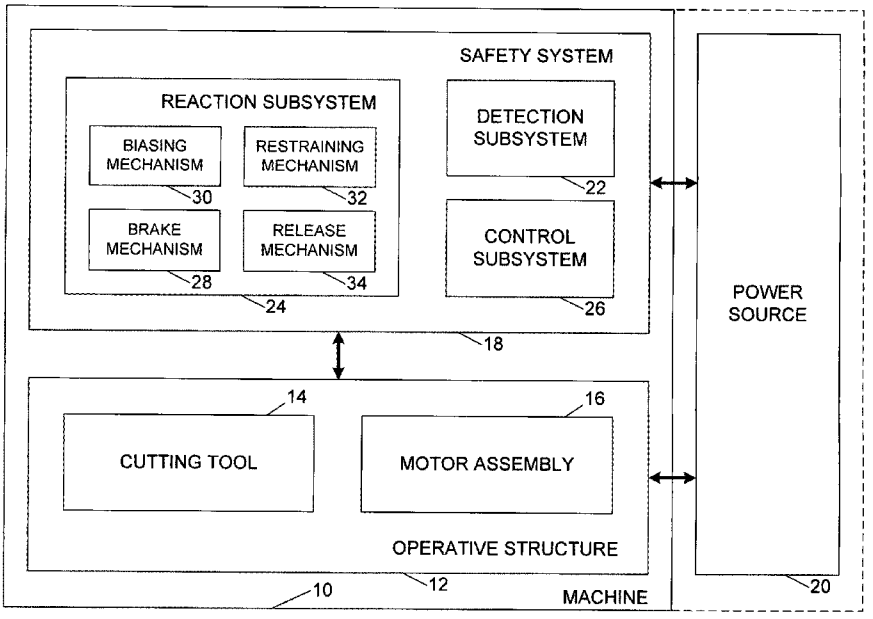
(Continued)

Primary Examiner—Jason Daniel Prone

(57) **ABSTRACT**

Woodworking machines and safety methods for use with those machines are disclosed. The machines include a detection system adapted to detect one or more dangerous conditions and a reaction system associated with the detection system. The reaction system can include an explosive to trigger the system, and also can be configured to retract a cutting tool at least partially away from a cutting region upon detection of a dangerous condition by the detection system.

12 Claims, 16 Drawing Sheets



Related U.S. Application Data

(63) No. 09/929,426, filed on Aug. 13, 2001, now Pat. No. 7,210,383, application No. 12/800,607, which is a continuation of application No. 12/655,695, filed on Jan. 4, 2010, which is a continuation of application No. 11/975,985, filed on Oct. 22, 2007, now Pat. No. 7,640,835, which is a continuation of application No. 09/929,221, filed on Aug. 13, 2001, now Pat. No. 7,284,467, application No. 12/800,607, which is a continuation of application No. 12/002,388, filed on Dec. 17, 2007, which is a continuation of application No. 09/929,227, filed on Aug. 13, 2001, now Pat. No. 7,308,843, application No. 12/800,607, which is a continuation of application No. 11/401,050, filed on Apr. 10, 2006, now Pat. No. 7,788,999, which is a continuation of application No. 09/929,240, filed on Aug. 13, 2001, now Pat. No. 7,100,483, said application No. 11/401,050 is a continuation of application No. 09/929,241, filed on Aug. 13, 2001, now Pat. No. 7,024,975, said application No. 11/401,050 is a continuation of application No. 09/929,425, filed on Aug. 13, 2001, now Pat. No. 7,137,326, said application No. 11/401,050 is a continuation of application No. 10/172,553, filed on Jun. 13, 2002, now Pat. No. 7,231,856, said application No. 11/401,050 is a continuation of application No. 10/189,027, filed on Jul. 2, 2002, now Pat. No. 7,712,403, said application No. 11/401,050 is a continuation of application No. 10/243,042, filed on Sep. 13, 2002, now Pat. No. 7,197,969, said application No. 11/401,050 is a continuation of application No. 10/643,296, filed on Aug. 18, 2003, now abandoned, said application No. 11/401,050 is a continuation of application No. 10/794,161, filed on Mar. 4, 2004, now Pat. No. 7,098,800, application No. 12/800,607, which is a continuation of application No. 10/984,643, filed on Nov. 8, 2004, which is a continuation of application No. 09/929,226, filed on Aug. 13, 2001, now Pat. No. 6,920,814, said application No. 10/984,643 is a continuation of application No. 09/929,240, filed on Aug. 13, 2001, now Pat. No. 7,100,483, said application No. 10/984,643 is a continuation of application No. 09/929,242, filed on Aug. 13, 2001, now Pat. No. 7,509,899, said application No. 10/984,643 is a continuation of application No. 10/051,782, filed on Jan. 15, 2002, now Pat. No. 6,877,410, said application No. 10/984,643 is a continuation of application No. 10/052,806, filed on Jan. 16, 2002, now Pat. No. 6,880,440, said application No. 10/984,643 is a continuation of application No. 10/205,164, filed on Jul. 25, 2002, now Pat. No. 6,945,149, said application No. 10/984,643 is a continuation of application No. 10/202,928, filed on Jul. 25, 2002, now Pat. No. 7,000,514, said application No. 10/984,643 is a continuation of application No. 10/785,361, filed on Feb. 23, 2004, now Pat. No. 6,997,090, which is a continuation of application No. 10/215,929, filed on Aug. 9, 2002, now abandoned, application No. 12/800,607, which is a continuation of application No. 11/542,938, filed on Oct. 2, 2006, which is a continuation of application No. 09/929,242, filed on Aug. 13, 2001, now Pat. No. 7,509,899, said application No. 11/542,938 is a continuation of application No. 11/401,774, filed on Apr. 11, 2006, now Pat. No. 7,525,055, which is a continuation of application No. 11/027,322, filed on Dec. 31, 2004, now abandoned, said application No. 11/542,938 is a continuation of application No. 11/445,548, filed on Jun. 2, 2006, now Pat. No. 7,347,131, said application No. 11/542,938 is a continuation of application No. 11/506,260, filed on Aug. 18, 2006, now Pat. No. 7,359,174, which is a continuation of application No. 10/923,282, filed on Aug. 20, 2004, now abandoned, application No. 12/800,607, which is a continuation of application No. 12/590,094, filed on Nov. 2, 2009, which is a continuation of application No. 09/929,236, filed on Aug. 13, 2001, now Pat. No. 7,610,836, application No. 12/800,607, which is a continuation of application No. 11/811,719, filed on Jun. 11, 2007, now Pat. No. 7,832,314, which is a continuation of application No. 11/061,162, filed on Feb. 18, 2005, now Pat. No. 7,228,772, which is a continuation of application No. 09/929,244, filed on Aug. 13, 2001, now Pat. No. 6,857,345, application No. 12/800,607, which is a continuation of application No. 12/587,695, filed on Oct. 9, 2009, which is a continuation of application No. 09/929,237, filed on Aug. 13, 2001, now Pat. No. 7,600,455, application No. 12/800,607, which is a continuation of application No. 12/661,766, filed on Mar. 22, 2010, which is a continuation of application No. 11/810,196, filed on Jun. 4, 2007, now Pat. No. 7,681,479, which is a continuation of application No. 09/929,234, filed on Aug. 13, 2001, now Pat. No. 7,225,712, application No. 12/800,607, which is a continuation of application No. 12/655,694, filed on Jan. 4, 2010, which is a continuation of application No. 12/079,836, filed on Mar. 27, 2008, now Pat. No. 7,640,837, which is a continuation of application No. 09/929,235, filed on Aug. 13, 2001, now Pat. No. 7,350,444, said application No. 12/800,607 is a continuation of application No. 12/799,211, filed on Apr. 19, 2010, which is a continuation of application No. 12/220,946, filed on Jul. 29, 2008, now Pat. No. 7,698,976, which is a continuation of application No. 09/929,238, filed on Aug. 13, 2001, now abandoned, application No. 12/800,607, which is a continuation of application No. 12/288,578, filed on Oct. 21, 2008, now abandoned, which is a continuation of application No. 11/447,449, filed on Jun. 5, 2006, now abandoned, which is a continuation of application No. 09/676,190, filed on Sep. 29, 2000, now Pat. No. 7,055,417, application No. 12/800,607, which is a continuation of application No. 12/590,924, filed on Nov. 16, 2009, which is a continuation of application No. 12/154,675, filed on May 23, 2008, now Pat. No. 7,617,752, which is a continuation of application No. 10/053,390, filed on Jan. 16, 2002, now Pat. No. 7,377,199, which is a continuation-in-part of application No. 09/676,190, filed on Sep. 29, 2000, now Pat. No. 7,055,417, application No. 12/800,607, which is a continuation of application No. 12/313,162, filed on Nov. 17, 2008, now Pat. No. 7,789,002, which is a continuation of application No. 11/348,580, filed on Feb. 6, 2006, now abandoned, which is a continuation of application No. 10/052,705, filed on Jan. 16, 2002, now Pat. No. 6,994,004, said application No. 12/313,162 is a continuation of application No. 11/098,984, filed on Apr. 4, 2005, now Pat. No. 7,353,737, which is a continuation of application No. 09/929,238, filed on Aug. 13, 2001, now abandoned, and a continuation of application No. 10/047,066, filed on Jan. 14, 2002, now Pat. No. 6,945,148, and a continuation of application No. 10/051,782,

filed on Jan. 15, 2002, now Pat. No. 6,877,410, application No. 12/800,607, which is a continuation of application No. 12/661,993, filed on Mar. 26, 2010, which is a continuation of application No. 11/982,972, filed on Nov. 5, 2007, now Pat. No. 7,685,912, which is a continuation of application No. 10/932,339, filed on Sep. 1, 2004, now Pat. No. 7,290,472, which is a continuation of application No. 10/047,066, filed on Jan. 14, 2002, now Pat. No. 6,945,148, application No. 10/932,339, which is a continuation of application No. 10/050,085, filed on Jan. 14, 2002, now abandoned, application No. 12/800,607, which is a continuation of application No. 10/100,211, filed on Mar. 13, 2002, application No. 12/800,607, which is a continuation of application No. 11/256,757, filed on Oct. 24, 2005, which is a continuation of application No. 09/955,418, filed on Sep. 17, 2001, now Pat. No. 6,957,601, application No. 12/800,607, which is a continuation of application No. 10/146,527, filed on May 15, 2002, application No. 12/800,607, which is a continuation of application No. 12/586,469, filed on Sep. 21, 2009, which is a continuation of application No. 11/702,330, filed on Feb. 5, 2007, now Pat. No. 7,591,210, which is a continuation of application No. 10/189,031, filed on Jul. 2, 2002, now Pat. No. 7,171,879, application No. 12/800,607, which is a continuation of application No. 11/208,214, filed on Aug. 19, 2005, now Pat. No. 7,784,507, which is a continuation of application No. 10/251,576, filed on Sep. 20, 2002, now abandoned, which is a continuation of application No. 10/197,975, filed on Jul. 18, 2002, now abandoned, said application No. 11/208,214 is a continuation of application No. 09/676,190, filed on Sep. 29, 2000, now Pat. No. 7,055,417, application No. 12/800,607, which is a continuation of application No. 12/231,080, filed on Aug. 29, 2008, which is a continuation of application No. 11/487,717, filed on Jul. 17, 2006, now Pat. No. 7,421,315, which is a continuation of application No. 10/292,607, filed on Nov. 12, 2002, now Pat. No. 7,077,039, application No. 12/800,607, which is a continuation of application No. 12/655,962, filed on Jan. 11, 2010, which is a continuation of application No. 12/313,277, filed on Nov. 17, 2008, now Pat. No. 7,644,645, which is a continuation of application No. 10/345,630, filed on Jan. 15, 2003, now abandoned, application No. 12/800,607, which is a continuation of application No. 12/658,759, filed on Feb. 12, 2010, which is a continuation of application No. 11/787,471, filed on Apr. 17, 2007, now Pat. No. 7,661,343, which is a continuation of application No. 10/341,260, filed on Jan. 13, 2003, now abandoned, application No. 12/800,607, which is a continuation of application No. 11/647,676, filed on Dec. 29, 2006, now Pat. No. 7,836,804, which is a continuation of application No. 10/923,290, filed on Aug. 20, 2004, now Pat. No. 7,472,634, application No. 12/800,607, which is a continuation of application No. 12/079,820, filed on Mar. 27, 2008, now Pat. No. 7,485,258, which is a continuation of application No. 10/923,273, filed on Aug. 20, 2004, now Pat. No. 7,350,445, application No. 12/800,607, which is a continuation of application No. 12/454,569, filed on May 18, 2009, which is a continuation of application No. 11/027,600, filed on Dec. 31, 2004, now Pat. No. 7,536,238, application No. 12/800,607, which is a continuation of application No. 12/799,915, filed on May 3, 2010, which is a continuation of application No. 12/322,069, filed on Jan. 26, 2009, now Pat. No. 7,707,918, which is a continuation of application No. 11/107,499, filed on Apr. 15, 2005, now Pat. No. 7,481,140, application No. 12/800,607, which is a continuation of application No. 12/077,576, filed on Mar. 19, 2008, which is a continuation of application No. 11/027,254, filed on Dec. 31, 2004, now abandoned, application No. 12/800,607, which is a continuation of application No. 12/799,920, filed on May 3, 2010, which is a continuation of application No. 11/026,114, filed on Dec. 31, 2004, now Pat. No. 7,707,920, application No. 12/800,607, which is a continuation of application No. 11/026,006, filed on Dec. 31, 2004, application No. 12/800,607, which is a continuation of application No. 11/045,972, filed on Jan. 28, 2005, now Pat. No. 7,827,890, application No. 12/800,607, which is a continuation of application No. 12/454,730, filed on May 20, 2009, which is a continuation of application No. 11/395,502, filed on Mar. 31, 2006, now abandoned.

(60) filed on Aug. 14, 2000, provisional application No. 60/225,170, filed on Aug. 14, 2000, provisional application No. 60/225,056, filed on Aug. 14, 2000, provisional application No. 60/225,169, filed on Aug. 14, 2000, provisional application No. 60/225,210, filed on Aug. 14, 2000, provisional application No. 60/298,207, filed on Jun. 13, 2001, provisional application No. 60/302,916, filed on Jul. 3, 2001, provisional application No. 60/324,729, filed on Sep. 24, 2001, provisional application No. 60/406,138, filed on Aug. 27, 2002, provisional application No. 60/452,159, filed on Mar. 5, 2003, provisional application No. 60/225,206, filed on Aug. 14, 2000, provisional application No. 60/225,056, filed on Aug. 14, 2000, provisional application No. 60/225,089, filed on Aug. 14, 2000, provisional application No. 60/279,313, filed on Mar. 27, 2001, provisional application No. 60/270,942, filed on Feb. 22, 2001, provisional application No. 60/307,756, filed on Jul. 25, 2001, provisional application No. 60/308,492, filed on Jul. 27, 2001, provisional application No. 60/312,141, filed on Aug. 13, 2001, provisional application No. 60/533,598, filed on Dec. 31, 2003, provisional application No. 60/496,568, filed on Aug. 20, 2003, provisional application No. 60/225,201, filed on Aug. 14, 2000, provisional application No. 60/225,212, filed on Aug. 14, 2000, provisional application No. 60/225,059, filed on Aug. 14, 2000, provisional application No. 60/225,094, filed on Aug. 14, 2000, provisional application No. 60/225,058, filed on Aug. 14, 2000, provisional application No. 60/225,057, filed on Aug. 14, 2000, provisional application No. 60/182,866, filed on Feb. 16, 2000, provisional application No. 60/157,340, filed on Oct. 1, 1999, provisional application No. 60/270,011, filed on Feb. 20, 2001, provisional application No. 60/270,941, filed on Feb. 22, 2001, provisional application No. 60/270,942, filed on Feb. 22, 2001, provisional application No. 60/273,177, filed on Mar. 2, 2001, provisional application No. 60/273,178, filed on Mar. 2, 2001, provisional application No. 60/667,485, filed on Mar. 31, 2005, provisional application No. 60/273,902, filed on Mar. 6, 2001, provisional application No. 60/275,583, filed on Mar. 13, 2001, provisional appli-

cation No. 60/233,459, filed on Sep. 18, 2000, provisional application No. 60/275,594, filed on Mar. 13, 2001, provisional application No. 60/275,595, filed on Mar. 13, 2001, provisional application No. 60/279,313, filed on Mar. 27, 2001, provisional application No. 60/292,081, filed on May 17, 2001, provisional application No. 60/292,100, filed on May 17, 2001, provisional application No. 60/298,207, filed on Jun. 13, 2001, provisional application No. 60/302,937, filed on Jul. 2, 2001, provisional application No. 60/302,916, filed on Jul. 3, 2001, provisional application No. 60/306,202, filed on Jul. 18, 2001, provisional application No. 60/307,756, filed on Jul. 25, 2001, provisional application No. 60/308,492, filed on Jul. 27, 2001, provisional application No. 60/312,141, filed on Aug. 13, 2001, provisional application No. 60/292,100, filed on May 17, 2001, provisional application No. 60/302,937, filed on Jul. 2, 2001, provisional application No. 60/323,975, filed on Sep. 21, 2001, provisional application No. 60/157,340, filed on Oct. 1, 1999, provisional application No. 60/182,866, filed on Feb. 16, 2000, provisional application No. 60/335,970, filed on Nov. 13, 2001, provisional application No. 60/349,989, filed on Jan. 16, 2002, provisional application No. 60/351,797, filed on Jan. 25, 2002, provisional application No. 60/496,550, filed on Aug. 20, 2003, provisional application No. 60/496,574, filed on Aug. 20, 2003, provisional application No. 60/533,791, filed on Dec. 31, 2003, provisional application No. 60/533,852, filed on Dec. 31, 2003, provisional application No. 60/533,811, filed on Dec. 31, 2003, provisional application No. 60/533,575, filed on Dec. 31, 2003, provisional application No. 60/540,377, filed on Jan. 29, 2004, provisional application No. 60/667,485, filed on Mar. 31, 2005.

(56) **References Cited**

U.S. PATENT DOCUMENTS

162,814	A	5/1875	Graves et al.
261,090	A	7/1882	Grill
264,412	A	9/1882	Kuhlmann
299,480	A	5/1884	Kuhlman et al.
302,041	A	7/1884	Sill
307,112	A	10/1884	Groff
509,253	A	11/1893	Shields
545,504	A	9/1895	Hoover
869,513	A	10/1907	Pfeil
941,726	A	11/1909	Pfalzgraf
982,312	A	1/1911	Swafford
997,720	A	7/1911	Troupenat
1,037,843	A	9/1912	Ackley
1,050,649	A	1/1913	Harrold et al.
1,054,558	A	2/1913	Jones
1,074,198	A	9/1913	Phillips
1,082,870	A	12/1913	Humason
1,101,515	A	6/1914	Adam
1,126,970	A	2/1915	Folmer
1,132,129	A	3/1915	Stevens
1,148,169	A	7/1915	Howe
1,154,209	A	9/1915	Rushton
1,205,246	A	11/1916	Mowry
1,228,047	A	5/1917	Reinhold
1,240,430	A	9/1917	Erickson
1,244,187	A	10/1917	Frisbie
1,255,886	A	2/1918	Jones
1,258,961	A	3/1918	Tattersall
1,311,508	A	7/1919	Harrold
1,324,136	A	12/1919	Turner
1,381,612	A	6/1921	Anderson
1,397,606	A	11/1921	Smith
15,262	A	1/1922	Gurgel
1,427,005	A	8/1922	McMichael
1,430,983	A	10/1922	Granberg
1,450,906	A	4/1923	Anderson
1,464,924	A	8/1923	Drummond
1,465,224	A	8/1923	Lantz
1,492,145	A	4/1924	Talley
1,496,212	A	6/1924	French
1,511,797	A	10/1924	Berghold
1,526,128	A	2/1925	Flohr
1,527,587	A	2/1925	Hutchinson
1,551,900	A	9/1925	Morrow
1,553,996	A	9/1925	Federer
1,582,483	A	4/1926	Runyan
1,584,086	A	5/1926	Fonda
1,590,988	A	6/1926	Campbell
1,600,604	A	6/1926	Sorlien
1,616,478	A	2/1927	Watson
1,640,517	A	8/1927	Procknow
1,662,372	A	3/1928	Ward
1,668,061	A	5/1928	Falkins
1,701,948	A	2/1929	Crowe
1,711,490	A	5/1929	Dummond
1,712,828	A	5/1929	Klehm
1,774,521	A	9/1930	Neighbour
1,807,120	A	5/1931	Lewis
1,811,066	A	6/1931	Tannewitz
1,879,280	A	9/1932	James
1,896,924	A	2/1933	Ulrich
1,902,270	A	3/1933	Tate
1,904,005	A	4/1933	Masset
1,910,651	A	5/1933	Tautz
1,938,548	A	12/1933	Tautz
1,938,549	A	12/1933	Tautz
1,963,688	A	6/1934	Tautz
1,988,102	A	1/1935	Woodward
1,993,219	A	3/1935	Merrigan
2,007,887	A	7/1935	Tautz
2,010,851	A	8/1935	Dummond
2,020,222	A	11/1935	Tautz
2,038,810	A	4/1936	Tautz
2,044,481	A	6/1936	Manley et al.
2,075,282	A	3/1937	Hedgpeth
2,095,330	A	10/1937	Hedgpeth
2,106,288	A	1/1938	Tautz
2,106,321	A	1/1938	Guertin
2,121,069	A	6/1938	Collins
2,131,492	A	9/1938	Ocenasek
2,163,320	A	6/1939	Hammond
2,168,282	A	8/1939	Tautz
2,241,556	A	5/1941	MacMillin et al.
2,261,696	A	11/1941	Ocenasek
2,265,407	A	12/1941	Tautz
2,286,589	A	6/1942	Tannewitz
2,292,872	A	8/1942	Eastman
2,299,262	A	10/1942	Uremovich
2,312,118	A	2/1943	Neisewander
2,313,686	A	3/1943	Uremovich
2,328,244	A	8/1943	Woodward
2,352,235	A	6/1944	Tautz
2,377,265	A	3/1945	Rady
2,392,486	A	1/1946	Larsen
2,402,232	A	6/1946	Baker
2,425,331	A	8/1947	Kramer
2,434,174	A	1/1948	Morgan
2,452,589	A	11/1948	McWhirter et al.
2,466,325	A	4/1949	Ocenasek
2,496,613	A	2/1950	Wooward
2,501,134	A	3/1950	Meckoski et al.
2,509,813	A	5/1950	Dineen

2,517,649	A	8/1950	Frechtmann
2,518,684	A	8/1950	Harris
2,530,290	A	11/1950	Collins
2,554,124	A	5/1951	Salmont
2,562,396	A	7/1951	Schutz
2,572,326	A	10/1951	Evans
2,590,035	A	3/1952	Pollak
2,593,596	A	4/1952	Olson
2,601,878	A	7/1952	Anderson
2,623,555	A	12/1952	Eschenburg
2,625,966	A	1/1953	Copp
2,626,639	A	1/1953	Hess
2,661,777	A	12/1953	Hitchcock
2,661,780	A	12/1953	Morgan
2,675,707	A	4/1954	Brown
2,678,071	A	5/1954	Odlum et al.
2,690,084	A	9/1954	Van Dam
2,695,638	A	11/1954	Gaskell
2,704,560	A	3/1955	Woessner
2,711,762	A	6/1955	Gaskell
2,719,547	A	10/1955	Gjerde
2,722,246	A	11/1955	Arnoldy
2,731,049	A	1/1956	Akin
2,736,348	A	2/1956	Nelson
2,737,213	A	3/1956	Richards et al.
2,758,615	A	8/1956	Mastriforte
2,785,710	A	3/1957	Mowery, Jr.
2,786,496	A	3/1957	Eschenburg
2,804,890	A	9/1957	Fink
2,810,408	A	10/1957	Boice et al.
2,839,943	A	6/1958	Caldwell et al.
2,844,173	A	7/1958	Gaskell
2,850,054	A	9/1958	Eschenburg
2,852,047	A	9/1958	Odlum et al.
2,873,773	A	2/1959	Gaskell
2,876,809	A	3/1959	Rentsch et al.
2,883,486	A	4/1959	Mason
2,894,546	A	7/1959	Eschenburg
2,913,025	A	11/1959	Richards
2,913,581	A	11/1959	Simonton et al.
2,937,672	A	5/1960	Gjerde
2,945,516	A	7/1960	Edgemond, Jr. et al.
2,954,118	A	9/1960	Anderson
2,957,166	A	10/1960	Gluck
2,978,084	A	4/1961	Vilkaitis
2,984,268	A	5/1961	Vuichard
2,991,593	A	7/1961	Cohen
3,005,477	A	10/1961	Sherwen
3,007,501	A	11/1961	Mundell et al.
3,011,529	A	12/1961	Copp
3,011,610	A	12/1961	Stiebel et al.
3,013,592	A	12/1961	Ambrosio et al.
3,021,881	A	2/1962	Edgemond, Jr. et al.
3,035,995	A	5/1962	Seeley et al.
3,047,116	A	7/1962	Stiebel et al.
3,085,602	A	4/1963	Gaskell
3,105,530	A	10/1963	Peterson
3,129,731	A	4/1964	Tyrrell
3,163,732	A	12/1964	Abbott
3,184,001	A	5/1965	Reinsch et al.
3,186,256	A	6/1965	Reznick
3,207,273	A	9/1965	Jurin
3,213,731	A	10/1965	Renard
3,224,474	A	12/1965	Bloom
3,232,326	A	2/1966	Speer et al.
3,246,205	A	4/1966	Miller
3,249,134	A	5/1966	Vogl et al.
3,274,876	A	9/1966	Debus
3,276,497	A	10/1966	Heer
3,280,861	A	10/1966	Gjerde
3,306,149	A	2/1967	John
3,313,185	A	4/1967	Drake et al.
3,315,715	A	4/1967	Mytinger
3,323,814	A	6/1967	Phillips
3,337,008	A	8/1967	Trachte
3,356,111	A	12/1967	Mitchell
3,368,596	A	2/1968	Comer
3,386,322	A	6/1968	Stone et al.
3,439,183	A	4/1969	Hurst, Jr.
3,445,835	A	5/1969	Fudaley
3,454,286	A	7/1969	Anderson et al.
3,456,696	A	7/1969	Gregory et al.
3,512,440	A	5/1970	Frydmann
3,538,964	A	11/1970	Warrick et al.
3,540,338	A	11/1970	McEwan et al.
3,547,232	A	12/1970	Fergle
3,554,067	A	1/1971	Scutella
3,566,934	A	3/1971	Thrasher
3,566,996	A	3/1971	Crossman
3,580,376	A	5/1971	Loshbough
3,581,784	A	6/1971	Warrick
3,593,266	A	7/1971	Van Sickle
3,613,748	A	10/1971	De Pue
3,621,894	A	11/1971	Niksich
3,648,126	A	3/1972	Boos et al.
3,670,788	A	6/1972	Pollak et al.
3,675,444	A	7/1972	Whipple
3,680,609	A	8/1972	Menge
3,688,815	A	9/1972	Ridenour
3,695,116	A	10/1972	Baur
3,696,844	A	10/1972	Bernatschek
3,716,113	A	2/1973	Kobayashi et al.
3,719,103	A	3/1973	Streander
3,740,000	A	6/1973	Takada
3,745,546	A	7/1973	Struger et al.
3,749,933	A	7/1973	Davidson
3,754,493	A	8/1973	Niehaus et al.
3,772,590	A	11/1973	Mikulecky et al.
3,785,230	A	1/1974	Lokey
3,793,915	A	2/1974	Huier
3,805,639	A	4/1974	Peter
3,805,658	A	4/1974	Scott et al.
3,808,932	A	5/1974	Russell
3,829,850	A	8/1974	Guetersloh
3,829,970	A	8/1974	Anderson
3,858,095	A	12/1974	Friemann et al.
3,861,016	A	1/1975	Johnson et al.
3,863,208	A	1/1975	Balban
3,874,747	A	4/1975	Case et al.
3,880,032	A	4/1975	Green
3,882,744	A	5/1975	McCarroll
3,886,413	A	5/1975	Dow et al.
3,889,567	A	6/1975	Sato et al.
3,905,263	A	9/1975	Smith
3,922,785	A	12/1975	Fushiya
3,924,688	A	12/1975	Cooper et al.
3,931,727	A	1/1976	Luenser
3,935,777	A	2/1976	Bassett
3,942,607	A	3/1976	Sobat
3,945,286	A	3/1976	Smith
3,946,631	A	3/1976	Malm
3,947,734	A	3/1976	Flyer
3,949,636	A	4/1976	Ball et al.
3,953,770	A	4/1976	Hayashi
3,960,310	A	6/1976	Nussbaum
3,967,161	A	6/1976	Lichtblau
3,974,565	A	8/1976	Ellis
3,975,600	A	8/1976	Marston
3,978,624	A	9/1976	Merkel et al.
3,994,192	A	11/1976	Faig
4,007,679	A	2/1977	Edwards
4,016,490	A	4/1977	Weckenmann et al.
4,026,174	A	5/1977	Fierro
4,026,177	A	5/1977	Lokey
4,029,159	A	6/1977	Nymann
4,047,156	A	9/1977	Atkins

4,048,886 A	9/1977	Zettler
4,060,160 A	11/1977	Lieber
4,063,777 A	12/1977	Takada
4,070,940 A	1/1978	McDaniel et al.
4,075,961 A	2/1978	Harris
4,077,161 A	3/1978	Wyle et al.
4,085,303 A	4/1978	McIntyre et al.
4,090,345 A	5/1978	Harkness
4,091,698 A	5/1978	Obear et al.
4,106,378 A	8/1978	Kaiser
4,117,752 A	10/1978	Yoneda
4,145,940 A	3/1979	Woloveke et al.
4,152,833 A	5/1979	Phillips
4,161,649 A	7/1979	Klos et al.
4,175,452 A	11/1979	Idel
4,184,394 A	1/1980	Gjerde
4,190,000 A	2/1980	Shaull et al.
4,195,722 A	4/1980	Anderson et al.
4,199,930 A	4/1980	Lebet et al.
4,200,002 A	4/1980	Takahashi
4,206,666 A	6/1980	Ashton
4,206,910 A	6/1980	Biesemeyer
4,249,117 A	2/1981	Leukhardt et al.
4,249,442 A	2/1981	Fittery
4,251,599 A	2/1981	McCormick
4,255,995 A	3/1981	Connor
4,262,278 A	4/1981	Howard et al.
4,267,914 A	5/1981	Saar
4,270,427 A	6/1981	Colberg et al.
4,276,459 A	6/1981	Willett et al.
4,276,799 A	7/1981	Muehling
4,291,794 A	9/1981	Bauer
4,305,442 A	12/1981	Currie
4,319,146 A	3/1982	Wires, Sr.
4,321,841 A	3/1982	Felix
4,334,450 A	6/1982	Benuzzi
4,351,423 A	9/1982	Rogier
4,372,202 A	2/1983	Cameron
4,372,427 A	2/1983	Rogier
4,374,552 A	2/1983	Dayen
4,385,539 A	5/1983	Meyerhoefer et al.
4,391,358 A	7/1983	Haeger
4,418,597 A	12/1983	Krusemark et al.
4,427,042 A	1/1984	Mitchell et al.
4,453,112 A	6/1984	Sauer et al.
4,466,170 A	8/1984	Davis
4,466,233 A	8/1984	Thesman
4,470,046 A	9/1984	Betsill
4,492,291 A	1/1985	Chometon et al.
4,503,739 A	3/1985	Konieczka
4,510,489 A	4/1985	Anderson, III et al.
4,512,224 A	4/1985	Terauchi
4,518,043 A	5/1985	Anderson et al.
4,532,501 A	7/1985	Hoffman
4,532,844 A	8/1985	Chang et al.
4,557,168 A	12/1985	Tokiwa
4,559,858 A	12/1985	Laskowski et al.
4,560,033 A	12/1985	DeWoody et al.
4,566,512 A	1/1986	Wilson
4,573,556 A	3/1986	Andreasson
4,576,073 A	3/1986	Stinson
4,589,047 A	5/1986	Gaus et al.
4,589,860 A	5/1986	Brandenstein et al.
4,599,597 A	7/1986	Rotbart
4,599,927 A	7/1986	Eccardt et al.
4,606,251 A	8/1986	Boileau
4,615,247 A	10/1986	Berkeley
4,621,300 A	11/1986	Summerer
4,625,604 A	12/1986	Handler et al.
4,637,188 A	1/1987	Crothers
4,637,289 A	1/1987	Ramsden
4,644,832 A	2/1987	Smith
4,653,189 A	3/1987	Andreasson
4,657,428 A	4/1987	Wiley
4,661,797 A	4/1987	Schmall
4,672,500 A	6/1987	Tholome et al.
4,675,664 A	6/1987	Cloutier et al.
4,679,719 A	7/1987	Kramer
4,694,721 A	9/1987	Brickner, Jr.
4,718,229 A	1/1988	Riley
4,721,023 A	1/1988	Bartlett et al.
4,722,021 A	1/1988	Hornung et al.
4,751,603 A	6/1988	Kwan
4,756,220 A	7/1988	Olsen et al.
4,757,881 A	7/1988	Jonsson et al.
4,774,866 A	10/1988	Dehari et al.
4,792,965 A	12/1988	Morgan
4,805,504 A	2/1989	Fushiya et al.
4,805,505 A	2/1989	Cantlin
4,831,279 A	5/1989	Ingraham
4,840,135 A	6/1989	Yamauchi
4,845,476 A	7/1989	Rangeard et al.
4,864,455 A	9/1989	Shimomura et al.
4,875,398 A	10/1989	Taylor et al.
4,888,869 A	12/1989	Leatherman
4,896,607 A	1/1990	Hall et al.
4,906,962 A	3/1990	Duimstra
4,907,679 A	3/1990	Menke
4,934,233 A	6/1990	Brundage et al.
4,936,876 A	6/1990	Reyes
4,937,554 A	6/1990	Herman
4,962,685 A	10/1990	Hagstrom
4,964,450 A	10/1990	Hughes et al.
4,965,909 A	10/1990	McCullough et al.
4,969,063 A	11/1990	Scott et al.
4,975,798 A	12/1990	Edwards et al.
5,020,406 A	6/1991	Sasaki et al.
5,025,175 A	6/1991	Dubois, III
5,042,348 A	8/1991	Brundage et al.
5,046,426 A	9/1991	Julien et al.
5,052,255 A	10/1991	Gaines
5,074,047 A	12/1991	King
5,081,406 A	1/1992	Hughes et al.
5,082,316 A	1/1992	Wardlaw
5,083,973 A	1/1992	Townsend
5,086,890 A	2/1992	Turczyn et al.
5,094,000 A	3/1992	Becht et al.
5,116,249 A	5/1992	Shiotani et al.
5,119,555 A	6/1992	Johnson
5,122,091 A	6/1992	Townsend
5,123,317 A	6/1992	Barnes, Jr. et al.
5,146,714 A	9/1992	Liiber
5,156,508 A	10/1992	Grisley
5,174,349 A	12/1992	Svetlik et al.
5,184,534 A	2/1993	Lee
5,198,702 A	3/1993	McCullough et al.
5,199,343 A	4/1993	OBanion
5,201,110 A	4/1993	Bane
5,201,684 A	4/1993	DeBois, III
5,201,863 A	4/1993	Peot
5,206,625 A	4/1993	Davis
5,207,253 A	5/1993	Hoshino et al.
5,212,621 A	5/1993	Panter
5,218,189 A	6/1993	Hutchison
5,230,269 A	7/1993	Shiotani et al.
5,231,359 A	7/1993	Masuda et al.
5,231,906 A	8/1993	Kogej
5,239,978 A	8/1993	Plangetis
5,245,879 A	9/1993	McKeon
5,257,570 A	11/1993	Shiotani et al.
5,265,510 A	11/1993	Hoyer-Ellefsen
5,272,946 A	12/1993	McCullough et al.
5,276,431 A	1/1994	Piccoli et al.
5,285,708 A	2/1994	Bosten et al.
5,293,802 A	3/1994	Shiontani et al.
5,320,382 A	6/1994	Goldstein et al.

5,321,230	A	6/1994	Shanklin et al.
5,331,875	A	7/1994	Mayfield
5,353,670	A	10/1994	Metzger, Jr.
5,377,554	A	1/1995	Reulein et al.
5,377,571	A	1/1995	Josephs
5,392,568	A	2/1995	Howard, Jr. et al.
5,392,678	A	2/1995	Sasaki et al.
5,401,928	A	3/1995	Kelley
5,411,221	A	5/1995	Collins et al.
5,423,232	A	6/1995	Miller et al.
5,436,613	A	7/1995	Ghosh et al.
5,447,085	A	9/1995	Gochnauer
5,451,750	A	9/1995	An
5,453,903	A	9/1995	Chow
5,471,888	A	12/1995	McCormick
5,480,009	A	1/1996	Wieland et al.
5,503,059	A	4/1996	Pacholok
5,510,587	A	4/1996	Reiter
5,510,685	A	4/1996	Grasselli
5,513,548	A	5/1996	Garuglieri
5,531,147	A	7/1996	Serban
5,534,836	A	7/1996	Schenkel et al.
5,572,916	A	11/1996	Takano
5,587,618	A	12/1996	Hathaway
5,592,353	A	1/1997	Shinohara et al.
5,606,889	A	3/1997	Bielinski et al.
5,619,896	A	4/1997	Chen
5,623,860	A	4/1997	Schoene et al.
5,647,258	A	7/1997	Brazell et al.
5,648,644	A	7/1997	Nagel
5,659,454	A	8/1997	Vermesse
5,667,152	A	9/1997	Mooring
5,671,633	A	9/1997	Wagner
5,695,306	A	12/1997	Nygren, Jr.
5,700,165	A	12/1997	Harris et al.
5,720,213	A	2/1998	Sberveglieri
5,722,308	A	3/1998	Ceroll et al.
5,724,875	A	3/1998	Meredith et al.
5,730,165	A	3/1998	Philipp
5,741,048	A	4/1998	Eccleston
5,755,148	A	5/1998	Stumpf et al.
5,768,786	A	6/1998	Kane et al.
5,771,742	A	6/1998	Bokaie et al.
5,782,001	A	7/1998	Gray
5,787,779	A	8/1998	Garuglieri
5,791,057	A	8/1998	Nakamura et al.
5,791,223	A	8/1998	Lanzer
5,791,224	A	8/1998	Suzuki et al.
5,791,441	A	8/1998	Matos et al.
5,797,307	A	8/1998	Horton
5,819,619	A	10/1998	Miller et al.
5,819,625	A	10/1998	Sberveglieri
5,852,951	A	12/1998	Santi
5,857,507	A	1/1999	Puzio et al.
5,861,809	A	1/1999	Eckstein et al.
5,875,698	A	3/1999	Ceroll et al.
5,880,954	A	3/1999	Thomson et al.
5,921,367	A	7/1999	Kashioka et al.
5,927,857	A	7/1999	Ceroll et al.
5,930,096	A	7/1999	Kim
5,937,720	A	8/1999	Itzov
5,942,975	A	8/1999	Sorensen
5,943,932	A	8/1999	Sberveglieri
5,950,514	A	9/1999	Benedict et al.
5,963,173	A	10/1999	Lian et al.
5,974,927	A	11/1999	Tsune
5,989,116	A	11/1999	Johnson et al.
6,009,782	A	1/2000	Tajima et al.
6,018,284	A	1/2000	Rival et al.
6,037,729	A	3/2000	Woods et al.
D422,290	S	4/2000	Welsh et al.
6,050,174	A	4/2000	Schonlau et al.
6,052,884	A	4/2000	Steckler et al.
6,062,121	A	5/2000	Ceroll et al.
6,070,484	A	6/2000	Sakamaki
6,095,092	A	8/2000	Chou
6,109,157	A	8/2000	Talesky
6,112,785	A	9/2000	Yu
6,119,984	A	9/2000	Devine
6,131,629	A	10/2000	Puzio et al.
6,133,818	A	10/2000	Shieh et al.
6,141,192	A	10/2000	Garzon
6,148,504	A	11/2000	Schmidt et al.
6,148,526	A	11/2000	Kirn et al.
6,148,703	A	11/2000	Ceroll et al.
6,150,826	A	11/2000	Hokodate et al.
6,161,459	A	12/2000	Ceroll et al.
6,170,370	B1	1/2001	Sommerville
6,244,149	B1	6/2001	Ceroll et al.
6,250,190	B1	6/2001	Ceroll et al.
6,257,061	B1	7/2001	Nonoyama et al.
6,283,002	B1	9/2001	Chiang
6,295,910	B1	10/2001	Childs et al.
6,312,028	B1	11/2001	Wilkosz
6,325,195	B1	12/2001	Doherty
6,330,848	B1	12/2001	Nishio et al.
6,336,273	B1	1/2002	Nilsson et al.
6,352,137	B1	3/2002	Stegall et al.
6,357,328	B1	3/2002	Ceroll et al.
6,361,092	B1	3/2002	Eagle et al.
6,366,099	B1	4/2002	Reddi
6,376,939	B1	4/2002	Suzuki et al.
6,404,098	B1	6/2002	Kayama et al.
6,405,624	B2	6/2002	Sutton
6,418,829	B1	7/2002	Pilchowski
6,420,814	B1	7/2002	Bobbio
6,427,570	B1	8/2002	Miller et al.
6,430,007	B1	8/2002	Jabbari
6,431,425	B1	8/2002	Moorman et al.
6,450,077	B1	9/2002	Ceroll et al.
6,453,786	B1	9/2002	Ceroll et al.
6,460,442	B2	10/2002	Talesky et al.
6,471,106	B1	10/2002	Reining
6,479,958	B1	11/2002	Thompson et al.
6,484,614	B1	11/2002	Huang
D466,913	S	12/2002	Ceroll et al.
6,492,802	B1	12/2002	Bielski
D469,354	S	1/2003	Curtsinger
6,502,493	B1	1/2003	Eccardt et al.
6,530,303	B1	3/2003	Parks et al.
6,536,536	B1	3/2003	Gass et al.
6,543,324	B2	4/2003	Dils
6,546,835	B2	4/2003	Wang
6,564,909	B1	5/2003	Razzano
6,575,067	B2	6/2003	Parks et al.
6,578,460	B2	6/2003	Sartori
6,578,856	B2	6/2003	Kahle
6,581,655	B2	6/2003	Huang
6,595,096	B2	7/2003	Ceroll et al.
D478,917	S	8/2003	Ceroll et al.
6,601,493	B1	8/2003	Crofutt
6,607,015	B1	8/2003	Chen
D479,538	S	9/2003	Welsh et al.
6,617,720	B1	9/2003	Egan, III et al.
6,619,348	B2	9/2003	Wang
6,640,683	B2	11/2003	Lee
6,644,157	B2	11/2003	Huang
6,647,847	B2	11/2003	Hewitt et al.
6,659,233	B2	12/2003	DeVlieg
6,684,750	B2	2/2004	Yu
6,722,242	B2	4/2004	Chuang
6,734,581	B1	5/2004	Griffis
6,736,042	B2	5/2004	Behne et al.
6,742,430	B2	6/2004	Chen
6,796,208	B1	9/2004	Jorgensen
6,800,819	B2	10/2004	Sato et al.

6,826,988	B2	12/2004	Gass et al.	
6,826,992	B1	12/2004	Huang	
6,840,144	B2	1/2005	Huang	
6,854,371	B2	2/2005	Yu	
6,857,345	B2	2/2005	Gass et al.	
6,874,397	B2	4/2005	Chang	
6,874,399	B2	4/2005	Lee	
6,877,410	B2	4/2005	Gass et al.	
6,880,440	B2	4/2005	Gass et al.	
6,883,397	B2	4/2005	Kimizuka	
6,889,585	B1	5/2005	Harris et al.	
6,920,814	B2	7/2005	Gass et al.	
6,922,153	B2	7/2005	Pierga et al.	
6,945,148	B2	9/2005	Gass et al.	
6,945,149	B2	9/2005	Gass et al.	
6,957,601	B2	10/2005	Gass et al.	
6,968,767	B2	11/2005	Yu	
6,986,370	B1	1/2006	Schoene et al.	
6,994,004	B2	2/2006	Gass et al.	
6,997,090	B2	2/2006	Gass et al.	
7,000,514	B2	2/2006	Gass et al.	
7,024,975	B2	4/2006	Gass et al.	
7,055,417	B1	6/2006	Gass et al.	
7,077,039	B2	7/2006	Gass et al.	
7,098,800	B2	8/2006	Gass	
7,100,483	B2	9/2006	Gass et al.	
7,137,326	B2	11/2006	Gass et al.	
7,171,879	B2	2/2007	Gass et al.	
7,197,969	B2	4/2007	Gass et al.	
7,210,383	B2	5/2007	Gass et al.	
7,357,056	B2	4/2008	Gass et al.	
7,373,863	B2	5/2008	O'Banion et al.	
7,509,899	B2 *	3/2009	Gass et al.	83/62.1
7,827,889	B2 *	11/2010	Carrier	83/DIG. 1
2001/0032534	A1	10/2001	Ceroll et al.	
2002/0017175	A1	2/2002	Gass et al.	
2002/0017176	A1	2/2002	Gass et al.	
2002/0017178	A1	2/2002	Gass et al.	
2002/0017179	A1	2/2002	Gass et al.	
2002/0017180	A1	2/2002	Gass et al.	
2002/0017181	A1	2/2002	Gass et al.	
2002/0017182	A1	2/2002	Gass et al.	
2002/0017183	A1	2/2002	Gass et al.	
2002/0017184	A1	2/2002	Gass et al.	
2002/0017336	A1	2/2002	Gass et al.	
2002/0020261	A1	2/2002	Gass et al.	
2002/0020262	A1	2/2002	Gass et al.	
2002/0020263	A1	2/2002	Gass et al.	
2002/0020265	A1	2/2002	Gass et al.	
2002/0020271	A1	2/2002	Gass et al.	
2002/0043776	A1	4/2002	Chuang	
2002/0050201	A1	5/2002	Lane et al.	
2002/0056348	A1	5/2002	Gass et al.	
2002/0056349	A1	5/2002	Gass et al.	
2002/0056350	A1	5/2002	Gass et al.	
2002/0059853	A1	5/2002	Gass et al.	
2002/0059854	A1	5/2002	Gass et al.	
2002/0069734	A1	6/2002	Gass et al.	
2002/0088325	A1	7/2002	Talesky et al.	
2002/0096030	A1	7/2002	Wang	
2002/0096591	A1	7/2002	Tanji	
2002/0109036	A1	8/2002	Denen et al.	
2002/0134212	A1	9/2002	Ceroll et al.	
2002/0170399	A1	11/2002	Gass et al.	
2002/0170400	A1	11/2002	Gass	
2002/0174755	A1	11/2002	Behne et al.	
2002/0190581	A1	12/2002	Gass et al.	
2003/0000359	A1	1/2003	Eccardt et al.	
2003/0002942	A1	1/2003	Gass et al.	
2003/0005588	A1	1/2003	Gass et al.	
2003/0015253	A1	1/2003	Gass et al.	
2003/0019341	A1	1/2003	Gass et al.	
2003/0020336	A1	1/2003	Gass et al.	
2003/0037651	A1	2/2003	Gass et al.	
2003/0037655	A1	2/2003	Chin-Chin	
2003/0056853	A1	3/2003	Gass et al.	
2003/0058121	A1	3/2003	Gass et al.	
2003/0074873	A1	4/2003	Freiberg et al.	
2003/0089212	A1	5/2003	Parks et al.	
2003/0090224	A1	5/2003	Gass et al.	
2003/0101857	A1	6/2003	Chuang	
2003/0109798	A1	6/2003	Kermani	
2003/0131703	A1	7/2003	Gass et al.	
2003/0140749	A1	7/2003	Gass et al.	
2003/0213349	A1	11/2003	Chang	
2004/0011177	A1	1/2004	Huang	
2004/0040426	A1	3/2004	Gass et al.	
2004/0060404	A1	4/2004	Metzger, Jr.	
2004/0103544	A1	6/2004	Hartmann	
2004/0104085	A1	6/2004	Lang et al.	
2004/0118261	A1	6/2004	Garcia et al.	
2004/0159198	A1	8/2004	Peot et al.	
2004/0194594	A1	10/2004	Dils et al.	
2004/0200329	A1	10/2004	Sako	
2004/0226424	A1	11/2004	O'Banion et al.	
2004/0226800	A1	11/2004	Pierga et al.	
2004/0255745	A1	12/2004	Peot et al.	
2005/0057206	A1	3/2005	Uneyama	
2005/0066784	A1	3/2005	Gass	
2005/0087049	A1	4/2005	Miller et al.	
2005/0092149	A1	5/2005	Hartmann	
2005/0139051	A1	6/2005	Gass et al.	
2005/0139056	A1	6/2005	Gass et al.	
2005/0139057	A1	6/2005	Gass et al.	
2005/0139058	A1	6/2005	Gass et al.	
2005/0139459	A1	6/2005	Gass et al.	
2005/0155473	A1	7/2005	Gass	
2005/0166736	A1	8/2005	Gass et al.	
2005/0178259	A1	8/2005	Gass et al.	
2005/0204885	A1	9/2005	Gass et al.	
2005/0211034	A1	9/2005	Sasaki et al.	
2005/0235793	A1	10/2005	O'Banion et al.	
2005/0268767	A1	12/2005	Pierga et al.	
2005/0274432	A1	12/2005	Gass et al.	
2006/0000337	A1	1/2006	Gass	
2006/0032352	A1	2/2006	Gass et al.	
2006/0096425	A1	5/2006	Keller	
2006/0123960	A1	6/2006	Gass et al.	
2006/0123964	A1	6/2006	Gass et al.	
2006/0179983	A1	8/2006	Gass et al.	
2006/0219076	A1	10/2006	Gass et al.	
2006/0225551	A1	10/2006	Gass	
2006/0230896	A1	10/2006	Gass	
2006/0247795	A1	11/2006	Gass et al.	
2006/0254401	A1	11/2006	Gass et al.	
2006/0272463	A1	12/2006	Gass	
2007/0028733	A1	2/2007	Gass	
2007/0199622	A1 *	8/2007	Gass et al.	192/129 R
2008/0016998	A1	1/2008	Keller	
2008/0078470	A1 *	4/2008	O'Branion et al.	700/90

FOREIGN PATENT DOCUMENTS

CH	297525	6/1954
DE	76186	8/1921
DE	2917497	4/1979
DE	2800403	7/1979
DE	3427733	1/1986
DE	4205965 C1	2/1992
DE	4235161	5/1993
DE	4326313	2/1995
DE	19609771	6/1998
DE	20102704	2/2001
EP	146460	11/1988
EP	0362937	4/1990
ES	2152184	1/2001

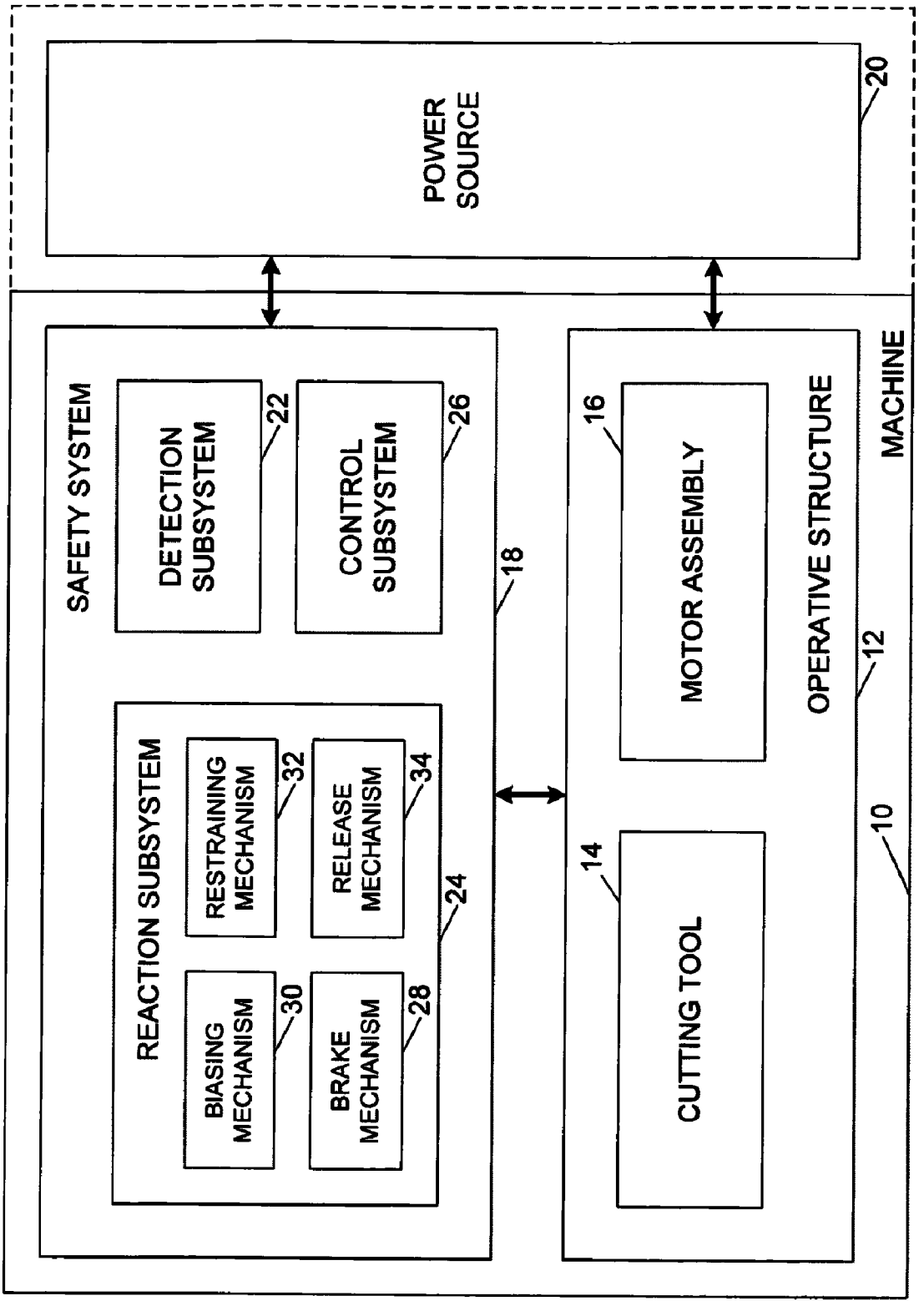
FR	2556643	6/1985
FR	2570017	3/1986
GB	598204	2/1948
GB	1132708	11/1968
GB	2096844	10/1982
GB	2142571	1/1985
JP	06328359	11/1994
WO	WO 01/26064	4/2001

OTHER PUBLICATIONS

Skil Model 3400-Type 1 10" Table Saw Parts List and Technical Bulletin, S-B Power Tool Company, Jun. 1993.
Shop Fox® Fence Operating Manual, Woodstock International, Inc., 1996, revised May 1997.
Gordon Engineering Corp., Product Catalog, pp. cover, 1, 3 and back, Brookfield, Connecticut, US, Oct. 1997.
Analog Devices, Inc., 3-Axis Capacitive Sensor—Preliminary Technical Data AD7103, pp. 1-40, © 1998.
Provisional U.S. Appl. No. 60/157,340, filed Oct. 1, 1999, entitled "Fast-Acting Safety Stop."
U.S. Appl. No. 60/182,866, filed Feb. 16, 2000, entitled "Fast-Acting Safety Stop."
IWF 2000 Challengers Award Official Entry Form, submitted Apr. 26, 2000, 6 pages plus CD (the portions of U.S. patent applications referenced in the form are from U.S. Appl. No. 60/157,340, filed Oct. 1, 1999 and U.S. Appl. No. 60/182,866, filed Feb. 16, 2000).
Excaliber T-Slot Precision Saw Fence Model TT45 Owner's Manual, Sommerville Design & Manufacturing, Inc., May 2000.
Bosch Model 4000 Worksite Table Saw Operating/Safety Instructions, S-B Power Tool Company, Jul. 2000.
XACTA Fence II™ Homeshop 30/52 Owner's Manual, JET Equipment & Tools, Mar. 2001.
XACTA Fence II™ Commercial 30/50 Owner's Manual, JET Equipment & Tools, Mar. 2001.
Bosch 10" Table Saw Model 0601476139 Parts List and Technical Bulletin, S-B Power Tool Company, Apr. 2001.
Biesemeyer® T-Square® Universal Home Shop Fence system Instruction Manual, Delta Machinery, Jun. 1, 2001.
Powermatic 10" Tilting Arbor Saw Model 66 Instruction Manual & Parts List, JET Equipment & Tools, Jun. 2001.
Skil Model 3400 Table Saw Operating/Safety Instructions, S-B Power Tool Co., Sep. 2001.
Tablesaw Splitters and Blade Covers, Fine Woodworking, pp. 77-81, Dec. 2001.
The Merlin Splitter by Excalibur a Sommerville Design Product Overview & Generic Installation Notes, Sommerville Design & Manufacturing Inc., at least as early as 2002.
INCRA Incremental Micro Precision Table Saw Fence Owner's Manual, Taylor Design Group, Inc., 2003.
Craftsman® Power and Hand Tools, pp. 142-143, 2003.
Shop Fox® Models W2005, W2006, W2007 Classic Fence Instruction Manual, Woodstock International, Jan. 2000, revised Mar. 2004.
ACCU-FENCE® 64A Fence and Rail System Owner's Manual, WMH Tool Group, Sep. 2004.
Unifence™ Saw Guide Instruction Manual, Delta Machinery, Feb. 22, 2005.
Biesemeyer® T-Square® Commercial Fence System Instruction Manual, Delta Machinery, May 2, 2005.
Young Inventor: Teen's Device Earns Her Trip to Science Fair, The Arizona Republic, May 5, 2006.
Grizzly Industrial, Inc. Model G0605X/G0606X Extreme Series 12" Table Saw Owner's Manual, Grizzly Industrial, Inc., Oct. 2006.
Decision on Appeal No. 2007-002769 for U.S. Appl. No. 09/929,242, decided Aug. 29, 2007.
Decision on Appeal No. 2009-004424 for U.S. Appl. No. 10/984,643, decided Mar. 25, 2010.
You Should Have Invented It, French television show video/DVD.
Operator Injury Mitigation Using Electronic Sensing and Mechanical Braking and Decoupling Devices in Handheld Circular Saws, Erin F. Eppard, date unknown.
Laguna Tools table saw owner's manual, date unknown.

* cited by examiner

Fig. 1


POWER SOURCE
20
SAFETY SYSTEM
DETECTION SUBSYSTEM
22
CONTROL SUBSYSTEM
26
18
REACTION SUBSYSTEM
RESTRAINING MECHANISM
32
RELEASE MECHANISM
34
24
BIASING MECHANISM
30
BRAKE MECHANISM
28
MACHINE
OPERATIVE STRUCTURE
12
MOTOR ASSEMBLY
16
CUTTING TOOL
14
10

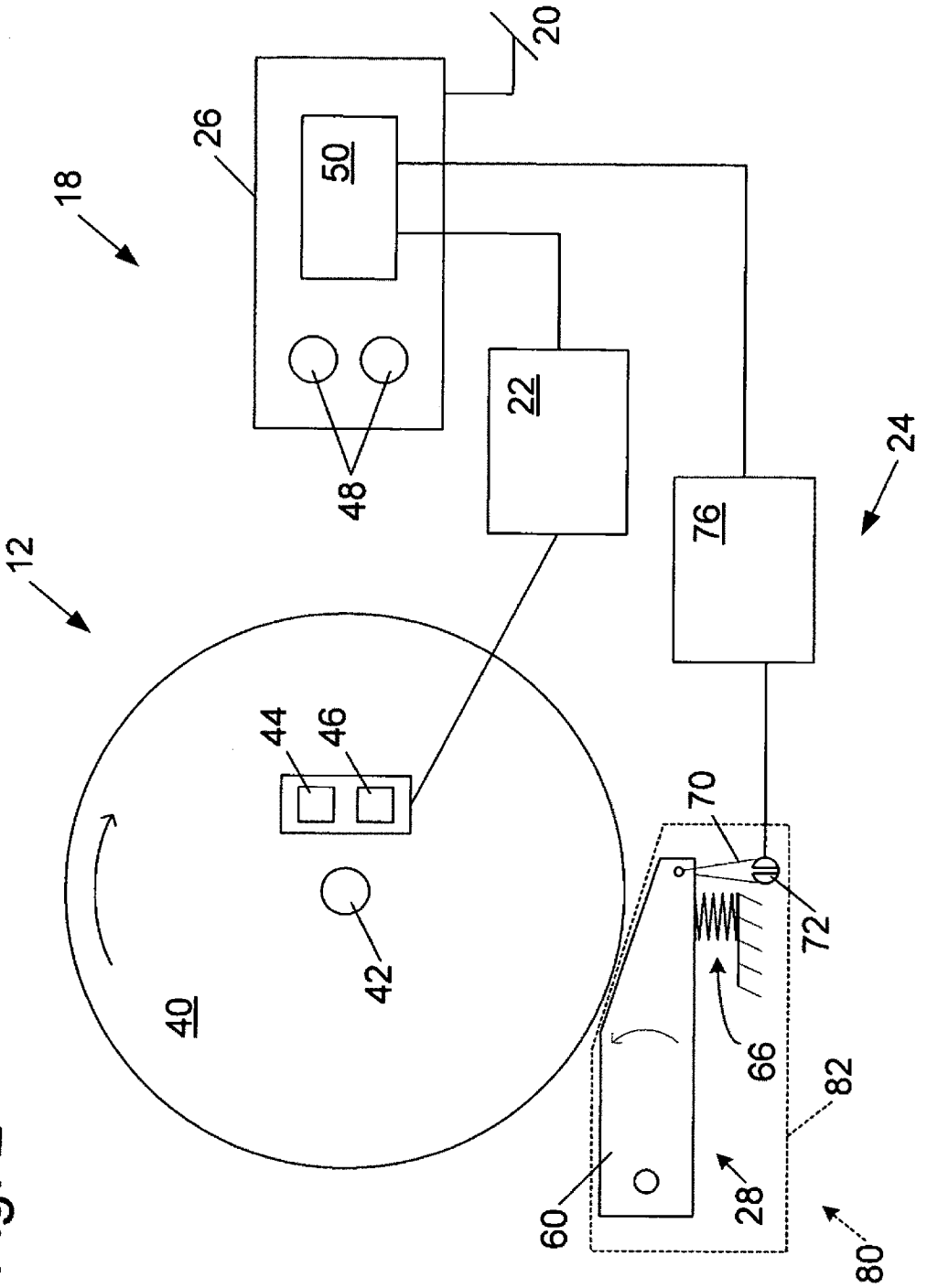


Fig. 2

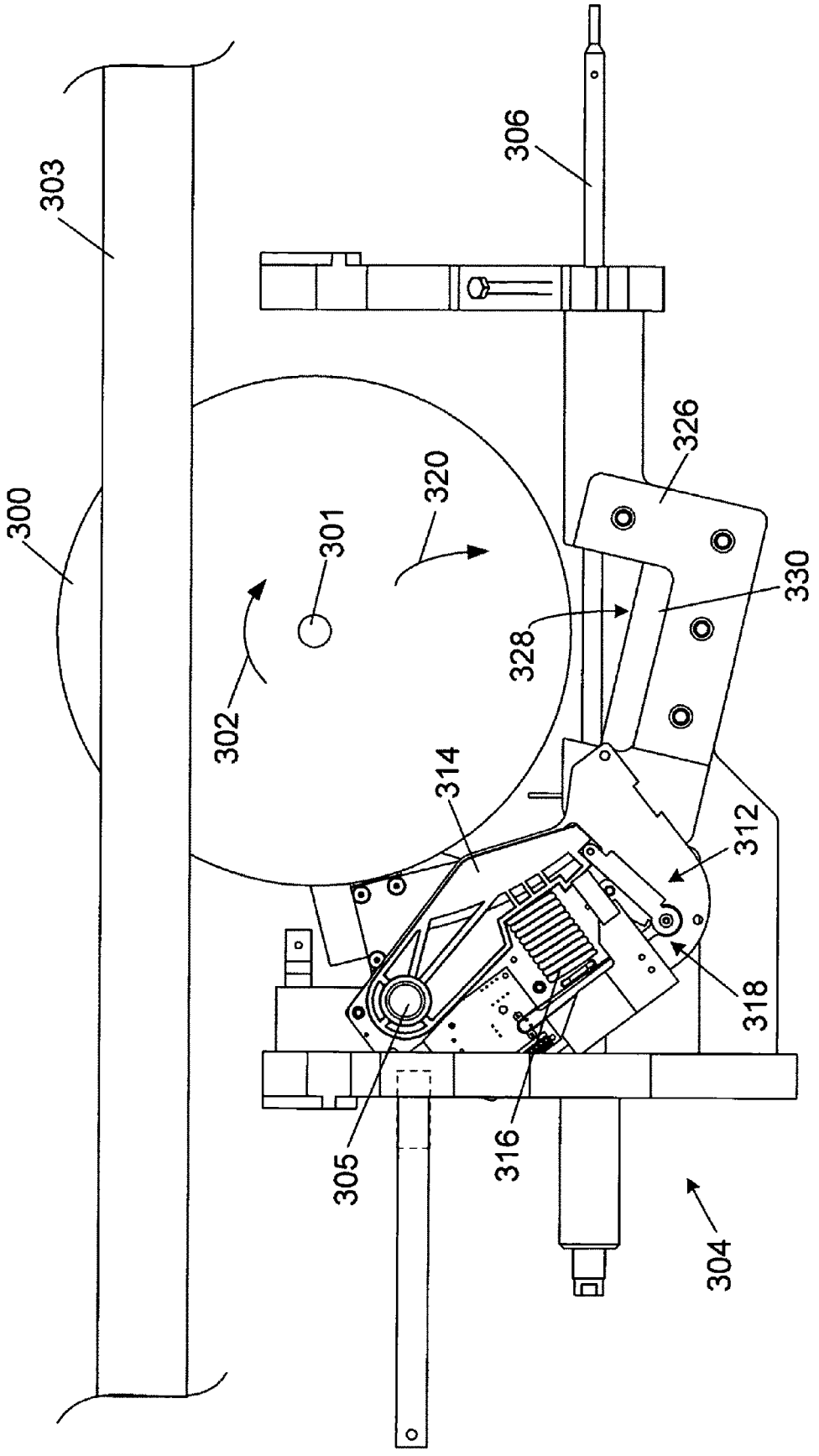


Fig. 3

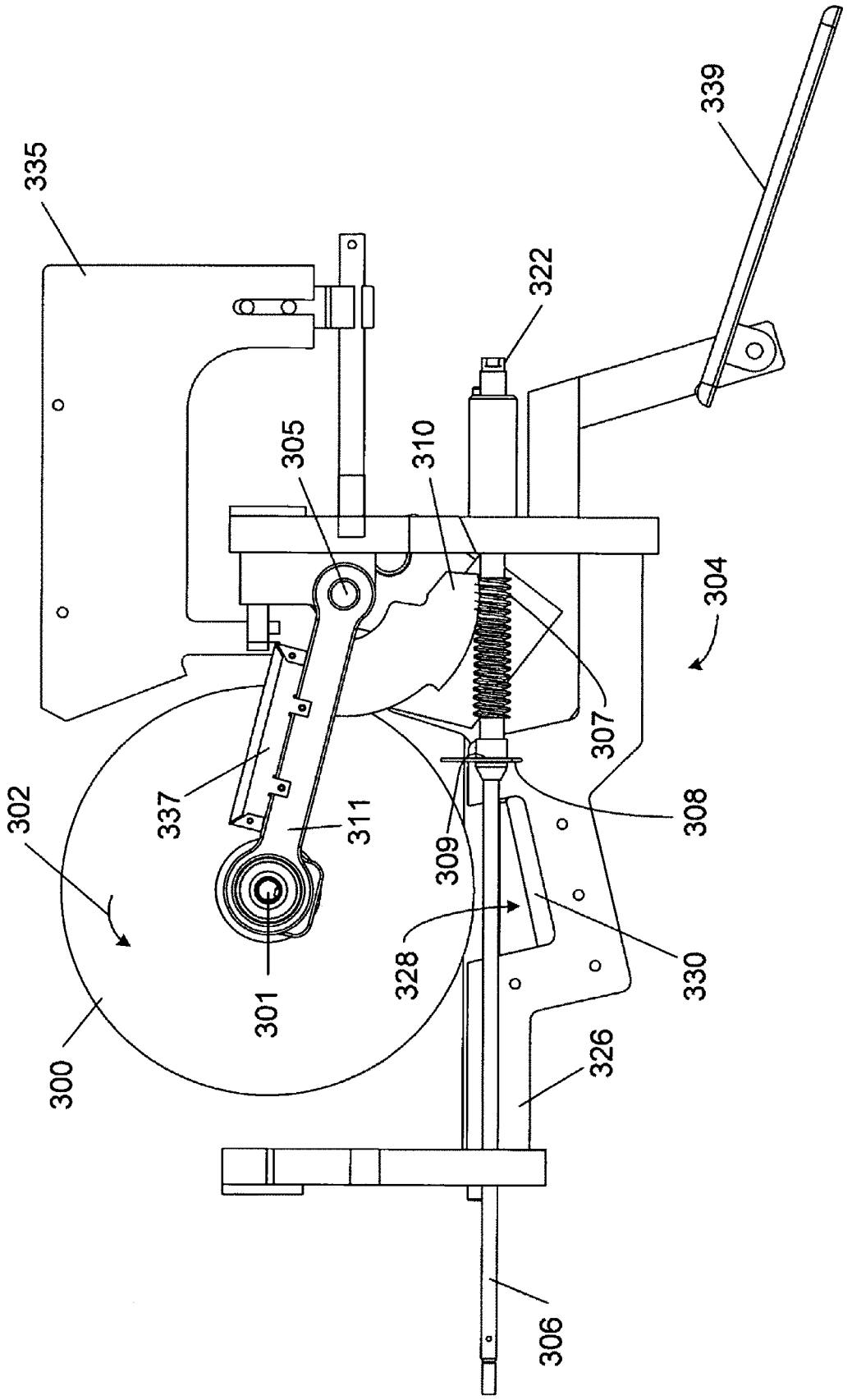

339
335
322
305
310
304
307
308
337
311
309
302
328
330
301
326
300
306

Fig. 4

Fig. 5

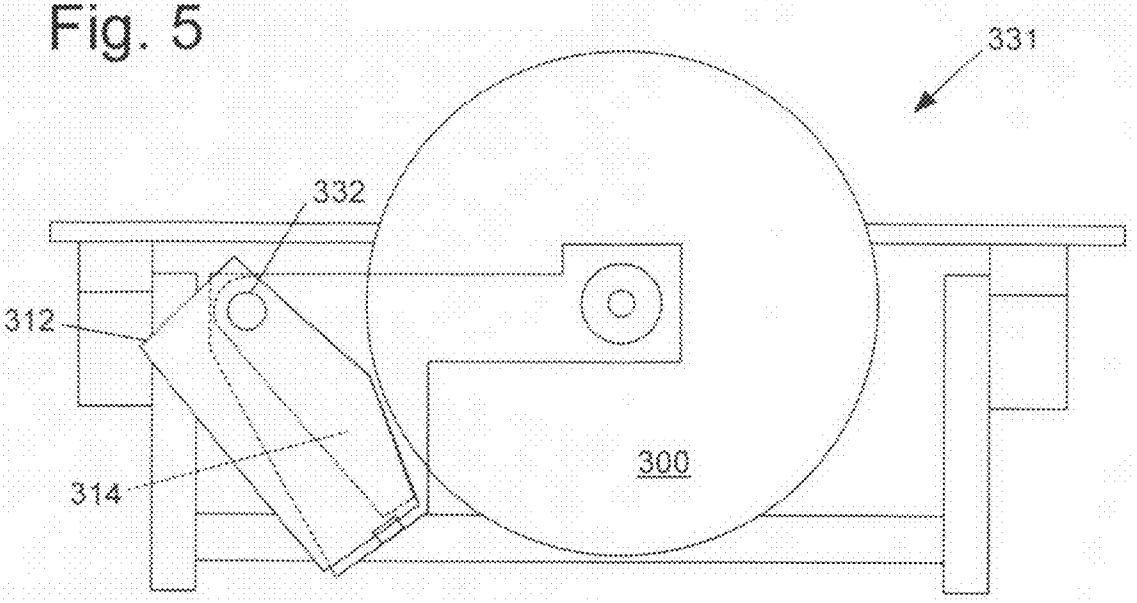
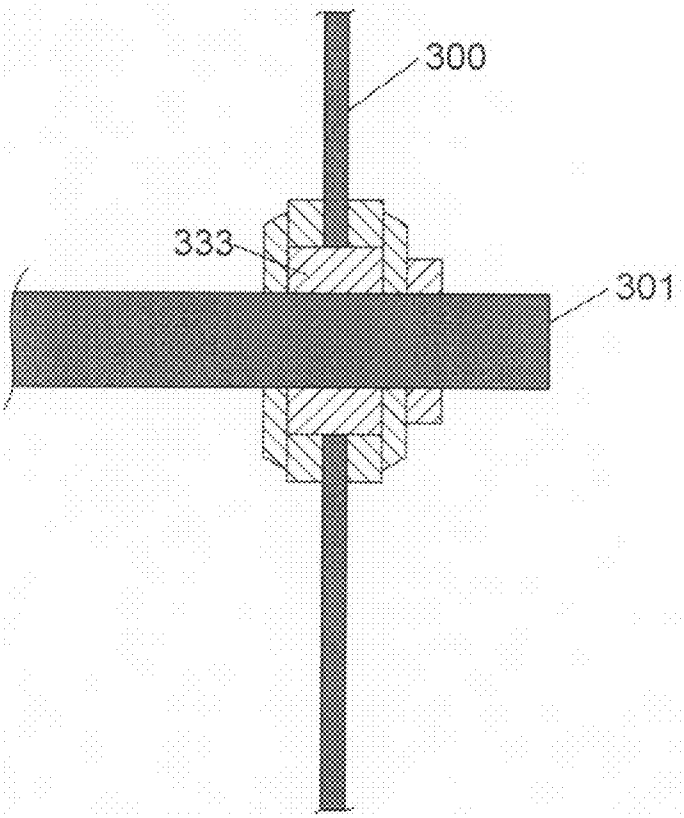


Fig. 6



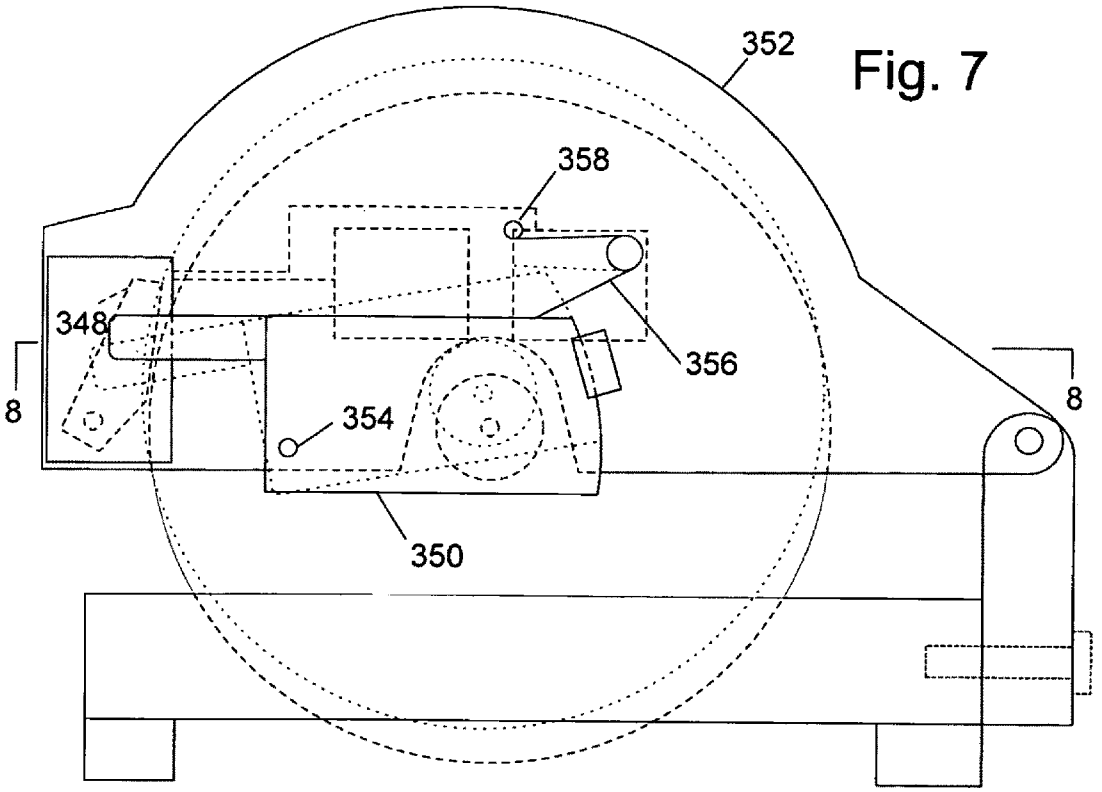


Fig. 7

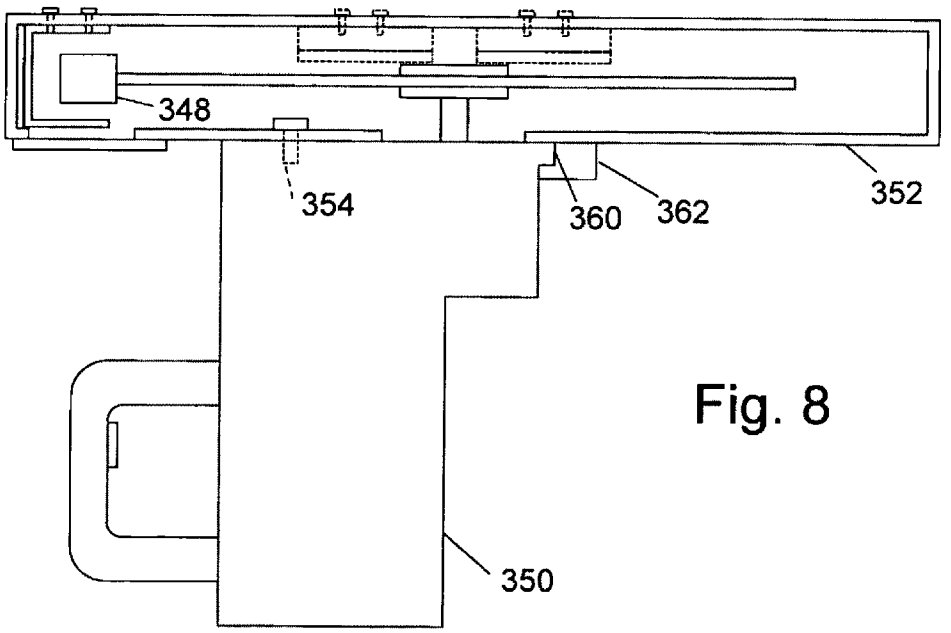


Fig. 8

Fig. 9

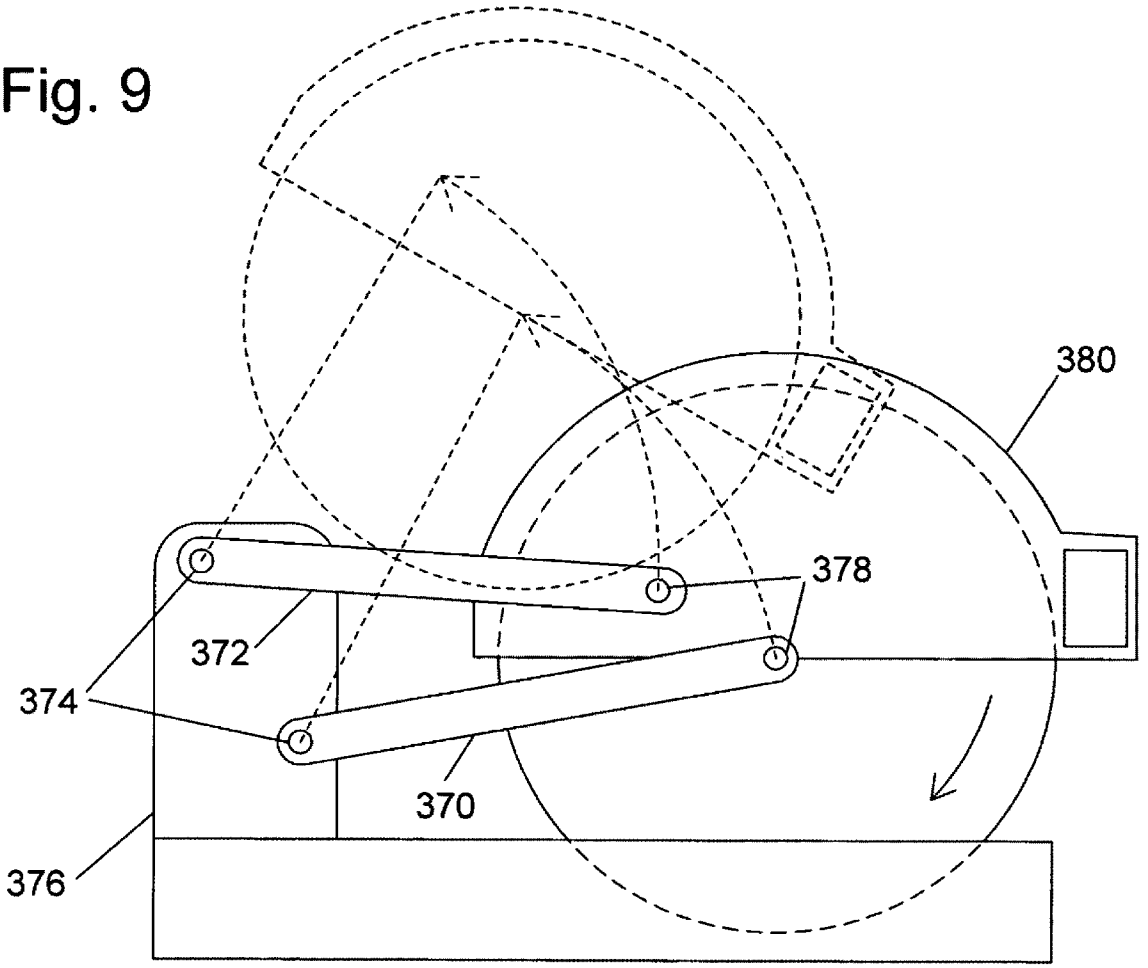


Fig. 10

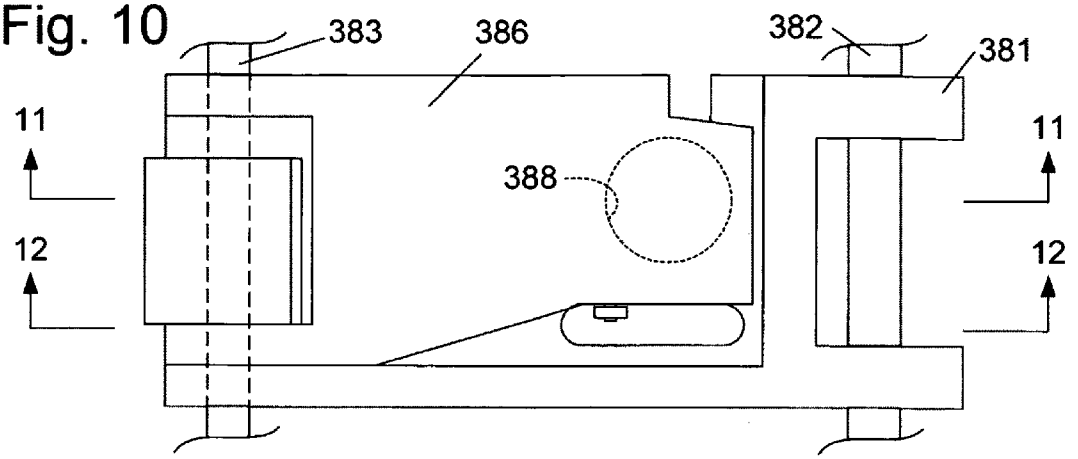


Fig. 11

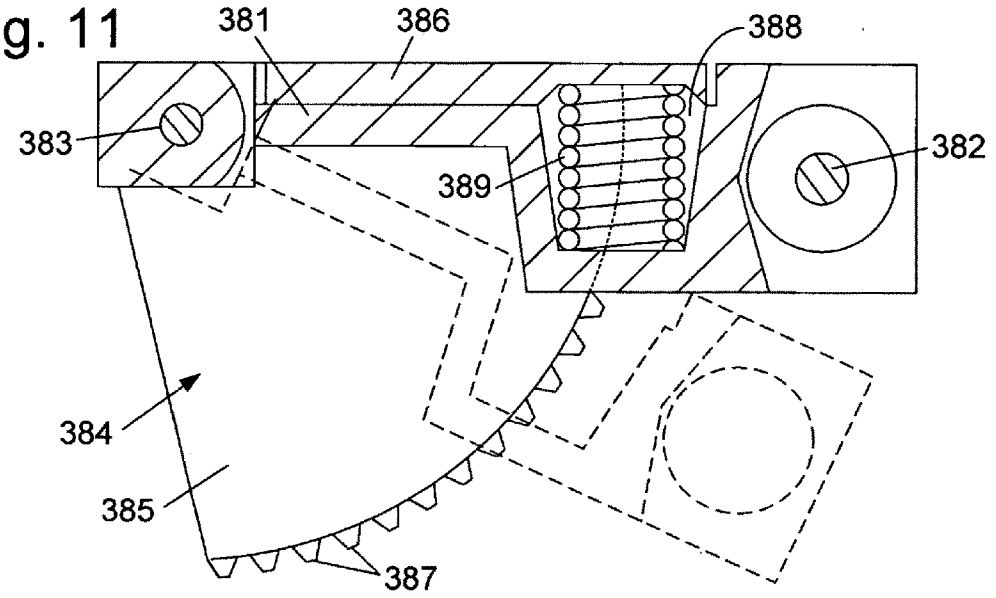
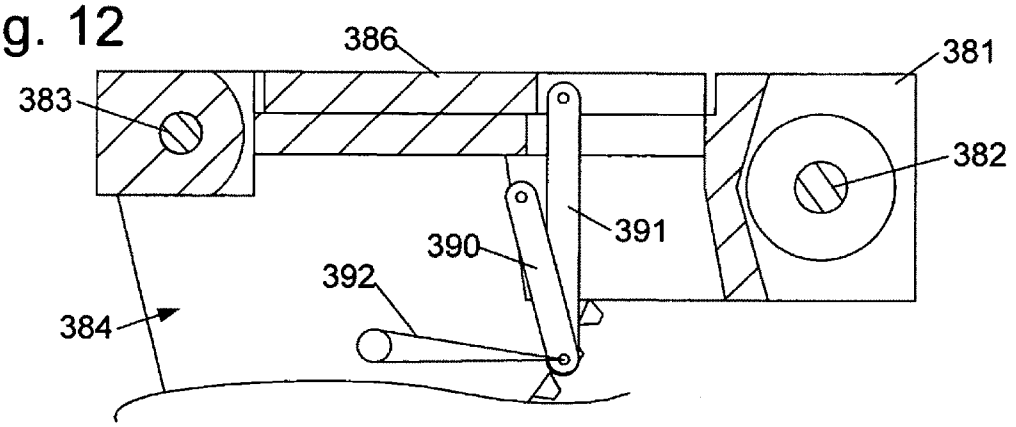


Fig. 12



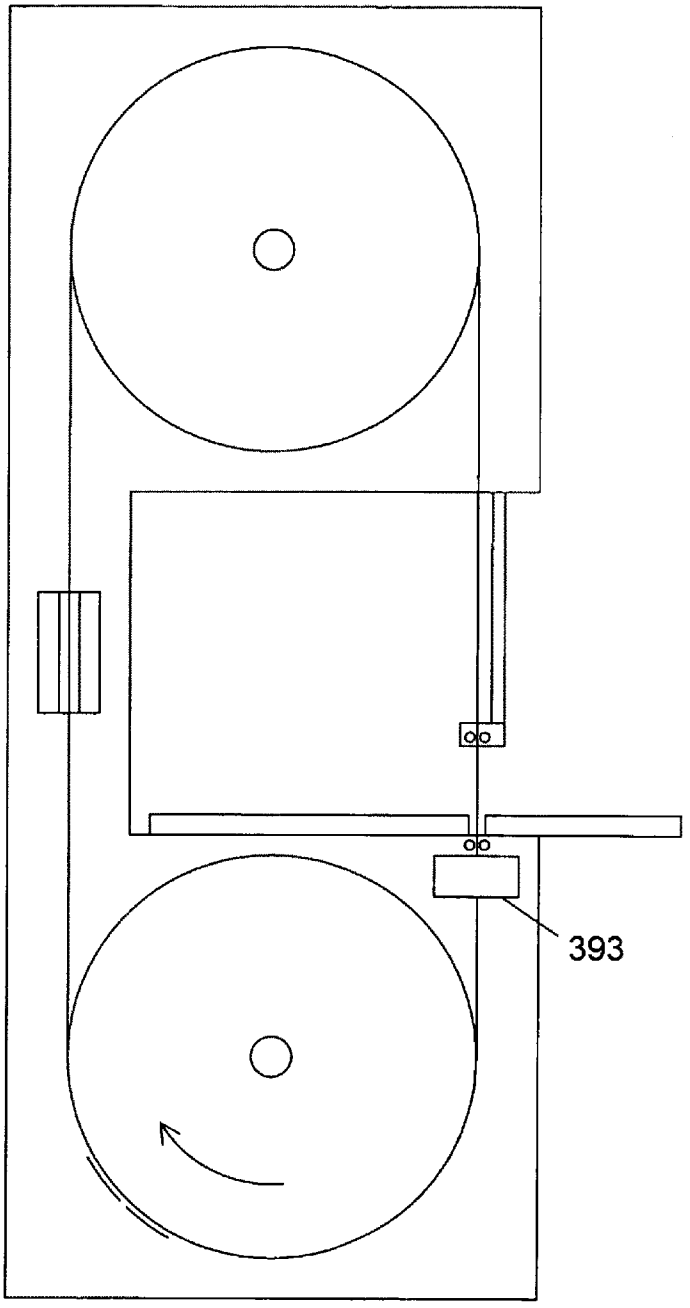


Fig. 13

Fig. 14

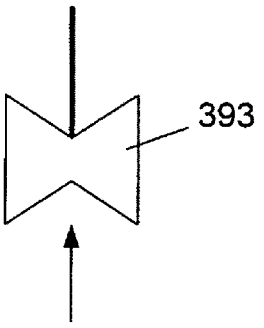


Fig. 15

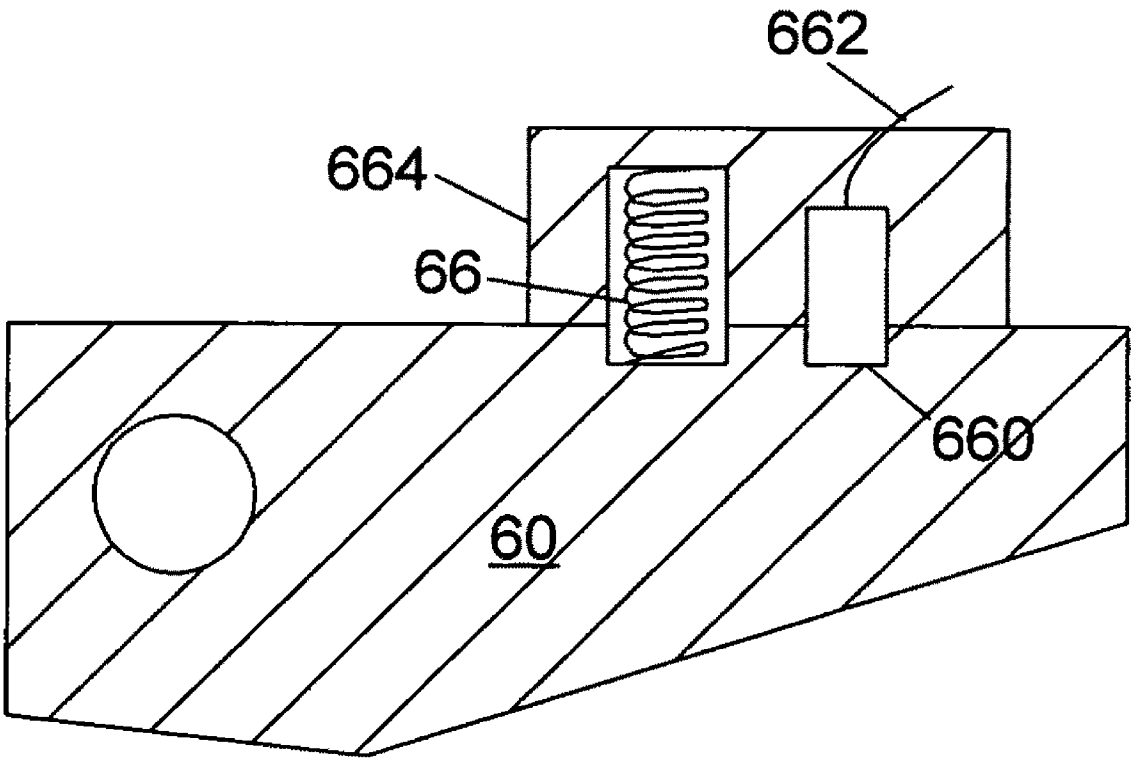


Fig. 16

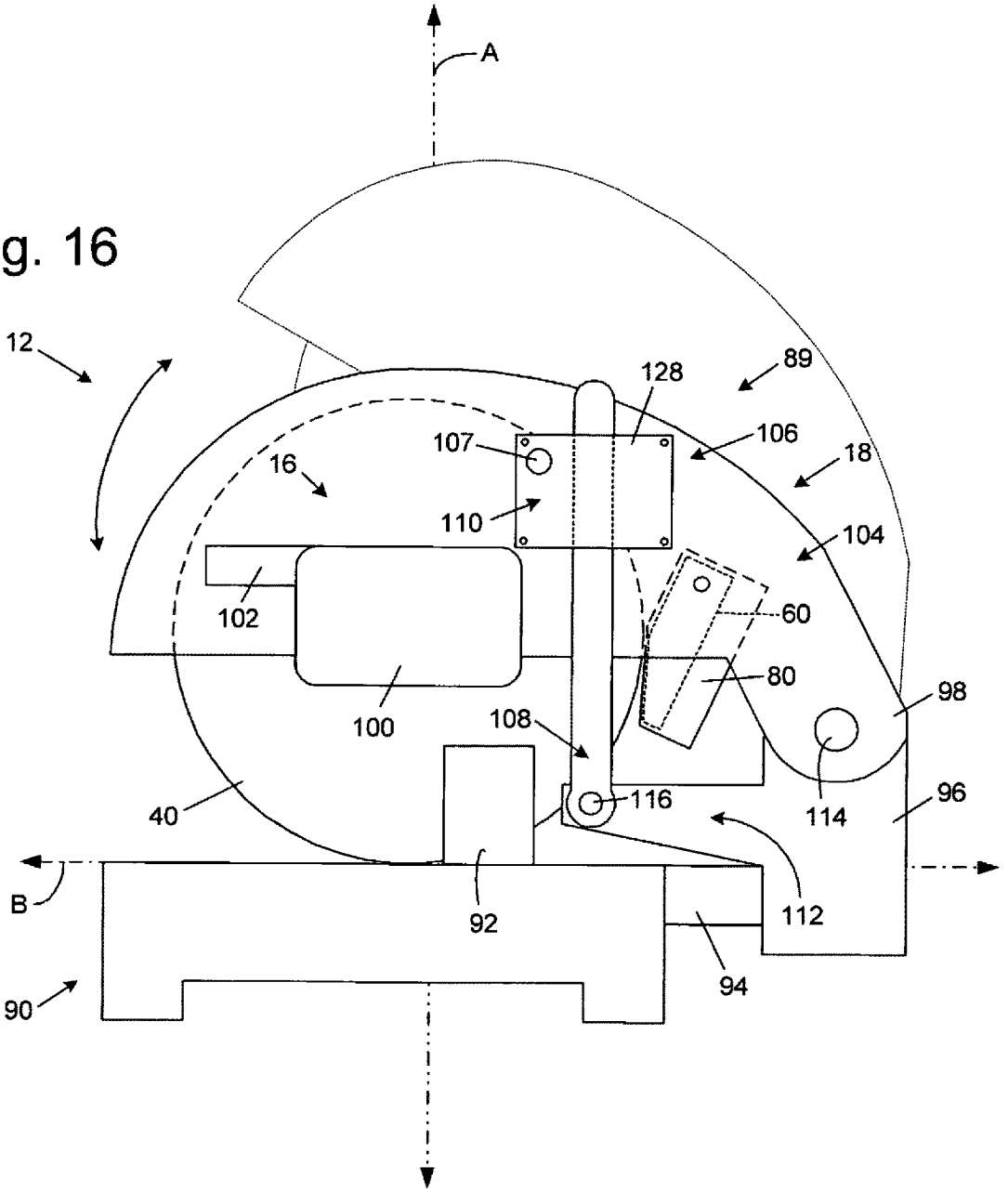

A
12
89
128
107
106
18
16
110
104
102
60
80
98
100
108
116
96
40
114
B
92
112
90
94

Fig. 17

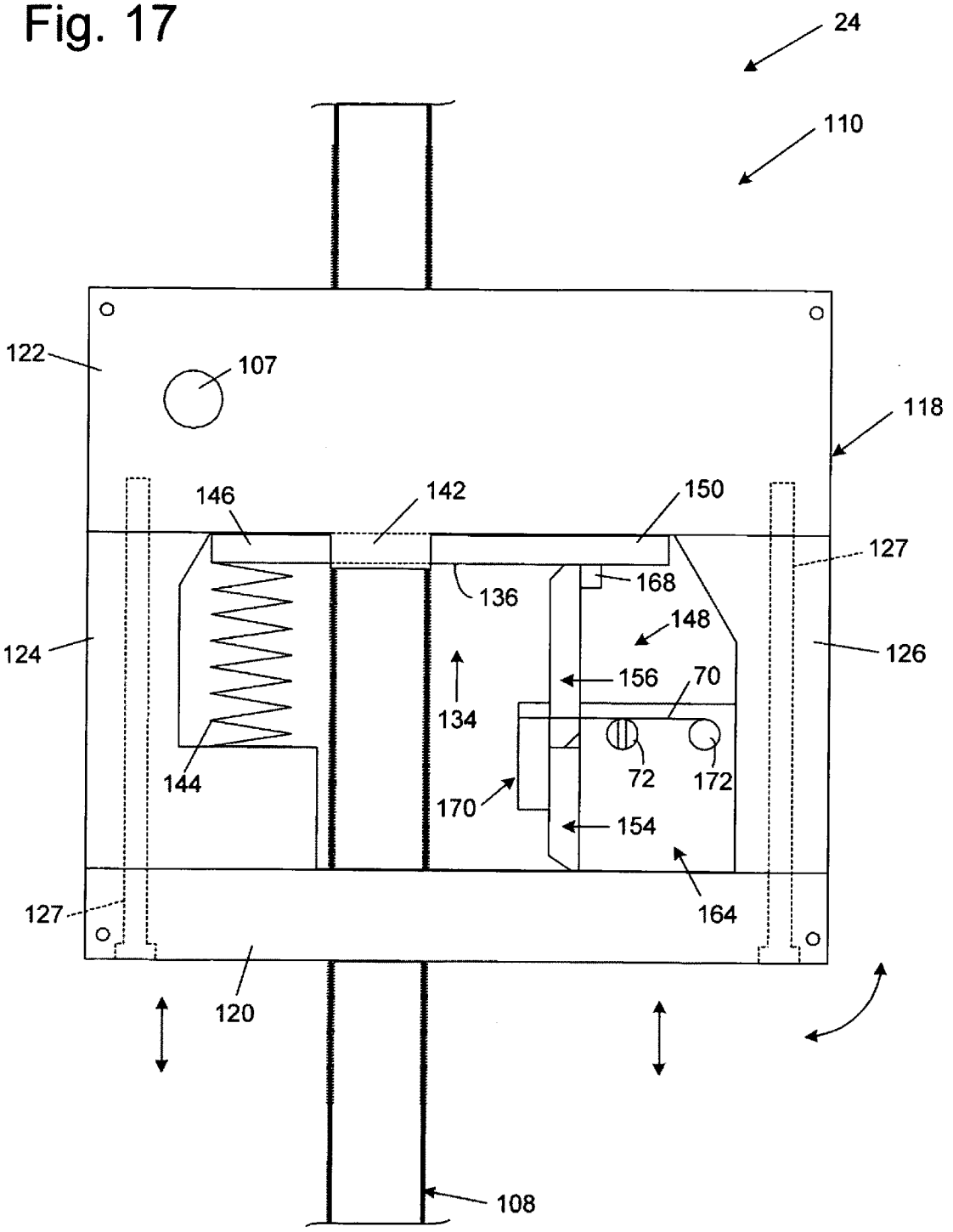

24
110
122
107
118
146
142
150
127
136
168
148
124
126
156
70
134
144
72
172
170
154
164
127
120
108

Fig. 18

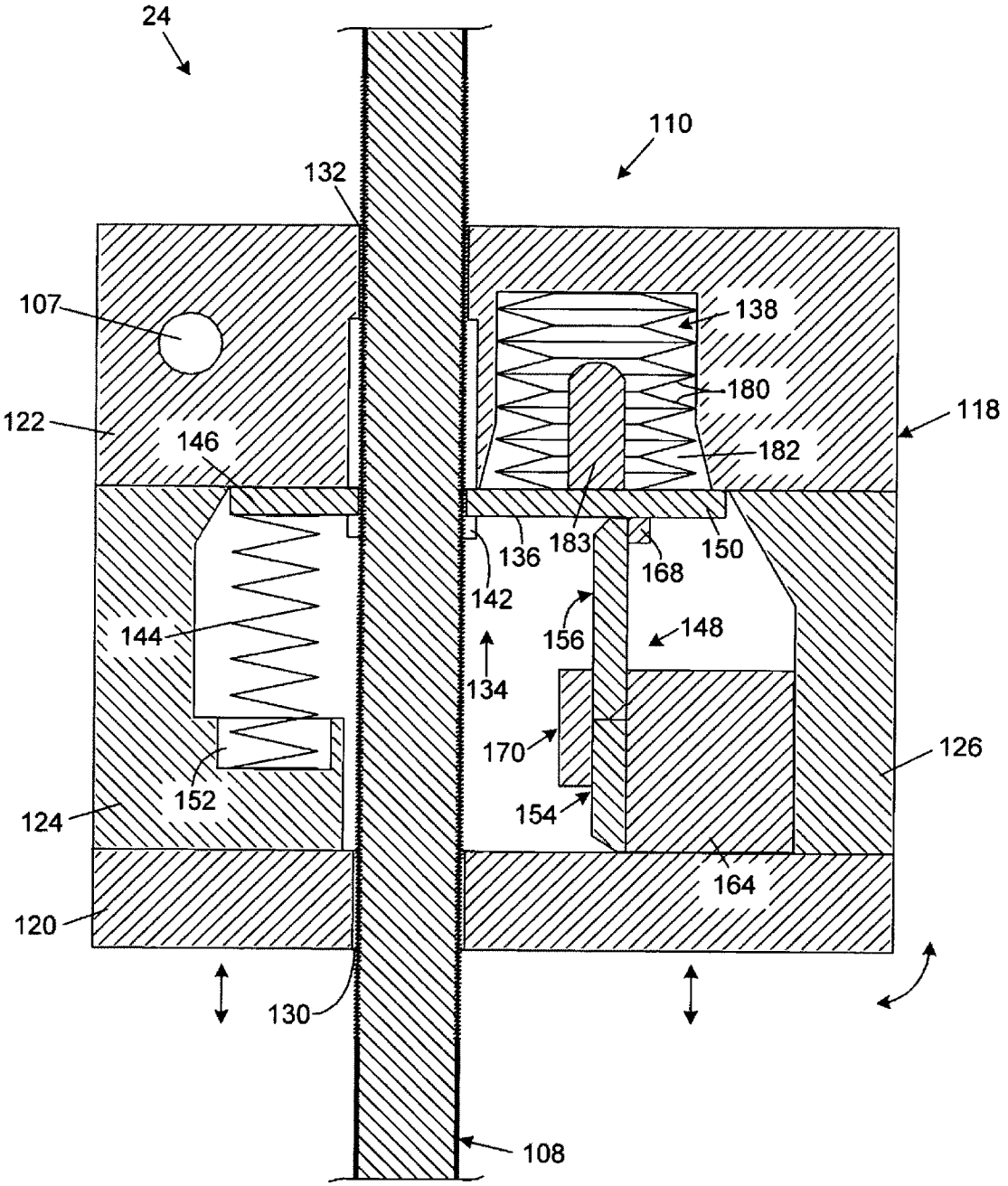

24
110
132
107
138
180
118
122
146
182
136
183
150
168
142
144
156
148
134
170
126
152
124
154
164
120
130
108

Fig. 19

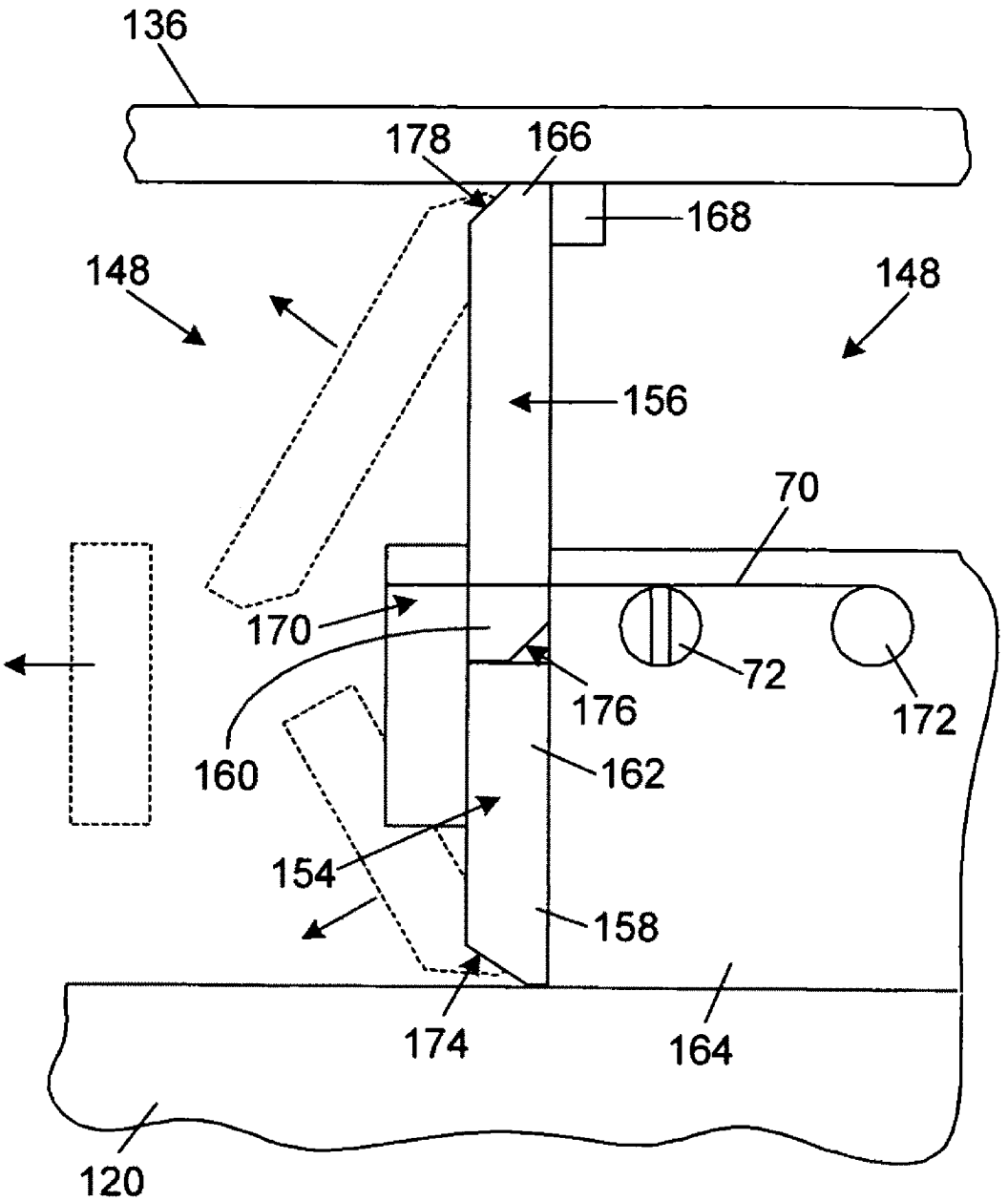

136
178
166
168
148
148
156
70
170
72
172
176
160
162
154
158
174
164
120

Fig. 20

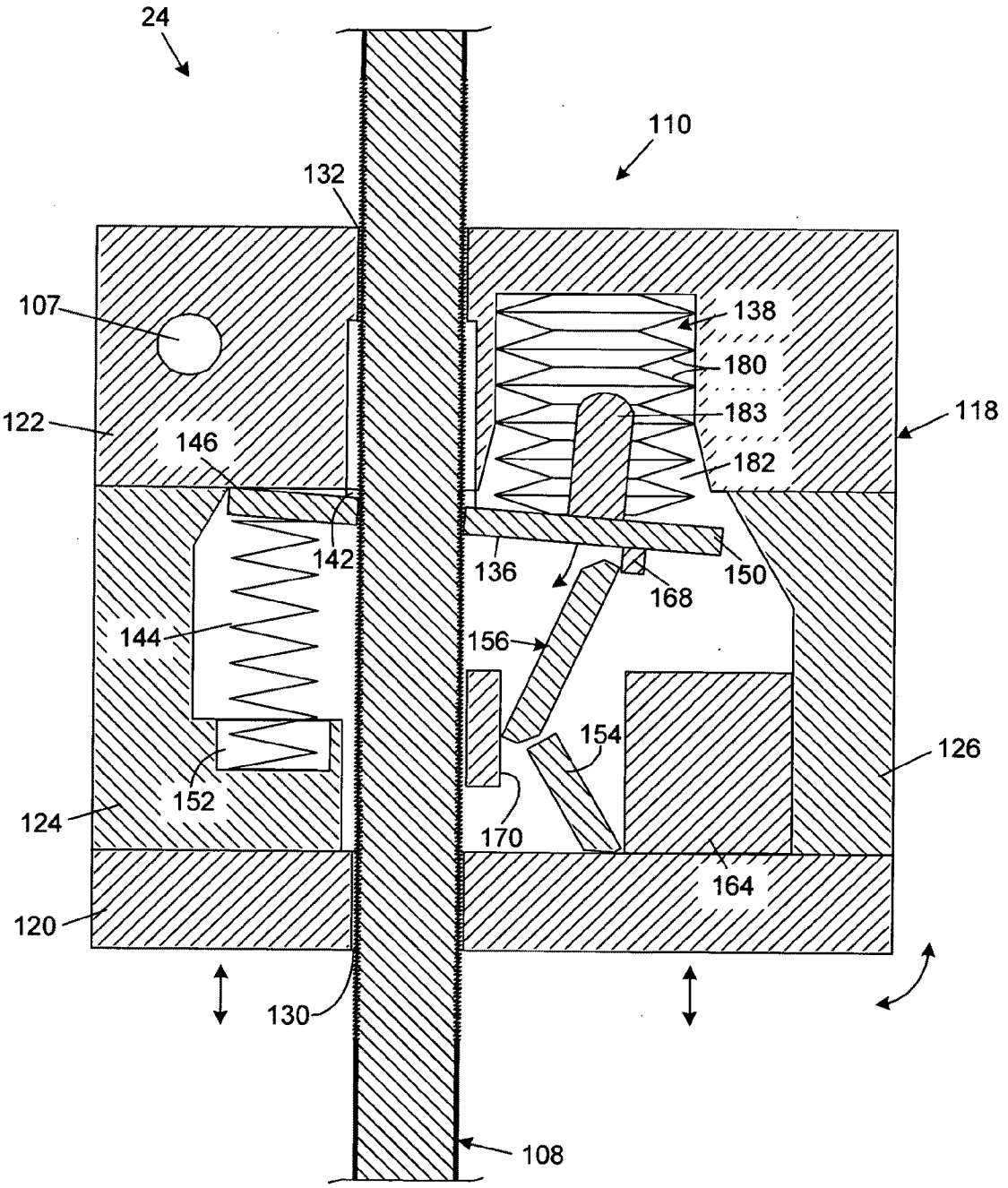
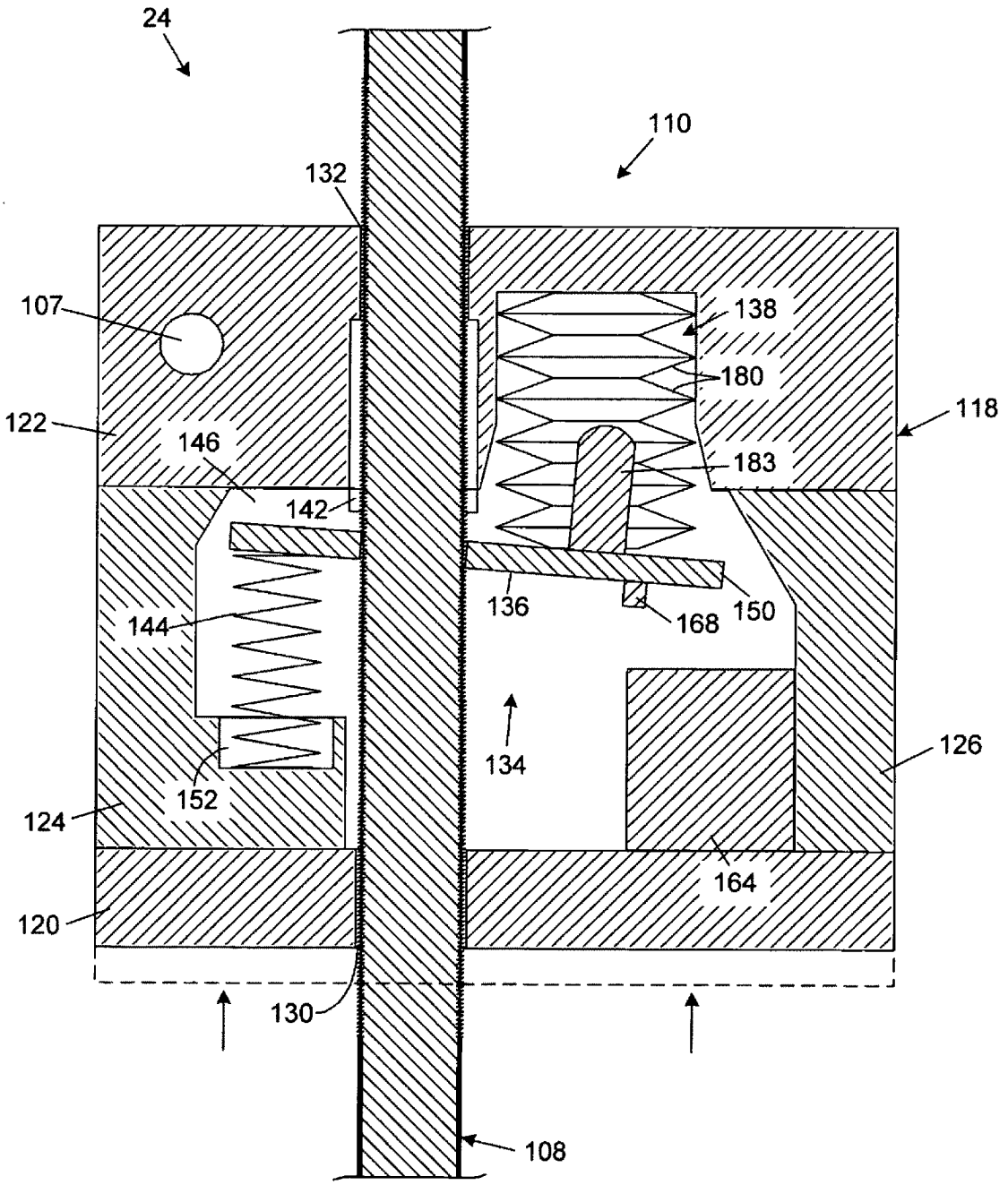

24
110
132
107
138
180
183
118
122
146
182
142
136
150
168
144
156
154
126
152
124
170
164
120
130
108

Fig. 21


24
110
132
107
138
180
118
122
146
183
142
136
150
168
144
134
126
152
124
164
120
130
108

POWER EQUIPMENT WITH DETECTION AND REACTION SYSTEMS

CROSS-REFERENCE TO RELATED APPLICATIONS

This application is a continuation of the following U.S. Patent Applications, all of which are hereby incorporated by reference in their entireties:

Ser. No. 11/796,819, filed Apr. 30, 2007, which is a continuation of Ser. No. 09/929,426, filed Aug. 13, 2001, issuing as U.S. Pat. No. 7,210,383 on May 1, 2007, which claims the benefit of and priority from a number of U.S. Provisional Patent Applications including Ser. No. 60/225,200, filed Aug. 14, 2000;

Ser. No. 12/655,695, filed Jan. 4, 2010, which is a continuation of Ser. No. 11/975,985, filed Oct. 22, 2007, issuing as U.S. Pat. No. 7,640,835 on Jan. 5, 2010, which is a continuation of Ser. No. 09/929,221, filed Aug. 13, 2001, issuing as U.S. Pat. No. 7,284,467 on Oct. 23, 2007, which claims the benefit of and priority from a number of U.S. Provisional Patent Applications including Ser. No. 60/225,211, filed Aug. 14, 2000;

Ser. No. 12/002,388 filed Dec. 17, 2007, which is a continuation of Ser. No. 09/929,227, filed Aug. 13, 2001, issuing as U.S. Pat. No. 7,308,843 on Dec. 18, 2007, which claims the benefit of and priority from a number of U.S. Provisional Patent Applications including Ser. No. 60/225,170, filed Aug. 14, 2000;

Ser. No. 11/401,050, filed Apr. 10, 2006, now U.S. Pat. No. 7,788,999 which is a continuation of a number of applications including Ser. No. 09/929,240, filed Aug. 13, 2001, issuing as U.S. Pat. No. 7,100,483 on Sep. 5, 2006, which in turn claims the benefit of and priority from U.S. Provisional Patent Application Ser. No. 60/225,056, filed Aug. 14, 2000; Ser. No. 09/929,241, filed Aug. 13, 2001, issuing as U.S. Pat. No. 7,024,975 on Apr. 11, 2006, which in turn claims the benefit of and priority from a number of U.S. Provisional Patent Applications including Ser. No. 60/225,169, filed Aug. 14, 2000; Ser. No. 09/929,425, filed Aug. 13, 2001, issuing as U.S. Pat. No. 7,137,326 on Nov. 21, 2006, which in turn claims the benefit of and priority from U.S. Provisional Patent Application Ser. No. 60/225,210, filed Aug. 14, 2000; Ser. No. 10/172,553, filed Jun. 13, 2002, issuing as U.S. Pat. No. 7,231,856 on Jun. 19, 2007, which in turn claims the benefit of and priority from U.S. Provisional Patent Application Ser. No. 60/298,207, filed Jun. 13, 2001; Ser. No. 10/189,027, filed Jul. 2, 2002, issuing as U.S. Pat. No. 7,712,403 on May 11, 2010, which in turn claims the benefit of and priority from U.S. Provisional Patent Application Ser. No. 60/302,916, filed Jul. 3, 2001; Ser. No. 10/243,042, filed Sep. 13, 2002, issuing as U.S. Pat. No. 7,197,969 on Apr. 3, 2007, which in turn claims the benefit of and priority from U.S. Provisional Patent Application Ser. No. 60/324,729, filed Sep. 24, 2001; Ser. No. 10/643,296, filed Aug. 18, 2003, now abandoned, which in turn claims the benefit of and priority from U.S. Provisional Patent Application Ser. No. 60/406,138, filed Aug. 27, 2002; and Ser. No. 10/794,161, filed Mar. 4, 2004, issuing as U.S. Pat. No. 7,098,800 on Aug. 29, 2006, which in turn claims the benefit of and priority from U.S. Provisional Patent Application Ser. No. 60/452,159, filed Mar. 5, 2003;

Ser. No. 10/984,643, filed Nov. 8, 2004, which is a continuation of a number of applications, including Ser. No. 09/929,226, filed Aug. 13, 2001, issuing as U.S. Pat. No. 6,920,814 on Jul. 26, 2005, which in turn claims the benefit of and priority from U.S. Provisional Patent Application Ser. No. 60/225,206, filed Aug. 14, 2000; Ser. No. 09/929,240, filed Aug. 13, 2001, issuing as U.S. Pat. No. 7,100,483 on Sep. 5, 2006, which in turn claims the benefit of and priority from U.S. Provisional Patent Application Ser. No. 60/225,056, filed Aug. 14, 2000; Ser. No. 09/929,242, filed Aug. 13, 2001, issuing as U.S. Pat. No. 7,509,899 on Mar. 31, 2009, which claims the benefit of and priority from a number of U.S. Provisional Patent Applications including Ser. No. 60/225,089, filed Aug. 14, 2000; Ser. No. 10/051,782, filed Jan. 15, 2002, issuing as U.S. Pat. No. 6,877,410 on Apr. 12, 2005, which in turn claims the benefit of and priority from U.S. Provisional Patent Application Ser. No. 60/279,313, filed Mar. 27, 2001; Ser. No. 10/052,806, filed Jan. 16, 2002, issuing as U.S. Pat. No. 6,880,440 on Apr. 19, 2005, which in turn claims the benefit of and priority from U.S. Provisional Patent Application Ser. No. 60/270,942, filed Feb. 22, 2001; Ser. No. 10/205,164, filed Jul. 25, 2002, issuing as U.S. Pat. No. 6,945,149 on Sep. 20, 2005, which in turn claims the benefit of and priority from U.S. Provisional Patent Application Ser. No. 60/307,756, filed Jul. 25, 2001; Ser. No. 10/202,928, filed Jul. 25, 2002, issuing as U.S. Pat. No. 7,000,514 on Feb. 21, 2006, which in turn claims the benefit of and priority from U.S. Provisional Patent Application Ser. No. 60/308,492, filed Jul. 27, 2001; and Ser. No. 10/785,361, filed Feb. 23, 2004, issuing as U.S. Pat. No. 6,997,090 on Feb. 14, 2006, which is a continuation of Ser. No. 10/215,929, filed Aug. 9, 2002, now abandoned, which in turn claims the benefit of and priority from U.S. Provisional Patent Application Ser. No. 60/312,141, filed Aug. 13, 2001;

Ser. No. 11/542,938, filed Oct. 2, 2006, which is a continuation of a number of applications, including Ser. No. 09/929,242, filed Aug. 13, 2001, issuing as U.S. Pat. No. 7,509,899 on Mar. 31, 2009, which claims the benefit of and priority from a number of U.S. Provisional Patent Applications including Ser. No. 60/225,089, filed Aug. 14, 2000; Ser. No. 11/401,774, filed Apr. 11, 2006, issuing as U.S. Pat. No. 7,525,055 on Apr. 28, 2009, which is a continuation of Ser. No. 11/027,322, filed Dec. 31, 2004, now abandoned, which claims the benefit of and priority from U.S. Provisional Patent Application Ser. No. 60/533,598, filed Dec. 31, 2003; Ser. No. 11/445,548, filed Jun. 2, 2006, issuing as U.S. Pat. No. 7,347,131 on Mar. 25, 2008; and Ser. No. 11/506,260, filed Aug. 18, 2006, issuing as U.S. Pat. No. 7,359,174 on Apr. 15, 2008, which is a continuation of a number of application including Ser. No. 10/923,282, filed Aug. 20, 2004, now abandoned, which in turn claims the benefit of and priority from U.S. Provisional Patent Application Ser. No. 60/496,568, filed Aug. 20, 2003;

Ser. No. 12/590,094, filed Nov. 2, 2009, which is a continuation of Ser. No. 09/929,236, filed Aug. 13, 2001, issuing as U.S. Pat. No. 7,610,836 on Nov. 3, 2009, which claims the benefit of and priority from a number of U.S. Provisional Patent Applications including Ser. No. 60/225,201, filed Aug. 14, 2000;

Ser. No. 11/811,719, filed Jun. 11, 2007, now U.S. Pat. No. 7,832,314 which is a continuation of Ser. No. 11/061,162, filed Feb. 18, 2005, issuing as U.S. Pat. No. 7,228,772 on Jun. 12, 2007, which is a continuation of Ser. No. 09/929,244, filed Aug. 13, 2001, issuing as U.S. Pat. No. 6,857,345 on Feb. 22, 2005, which in turn claimed the benefit of and priority from a number of U.S. Provisional Patent Applications including Ser. No. 60/225,212, filed Aug. 14, 2000;

Ser. No. 12/587,695, filed Oct. 9, 2009, which is a continuation of Ser. No. 09/929,237, filed Aug. 13, 2001, issuing as U.S. Pat. No. 7,600,455 on Oct. 13, 2009, which claims the benefit of and priority from a number of U.S. Provisional Patent Applications including Ser. No. 60/225,059, filed Aug. 14, 2000;

Ser. No. 12/661,766, filed Mar. 22, 2010, which is a continuation of Ser. No. 11/810,196, filed Jun. 4, 2007, issuing as U.S. Pat. No. 7,681,479 on Mar. 23, 2010, which is a continuation of Ser. No. 09/929,234, filed Aug. 13, 2001, issuing as U.S. Pat. No. 7,225,712 on Jun. 5, 2007, which claims the benefit of and priority from a number of U.S. Provisional Patent Applications including Ser. No. 60/225,094, filed Aug. 14, 2000;

Ser. No. 12/655,694, filed Jan. 4, 2010, which is a continuation of Ser. No. 12/079,836, filed Mar. 27, 2008, issuing as U.S. Pat. No. 7,640,837 on Jan. 5, 2010, which is a continuation of Ser. No. 09/929,235, filed Aug. 13, 2001, issuing as U.S. Pat. No. 7,350,444 on Apr. 1, 2008, which claims the benefit of and priority from a number of U.S. Provisional patent applications including Ser. No. 60/225,058, filed Aug. 14, 2000;

Ser. No. 12/799,211, filed Apr. 19, 2010, which is a continuation of Ser. No. 12/220,946, filed Jul. 29, 2008, issuing as U.S. Pat. No. 7,698,976 on Apr. 20, 2010, which is a continuation of Ser. No. 09/929,238, filed Aug. 13, 2001, now abandoned, which claims the benefit of and priority from a number of U.S. Provisional Patent Applications including Ser. No. 60/225,057, filed Aug. 14, 2000;

Ser. No. 12/288,578, filed Oct. 21, 2008, now abandoned which is a continuation of Ser. No. 11/447,449, filed Jun. 5, 2006, now abandoned, which is a continuation of Ser. No. 09/676,190, filed Sep. 29, 2000, issuing as U.S. Pat. No. 7,055,417 on Jun. 6, 2006, which in turn claimed the benefit of and priority from the following U.S. Provisional patent applications: Ser. No. 60/182,866, filed Feb. 16, 2000, and Ser. No. 60/157,340, filed Oct. 1, 1999;

Ser. No. 12/590,924, filed Nov. 16, 2009, which is a continuation of Ser. No. 12/154,675, filed May 23, 2008, issuing as U.S. Pat. No. 7,617,752 on Nov. 17, 2009, which is a continuation of Ser. No. 10/053,390, filed Jan. 16, 2002, issuing as U.S. Pat. No. 7,377,199 on May 27, 2008, which is a continuation-in-part of a number of applications including Ser. No. 09/676,190, filed Sep. 29, 2000, issuing as U.S. Pat. No. 7,055,417 on Jun. 6, 2006; and Ser. No. 10/053,390 also claims the benefit of and priority from U.S. Provisional Patent Application Ser. No. 60/270,011, filed Feb. 20, 2001;

Ser. No. 12/313,162, filed Nov. 17, 2008, now U.S. Pat. No. 7,789,002, which is a continuation of Ser. No. 11/348,580, filed Feb. 6, 2006, now abandoned, which is a continuation of a number of applications including Ser. No. 10/052,705, filed Jan. 16, 2002, issuing as U.S. Pat. No. 6,994,004 on Feb. 7, 2006, which in turn claimed the benefit of and priority from the following U.S. Provisional Patent Applications: Ser. No. 60/270,011, filed Feb. 20, 2001, Ser. No. 60/270,941, filed Feb. 22, 2001, Ser. No. 60/270,942, filed Feb. 22, 2001, Ser. No. 60/273,177, filed Mar. 2, 2001, and Ser. No. 60/273,178, filed Mar. 2, 2001; and Ser. No. 11/348,580 also claims the benefit of and priority from U.S. Provisional Patent Application Ser. No. 60/667,485, filed Mar. 31, 2005; and Ser. No. 12/313,162 is also a continuation of Ser. No. 11/098,984, filed Apr. 4, 2005, issuing as U.S. Pat. No. 7,353,737 on Apr. 8, 2008, which is a continuation of a Ser. No. 09/929,238, filed Aug. 13, 2001, now abandoned Ser. No. 10/047,066, filed Jan. 14, 2002, issuing as U.S. Pat. No. 6,945,148 on Sep. 20, 2005, and Ser. No. 10/051,782, filed Jan. 15, 2002, issuing as U.S. Pat. No. 6,877,410 on Apr. 12, 2005;

Ser. No. 12/661,993, filed Mar. 26, 2010, which is a continuation of Ser. No. 11/982,972, filed Nov. 5, 2007, issuing as U.S. Pat. No. 7,685,912 on Mar. 30, 2010, which is a continuation of Ser. No. 10/932,339, filed Sep. 1, 2004, issuing as U.S. Pat. No. 7,290,472 on Nov. 6, 2007, which is a continuation of Ser. No. 10/047,066, filed Jan. 14, 2002, issuing as U.S. Pat. No. 6,945,148 on Sep. 20, 2005, which in turn claimed the benefit of and priority from the following U.S. Provisional Patent Applications: Ser. No. 60/270,011, filed Feb. 20, 2001, Ser. No. 60/270,941, filed Feb. 22, 2001, Ser. No. 60/270,942, filed Feb. 22, 2001, Ser. No. 60/273,177, filed Mar. 2, 2001, Ser. No. 60/273,178, filed Mar. 2, 2001, and Ser. No. 60/273,902, filed Mar. 6, 2001; and Ser. No. 10/932,339 filed Sep. 1, 2004, now U.S. Pat. No. 7,290,472, is also a continuation of Ser. No. 10/050,085, filed Jan. 14, 2002, now abandoned;

Ser. No. 10/100,211, filed Mar. 13, 2002, which claims the benefit of and priority from U.S. Provisional Patent Application Ser. No. 60/275,583, filed Mar. 13, 2001;

Ser. No. 11/256,757, filed Oct. 24, 2005, which is a continuation of Ser. No. 09/955,418, filed Sep. 17, 2001, issuing as U.S. Pat. No. 6,957,601 on Oct. 25, 2005, which in turn claimed the benefit of and priority to a number of U.S. Provisional Patent Applications, including: Ser. No. 60/233,459, filed Sep. 18, 2000, Ser. No. 60/270,011, filed Feb. 20, 2001, Ser. No. 60/270,941, filed Feb. 22, 2001, Ser. No. 60/270,942, filed Feb. 22, 2001, Ser. No. 60/273,177, filed Mar. 13, 2001, Ser. No. 60/273,178, filed Mar. 2, 2001, Ser. No. 60/273,902, filed Mar. 6, 2001, Ser. No. 60/275,594, filed Mar. 13, 2001, Ser. No. 60/275,595, filed Mar. 13, 2001, Ser. No. 60/279,313, filed Mar. 27, 2001, Ser. No. 60/292,081, filed May 17, 2001, Ser. No. 60/292,100, filed May 17, 2001, Ser. No. 60/298,207, filed Jun. 13, 2001, Ser. No. 60/302,937, filed Jul. 2, 2001, Ser. No. 60/302,916, filed Jul. 3, 2001, Ser. No. 60/306,202, filed Jul. 18, 2001, Ser. No. 60/307,756, filed Jul. 25, 2001, Ser. No. 60/308,492, filed Jul. 27, 2001, and Ser. No. 60/312,141, filed Aug. 13, 2001;

Ser. No. 10/146,527, filed May 15, 2002, which claims the benefit of and priority from U.S. Provisional Patent Application Ser. No. 60/292,100, filed May 17, 2001;

Ser. No. 12/586,469, filed Sep. 21, 2009, which is a continuation of Ser. No. 11/702,330, filed Feb. 5, 2007, issuing as U.S. Pat. No. 7,591,210 on Sep. 22, 2009, which is a continuation of Ser. No. 10/189,031, filed Jul. 2, 2002, issuing as U.S. Pat. No. 7,171,879 on Feb. 6, 2007, which claims the benefit of and priority from U.S. Provisional Patent Application Ser. No. 60/302,937, filed Jul. 2, 2001;

Ser. No. 11/208,214, filed Aug. 19, 2005, now U.S. Pat. No. 7,784,507, which is a continuation of Ser. No. 10/251,576, filed Sep. 20, 2002, now abandoned, which is a continuation of Ser. No. 10/197,975, filed Jul. 18, 2002, now abandoned and which claimed the benefit of and priority to U.S. Provisional Patent Application Ser. No. 60/323,975, filed Sep. 21, 2001, and Ser. No. 11/208,214 is also a continuation of Ser. No. 09/676,190, filed Sep. 29, 2000, issuing as U.S. Pat. No. 7,055,417 on Jun. 6, 2006, which in turn claimed the benefit of and priority from U.S. Provisional Patent Application Ser. No. 60/157,340, filed Oct. 1, 1999 and Ser. No. 60/182,866, filed Feb. 16, 2000;

Ser. No. 12/231,080, filed Aug. 29, 2008, which is a continuation of Ser. No. 11/487,717, filed Jul. 17, 2006, issuing as U.S. Pat. No. 7,421,315, on Sep. 2, 2008, which is a continuation of U.S. patent application Ser. No. 10/292,607, filed Nov. 12, 2002, issued as U.S. Pat. No. 7,077,039 on Jul. 18, 2006, which claims the benefit of and priority from U.S. Provisional Patent Application Ser. No. 60/335,970, filed Nov. 13, 2001;

Ser. No. 12/655,962, filed Jan. 11, 2010, which is a continuation of Ser. No. 12/313,277, filed Nov. 17, 2008, issuing as U.S. Pat. No. 7,644,645 on Jan. 12, 2010, which is a continuation of Ser. No. 10/345,630, filed Jan. 15, 2003, now

abandoned which claims the benefit of and priority from U.S. Provisional Patent Application Ser. No. 60/349,989, filed Jan. 16, 2002;

Ser. No. 12/658,759, filed Feb. 12, 2010, which is a continuation of Ser. No. 11/787,471, filed Apr. 17, 2007, issuing as U.S. Pat. No. 7,661,343 on Feb. 16, 2010, which is a continuation of Ser. No. 10/341,260, filed Jan. 13, 2003, now abandoned, which claims the benefit of and priority from U.S. Provisional Patent Application Ser. No. 60/351,797, filed Jan. 25, 2002;

Ser. No. 11/647,676, filed Dec. 29, 2006, now U.S. Pat. No. 7,836,804, which is a continuation of Ser. No. 10/923,290, filed Aug. 20, 2004, issuing as U.S. Pat. No. 7,472,634 on Jan. 6, 2009, which claims the benefit of and priority from U.S. Provisional Patent Application Ser. No. 60/496,550, filed Aug. 20, 2003;

Ser. No. 12/079,820, filed Mar. 27, 2008, now U.S. Pat. No. 7,485,258, which is a continuation of Ser. No. 10/923,273, filed Aug. 20, 2004, issuing as U.S. Pat. No. 7,350,445 on Apr. 1, 2008, which claims the benefit of and priority from U.S. Provisional Patent Application Ser. No. 60/496,574, filed Aug. 20, 2003;

Ser. No. 12/454,569, filed May 18, 2009, which is a continuation of Ser. No. 11/027,600, filed Dec. 31, 2004, issuing as U.S. Pat. No. 7,536,238 on May 19, 2009, which claims the benefit of and priority from U.S. Provisional Patent Application Ser. No. 60/533,791, filed Dec. 31, 2003;

Ser. No. 12/799,915, filed May 3, 2010, which is a continuation of Ser. No. 12/322,069, filed Jan. 26, 2009, issuing as U.S. Pat. No. 7,707,918 on May 4, 2010, which is a continuation of U.S. patent application Ser. No. 11/107,499, filed Apr. 15, 2005, issuing as U.S. Pat. No. 7,481,140 on Jan. 27, 2009;

Ser. No. 12/077,576, filed Mar. 19, 2008, which is a continuation of Ser. No. 11/027,254, filed Dec. 31, 2004, now abandoned, which claims the benefit of and priority from U.S. Provisional Patent Application Ser. No. 60/533,852, filed Dec. 31, 2003;

Ser. No. 12/799,920, filed May 3, 2010, which is a continuation of Ser. No. 11/026,114, filed Dec. 31, 2004, issuing as U.S. Pat. No. 7,707,920 on May 4, 2010, which claims the benefit of and priority from U.S. Provisional Patent Application Ser. No. 60/533,811, filed Dec. 31, 2003;

Ser. No. 11/026,006, filed Dec. 31, 2004, which claims the benefit of and priority from U.S. Provisional Patent Application Ser. No. 60/533,575, filed Dec. 31, 2003;

Ser. No. 11/045,972, filed Jan. 28, 2005, now U.S. Pat. No. 7,827,890, which claims the benefit of and priority from U.S. Provisional Patent Application Ser. No. 60/540,377, filed Jan. 29, 2004; and

Ser. No. 12/454,730, filed May 20, 2009, which is a continuation of Ser. No. 11/395,502, filed Mar. 31, 2006, now abandoned which claims the benefit of and priority from U.S. Provisional Patent Application Ser. No. 60/667,485, filed Mar. 31, 2005.

FIELD

The present disclosure relates to safety systems and more particularly to methods for enhancing the safety of power equipment.

BACKGROUND

Power equipment such as table saws, miter saws and other woodworking machinery include cutting tools like circular saw blades and knife blades that present a risk of injury to a user of the equipment. Accordingly, safety features or systems are incorporated with power equipment to minimize the risk of injury. Probably the most common safety feature is a guard that physically blocks an operator from making contact with dangerous components of machinery, such as belts, shafts or blades. In many cases, guards effectively reduce the risk of injury, however, there are many instances where the nature of the operations to be performed precludes using a guard that completely blocks access to hazardous machine parts.

Other safety systems try to prevent or minimize injury by detecting and reacting to an event. For instance, U.S. Pat. Nos. 3,953,770, 4,075,961, 4,470,046, 4,532,501 and 5,212,621, the disclosures of which are incorporated herein by reference, disclose radio-frequency safety systems which utilize radio-frequency signals to detect the presence of a user's hand in a dangerous area of the machine and thereupon prevent or interrupt operation of the machine. U.S. Pat. Nos. 3,785,230 and 4,026,177, the disclosures of which are herein incorporated by reference, disclose a safety system for use on circular saws to stop the blade when a user's hand approaches the blade. The system uses the blade as an antenna in an electromagnetic proximity detector to detect the approach of a user's hand prior to actual contact with the blade. Upon detection of a user's hand, the system engages a brake using a standard solenoid.

U.S. Pat. No. 4,117,752, which is herein incorporated by reference, discloses a braking system for use with a band saw, where the brake is triggered by actual contact between the user's hand and the blade. However, the system described for detecting blade contact does not appear to be functional to accurately and reliably detect contact. Furthermore, the system relies on standard electromagnetic brakes operating off of line voltage to stop the blade and pulleys of the band saw. It is believed that such brakes would take 50 ms-1 s to stop the blade. Therefore, the system is too slow to stop the blade quickly enough to avoid serious injury.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a schematic block diagram of a machine with a fast-acting safety system.

FIG. **2** is a schematic diagram of an exemplary safety system in the context of a machine having a circular blade.

FIG. **3** is a schematic side view of a table saw with a retraction system.

FIG. **4** is a schematic side view of a second side of a table saw with a retraction system.

FIG. **5** is a schematic, side view of a saw with another embodiment of a retraction system.

FIG. **6** is a section view of a retraction system using a deformable bushing.

FIG. **7** is a schematic side view of a miter saw with a retraction system.

FIG. **8** is a section view of the miter saw shown in FIG. **7**.

FIG. **9** shows another embodiment of a miter saw with a retraction system.

FIG. **10** shows a schematic drawing of a retraction system using a spring to retract a cutting tool.

FIG. **11** is a sectional view of the retraction system shown in FIG. **10**.

FIG. **12** also is a sectional view of the retraction system shown in FIG. **10**.

FIG. **13** is a schematic view of a band saw with a retraction system.

FIG. **14** is a top view of a roller used in the system shown in FIG. **13**.

FIG. **15** shows an explosive charge that can be triggered by a firing subsystem.

FIG. **16** is a schematic side elevation view of a miter saw having an alternative exemplary safety system configured to stop the miter saw pivot arm as well as the blade.

FIG. **17** is a magnified side view of an exemplary retraction assembly according to the present invention.

FIG. **18** is a magnified cross-sectional view of the retraction assembly of FIG. **17**.

FIG. **19** is a magnified, fragmentary view of the retraction assembly of FIG. **17**, showing the restraining mechanism in detail.

FIG. **20** is similar to FIG. **18** except that the clamping device is shown pivoted to the locked position.

FIG. **21** is similar to FIG. **20** except that the housing is shown pushed upward relative to the brace member. For clarity, the components of the restraining member are not shown.

DETAILED DESCRIPTION

A machine that may incorporate a retraction system according to the present disclosure is shown schematically in FIG. **1** and indicated generally at **10**. Machine **10** may be any of a variety of different machines adapted for cutting workpieces, such as wood, including a table saw, miter saw (chop saw), radial arm saw, circular saw, band saw, jointer, planer, etc. Machine **10** includes an operative structure **12** having a cutting tool **14** and a motor assembly **16** adapted to drive the cutting tool. Machine **10** also includes a safety system **18** configured to minimize the potential of a serious injury to a person using machine **10**. Safety system **18** is adapted to detect the occurrence of one or more dangerous conditions during use of machine **10**. If such a dangerous condition is detected, safety system **18** is adapted to engage operative structure **12** to limit any injury to the user caused by the dangerous condition.

Machine **10** also includes a suitable power source **20** to provide power to operative structure **12** and safety system **18**. Power source **20** may be an external power source such as line current, or an internal power source such as a battery. Alternatively, power source **20** may include a combination of both external and internal power sources. Furthermore, power source **20** may include two or more separate power sources, each adapted to power different portions of machine **10**.

It will be appreciated that operative structure **12** may take any one of many different forms, depending on the type of machine **10**. For example, operative structure **12** may include a stationary housing configured to support motor assembly **16** in driving engagement with cutting tool **14**. Alternatively, operative structure **12** may include a movable structure configured to carry cutting tool **14** between multiple operating positions. As a further alternative, operative structure **12** may include one or more transport mechanisms adapted to convey a workpiece toward and/or away from cutting tool **14**.

Motor assembly **16** includes one or more motors adapted to drive cutting tool **14**. The motors may be either directly or indirectly coupled to the cutting tool, and may also be adapted to drive workpiece transport mechanisms. Cutting tool **14** typically includes one or more blades or other suitable cutting implements that are adapted to cut or remove portions from the workpieces. The particular form of cutting tool **14** will vary depending upon the various embodiments of machine **10**. For example, in table saws, miter saws, circular saws and radial arm saws, cutting tool **14** will typically include one or more circular rotating blades having a plurality of teeth disposed along the perimetrical edge of the blade. For a jointer or planer, the cutting tool typically includes a plurality of radially spaced-apart blades. For a band saw, the cutting tool includes an elongate, circuitous tooth-edged band.

Safety system **18** includes a detection subsystem **22**, a reaction subsystem **24** and a control subsystem **26**. Control subsystem **26** may be adapted to receive inputs from a variety of sources including detection subsystem **22**, reaction subsystem **24**, operative structure **12** and motor assembly **16**. The control subsystem may also include one or more sensors adapted to monitor selected parameters of machine **10**. In addition, control subsystem **26** typically includes one or more instruments operable by a user to control the machine. The control subsystem is configured to control machine **10** in response to the inputs it receives.

Detection subsystem **22** is configured to detect one or more dangerous, or triggering, conditions during use of machine **10**. For example, the detection subsystem may be configured to detect that a portion of the user's body is dangerously close to, or in contact with, a portion of cutting tool **14**. As another example, the detection subsystem may be configured to detect the rapid movement of a workpiece due to kickback by the cutting tool, as is described in U.S. Provisional Patent Application Ser. No. 60/182,866, the disclosure of which is herein incorporated by reference. In some embodiments, detection subsystem **22** may inform control subsystem **26** of the dangerous condition, which then activates reaction subsystem **24**. In other embodiments, the detection subsystem may be adapted to activate the reaction subsystem directly.

Once activated in response to a dangerous condition, reaction subsystem **24** is configured to engage operative structure **12** quickly to prevent serious injury to the user. It will be appreciated that the particular action to be taken by reaction subsystem **24** will vary depending on the type of machine **10** and/or the dangerous condition that is detected. For example, reaction subsystem **24** may be configured to do one or more of the following: stop the movement of cutting tool **14**, disconnect motor assembly **16** from power source **20**, place a barrier between the cutting tool and the user, or retract the cutting tool from its operating position, etc. The reaction subsystem may be configured to take a combination of steps to protect the user from serious injury. Placement of a barrier between the cutting tool and teeth is described in more detail in U.S. Provisional Patent Application Ser. No. 60/225,206, entitled "Cutting Tool Safety System," filed Aug. 14, 2000 by SD3, LLC, the disclosure of which is herein incorporated by reference.

The configuration of reaction subsystem **24** typically will vary depending on which action(s) are taken. In the exemplary embodiment depicted in FIG. **1**, reaction subsystem **24** is configured to stop the movement of cutting tool **14** and includes a brake mechanism **28**, a biasing mechanism **30**, a restraining mechanism **32**, and a release mechanism **34**. Brake mechanism **28** is adapted to engage operative structure **12** under the urging of biasing mechanism **30**. During normal operation of machine **10**, restraining mechanism **32** holds the brake mechanism out of engagement with the operative structure. However, upon receipt of an activation signal by reaction subsystem **24**, the brake mechanism is released from the restraining mechanism by release mechanism **34**, whereupon, the brake mechanism quickly engages at least a portion of the operative structure to bring the cutting tool to a stop.

It will be appreciated by those of skill in the art that the exemplary embodiment depicted in FIG. **1** and described above may be implemented in a variety of ways depending on the type and configuration of operative structure **12**. Turning attention to FIG. **2**, one example of the many possible implementations of safety system **18** is shown. System **18** is configured to engage an operative structure having a cutting tool

in the form of a circular blade **40** mounted on a rotating shaft or arbor **42**. Blade **40** includes a plurality of cutting teeth (not shown) disposed around the outer edge of the blade. As described in more detail below, braking mechanism **28** is adapted to engage the teeth of blade **40** and stop the rotation of the blade. U.S. Provisional Patent Application Ser. No. 60/225,210, entitled "Translation Stop For Use In Power Equipment," filed Aug. 14, 2000 by SD3, LLC, the disclosure of which is herein incorporated by reference, describes other systems for stopping the movement of the cutting tool. U.S. Provisional Patent Application Ser. No. 60/225,058, entitled "Table Saw With Improved Safety System," filed Aug. 14, 2000 by SD3, LLC, and U.S. Provisional Patent Application Ser. No. 60/225,057, entitled "Miter Saw With Improved Safety System," filed Aug. 14, 2000 by SD3, LLC, the disclosures of which are herein incorporated by reference, describe safety system **18** in the context of particular types of machines **10**.

In the exemplary implementation, detection subsystem **22** is adapted to detect the dangerous condition of the user coming into contact with blade **40**. The detection subsystem includes a sensor assembly, such as contact detection plates **44** and **46**, capacitively coupled to blade **40** to detect any contact between the user's body and the blade. Typically, the blade, or some larger portion of cutting tool **14** is electrically isolated from the remainder of machine **10**. Alternatively, detection subsystem **22** may include a different sensor assembly configured to detect contact in other ways, such as optically, resistively, etc. In any event, the detection subsystem is adapted to transmit a signal to control subsystem **26** when contact between the user and the blade is detected. Various exemplary embodiments and implementations of detection subsystem **22** are described in more detail in U.S. Provisional Patent Application Ser. No. 60/225,200, entitled "Contact Detection System For Power Equipment," filed Aug. 14, 2000 by SD3, LLC, and U.S. Provisional Patent Application Ser. No. 60/225,211, entitled "Apparatus And Method For Detecting Dangerous Conditions In Power Equipment," filed Aug. 14, 2000 by SD3, LLC, the disclosures of which are herein incorporated by reference.

Control subsystem **26** includes one or more instruments **48** that are operable by a user to control the motion of blade **40**. Instruments **48** may include start/stop switches, speed controls, direction controls, etc. Control subsystem **26** also includes a logic controller **50** connected to receive the user's inputs via instruments **48**. Logic controller **50** is also connected to receive a contact detection signal from detection subsystem **22**. Further, the logic controller may be configured to receive inputs from other sources (not shown) such as blade motion sensors, workpiece sensors, etc. In any event, the logic controller is configured to control operative structure **12** in response to the user's inputs through instruments **48**. However, upon receipt of a contact detection signal from detection subsystem **22**, the logic controller overrides the control inputs from the user and activates reaction subsystem **24** to stop the motion of the blade. Various exemplary embodiments and implementations of control subsystem **26** are described in more detail in U.S. Provisional Patent Application Ser. No. 60/225,059, entitled "Logic Control For Fast Acting Safety System," filed Aug. 14, 2000 by SD3, LLC, and U.S. Provisional Patent Application Ser. No. 60/225,094, entitled "Motion Detecting System For Use In Safety System For Power Equipment," filed Aug. 14, 2000 by SD3, LLC, the disclosures of which are herein incorporated by reference.

In the exemplary implementation, brake mechanism **28** includes a pawl **60** mounted adjacent the edge of blade **40** and selectively moveable to engage and grip the teeth of the blade. Pawl **60** may be constructed of any suitable material adapted to engage and stop the blade. As one example, the pawl may be constructed of a relatively high strength thermoplastic material such as polycarbonate, ultrahigh molecular weight polyethylene (UHMW) or Acrylonitrile Butadiene Styrene (ABS), etc., or a metal such as aluminum, etc. It will be appreciated that the construction of pawl **60** will vary depending on the configuration of blade **40**. In any event, the pawl is urged into the blade by a biasing mechanism in the form of a spring **66**. In the illustrative embodiment shown in FIG. **2**, pawl **60** is pivoted into the teeth of blade **40**. It should be understood that sliding or rotary movement of pawl **60** might also be used. The spring is adapted to urge pawl **60** into the teeth of the blade with sufficient force to grip the blade and quickly bring it to a stop.

The pawl is held away from the edge of the blade by a restraining mechanism in the form of a fusible member **70**. The fusible member is constructed of a suitable material adapted to restrain the pawl against the bias of spring **66**, and also adapted to melt under a determined electrical current density. Examples of suitable materials for fusible member **70** include NiChrome wire, stainless steel wire, etc. The fusible member is connected between the pawl and a contact mount **72**. Preferably, fusible member **70** holds the pawl relatively close to the edge of the blade to reduce the distance the pawl must travel to engage the blade. Positioning the pawl relatively close to the edge of the blade reduces the time required for the pawl to engage and stop the blade. Typically, the pawl is held approximately 1/32-inch to 1/4-inch from the edge of the blade by fusible member **70**, however other pawl-to-blade spacings may also be used within the scope of the invention.

Pawl **60** is released from its unactuated, or cocked, position to engage blade **40** by a release mechanism in the form of a firing subsystem **76**. The firing subsystem is coupled to contact mount **72**, and is configured to melt fusible member **70** by passing a surge of electrical current through the fusible member. Firing subsystem **76** is coupled to logic controller **50** and activated by a signal from the logic controller. When the logic controller receives a contact detection signal from detection subsystem **22**, the logic controller sends an activation signal to firing subsystem **76**, which melts fusible member **70**, thereby releasing the pawl to stop the blade. Various exemplary embodiments and implementations of reaction subsystem **24** are described in more detail in U.S. Provisional Patent Application Ser. No. 60/225,056, entitled "Firing Subsystem For Use In Fast Acting Safety System," filed Aug. 14, 2000 by SD3, LLC, U.S. Provisional Patent Application Ser. No. 60/225,170, entitled "Spring-Biased Brake Mechanism for Power Equipment," filed Aug. 14, 2000 by SD3, LLC, and U.S. Provisional Patent Application Ser. No. 60/225,169, entitled "Brake Mechanism For Power Equipment," filed Aug. 14, 2000 by SD3, LLC, the disclosures of which are herein incorporated by reference.

Other systems can also be used to shift the pawl or pawls into contact with the blade, and firing system **76** may also be used to trigger some action other than burning a fusible member. For example, firing system **76** can fire a small explosive charge to move a pawl. FIG. **15** shows a relatively small, self-contained explosive charge **660** in the form of a squib or detonator that can be used to drive pawl **60** against a blade. An example of a suitable explosive charge is an M-100 detonator available, for example, from Stresau Laboratory, Inc., of Spooner, Wis. Although any suitable explosive charge system may be used, the exemplary embodiment preferably uses a self-contained charge or squib to increase safety and focus the force of the explosion along the direction of movement of the

pawl. A trigger line **662** extends from the charge, and it may be connected to firing system **76** to trigger detonation.

Explosive charge **660** can be used to move pawl **60** by inserting the charge between the pawl and a stationary block **664** adjacent the charge. When the charge detonates, the pawl is pushed away from the block. A compression spring **66** is placed between the block and pawl to ensure the pawl does not bounce back from the blade when the charge is detonated. Prior to detonation, the pawl is held away from the blade by the friction-fit of the charge in both the block and pawl. However, the force created upon detonation of the charge is more than sufficient to overcome the friction fit. Alternatively, the pawl may be held away from the blade by other mechanisms such as a frangible member, gravity, a spring between the pawl and block, etc.

Firing system **76** may also trigger a DC solenoid, which can be over-driven with a current surge to create a rapid displacement, a pressurized air or gas cylinder to supply the pressure in place of the spring or charge, or an electromagnet to either repel the pawl against the blade or to release a spring-loaded pawl toward the blade.

It will be appreciated that activation of the brake mechanism will require the replacement of one or more portions of safety system **18**. For example, pawl **60** and fusible member **70** typically must be replaced before the safety system is ready to be used again. Thus, it may be desirable to construct one or more portions of safety system **18** in a cartridge that can be easily replaced. For example, in the exemplary implementation depicted in FIG. **2**, safety system **18** includes a replaceable cartridge **80** having a housing **82**. Pawl **60**, spring **66**, fusible member **70** and contact mount **72** are all mounted within housing **82**. Alternatively, other portions of safety system **18** may be mounted within the housing. In any event, after the reaction system has been activated, the safety system can be reset by replacing cartridge **80**. The portions of safety system **18** not mounted within the cartridge may be replaced separately or reused as appropriate. Various exemplary embodiments and implementations of a safety system using a replaceable cartridge are described in more detail in U.S. Provisional Patent Application Ser. No. 60/225,201, entitled "Replaceable Brake Mechanism For Power Equipment," filed Aug. 14, 2000 by SD3, LLC, and U.S. Provisional Patent Application Ser. No. 60/225,212, entitled "Brake Positioning System," filed Aug. 14, 2000 by SD3, LLC, the disclosures of which are herein incorporated by reference.

While one particular implementation of safety system **18** has been described, it will be appreciated that many variations and modifications are possible within the scope of the invention. Many such variations and modifications are described in U.S. Provisional Patent Application Ser. Nos. 60/182,866 and 60/157,340, the disclosures of which are herein incorporated by reference.

As briefly mentioned above, reaction subsystem **24** can be configured with a retraction system to retract or move a cutting tool away from the point of accidental contact with a user. Moving away from the point of accidental contact reduces the time the cutting tool is in contact with the user, thereby minimizing any injury to the user. Moving the cutting tool away from the point of accidental contact also prevents the cutting tool from moving toward the user, which could increase any injury to the user. For example, a spinning blade in a miter saw has substantial angular momentum, and that angular momentum could cause the blade to move downward toward a user when a brake pawl hits the blade. The spinning blade in a table saw also has substantial angular momentum that could cause the blade to move upward toward a user when a brake pawl hits the blade, depending on the position of the brake, the weight of the blade and the amount of play in the structure supporting the blade. Preventing any such movement lessens the potential injury to the user. A retraction system may be used in addition to or instead of other safety mechanisms.

FIGS. **3** and **4** show side views of a table saw configured with both a retraction system and a braking mechanism. A blade **300** is mounted on an arbor **301** to spin in the direction of arrow **302**. A table **303** (not shown in FIG. **4**), which defines the work surface or cutting region for the table saw, is adjacent the blade and the blade extends above the table. A support structure **304** may support blade **300** and arbor **301** in any known way, or as described in more detail in U.S. Provisional Patent Application Ser. No. 60/225,058, titled "Table Saw with Improved Safety System," filed Aug. 14, 2000.

Blade **300** is configured to pivot up and down so that a user can position the blade to extend above the table as needed. The blade pivots around a pin **305**. A user may pivot the blade to adjust its position by turning a shaft **306** on which a worm gear **307** is mounted. The worm gear is mounted on the shaft so that it turns with the shaft, but so that it may slide on the shaft when necessary, as explained below. Worm gear **307** is mounted on shaft **306** like a collar, with the shaft extending through a longitudinal hole in the worm gear. The worm gear is held in place during normal operation of the saw by a spring clip **308**, which is positioned in a groove or channel **309** on the worm gear and which also engages a detent or shoulder on shaft **306** to hold the worm gear in place. The worm gear engages an arcuate rack **310** that supports an arbor block **311**, which in turn supports arbor **301** and blade **300**. Thus, when a user turns shaft **306**, such as by turning a knob attached to the shaft (not shown), worm gear **307** moves arbor block **311** and the blade up or down, depending on the direction that the worm gear is turned.

A brake cartridge **312** is mounted in the saw adjacent blade **300**. The brake cartridge includes a pawl **314** biased toward blade **300** by a spring **316**. The pawl is held away from blade **300** by a release mechanism **318**, as described generally above and as described in more detail in U.S. Provisional Patent Application Ser. No. 60/225,170, entitled "Spring-Biased Brake Mechanism for Power Equipment," U.S. Provisional Patent Application Ser. No. 60/225,169, entitled "Brake Mechanism for Power Equipment," U.S. Provisional Patent Application Ser. No. 60/225,201, entitled "Replaceable Brake Mechanism for Power Equipment," and U.S. Provisional Patent Application Ser. No. 60/225,212, entitled "Brake Positioning System," all filed Aug. 14, 2000. The cartridge is configured so that the release mechanism releases the pawl into the blade upon the receipt of a detection signal, as explained generally above and as explained in more detail in U.S. Provisional Patent Application Ser. No. 60/225,056, titled "Firing Subsystem for use in a Fast-Acting Safety System," filed Aug. 14, 2000.

Brake cartridge **312** is positioned on the blade's pivot axis so that pawl **314** can move around pin **305**. Thus, when pawl **314** hits the blade, the angular momentum of the blade is transferred to the arbor block, and the blade, arbor block, rack and cartridge try to retract or move down in the direction of arrow **320**. Alternatively, the cartridge may be positioned on a pin different from pin **305**, but that still pivots with the blade.

The blade will move down to the extent permitted by the contact between rack **310** and worm gear **307**. If the worm gear is fixed in place, the downward movement of the blade may strip teeth on the rack and/or worm gear, and may prevent the blade from moving down as far as desired. In the embodiment shown in FIGS. **3** and **4**, the worm gear is adapted to snap free and move on shaft **306** when the pawl hits the blade.

When the pawl hits the blade, the resultant angular momentum impulse causes spring clip **308** to snap loose, allowing the worm gear to slide down the shaft toward an end **322** of the shaft. The spring clip snaps loose because the rack moves down when the blade is stopped, and the rack contacts the worm gear and forces the worm gear to move. The force of the rack against the worm gear causes the spring clip to snap loose. The worm gear is put back in place by moving it back along shaft **306** until the spring clip snaps into place on the shaft.

The table saw shown in FIGS. **3** and **4** also includes a support **326** configured with a seat or region **328** in which is placed an impact-absorbing material **330**. The support is positioned under the arbor and arbor block so that when the blade retracts, the arbor block strikes impact-absorbing material **330**. Support **326** and impact absorbing material **330** act as a barrier to stop the downward movement of the blade. The support is positioned so that blade **300** may retract a sufficient distance. The impact-absorbing material can be any one of a number of cushioning materials, such as rubber, dense foam, plastic, etc. One material found to be suitable is available under the part number C-1002-06 from AearoEAR, of Indianapolis, Ind. Alternatively, impact-absorbing material **330** may be attached to the undersurface of the arbor block instead of on support **326**. Additionally, support **326** may take many forms. In fact, shaft **306** may be configured and positioned so that it provides a surface to stop the downward movement of the blade.

FIG. **4** also shows a splitter **335** that extends above table **303** behind blade **300** to prevent kickback. A blade guard may also substantially enclose blade **300**. FIG. **4** further shows a housing **337** for electronic components relating to the safety system, and a motor mount **339**, which are not shown in FIG. **3**.

In the construction described above, the angular momentum of the blade causes the blade, arbor block and cartridge to all pivot down away from the cutting region when the pawl strikes the blade. Thus, the angular momentum of the blade causes the retraction. Blade **300** is permitted to move downward a sufficient distance so that the blade is completely retracted. In independent experiments, the safety system depicted in FIGS. **3** and **4** and described above has been shown to retract the blade completely below table **303** within approximately 14 milliseconds after contact is detected. Indeed the downward motion of the blade during retraction is too fast to detect with the human eye, i.e., the blade disappears below table **303** with no discernable transition or downward motion. The ability of the blade to retract minimizes any injury from accidental contact with the blade.

FIG. **5** shows another embodiment of a retraction system used with a brake pawl. A saw **331** includes a blade **300** and a brake cartridge **312** housing a brake pawl **314**. The cartridge and pawl are mounted to the frame of the saw by a pin **332**. The pin is mounted to the saw in such a way that it may not pivot up and down with the blade. When the blade hits the pawl, the blade climbs down the pawl, or in other words, moves generally around the point of contact with the pawl. The pawl and blade do not pivot downward together, as in the embodiment shown in FIGS. **3** and **4**, because the pawl is fixed to the frame of the saw. In this embodiment, the blade retracts by "climbing" down the pawl.

Another embodiment of a retraction system comprises a compressible bushing. Typically, a blade **300** in a table saw, miter saw or other machine is mounted to an arbor over a bushing **333**, as shown in FIG. **6**. A locking nut, washers and an arbor flange are used to secure the blade to the arbor. Bushing **333** may be constructed from a material that is soft enough to deform when the blade is stopped suddenly. For example, depending on the type of braking system used, a substantial radial impact load may be transmitted to the arbor when the brake is actuated. A deformable bushing can be used to absorb some of this impact and reduce the chance of damage to the arbor. In addition, proper positioning of the brake in combination with a deformable bushing may be employed to cause the blade to move away from the user upon activation of the brake. Where a plastic bushing is placed between the blade and the arbor, the substantial force created by stopping the blade almost instantly may cause the bushing to deform. Typically, the edge of the mounting hole of the blade will bite into the bushing as the blade attempts to rotate about the pawl. Therefore, if the pawl is mounted at the back of the blade, then the blade will tend to move downward into the bushing and away from the user when the pawl engages the blade.

FIGS. **7** and **8** show a miter saw equipped with both a brake and a retraction system. The miter saw is configured with a pivotal motor assembly to allow the blade to move upward into the housing upon engagement with a brake pawl **348**. Motor assembly **350** is connected to housing **352** via pivot bolt **354**, allowing the motor assembly to pivot about bolt **354** in the direction of blade rotation. A spring **356** is compressed between the motor assembly and an anchor **358** to bias the motor assembly against the direction of blade rotation. The motor assembly may include a lip **360**, which slides against a flange **362** on the housing to hold the end of the motor assembly opposite the pivot bolt against the housing.

When the saw is in use, spring **356** holds the motor assembly in a normal position rotated fully counter to the direction of blade rotation. However, once the pawl is released to engage the blade, the motor assembly and blade pivot upward against the bias of the spring. In this embodiment, the pawl is positioned at the front of the blade so that the pivot bolt **354** is between the pawl and the arbor. This arrangement encourages the blade to move upward into the housing when stopped. The spring is selected to be sufficiently strong to hold the motor assembly down when cutting through a workpiece, but sufficiently compressible to allow the blade and motor assembly to move upward when the blade is stopped. Of course, the blade and motor assembly may be configured in any of a variety of ways to at least partially absorb the angular momentum of the blade.

FIG. **9** shows an alternative configuration of a miter saw adapted to move away from an accidental contact with a user by absorbing the angular momentum of the blade. In this configuration, the miter saw includes two swing arms **370** and **372**. One end **374** of each swing arm **370**, **372** is connected to base **376**, and the opposite end **378** of each swing arm is connected to housing **380**, the blade, and/or the motor assembly (not shown). The position of the swing arms relative to each other may vary depending on the swing arm motion desired. In FIG. **9**, swing arm **370** is connected to base **376** somewhat below and forward of swing arm **372**. Typically, the motor assembly is rigidly attached to end **378** of swing arm **370**, while housing **380** is connected to rotate about end **378** of swing arm **370**. End **378** of swing arm **372** is connected only to the housing. Alternatively, the motor assembly may be connected to rotate about end **378** of swing arm **370** along with the housing.

The geometry of the configuration shown in FIG. **9** causes the housing and/or motor assembly to rotate as the swing arms pivot. Significantly, when the swing arms move upward, the housing and/or motor assembly rotate in the same direction in which the blade rotates during cutting. As a result, when a brake pawl engages the blade and transfers the angular momentum of the blade to the housing and/or motor assem-

bly, the housing and/or motor assembly tend to rotate in the same direction as the blade. This causes the swing arms to pivot upward, drawing the blade away from the workpiece and the user's body. Thus, the miter saw configuration illustrated in FIG. **9** is adapted to absorb the angular momentum of the blade and translate that angular momentum into an upward force on the swing arms.

In any of the systems described above, a spring or other force can be used to push the blade away from the point of contact with the user. The spring could be released by a mechanism similar to the mechanism that releases the pawl to strike the blade. FIGS. **10-12** show how a spring may be used to retract a blade in a table saw. FIG. **10** is a top view and FIGS. **11** and **12** are side views of an arbor block **381** holding an arbor **382** used to drive a blade (not shown). Arbor block **381** is pivotally mounted to pin **383** so that the arbor block and blade may pivot up and down to adjust the position of the blade in the saw.

A segment gear **384**, like rack **310** described above in connection with FIGS. **3** and **4**, is also mounted on pin **383**, and is connected to arbor block **381** in the manner described below, to raise and lower the arbor. Segment gear **384** includes a side portion **385** positioned substantially perpendicularly to the plane of arbor block **381**, and a top portion **386** positioned over arbor block **381**. The side portion **385** includes gear teeth **387** to engage a worm gear to raise and lower the arbor block. Side portion **385** and top portion **386** are connected to each other and move together. Top portion **386** extends over the top of the entire arbor block, as shown. The arbor block is constructed with a region to accommodate top portion **386** so that top portion **386** does not extend substantially above the arbor block, which could limit the ability of the arbor block and blade to pivot upward when desired, such as by contacting the underside of a table in a table saw.

A pocket **388** is formed in arbor block **381** to house a spring **389**. In the position shown in FIG. **11**, spring **389** is compressed between top portion **386** of segment gear **384** and arbor block **381** because the segment gear and arbor block are coupled together.

The segment gear and arbor block are coupled by a compound linkage having, as shown in FIG. **12**, a first arm **390** attached at one end to the arbor block and at its other end to a second arm **391**. The second arm, in turn, is attached to top portion **386** of segment gear **384**, as shown. First and second arms **390** and **391** are hingedly connected to each other, and to the arbor block and segment gear. The arms are configured so that the force of the spring pushing apart the arbor block and the top portion of the segment gear biases the first and second arms in such a way that the arms want to move. A fusible member **392**, which may take the form of a wire as described above, restrains the arms from movement. Of course, numerous different linkages may be used, and numerous types and configurations of fusible members or other release mechanisms may be used. The linkage may be selected to provide a sufficient mechanical advantage so that the arbor block and top portion of the segment gear may be held together with as thin a fusible member as possible, so that the fusible member may be burned as easily as possible. Various analogous compound linkages are described in U.S. Provisional Patent Application Ser. No. 60/225,170, entitled "Spring-Biased Brake Mechanism for Power Equipment," filed Aug. 14, 2000. The fusible member may be burned by a system as described above, or as described in more detail in U.S. Provisional Patent Application Ser. No. 60/225,056, entitled "Firing Subsystem for Use in Fast-Acting Safety System," filed Aug. 14, 2000, the disclosure of which is hereby incorporated by reference. The compound linkage and the fusible member are preferably configured so that they accommodate spring forces of 100 to 500 pounds or more. In other embodiments, the restraining member may include various mechanical linkages, or may be part of various actuators, and those linkages and/or actuators may be released or fired by solenoids, gas cylinders, electromagnets, and/or explosives, as explained in U.S. Provisional Patent Application Ser. No. 60/302,916, entitled "Actuators for Use in Fast-Acting Safety Systems," filed Jul. 3, 2001, the disclosure of which is hereby incorporated by reference.

When the fusible member is burned, the compound linkage is free to move, and the spring pushes arbor block **381** down, away from top portion **386** of the segment gear, as shown by the dashed lines in FIG. **11**, thereby retracting the blade. The stronger the spring, the faster the blade will be retracted. The segment gear does not move because it is coupled through teeth **387** to a worm gear or some other structure.

Retracting a blade by a spring or some other force may be thought of as direct retraction. A spring or other force may be used with some other retraction system to increase the speed that a cutting tool retracts, or a spring or other force may be used as the sole means of retraction. The systems for direct retraction described above may be used on various pieces of equipment, including table saws, miter saws and band saws.

FIG. **13** is a schematic diagram of a system to retract the blade of a band saw. Typically, a band saw includes a main housing enclosing a pair of vertically spaced-apart wheels. The perimeter of each wheel is coated or covered in a high-friction material such as rubber, etc. A relatively thin, continuous loop blade tightly encircles both wheels. A workpiece is cut by passing it toward the blade in a cutting zone between the wheels. The workpiece is passed toward the blade on a table, which forms the bottom of the cutting zone.

The band saw shown in FIG. **13** includes roller **393** positioned adjacent the blade. The roller is configured to contact the blade and push the blade away from the point of accidental contact with a user. In addition, the roller may be configured to push the blade off the wheels, thereby stopping the motion of the blade. A top view of the roller is shown in FIG. **14** pushing against a blade in the direction of the arrow. The roller may be part of a cartridge, and may be released into the blade just as the pawls described above are released. The roller should have a diameter large enough so that the roller can roll over the teeth of the blade.

The systems for direct retraction of a cutting tool may also be implemented on hand-held circular saws. Such saws typically include a base plate that contacts a workpiece during sawing. The base plate supports the saw on the workpiece. The base plate may be configured so that it is pushed down when the blade contacts a user. The result of that action is to effectively retract the blade because the base plate would push the user away from the blade.

FIG. **16** illustrates an exemplary miter saw **89** having an alternative embodiment of safety system **18** configured to at least partially retract the pivot arm in the event of contact between the blade and the user's body.

Exemplary miter saw **89** includes a base assembly **90** adapted to support a workpiece (not shown) during cutting. Typically, one or more fences **92** are mounted on base assembly **90** and adapted to prevent the workpiece from shifting across the base assembly during cutting. Operative structure **12** is coupled to base assembly **90** and includes a platen **94**, a tilt mechanism **96**, and a pivot arm **98**. Platen **94** is coupled to base assembly **90** and rotatable, relative to the base assembly, about the axis indicated at A. Tilt mechanism **96** is coupled to platen **94**. At least a portion of the tilt mechanism is rotatable, relative to base assembly **90**, about the axis indicated at B.

Pivot arm **98** is coupled to tilt mechanism **96** and selectively pivotal toward and away from base assembly **90**, as illustrated in FIG. **16**. Typically, the pivot arm is biased upward away from base assembly **90** by a spring or other suitable mechanism.

Motor assembly **16** is mounted on pivot arm **98** and includes at least one motor **100** and a control handle **102**. Blade **40** is coupled to an arbor shaft (not shown) that is rotatably driven by motor **100**. Control handle **102** includes one or more controls (not shown) that are operable by a user to control motor **100**. A user brings blade **40** into contact with a workpiece by grasping control handle **102** and pulling pivot arm **98** downward against the upward bias from a nominal position (indicated generally by dash lines in FIG. **16**), toward base assembly **90**. Once the cutting operation is completed, the user allows the pivot arm to pivot upward toward the nominal position.

It will be appreciated by those of skill in the art that the miter saw configuration depicted in FIG. **16** and described above is one commonly referred to as a "compound miter saw," which allows a user to make a compound (i.e., both mitered and beveled) cut in a workpiece by adjusting the position of platen **94** and/or tilt mechanism **96**. However, there are many other miter saw configurations known to those of skill in the art which are also suitable for use with the present invention. Thus, it will be understood that the particular miter saw configurations depicted and described herein are provided to illustrate exemplary embodiments of the invention, and should not be interpreted to limit the scope or application of the present invention.

Although not shown in FIG. **16**, detection subsystem **22** and control subsystem **26** may be mounted at any desired location on miter saw **89** and configured to detect contact between blade **40** and a user's body as described above and in the references incorporated herein. Alternatively, the detection and control subsystems may be configured to detect contact between the user's body and some other portion of the miter saw such as a guard, etc. Upon receiving an activation signal, a first portion **104** of reaction subsystem **24** is configured to stop the rotation of blade **40**, while a second portion **106** of the reaction subsystem is configured to move pivot arm **98** upward away from the base assembly. In the exemplary embodiment, first portion **104** includes a brake pawl **60** mounted in a cartridge **80**, such as described above and in the incorporated references. Brake pawl **60** is selectively pivotal into blade **40** to stop the rotation of the blade. Alternatively, the first portion may employ other brake mechanisms such as described in the incorporated references. As a further alternative, first portion **104** may be omitted so that the rotation of blade **40** is not stopped in response to the occurrence of a dangerous condition.

In any event, second portion **106** retracts the pivot arm upward far enough to remove the blade from contact with the user's body. Preferably, the second portion is configured to move the pivot arm upward at least ⅛-inch, more preferably at least ¼-inch, and most preferably at least ½-inch or more. In embodiments where the reaction subsystem is configured to stop the rotation of blade **40**, the second portion preferably retracts the pivot arm before or at the same time the blade is stopped. This prevents the pivot arm from moving downward as a result of angular momentum transferred to the pivot arm from the blade. The second portion of the reaction subsystem may be triggered prior to the first portion, or the second portion may be configured to engage the pivot arm more quickly than the brake pawl engages the blade.

Second portion **106** of exemplary reaction subsystem **24** includes a brace member **108** and a retraction assembly **110**. Brace member **108** is pivotally coupled to tilt mechanism **96** at **105**. Retraction assembly **110** is pivotally coupled to pivot arm **98** at **107** and configured to slidably receive at least a portion of brace member **108**. The retraction assembly is configured to quickly grip or lock onto the brace member and urge the pivot arm upward upon receipt of an actuation signal from control subsystem **26**. Once the retraction assembly has been triggered, pivot arm **98** is prevented from further downward movement toward base assembly **90**. While second portion **106** is illustrated as having a single brace member and a single retraction assembly on one side of miter saw **89**, it will be appreciated that the reaction subsystem may alternatively include a plurality of brace members and/or retraction assemblies positioned at selected locations on miter saw **89**.

Brace member **108** may take any of a variety of different forms. In the exemplary embodiment, the brace member is an elongate bar or shaft pivotally coupled to tilt mechanism **96**. Brace member **108** may be constructed of any suitably rigid material such as steel, aluminum, plastic, ceramic, etc. The pivotal coupling between the brace member and the tilt mechanism allows the brace member to pivot as necessary to follow the retraction assembly as the pivot arm moves toward and away from the base assembly. In the exemplary embodiment, the brace member is coupled to the tilt mechanism by a ball-joint-rod-end-bearing coupling **105**, such as are available from a variety of sources including MSC Industrial Supply Company of Melville, N.Y. Alternatively, other types of couplings may be used, such as universal couplings, etc.

In the exemplary embodiment, brace member **108** is coupled to an arm portion **112** of tilt mechanism **96** that extends outward from the tilt mechanism toward the base assembly. While arm **112** is depicted as an integral, unitary portion of the tilt mechanism, the arm portion may alternatively take the form of a separate bracket attached to the tilt mechanism. Alternatively, the arm may be omitted and brace member **108** may be coupled to another portion of the tilt mechanism. As further alternatives, the brace member may be coupled to a different portion of miter saw **10** such as platen **94**, fence **92**, or base assembly **90**, etc. In any event, the brace member should be relatively rigidly supported to ensure that pivot arm **98** is moved upward when retraction assembly **110** is triggered.

Retraction assembly **110** may be coupled to pivot arm **98** in any of a variety of different places. Typically, the retraction assembly and pivot point **107** are disposed to position brace member **108** spaced apart from pivot point **114** of arm **98** to increase the moment of the upward force applied by reaction subsystem **24** to pivot arm **98**. It will be appreciated that the further brace member **108** is positioned from pivot point **114**, the greater the moment of force provided by the retraction assembly. Thus, it is generally desirable, though not necessary, to position the brace member as close to the front of miter saw **89** (i.e., the left side as shown in FIG. **16**) as possible without interfering with the use of the miter saw. Similarly, the pivot point **105** of the brace member is disposed, relative to the retraction assembly, to orient the brace member generally perpendicular to the direction in which the pivot arm moves. This arrangement ensures that the downward force on the brace member is substantially a compression force rather than torque. Alternatively, retraction assembly **110** and pivot point **105** may be disposed at any selected positions suitable for stopping downward movement of pivot arm **98**.

Since brace member **108** is coupled to tilt mechanism **96**, the brace member will rotate along with pivot arm **98** about axis A when the miter saw is adjusted for mitered cuts. Similarly, the brace member will tilt about axis B when the miter

saw is adjusted for beveled cuts. Thus, the exemplary configuration of reaction subsystem **24** depicted in FIG. **16** allows a user to adjust miter saw **89** throughout its full range of movement.

Optionally, reaction subsystem **24** may include one or more positioning mechanisms configured to remove any play or looseness in the couplings between brace member **108** and tilt mechanism **96**, and/or the couplings between retraction assembly **110** and pivot arm **98**. In situations where play or looseness may be present, the positioning mechanism ensures that the brace member and retraction assembly do not shift when the reaction subsystem is triggered.

Turning attention now to FIGS. **17-21**, one exemplary embodiment of retraction assembly **110** is illustrated. Exemplary retraction assembly **110** is configured to grip and push downward on brace member **108** to move pivot arm **98** upward in response to an activation signal from control subsystem **26**. Retraction assembly **110** includes a housing **118** configured to slidably receive brace member **108**. Housing **118** includes a lower wall **120**, and an upper wall **122** spaced apart from the lower wall. Housing **118** also includes a first end wall **124** and a second end wall **126** extending between opposite ends of lower wall **120** and upper wall **122**. The lower, upper and end walls are connected together by any suitable mechanism such as bolts **127**. A pair of side walls **128** (shown in FIG. **16**) cover the sides of the lower, upper and end walls to enclose the housing.

Housing **118** is connected to the side of pivot arm **98** by a pivotal coupling **107** that allows the housing to move relative to the pivot arm as needed. Any of a variety of different couplings may be used which are known to those of skill in the art, such as a shoulder screw, etc. The pivotal coupling allows housing **118** to move as necessary to maintain a constant orientation or alignment with the brace member. In embodiments where the brace member is connected to a different structure on miter saw **89** such as platen **94** or fence **92**, coupling **107** may be configured to allow the housing to both pivot parallel to the side of the pivot arm and tilt away from the pivot arm as needed.

As mentioned above, housing **118** is configured to slide along brace member **108**. Lower wall portion **120** includes an orifice **130** configured to slide over the brace member. Similarly, upper wall portion **122** includes an orifice **132** configured to slide over the brace member. Orifices **130** and **132** are generally axially aligned and sized to closely fit around the brace member, thereby maintaining the housing in a uniform orientation relative to the brace member as pivot arm **98** is moved toward and away from the workpiece.

Retraction assembly **110** also includes an actuator **134** configured to selectively grip brace member **108** and push the housing upward. Actuator **134** may be any one or a combination of elements, devices or mechanisms configured to quickly and securely grip the brace member.

In the exemplary embodiment, actuator **134** includes a clamping device **136** adapted to selectively grip the brace member, and a drive mechanism **138** adapted to urge the housing upward relative to the clamping device. Clamping device **136** is formed to define an orifice **140** adapted to closely fit and slide along the brace member. The clamping device is pivotal between a nominal or unactuated position (as shown in FIGS. **17** and **18**), and an actuated or locked position (as shown in FIG. **20**). When the clamping device is in the nominal position, the sides of orifice **140** are substantially aligned with the sides of brace member **108** so that the clamping device slides relatively freely along the brace member. Conversely, when the clamping device is pivoted into the locked or actuated position, the sides of orifice **140** press into and bind against the brace member to releasably lock the clamping device onto the brace member. Drive mechanism **138** is disposed between the clamping device and upper wall **122** and configured to push the upper wall away from the clamping device when the clamping device is in the locked position. As a result, housing **118** and pivot arm **98** are pushed upward relative to the brace member and base assembly **90**.

Clamping device **136** may be constructed of any suitable material adapted to grip the brace member and support the force exerted by drive mechanism **138**. Typically, the clamping device is constructed of a material which does not cause damage to brace member **108** when the retraction assembly is triggered. For example, the clamping device and brace member may each be formed from a relatively rigid material such as hardened steel. Alternatively, the clamping device and/or brace member may be formed of any of a variety of other suitable materials known to those of skill in the art.

When in the nominal position, clamping device **136** is disposed adjacent the lower surface of upper wall **122** between end walls **124** and **126**. The end walls are spaced to align the clamping device and orifice **140** end-to-end with the upper wall and orifice **132**. Each end wall is inwardly tapered adjacent the upper wall so as not to obstruct the movement of the clamping device. Upper wall **122** includes a pair of alignment structures **142** adapted to align the clamping device and orifice **140** side-to-side with the upper wall and orifice **132**. When clamping device **136** is in the nominal position, orifice **140** is generally axially aligned with orifice **132** and orifice **130** to slidably receive the brace member.

Clamping device **136** is held in the nominal position by a yieldable support element such as spring **144** that engages the clamping device adjacent a first end **146**, as well as a releasable restraining mechanism **148** that engages the clamping device adjacent a second end **150**. First end wall **124** includes a recessed region adapted to hold a portion of spring **144** and align the spring with the clamping device. Although spring **144** is depicted as a compression spring, it will be appreciated that spring **144** may be any type of spring or other mechanism adapted to yieldably hold first end **146** adjacent the lower surface of upper wall **122**.

Restraining mechanism **148** may take any of a variety of different configurations adapted to releasably support second end **150** of the clamping device. In the exemplary embodiment, drive mechanism **138** (which will be discussed in more detail below) exerts a constant downward force on the clamping device adjacent second end **150**. Restraining mechanism **148** is configured to support the clamping device against the force exerted by the drive mechanism. Typically, though not necessarily, the restraining mechanism is generally aligned with the drive mechanism to reduce any bending stress to the clamping device.

Exemplary restraining mechanism **148** is selectively collapsible to release the second end of the clamping device. The restraining mechanism includes an elongate collapsible base **154** adapted to support an elongate brace **156**. In its uncollapsed state illustrated in FIGS. **17-19**, a lower end **158** of base **154** rests on the upper surface of lower wall **120**. The base extends upward from the lower wall toward the clamping device. A lower end **160** of brace **156** rests on an upper end **162** of base **154**. The brace extends upward from the base to support the clamping device. When the base collapses, the brace is dislodged, thereby releasing the clamping device as shown in FIGS. **20-21**.

When in the uncollapsed, upright position, one side of base **154** is disposed against a buttress structure **164**. One side of lower end **160** of the brace is also disposed against the buttress structure, while an upper end **166** of the brace is disposed

against a shoulder structure **168** on the clamping device. Shoulder structure **168** is configured to position the brace in upright alignment on top of the base. Base **154** and brace **156** are clamped against the buttress structure by a stabilizer member **170**. The stabilizer member is held in clamping engagement with the base and the brace by a fusible member **70** such as described above and in the incorporated references. Fusible member **70** extends from the stabilizer member, over a contact mount **72** to an anchor point **172**. Contact mount **72** is coupled to a firing subsystem (not shown) adapted to supply sufficient electrical current to melt the fusible member. In the exemplary embodiment, contact mount **72** is anchored to buttress structure **164**, which is constructed of an electrically non-conducting material such as plastic, etc.

Lower end **158** of the base includes a beveled region **174** opposite the buttress structure. As shown in FIG. **19**, beveled region **174** extends through more than half the thickness of the base. Lower end **160** of the brace includes a beveled region **176** adjacent the buttress structure. As a result, a portion of the downward pressure exerted on the clamping device by the drive mechanism is translated onto upper end **162** as a pivoting force away from the buttress structure. The remainder of the downward force is translated into a downward force on lower wall **128**. The upper end of the base is prevented from pivoting outward so long as stabilizer structure **170** remains in place.

Those of skill in the art will appreciate that the particular configuration of restraining mechanism **148** described above provides a mechanical advantage for supporting second end **150** of the clamping device under the downward force of the drive mechanism. The proportion of downward force translated into pivoting force on the base will vary with the depth of beveled regions **174** and **176**. Beveled regions **174** and **176** typically are configured so that much of the downward force applied by the drive mechanism is translated into downward force on base **154** rather than pivoting force. As a result, fusible member **70** is only required to support a portion of the force exerted by the drive mechanism. Indeed, several hundred pounds of downward force may be translated into only 10-20 pounds of outward pivoting force on stabilizer structure **170**. This allows the fusible member to have a smaller diameter, thereby requiring less energy to melt. Nevertheless, the outward pivoting force should be sufficient to ensure the base collapses within 5-10 milliseconds, and preferably within 1-5 milliseconds.

In any event, when stabilizer member **170** is released, the upper end of base **154** quickly pivots outward from the buttress structure and collapses beneath the brace, as illustrated in FIGS. **19** and **20**. Upper end **166** of the brace includes a beveled region **178** opposite shoulder structure **168** to allow the lower end of the brace to freely pivot outward from the buttress structure along with the base. Second end **150** of the clamping device is thereby released to move downward under the urging of the drive mechanism.

While second end **150** of the clamping device is pushed downward by the drive mechanism, first end **146** is pushed upward by spring **144**. As a result, clamping device **136** pivots about brace member **108** into the locked position where the edges of orifice **140** bind against the sides of the brace member as shown in FIG. **20**. The angle through which the clamping device must pivot before binding against the brace member will vary based at least partially on the size differential between orifice **140** and brace member **108**. It is believed that the binding force generated by the clamping device against the brace member is increased where the pivot angle between the nominal position and the locked position is relatively small. Therefore, orifice **140** typically is sized to fit relatively closely around the brace member. For example, in an embodiment where brace member **108** takes the form of a rod having a circular cross-section with a diameter of approximately 0.375-inch, one suitable diameter for orifice **140** would be approximately 0.376-inch. Alternatively, other diameters may also be used within the scope of the invention. For clarity, the size difference between orifice **140** and brace member **108** is shown substantially exaggerated in FIGS. **18**, **20** and **21**.

As mentioned above, drive mechanism **138** is disposed between upper wall **122** and second end **150** of the clamping device. The drive mechanism is configured to urge the second end and upper wall apart when the clamping device is released from restraining mechanism **148**. Once clamping device **136** pivots to the locked position, further downward movement of second end **150** is prevented because the clamping device is locked against the brace member. As a result, the additional drive force exerted by the drive mechanism forces upper wall **122** and housing **118** upward relative to the clamping device and brace member, as illustrated in FIG. **21**. Since the housing is coupled to pivot arm **98**, the pivot arm is forced upward as well.

Drive mechanism **138** should be configured to overcome the downward momentum of the pivot arm as well as any transferred angular momentum caused by stopping blade **40**. In addition, the upward force exerted by the drive mechanism on the housing should be substantially larger than any downward force exerted by spring **144**. Typically, the drive mechanism is configured to provide 100-500 pounds of upward force on the pivot arm. The length of upward travel of the pivot arm will depend on the length of translation, or 'throw,' of the drive mechanism as well as the distance second end **150** pivots downward before locking against the brace member.

In the exemplary embodiment, drive mechanism **138** includes a plurality of Belleville springs **180** stacked in series. The number of springs in the series is selected to provide a desired throw. Optionally, each spring in the series may alternatively be plural springs stacked in parallel to provide a desired amount of driving force. Springs **180** are disposed in a recessed region **182** of upper wall **122**. The recessed region is sized to maintain the springs in general axial alignment. Additionally, clamping device **136** includes a spindle structure **183**, adapted to fit within the central bores of at least a portion of the springs to maintain alignment between the springs. The spindle structure also serves to maintain alignment between the springs and the clamping device. It will be appreciated by those of skill in the art that drive mechanism **138** may alternatively take any of a variety of other configurations adapted to lock the clamping device against the brace member and force the pivot arm upward. For example, the drive mechanism may include a coil compression spring, explosive device, etc.

In any event, once the retraction assembly has been triggered, it may be uncoupled from the pivot arm and slid off the brace member. A new, untriggered retraction assembly may then be installed to place miter saw **89** and safety system **18** back in operation. Alternatively, the triggered retraction assembly may be reset using a new fusible member.

While one particular implementation of retraction assembly **110** has been described, it will be appreciated that numerous alterations and modifications are possible within the scope of the invention. Additionally, while the retraction assembly has been described in the context of retracting the pivot arm of a miter saw, it will be appreciated that the retraction assembly may also be adapted for use in other ways and on other machines.

Machines that include various components and features discussed above may be described as follows:

A cutting machine comprising a cutter; a brake adapted to stop the cutter, where the brake has an idle position and a braking position; and an actuation system adapted to selectively move the brake from the idle position to the braking position, where at least a portion of the actuation system must be replaced after moving the brake from the idle position to the braking position; wherein the actuation system includes an explosive device.

A cutting machine comprising a support structure; a cutting tool adapted to cut a workpiece, where the cutting tool is supported by the support structure; a detection system adapted to detect a dangerous condition between the cutting tool and a person; a reaction system adapted to perform a specified action upon detection of the dangerous condition; an explosive to trigger the reaction system to perform the specified action upon firing of the explosive; and a firing subsystem to fire the explosive upon detection of the dangerous condition.

INDUSTRIAL APPLICABILITY

The present invention is applicable to power equipment, and specifically to woodworking equipment such as table saws, miter saws, band saws, circular saws, jointers, etc. The present invention provides a safety system or reaction system wherein a cutting tool or other dangerous item is retracted upon the occurrence of a specified event, such as when accidental contact between a user and a blade is detected. Retraction of a cutting tool, for example, can minimize any injury from accidental contact with the cutting tool by reducing the amount of time the cutting tool is in contact with a user or by moving the cutting tool to a position where the user cannot contact it. A retraction system may be used in combination with other safety features to maximize the performance of an overall safety system. For example, a retraction system may be used with a system that quickly stops a cutting tool so that the cutting tool simultaneously stops and moves away from a user. A fusible member or explosive may be used to trigger the reaction system to perform the specified action. A firing subsystem may be used to fuse the fusible member or fire the explosive upon detection of the dangerous condition.

It is believed that the disclosure set forth above encompasses multiple distinct inventions with independent utility. While each of these inventions has been disclosed in its preferred form, the specific embodiments thereof as disclosed and illustrated herein are not to be considered in a limiting sense as numerous variations are possible. The subject matter of the inventions includes all novel and non-obvious combinations and subcombinations of the various elements, features, functions and/or properties disclosed herein. No single feature, function, element or property of the disclosed embodiments is essential to all of the disclosed inventions. Similarly, where the claims recite "a" or "a first" element or the equivalent thereof, such claims should be understood to include incorporation of one or more such elements, neither requiring nor excluding two or more such elements.

It is believed that the following claims particularly point out certain combinations and subcombinations that are directed to one of the disclosed inventions and are novel and non-obvious. Inventions embodied in other combinations and subcombinations of features, functions, elements and/or properties may be claimed through amendment of the present claims or presentation of new claims in this or a related application. Such amended or new claims, whether they are directed to a different invention or directed to the same invention, whether different, broader, narrower or equal in scope to the original claims, are also regarded as included within the subject matter of the inventions of the present disclosure.

The invention claimed is:

1. A method of operating a woodworking machine, where the woodworking machine has a work surface defining a cutting region and a cutting tool that extends at least partially into the cutting region, the method comprising:

moving the cutting tool;

detecting a dangerous condition between a person and the cutting tool; and

retracting the cutting tool below the work surface within approximately 14 milliseconds after the dangerous condition is detected by the detection system.

2. The method of claim **1**, where the dangerous condition is contact between a person and the cutting tool.

3. The method of claim **1**, where the dangerous condition is proximity of a person to the cutting tool.

4. The method of claim **1**, further comprising firing an explosive to cause the retracting of the cutting tool.

5. The method of claim **1**, further comprising stopping the retracting of the cutting tool.

6. The method of claim **1**, further comprising providing a stop to limit the retracting of the cutting tool.

7. A woodworking machine comprising:

a work surface defining a cutting region;

a cutting tool positioned to extend at least partially into the cutting region;

a detection system adapted to detect a dangerous condition between a person and the cutting tool; and

a reaction system associated with the detection system and the cutting tool, where the reaction system is configured to retract the cutting tool below the work surface within approximately 14 milliseconds after the dangerous condition is detected by the detection system.

8. The woodworking machine of claim **7** where the dangerous condition is contact between a person and the cutting tool.

9. The woodworking machine of claim **7** where the dangerous condition is proximity of a person to the cutting tool.

10. The woodworking machine of claim **7** further comprising a stop to limit the retraction of the cutting tool.

11. The woodworking machine of claim **10** where the stop includes an impact-absorbing material.

12. The woodworking machine of claim **7**, where the reaction system includes an explosive.

* * * * *

EXHIBIT E

US008011279B2

(12) **United States Patent**
Gass et al.

(10) **Patent No.: US 8,011,279 B2**
(45) **Date of Patent: Sep. 6, 2011**

(54) **POWER EQUIPMENT WITH SYSTEMS TO MITIGATE OR PREVENT INJURY**

(75) Inventors: **Stephen F. Gass**, Wilsonville, OR (US); **David S. D'Ascenzo**, Portland, OR (US)

(73) Assignee: **SD3, LLC**, Tualatin, OR (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 172 days.

(21) Appl. No.: **12/002,388**

(22) Filed: **Dec. 17, 2007**

(65) **Prior Publication Data**

US 2008/0092702 A1 Apr. 24, 2008

Related U.S. Application Data

(63) Continuation of application No. 09/929,227, filed on Aug. 13, 2001, now Pat. No. 7,308,843.

(60) Provisional application No. 60/225,056, filed on Aug. 14, 2000, provisional application No. 60/225,057, filed on Aug. 14, 2000, provisional application No. 60/225,058, filed on Aug. 14, 2000, provisional application No. 60/225,059, filed on Aug. 14, 2000, provisional application No. 60/225,089, filed on Aug. 14, 2000, provisional application No. 60/225,094, filed on Aug. 14, 2000, provisional application No. 60/225,169, filed on Aug. 14, 2000, provisional application No. 60/225,170, filed on Aug. 14, 2000, provisional application No. 60/225,200, filed on Aug. 14, 2000, provisional application No. 60/225,201, filed on Aug. 14, 2000, provisional application No. 60/225,206, filed on Aug. 14, 2000, provisional application No. 60/225,210, filed on Aug. 14, 2000, provisional application No. 60/225,211, filed on Aug. 14, 2000, provisional application No. 60/225,212, filed on Aug. 14, 2000.

(51) **Int. Cl.**
B26D 5/00 (2006.01)
B27B 3/28 (2006.01)

(52) **U.S. Cl.** **83/58**; 83/59; 83/62.1; 83/581; 83/397.1; 83/477.1

(58) **Field of Classification Search** ..... 83/58, 59, 83/62.1, DIG. 1, 581, 397.1, 477.1, 577.2, 83/471; 144/3.1
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

1,551,900 A 9/1925 Morrow
(Continued)

FOREIGN PATENT DOCUMENTS

CA 2140991 1/1995
(Continued)

OTHER PUBLICATIONS

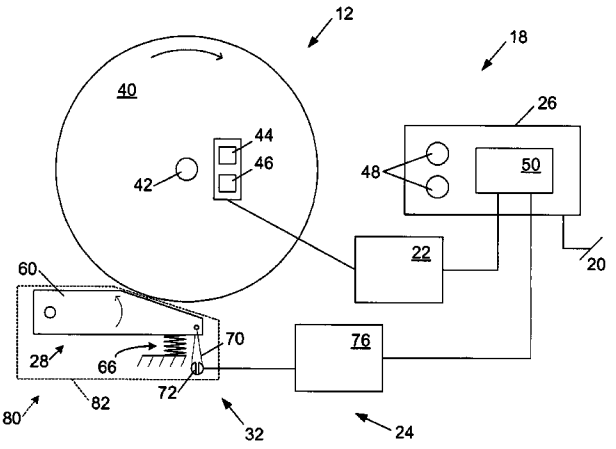
U.S. Appl. No. 60/157,340, filed Oct. 1, 1999, entitled "Fast-Acting Safety Stop."
(Continued)

Primary Examiner — Ghassem Alie

(57) **ABSTRACT**

Woodworking machines are disclosed having cutting tools for cutting workpieces. The machines include a detection system adapted to detect one or more dangerous conditions between a person and the cutting tool. The machines also include a mechanism having a moveable component adapted to move upon detection of the dangerous condition by the detection system. Movement of the moveable component contributes to one or more of the following actions to mitigate or prevent injury to the person: deceleration of the cutting tool, retraction of the cutting tool, and placement of a barrier over at least a part of the cutting tool. An actuator is adapted to move the moveable component at a high acceleration when the dangerous condition is detected.

18 Claims, 24 Drawing Sheets



U.S. PATENT DOCUMENTS

1,584,086	A		5/1926	Fonda
2,434,174	A		1/1948	Morgan
2,785,710	A		3/1957	Mowery, Jr
3,785,230	A	*	1/1974	Lokey 30/388
3,858,095	A	*	12/1974	Friemann et al. ..... 192/129 A
4,117,752	A	*	10/1978	Yoneda 83/58
4,453,112	A		6/1984	Sauer et al.
4,512,224	A		4/1985	Terauchi
4,637,289	A		1/1987	Ramsden
4,653,189	A		3/1987	Andreasson
4,965,909	A		10/1990	McCullough et al.
5,052,255	A		10/1991	Gaines
5,081,406	A		1/1992	Hughes et al.
5,205,069	A	*	4/1993	Shapiro 49/31
5,272,946	A		12/1993	McCullough et al.
5,377,554	A		1/1995	Reulein et al.
5,422,551	A		6/1995	Takeda et al.
5,942,975	A		8/1999	Sorensen
6,418,829	B1		7/2002	Pilchowski
6,900,728	B2		5/2005	Metzger, Jr.
6,922,153	B2		7/2005	Pierga et al.
6,959,631	B2		11/2005	Sako
7,009,552	B2		3/2006	Sako
7,047,854	B2		5/2006	Sako
7,084,779	B2		8/2006	Uneyama
7,173,537	B2		2/2007	Voigtlaender
7,308,843	B2	*	12/2007	Gass et al. 83/58
7,373,863	B2		5/2008	O'Banion et al.
7,421,932	B1		9/2008	Heinzmann et al.
2004/0060404	A1		4/2004	Metzger, Jr.
2004/0123709	A1		7/2004	Metzger, Jr.
2004/0159198	A1		8/2004	Peot et al.
2004/0194594	A1		10/2004	Dils et al.
2004/0200329	A1		10/2004	Sako
2004/0226424	A1		11/2004	O'Banion et al.
2004/0226800	A1		11/2004	Pierga et al.
2005/0057206	A1		3/2005	Uneyama
2005/0145080	A1		7/2005	Voigtlaender
2005/0268767	A1		12/2005	Pierga et al.
2006/0096425	A1		5/2006	Keller
2006/0101960	A1		5/2006	Smith et al.
2008/0016998	A1		1/2008	Keller
2008/0173147	A1		7/2008	Kovarik et al.
2008/0196565	A1		8/2008	Eppard
2008/0196991	A1		8/2008	Eppard
2008/0200263	A1		8/2008	Eppard

FOREIGN PATENT DOCUMENTS

DE	76186	8/1921
DE	2917497	4/1979
DE	3427733	1/1986
DE	4326313	2/1995
DE	19609771	6/1998
DE	20102704	2/2001
EP	0362937	4/1990
WO	WO 03/006213	1/2003

OTHER PUBLICATIONS

U.S. Appl. No. 60/182,866, filed Feb. 16, 2000, entitled "Fast-Acting Safety Stop."

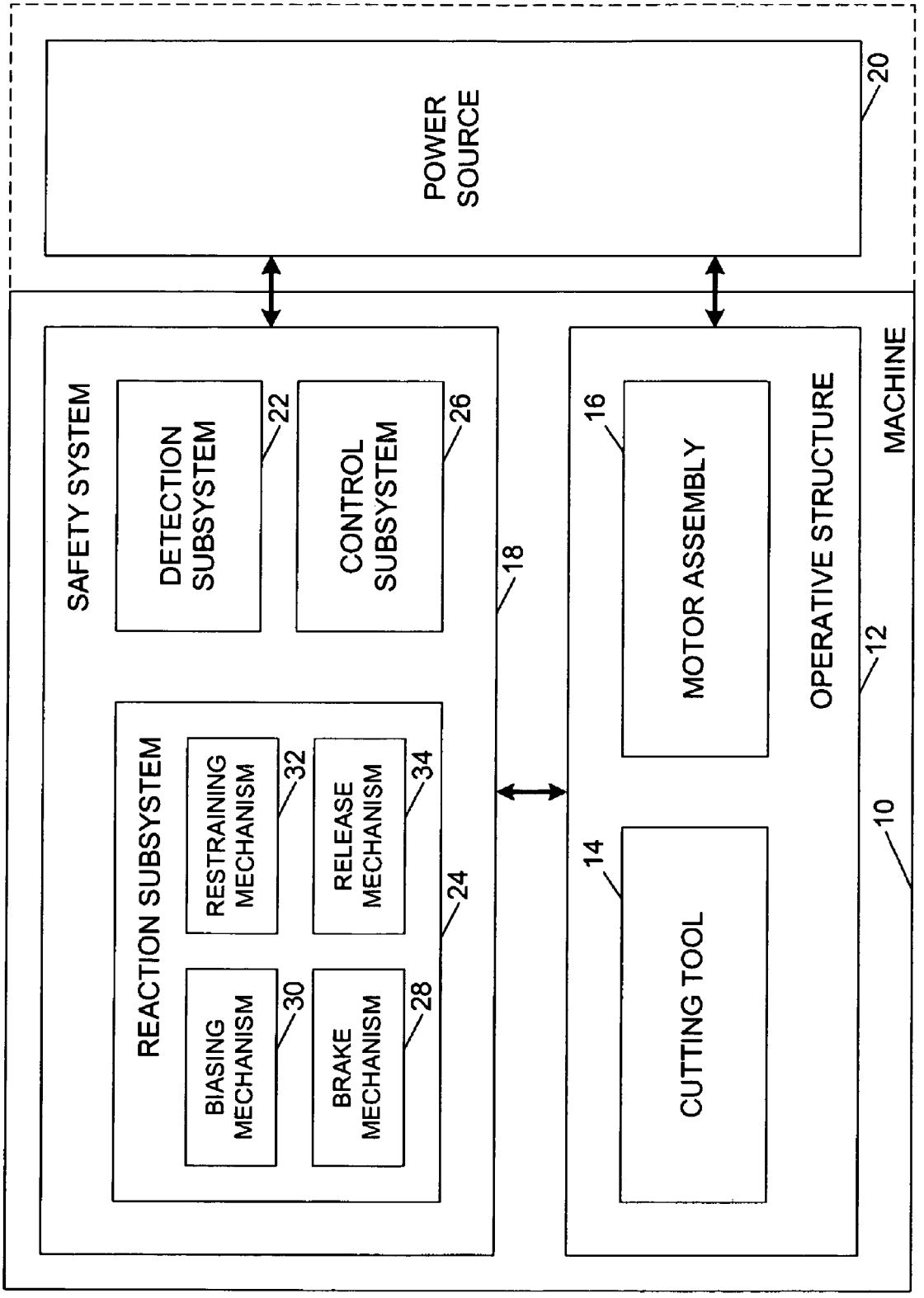
IWF 2000 Challengers Award Official Entry Form, submitted Apr. 26, 2000, 6 pages plus CD (the portions of U.S. patent applications referenced in the form are from U.S. App. No. 60/157,340, filed Oct. 1, 1999 and U.S. Appl. No. 60/182,866, filed Feb. 16, 2000).

Two photographs of a saw displayed at a trade show on Aug. 23, 2000.

You Should Have Invented It, French television show video.

* cited by examiner

Fig. 1


POWER SOURCE
20
MACHINE
10
SAFETY SYSTEM
DETECTION SUBSYSTEM
22
CONTROL SUBSYSTEM
26
18
REACTION SUBSYSTEM
RESTRAINING MECHANISM
32
RELEASE MECHANISM
34
24
BIASING MECHANISM
30
BRAKE MECHANISM
28
OPERATIVE STRUCTURE
12
MOTOR ASSEMBLY
16
CUTTING TOOL
14

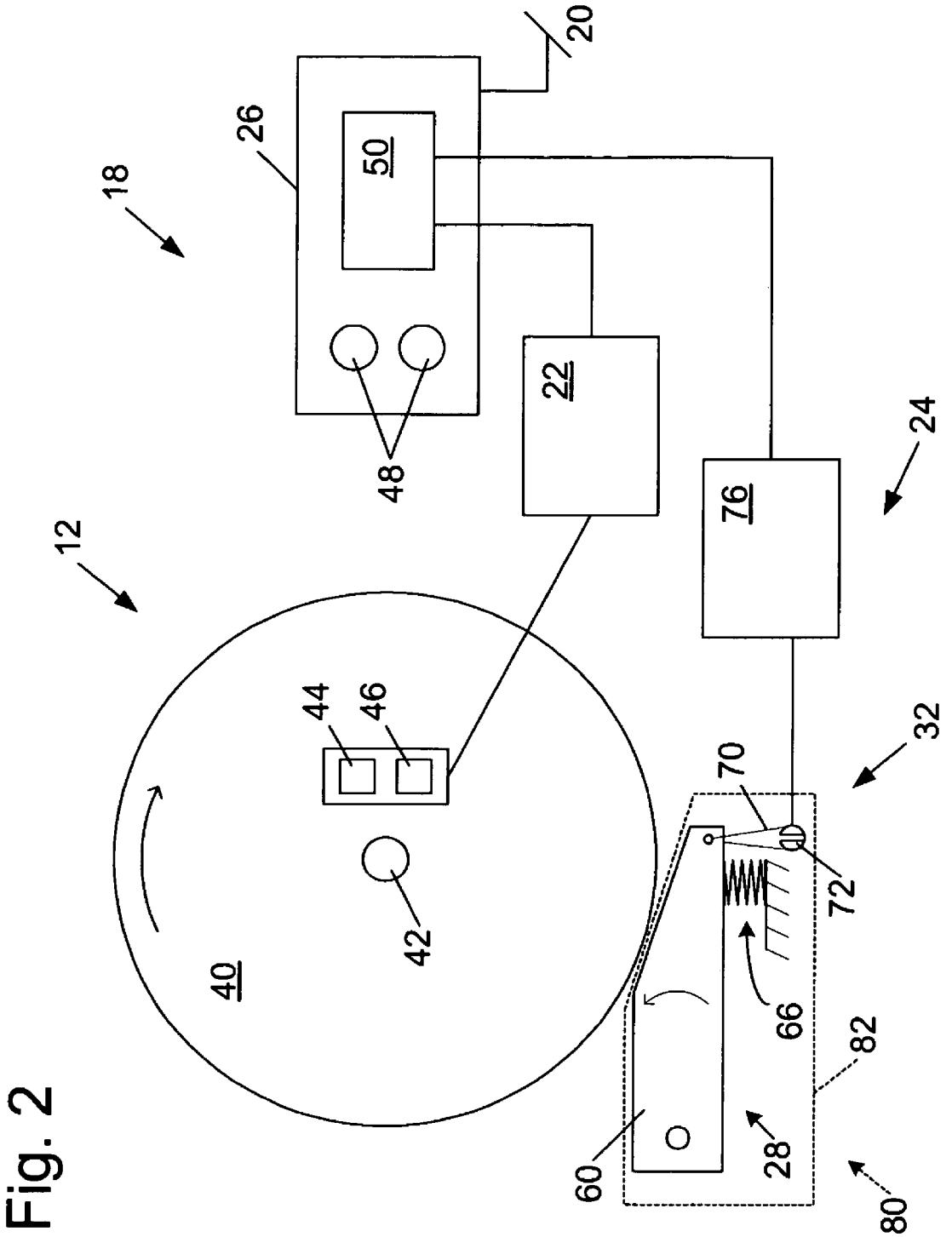


Fig. 2

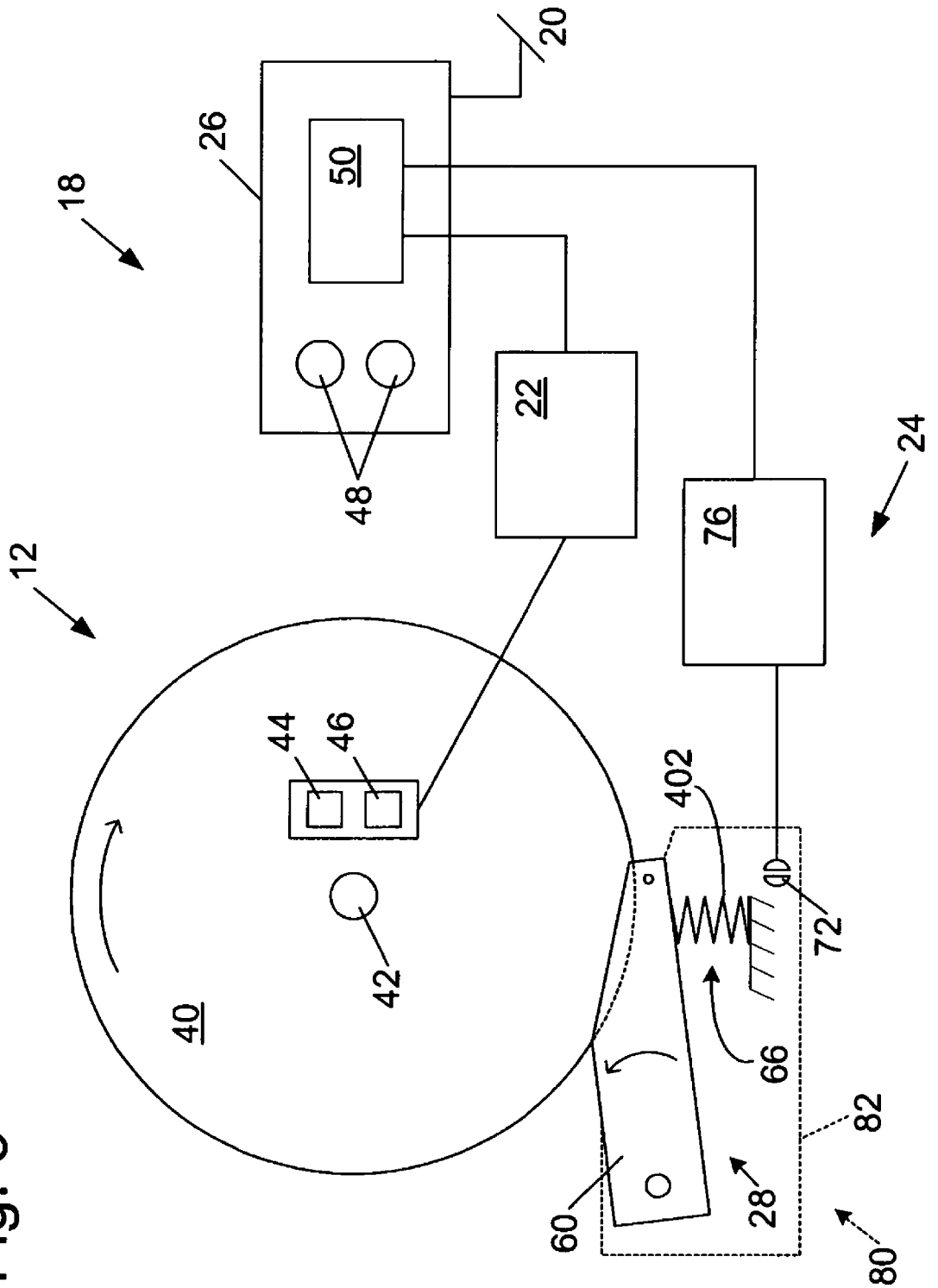


Fig. 3

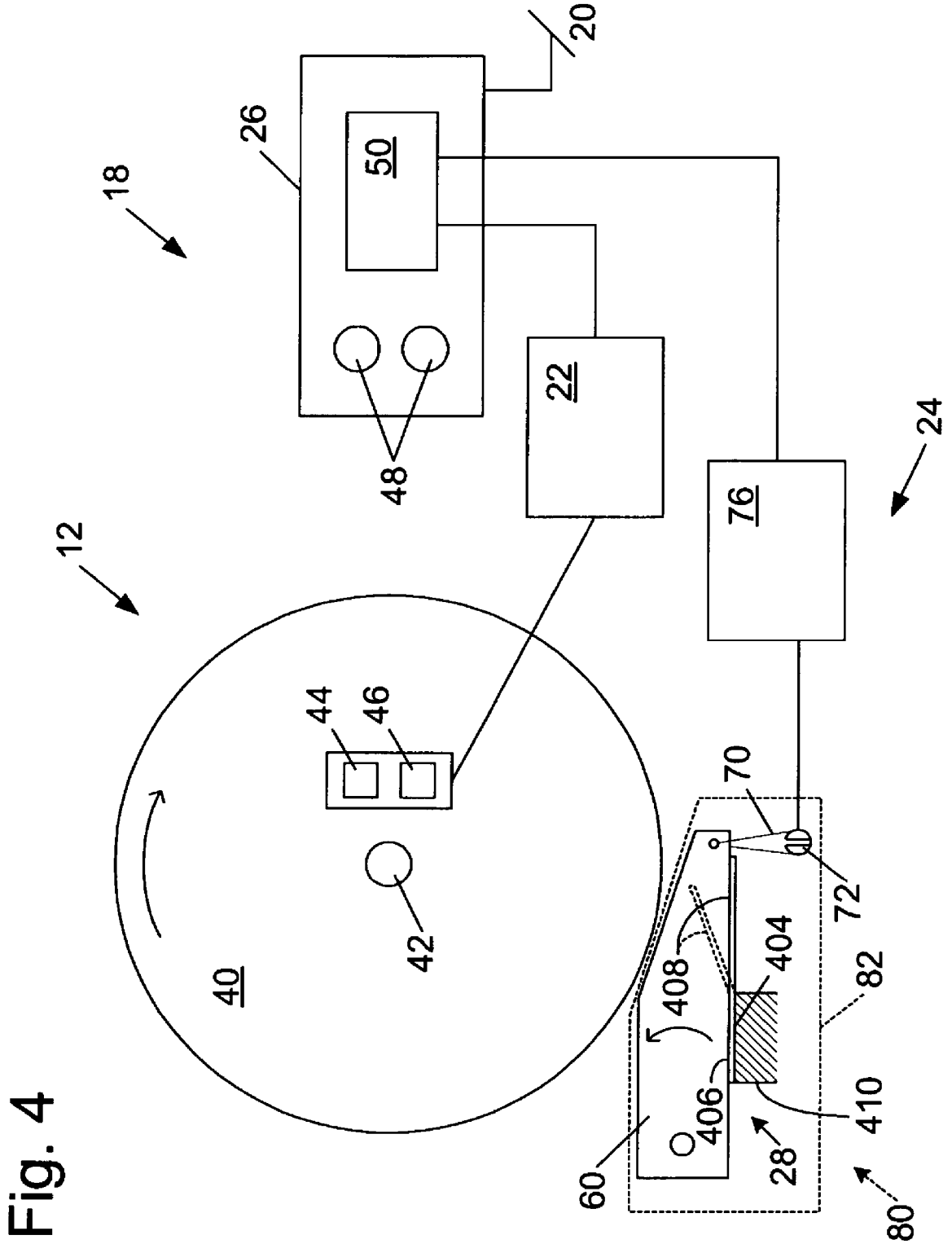

20
26
50
18
48
22
24
76
12
44
46
70
72
42
40
404
408
82
406
410
60
28
80

Fig. 4

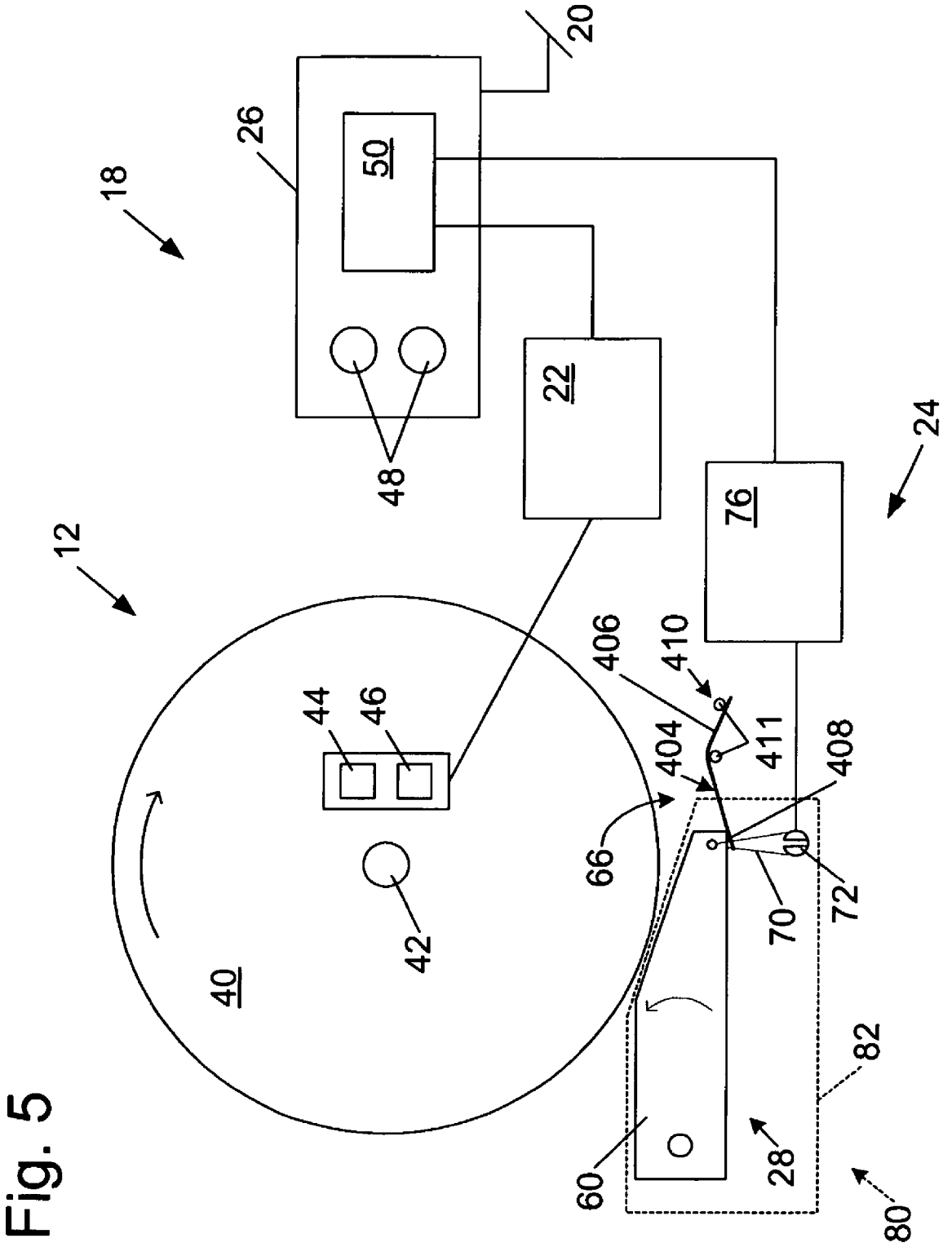

20
26
50
18
22
24
48
76
12
406
410
44
46
404
411
408
66
40
42
70
72
82
60
28
80

Fig. 5

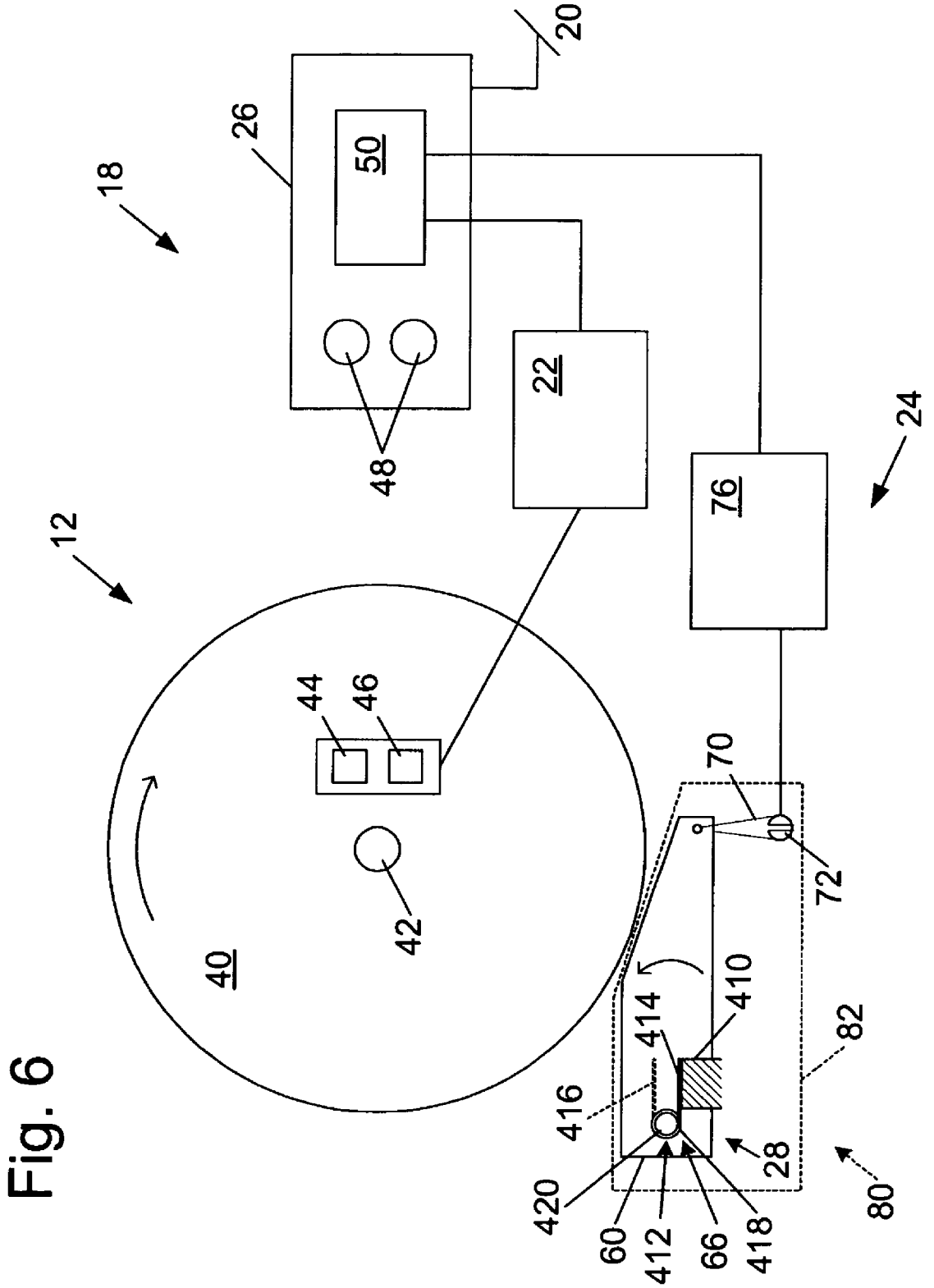

18
20
26
50
48
22
24
76
12
44
46
42
40
70
72
410
414
82
416
28
420
60
412
66
418
80

Fig. 6

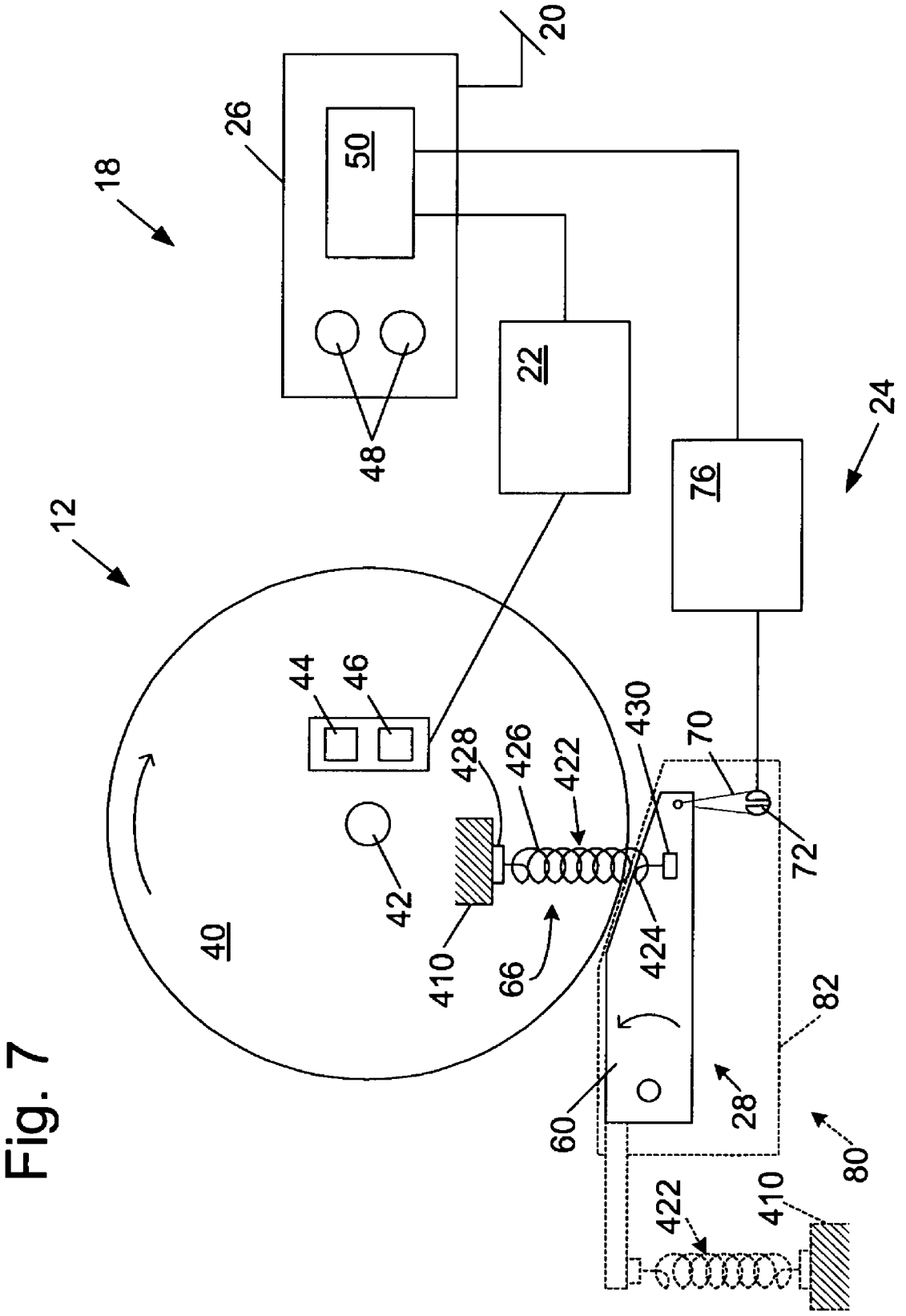

20
26
50
18
48
22
24
76
12
44
46
428
426
422
430
70
72
42
40
410
66
424
82
60
28
80
422
410

Fig. 7

Fig. 8

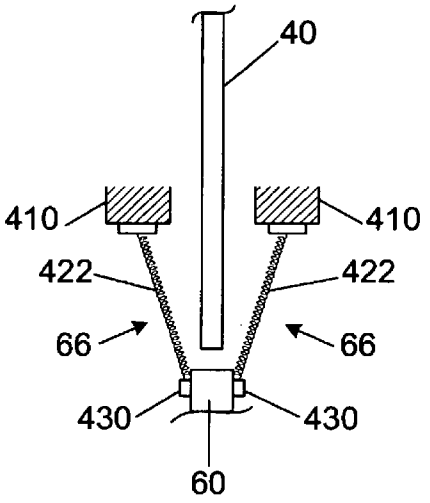


Fig. 9

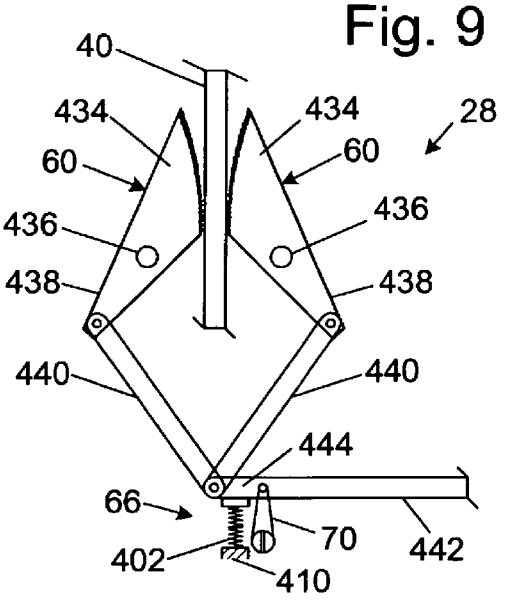


Fig. 10

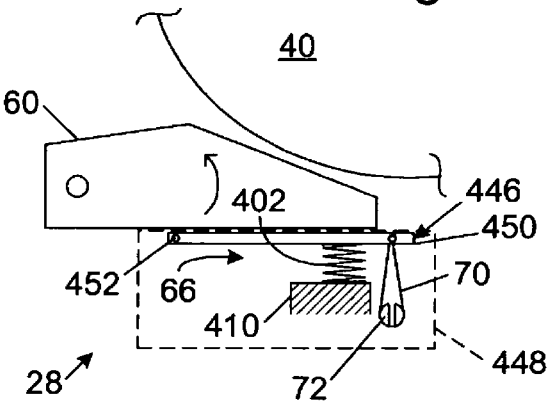


Fig. 11

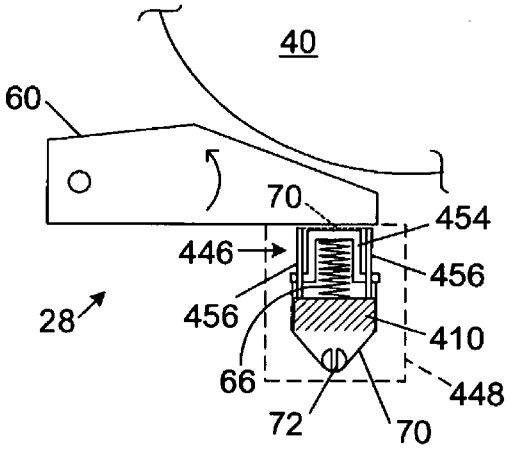


Fig. 12

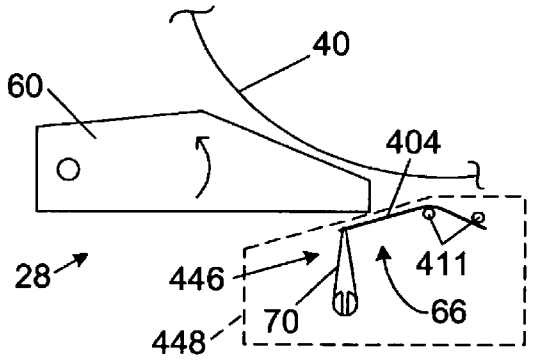


Fig. 13

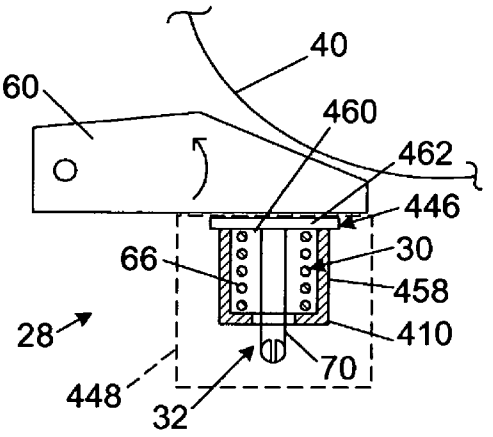


Fig. 14

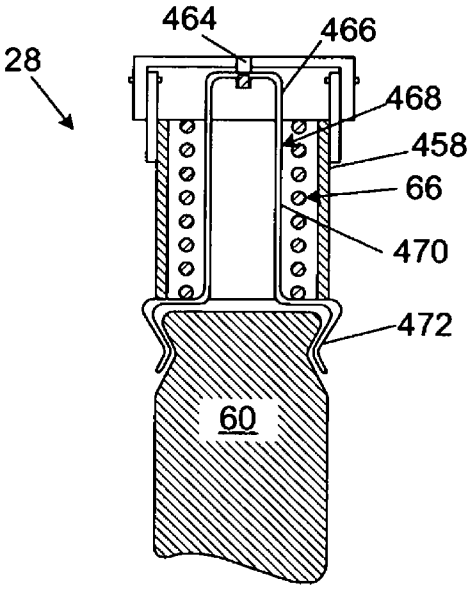


Fig. 15

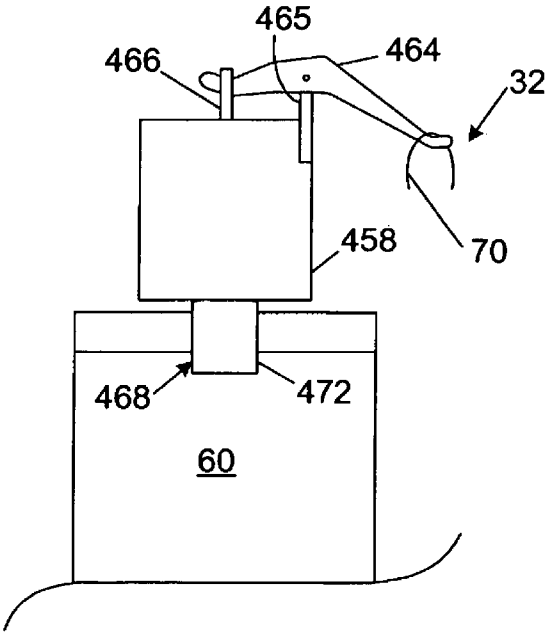


Fig. 16

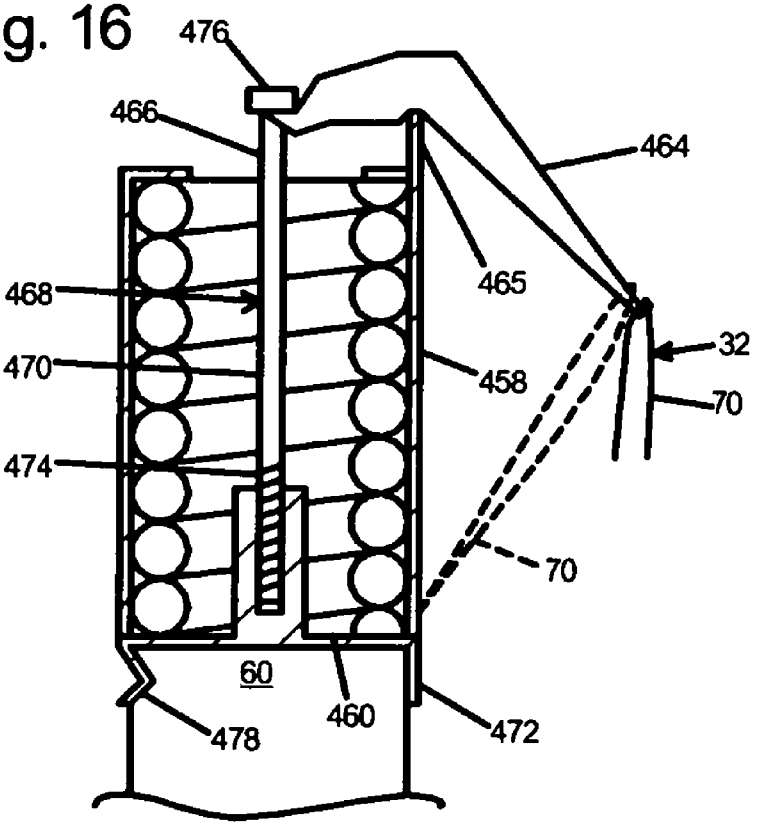

476
466
464
465
468
470
458
32
70
474
70
60
460
478
472

Fig. 17

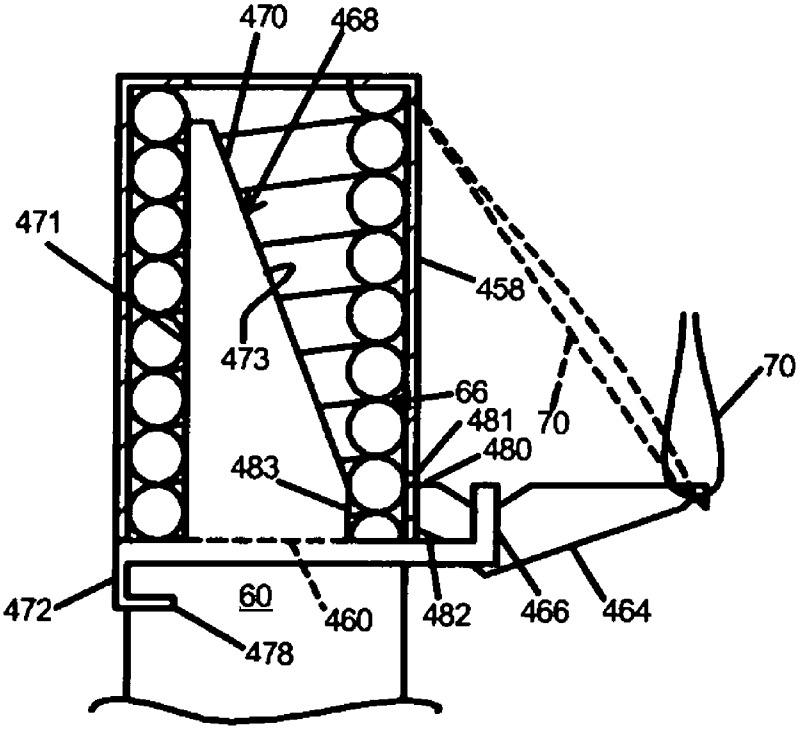

470
468
471
458
473
70
66
481
70
480
483
472
60
460
482
466
464
478

Fig. 18

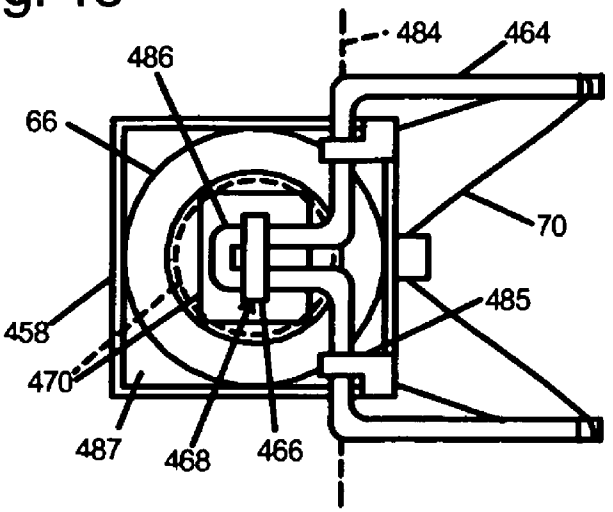


Fig. 20

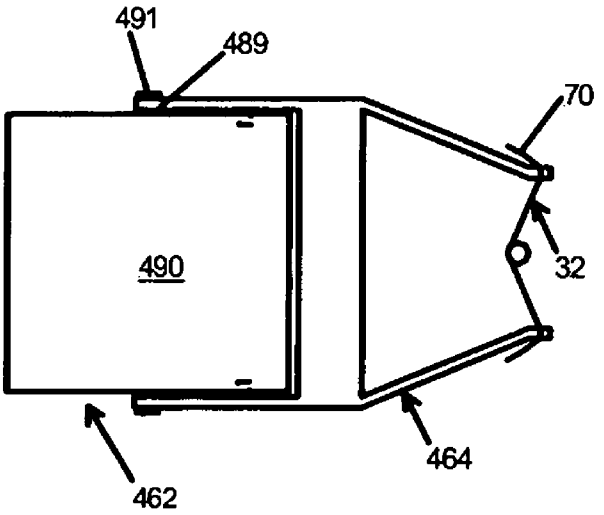


Fig. 19

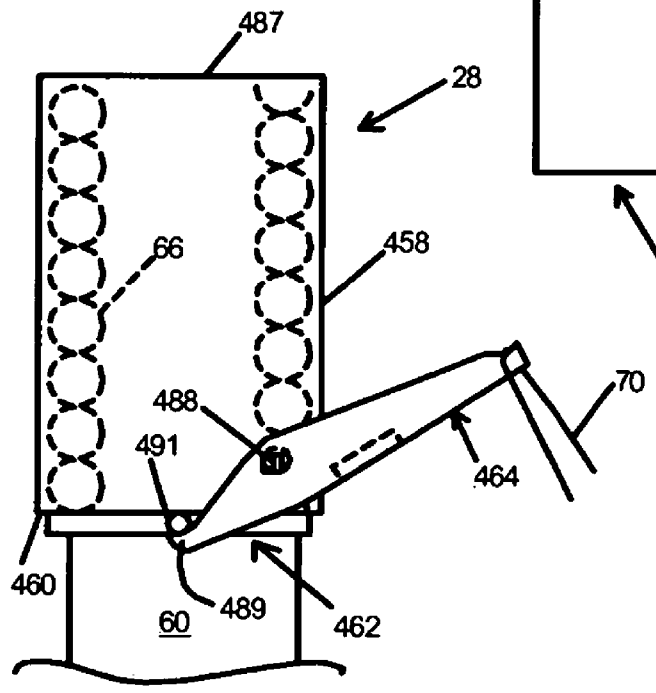


Fig. 21

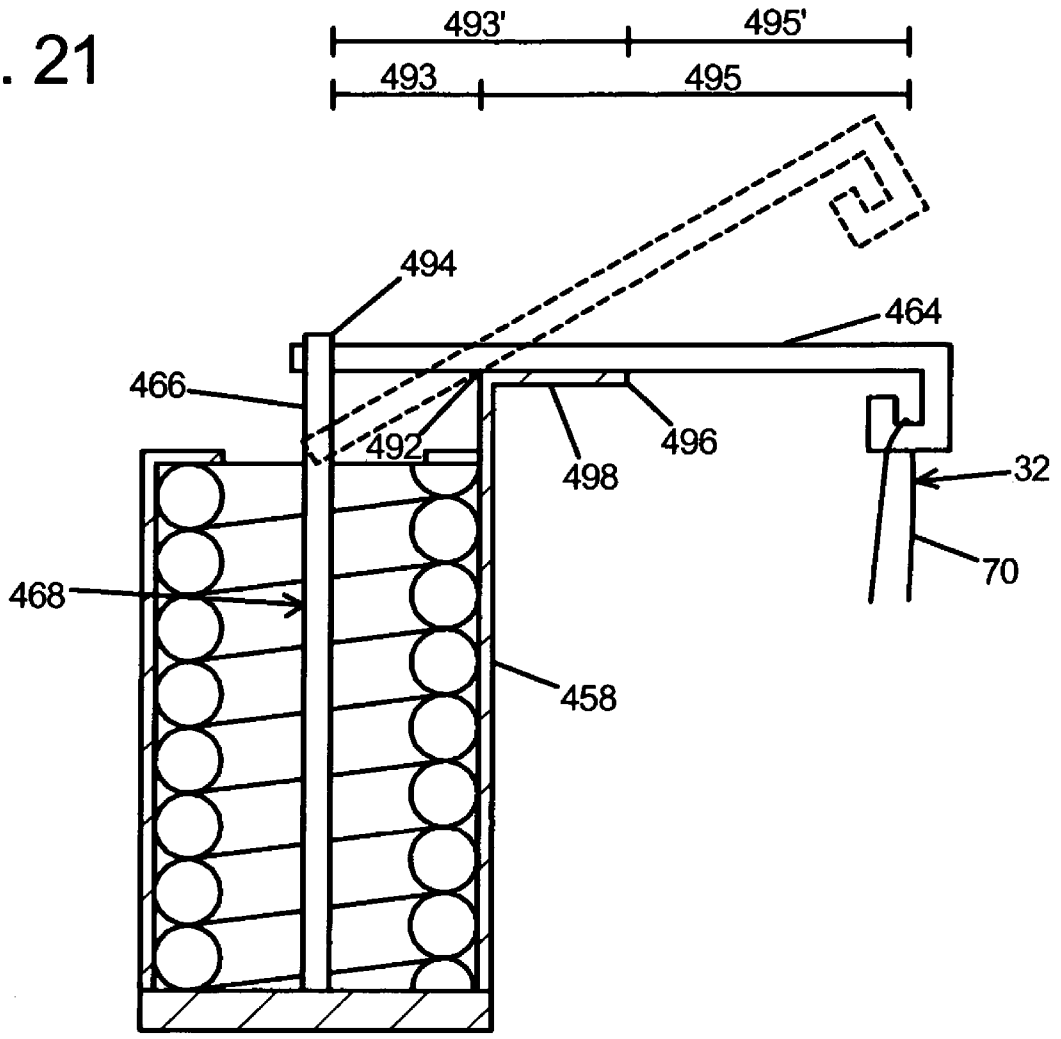
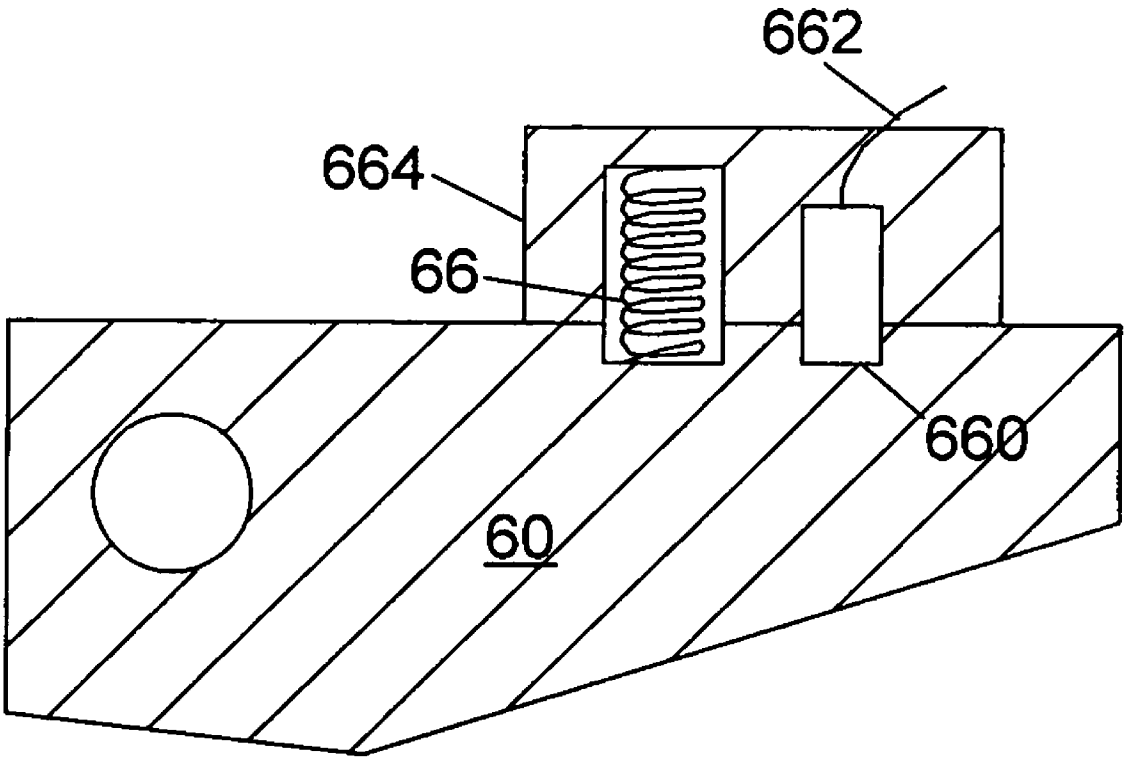


Fig. 22



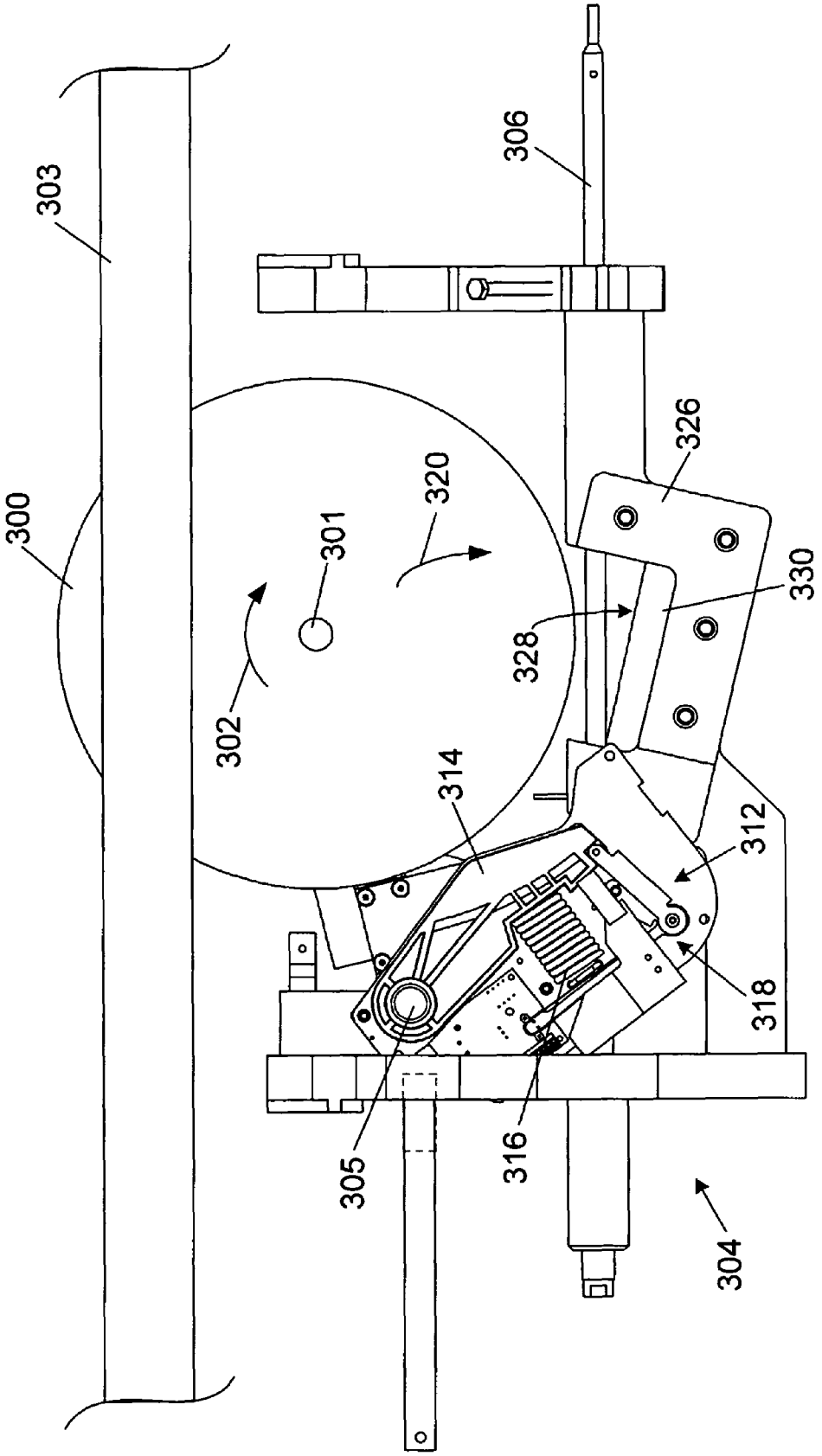


Fig. 23

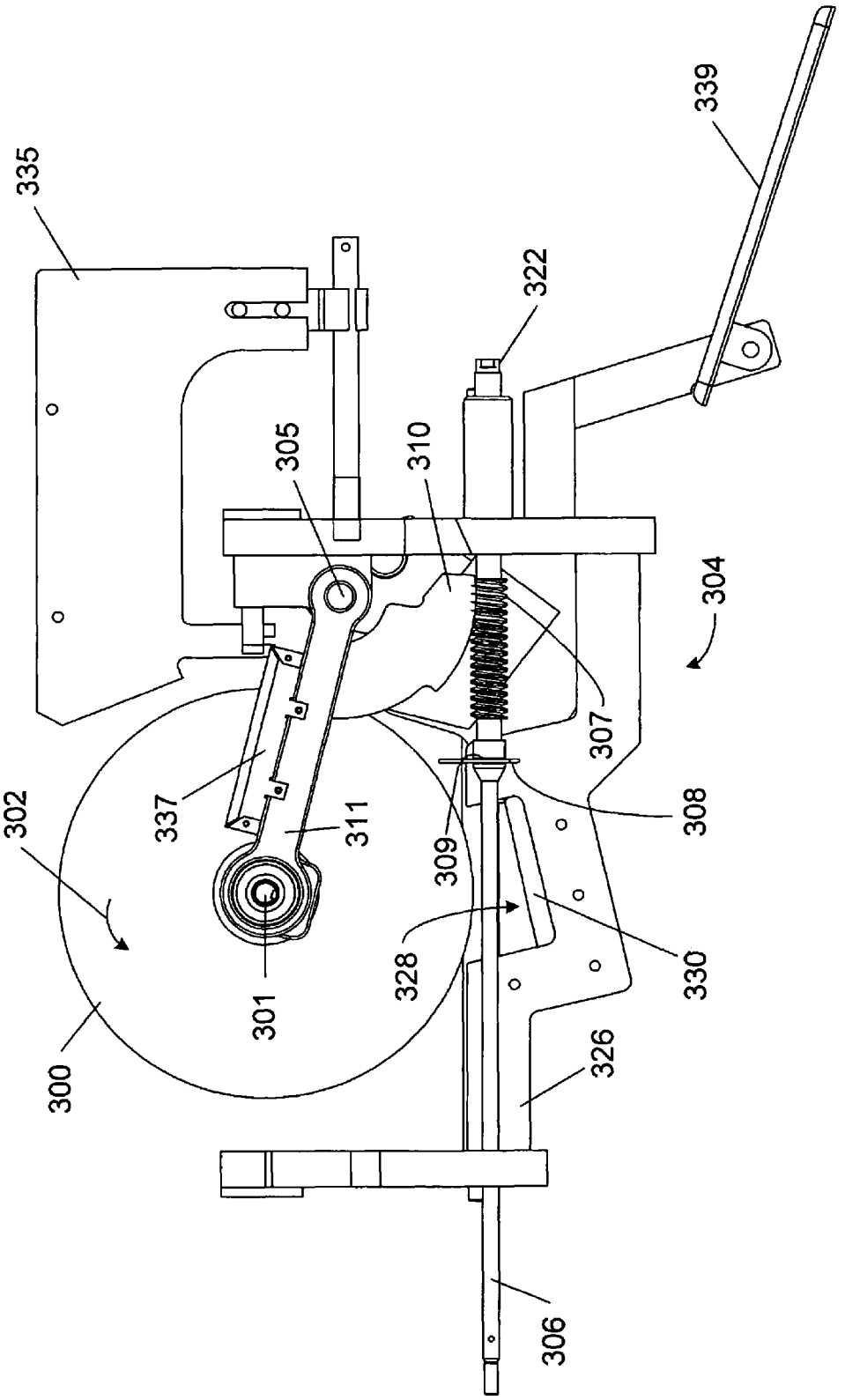

339
335
322
305
310
304
307
308
302
337
311
309
328
330
301
326
300
306

Fig. 24

Fig. 25

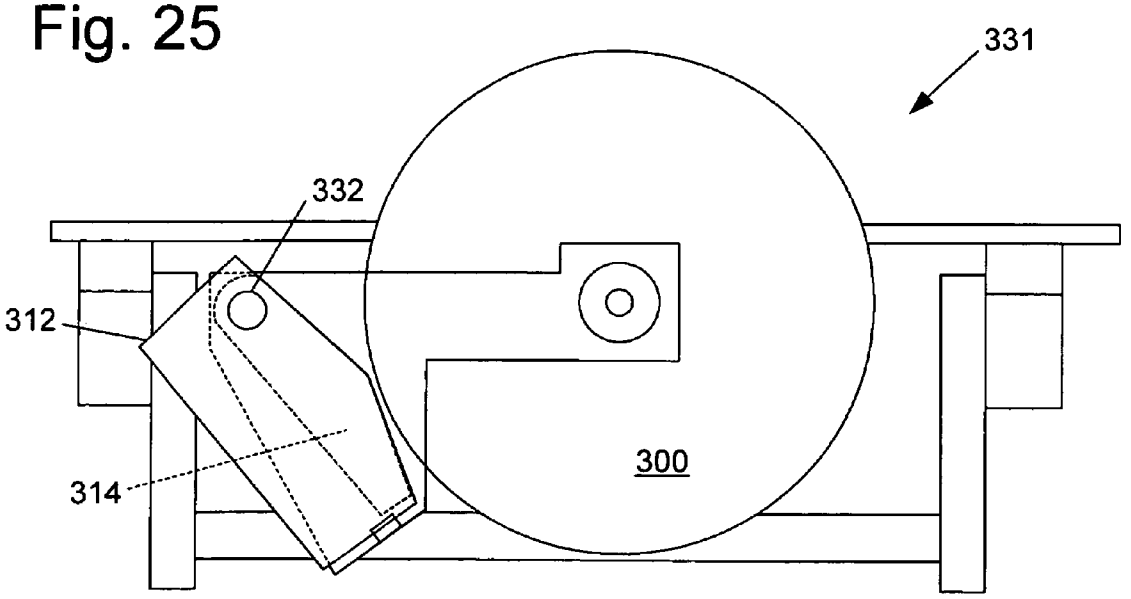
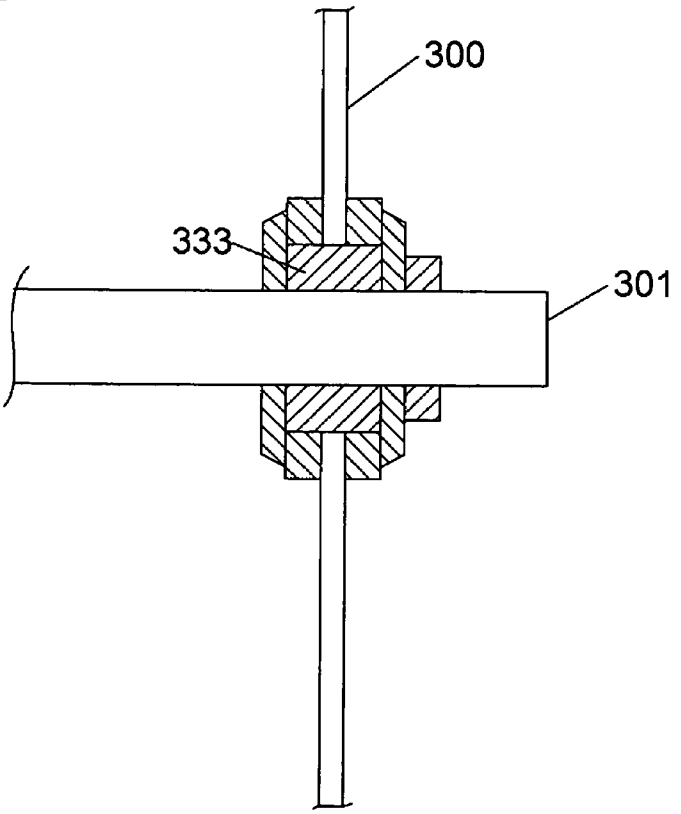


Fig. 26



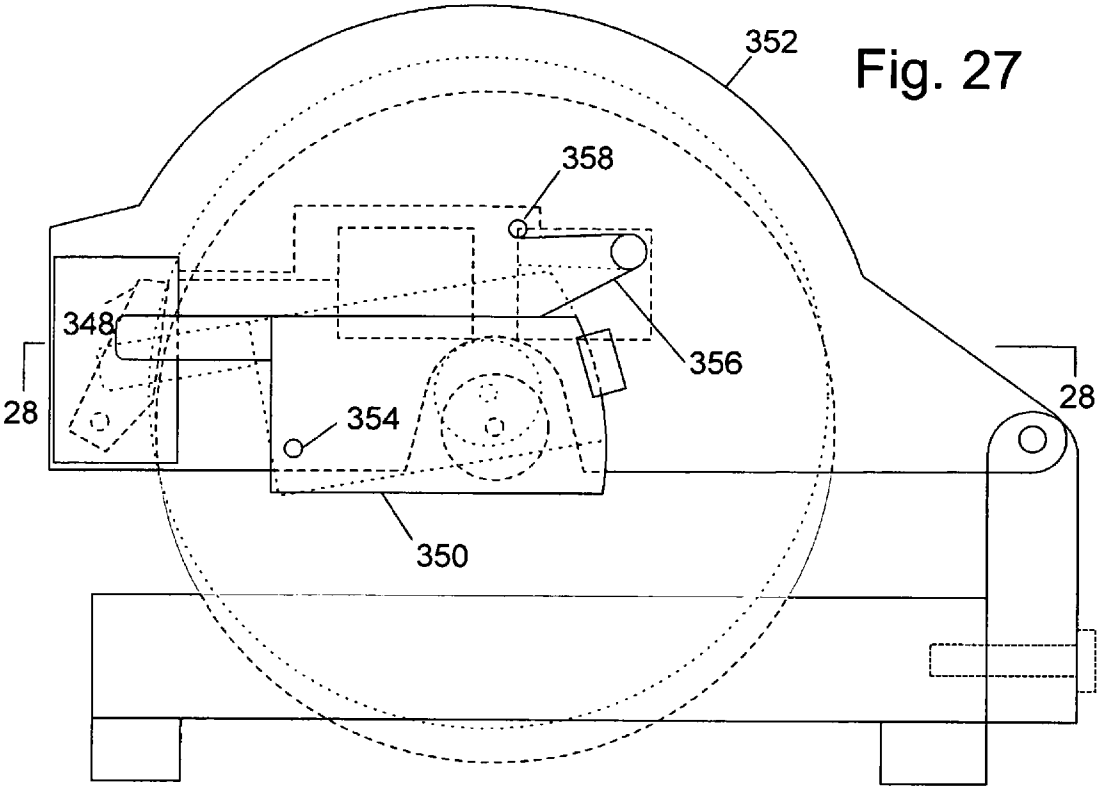


Fig. 27

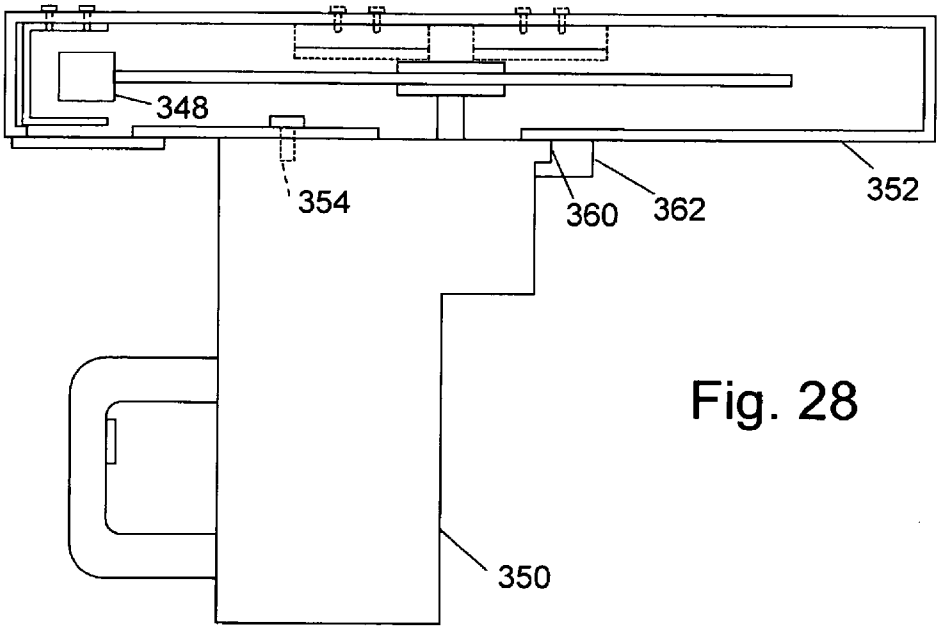


Fig. 28

Fig. 29

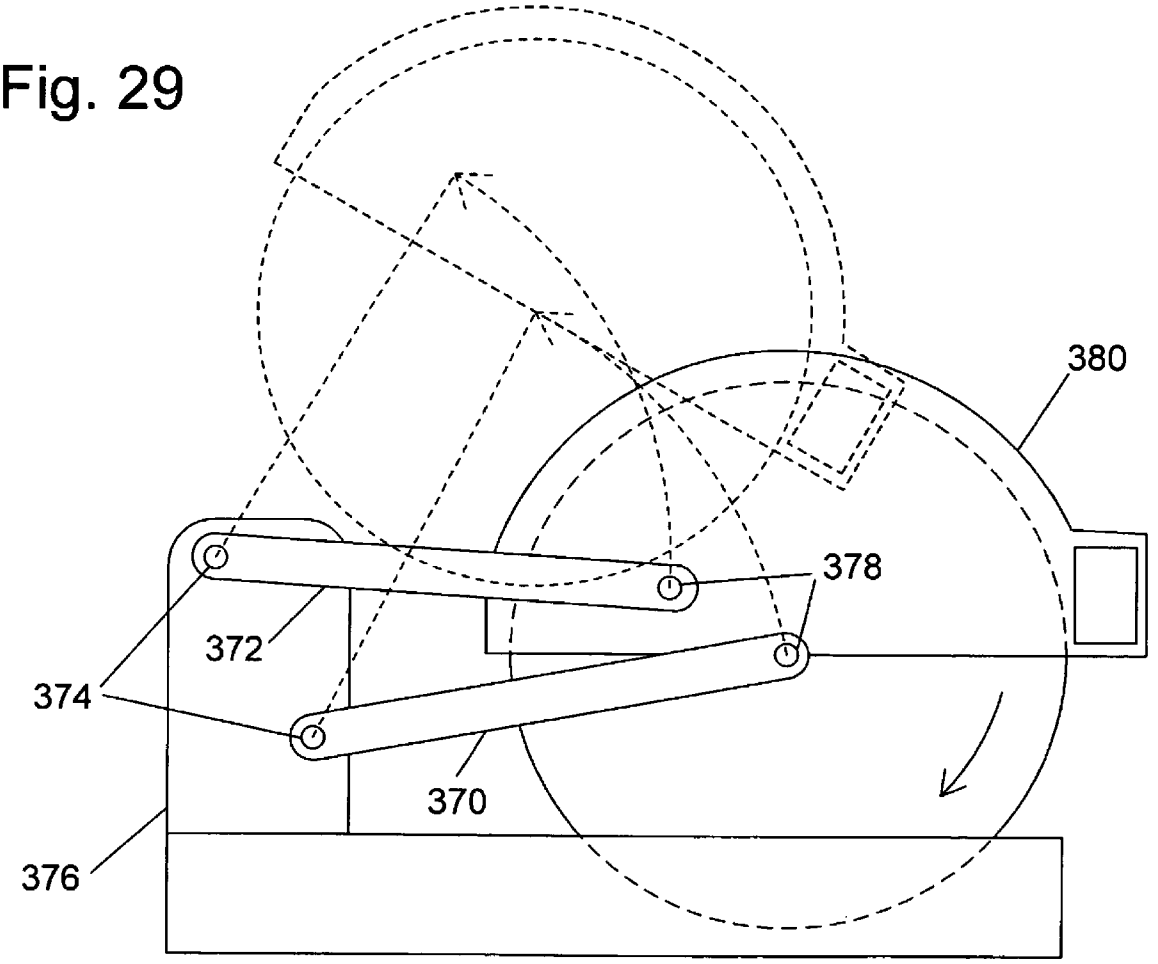


Fig. 30

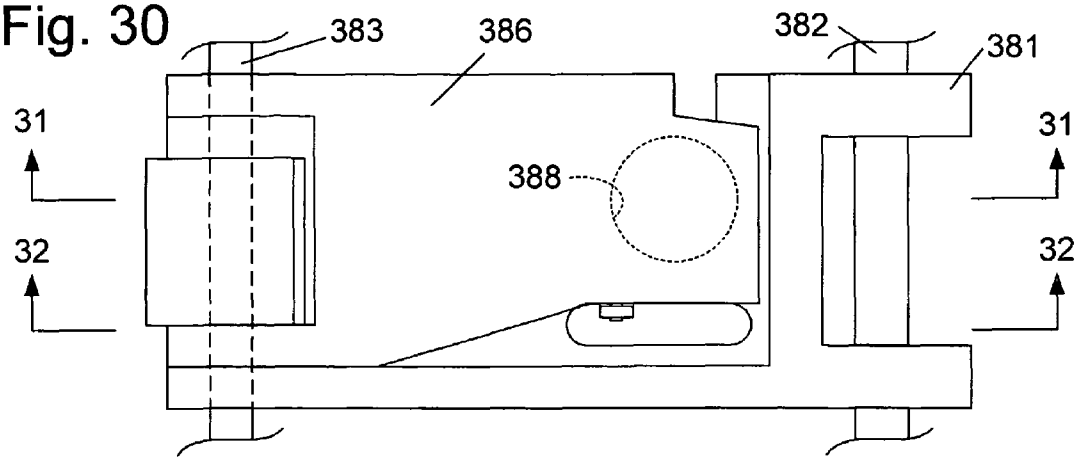


Fig. 31

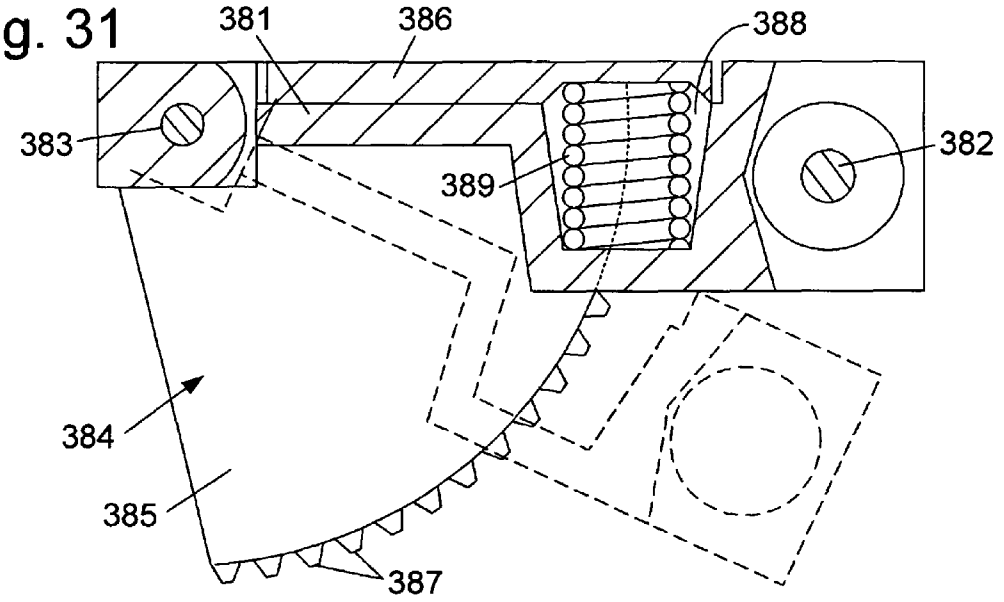
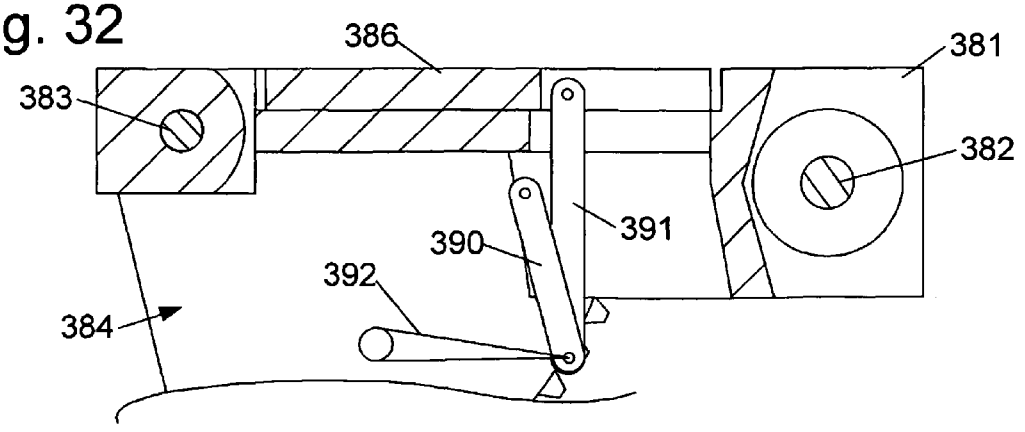


Fig. 32



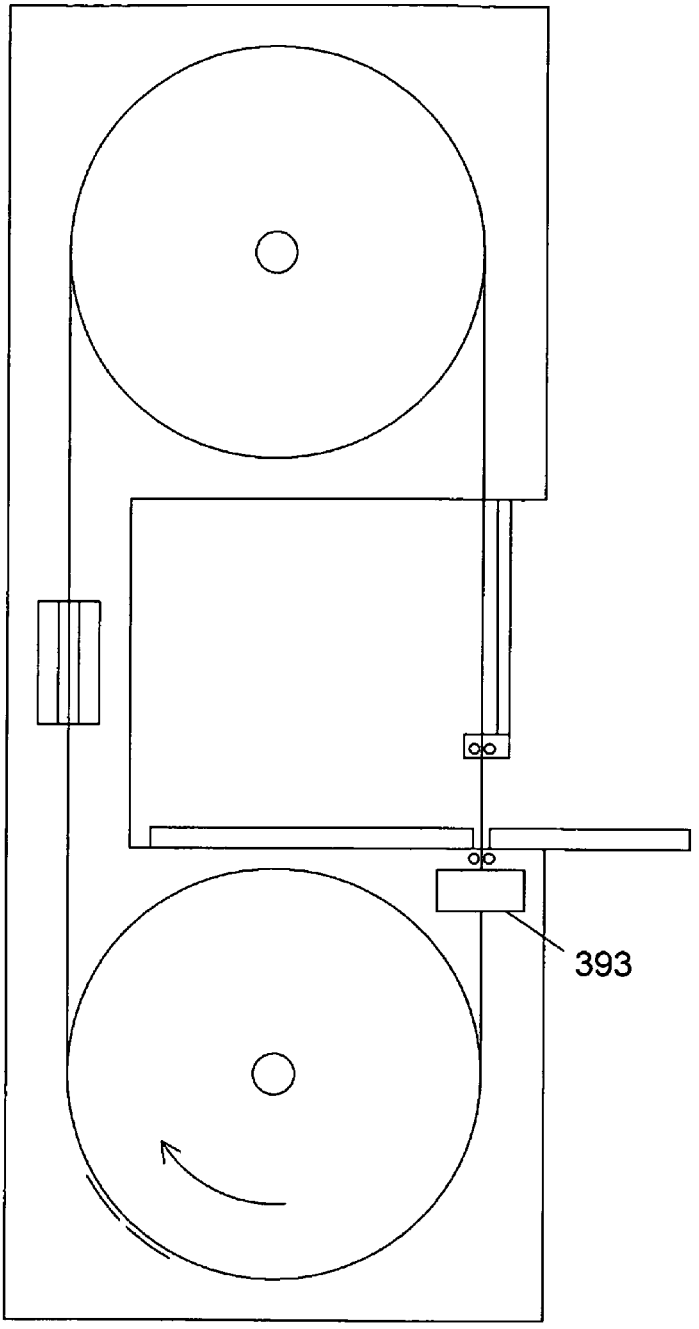


Fig. 33

Fig. 34

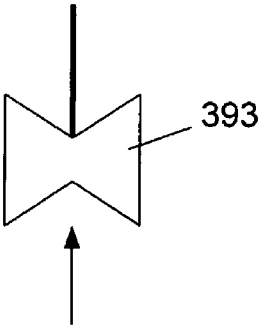


Fig. 35

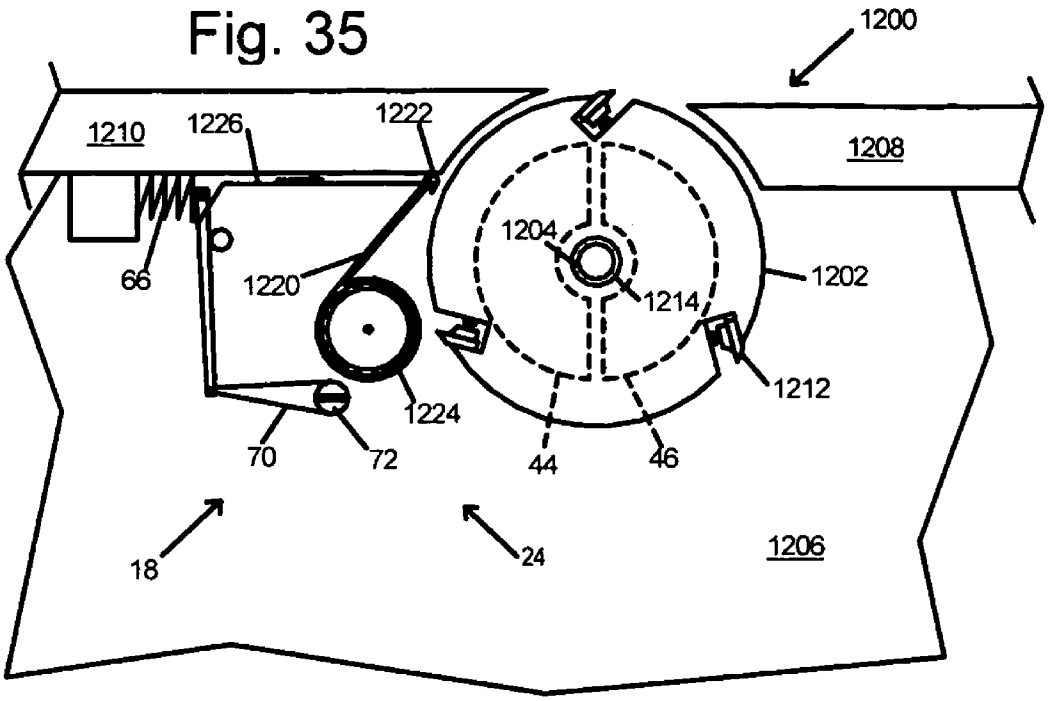


Fig. 36

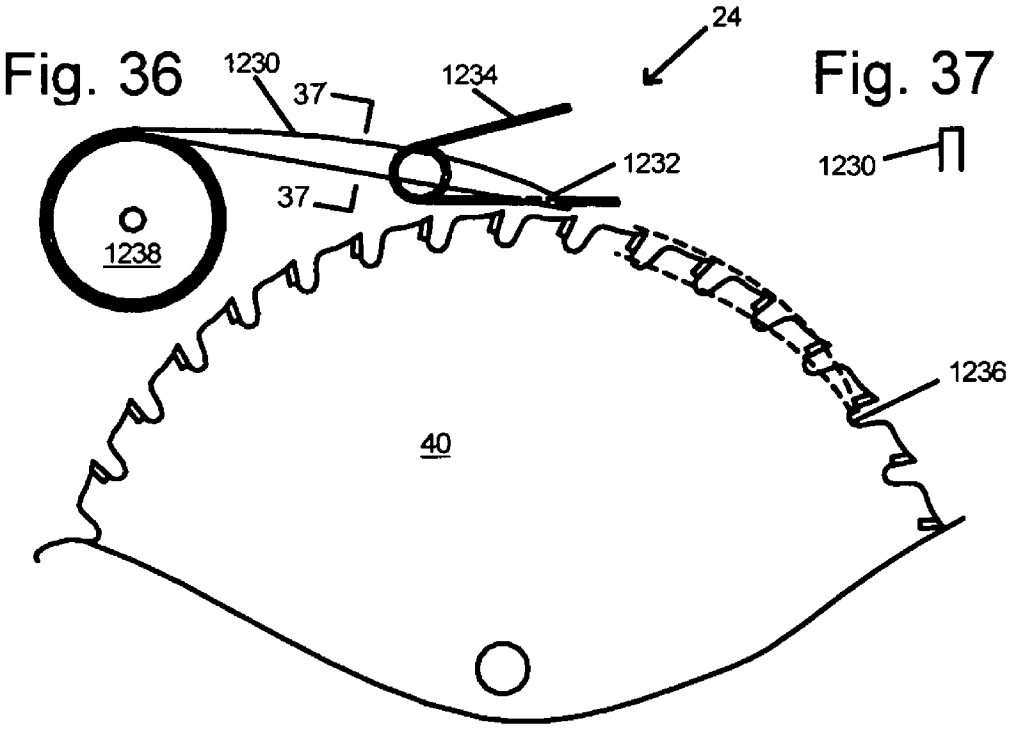


Fig. 37

Fig. 38

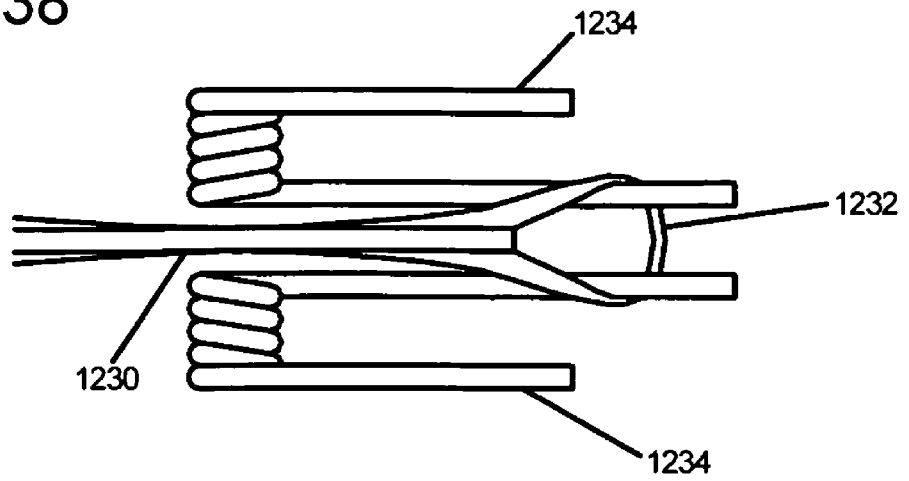


Fig. 39

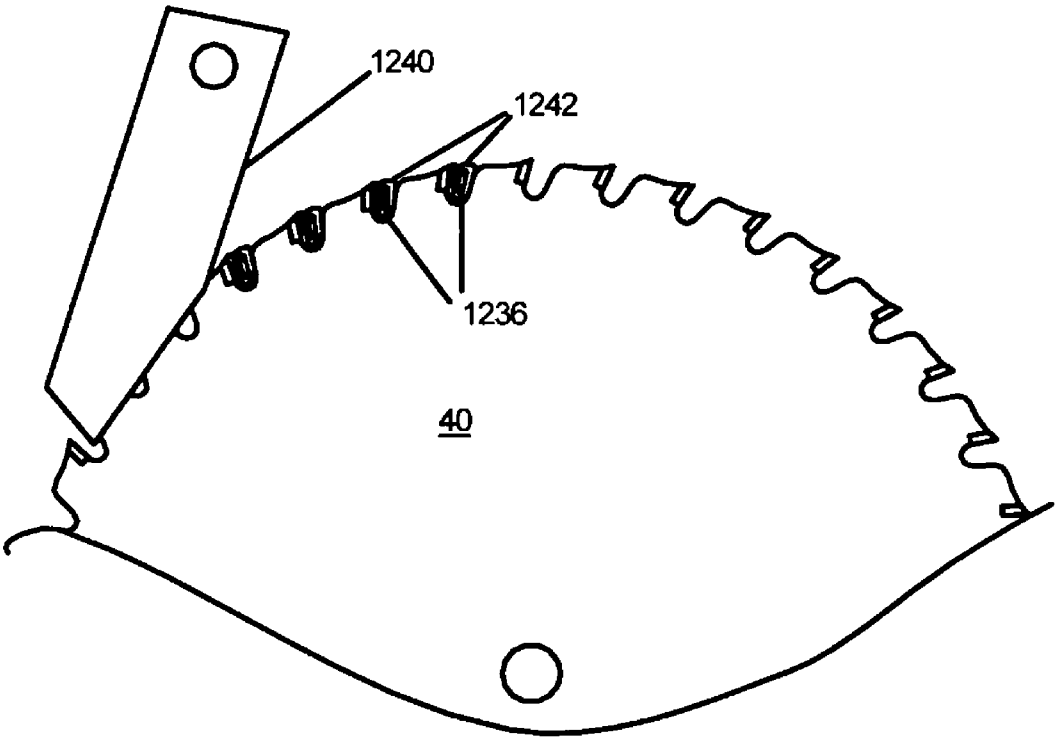


Fig. 40

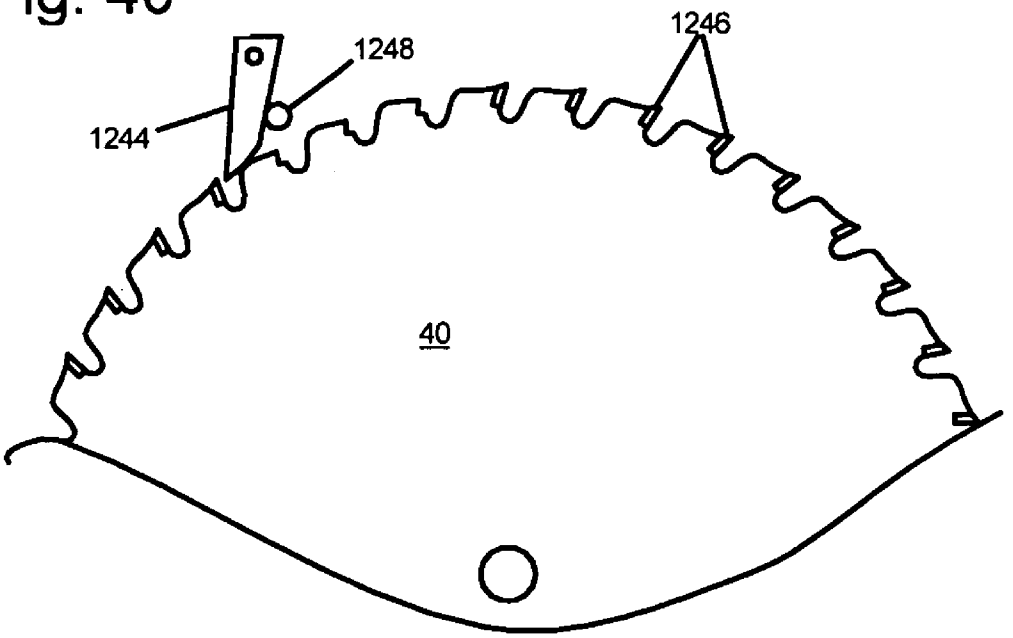

1246
1248
1244
40

Fig. 41

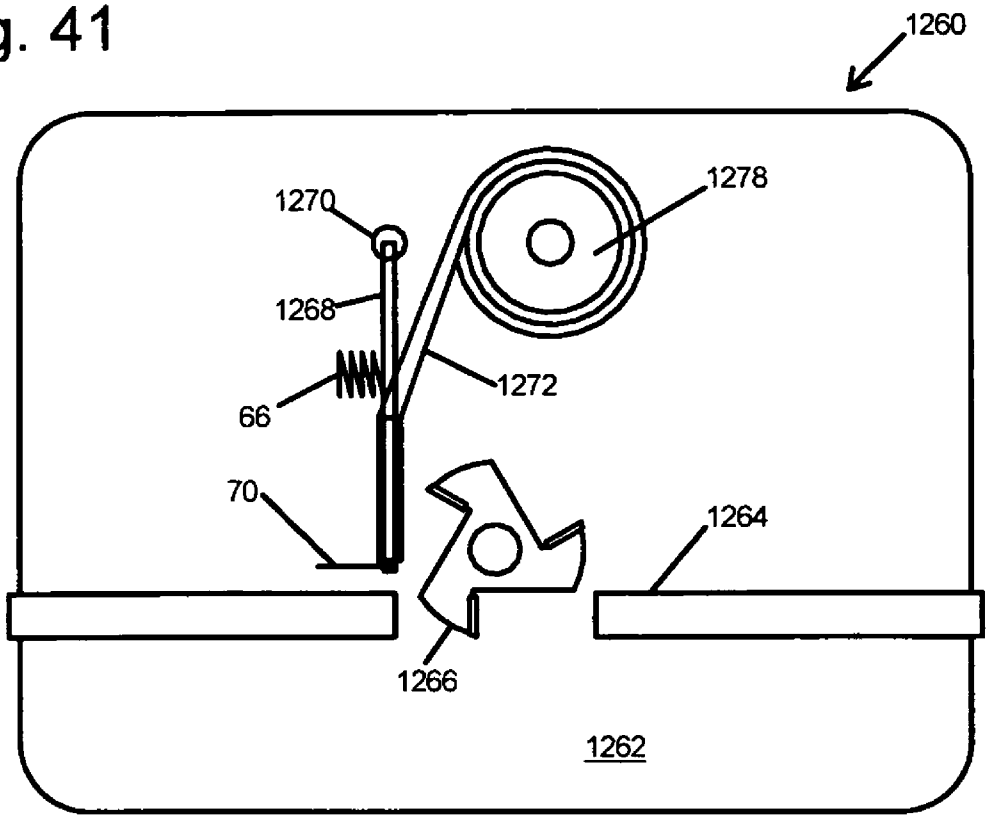
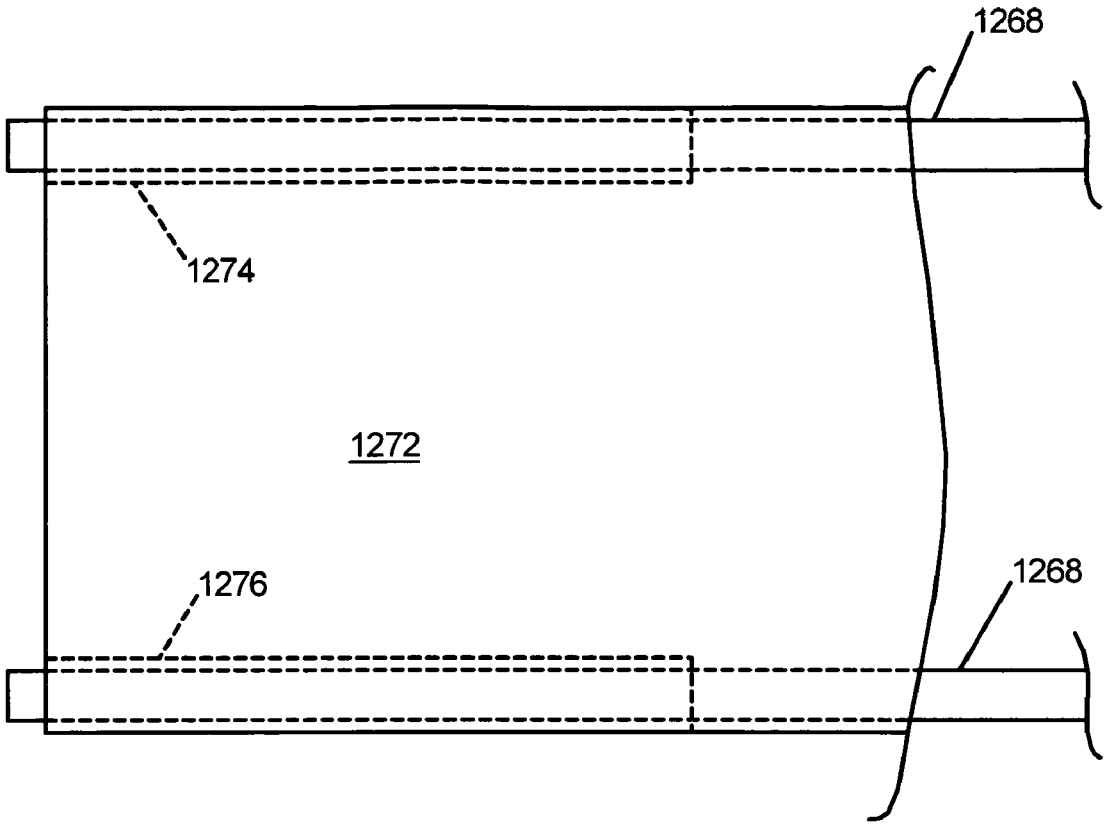

1260
1278
1270
1268
1272
66
70
1264
1266
1262

Fig. 42



POWER EQUIPMENT WITH SYSTEMS TO MITIGATE OR PREVENT INJURY

CROSS-REFERENCE TO RELATED APPLICATIONS

This application is a continuation of U.S. patent application Ser. No. 09/929,227, filed Aug. 13, 2001, issuing as U.S. Pat. No. 7,308,843 on Dec. 18, 2007, which in turn claimed the benefit of and priority from the following U.S. Provisional Patent Applications: Ser. No. 60/225,056, filed Aug. 14, 2000, Ser. No. 60/225,057, filed Aug. 14, 2000, Ser. No. 60/225,058, filed Aug. 14, 2000, Ser. No. 60/225,059, filed Aug. 14, 2000, Ser. No. 60/225,089, filed Aug. 14, 2000, Ser. No. 60/225,094, filed Aug. 14, 2000, Ser. No. 60/225,169, filed Aug. 14, 2000, Ser. No. 60/225,170, filed Aug. 14, 2000, Ser. No. 60/225,200, filed Aug. 14, 2000, Ser. No. 60/225,201, filed Aug. 14, 2000, Ser. No. 60/225,206, filed Aug. 14, 2000, Ser. No. 60/225,210, filed Aug. 14, 2000, Ser. No. 60/225,211, filed Aug. 14, 2000, and Ser. No. 60/225,212, filed Aug. 14, 2000.

FIELD

The present invention relates to safety systems for power equipment, and more particularly to a spring-biased brake mechanism for use on power equipment, such as woodworking machines.

BACKGROUND

Safety systems are often employed with power equipment such as table saws, miter saws, band saws, jointers, shapers, circular saws and other woodworking machinery, to minimize the risk of injury when using the equipment. Probably the most common safety feature is a guard that physically blocks an operator from making contact with dangerous components of machinery, such as belts, shafts or blades. In many cases, guards effectively reduce the risk of injury, however, there are many instances where the nature of the operations to be performed precludes using a guard that completely blocks access to hazardous machine parts.

The present invention discloses a safety system, and power equipment incorporating a safety system, that includes a spring-biased brake mechanism adapted to engage the blade or other cutting tool to protect the user against serious injury if a dangerous, or triggering, condition, such as contact between the user's body and the blade or other cutting tool, occurs. The brake mechanism includes a pawl that is biased to engage and quickly stop the blade or other cutting tool.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a schematic block diagram of a machine with a fast-acting safety system according to the present invention.

FIG. **2** is a schematic diagram of an exemplary safety system in the context of a machine having a circular blade.

FIG. **3** is a schematic diagram of the safety system of FIG. **2** including another spring-biased brake mechanism according to the present invention.

FIG. **4** is a schematic diagram of the safety system of FIG. **2** including another spring-biased brake mechanism according to the present invention.

FIG. **5** is a schematic diagram of the safety system of FIG. **2** including another spring-biased brake mechanism according to the present invention.

FIG. **6** is a schematic diagram of the safety system of FIG. **2** including another spring-biased brake mechanism according to the present invention.

FIG. **7** is a schematic diagram of the safety system of FIG. **2** including another spring-biased brake mechanism according to the present invention.

FIG. **8** is a fragmentary top plan view of another spring-biased brake mechanism according to the present invention.

FIG. **9** is a fragmentary top plan view of another spring-biased brake mechanism according to the present invention.

FIG. **10** is a fragmentary side elevation view of another spring-biased brake mechanism according to the present invention.

FIG. **11** is a fragmentary side elevation view of another spring-biased brake mechanism according to the present invention.

FIG. **12** is a fragmentary side elevation view of another spring-biased brake mechanism according to the present invention.

FIG. **13** is a fragmentary side elevation view of another spring-biased brake mechanism according to the present invention.

FIG. **14** is a cross-sectional side elevation view of another spring-biased brake mechanism according to the present invention.

FIG. **15** is an end elevation view of the brake mechanism of FIG. **14**.

FIG. **16** is a cross-sectional side elevation view of another spring-biased brake mechanism according to the present invention.

FIG. **17** is a cross-sectional side elevation view of another spring-biased brake mechanism according to the present invention.

FIG. **18** is a top plan view of another spring-biased brake mechanism according to the present invention.

FIG. **19** is a side elevation view of another spring-biased brake mechanism according to the present invention.

FIG. **20** is a bottom plan view of the brake mechanism of FIG. **19**.

FIG. **21** is a side elevation view of another spring-biased brake mechanism according to the present invention.

FIG. **22** shows an explosive charge that can be triggered by a firing subsystem.

FIG. **23** is a schematic side view of a table saw with a retraction system.

FIG. **24** is a schematic side view of a second side of a table saw with a retraction system.

FIG. **25** is a schematic, side view of a saw with another embodiment of a retraction system.

FIG. **26** is a section view of a retraction system using a deformable bushing.

FIG. **27** is a schematic side view of a miter saw with a retraction system.

FIG. **28** is a section view of the miter saw shown in FIG. **27**.

FIG. **29** shows another embodiment of a miter saw with a retraction system.

FIG. **30** shows a schematic drawing of a retraction system using a spring to retract a cutting tool.

FIG. **31** is a sectional view of the retraction system shown in FIG. **30**.

FIG. **32** also is a sectional view of the retraction system shown in FIG. **30**.

FIG. **33** is a schematic view of a band saw with a retraction system.

FIG. **34** is a top view of a roller used in the system shown in FIG. **33**.

FIG. **35** is a breakaway side elevation view of a reaction system according to the present invention.

FIG. **36** is a schematic view of an alternative reaction system according to the present invention.

FIG. **37** is a cross-sectional view along lines **37-37** of FIG. **36** of a band forming part of the reaction system of FIG. **36**.

FIG. **38** is a top elevation view of a hook on the end of the band of FIG. **37**.

FIG. **39** is a schematic view of an alternative reaction system for obstructing a blade.

FIG. **40** is a schematic view of an alternative reaction system that breaks the teeth of a blade.

FIG. **41** is a top view of an alternative reaction system that wraps a cutting tool.

FIG. **42** shows a covering used in the reaction system of FIG. **41**.

DETAILED DESCRIPTION

A machine is shown schematically in FIG. **1** and indicated generally at **10**. Machine **10** may be any of a variety of different machines adapted for cutting workpieces, such as wood, including a table saw, miter saw (chop saw), radial arm saw, circular saw, band saw, jointer, planer, etc. Machine **10** includes an operative structure **12** having a cutting tool **14** and a motor assembly **16** adapted to drive the cutting tool. Machine **10** also includes a safety system **18** configured to minimize the potential of a serious injury to a person using machine **10**. Safety system **18** is adapted to detect the occurrence of one or more dangerous, or triggering, conditions during use of machine **10**. If such a dangerous condition is detected, safety system **18** is adapted to engage operative structure **12** to limit any injury to the user caused by the dangerous condition.

Machine **10** also includes a suitable power source **20** to provide power to operative structure **12** and safety system **18**. Power source **20** may be an external power source such as line current, or an internal power source such as a battery. Alternatively, power source **20** may include a combination of both external and internal power sources. Furthermore, power source **20** may include two or more separate power sources, each adapted to power different portions of machine **10**.

It will be appreciated that operative structure **12** may take any one of many different forms, depending on the type of machine **10**. For example, operative structure **12** may include a stationary housing configured to support motor assembly **16** in driving engagement with cutting tool **14**. Alternatively, operative structure **12** may include a movable structure configured to carry cutting tool **14** between multiple operating positions. As a further alternative, operative structure **12** may include one or more transport mechanisms adapted to convey a workpiece toward and/or away from cutting tool **14**.

Motor assembly **16** includes one or more motors adapted to drive cutting tool **14**. The motors may be either directly or indirectly coupled to the cutting tool, and may also be adapted to drive workpiece transport mechanisms. Cutting tool **14** typically includes one or more blades or other suitable cutting implements that are adapted to cut or remove portions from the workpieces. The particular form of cutting tool **14** will vary depending upon the various embodiments of machine **10**. For example, in table saws, miter saws, circular saws and radial arm saws, cutting tool **14** will typically include one or more circular rotating blades having a plurality of teeth disposed along the perimetrical edge of the blade. For a jointer or planer, the cutting tool typically includes a plurality of radially spaced-apart blades. For a band saw, the cutting tool includes an elongate, circuitous tooth-edged band.

Safety system **18** includes a detection subsystem **22**, a reaction subsystem **24** and a control subsystem **26**. Control subsystem **26** may be adapted to receive inputs from a variety of sources including detection subsystem **22**, reaction subsystem **24**, operative structure **12** and motor assembly **16**. The control subsystem may also include one or more sensors adapted to monitor selected parameters of machine **10**. In addition, control subsystem **26** typically includes one or more instruments operable by a user to control the machine. The control subsystem is configured to control machine **10** in response to the inputs it receives.

Detection subsystem **22** is configured to detect one or more dangerous, or triggering, conditions during use of machine **10**. For example, the detection subsystem may be configured to detect that a portion of the user's body is dangerously close to, or in contact with, a portion of cutting tool **14**. As another example, the detection subsystem may be configured to detect the rapid movement of a workpiece due to kickback by the cutting tool, as is described in U.S. Provisional Patent Application Ser. No. 60/182,866, filed Feb. 16, 2000, the disclosure of which is herein incorporated by reference. In some embodiments, detection subsystem **22** may inform control subsystem **26** of the dangerous condition, which then activates reaction subsystem **24**. In other embodiments, the detection subsystem may be adapted to activate the reaction subsystem directly.

Once activated in response to a dangerous condition, reaction subsystem **24** is configured to engage operative structure **12** quickly to prevent serious injury to the user. It will be appreciated that the particular action to be taken by reaction subsystem **24** will vary depending on the type of machine **10** and/or the dangerous condition that is detected. For example, reaction subsystem **24** may be configured to do one or more of the following: stop the movement of cutting tool **14**, disconnect motor assembly **16** from power source **20**, place a barrier between the cutting tool and the user, or retract the cutting tool from its operating position, etc. The reaction subsystem may be configured to take a combination of steps to protect the user from serious injury. Placement of a barrier between the cutting tool and teeth is described in more detail in U.S. Provisional Patent Application Ser. No. 60/225,206, filed Aug. 14, 2000, entitled "Cutting Tool Safety System," and U.S. Pat. No. 6,920,814, filed Aug. 13, 2001, entitled "Cutting Tool Safety System," the disclosures of which are herein incorporated by reference. Retraction of the cutting tool from its operating position is described in more detail in U.S. Provisional Patent Application Ser. No. 60/225,089, filed Aug. 14, 2000, entitled "Retraction System For Use In Power Equipment," and U.S. patent application Ser. No. 09/929,242, filed Aug. 13, 2001, entitled "Retraction System For Use In Power Equipment," the disclosures of which are herein incorporated by reference.

The configuration of reaction subsystem **24** typically will vary depending on which action(s) are taken. In the exemplary embodiment depicted in FIG. **1**, reaction subsystem **24** is configured to stop the movement of cutting tool **14** and includes a brake mechanism **28**, a biasing mechanism **30**, a restraining mechanism **32**, and a release mechanism **34**. Brake mechanism **28** is adapted to engage operative structure **12** under the urging of biasing mechanism **30**. During normal operation of machine **10**, restraining mechanism **32** holds the brake mechanism out of engagement with the operative structure. However, upon receipt of an activation signal by reaction subsystem **24**, the brake mechanism is released from the restraining mechanism by release mechanism **34**, whereupon, the brake mechanism quickly engages at least a portion of the operative structure to bring the cutting tool to a stop.

It will be appreciated by those of skill in the art that the exemplary embodiment depicted in FIG. **1** and described above may be implemented in a variety of ways depending on the type and configuration of operative structure **12**. Turning attention to FIG. **2**, one example of the many possible implementations of safety system **18** is shown. System **18** is configured to engage an operative structure having a cutting tool in the form of a circular blade **40** mounted on a rotating shaft or arbor **42**. Blade **40** includes a plurality of cutting teeth (not shown) disposed around the outer edge of the blade. As described in more detail below, braking mechanism **28** is adapted to engage the teeth of blade **40** and stop the rotation of the blade. U.S. Provisional Patent Application Ser. No. 60/225,210, filed Aug. 14, 2000, entitled "Translation Stop For Use In Power Equipment," and U.S. Pat. No. 7,137,326, filed Aug. 13, 2001, entitled "Translation Stop For Use In Power Equipment," the disclosures of which are herein incorporated by reference, describes other systems for stopping the movement of the cutting tool. U.S. Provisional Patent Application Ser. No. 60/225,058, filed Aug. 14, 2000, entitled "Table Saw With Improved Safety System," U.S. patent application Ser. No. 09/929,235, filed Aug. 13, 2001, entitled "Table Saw With Improved Safety System," U.S. Provisional Patent Application Ser. No. 60/225,057, filed Aug. 14, 2000, entitled "Miter Saw With Improved Safety System," and U.S. patent application Ser. No. 09/929,238, filed Aug. 13, 2001, entitled "Miter Saw With Improved Safety System," the disclosures of which are herein incorporated by reference, describe safety system **18** in the context of particular types of machines **10**.

In the exemplary implementation, detection subsystem **22** is adapted to detect the dangerous condition of the user coming into contact with blade **40**. The detection subsystem includes a sensor assembly, such as contact detection plates **44** and **46**, capacitively coupled to blade **40** to detect any contact between the user's body and the blade. Typically, the blade, or some larger portion of cutting tool **14** is electrically isolated from the remainder of machine **10**. Alternatively, detection subsystem **22** may include a different sensor assembly configured to detect contact in other ways, such as optically, resistively, etc. In any event, the detection subsystem is adapted to transmit a signal to control subsystem **26** when contact between the user and the blade is detected. Various exemplary embodiments and implementations of detection subsystem **22** are described in more detail in U.S. Provisional Patent Application Ser. No. 60/225,200, filed Aug. 14, 2000, entitled "Contact Detection System For Power Equipment," U.S. Pat. No. 7,210,383, filed Aug. 13, 2001, entitled "Detection System for Power Equipment," U.S. Provisional Patent Application Ser. No. 60/225,211, filed Aug. 14, 2000, entitled "Apparatus And Method For Detecting Dangerous Conditions In Power Equipment," and U.S. Pat. No. 7,284,467, filed Aug. 13, 2001, entitled "Apparatus And Method For Detecting Dangerous Conditions In Power Equipment," the disclosures of which are herein incorporated by reference.

Control subsystem **26** includes one or more instruments **48** that are operable by a user to control the motion of blade **40**. Instruments **48** may include start/stop switches, speed controls, direction controls, etc. Control subsystem **26** also includes a logic controller **50** connected to receive the user's inputs via instruments **48**. Logic controller **50** is also connected to receive a contact detection signal from detection subsystem **22**. Further, the logic controller may be configured to receive inputs from other sources (not shown) such as blade motion sensors, workpiece sensors, etc. In any event, the logic controller is configured to control operative structure **12** in response to the user's inputs through instruments **48**. However, upon receipt of a contact detection signal from detection subsystem **22**, the logic controller overrides the control inputs from the user and activates reaction subsystem **24** to stop the motion of the blade. Various exemplary embodiments and implementations of control subsystem **26** are described in more detail in U.S. Provisional Patent Application Ser. No. 60/225,059, filed Aug. 14, 2000, entitled "Logic Control For Fast-Acting Safety System," U.S. patent application Ser. No. 09/929,237, filed Aug. 13, 2001, entitled "Logic Control For Fast-Acting Safety System," U.S. Provisional Patent Application Ser. No. 60/225,094, filed Aug. 14, 2000, entitled "Motion Detecting System For Use In Safety System For Power Equipment," and U.S. Pat. No. 7,225,712, filed Aug. 13, 2001, entitled "Motion Detecting System For Use In A Safety System For Power Equipment," the disclosures of which are herein incorporated by reference.

In the exemplary implementation, brake mechanism **28** includes a pawl **60** mounted adjacent the edge of blade **40** and selectively moveable to engage and grip the teeth of the blade. Pawl **60** may be constructed of any suitable material adapted to engage and stop the blade. As one example, the pawl may be constructed of a relatively high strength thermoplastic material such as polycarbonate or Acrylonitrile Butadiene Styrene (ABS), etc., or a metal such as aluminum, etc. It will be appreciated that the construction of pawl **60** will vary depending on the configuration of blade **40**. In any event, the pawl is urged into the blade by a biasing mechanism in the form of a spring **66**. In the illustrative embodiment shown in FIG. **2**, pawl **60** is pivoted into the teeth of blade **40**. It should be understood that sliding or rotary movement of pawl **60** may also be used. The spring is adapted to urge pawl **60** into the teeth of the blade with sufficient force to grip the blade and quickly bring it to a stop.

The pawl is held away from the edge of the blade by a restraining mechanism in the form of a fusible member **70**. The fusible member is constructed of a suitable material adapted to restrain the pawl against the bias of spring **66**, and also adapted to melt under a determined electrical current density. Examples of suitable materials for fusible member **70** include NiChrome wire, stainless steel wire, etc. The fusible member is connected between the pawl and a contact mount **72**. Preferably, fusible member **70** holds the pawl relatively close to the edge of the blade to reduce the distance the pawl must travel to engage the blade. Positioning the pawl relatively close to the edge of the blade reduces the time required for the pawl to engage and stop the blade. Typically, the pawl is held approximately 1/32-inch to 1/4-inch from the edge of the blade by fusible member **70**, however other pawl-to-blade spacings may also be used within the scope of the invention.

Pawl **60** is released from its unactuated, or cocked, position to engage blade **40** by a release mechanism in the form of a firing subsystem **76**. The firing subsystem is coupled to contact mount **72**, and is configured to melt fusible member **70** by passing a surge of electrical current through the fusible member. Firing subsystem **76** is coupled to logic controller **50** and activated by a signal from the logic controller. When the logic controller receives a contact detection signal from detection subsystem **22**, the logic controller sends an activation signal to firing subsystem **76**, which melts fusible member **70**, thereby releasing the pawl to stop the blade. Various exemplary embodiments and implementations of reaction subsystem **24** are described in more detail in U.S. Provisional Patent Application Ser. No. 60/225,056, filed Aug. 14, 2000, entitled "Firing Subsystem For Use In A Fast Acting Safety System," U.S. Pat. No. 7,100,483, filed Aug. 13, 2001, entitled "Firing Subsystem For Use In A Fast-Acting Safety System," U.S. Provisional Patent Application Ser. No.

60/225,169, filed Aug. 14, 2000; entitled "Brake Mechanism For Power Equipment," and U.S. Pat. No. 7,024,975, filed Aug. 13, 2001, entitled "Brake Mechanism For Power Equipment," the disclosures of which are herein incorporated by reference.

Firing system **76** may also be used to trigger some action other than burning a fusible member. For example, firing system **76** can fire a small explosive charge to move a pawl. FIG. **22** shows a relatively small, self-contained explosive charge **660** in the form of a squib or detonator that can be used to drive pawl **60** against a blade. An example of a suitable explosive charge is an M-100 detonator available, for example, from Stresau Laboratory, Inc., of Spooner, Wis. The self-contained charge or squib focuses the force of the explosion along the direction of movement of the pawl. A trigger line **662** extends from the charge, and it may be connected to firing system **76** to trigger detonation. Any suitable explosive charge system may be used.

Explosive charge **660** can be used to move pawl **60** by inserting the charge between the pawl and a stationary block **664** adjacent the charge. When the charge detonates, the pawl is pushed away from the block. A compression spring **66** is placed between the block and pawl to ensure the pawl does not bounce back from the blade when the charge is detonated. Prior to detonation, the pawl is held away from the blade by the friction-fit of the charge in both the block and pawl. However, the force created upon detonation of the charge is more than sufficient to overcome the friction fit. Alternatively, the pawl may be held away from the blade by other mechanisms such as a frangible member, gravity, a spring between the pawl and block, etc.

Firing system **76** may also trigger a DC solenoid, which can be over-driven with a current surge to create a rapid displacement, a pressurized air or gas cylinder to supply the pressure in place of the spring or charge, or an electromagnet to either repel the pawl against the blade or to release a spring-loaded pawl toward the blade.

It will be appreciated that activation of the brake mechanism will require the replacement of one or more portions of safety system **18**. For example, pawl **60** and fusible member **70** typically must be replaced before the safety system is ready to be used again. Thus, it may be desirable to construct one or more portions of safety system **18** in a cartridge that can be easily replaced. For example, in the exemplary implementation depicted in FIG. **2**, safety system **18** includes a replaceable cartridge **80** having a housing **82**. Pawl **60**, spring **66**, fusible member **70** and contact mount **72** are all mounted within housing **82**. Alternatively, other portions of safety system **18** may be mounted within the housing. In any event, after the reaction system has been activated, the safety system can be reset by replacing cartridge **80**. The portions of safety system **18** not mounted within the cartridge may be replaced separately or reused as appropriate. Various exemplary embodiments and implementations of a safety system using a replaceable cartridge are described in more detail in U.S. Provisional Patent Application Ser. No. 60/225,201, filed Aug. 14, 2000, entitled "Replaceable Brake Mechanism For Power Equipment," U.S. Patent application Ser. No. 09/929,236, filed Aug. 13, 2001, entitled "Replaceable Brake Mechanism For Power Equipment," U.S. Provisional Patent Application Ser. No. 60/225,212, filed Aug. 14, 2000, entitled "Brake Positioning System," and U.S. Pat. No. 6,857,345, filed Aug. 13, 2001, entitled "Brake Positioning System," the disclosures of which are herein incorporated by reference.

While one particular implementation of safety system **18** has been described, it will be appreciated that many variations and modifications are possible within the scope of the invention. Many such variations and modifications are described in U.S. Provisional Patent Application Ser. No. 60/182,866, filed Feb. 16, 2000, and U.S. Provisional Patent Application Ser. No. 60/157,340, filed Oct. 1, 1999, the disclosures of which are herein incorporated by reference.

As discussed, safety system **18** includes a brake mechanism **28** that is adapted to stop the cutting tool, thereby preventing or reducing injury to the user. As also discussed previously, brake mechanism may include at least one pawl **60** adapted to engage the cutting tool to stop its rotation. Illustrative examples of suitable pawls are disclosed in copending U.S. Provisional Patent Application Ser. No. 60/225,169, filed Aug. 14, 2000, entitled "Brake Mechanism For Power Equipment," and U.S. Pat. No. 7,024,975, filed Aug. 13, 2001, entitled "Brake Mechanism For Power Equipment," which are incorporated herein by reference. For purposes of the following discussion, cutting tool **14** will be described in the context of a blade **40**, such as on a table saw, miter saw, circular saw or the like. It should be understood that blade **40** may include single blades, such as plywood or carbide-tipped blades, or an assembly of several blades, such as a dado blade.

As further discussed, pawl **60** is urged from its cocked, or restrained, position toward blade **40** or other cutting tool by biasing mechanism **30**. In FIG. **2**, biasing mechanism **30** includes a spring **66**. From its compressed position shown in FIG. **2**, spring **66** biases the pawl to move into engagement with blade **40**. In FIG. **2**, a restraining mechanism **32** is shown restraining pawl **60** from moving toward the blade under the biasing force exerted by spring **66**. However, upon release of restraining mechanism **32**, the pawl is no longer retained in its cocked position. As such, the pawl moves quickly into engagement with the blade under the force exerted by spring **66**, such as shown in FIG. **3**. An example of how restraining mechanism **32** may release the pawl is when a sufficiently high current is passed through fusible member **70**. Other suitable release and restraining mechanisms are disclosed in copending U.S. Provisional Patent Application Ser. No. 60/225,056, filed Aug. 14, 2000, entitled "Firing Subsystem For Use In A Fast-Acting Safety System," and U.S. Pat. No. 7,100,483, filed Aug. 13, 2001, entitled "Firing Subsystem For Use In A Fast-Acting Safety System," which are incorporated herein by reference.

In FIG. **2**, the particular embodiment of spring **66** shown is a coiled compression spring. As used herein, spring **66** will be used to refer to any suitable spring generally, such as any of the particular types of springs discussed herein or other suitable spring mechanisms known in the art. Particular types of springs are referred to herein with particular reference numbers, such as coiled compression spring **402**. In FIGS. **2-3** and the subsequent figures, various embodiments of spring-biased brake mechanisms are shown and described and include various elements, subelements and possible variations. It should be understood that spring-biased brake mechanisms according to the present invention may include any one or more of these elements, subelements and variations, regardless of whether those elements, subelements or variations are shown in the same or different figures or descriptions.

The speed at which the pawl will engage and stop the blade is dependent upon the force exerted upon pawl **60** by the spring. Therefore, the more force the spring exerts upon the pawl, the faster the pawl will travel the distance from its restrained position to the blade. In experiments, springs that exert forces in the range of 10 pounds to 500 pounds upon the pawl have proven effective, with springs that exert forces in the range of 50 and 200 pounds being preferred, and a 100-pound force proving particularly effective.

The spring selected should have sufficient force to move the brake pawl into contact with the blade or other cutting tool or portion of operative structure **12** within the desired time frame. It will be understood by those of skill in the art that the appropriate spring force may be calculated from the pawl-to-blade separation, the weight of the pawl, and the desired length of time necessary to move the pawl into contact with the blade (transit time). As discussed in U.S. Provisional Patent Application Ser. No. 60/225,200, filed Aug. 14, 2000, entitled "Contact Detection System For Power Equipment," and U.S. Pat. No. 7,210,383, filed Aug. 13, 2001, entitled "Detection System For Power Equipment," which are incorporated herein by reference, it may be desirable that the brake pawl move into contact with the blade or other cutting tool within approximately one to approximately three milliseconds (ms) after being released from the restraining mechanism. Thus, for a pawl-to-blade separation of 1/32-inch, the selected spring should have sufficient force to accelerate the pawl at over 500 ft/s^2 to achieve a transit time of approximately 3-ms, or sufficient force to accelerate the pawl at over 5,000 ft/s^2 to achieve a transit time of approximately 1-ms. Similarly, for a pawl-to-blade separation of 1/8-inch, the spring should have sufficient force to generate a pawl acceleration of over 2,000 ft/s^2 for a transit time of approximately 3-ms, or a pawl acceleration of over 20,000 ft/s^2 for a transit time of approximately 1-ms. Likewise, for a pawl-to-blade separation of 1/4-inch, the spring should have sufficient force to generate a pawl acceleration of over 4,500 ft/s^2 for a transit time of approximately 3-ms, or a pawl acceleration of over 40,000 ft/s^2 for a transit time of approximately 1-ms.

Once the acceleration has been determined (and ignoring frictional forces), the necessary spring force may be calculated from the acceleration and the weight of the pawl. For example, given a pawl-to-blade separation of 1/32-inch, the 100-lb. spring mentioned above would be sufficient to move a 5-lb. brake pawl into contact with the blade in approximately 3-ms, or a 9-oz. brake pawl in approximately 1-ms. Similarly, given a pawl-to-blade separation of 1/8-inch, the 100-lb. spring would be sufficient to move a 1.4-lb. brake pawl into contact with the blade in approximately 3-ms, or a 2-oz. brake pawl in approximately 1-ms. Likewise, given a pawl-to-blade separation of 1/4-inch, the 100-lb. spring would be sufficient to move an 11-oz. brake pawl into contact with the blade in approximately 3-ms, or a 1-oz. brake pawl in approximately 1-ms. Similar calculations may be performed for the 10-lb., 50-lb., 200-lb., and 500-lb. springs mentioned above, as well as for any other spring force or pawl weight.

However, it should be remembered that the restraining mechanism not only must counteract the force exerted by the spring, but also must be able to quickly release the pawl from its cocked position. Therefore, there may be a tradeoff between increasing the spring force and increasing the complexity, strength and cost of the restraining mechanism to be able to restrain the increase in spring force. Also, any mechanical advantage from the placement and associated structure, if any, coupling the spring to the pawl should be taken into account.

Brake mechanisms utilizing other springs **66** are shown in FIGS. **4-6**. In FIG. **4**, spring **66** takes the form of a leaf spring **404**, which has base portion **406** and a pawl-engaging portion **408** adapted to engage and urge pawl **60** toward blade **40**. Base portion **406** is secured to a suitable mounting assembly **410**. Mounting assembly **410** may be any suitable structure that supports the base portion of the leaf spring to bias the pawl-engaging portion **408** toward the pawl. As shown, leaf spring **404** is a cantilevered leaf spring. Another example of a suitable mounting assembly **410** is shown in FIG. **5**, in which the mounting assembly includes a plurality of spaced-apart supports **411**.

In FIG. **6**, a torsion spring **412** is utilized to bias pawl **60** into engagement with blade **40**. Spring **412** includes a fixed end **414**, a biasing end **416** adapted to engage pawl **60**, and a coiled portion **418** intermediate the ends. As shown, torsion spring **412** is mounted on the same pin or axle **420** that pawl **60** is mounted upon. It is within the scope of the invention that spring **412** may be interposed between the axle and the pawl, mounted on the axle adjacent or spaced-apart from the pawl, or mounted on structure other than axle **420**.

In FIG. **7**, an extension spring **422** is shown. Unlike a compression spring that resists compressive forces, extension spring **422** resists being elongated from its resting, or zero load, position. Therefore, instead of pushing or urging pawl **60** toward the blade by pushing upon the pawl, extension spring **422** pulls the pawl toward the blade or other cutting tool. As shown, extension spring **422** includes a biasing end portion **424** coupled to the pawl and a fixed end portion **426** coupled to a suitable mounting assembly **410** disposed generally toward the blade relative to the biasing end portion. The mounting assembly to which fixed end portion **426** is coupled may include a linkage, or mount, **428** that couples the end portion to the mounting assembly. Similarly, biased end portion **426** may be coupled to the pawl or other structure that moves with the pawl by a linkage or mount **430**. Mounting assembly **410** may include any suitable structure able to support fixed end portion **426** without interfering with the operation of machine **10**. For example, it may be mounted adjacent blade **40**, coupled to the blade's arbor, mounted on structure that moves with the blade as the blade is tilted, raised or lowered, etc. Alternatively, extension spring **422** may act upon a portion of the pawl, or linkage coupled thereto, that is on the other end of the pawl's pivot axis than the blade-engaging portion of the pawl. This configuration is illustrated in dashed lines in FIG. **7**. This configuration may be preferred because mounting assembly **410** is spaced further away from the blade, and may be more easily positioned.

Although a single spring **66** is shown in FIGS. **2-7**, it should be understood that brake mechanism **28** may include more than one spring. For example, in the illustrative embodiment shown in FIG. **7**, a pair of extension springs **422** may be used, such as shown in FIG. **8**. When two or more springs are used, they may be of similar or different types and strengths.

In FIGS. **2-8**, springs **66** are shown directly engaging pawls **60**. It should be understood that the springs may alternatively engage other structure in communication with pawl **60**. For example, springs **66** may engage one or more linkages through which the spring's biasing force is passed to the pawl. In such a configuration, restraining mechanism **32** may restrain any suitable portion of the biasing mechanism and pawl assembly to prevent the pawl from being moved into engagement with the blade or other cutting tool. For example, in the context of a restraining mechanism that includes a fusible member **70**, the fusible member may be coupled to pawl **60**, spring **66**, or the one or more linkages interconnecting the spring and pawl.

An example of a brake mechanism **28** in which spring **66** directly engages a linkage instead of pawl **60** is shown in FIG. **9** in the context of a brake mechanism having a pair of pawls **60** adapted to engage a blade **40**. As shown, pawls **60** include blade-engaging portions **434** adapted to engage blade **40**. Pawls **60** are pivotal about axles or pins **436** and include distal portions **438** to which linkages **440** are coupled. Linkages **440** are further coupled to a spring-engaging linkage **442**, which as shown, includes an end **444** adapted to be moved toward

blade **40**, thereby drawing the blade-engaging portions of the pawls into contact with the blade. In FIG. **9**, a compression spring **402** is shown engaging linkage **442**, however, any of the springs described herein could be used.

Springs **66** may also exert a biasing force upon an engagement mechanism instead of pawl **60**. In such an embodiment, the force of the spring is not applied to the pawl unless restraining mechanism **32** releases the engagement mechanism or biasing mechanism to urge the pawl into engagement with the blade or cutting tool of machine **10**. An advantage of such a brake mechanism is that the biasing mechanism is not exerting force upon the pawl until the pawl is urged into contact with blade **40**. This may, but does not necessarily, enable pawl **60** to be selectively removed and replaced from the brake mechanism without disabling biasing mechanism **30**.

Additionally, or alternatively, biasing mechanism **30** may be self-contained as a module or cartridge that can be selectively removed and replaced from the rest of the brake mechanism when the fusible member or other portion of restraining mechanism **32** that counteracts the force of spring **66** is secured between portions of this module.

An example of a brake mechanism with an engagement mechanism is shown in FIG. **10**. As shown, spring **66** acts upon engagement mechanism **446**, which is depicted to include a pivotal plate **450**. Plate **450** selectively prevents the spring's biasing force from being exerted upon pawl **60**. As shown, a restraining mechanism, such as fusible member **70**, prevents plate **450** from pivoting about its axle **452** under the biasing force of spring **66**. As a result, the pawl is not urged toward the blade. A module or cartridge **448** is shown schematically in dashed lines, and is a possible rather than necessary element of brake mechanism **28**. Module **448** typically will be mounted upon a suitable support or receiver in the machine, and may also include a connection with a suitable mechanism for releasing restraining mechanism **32**. For example, contact mount **72** may be electrically connected to a portion of the release mechanism that does not form part of the replaceable module.

A variation of this brake mechanism is shown in FIG. **11**, in which engagement mechanism **446** takes the form of a slidable member **454** that is adapted to translate, or slide, along tracks **456** toward and away from blade **40**. As shown, fusible member **70** restrains the slidable member **454** from moving toward the blade, thereby preventing the spring from urging pawl **60** into contact with blade **40**. Also shown in FIG. **11**, is a variation of this brake mechanism, in which fusible member **70** extends across the travel path of slidable member **454** to prevent member **454** from moving under the force exerted by spring **66**. In fact, fusible member **70** may itself form engagement mechanism **446**, such as shown in FIG. **12**, where the fusible member extends across the path of spring **66**, thereby preventing the spring from urging pawl **60** into the blade or other cutting tool.

The brake mechanisms shown in FIGS. **9-11** may also be understood as including biasing mechanisms **30** with compound release mechanisms because there is more than one step for the brake mechanism to be actuated and pawl **60** to engage the blade or other cutting tool. Unlike the brake mechanisms shown in FIGS. **3-8**, in which the release of restraining mechanism **32** was all that was required for spring **66** to urge pawl **60** into the blade or other cutting tool, the brake mechanisms shown in FIGS. **9-11** utilize a compound release to engage blade **40** with pawl **60**. For example, the release of restraining mechanism **32** may free a portion of biasing mechanism **30** to move, such as to engage engagement mechanism **446** or a linkage, which in turn transfers this force to pawl **60**.

In FIG. **13**, another example of a brake mechanism **28** with a compound release, or compound release mechanism, is shown in the form of a self-contained actuator assembly. As shown, spring **66** is housed in a shell **458** with an open end **460** through which the spring, or a suitable linkage coupled to the spring, may extend upon release of restraining mechanism **32**. In the illustrative embodiment shown in FIG. **13**, end **460** is at least partially covered by a spanning member **462** positioned between the spring and pawl **60**. Member **462** does not need to completely close end **460**, however, it should prevent spring **60** from passing through end **460** and engaging pawl **60**. Fusible member **70**, or another suitable embodiment of restraining mechanism **32**, is coupled to member **462** and prevents spring **66** from urging the spanning member into contact with pawl **60**. As shown, member **70** passes through shell **458**, and in the illustrated embodiment, spring **66**. It should be understood that shell **458** may be used with embodiments of brake mechanism **28** that do not include a compound release, in which case pawl **60** would typically abut the open end of the shell.

Other exemplary embodiments of self-contained actuator assemblies are shown in FIGS. **14** and **15**, where restraining mechanism **32** is releasably coupled to a lever arm **464** that in turn is coupled to an end portion **466** of a carrier **468**. Lever, or pivot, arm **464** pivots about a pivot axis defined by a projecting portion **465** on shell **458**. It should be remembered that arm **464**, carrier **468** and shell **458** (including portion **465**) must be sufficiently strong to withstand the force of spring **66**. End portion **466** of carrier **468** should be mounted on arm **464** so that it will release relatively immediately upon release of restraining mechanism **32** and initial pivoting of arm **464** about portion **465**. Alternatively, arm **464** should be able to pivot without obstruction until pawl **60** is fully engaged with blade **40** so that the pivot arm does not impede the motion of pawl **60**, and thereby increase the time required to stop blade **40**. In such a configuration where arm **464** pivots without restricting the motion of the pawl, arm **464** does not need to release from carrier **468**, and instead these portions may remain coupled together.

Carrier **468** includes an elongate support **470** that extends through shell **458** and further includes a pawl-receiving portion **472** that is adapted to releasably receive pawl **60**, thereby allowing the pawl to be selectively removed and replaced without dismantling or otherwise disassembling the rest of brake mechanism **28**. As shown, pawl-receiving portion **472** also forms a spanning member in that it prevents the spring from urging the pawl into engagement with blade **40**. In FIGS. **14** and **15**, portion **472** and pawl **60** are shown having complimentary configurations so that the pawl may be coupled to the pawl-receiving portion without requiring additional securing mechanisms. In the embodiment shown, the pawl may be either slid onto portion **472** from an end, or alternatively by briefly deflecting portion **472** outwardly as the pawl is inserted into its mounted position. It will be appreciated, however, that additional securing mechanisms may be used, such as screws, pins, and other releasable fasteners. Because neither spring **66** nor fusible member **70** acts directly upon the pawl or pawl-receiving portion, the coupling between these portions does not have to be strong. As a further variation, pawl **60** may be fixedly secured to, or even integrally formed with, carrier **468**, or at least the pawl-engaging portion thereof.

A variation of a self-contained actuator is shown in FIG. **16**, in which the length of carrier **468** is selectively adjustable,

thereby allowing the relative positioning of the pawl relative to blade **40** to also be adjustable. As shown, support **470** includes a threaded portion **474** that is threadingly received into pawl-receiving portion **472**. The length of carrier **468** may be adjusted by rotating support **470**, such as via a user-manipulable portion **476**, to increase or decrease the extent to which portion **474** is received into pawl-receiving portion **472**. In FIG. **16**, pawl-receiving portion **472** is also shown including key structure **478** that prevents pawl **60** from being installed into the pawl-receiving portion other than in a position defined by key structure **478**.

Another embodiment of a spring-biased brake mechanism is shown in FIG. **17**. As shown, lever arm **464** includes an end portion **480** that couples to shell **458** proximate open end **460**. In the embodiment shown, end portion **480** is received into a notch **481** in the shell, and includes a shoulder **482** about which the arm pivots upon release of restraining mechanism **32**. Alternatively, shell **458** may include a ledge or projection upon which arm **464** is seated. Preferably, at least an end region **483** of elongate support **470** generally conforms to the inner diameter of spring **66** to resist shifting or tilting of the carrier when in the restrained position shown in FIG. **17**.

As shown, support **470** includes an edge **471** that extends generally parallel and against spring **66**, with a generally opposed edge **473** tapering from pawl-receiving portion **472** toward end portion **466**. Also shown in FIG. **17** is another example of a pawl-receiving portion **472** with a key structure **478**. Edge **471** is on the side of support **470** distal pivot arm **464** to stabilize the carrier during installation and while in the restrained position. Edge **473** is on the side of support **470** proximate lever arm **464** to allow the support to tilt as it is urged from shell **458** upon release of restraining mechanism **32**. This configuration of carrier **468** is an example of a carrier that may be integrally formed, or monolithic, with pawl **60**.

In the brake mechanisms shown in FIGS. **14-17**, the portion of fusible member **70** not coupled to pivot arm **464** may be secured to any suitable supporting structure to allow the fusible member to counteract the force of spring **66**. This supporting structure may form part of the brake mechanism shown in FIGS. **14-17**, such as securing the fusible member to shell **458** or pawl-receiving portion **472**. In such a configuration, the portions of the brake, biasing and restraining mechanisms shown in FIGS. **14-17** form a self-contained module or self-contained actuator.

In FIG. **18**, an embodiment of a shell and pivot arm assembly is shown in which the distance between the pivot axis **484** of arm **464** and the region upon which arm **464** supports carrier **468** is reduced from the embodiments shown in FIGS. **14-16**. As shown, arm **464** is pivotally coupled to shell **458** by a pair of mounts **485** and includes a carrier-receiving portion **486**. In the embodiment shown in FIG. **18**, arm **464** may have a generally planar configuration that allows the arm to extend against a portion of the shell's end **487**. Upon release of the restraining mechanism, arm **464** pivots relative to shell **458** and portion **486** pivots into the shell and releases the carrier to move under the force of spring **66**. As shown, end **487** of shell **484** is sufficiently open to permit portion **486** to pivot into the shell and release carrier **468**. As shown, end **487** is also sufficiently obstructed to prevent spring **66** from passing therethrough. Also illustrated in FIG. **18** is an embodiment of support **470** that generally conforms to the inner dimension of spring **66**, thereby supporting carrier **468** against axial tilting within the shell as the carrier passes through the shell. Another suitable configuration for support **470** is shown in dashed lines in FIG. **18**.

In FIGS. **19** and **20**, another example of a spring-biased brake mechanism with a lever arm **464** that releases from open end **460** of shell **458** is shown. As shown, arm **464** is pivotally coupled to shell **458** by pins **488** and includes a pair of catches **489** that engage a spanning member **462**. As shown, spanning member **462** includes a cover **490** that covers open end **460** of shell **458** and includes projections **491** that are engaged by catches **489**. Alternatively, spanning member **462** may include any other suitable configuration sufficient to prevent spring **66** from passing through, or urging another member through, end **460** prior to release of restraining mechanism **32**. Preferably, catches **489** are shaped to release spanning member **462** as arm **464** begins to pivot upon release of restraining mechanism **32**.

In FIG. **21**, another example of a spring-biased brake mechanism is shown. As shown, lever arm **464** and shell **458** are adapted to facilitate more uniform positioning of carrier **468**, and thereby pawl **60**, as arm **464** is secured in a cocked, or restrained, position by restraining mechanism **32**, such as fusible member **70**. Prior to attachment of fusible member **70**, lever arm **464** is pivoted about edge **492** of shell **458** as the arm is pivoted to the position shown in solid lines in FIG. **21**. In this interval, there is a mechanical advantage achieved because the distance **493** between edge **492** and the proximate edge **494** of carrier **468** is much less than the distance **495** between edge **492** and fusible member **70**. However, to continue pivoting arm **464** downward, this mechanical advantage is lost because the fulcrum about which the arm is pivoted changes, as reflected by distances **493'** and **495'**. As shown, arm **464** now pivots about the edge **496** of extension **498**. The corresponding amount of force required to pivot arm **464** may be used as an indicator of when arm **464** is positioned properly, at which point fusible member **70** may be attached. Of course, if fusible member **70** is a preformed member of fixed length, then precise positioning of the lever arm **464** and pawl **60** are achieved simply by the attachment of the fusible member.

It will be appreciated that the spring-biased brake mechanism described above may be implemented with many variations within the scope of the invention. For example, the spring-biased mechanisms disclosed herein may be used to drive the retraction of blade **40**, such as on a table saw or a miter saw, such as described in copending U.S. Provisional Patent Application Ser. No. 60/225,089, filed Aug. 14, 2000, entitled "Retraction System For Use In Power Equipment," U.S. patent application Ser. No. 09/929,242, filed Aug. 13, 2001, entitled "Retraction System For Use In Power Equipment," U.S. Provisional Patent Application Ser. No. 60/225,057, filed Aug. 14, 2000, entitled "Miter Saw With Improved Safety System," and U.S. patent application Ser. No. 09/929,238, filed Aug. 13, 2001, entitled "Miter Saw With Improved Safety System," which are incorporated herein by reference.

FIGS. **23** and **24** show side views of a table saw configured with both a retraction system and a braking mechanism. A blade **300** is mounted on an arbor **301** to spin in the direction of arrow **302**. A table **303** (not shown in FIG. **24**), which defines the work surface or cutting region for the table saw, is adjacent the blade and the blade extends above the table. A support structure **304** may support blade **300** and arbor **301** in any known way, or as described in more detail in U.S. Provisional Patent Application Ser. No. 60/225,058, titled "Table Saw with Improved Safety System," filed Aug. 14, 2000.

Blade **300** is configured to pivot up and down so that a user can position the blade to extend above the table as needed. The blade pivots around a pin **305**. A user may pivot the blade to adjust its position by turning a shaft **306** on which a worm gear **307** is mounted. The worm gear is mounted on the shaft so that it turns with the shaft, but so that it may slide on the shaft when necessary, as explained below. Worm gear **307** is

mounted on shaft **306** like a collar, with the shaft extending through a longitudinal hole in the worm gear. The worm gear is held in place during normal operation of the saw by a spring clip **308**, which is positioned in a groove or channel **309** on the worm gear and which also engages a detent or shoulder on shaft **306** to hold the worm gear in place. The worm gear engages an arcuate rack **310** that supports an arbor block **311**, which in turn supports arbor **301** and blade **300**. Thus, when a user turns shaft **306**, such as by turning a knob attached to the shaft (not shown), worm gear **307** moves arbor block **311** and the blade up or down, depending on the direction that the worm gear is turned.

A brake cartridge **312** is mounted in the saw adjacent blade **300**. The brake cartridge includes a pawl **314** biased toward blade **300** by a spring **316**. The pawl is held away from blade **300** by a release mechanism **318**, as described generally above and as described in more detail in U.S. Provisional Patent Application Ser. No. 60/225,170, entitled "Spring-Biased Brake Mechanism for Power Equipment," U.S. Provisional Patent Application Ser. No. 60/225,169, entitled "Brake Mechanism for Power Equipment," U.S. Provisional Patent Application Ser. No. 60/225,201, entitled "Replaceable Brake Mechanism for Power Equipment," and U.S. Provisional Patent Application Ser. No. 60/225,212, entitled "Brake Positioning System," all filed Aug. 14, 2000. The cartridge is configured so that the release mechanism releases the pawl into the blade upon the receipt of a detection signal, as explained generally above and as explained in more detail in U.S. Provisional Patent Application Ser. No. 60/225,056, titled "Firing Subsystem for use in a Fast-Acting Safety System," filed Aug. 14, 2000.

Brake cartridge **312** is positioned on the blade's pivot axis so that pawl **314** can move around pin **305**. Thus, when pawl **314** hits the blade, the angular momentum of the blade is transferred to the arbor block, and the blade, arbor block, rack and cartridge try to retract or move down in the direction of arrow **320**. Alternatively, the cartridge may be positioned on a pin different from pin **305**, but that still pivots with the blade.

The blade will move down to the extent permitted by the contact between rack **310** and worm gear **307**. If the worm gear is fixed in place, the downward movement of the blade may strip teeth on the rack and/or worm gear, and may prevent the blade from moving down as far as desired. In the embodiment shown in FIGS. **23** and **24**, the worm gear is adapted to snap free and move on shaft **306** when the pawl hits the blade.

When the pawl hits the blade, the resultant angular momentum impulse causes spring clip **308** to snap loose, allowing the worm gear to slide down the shaft toward an end **322** of the shaft. The spring clip snaps loose because the rack moves down when the blade is stopped, and the rack contacts the worm gear and forces the worm gear to move. The force of the rack against the worm gear causes the spring clip to snap loose. The worm gear is put back in place by moving it back along shaft **306** until the spring clip snaps into place on the shaft.

The table saw shown in FIGS. **23** and **24** also includes a support **326** configured with a seat or region **328** in which is placed an impact-absorbing material **330**. The support is positioned under the arbor and arbor block so that when the blade retracts, the arbor block strikes impact-absorbing material **330**. Support **326** and impact absorbing material **330** act as a barrier to stop the downward movement of the blade. The support is positioned so that blade **300** may retract a sufficient distance. The impact-absorbing material can be any one of a number of cushioning materials, such as rubber, dense foam, plastic, etc. One material found to be suitable is available under the part number C-1002-06 from AearoEAR, of Indianapolis, Ind. Alternatively, impact-absorbing material **330** may be attached to the undersurface of the arbor block instead of on support **326**. Additionally, support **326** may take many forms. In fact, shaft **306** may be configured and positioned so that it provides a surface to stop the downward movement of the blade.

FIG. **24** also shows a splitter **335** that extends above table **303** behind blade **300** to prevent kickback. A blade guard may also substantially enclose blade **300**. FIG. **24** further shows a housing **337** for electronic components relating to the safety system, and a motor mount **339**, which are not shown in FIG. **23**.

In the construction described above, the angular momentum of the blade causes the blade, arbor block and cartridge to all pivot down away from the cutting region when the pawl strikes the blade. Thus, the angular momentum of the blade causes the retraction. Blade **300** is permitted to move downward a sufficient distance so that the blade is completely retracted. In independent experiments, the safety system depicted in FIGS. **23** and **24** and described above has been shown to retract the blade completely below table **303** within approximately 14 milliseconds after contact is detected. Indeed the downward motion of the blade during retraction is too fast to detect with the human eye, i.e., the blade disappears below table **303** with no discernable transition or downward motion. The ability of the blade to retract minimizes any injury from accidental contact with the blade.

FIG. **25** shows another embodiment of a retraction system used with a brake pawl. A saw **331** includes a blade **300** and a brake cartridge **312** housing a brake pawl **314**. The cartridge and pawl are mounted to the frame of the saw by a pin **332**. The pin is mounted to the saw in such a way that it may not pivot up and down with the blade. When the blade hits the pawl, the blade climbs down the pawl, or in other words, moves generally around the point of contact with the pawl. The pawl and blade do not pivot downward together, as in the embodiment shown in FIGS. **23** and **24**, because the pawl is fixed to the frame of the saw. In this embodiment, the blade retracts by "climbing" down the pawl.

Another embodiment of a retraction system comprises a compressible bushing. Typically, a blade **300** in a table saw, miter saw or other machine is mounted to an arbor over a bushing **333**, as shown in FIG. **26**. A locking nut, washers and an arbor flange are used to secure the blade to the arbor. Bushing **333** may be constructed from a material that is soft enough to deform when the blade is stopped suddenly. For example, depending on the type of braking system used, a substantial radial impact load may be transmitted to the arbor when the brake is actuated. A deformable bushing can be used to absorb some of this impact and reduce the chance of damage to the arbor. In addition, proper positioning of the brake in combination with a deformable bushing may be employed to cause the blade to move away from the user upon activation of the brake. Where a plastic bushing is placed between the blade and the arbor, the substantial force created by stopping the blade almost instantly may cause the bushing to deform. Typically, the edge of the mounting hole of the blade will bite into the bushing as the blade attempts to rotate about the pawl. Therefore, if the pawl is mounted at the back of the blade, then the blade will tend to move downward into the bushing and away from the user when the pawl engages the blade.

FIGS. **27** and **28** show a miter saw equipped with both a brake and a retraction system. The miter saw is configured with a pivotal motor assembly to allow the blade to move upward into the housing upon engagement with a brake pawl **348**. Motor assembly **350** is connected to housing **352** via pivot bolt **354**, allowing the motor assembly to pivot about

bolt **354** in the direction of blade rotation. A spring **356** is compressed between the motor assembly and an anchor **358** to bias the motor assembly against the direction of blade rotation. The motor assembly may include a lip **360**, which slides against a flange **362** on the housing to hold the end of the motor assembly opposite the pivot bolt against the housing.

When the saw is in use, spring **356** holds the motor assembly in a normal position rotated fully counter to the direction of blade rotation. However, once the pawl is released to engage the blade, the motor assembly and blade pivot upward against the bias of the spring. In this embodiment, the pawl is positioned at the front of the blade so that the pivot bolt **354** is between the pawl and the arbor. This arrangement encourages the blade to move upward into the housing when stopped. The spring is selected to be sufficiently strong to hold the motor assembly down when cutting through a workpiece, but sufficiently compressible to allow the blade and motor assembly to move upward when the blade is stopped. Of course, the blade and motor assembly may be configured in any of a variety of ways to at least partially absorb the angular momentum of the blade.

FIG. **29** shows an alternative configuration of a miter saw adapted to move away from an accidental contact with a user by absorbing the angular momentum of the blade. In this configuration, the miter saw includes two swing arms **370** and **372**. One end **374** of each swing arm **370**, **372** is connected to base **376**, and the opposite end **378** of each swing arm is connected to housing **380**, the blade, and/or the motor assembly (not shown). The position of the swing arms relative to each other may vary depending on the swing arm motion desired. In FIG. **29**, swing arm **370** is connected to base **376** somewhat below and forward of swing arm **372**. Typically, the motor assembly is rigidly attached to end **378** of swing arm **370**, while housing **380** is connected to rotate about end **378** of swing arm **370**. End **378** of swing arm **372** is connected only to the housing. Alternatively, the motor assembly may be connected to rotate about end **378** of swing arm **370** along with the housing.

The geometry of the configuration shown in FIG. **29** causes the housing and/or motor assembly to rotate as the swing arms pivot. Significantly, when the swing arms move upward, the housing and/or motor assembly rotate in the same direction in which the blade rotates during cutting. As a result, when a brake pawl engages the blade and transfers the angular momentum of the blade to the housing and/or motor assembly, the housing and/or motor assembly tend to rotate in the same direction as the blade. This causes the swing arms to pivot upward, drawing the blade away from the workpiece and the user's body. Thus, the miter saw configuration illustrated in FIG. **29** is adapted to absorb the angular momentum of the blade and translate that angular momentum into an upward force on the swing arms.

In any of the systems described above, a spring or other force can be used to push the blade away from the point of contact with the user. The spring could be released by a mechanism similar to the mechanism that releases the pawl to strike the blade. FIGS. **30-32** show how a spring may be used to retract a blade in a table saw. FIG. **30** is a top view and FIGS. **31** and **32** are side views of an arbor block **381** holding an arbor **382** used to drive a blade (not shown). Arbor block **381** is pivotally mounted to pin **383** so that the arbor block and blade may pivot up and down to adjust the position of the blade in the saw.

A segment gear **384**, like rack **310** described above in connection with FIGS. **23** and **24**, is also mounted on pin **383**, and is connected to arbor block **381** in the manner described below, to raise and lower the arbor. Segment gear **384** includes a side portion **385** positioned substantially perpendicularly to the plane of arbor block **381**, and a top portion **386** positioned over arbor block **381**. The side portion **385** includes gear teeth **387** to engage a worm gear to raise and lower the arbor block. Side portion **385** and top portion **386** are connected to each other and move together. Top portion **386** extends over the top of the entire arbor block, as shown. The arbor block is constructed with a region to accommodate top portion **386** so that top portion **386** does not extend substantially above the arbor block, which could limit the ability of the arbor block and blade to pivot upward when desired, such as by contacting the underside of a table in a table saw.

A pocket **388** is formed in arbor block **381** to house a spring **389**. In the position shown in FIG. **31**, spring **389** is compressed between top portion **386** of segment gear **384** and arbor block **381** because the segment gear and arbor block are coupled together.

The segment gear and arbor block are coupled by a compound linkage having, as shown in FIG. **32**, a first arm **390** attached at one end to the arbor block and at its other end to a second arm **391**. The second arm, in turn, is attached to top portion **386** of segment gear **384**, as shown. First and second arms **390** and **391** are hingedly connected to each other, and to the arbor block and segment gear. The arms are configured so that the force of the spring pushing apart the arbor block and the top portion of the segment gear biases the first and second arms in such a way that the arms want to move. A fusible member **392**, which may take the form of a wire as described above, restrains the arms from movement. Of course, numerous different linkages may be used, and numerous types and configurations of fusible members or other release mechanisms may be used. The linkage may be selected to provide a sufficient mechanical advantage so that the arbor block and top portion of the segment gear may be held together with as thin a fusible member as possible, so that the fusible member may be burned as easily as possible. Various analogous compound linkages are described in U.S. Provisional Patent Application Ser. No. 60/225,170, entitled "Spring-Biased Brake Mechanism for Power Equipment," filed Aug. 14, 2000. The fusible member may be burned by a system as described above, or as described in more detail in U.S. Provisional Patent Application Ser. No. 60/225,056, entitled "Firing Subsystem for Use in Fast-Acting Safety System," filed Aug. 14, 2000. The compound linkage and the fusible member are preferably configured so that they accommodate spring forces of 100 to 500 pounds or more.

When the fusible member is burned, the compound linkage is free to move, and the spring pushes arbor block **381** down, away from top portion **386** of the segment gear, as shown by the dashed lines in FIG. **31**, thereby retracting the blade. The stronger the spring, the faster the blade will be retracted. The segment gear does not move because it is coupled through teeth **387** to a worm gear or some other structure.

Retracting a blade by a spring or some other force may be thought of as direct retraction. A spring or other force may be used with some other retraction system to increase the speed that a cutting tool retracts, or a spring or other force may be used as the sole means of retraction. The systems for direct retraction described above may be used on various pieces of equipment, including table saws, miter saws and band saws.

FIG. **33** is a schematic diagram of a system to retract the blade of a band saw. Typically, a band saw includes a main housing enclosing a pair of vertically spaced-apart wheels. The perimeter of each wheel is coated or covered in a high-friction material such as rubber, etc. A relatively thin, continuous loop blade tightly encircles both wheels. A workpiece

is cut by passing it toward the blade in a cutting zone between the wheels. The workpiece is passed toward the blade on a table, which forms the bottom of the cutting zone.

The band saw shown in FIG. **33** includes roller **393** positioned adjacent the blade. The roller is configured to contact the blade and push the blade away from the point of accidental contact with a user. In addition, the roller may be configured to push the blade off the wheels, thereby stopping the motion of the blade. A top view of the roller is shown in FIG. **34** pushing against a blade in the direction of the arrow. The roller may be part of a cartridge, and may be released into the blade just as the pawls described above are released. The roller should have a diameter large enough so that the roller can roll over the teeth of the blade.

The systems for direct retraction of a cutting tool may also be implemented on hand-held circular saws. Such saws typically include a base plate that contacts a workpiece during sawing. The base plate supports the saw on the workpiece. The base plate may be configured so that it is pushed down when the blade contacts a user. The result of that action is to effectively retract the blade because the base plate would push the user away from the blade.

FIG. **35** illustrates one embodiment of a reaction system adapted to disable the dangerous portions of a cutting tool. In the embodiment of FIG. **35**, the cutting tool is a generally cylindrical cutting head having one or more elongate blades mounted on the outer surface of the cutting head. Such cutters are used in jointers, such as jointer **1200**, and planers. In operation, the cutting head is rotated about its cylindrical axis. When a workpiece is passed across the cutting head, the blades make wide cuts into the adjacent surface of the workpiece. As with machines using circular blades described above, machines using cylindrical cutting heads may also cause severe injury if the blades come into contact with the user's body during operation. The reaction subsystem of FIG. **35**, indicated at **24**, is designed to prevent or minimize such injury. For clarity, many of the components of safety system **18** are not shown in FIG. **35** since they are similar to the components described above in the context of other cutting machines described in the applications incorporated by reference above.

Jointer **1200** includes a generally cylindrical cutterhead **1202** mounted to rotate on an arbor **1204**. The arbor typically is mounted in one or more bearing assemblies (not shown) and rotationally driven by a motor assembly (not shown), which is coupled to the arbor either directly or by a belt-and-pulley system. The cutterhead is mounted in a main frame assembly **1206** to extend upward in the space between infeed table **1208** and outfeed table **1210**. A workpiece is cut by sliding it along infeed table **1208**, past the cutterhead and onto outfeed table **1210**. Typically, the vertical positions of the infeed and outfeed tables are independently adjustable to control the depth of cut into a workpiece and alignment with the upper surface of the cutterhead.

The cutterhead is usually constructed of metal, such as steel, and typically includes three knife blades **1212** mounted to extend above the surface of the cutterhead. It will be appreciated that fewer or more knife blades may be used and that the utility of safety system **18** is not limited by the number of blades on cutterhead **1202**. One or more electrically non-conductive bushings **1214** are placed between the cutterhead and arbor to insulate the cutterhead and blades from frame **1206**. Charge plates **44** and **46** may be placed adjacent the cutterhead to couple the signal generated by detection subsystem **22** across the cutterhead. In FIG. **35**, the charge plates (shown in dashed lines) are mounted adjacent one flat end of the cutterhead. Alternatively, the arbor may be insulated from the frame and the charge plates may be positioned around the arbor as described above in U.S. Provisional Patent Application Ser. No. 60/225,211, filed Aug. 14, 2000, entitled "Apparatus And Method For Detecting Dangerous Conditions In Power Equipment," and U.S. patent application Ser. No. 09/929,221, filed Aug. 13, 2001, entitled "Apparatus And Method For Detecting Dangerous Conditions In Power Equipment," which are incorporated herein by reference.

Due to the relatively few blades, first contact between the user's body and the cutterhead may be on one of the blades or on the surface of the cutterhead itself. However, the blades and cutterhead are electrically coupled so that any contact with the user's body is detected regardless of whether or not it occurs on the blades. Once contact is detected, the reaction system is actuated to quickly stop the rotation of cutterhead **1202** and/or disable the blades.

In the embodiment depicted in FIG. **35**, safety system **18** includes a reaction system **24** configured to cover the blades to prevent them from causing injury to the user. Specifically, the reaction system of FIG. **35** includes a flexible sheet **1220** such as plastic, rubber, metal foil, metal sheet, metal mesh, fabric, etc., configured to cover the blades. A particularly preferred material is stainless steel sheet 0.005-0.050 inches thick. Sheet **1220** includes a hook **1222** disposed at one end to engage any of the blades **1212**. The hook is preferably formed integrally with the sheet in the form of a short fold shaped to catch on a blade. Alternatively, the hook may be separate and joined to the sheet. When hook **1222** is pushed against cutterhead **1202**, the next passing blade catches the hook, causing sheet **1220** to wrap around the cutterhead as it rotates. Thus, the blades are covered by sheet **1220**, which protects the user from serious injury. Typically, the outer surface of hook **1222** is rounded or beveled to prevent injury to the user when the hook is pulled around the cutterhead.

The sheet preferably extends across the entire width of the cutterhead and is preferably longer than two-thirds of the circumference of the cutterhead to allow it to cover all three blades simultaneously. More preferably, the sheet should be longer than the circumference of the cutterhead to wrap more than once around the head. The sheet is typically formed with an inward curl. The curl reduces the tendency of the sheet to spring away from the cutter head. The free end of the sheet is stored around a spool **1224**. The spool may include a torsion spring or other device to limit the number of rotations the spool can undergo, thereby pulling the cutterhead to a stop. Alternatively, the end of material **1220** opposite the hook may be anchored to stop the cutterhead before it makes a full rotation. Additionally or alternatively, the jointer motor assembly may be shut off to stop rotation of the cutterhead.

The hook is moved into contact with the cutterhead by being mounted to the front of a drive plate **1226** or other high speed actuator assembly. The hook may be spot welded or adhesively attached to the plate, secured thereto with soft rivets, or may be provided with several holes through which protrusions on the plate can be pushed. The attachment needs to hold the hook securely during normal use, while allowing it to split away when caught by a blade. The drive plate is preferably substantially as wide as the hook to provide sufficient rigidity to insure that the entire hook engages a blade simultaneously.

FIGS. **36-38** illustrate an alternative blade covering system for a machine using a circular blade. The reaction system of FIG. **36** includes a band **1230** of flexible material that is used to wrap around the teeth of blade **40**. Band **1230** includes a loop **1232** formed at the leading end. The loop is hooked around a pair of torsion springs **1234** and held in place by a guide structure (not shown) secured to the frame of the saw.

The springs are held in a cocked position by a fast-acting release system (not shown), such as described above and in U.S. Provisional Patent Application Ser. No. 60/225,056, filed Aug. 14, 2000, entitled "Firing Subsystem For Use In A Fast-Acting Safety System," U.S. patent application Ser. No. 09/929,240, filed Aug. 13, 2001, entitled "Firing Subsystem For Use In A Fast-Acting Safety System," U.S. Provisional Patent Application Ser. No. 60/225,170, filed Aug. 14, 2000, entitled "Spring-Biased Brake Mechanism For Power Equipment," and U.S. patent application Ser. No. 09/929,227, filed Aug. 13, 2001, entitled "Spring-Biased Brake Mechanism For Power Equipment," which are incorporated herein by reference. When the springs are released, they pull loop **1232** down into a gullet **1236** of blade **40**. The gullet captures the leading edge of the loop and pulls the loop off of the springs and drags the band forward as illustrated by the dashed lines in FIG. **36**. The width of the loop forms a shock absorbing structure to absorb some of the impact of the gullet catching the loop. It is also possible to provide a compressible material at the leading end of the loop as a shock absorbing system to reduce impact loading.

The trailing section of the band is shaped to fold over the teeth of the blade, as shown in FIG. **37**. The trailing section of the band is stored on a spool **1238**. The C-shape of the band flattens out when the band is wound on the spool. The band is preferably formed of a spring-temper material to return to an unbiased C-shape when curved to match the perimeter of the blade, such as spring temper stainless steel of 0.005 to 0.050 thickness.

The leading end of the band is preferably positioned as close as possible to the location where the blade emerges from the guard or housing on the saw. This insures that the band will reach the location of the user as soon as possible to minimize injury. The motor of the saw will preferably be disengaged as soon as the reaction system is actuated. In addition, the reaction system of FIGS. **36-38** is also preferably used in connection with translation stopping systems such as described in U.S. Provisional Patent Application Ser. No. 60/225,210, filed Aug. 14, 2000, entitled "Translation Stop For Use In Power Equipment," and U.S. patent application Ser. No. 09/929,425, filed Aug. 13, 2001, entitled "Translation Stop For Use In Power Equipment," or retraction systems such as shown in U.S. Provisional Patent Application Ser. No. 60/225,089, filed Aug. 14, 2000, entitled "Retraction System For Use In Power Equipment," and U.S. patent application Ser. No. 09/929,242, filed Aug. 13, 2001, entitled "Retraction System For Use In Power Equipment," which are incorporated herein by reference, to further minimize injury.

FIG. **39** illustrates another alternative reaction system in which the cutter is obstructed upon actuation of the reaction system. In particular, a pawl **1240** is pushed into contact with the teeth of blade **40** upon actuation of the reaction system. The pawl is preferably formed from a plastic material, such as polycarbonate, that forms curls **1242** in gullets **1236** between the teeth upon being cut by the teeth. The curls block the sharp edges of the teeth to prevent the teeth from cutting into a user. The pawl may also be constructed from material softer than polycarbonate, such as ultra-high molecular weight polyethylene (UHMWPE) to reduce the braking effect on the blade as the curls are formed. The blade should preferably have gullets that are shaped with relatively parallel sides to minimize the tendency of the curls to slip out. As with the band system described above, it is preferable that the pawl be located as close as possible to where the blade emerges from the guard or housing to minimize the number of unblocked teeth to which the user is exposed. Of course, the same principle can be applied to other cutters, such as a jointer or shaper, with appropriate modification.

FIG. **40** illustrates another alternative reaction system in which the teeth on the cutter are broken or shifted. A pawl **1244** is provided to selectively engage the teeth of blade **40**. The pawl is formed of a material hard enough to dislodge or break the carbide inserts **1246** on the teeth upon contact. Suitable materials would include carbide and hardened steel. The pawl is actuated by the mechanism described above for brake pawl **60**. When actuated, the pawl shifts into the path of the teeth of the blade, as illustrated in FIG. **40**. The pawl shifts into contact with a brace structure **1248** adapted and positioned to support the pawl against the teeth. Brace structure may be in any suitable form including a pin, post, bracket, etc. In any event, the carbide inserts are shattered by the impact from striking the pawl. This reaction system is preferably used in conjunction with translation stopping systems or retraction systems, and serves primarily to generate sufficient user-to-blade clearance to give the translation or retraction system more time to operate.

FIGS. **41** and **42** illustrate another embodiment of a reaction system in which a cutting tool is wrapped with a covering. A shaper is shown at **1260** with a work surface **1262**, a fence **1264** and a cutting head **1266**. A workpiece is slid on the work surface and along the fence past the cutting tool. The cutting tool shapes the workpiece at is moves past. The safety system on shaper **1260** includes a pair of vertically spaced shafts **1268** that pivot around pin **1270**. Shafts **1268** are biased toward cutting head **1266** by spring **66**, as explained above in connection with other embodiments. A fusible member **70** restrains shafts **1268** from pivoting toward the cutting head. A covering **1272**, which takes the form of a sheet of material, is mounted between the two shafts as shown in FIG. **42**. The covering is mounted to the shafts by pockets **1274** and **1276** formed in the material. The shafts are slipped into the pockets so that the covering spans the area between the shafts. The pockets extend along the upper and lower edges of the covering on the end of the covering adjacent the shafts. The covering extends away from the shafts and is wound on a spool **1278**. When the system detects accidental contact with cutting head **1266**, as described above in connection with other embodiments, fusible member **70** is burned and shafts **1268** are released to pivot toward the cutting head because of spring **66**. When shafts **1268** move toward the cutting head, the covering contacts the cutting head and the cutting head catches on or bites into the covering and pulls the covering off of shafts **1268** and off of spindle **1278** until the covering has wrapped the cutting head. The covering can be any material sufficiently strong to absorb the sudden acceleration when caught on the cutting head, and sufficiently pliable to catch on the cutting head and wrap around it. Possible materials include Kevlar fabric, stainless steel mesh, natural or synthetic fabrics, etc. The covering may be used in connection with an internal brake to more rapidly slow the cutting head or the power to the motor may be disengaged to stop the cutting head.

The various embodiments described above for covering, blocking or disabling the cutter are particularly suitable for use on relatively light machinery, such as portable circular saws and miter saws, or on machinery with relatively heavy cutters such as jointers, shapers and planers.

Machines that include various components and features discussed above may be described as follows:

1) A cutting machine comprising a cutter; a brake adapted to stop the cutter, where the brake has an idle position and a braking position; and an actuation system adapted to selec-

tively move the brake from the idle position to the braking position, where at least a portion of the actuation system must be replaced after moving the brake from the idle position to the braking position; wherein the actuation system includes an explosive device; and/or

2) A cutting machine comprising a support structure; a cutting tool adapted to cut a workpiece, where the cutting tool is supported by the support structure; a detection system adapted to detect a dangerous condition between the cutting tool and a person; a reaction system adapted to perform a specified action upon detection of the dangerous condition; an explosive to trigger the reaction system to perform the specified action upon firing of the explosive; and a firing subsystem to fire the explosive upon detection of the dangerous condition.

It is believed that the disclosure set forth above encompasses multiple distinct inventions with independent utility. While each of these inventions has been disclosed in its preferred form, the specific embodiments thereof as disclosed and illustrated herein are not to be considered in a limiting sense as numerous variations are possible. The subject matter of the inventions includes all novel and non-obvious combinations and subcombinations of the various elements, features, functions and/or properties disclosed herein. No single feature, function, element or property of the disclosed embodiments is essential to all of the disclosed inventions. Similarly, where the claims recite "a" or "a first" element or the equivalent thereof, such claims should be understood to include incorporation of one or more such elements, neither requiring nor excluding two or more such elements.

It is believed that the following claims particularly point out certain combinations and subcombinations that are directed to one of the disclosed inventions and are novel and non-obvious. Inventions embodied in other combinations and subcombinations of features, functions, elements and/or properties may be claimed through amendment of the present claims or presentation of new claims in this or a related application. Such amended or new claims, whether they are directed to a different invention or directed to the same invention, whether different, broader, narrower or equal in scope to the original claims, are also regarded as included within the subject matter of the inventions of the present disclosure.

The invention claimed is:

1. A woodworking machine comprising:

a support frame;

a motor supported by the frame;

a cutting tool supported by the frame and moveable by the motor;

a detection system adapted to detect a dangerous condition between a person and the cutting tool;

a mechanism having a moveable component adapted to move upon detection of the dangerous condition by the detection system, where movement of the moveable component contributes to one or more of the following actions to mitigate or prevent injury to the person: deceleration of the cutting tool, and retraction of the cutting tool; and

an actuator having stored energy sufficient to move the moveable component $\frac{1}{32}^{nd}$ of an inch within approximately 3 milliseconds or less after the dangerous condition is detected.

2. The machine of claim **1**, where the actuator includes one or more springs.

3. The machine of claim **2**, where the one or more springs are adapted to apply at least 50 lbs. of force to move the moveable component.

4. The machine of claim **2**, where the one or more springs are adapted to apply at least 100 lbs. of force to move the moveable component.

5. The machine of claim **1**, where the actuator is adapted to move the moveable component at an acceleration of over 500 ft/s^2 when the detection system detects the dangerous condition.

6. The machine of claim **1**, where the actuator is adapted to move the moveable component at an acceleration of over 2000 ft/s^2 when the detection system detects the dangerous condition.

7. The machine of claim **1**, where the movement of the moveable component contributes to the deceleration of the cutting tool.

8. The machine of claim **7**, where the moveable component is a brake.

9. The machine of claim **1**, where the movement of the moveable component contributes to deceleration of the cutting tool and to retraction of the cutting tool.

10. The machine of claim **1**, where the support frame includes a table and the cutting tool comprises a blade adapted to extend at least partially above the table.

11. The machine of claim **10**, where the movement of the moveable component contributes to the retraction of the cutting tool at least partially below the table.

12. The machine of claim **1**, where the support frame includes a table and a housing, and where the moveable component is within the housing.

13. A woodworking machine comprising:

a support frame;

a motor supported by the frame;

a cutting tool supported by the frame and moveable by the motor;

a detection system adapted to detect a dangerous condition between a person and the cutting tool;

a mechanism having a moveable component adapted to move upon detection of the dangerous condition by the detection system, where movement of the moveable component contributes to the mitigation or prevention of injury to the person; and

an actuator having stored energy sufficient to move the moveable component $\frac{1}{32}^{nd}$ of an inch within approximately 3 milliseconds or less after the dangerous condition is detected at an acceleration of 500 ft/sec^2 or more.

14. The machine of claim **13**, where the actuator is adapted to move the moveable component at an acceleration of approximately 2000 ft/s^2.

15. The machine of claim **13**, where movement of the moveable component contributes to deceleration of the cutting tool.

16. A woodworking machine comprising:

a support frame;

a motor supported by the frame;

a cutting tool supported by the frame and moveable by the motor;

a detection system adapted to detect a dangerous condition between a person and the cutting tool;

a mechanism having a moveable component adapted to move upon detection of the dangerous condition by the detection system, where movement of the moveable component contributes to the mitigation or prevention of injury to the person through retraction of the cutting tool; and

an actuator having stored energy sufficient to move the moveable component 1/32nd of an inch within approximately 3 milliseconds or less after the dangerous condition is detected.

17. The machine of claim **16**, where the actuator is configured to move the moveable component at an acceleration of 500 ft/sec^2 or more.

18. The machine of claim **16**, where the cutting tool is a circular blade and where the mechanism comprises brake means for decelerating the circular blade.

* * * * *

EXHIBIT F

US008191450B2

(12) **United States Patent**
Gass

(10) **Patent No.: US 8,191,450 B2**
(45) **Date of Patent: *Jun. 5, 2012**

(54) **POWER EQUIPMENT WITH DETECTION AND REACTION SYSTEMS**

(75) Inventor: **Stephen F. Gass**, West Linn, OR (US)

(73) Assignee: **SD3, LLC**, Tualatin, OR (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

This patent is subject to a terminal disclaimer.

(21) Appl. No.: **12/806,830**

(22) Filed: **Aug. 20, 2010**

(65) **Prior Publication Data**

US 2011/0023670 A1 Feb. 3, 2011

Related U.S. Application Data

(63) Continuation of application No. 11/796,819, filed on Apr. 30, 2007, which is a continuation of application No. 09/929,426, filed on Aug. 13, 2001, now Pat. No. 7,210,383, application No. 12/806,830, which is a continuation of application No. 12/655,695, filed onJan. 4, 2010, now Pat. No. 8,006,595, which is a continuation of application No. 11/975,985, filed on Oct. 22, 2007, now Pat. No. 7,640,835, which is a continuation of application No. 09/929,221, filed on Aug. 13, 2001, now Pat. No. 7,284,467, application No. 12/806,830, which is a continuation of application

(Continued)

(51) **Int. Cl.**
B26D 5/00 (2006.01)

(52) **U.S. Cl.** ..... **83/62.1**; 83/522.12; 83/DIG. 1; 192/129 R

(58) **Field of Classification Search** ..... 83/DIG. 1, 83/58, 62, 62.1, 72, 76.7, 788, 581, 471.2, 83/477.1, 477.2, 522.12, 526, 397.1, 522.121; 144/154.5, 356, 384, 391, 427, 286.5; 29/708, 29/254, 413; 324/550, 424; 408/5; 56/10.9, 56/11.3; 192/192 A, 129 R, 130; 102/202.7; 89/1.56; 137/68.12, 72, 76; 188/5, 6, 110, 188/189; 169/57, 59, 42, DIG. 3; 74/2; 403/2, 403/28; 411/2, 39, 390; 335/1, 242, 132; 318/362; 241/32.5; 337/239, 148, 1, 5, 10, 337/17, 140, 170, 190, 237, 401, 290, 404, 337/405; 218/2, 154; 307/639, 328, 115, 307/326, 142, 117, 126, 131; 451/409; 280/806; 297/480; 187/69, 77, 89, 189, 216, 166, 72.3; 340/679, 680, 686.1, 687, 686.3, 686.6
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

146,886 A 1/1874 Doane et al.

(Continued)

FOREIGN PATENT DOCUMENTS

CA 2140991 1/1995

(Continued)

OTHER PUBLICATIONS

Sink Drain Plug Lifter, circa 1974.

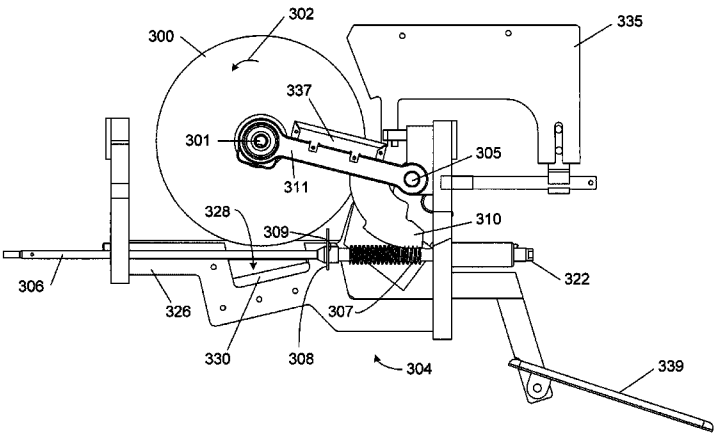
(Continued)

Primary Examiner — Jason Daniel Prone

(57) **ABSTRACT**

Woodworking machines and safety methods for use with those machines are disclosed. The machines include a detection system adapted to detect one or more dangerous conditions and a reaction system associated with the detection system. The reaction system can include an explosive to trigger the system, and also can be configured to retract a cutting tool at least partially away from a cutting region upon detection of a dangerous condition by the detection system.

11 Claims, 16 Drawing Sheets



Related U.S. Application Data

No. 12/002,388, filed on Dec. 17, 2007, now Pat. No. 8,011,279, which is a continuation of application No. 09/929,227, filed on Aug. 13, 2001, now Pat. No. 7,308,843, application No. 12/806,830, which is a continuation of application No. 11/401,050, filed on Apr. 10, 2006, now Pat. No. 7,788,999, which is a continuation of application No. 09/929,240, filed on Aug. 13, 2001, now Pat. No. 7,100,483, and a continuation of application No. 09/929,241, filed on Aug. 13, 2001, now Pat. No. 7,024,975, and a continuation of application No. 09/929,425, filed on Aug. 13, 2001, now Pat. No. 7,137,326, and a continuation of application No. 10/172,553, filed on Jun. 13, 2002, now Pat. No. 7,231,856, and a continuation of application No. 10/189,027, filed on Jul. 2, 2002, now Pat. No. 7,712,403, and a continuation of application No. 10/243,042, filed on Sep. 13, 2002, now Pat. No. 7,197,969, and a continuation of application No. 10/643,296, filed on Aug. 18, 2003, now abandoned, and a continuation of application No. 10/794,161, filed on Mar. 4, 2004, now Pat. No. 7,098,800, application No. 12/806,830, which is a continuation of application No. 12/800,607, filed on May 19, 2010, now Pat. No. 7,895,927, which is a continuation of application No. 11/542,938, filed on Oct. 2, 2006, now abandoned, which is a continuation of application No. 10/984,643, filed on Nov. 8, 2004, which is a continuation of application No. 09/929,226, filed on Aug. 13, 2001, now Pat. No. 6,920,814, and a continuation of application No. 09/929,240, and a continuation of application No. 09/929,242, filed on Aug. 13, 2001, now Pat. No. 7,509,899, and a continuation of application No. 10/051,782, filed on Jan. 15, 2002, now Pat. No. 6,877,410, and a continuation of application No. 10/052,806, filed on Jan. 16, 2002, now Pat. No. 6,880,440, and a continuation of application No. 10/205,164, filed on Jul. 25, 2002, now Pat. No. 6,945,149, and a continuation of application No. 10/202,928, filed on Jul. 25, 2002, now Pat. No. 7,000,514, and a continuation of application No. 10/785,361, filed on Feb. 23, 2004, now Pat. No. 6,997,090, which is a continuation of application No. 10/215,929, filed on Aug. 9, 2002, now abandoned, application No. 12/806,830, which is a continuation of application No. 11/542,938, which is a continuation of application No. 09/929,242, and a continuation of application No. 11/401,774, filed on Apr. 11, 2006, now Pat. No. 7,525,055, which is a continuation of application No. 11/027,322, filed on Dec. 31, 2004, now abandoned, said application No. 11/542,938 is a continuation of application No. 11/445,548, filed on Jun. 2, 2006, now Pat. No. 7,347,131, and a continuation of application No. 11/506,260, filed on Aug. 18, 2006, now Pat. No. 7,359,174, which is a continuation of application No. 10/923,282, filed on Aug. 20, 2004, now abandoned, application No. 12/806,830, which is a continuation of application No. 12/590,094, filed on Nov. 2, 2009, now Pat. No. 7,958,806, which is a continuation of application No. 09/929,236, filed on Aug. 13, 2001, now Pat. No. 7,610,836, application No. 12/806,830, which is a continuation of application No. 11/811,719, filed on Jun. 11, 2007, now Pat. No. 7,832,314, which is a continuation of application No. 11/061,162, filed on Feb. 18, 2005, now Pat. No. 7,228,772, which is a continuation of application No. 09/929,244, filed on Aug. 13, 2001, now Pat. No. 6,857,345, application No. 12/806,830, which is a continuation of application No. 12/587,695, filed on Oct. 9, 2009, now Pat. No. 7,921,754, which is a continuation of application No. 09/929,237, filed on Aug. 13, 2001, now Pat. No. 7,600,455, application No. 12/806,830, which is a continuation of application No. 12/661,766, filed on Mar. 22, 2010, now Pat. No. 8,051,759, which is a continuation of application No. 11/810,196, filed on Jun. 4, 2007, now Pat. No. 7,681,479, which is a continuation of application No. 09/929,234, filed on Aug. 13, 2001, now Pat. No. 7,225,712, application No. 12/806,830, which is a continuation of application No. 12/655,694, filed on Jan. 4, 2010, now Pat. No. 7,908,950, which is a continuation of application No. 12/079,836, filed on Mar. 27, 2008, now Pat. No. 7,640,837, which is a continuation of application No. 09/929,235, filed on Aug. 13, 2001, now Pat. No. 7,350,444, application No. 12/806,830, which is a continuation of application No. 12/799,211, filed on Apr. 19, 2010, which is a continuation of application No. 12/220,946, filed on Jul. 29, 2008, now Pat. No. 7,698,976, which is a continuation of application No. 09/929,238, filed on Aug. 13, 2001, now abandoned, application No. 12/806,830, which is a continuation of application No. 12/590,924, filed on Nov. 16, 2009, which is a continuation of application No. 12/154,675, filed on May 23, 2008, now Pat. No. 7,617,752, which is a continuation of application No. 10/053,390, filed on Jan. 16, 2002, now Pat. No. 7,377,199, which is a continuation-in-part of application No. 09/676,190, filed on Sep. 29, 2000, now Pat. No. 7,055,417, application No. 12/806,830, which is a continuation of application No. 12/313,162, filed on Nov. 17, 2008, now Pat. No. 7,789,002, which is a continuation of application No. 11/348,580, filed on Feb. 6, 2006, now abandoned, which is a continuation of application No. 10/052,705, filed on Jan. 16, 2002, now Pat. No. 6,994,004, said application No. 12/313,162 is a continuation of application No. 11/098,984, filed on Apr. 4, 2005, now Pat. No. 7,353,737, which is a continuation of application No. 09/929,238, and a continuation of application No. 10/047,066, filed on Jan. 14, 2002, now Pat. No. 6,945,148, and a continuation of application No. 10/051,782, application No. 12/806,830, which is a continuation of application No. 12/661,993, filed on Mar. 26, 2010, which is a continuation of application No. 11/982,972, filed on Nov. 5, 2007, now Pat. No. 7,685,912, which is a continuation of application No. 10/932,339, filed on Sep. 1, 2004, now Pat. No. 7,290,472, which is a continuation of application No. 10/047,066, and a continuation of application No. 10/050,085, filed on Jan. 14, 2002, now abandoned, application No. 12/806,830, which is a continuation of application No. 10/100,211, filed on Mar. 13, 2002, and a continuation of application No. 11/256,757, filed on Oct. 24, 2005, which is a continuation of application No. 09/955,418, filed on Sep. 17, 2001, now Pat. No. 6,957,601, application No. 12/806,830, which is a continuation of application No. 10/146,527, filed on May 15, 2002, and a continuation of application No. 12/586,469, filed on Sep. 21, 2009, which is a continuation of application No. 11/702,330, filed on Feb. 5, 2007, now Pat. No. 7,591,210, which is a continuation of application No. 10/189,031, filed on Jul. 2, 2002, now Pat. No. 7,171,879, application No. 12/806,830, which is a continuation of application No. 11/208,214, filed on Aug. 19, 2005, now Pat. No. 7,784,507, which is a continuation of application No. 10/251,

576, filed on Sep. 20, 2002, now abandoned, which is a continuation of application No. 10/197,975, filed on Jul. 18, 2002, now abandoned, said application No. 11/208,214 is a continuation of application No. 09/676,190, application No. 12/806,830, which is a continuation of application No. 12/231,080, filed on Aug. 29, 2008, now Pat. No. 7,900,541, which is a continuation of application No. 11/487,717, filed on Jul. 17, 2006, now Pat. No. 7,421,315, which is a continuation of application No. 10/292,607, filed on Nov. 12, 2002, now Pat. No. 7,077,039, application No. 12/806,830, which is a continuation of application No. 12/655,962, filed on Jan. 11, 2010, now abandoned, which is a continuation of application No. 12/313,277, filed on Nov. 17, 2008, now Pat. No. 7,644,645, which is a continuation of application No. 10/345,630, filed on Jan. 15, 2003, application No. 12/806,830, which is a continuation of application No. 12/658,759, filed on Feb. 12, 2010, now abandoned, which is a continuation of application No. 11/787,471, filed on Apr. 17, 2007, now Pat. No. 7,661,343, which is a continuation of application No. 10/341,260, filed on Jan. 13, 2003, now abandoned, application No. 12/806,830, which is a continuation of application No. 11/647,676, filed on Dec. 29, 2006, now Pat. No. 7,836,804, which is a continuation of application No. 10/923,290, filed on Aug. 20, 2004, now Pat. No. 7,472,634, application No. 12/806,830, which is a continuation of application No. 12/079,820, filed on Mar. 27, 2008, now Pat. No. 7,845,258, which is a continuation of application No. 10/923,273, filed on Aug. 20, 2004, now Pat. No. 7,350,445, application No. 12/806,830, which is a continuation of application No. 12/454,569, filed on May 18, 2009, which is a continuation of application No. 11/027,600, filed on Dec. 31, 2004, now Pat. No. 7,536,238, application No. 12/806,830, which is a continuation of application No. 12/799,915, filed on May 3, 2010, which is a continuation of application No. 12/322,069, filed on Jan. 26, 2009, now Pat. No. 7,707,918, which is a continuation of application No. 11/107,499, filed on Apr. 15, 2005, now Pat. No. 7,481,140, application No. 12/806,830, which is a continuation of application No. 12/077,576, filed on Mar. 19, 2008, now abandoned, which is a continuation of application No. 11/027,254, filed on Dec. 31, 2004, now abandoned, application No. 12/806,830, which is a continuation of application No. 12/799,920, filed on May 3, 2010, which is a continuation of application No. 11/026,114, filed on Dec. 31, 2004, now Pat. No. 7,707,920, application No. 12/806,830, which is a continuation of application No. 11/026,006, filed on Dec. 31, 2004, and a continuation of application No. 11/045,972, filed on Jan. 28, 2005, now Pat. No. 7,827,890, and a continuation of application No. 12/454,730, filed on May 20, 2009, which is a continuation of application No. 11/395,502, filed on Mar. 31, 2006.

(60) Provisional application No. 60/225,200, filed on Aug. 14, 2000, provisional application No. 60/225,211, filed on Aug. 14, 2000, provisional application No. 60/225,170, filed on Aug. 14, 2000, provisional application No. 60/225,056, filed on Aug. 14, 2000, provisional application No. 60/225,169, filed on Aug. 14, 2000, provisional application No. 60/225,210, filed on Aug. 14, 2000, provisional application No. 60/298,207, filed on Jun. 13, 2001, provisional application No. 60/302,916, filed on Jul. 3, 2001, provisional application No. 60/324,729, filed on Sep. 24, 2001, provisional application No. 60/406,138, filed on Aug. 27, 2002, provisional application No. 60/452,159, filed on Mar. 5, 2003, provisional application No. 60/225,206, filed on Aug. 14, 2000, provisional application No. 60/225,089, filed on Aug. 14, 2000, provisional application No. 60/279,313, filed on Mar. 27, 2001, provisional application No. 60/270,942, filed on Feb. 22, 2001, provisional application No. 60/307,756, filed on Jul. 25, 2001, provisional application No. 60/308,492, filed on Jul. 27, 2001, provisional application No. 60/312,141, filed on Aug. 13, 2001, provisional application No. 60/533,598, filed on Dec. 31, 2003, provisional application No. 60/496,568, filed on Aug. 20, 2003, provisional application No. 60/225,201, filed on Aug. 14, 2000, provisional application No. 60/225,212, filed on Aug. 14, 2000, provisional application No. 60/225,059, filed on Aug. 14, 2000, provisional application No. 60/225,094, filed on Aug. 14, 2000, provisional application No. 60/225,058, filed on Aug. 14, 2000, provisional application No. 60/225,057, filed on Aug. 14, 2000, provisional application No. 60/270,011, filed on Feb. 20, 2001, provisional application No. 60/270,941, filed on Feb. 22, 2001, provisional application No. 60/270,942, filed on Feb. 22, 2001, provisional application No. 60/273,177, filed on Mar. 2, 2001, provisional application No. 60/273,178, filed on Mar. 2, 2001, provisional application No. 60/667,485, filed on Mar. 31, 2005, provisional application No. 60/273,902, filed on Mar. 6, 2001, provisional application No. 60/275,583, filed on Mar. 13, 2001, provisional application No. 60/233,459, filed on Sep. 18, 2000, provisional application No. 60/275,594, filed on Mar. 13, 2001, provisional application No. 60/275,595, filed on Mar. 13, 2001, provisional application No. 60/292,081, filed on May 17, 2001, provisional application No. 60/292,100, filed on May 17, 2001, provisional application No. 60/298,207, filed on Jun. 13, 2001, provisional application No. 60/302,937, filed on Jul. 2, 2001, provisional application No. 60/306,202, filed on Jul. 18, 2001, provisional application No. 60/323,975, filed on Sep. 21, 2001, provisional application No. 60/157,340, filed on Oct. 1, 1999, provisional application No. 60/182,866, filed on Feb. 16, 2000, provisional application No. 60/335,970, filed on Nov. 13, 2001, provisional application No. 60/349,989, filed on Jan. 16, 2002, provisional application No. 60/351,797, filed on Jan. 25, 2002, provisional application No. 60/496,550, filed on Aug. 20, 2003, provisional application No. 60/496,574, filed on Aug. 20, 2003, provisional application No. 60/533,791, filed on Dec. 31, 2003, provisional application No. 60/533,852, filed on Dec. 31, 2003, provisional application No. 60/533,811, filed on Dec. 31, 2003, provisional application No. 60/533,575, filed on Dec. 31, 2003, provisional application No. 60/540,377, filed on Jan. 29, 2004, provisional application No. 60/667,485, filed on Mar. 31, 2005.

(56) **References Cited**

U.S. PATENT DOCUMENTS

162,814	A	5/1875	Graves et al.
261,090	A	7/1882	Grill
264,412	A	9/1882	Kuhlmann
299,480	A	5/1884	Kuhlman et al.
302,041	A	7/1884	Sill

307,112	A	10/1884	Groff
509,253	A	11/1893	Shields
545,504	A	9/1895	Hoover
869,513	A	10/1907	Pfeil
941,726	A	11/1909	Pfalzgraf
982,312	A	1/1911	Swafford
997,720	A	7/1911	Troupenat
1,037,843	A	9/1912	Ackley
1,050,649	A	1/1913	Harrold et al.
1,054,558	A	2/1913	Jones
1,074,198	A	9/1913	Phillips
1,082,870	A	12/1913	Humason
1,101,515	A	6/1914	Adam
1,126,970	A	2/1915	Folmer
1,132,129	A	3/1915	Stevens
1,148,169	A	7/1915	Howe
1,154,209	A	9/1915	Rushton
1,205,246	A	11/1916	Mowry
1,228,047	A	5/1917	Reinhold
1,240,430	A	9/1917	Erickson
1,244,187	A	10/1917	Frisbie
1,255,886	A	2/1918	Jones
1,258,961	A	3/1918	Tattersall
1,311,508	A	7/1919	Harrold
1,324,136	A	12/1919	Turner
1,381,612	A	6/1921	Anderson
1,397,606	A	11/1921	Smith
RE15,262	A	1/1922	Gurgel
1,427,005	A	8/1922	McMichael
1,430,983	A	10/1922	Granberg
1,450,906	A	4/1923	Anderson
1,464,924	A	8/1923	Drummond
1,465,224	A	8/1923	Lantz
1,492,145	A	4/1924	Talley
1,496,212	A	6/1924	French
1,511,797	A	10/1924	Berghold
1,526,128	A	2/1925	Flohr
1,527,587	A	2/1925	Hutchinson
1,551,900	A	9/1925	Morrow
1,553,996	A	9/1925	Federer
1,582,483	A	4/1926	Runyan
1,584,086	A	5/1926	Fonda
1,590,988	A	6/1926	Campbell
1,600,604	A	6/1926	Sorlien
1,616,478	A	2/1927	Watson
1,640,517	A	8/1927	Procknow
1,662,372	A	3/1928	Ward
1,668,061	A	5/1928	Falkins
1,701,948	A	2/1929	Crowe
1,711,490	A	5/1929	Dummond
1,712,828	A	5/1929	Klehm
1,774,521	A	9/1930	Neighbour
1,807,120	A	5/1931	Lewis
1,811,066	A	6/1931	Tannewitz
1,879,280	A	9/1932	James
1,896,924	A	2/1933	Ulrich
1,902,270	A	3/1933	Tate
1,904,005	A	4/1933	Masset
1,910,651	A	5/1933	Tautz
1,938,548	A	12/1933	Tautz
1,938,549	A	12/1933	Tautz
1,963,688	A	6/1934	Tautz
1,988,102	A	1/1935	Woodward
1,993,219	A	3/1935	Merrigan
2,007,887	A	7/1935	Tautz
2,010,851	A	8/1935	Dummond
2,020,222	A	11/1935	Tautz
2,038,810	A	4/1936	Tautz
2,044,481	A	6/1936	Manley et al.
2,075,282	A	3/1937	Hedgpeth
2,095,330	A	10/1937	Hedgpeth
2,106,288	A	1/1938	Tautz
2,106,321	A	1/1938	Guertin
2,121,069	A	6/1938	Collins
2,131,492	A	9/1938	Ocenasek
2,163,320	A	6/1939	Hammond
2,168,282	A	8/1939	Tautz
2,241,556	A	5/1941	MacMillin et al.
2,261,696	A	11/1941	Ocenasek
2,265,407	A	12/1941	Tautz
2,286,589	A	6/1942	Tannewitz
2,292,872	A	8/1942	Eastman
2,299,262	A	10/1942	Uremovich
2,312,118	A	2/1943	Neisewander
2,313,686	A	3/1943	Uremovich
2,328,244	A	8/1943	Woodward
2,352,235	A	6/1944	Tautz
2,377,265	A	3/1945	Rady
2,392,486	A	1/1946	Larsen
2,402,232	A	6/1946	Baker
2,425,331	A	8/1947	Kramer
2,434,174	A	1/1948	Morgan
2,452,589	A	11/1948	McWhirter et al.
2,466,325	A	4/1949	Ocenasek
2,496,613	A	2/1950	Wooward
2,501,134	A	3/1950	Meckoski et al.
2,509,813	A	5/1950	Dineen
2,517,649	A	8/1950	Frechtmann
2,518,684	A	8/1950	Harris
2,530,290	A	11/1950	Collins
2,554,124	A	5/1951	Salmont
2,562,396	A	7/1951	Schutz
2,572,326	A	10/1951	Evans
2,590,035	A	3/1952	Pollak
2,593,596	A	4/1952	Olson
2,601,878	A	7/1952	Anderson
2,623,555	A	12/1952	Eschenburg
2,625,966	A	1/1953	Copp
2,626,639	A	1/1953	Hess
2,661,777	A	12/1953	Hitchcock
2,661,780	A	12/1953	Morgan
2,675,707	A	4/1954	Brown
2,678,071	A	5/1954	Odlum et al.
2,690,084	A	9/1954	Van Dam
2,695,638	A	11/1954	Gaskell
2,704,560	A	3/1955	Woessner
2,711,762	A	6/1955	Gaskell
2,719,547	A	10/1955	Gjerde
2,722,246	A	11/1955	Arnoldy
2,731,049	A	1/1956	Akin
2,736,348	A	2/1956	Nelson
2,737,213	A	3/1956	Richards et al.
2,758,615	A	8/1956	Mastriforte
2,785,710	A	3/1957	Mowery, Jr.
2,786,496	A	3/1957	Eschenburg
2,804,890	A	9/1957	Fink
2,810,408	A	10/1957	Boice et al.
2,839,943	A	6/1958	Caldwell et al.
2,844,173	A	7/1958	Gaskell
2,850,054	A	9/1958	Eschenburg
2,852,047	A	9/1958	Odlum et al.
2,873,773	A	2/1959	Gaskell
2,876,809	A	3/1959	Rentsch et al.
2,883,486	A	4/1959	Mason
2,894,546	A	7/1959	Eschenburg
2,913,025	A	11/1959	Richards
2,913,581	A	11/1959	Simonton et al.
2,937,672	A	5/1960	Gjerde
2,945,516	A	7/1960	Edgemond, Jr. et al.
2,954,118	A	9/1960	Anderson
2,957,166	A	10/1960	Gluck
2,978,084	A	4/1961	Vilkaitis
2,984,268	A	5/1961	Vuichard
2,991,593	A	7/1961	Cohen
3,005,477	A	10/1961	Sherwen
3,007,501	A	11/1961	Mundell et al.
3,011,529	A	12/1961	Copp
3,011,610	A	12/1961	Stiebel et al.
3,013,592	A	12/1961	Ambrosio et al.
3,021,881	A	2/1962	Edgemond, Jr. et al.
3,035,995	A	5/1962	Seeley et al.
3,085,602	A	4/1963	Gaskell
3,105,530	A	10/1963	Peterson
3,129,731	A	4/1964	Tyrrell
3,163,732	A	12/1964	Abbott
3,184,001	A	5/1965	Reinsch et al.
3,186,256	A	6/1965	Reznick
3,207,273	A	9/1965	Jurin

3,213,731	A		10/1965	Renard				
3,224,474	A		12/1965	Bloom				
3,232,326	A		2/1966	Speer et al.				
3,246,205	A		4/1966	Miller				
3,249,134	A		5/1966	Vogl et al.				
3,274,876	A		9/1966	Debus				
3,276,497	A		10/1966	Heer				
3,280,861	A		10/1966	Gjerde				
3,306,149	A		2/1967	John				
3,313,185	A		4/1967	Drake et al.				
3,315,715	A		4/1967	Mytinger				
3,323,814	A		6/1967	Phillips				
3,337,008	A		8/1967	Trachte				
3,356,111	A		12/1967	Mitchell				
3,368,596	A		2/1968	Comer				
3,386,322	A		6/1968	Stone et al.				
3,439,183	A		4/1969	Hurst, Jr.				
3,445,835	A		5/1969	Fudaley				
3,454,286	A		7/1969	Anderson et al.				
3,456,696	A		7/1969	Gregory et al.				
3,512,440	A		5/1970	Frydmann				
3,538,964	A		11/1970	Warrick et al.				
3,540,338	A		11/1970	McEwan et al.				
3,547,232	A	*	12/1970	Fergie	188/110			
3,554,067	A		1/1971	Scutella				
3,566,934	A		3/1971	Thrasher				
3,566,996	A		3/1971	Crossman				
3,580,376	A		5/1971	Loshbough				
3,581,784	A		6/1971	Warrick				
3,593,266	A		7/1971	Van Sickle				
3,613,748	A		10/1971	De Pue				
3,621,894	A		11/1971	Niksich				
3,648,126	A		3/1972	Boos et al.				
3,670,788	A		6/1972	Pollak et al.				
3,675,444	A		7/1972	Whipple				
3,680,609	A		8/1972	Menge				
3,688,815	A		9/1972	Ridenour				
3,695,116	A		10/1972	Baur				
3,696,844	A		10/1972	Bernatschek				
3,716,113	A		2/1973	Kobayashi et al.				
3,719,103	A		3/1973	Streander				
3,740,000	A		6/1973	Takada				
3,745,546	A		7/1973	Struger et al.				
3,749,933	A		7/1973	Davidson				
3,754,493	A		8/1973	Niehaus et al.				
3,772,590	A		11/1973	Mikulecky et al.				
3,785,230	A	*	1/1974	Lokey	83/58			
3,793,915	A		2/1974	Huier				
3,805,639	A		4/1974	Peter				
3,805,658	A		4/1974	Scott et al.				
3,808,932	A		5/1974	Russell				
3,829,850	A		8/1974	Guetersloh				
3,829,970	A		8/1974	Anderson				
3,858,095	A	*	12/1974	Friemann et al.	192/129 A			
3,861,016	A		1/1975	Johnson et al.				
3,863,208	A		1/1975	Balban				
3,874,747	A		4/1975	Case et al.				
3,880,032	A		4/1975	Green				
3,882,744	A		5/1975	McCarroll				
3,886,413	A		5/1975	Dow et al.				
3,889,567	A		6/1975	Sato et al.				
3,905,263	A		9/1975	Smith				
3,922,785	A		12/1975	Fushiya				
3,924,688	A		12/1975	Cooper et al.				
3,931,727	A		1/1976	Luenser				
3,935,777	A		2/1976	Bassett				
3,942,607	A		3/1976	Sobat				
3,945,286	A		3/1976	Smith				
3,946,631	A		3/1976	Malm				
3,947,734	A		3/1976	Flyer				
3,949,636	A		4/1976	Ball et al.				
3,953,770	A	*	4/1976	Hayashi	192/130			
3,960,310	A		6/1976	Nussbaum				
3,967,161	A		6/1976	Lichtblau				
3,974,565	A		8/1976	Ellis				
3,975,600	A		8/1976	Marston				
3,978,624	A		9/1976	Merkel et al.				
3,994,192	A		11/1976	Faig				
4,007,679	A		2/1977	Edwards				
4,016,490	A		4/1977	Weckenmann et al.				
4,026,174	A		5/1977	Fierro				
4,026,177	A		5/1977	Lokey				
4,029,159	A		6/1977	Nymann				
4,047,156	A		9/1977	Atkins				
4,048,886	A	*	9/1977	Zettler	83/58			
4,060,160	A		11/1977	Lieber				
4,063,777	A		12/1977	Takada				
4,070,940	A		1/1978	McDaniel et al.				
4,075,961	A		2/1978	Harris				
4,077,161	A		3/1978	Wyle et al.				
4,085,303	A		4/1978	McIntyre et al.				
4,090,345	A		5/1978	Harkness				
4,091,698	A		5/1978	Obear et al.				
4,106,378	A		8/1978	Kaiser				
4,117,752	A	*	10/1978	Yoneda	83/58			
4,145,940	A		3/1979	Woloveke et al.				
4,152,833	A		5/1979	Phillips				
4,161,649	A		7/1979	Klos et al.				
4,175,452	A		11/1979	Idel				
4,184,394	A		1/1980	Gjerde				
4,190,000	A		2/1980	Shaull et al.				
4,195,722	A		4/1980	Anderson et al.				
4,199,930	A		4/1980	Lebet et al.				
4,200,002	A		4/1980	Takahashi				
4,206,666	A		6/1980	Ashton				
4,206,910	A		6/1980	Biesemeyer				
4,249,117	A		2/1981	Leukhardt et al.				
4,249,442	A		2/1981	Fittery				
4,251,599	A		2/1981	McCormick				
4,255,995	A		3/1981	Connor				
4,262,278	A		4/1981	Howard et al.				
4,267,914	A		5/1981	Saar				
4,270,427	A		6/1981	Colberg et al.				
4,276,459	A		6/1981	Willett et al.				
4,276,799	A		7/1981	Muehling				
4,291,794	A		9/1981	Bauer				
4,305,442	A		12/1981	Currie				
4,319,146	A		3/1982	Wires, Sr.				
4,321,841	A		3/1982	Felix				
4,334,450	A		6/1982	Benuzzi				
4,351,423	A		9/1982	Rogier				
4,372,202	A		2/1983	Cameron				
4,372,427	A		2/1983	Rogier				
4,374,552	A		2/1983	Dayen				
4,385,539	A		5/1983	Meyerhoefer et al.				
4,391,358	A		7/1983	Haeger				
4,418,597	A		12/1983	Krusemark et al.				
4,427,042	A		1/1984	Mitchell et al.				
4,453,112	A		6/1984	Sauer et al.				
4,466,170	A		8/1984	Davis				
4,466,233	A		8/1984	Thesman				
4,470,046	A	*	9/1984	Betsill	700/117			
4,492,291	A		1/1985	Chometon et al.				
4,503,739	A		3/1985	Konieczka				
4,510,489	A		4/1985	Anderson, III et al.				
4,512,224	A		4/1985	Terauchi				
4,518,043	A		5/1985	Anderson et al.				
4,528,488	A	*	7/1985	Susemihl	83/DIG. 1			
4,532,501	A		7/1985	Hoffman				
4,532,844	A		8/1985	Chang et al.				
4,557,168	A		12/1985	Tokiwa				
4,559,858	A		12/1985	Laskowski et al.				
4,560,033	A		12/1985	DeWoody et al.				
4,566,512	A		1/1986	Wilson				
4,573,556	A		3/1986	Andreasson				
4,576,073	A		3/1986	Stinson				
4,589,047	A		5/1986	Gaus et al.				
4,589,860	A		5/1986	Brandenstein et al.				
4,599,597	A		7/1986	Rotbart				
4,599,927	A		7/1986	Eccardt et al.				
4,606,251	A		8/1986	Boileau				
4,615,247	A		10/1986	Berkeley				
4,621,300	A		11/1986	Summerer				
4,625,604	A		12/1986	Handler et al.				
4,637,188	A		1/1987	Crothers				
4,637,289	A		1/1987	Ramsden				
4,644,832	A		2/1987	Smith				
4,653,189	A	*	3/1987	Andreasson	83/DIG. 1			

4,657,428	A		4/1987	Wiley			
4,661,797	A		4/1987	Schmall			
4,672,500	A		6/1987	Tholome et al.			
4,675,664	A		6/1987	Cloutier et al.			
4,679,719	A		7/1987	Kramer			
4,694,721	A		9/1987	Brickner, Jr.			
4,718,229	A		1/1988	Riley			
4,721,023	A		1/1988	Bartlett et al.			
4,722,021	A		1/1988	Hornung et al.			
4,751,603	A		6/1988	Kwan			
4,756,220	A		7/1988	Olsen et al.			
4,757,881	A		7/1988	Jonsson et al.			
4,774,866	A		10/1988	Dehari et al.			
4,792,965	A		12/1988	Morgan			
4,805,504	A		2/1989	Fushiya et al.			
4,805,505	A		2/1989	Cantlin			
4,831,279	A		5/1989	Ingraham			
4,840,135	A		6/1989	Yamauchi			
4,845,476	A		7/1989	Rangeard et al.			
4,864,455	A		9/1989	Shimomura et al.			
4,875,398	A		10/1989	Taylor et al.			
4,888,869	A		12/1989	Leatherman			
4,896,607	A		1/1990	Hall et al.			
4,906,962	A		3/1990	Duimstra			
4,907,679	A		3/1990	Menke			
4,934,233	A		6/1990	Brundage et al.			
4,936,876	A		6/1990	Reyes			
4,937,554	A		6/1990	Herman			
4,962,685	A		10/1990	Hagstrom			
4,964,450	A		10/1990	Hughes et al.			
4,965,909	A		10/1990	McCullough et al.			
4,969,063	A		11/1990	Scott et al.			
4,975,798	A		12/1990	Edwards et al.			
5,020,406	A		6/1991	Sasaki et al.			
5,025,175	A		6/1991	Dubois, III			
5,042,348	A		8/1991	Brundage et al.			
5,046,426	A		9/1991	Julien et al.			
5,052,255	A		10/1991	Gaines			
5,074,047	A		12/1991	King			
5,081,406	A	*	1/1992	Hughes et al.	318/478		
5,082,316	A		1/1992	Wardlaw			
5,083,973	A		1/1992	Townsend			
5,086,890	A		2/1992	Turczyn et al.			
5,094,000	A		3/1992	Becht et al.			
5,116,249	A		5/1992	Shiotani et al.			
5,119,555	A		6/1992	Johnson			
5,122,091	A		6/1992	Townsend			
5,123,317	A		6/1992	Barnes, Jr. et al.			
5,146,714	A		9/1992	Liiber			
5,148,053	A	*	9/1992	Dubois, III	83/DIG. 1		
5,156,508	A		10/1992	Grisley			
5,174,349	A		12/1992	Svetlik et al.			
5,184,534	A		2/1993	Lee			
5,198,702	A		3/1993	McCullough et al.			
5,199,343	A		4/1993	OBanion			
5,201,110	A		4/1993	Bane			
5,201,684	A		4/1993	DeBois, III			
5,201,863	A		4/1993	Peot			
5,206,625	A		4/1993	Davis			
5,207,253	A		5/1993	Hoshino et al.			
5,212,621	A		5/1993	Panter			
5,218,189	A		6/1993	Hutchison			
5,230,269	A		7/1993	Shiotani et al.			
5,231,359	A		7/1993	Masuda et al.			
5,231,906	A		8/1993	Kogej			
5,239,978	A		8/1993	Plangetis			
5,245,879	A		9/1993	McKeon			
5,257,570	A		11/1993	Shiotani et al.			
5,265,510	A		11/1993	Hoyer-Ellefsen			
5,272,946	A		12/1993	McCullough et al.			
5,276,431	A		1/1994	Piccoli et al.			
5,285,708	A		2/1994	Bosten et al.			
5,293,802	A		3/1994	Shiotani et al.			
5,320,382	A		6/1994	Goldstein et al.			
5,321,230	A		6/1994	Shanklin et al.			
5,331,875	A		7/1994	Mayfield			
5,353,670	A		10/1994	Metzger, Jr.			
5,377,554	A		1/1995	Reulein et al.			
5,377,571	A		1/1995	Josephs			
5,392,568	A		2/1995	Howard, Jr. et al.			
5,392,678	A		2/1995	Sasaki et al.			
5,401,928	A		3/1995	Kelley			
5,411,221	A		5/1995	Collins et al.			
5,423,232	A		6/1995	Miller et al.			
5,436,613	A		7/1995	Ghosh et al.			
5,447,085	A		9/1995	Gochnauer			
5,451,750	A		9/1995	An			
5,453,903	A		9/1995	Chow			
5,471,888	A		12/1995	McCormick			
5,480,009	A		1/1996	Wieland et al.			
5,503,059	A		4/1996	Pacholok			
5,510,587	A		4/1996	Reiter			
5,510,685	A		4/1996	Grasselli			
5,513,548	A		5/1996	Garuglieri			
5,531,147	A		7/1996	Serban			
5,534,836	A		7/1996	Schenkel et al.			
5,572,916	A		11/1996	Takano			
5,587,618	A		12/1996	Hathaway			
5,592,353	A		1/1997	Shinohara et al.			
5,606,889	A		3/1997	Bielinski et al.			
5,619,896	A		4/1997	Chen			
5,623,860	A		4/1997	Schoene et al.			
5,647,258	A		7/1997	Brazell et al.			
5,648,644	A		7/1997	Nagel			
5,659,454	A		8/1997	Vermesse			
5,667,152	A		9/1997	Mooring			
5,671,633	A		9/1997	Wagner			
5,695,306	A		12/1997	Nygren, Jr.			
5,700,165	A		12/1997	Harris et al.			
5,720,213	A		2/1998	Sberveglieri			
5,722,308	A		3/1998	Ceroll et al.			
5,724,875	A		3/1998	Meredith et al.			
5,730,165	A		3/1998	Philipp			
5,741,048	A		4/1998	Eccleston			
5,755,148	A		5/1998	Stumpf et al.			
5,768,786	A		6/1998	Kane et al.			
5,771,742	A		6/1998	Bokaie et al.			
5,782,001	A		7/1998	Gray			
5,787,779	A		8/1998	Garuglieri			
5,791,057	A		8/1998	Nakamura et al.			
5,791,223	A		8/1998	Lanzer			
5,791,224	A		8/1998	Suzuki et al.			
5,791,441	A		8/1998	Matos et al.			
5,797,307	A		8/1998	Horton			
5,819,619	A		10/1998	Miller et al.			
5,819,625	A		10/1998	Sberveglieri			
5,852,951	A		12/1998	Santi			
5,857,507	A		1/1999	Puzio et al.			
5,861,809	A		1/1999	Eckstein et al.			
5,875,698	A		3/1999	Ceroll et al.			
5,880,954	A		3/1999	Thomson et al.			
5,921,367	A		7/1999	Kashioka et al.			
5,927,857	A		7/1999	Ceroll et al.			
5,930,096	A		7/1999	Kim			
5,937,720	A		8/1999	Itzov			
5,942,975	A	*	8/1999	Sorensen	318/478		
5,943,932	A		8/1999	Sberveglieri			
5,950,514	A		9/1999	Benedict et al.			
5,963,173	A		10/1999	Lian et al.			
5,974,927	A		11/1999	Tsune			
5,989,116	A		11/1999	Johnson et al.			
6,009,782	A		1/2000	Tajima et al.			
6,018,284	A		1/2000	Rival et al.			
6,037,729	A		3/2000	Woods et al.			
D422,290	S		4/2000	Welsh et al.			
6,050,174	A		4/2000	Schonlau et al.			
6,052,884	A		4/2000	Steckler et al.			
6,062,121	A		5/2000	Ceroll et al.			
6,070,484	A		6/2000	Sakamaki			
6,095,092	A		8/2000	Chou			
6,109,157	A		8/2000	Talesky			
6,112,785	A		9/2000	Yu			
6,119,984	A		9/2000	Devine			
6,131,629	A		10/2000	Puzio et al.			
6,133,818	A		10/2000	Shieh et al.			
6,141,192	A		10/2000	Garzon			
6,148,504	A		11/2000	Schmidt et al.			
6,148,526	A		11/2000	Kirn et al.			

6,148,703	A	11/2000	Ceroll et al.	
6,150,826	A	11/2000	Hokodate et al.	
6,161,459	A	12/2000	Ceroll et al.	
6,170,370	B1	1/2001	Sommerville	
6,244,149	B1	6/2001	Ceroll et al.	
6,250,190	B1	6/2001	Ceroll et al.	
6,257,061	B1	7/2001	Nonoyama et al.	
6,283,002	B1	9/2001	Chiang	
6,295,910	B1	10/2001	Childs et al.	
6,312,028	B1	11/2001	Wilkosz	
6,325,195	B1	12/2001	Doherty	
6,330,848	B1	12/2001	Nishio et al.	
6,336,273	B1	1/2002	Nilsson et al.	
6,352,137	B1	3/2002	Stegall et al.	
6,357,328	B1	3/2002	Ceroll et al.	
6,361,092	B1	3/2002	Eagle et al.	
6,366,099	B1 *	4/2002	Reddi	324/678
6,376,939	B1	4/2002	Suzuki et al.	
6,404,098	B1	6/2002	Kayama et al.	
6,405,624	B2	6/2002	Sutton	
6,418,829	B1	7/2002	Pilchowski	
6,420,814	B1	7/2002	Bobbio	
6,427,570	B1	8/2002	Miller et al.	
6,430,007	B1	8/2002	Jabbari	
6,431,425	B1	8/2002	Moorman et al.	
6,450,077	B1	9/2002	Ceroll et al.	
6,453,786	B1	9/2002	Ceroll et al.	
6,460,442	B2	10/2002	Talesky et al.	
6,471,106	B1	10/2002	Reining	
6,479,958	B1	11/2002	Thompson et al.	
6,484,614	B1	11/2002	Huang	
D466,913	S	12/2002	Ceroll et al.	
6,492,802	B1	12/2002	Bielski	
D469,354	S	1/2003	Curtsinger	
6,502,493	B1	1/2003	Eccardt et al.	
6,530,303	B1	3/2003	Parks et al.	
6,536,536	B1	3/2003	Gass et al.	
6,543,324	B2	4/2003	Dils	
6,546,835	B2	4/2003	Wang	
6,564,909	B1	5/2003	Razzano	
6,575,067	B2	6/2003	Parks et al.	
6,578,460	B2	6/2003	Sartori	
6,578,856	B2	6/2003	Kahle	
6,581,655	B2	6/2003	Huang	
6,595,096	B2	7/2003	Ceroll et al.	
D478,917	S	8/2003	Ceroll et al.	
6,601,493	B1	8/2003	Crofutt	
6,607,015	B1	8/2003	Chen	
D479,538	S	9/2003	Welsh et al.	
6,617,720	B1	9/2003	Egan, III et al.	
6,619,348	B2	9/2003	Wang	
6,640,683	B2	11/2003	Lee	
6,644,157	B2	11/2003	Huang	
6,647,847	B2	11/2003	Hewitt et al.	
6,659,233	B2	12/2003	DeVlieg	
6,684,750	B2	2/2004	Yu	
6,722,242	B2	4/2004	Chuang	
6,734,581	B1	5/2004	Griffis	
6,736,042	B2	5/2004	Behne et al.	
6,742,430	B2	6/2004	Chen	
6,796,208	B1	9/2004	Jorgensen	
6,800,819	B2	10/2004	Sato et al.	
6,826,988	B2	12/2004	Gass et al.	
6,826,992	B1	12/2004	Huang	
6,840,144	B2	1/2005	Huang	
6,854,371	B2	2/2005	Yu	
6,857,345	B2	2/2005	Gass et al.	
6,874,397	B2	4/2005	Chang	
6,874,399	B2	4/2005	Lee	
6,877,410	B2	4/2005	Gass et al.	
6,880,440	B2	4/2005	Gass et al.	
6,883,397	B2	4/2005	Kimizuka	
6,889,585	B1 *	5/2005	Harris et al.	83/62
6,920,814	B2	7/2005	Gass et al.	
6,922,153	B2 *	7/2005	Pierga et al.	324/661
6,945,148	B2	9/2005	Gass et al.	
6,945,149	B2	9/2005	Gass et al.	
6,957,601	B2 *	10/2005	Gass et al.	83/62.1
6,968,767	B2	11/2005	Yu	
6,986,370	B1	1/2006	Schoene et al.	
6,994,004	B2	2/2006	Gass et al.	
6,997,090	B2	2/2006	Gass et al.	
7,000,514	B2	2/2006	Gass et al.	
7,024,975	B2	4/2006	Gass et al.	
7,055,417	B1	6/2006	Gass et al.	
7,077,039	B2	7/2006	Gass et al.	
7,098,800	B2 *	8/2006	Gass	83/58
7,100,483	B2	9/2006	Gass et al.	
7,137,326	B2	11/2006	Gass et al.	
7,171,879	B2	2/2007	Gass et al.	
7,197,969	B2	4/2007	Gass et al.	
7,210,383	B2	5/2007	Gass et al	
7,357,056	B2	4/2008	Gass et al.	
7,373,863	B2 *	5/2008	O'Banion et al.	192/129 R
7,472,634	B2 *	1/2009	Gass et al.	83/58
7,509,899	B2 *	3/2009	Gass et al.	83/62.1
7,827,889	B2 *	11/2010	Carrier	83/DIG. 1
7,895,927	B2 *	3/2011	Gass	83/62.1
2001/0032534	A1	10/2001	Ceroll et al.	
2002/0017175	A1	2/2002	Gass et al.	
2002/0017176	A1	2/2002	Gass et al.	
2002/0017178	A1	2/2002	Gass et al.	
2002/0017179	A1	2/2002	Gass et al.	
2002/0017180	A1 *	2/2002	Gass et al.	83/58
2002/0017181	A1	2/2002	Gass et al.	
2002/0017182	A1	2/2002	Gass et al.	
2002/0017183	A1	2/2002	Gass et al.	
2002/0017184	A1	2/2002	Gass et al.	
2002/0017336	A1	2/2002	Gass et al.	
2002/0020261	A1	2/2002	Gass et al.	
2002/0020262	A1	2/2002	Gass et al.	
2002/0020263	A1	2/2002	Gass et al.	
2002/0020265	A1	2/2002	Gass et al.	
2002/0020271	A1 *	2/2002	Gass et al.	83/477.2
2002/0043776	A1	4/2002	Chuang	
2002/0050201	A1	5/2002	Lane et al.	
2002/0056348	A1	5/2002	Gass et al.	
2002/0056349	A1	5/2002	Gass et al.	
2002/0056350	A1	5/2002	Gass et al.	
2002/0059853	A1	5/2002	Gass et al.	
2002/0059854	A1	5/2002	Gass et al.	
2002/0069734	A1	6/2002	Gass et al.	
2002/0088325	A1	7/2002	Talesky et al.	
2002/0096030	A1	7/2002	Wang	
2002/0096591	A1	7/2002	Tanji	
2002/0109036	A1	8/2002	Denen et al.	
2002/0134212	A1	9/2002	Ceroll et al.	
2002/0170399	A1 *	11/2002	Gass et al.	83/62.1
2002/0170400	A1	11/2002	Gass	
2002/0174755	A1	11/2002	Behne et al.	
2002/0190581	A1	12/2002	Gass et al.	
2003/0000359	A1	1/2003	Eccardt et al.	
2003/0002942	A1	1/2003	Gass et al.	
2003/0005588	A1	1/2003	Gass et al.	
2003/0015253	A1	1/2003	Gass et al.	
2003/0019341	A1	1/2003	Gass et al.	
2003/0020336	A1	1/2003	Gass et al.	
2003/0037651	A1	2/2003	Gass et al.	
2003/0037655	A1	2/2003	Chin-Chin	
2003/0056853	A1	3/2003	Gass et al.	
2003/0058121	A1	3/2003	Gass et al.	
2003/0074873	A1	4/2003	Freiberg et al.	
2003/0089212	A1	5/2003	Parks et al.	
2003/0090224	A1	5/2003	Gass et al.	
2003/0101857	A1	6/2003	Chuang	
2003/0109798	A1	6/2003	Kermani	
2003/0131703	A1	7/2003	Gass et al.	
2003/0140749	A1	7/2003	Gass et al.	
2003/0213349	A1	11/2003	Chang	
2004/0011177	A1	1/2004	Huang	
2004/0040426	A1	3/2004	Gass et al.	
2004/0060404	A1	4/2004	Metzger, Jr.	
2004/0103544	A1	6/2004	Hartmann	
2004/0104085	A1	6/2004	Lang et al.	
2004/0118261	A1	6/2004	Garcia et al.	
2004/0159198	A1	8/2004	Peot et al.	
2004/0194594	A1	10/2004	Dils et al.	
2004/0200329	A1	10/2004	Sako	

2004/0226424	A1	11/2004	O'Banion et al.	
2004/0226800	A1	11/2004	Pierga et al.	
2004/0255745	A1	12/2004	Peot et al.	
2005/0057206	A1	3/2005	Uneyama	
2005/0066784	A1	3/2005	Gass	
2005/0087049	A1	4/2005	Miller	
2005/0092149	A1	5/2005	Hartmann	
2005/0139051	A1	6/2005	Gass et al.	
2005/0139056	A1	6/2005	Gass et al.	
2005/0139057	A1	6/2005	Gass et al.	
2005/0139058	A1	6/2005	Gass et al.	
2005/0139459	A1	6/2005	Gass et al.	
2005/0155473	A1	7/2005	Gass	
2005/0166736	A1	8/2005	Gass et al.	
2005/0178259	A1	8/2005	Gass et al.	
2005/0204885	A1	9/2005	Gass et al.	
2005/0211034	A1	9/2005	Sasaki et al.	
2005/0235793	A1	10/2005	O'Banion et al.	
2005/0268767	A1	12/2005	Pierga et al.	
2005/0274432	A1	12/2005	Gass et al.	
2006/0000337	A1	1/2006	Gass	
2006/0032352	A1 *	2/2006	Gass et al.	83/58
2006/0096425	A1	5/2006	Keller	
2006/0123960	A1	6/2006	Gass et al.	
2006/0123964	A1	6/2006	Gass et al.	
2006/0179983	A1	8/2006	Gass et al.	
2006/0219076	A1	10/2006	Gass et al.	
2006/0225551	A1	10/2006	Gass	
2006/0230896	A1	10/2006	Gass	
2006/0247795	A1	11/2006	Gass et al.	
2006/0254401	A1	11/2006	Gass et al.	
2006/0272463	A1	12/2006	Gass	
2007/0028733	A1	2/2007	Gass	
2008/0016998	A1	1/2008	Keller	
2009/0178524	A1 *	7/2009	Gass et al.	83/62.1
2011/0023673	A1 *	2/2011	Gass	83/58
2011/0056351	A1 *	3/2011	Gass et al.	83/58
2011/0072942	A1 *	3/2011	Gass	83/58
2011/0079124	A1 *	4/2011	Carrier	83/63

FOREIGN PATENT DOCUMENTS

CH	297525		6/1954
DE	76186		8/1921
DE	2917497		4/1979
DE	2800403		7/1979
DE	3427733		1/1986
DE	4205965	C1	2/1992
DE	4235161		5/1993
DE	4326313		2/1995
DE	19609771		6/1998
DE	20102704		2/2001
EP	146460		11/1988
EP	0362937		4/1990
ES	2152184		1/2001
FR	2556643		6/1985
FR	2570017		3/1986
GB	598204		2/1948
GB	1132708		11/1968
GB	2096844		10/1982
GB	2142571		1/1985
JP	06328359		11/1994
WO	WO 01/26064	A2 *	4/2001

OTHER PUBLICATIONS

Skil Model 3400-Type 1 10" Table Saw Parts List and Technical Bulletin, S-B Power Tool Company, Jun. 1993.

Shop Fox® Fence Operating Manual, Woodstock International, Inc., 1996, revised May 1997.

Gordon Engineering Corp., Product Catalog, pp. cover, 1, 3 and back, Brookfield, Connecticut, US, Oct. 1997.

Analog Devices, Inc., 3-Axis Capacitive Sensor—Preliminary Technical Data AD7103, pp. 1-40, © 1998.

U.S. Appl. No. 60/157,340, filed Oct. 1, 1999, entitled "Fast-Acting Safety Stop."

U.S. Appl. No. 60/182,866, filed Feb. 16, 2000, entitled "Fast-Acting Safety Stop."

IWF 2000 Challengers Award Official Entry Form, submitted Apr. 26, 2000, 6 pages plus CD (the portions of U.S. patent applications referenced in the form are from U.S. Appl. No. 60/157,340, filed Oct. 1, 1999 and U.S. Appl. No. 60/182,866, filed Feb. 16, 2000).

Excaliber T-Slot Precision Saw Fence Model TT45 Owner's Manual, Sommerville Design & Manufacturing, Inc., May 2000.

Bosch Model 4000 Worksite Table Saw Operating/Safety Instructions, S-B Power Tool Company, Jul. 2000.

XACTA Fence II™ Homeshop 30/52 Owner's Manual, JET Equipment & Tools, Mar. 2001.

XACTA Fence II™ Commercial 30/50 Owner's Manual, JET Equipment & Tools, Mar. 2001.

Bosch 10" Table Saw Model 0601476139 Parts List and Technical Bulletin, S-B Power Tool Company, Apr. 2001.

Biesemeyer® T-Square® Universal Home Shop Fence system Instruction Manual, Delta Machinery, Jun. 1, 2001.

Powermatic 10" Tilting Arbor Saw Model 66 Instruction Manual & Parts List, JET Equipment & Tools, Jun. 2001.

Skil Model 3400 Table Saw Operating/Safety Instructions, S-B Power Tool Co., Sep. 2001.

Tablesaw Splitters and Blade Covers, Fine Woodworking, pp. 77-81, Dec. 2001.

The Merlin Splitter by Excalibur a Sommerville Design Product Overview & Generic Installation Notes, Sommerville Design & Manufacturing Inc., at least as early as 2002.

INCRA Incremental Micro Precision Table Saw Fence Owner's Manual, Taylor Design Group, Inc., 2003.

Craftsman® Power and Hand Tools, pp. 142-143, 2003.

Shop Fox® Models W2005, W2006, W2007 Classic Fence Instruction Manual, Woodstock International, Jan. 2000, revised Mar. 2004.

ACCU-FENCE® 64A Fence and Rail System Owner's Manual, WMH Tool Group, Sep. 2004.

Unifence™ Saw Guide Instruction Manual, Delta Machinery, Feb. 22, 2005.

Biesemeyer® T-Square® Commercial Fence System Instruction Manual, Delta Machinery, May 2, 2005.

Young Inventor: Teen's Device Earns Her Trip to Science Fair, The Arizona Republic, May 5, 2006.

Grizzly Industrial, Inc. Model G0605X/G0606X Extreme Series 12" Table Saw Owner's Manual, Grizzly Industrial, Inc., Oct. 2006.

Decision on Appeal No. 2007-002769 for U.S. Appl. No. 09/929,242, decided Aug. 29, 2007.

Decision on Appeal No. 2009-004424 for U.S. Appl. No. 10/984,643, decided Mar. 25, 2010.

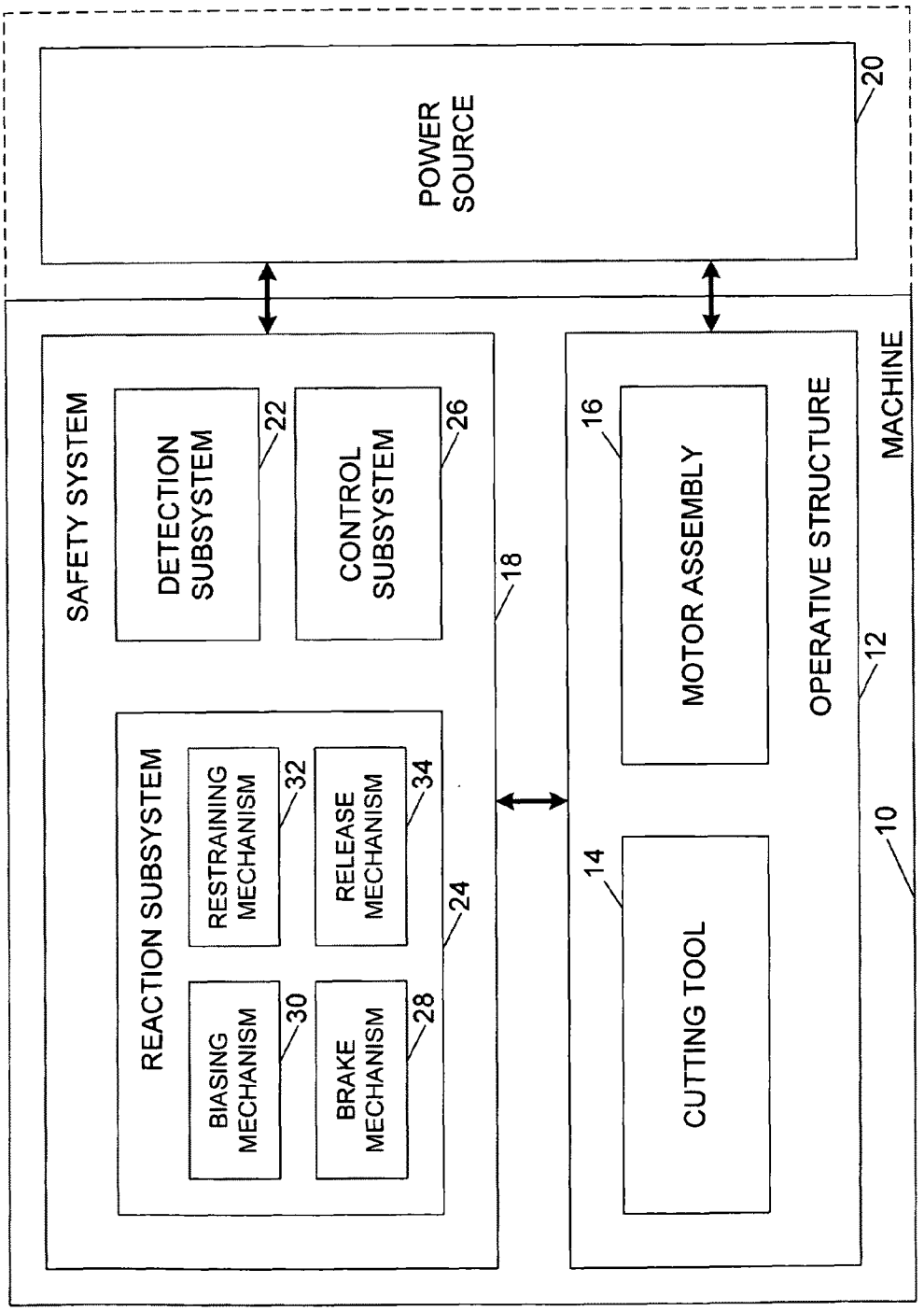
You Should Have Invented It, French television show video/DVD.

Operator Injury Mitigation Using Electronic Sensing and Mechanical Braking and Decoupling Devices in Handheld Circular Saws, Erin F. Eppard, date unknown.

Laguna Tools table saw owner's manual, date unknown.

* cited by examiner

Fig. 1


POWER SOURCE
20
SAFETY SYSTEM
DETECTION SUBSYSTEM
22
CONTROL SUBSYSTEM
26
18
REACTION SUBSYSTEM
RESTRAINING MECHANISM
32
RELEASE MECHANISM
34
24
BIASING MECHANISM
30
BRAKE MECHANISM
28
MACHINE
OPERATIVE STRUCTURE
12
16
MOTOR ASSEMBLY
14
CUTTING TOOL
10

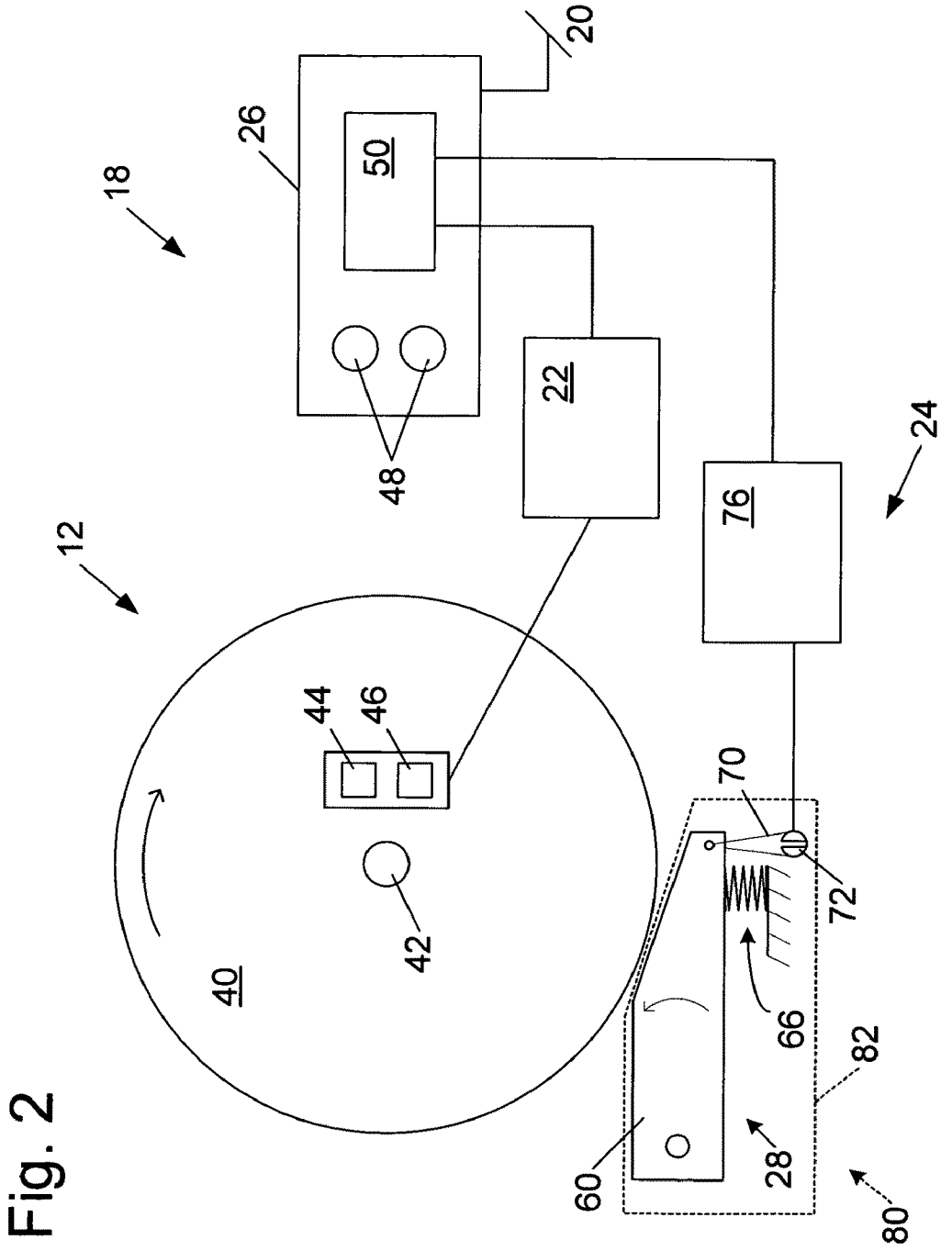


Fig. 2

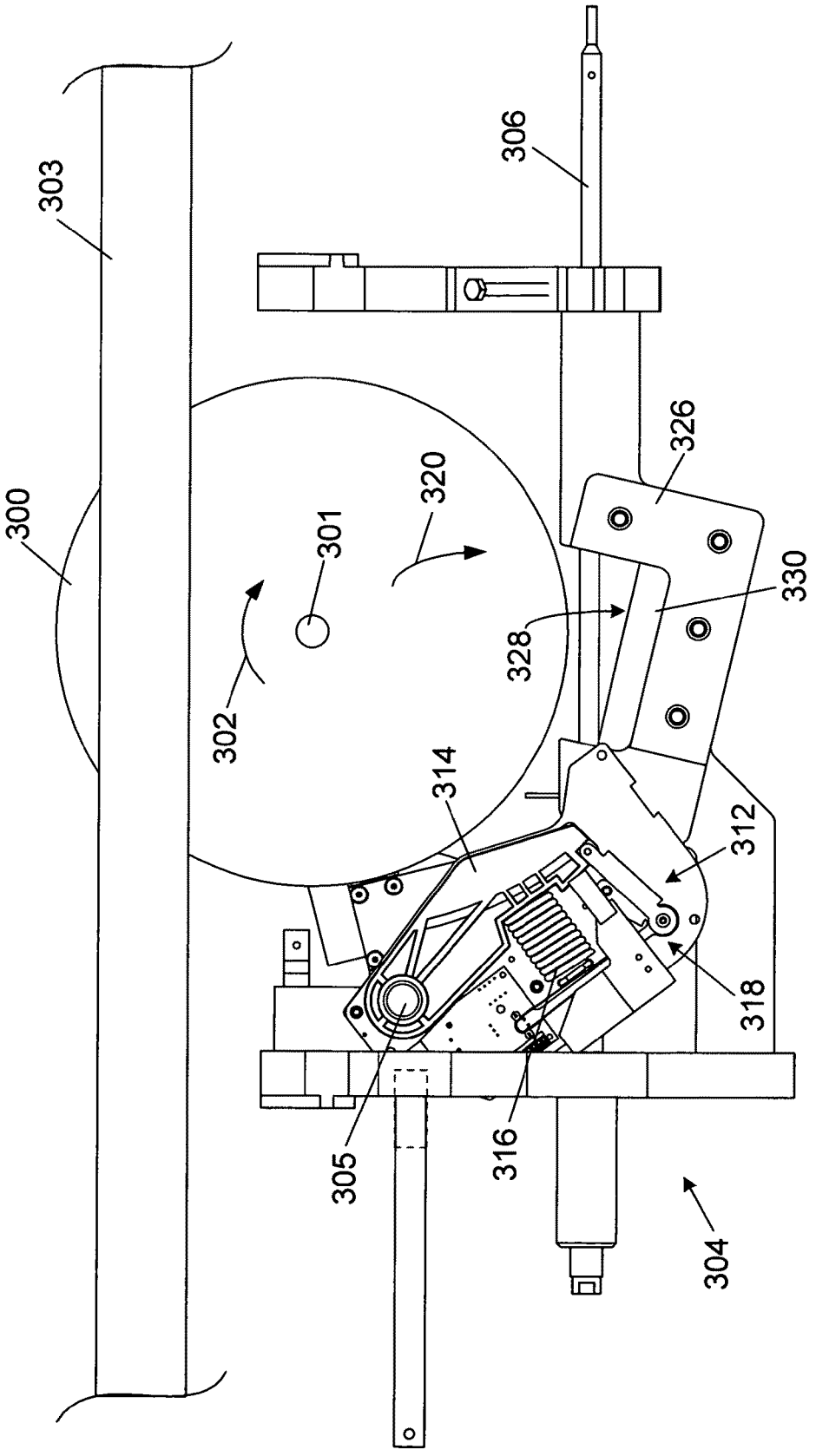


Fig. 3

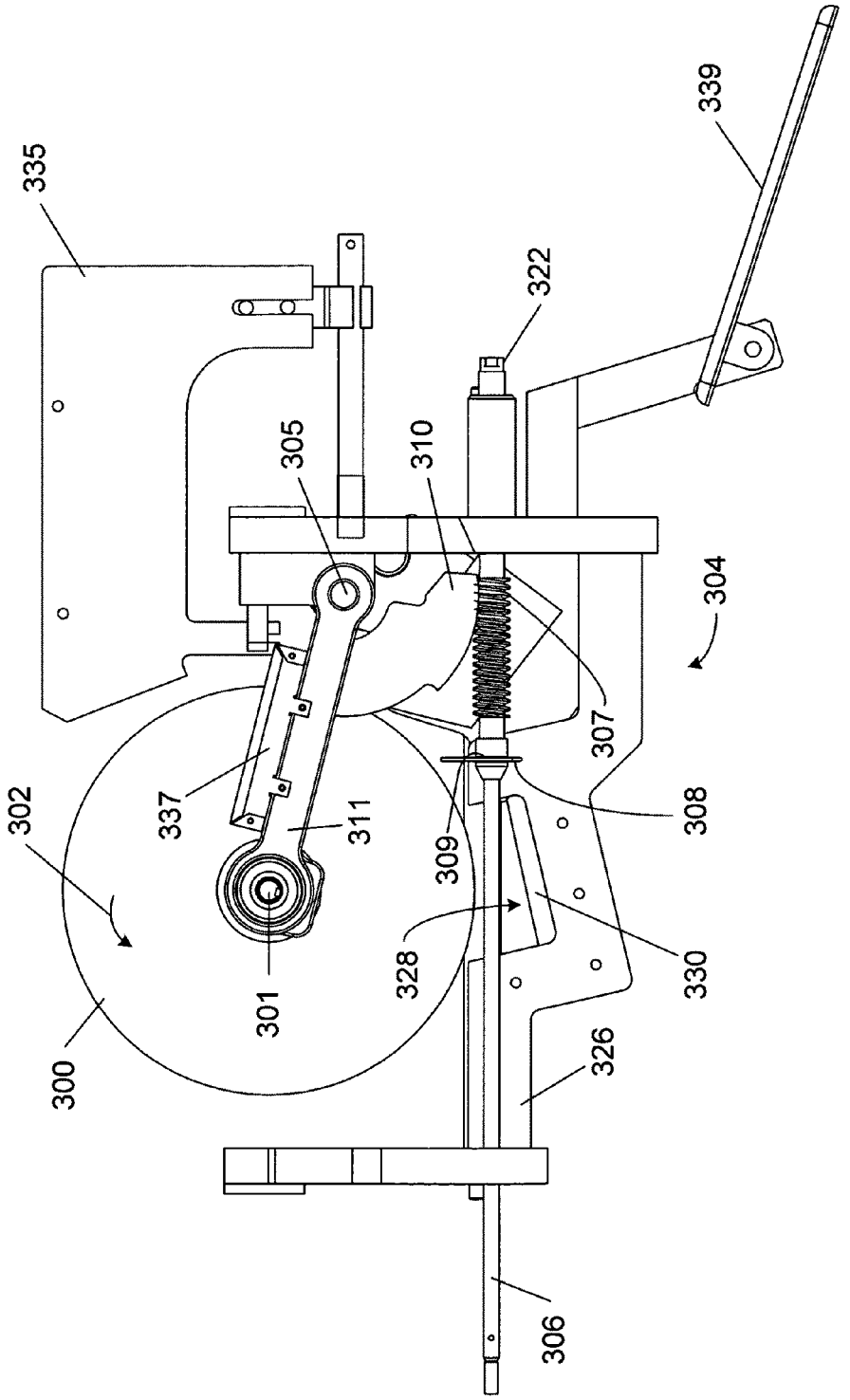

339
335
322
305
310
304
307
308
337
311
309
302
328
330
301
326
300
306

Fig. 4

Fig. 5

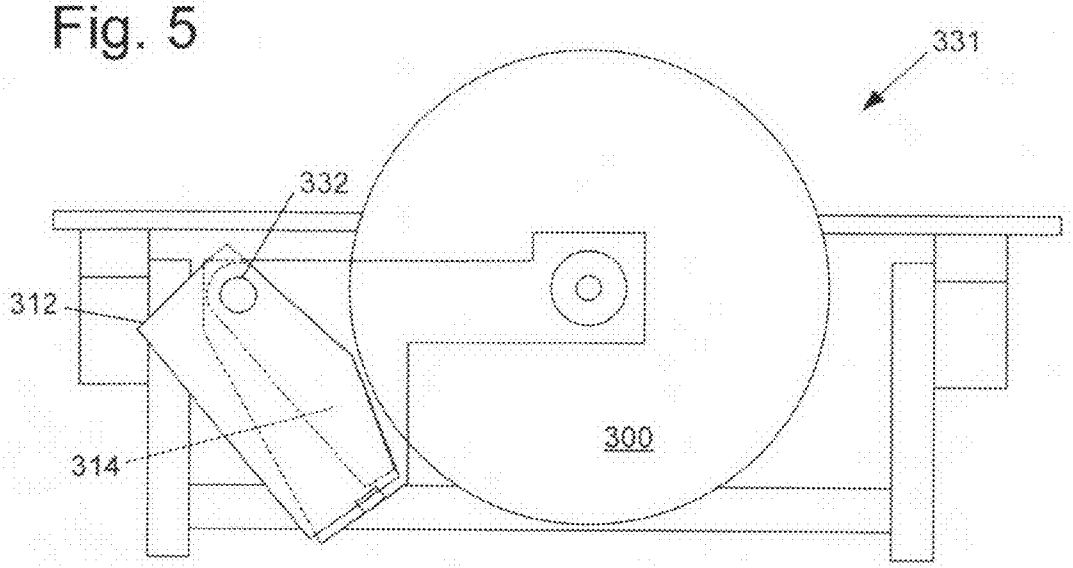
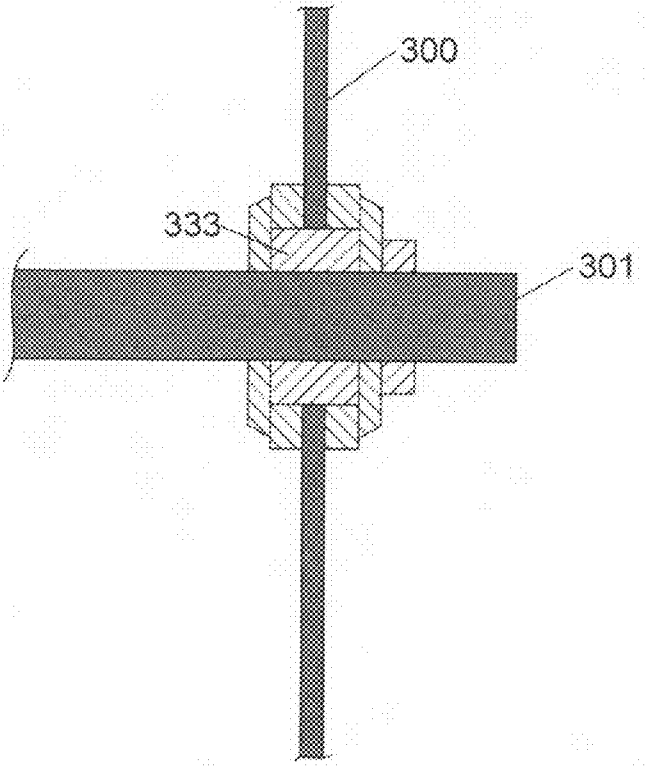


Fig. 6



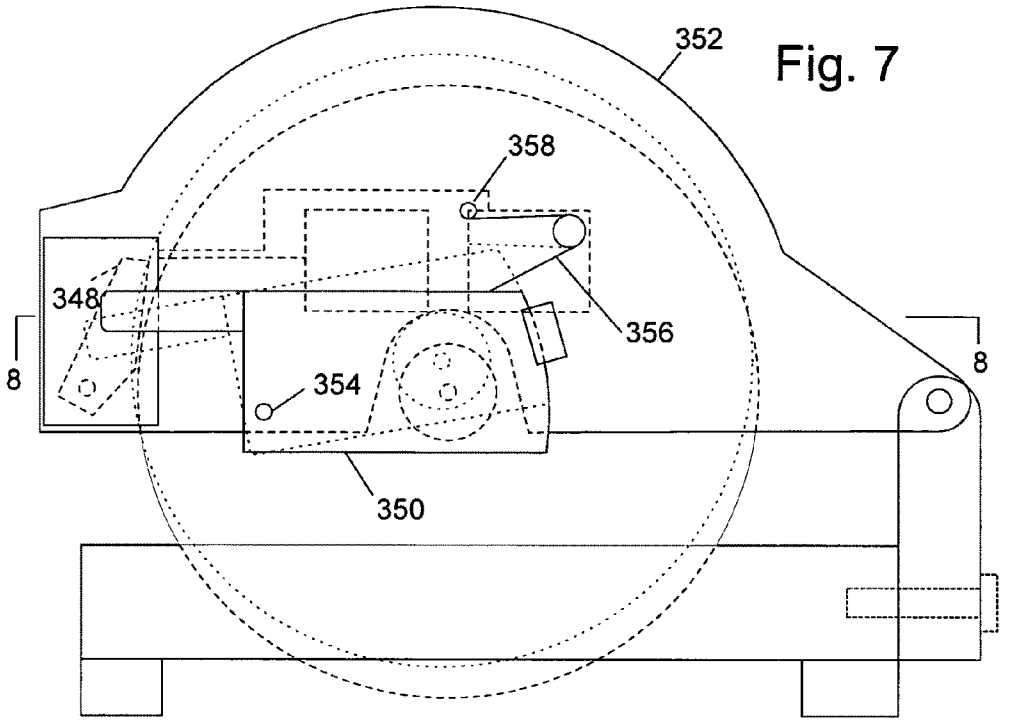


Fig. 7

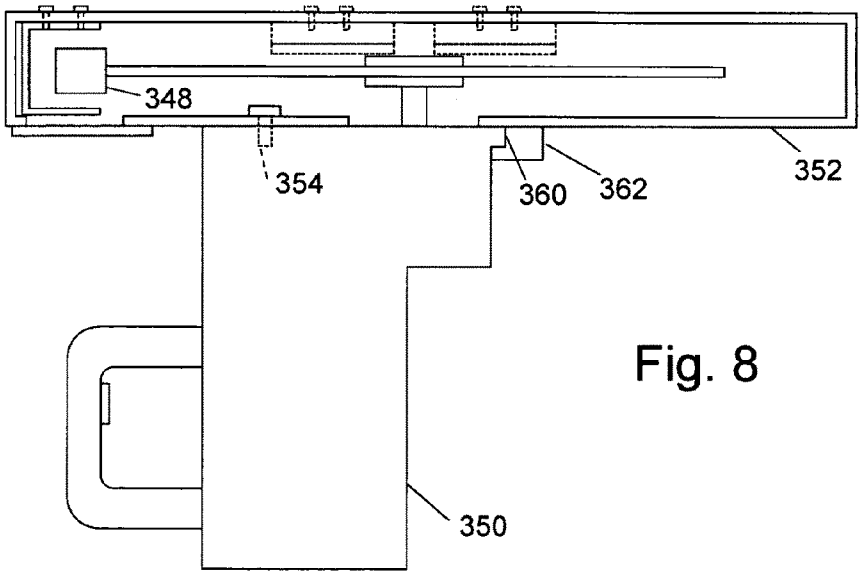


Fig. 8

Fig. 9

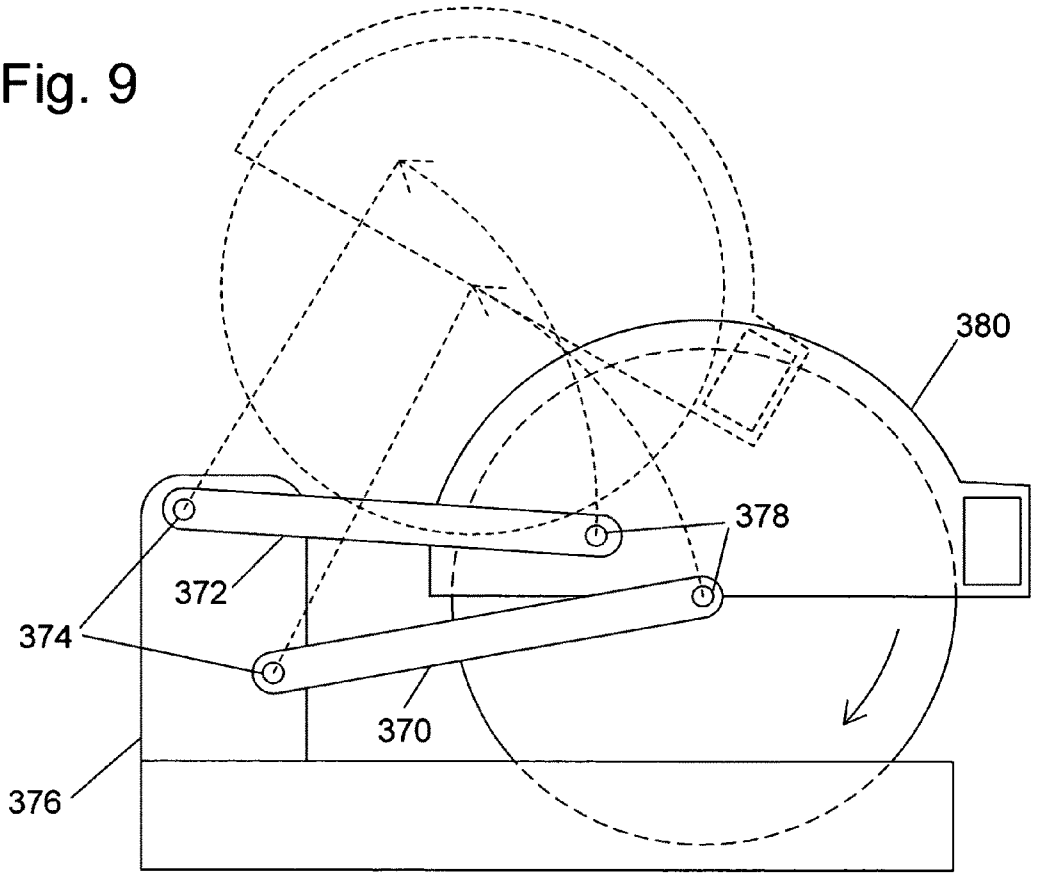


Fig. 10

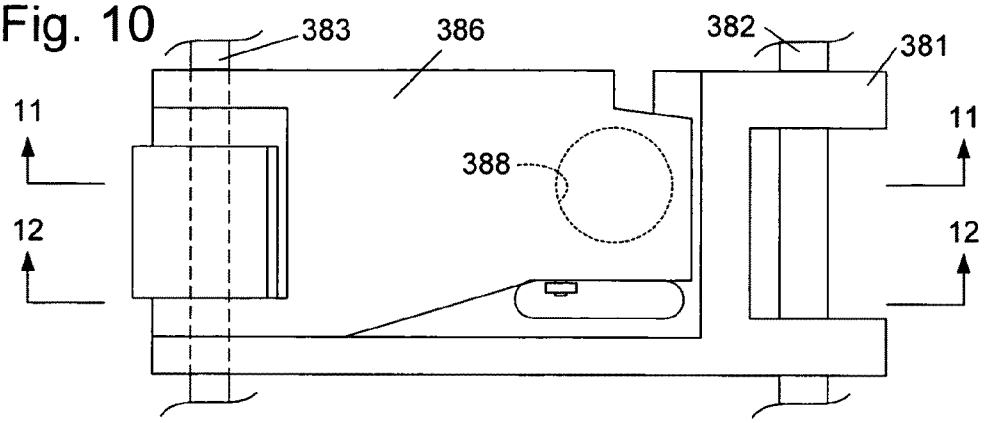


Fig. 11

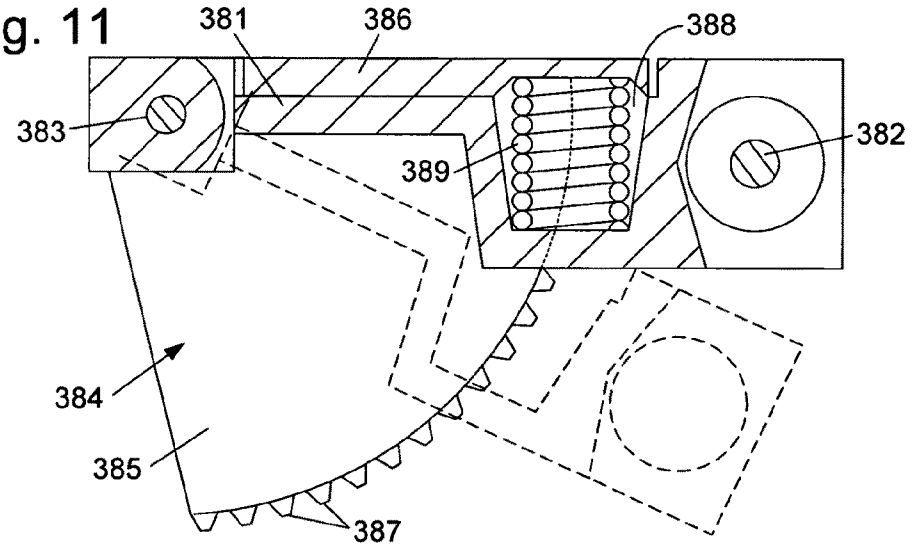
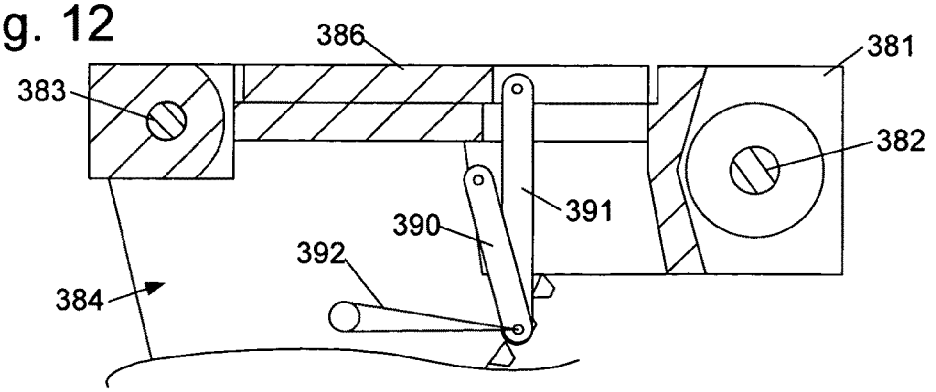


Fig. 12



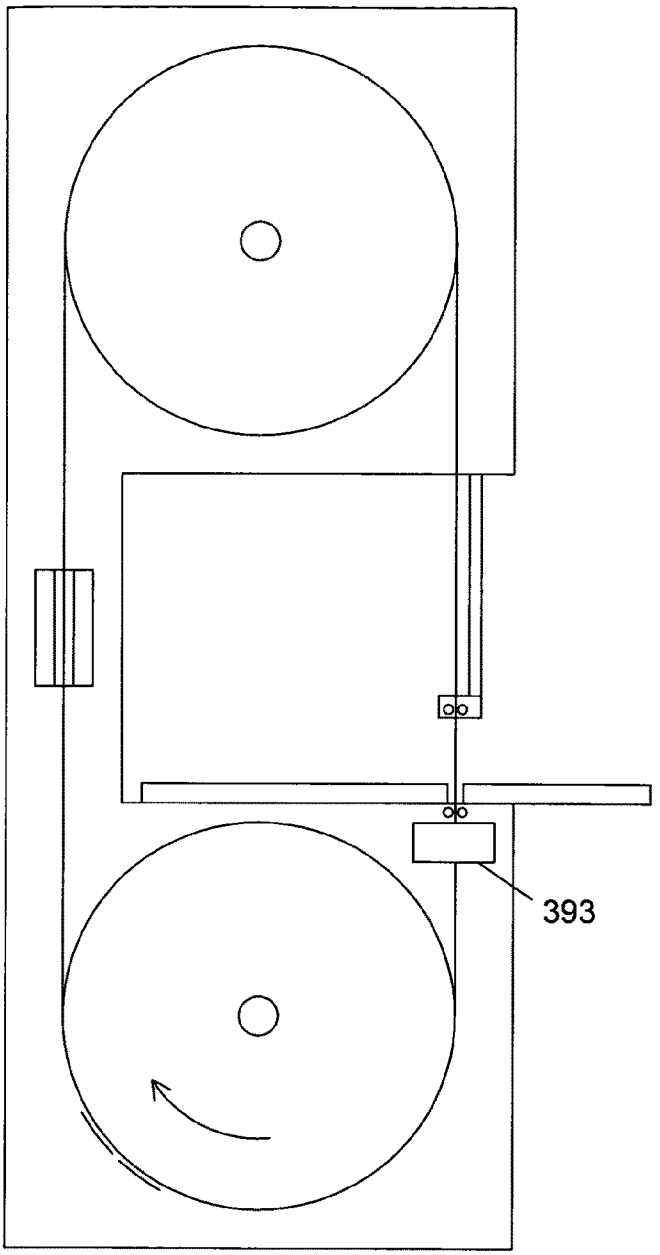


Fig. 13

Fig. 14

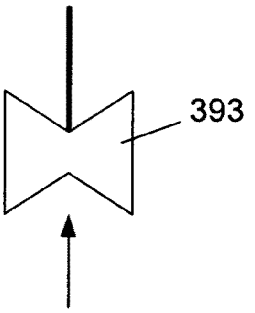


Fig. 15

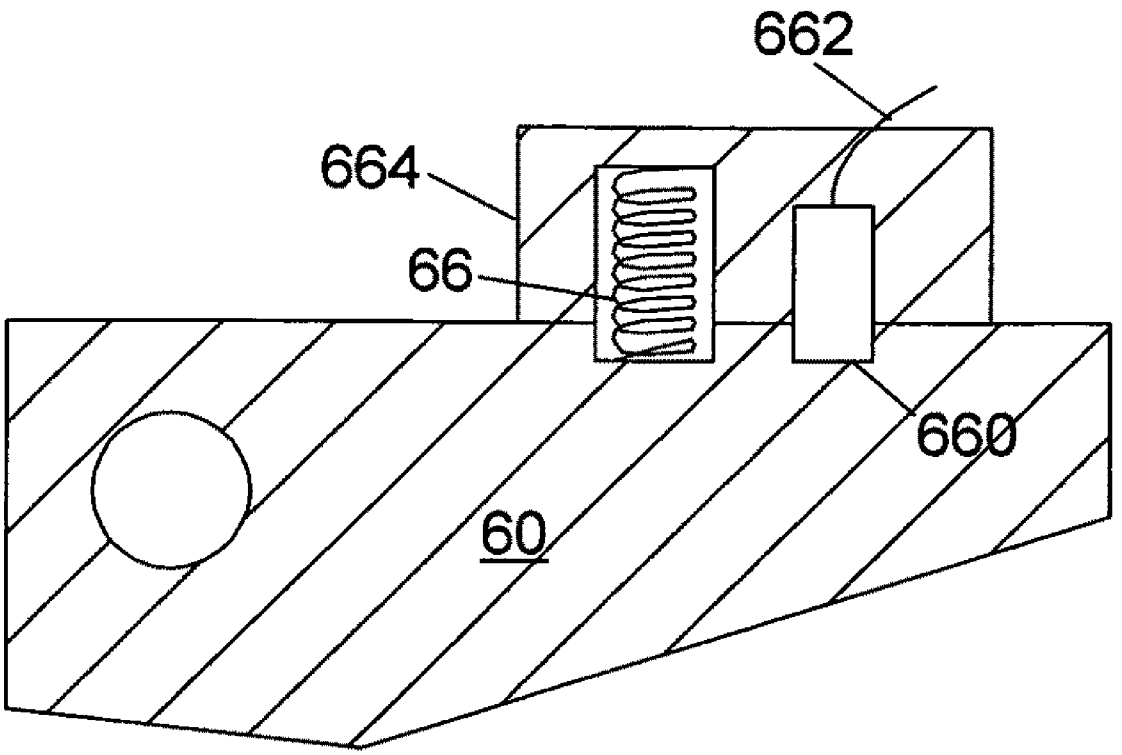


Fig. 16

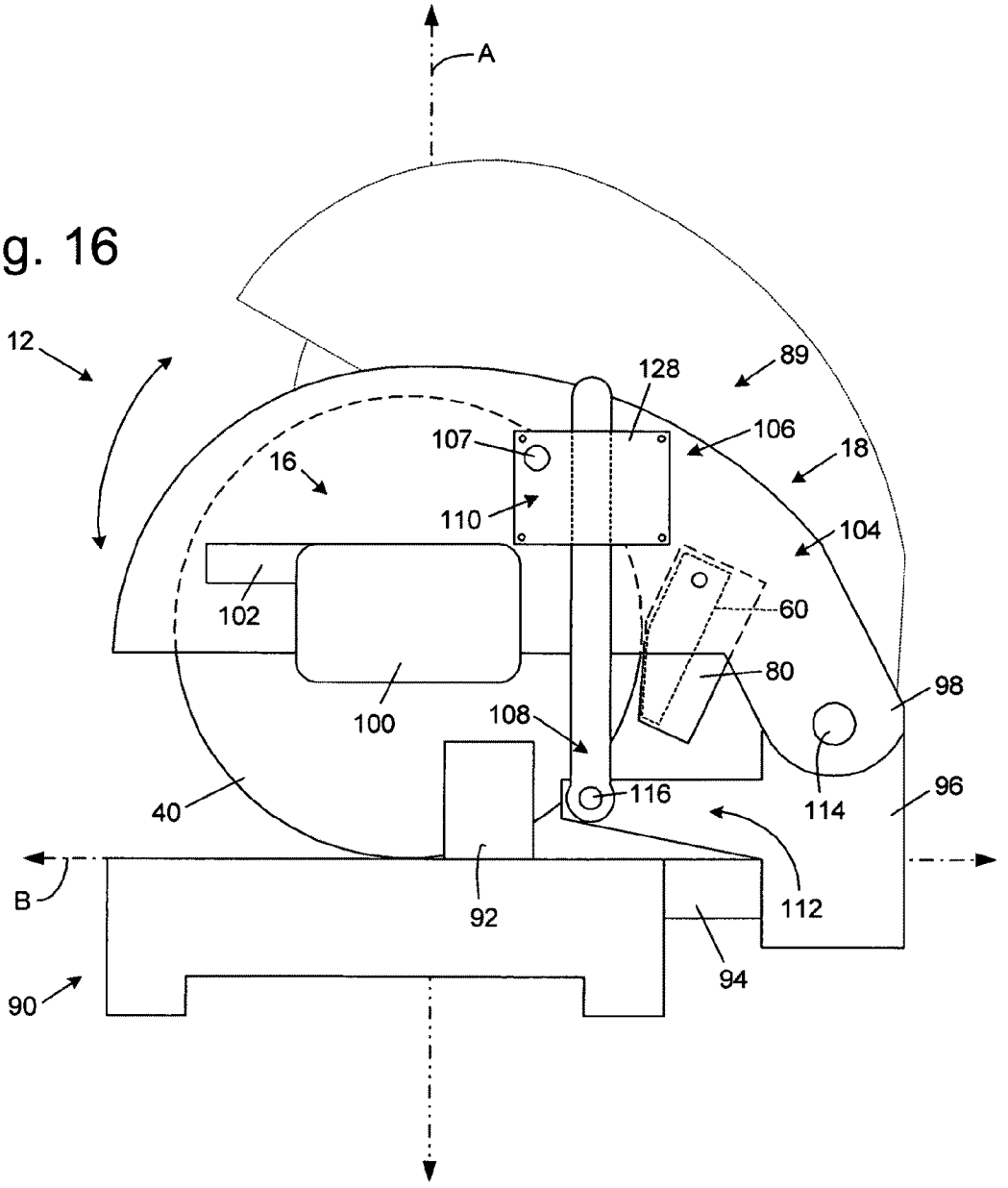

A
12
89
128
106
18
107
16
110
104
102
60
80
98
100
108
116
96
114
40
B
92
112
94
90

Fig. 17

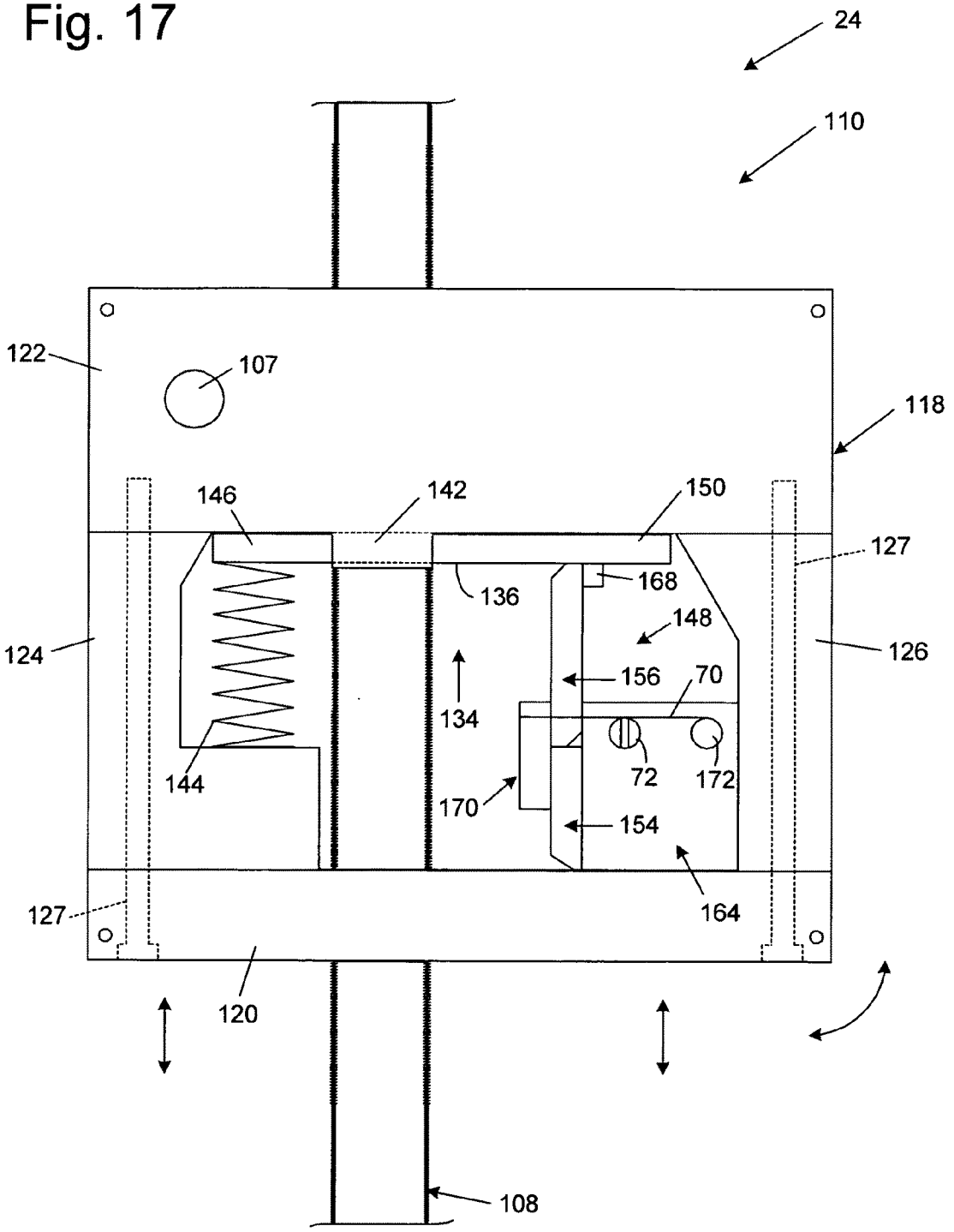

24
110
122
107
118
146
142
150
127
168
136
148
124
126
156
70
134
72
172
144
170
154
164
127
120
108

Fig. 18

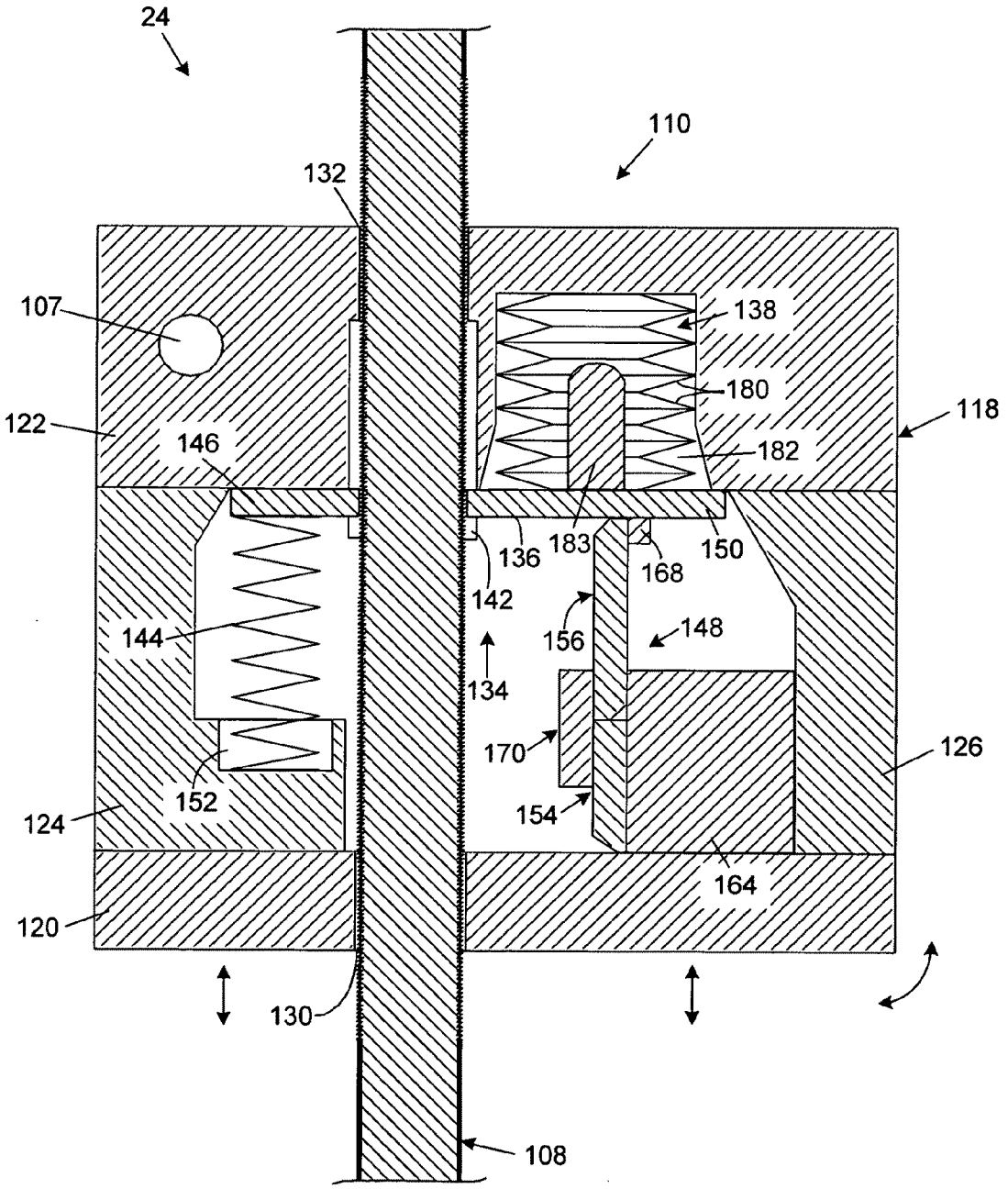

24
110
132
107
138
180
118
122
146
182
136
183
150
168
142
144
156
148
134
170
126
152
124
154
164
120
130
108

Fig. 19

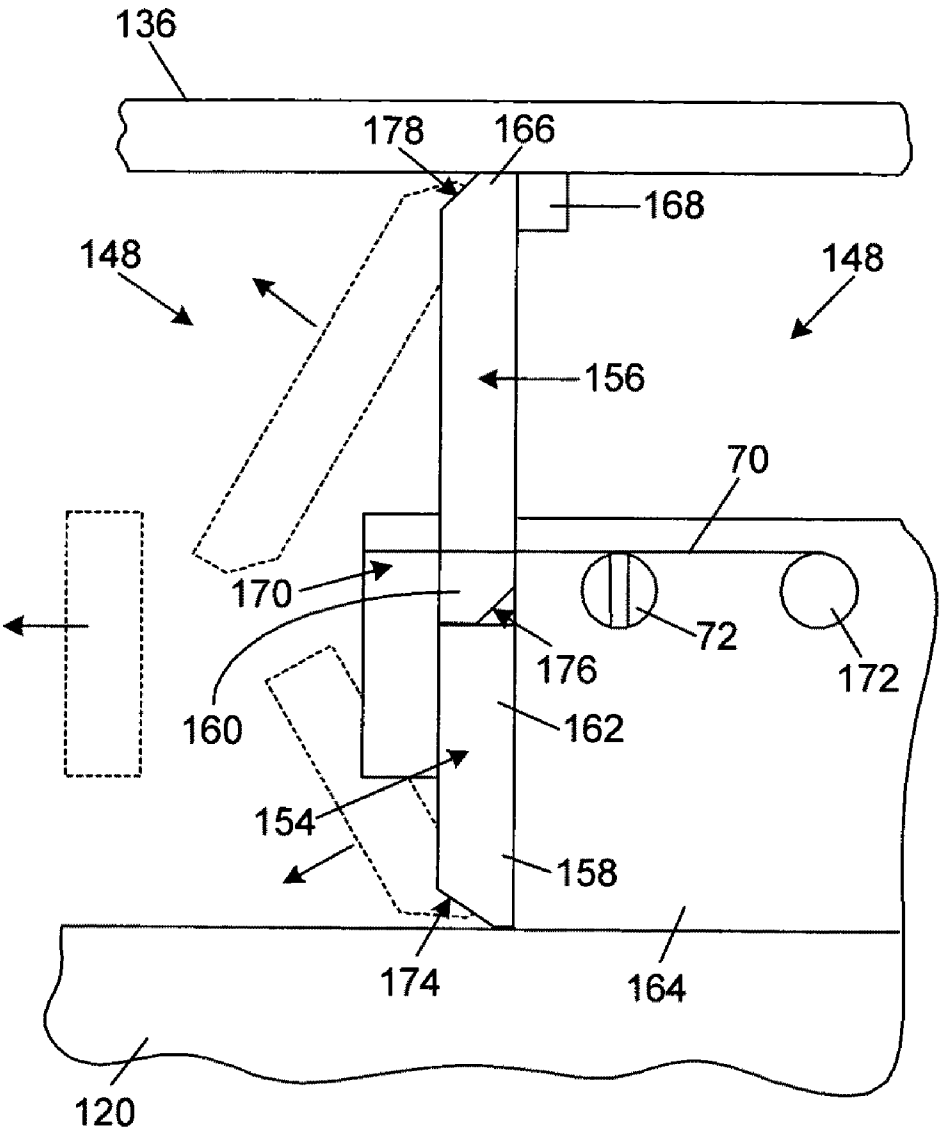

136
178
166
168
148
148
156
70
170
72
172
176
160
162
154
158
174
164
120

Fig. 20

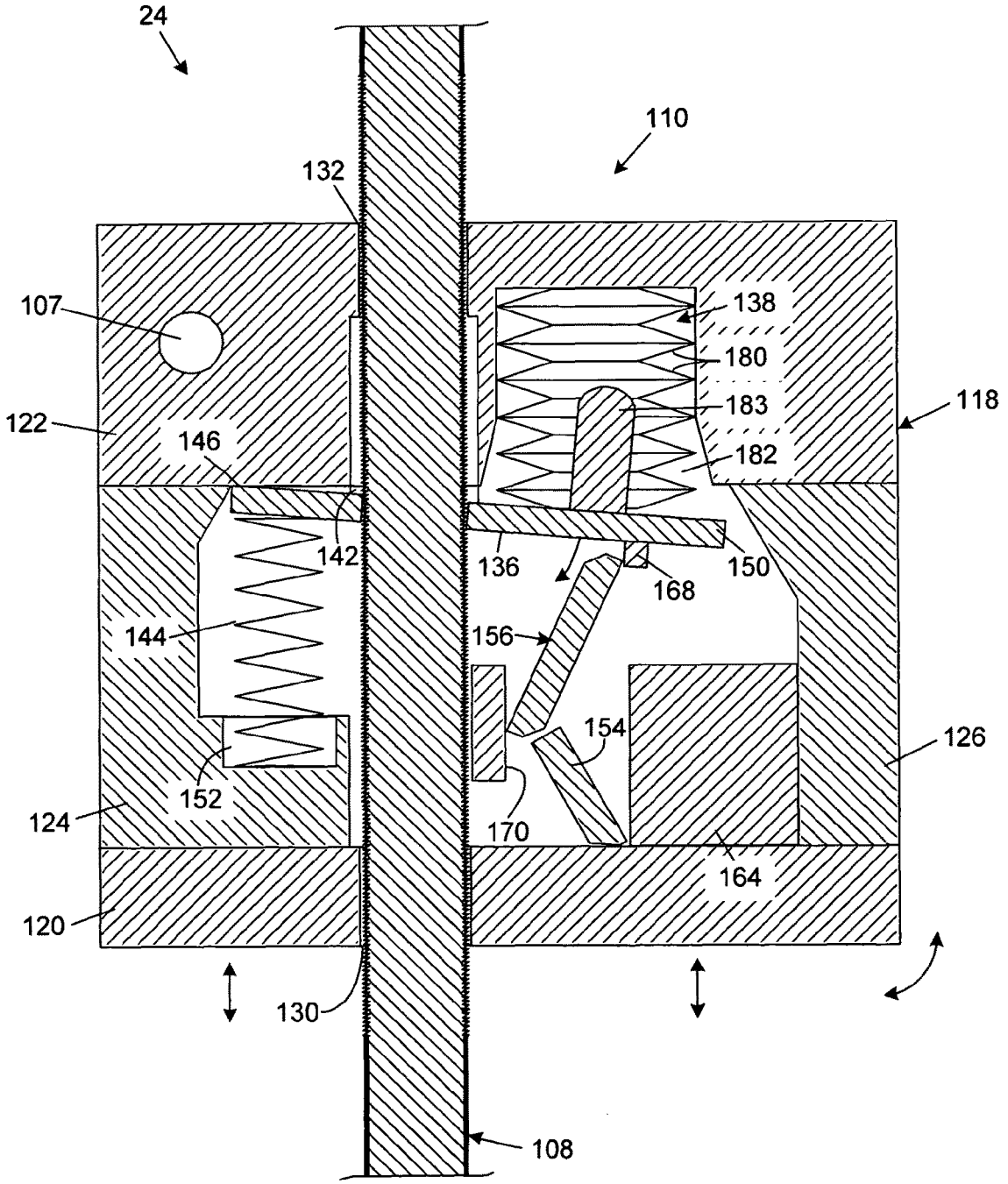
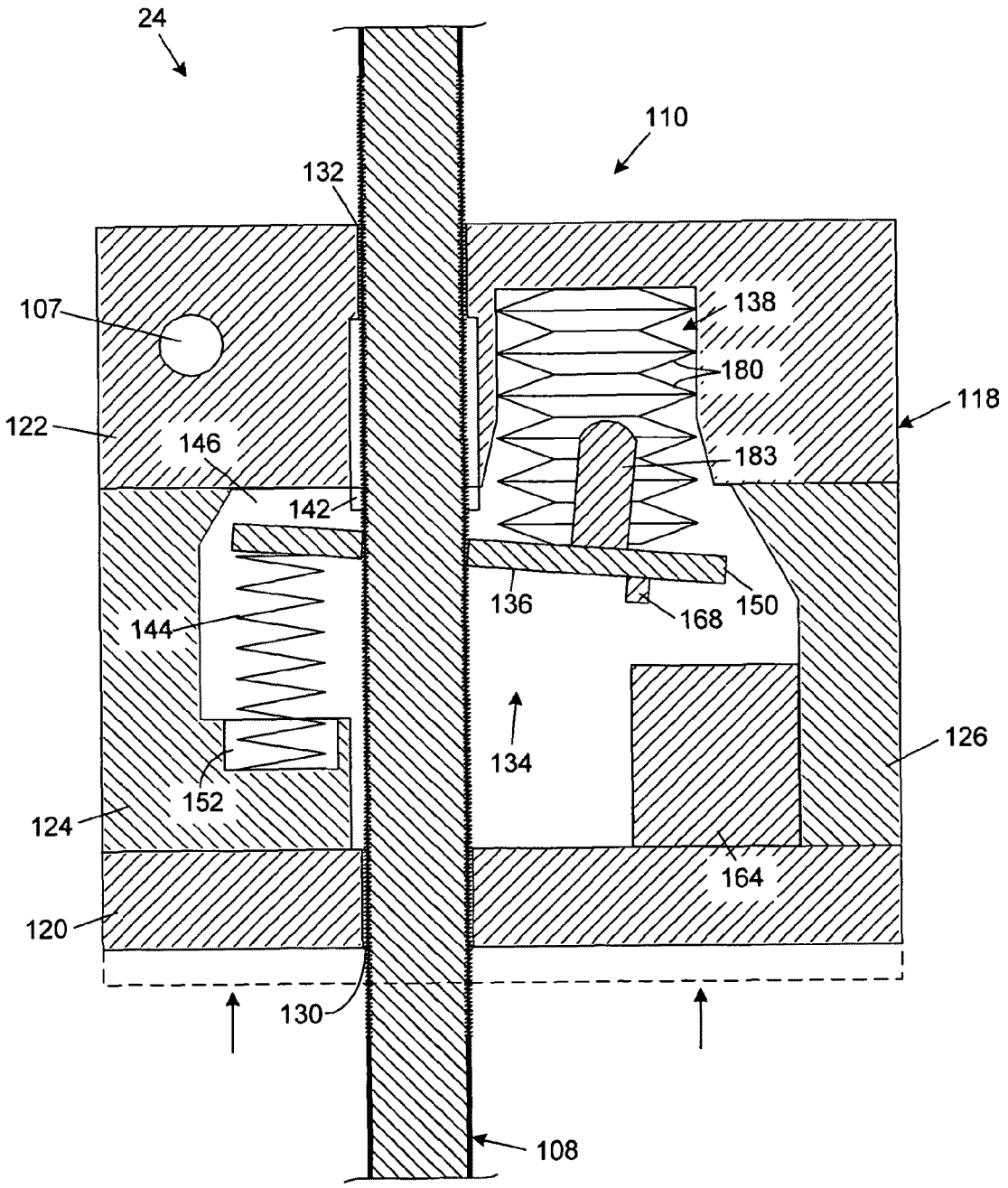

24
110
132
107
138
180
183
182
118
122
146
142
136
150
168
144
156
154
126
152
124
170
164
120
130
108

Fig. 21


24
110
132
107
138
180
118
122
146
183
142
136
150
168
144
134
126
152
124
164
120
130
108

POWER EQUIPMENT WITH DETECTION AND REACTION SYSTEMS

CROSS-REFERENCE TO RELATED APPLICATIONS

This application is a continuation of the following U.S. patent applications, all of which are hereby incorporated by reference in their entireties:

Ser. No. 11/796,819, filed Apr. 30, 2007, which is a continuation of Ser. No. 09/929,426, filed Aug. 13, 2001, issuing as U.S. Pat. No. 7,210,383 on May 1, 2007, which claims the benefit of and priority from a number of U.S. Provisional Patent Applications including Ser. No. 60/225,200, filed Aug. 14, 2000;

Ser. No. 12/655,695, filed Jan. 4, 2010, now U.S. Pat. No. 8,006,595 which is a continuation of Ser. No. 11/975,985, filed Oct. 22, 2007, issuing as U.S. Pat. No. 7,640,835 on Jan. 5, 2010, which is a continuation of Ser. No. 09/929,221, filed Aug. 13, 2001, issuing as U.S. Pat. No. 7,284,467 on Oct. 23, 2007, which claims the benefit of and priority from a number of U.S. Provisional Patent Applications including Ser. No. 60/225,211, filed Aug. 14, 2000;

Ser. No. 12/002,388 filed Dec. 17, 2007, now U.S. Pat. No. 8,011,279 which is a continuation of Ser. No. 09/929,227, filed Aug. 13, 2001, issuing as U.S. Pat. No. 7,308,843 on Dec. 18, 2007, which claims the benefit of and priority from a number of U.S. Provisional Patent Applications including Ser. No. 60/225,170, filed Aug. 14, 2000;

Ser. No. 11/401,050, filed Apr. 10, 2006, issuing as U.S. Pat. No. 7,788,999 on Sep. 7, 2010, which is a continuation of a number of applications including Ser. No. 09/929,240, filed Aug. 13, 2001, issuing as U.S. Pat. No. 7,100,483 on Sep. 5, 2006, which in turn claims the benefit of and priority from U.S. Provisional Patent Application Ser. No. 60/225,056, filed Aug. 14, 2000; Ser. No. 09/929,241, filed Aug. 13, 2001, issuing as U.S. Pat. No. 7,024,975 on Apr. 11, 2006, which in turn claims the benefit of and priority from a number of U.S. Provisional Patent Applications including Ser. No. 60/225,169, filed Aug. 14, 2000; Ser. No. 09/929,425, filed Aug. 13, 2001, issuing as U.S. Pat. No. 7,137,326 on Nov. 21, 2006, which in turn claims the benefit of and priority from U.S. Provisional Patent Application Ser. No. 60/225,210, filed Aug. 14, 2000; Ser. No. 10/172,553, filed Jun. 13, 2002, issuing as U.S. Pat. No. 7,231,856 on Jun. 19, 2007, which in turn claims the benefit of and priority from U.S. Provisional Patent Application Ser. No. 60/298,207, filed Jun. 13, 2001; Ser. No. 10/189,027, filed Jul. 2, 2002, issuing as U.S. Pat. No. 7,712,403 on May 11, 2010, which in turn claims the benefit of and priority from U.S. Provisional Patent Application Ser. No. 60/302,916, filed Jul. 3, 2001; Ser. No. 10/243,042, filed Sep. 13, 2002, issuing as U.S. Pat. No. 7,197,969 on Apr. 3, 2007, which in turn claims the benefit of and priority from U.S. Provisional Patent Application Ser. No. 60/324,729, filed Sep. 24, 2001; Ser. No. 10/643,296, filed Aug. 18, 2003, now abandoned, which in turn claims the benefit of and priority from U.S. Provisional Patent Application Ser. No. 60/406,138, filed Aug. 27, 2002; and Ser. No. 10/794,161, filed Mar. 4, 2004, issuing as U.S. Pat. No. 7,098,800 on Aug. 29, 2006, which in turn claims the benefit of and priority from U.S. Provisional Patent Application Ser. No. 60/452,159, filed Mar. 5, 2003;

Ser. No. 12/800,607, filed May 19, 2010, issuing as U.S. Pat. No. 7,895,927 on Mar. 1, 2011, which is a continuation of a number of applications, including Ser. No. 11/542,938, filed Oct. 2, 2006, now abandoned, which in turn is a continuation of a number of applications, including Ser. No. 10/984,643, filed Nov. 8, 2004, which also is a continuation of a number of applications, including Ser. No. 09/929,226, filed Aug. 13, 2001, issuing as U.S. Pat. No. 6,920,814 on Jul. 26, 2005, which in turn claims the benefit of and priority from U.S. Provisional Patent Application Ser. No. 60/225,206, filed Aug. 14, 2000; Ser. No. 09/929,240, filed Aug. 13, 2001, issuing as U.S. Pat. No. 7,100,483 on Sep. 5, 2006, which in turn claims the benefit of and priority from U.S. Provisional Patent Application Ser. No. 60/225,056, filed Aug. 14, 2000; Ser. No. 09/929,242, filed Aug. 13, 2001, issuing as U.S. Pat. No. 7,509,899 on Mar. 31, 2009, which claims the benefit of and priority from a number of U.S. Provisional Patent Applications including Ser. No. 60/225,089, filed Aug. 14, 2000; Ser. No. 10/051,782, filed Jan. 15, 2002, issuing as U.S. Pat. No. 6,877,410 on Apr. 12, 2005, which in turn claims the benefit of and priority from U.S. Provisional Patent Application Ser. No. 60/279,313, filed Mar. 27, 2001; Ser. No. 10/052,806, filed Jan. 16, 2002, issuing as U.S. Pat. No. 6,880,440 on Apr. 19, 2005, which in turn claims the benefit of and priority from U.S. Provisional Patent Application Ser. No. 60/270,942, filed Feb. 22, 2001; Ser. No. 10/205,164, filed Jul. 25, 2002, issuing as U.S. Pat. No. 6,945,149 on Sep. 20, 2005, which in turn claims the benefit of and priority from U.S. Provisional Patent Application Ser. No. 60/307,756, filed Jul. 25, 2001; Ser. No. 10/202,928, filed Jul. 25, 2002, issuing as U.S. Pat. No. 7,000,514 on Feb. 21, 2006, which in turn claims the benefit of and priority from U.S. Provisional Patent Application Ser. No. 60/308,492, filed Jul. 27, 2001; and Ser. No. 10/785,361, filed Feb. 23, 2004, issuing as U.S. Pat. No. 6,997,090 on Feb. 14, 2006, which is a continuation of Ser. No. 10/215,929, filed Aug. 9, 2002, now abandoned, which in turn claims the benefit of and priority from U.S. Provisional Patent Application Ser. No. 60/312,141, filed Aug. 13, 2001;

Ser. No. 11/542,938, filed Oct. 2, 2006, now abandoned, which is a continuation of a number of applications, including Ser. No. 09/929,242, filed Aug. 13, 2001, issuing as U.S. Pat. No. 7,509,899 on Mar. 31, 2009, which claims the benefit of and priority from a number of U.S. Provisional Patent Applications including Ser. No. 60/225,089, filed Aug. 14, 2000; Ser. No. 11/401,774, filed Apr. 11, 2006, issuing as U.S. Pat. No. 7,525,055 on Apr. 28, 2009, which is a continuation of Ser. No. 11/027,322, filed Dec. 31, 2004, now abandoned, which claims the benefit of and priority from U.S. Provisional Patent Application Ser. No. 60/533,598, filed Dec. 31, 2003; Ser. No. 11/445,548, filed Jun. 2, 2006, issuing as U.S. Pat. No. 7,347,131 on Mar. 25, 2008; and Ser. No. 11/506,260, filed Aug. 18, 2006, issuing as U.S. Pat. No. 7,359,174 on Apr. 15, 2008, which is a continuation of a number of application including Ser. No. 10/923,282, filed Aug. 20, 2004, now abandoned, which in turn claims the benefit of and priority from U.S. Provisional Patent Application Ser. No. 60/496,568, filed Aug. 20, 2003;

Ser. No. 12/590,094, filed Nov. 2, 2009, issuing as U.S. Pat. No. 7,958,806 on Jun. 14, 2011, which is a continuation of Ser. No. 09/929,236, filed Aug. 13, 2001, issuing as U.S. Pat. No. 7,610,836 on Nov. 3, 2009, which claims the benefit of and priority from a number of U.S. Provisional Patent Applications including Ser. No. 60/225,201, filed Aug. 14, 2000;

Ser. No. 11/811,719, filed Jun. 11, 2007, issuing as U.S. Pat. No. 7,832,314 on Nov. 16, 2010, which is a continuation of Ser. No. 11/061,162, filed Feb. 18, 2005, issuing as U.S. Pat. No. 7,228,772 on Jun. 12, 2007, which is a continuation of Ser. No. 09/929,244, filed Aug. 13, 2001, issuing as U.S. Pat. No. 6,857,345 on Feb. 22, 2005, which in turn claimed

the benefit of and priority from a number of U.S. Provisional Patent Applications including Ser. No. 60/225,212, filed Aug. 14, 2000;

Ser. No. 12/587,695, filed Oct. 9, 2009, issuing as U.S. Pat. No. 7,921,754 on Apr. 12, 2011, which is a continuation of Ser. No. 09/929,237, filed Aug. 13, 2001, issuing as U.S. Pat. No. 7,600,455 on Oct. 13, 2009, which claims the benefit of and priority from a number of U.S. Provisional Patent Applications including Ser. No. 60/225,059, filed Aug. 14, 2000;

Ser. No. 12/661,766, filed Mar. 22, 2010, which is a continuation of Ser. No. 11/810,196, filed Jun. 4, 2007, issuing as U.S. Pat. No. 7,681,479 on Mar. 23, 2010, which is a continuation of Ser. No. 09/929,234, filed Aug. 13, 2001, issuing as U.S. Pat. No. 7,225,712 on Jun. 5, 2007, which claims the benefit of and priority from a number of U.S. Provisional Patent Applications including Ser. No. 60/225,094, filed Aug. 14, 2000;

Ser. No. 12/655,694, filed Jan. 4, 2010, issuing as U.S. Pat. No. 7,908,950 on Mar. 22, 2011, which is a continuation of Ser. No. 12/079,836, filed Mar. 27, 2008, issuing as U.S. Pat. No. 7,640,837 on Jan. 5, 2010, which is a continuation of Ser. No. 09/929,235, filed Aug. 13, 2001, issuing as U.S. Pat. No. 7,350,444 on Apr. 1, 2008, which claims the benefit of and priority from a number of U.S. Provisional Patent Applications including Ser. No. 60/225,058, filed Aug. 14, 2000;

Ser. No. 12/799,211, filed Apr. 19, 2010, which is a continuation of Ser. No. 12/220,946, filed Jul. 29, 2008, issuing as U.S. Pat. No. 7,698,976 on Apr. 20, 2010, which is a continuation of Ser. No. 09/929,238, filed Aug. 13, 2001, now abandoned, which claims the benefit of and priority from a number of U.S. Provisional Patent Applications including Ser. No. 60/225,057, filed Aug. 14, 2000;

Ser. No. 12/590,924, filed Nov. 16, 2009, which is a continuation of Ser. No. 12/154,675, filed May 23, 2008, issuing as U.S. Pat. No. 7,617,752 on Nov. 17, 2009, which is a continuation of Ser. No. 10/053,390, filed Jan. 16, 2002, issuing as U.S. Pat. No. 7,377,199 on May 27, 2008, which is a continuation-in-part of a number of applications including Ser. No. 09/676,190, filed Sep. 29, 2000, issuing as U.S. Pat. No. 7,055,417 on Jun. 6, 2006; and Ser. No. 10/053,390 also claims the benefit of and priority from U.S. Provisional Patent Application Ser. No. 60/270,011, filed Feb. 20, 2001;

Ser. No. 12/313,162, filed Nov. 17, 2008, issuing as U.S. Pat. No. 7,789,002 on Sep. 7, 2010, which is a continuation of Ser. No. 11/348,580, filed Feb. 6, 2006, now abandoned, which is a continuation of a number of applications including Ser. No. 10/052,705, filed Jan. 16, 2002, issuing as U.S. Pat. No. 6,994,004 on Feb. 7, 2006, which in turn claimed the benefit of and priority from the following U.S. Provisional Patent Application Ser. No. 60/270,011, filed Feb. 20, 2001, Ser. No. 60/270,941, filed Feb. 22, 2001, Ser. No. 60/270,942, filed Feb. 22, 2001, Ser. No. 60/273,177, filed Mar. 2, 2001, and Ser. No. 60/273,178, filed Mar. 2, 2001; and Ser. No. 11/348,580 also claims the benefit of and priority from U.S. Provisional Patent Application Ser. No. 60/667,485, filed Mar. 31, 2005; and Ser. No. 12/313,162 is also a continuation of Ser. No. 11/098,984, filed Apr. 4, 2005, issuing as U.S. Pat. No. 7,353,737 on Apr. 8, 2008, which is a continuation of a Ser. No. 09/929,238, filed Aug. 13, 2001, now abandoned, Ser. No. 10/047,066, filed Jan. 14, 2002, issuing as U.S. Pat. No. 6,945,148 on Sep. 20, 2005, and Ser. No. 10/051,782, filed Jan. 15, 2002, issuing as U.S. Pat. No. 6,877,410 on Apr. 12, 2005;

Ser. No. 12/661,993, filed Mar. 26, 2010, which is a continuation of Ser. No. 11/982,972, filed Nov. 5, 2007, issuing as U.S. Pat. No. 7,685,912 on Mar. 30, 2010, which is a continuation of Ser. No. 10/932,339, filed Sep. 1, 2004, issuing as U.S. Pat. No. 7,290,472 on Nov. 6, 2007, which is a continuation of Ser. No. 10/047,066, filed Jan. 14, 2002, issuing as U.S. Pat. No. 6,945,148 on Sep. 20, 2005, which in turn claimed the benefit of and priority from the following U.S. Provisional Patent Application Ser. No. 60/270,011, filed Feb. 20, 2001, Ser. No. 60/270,941, filed Feb. 22, 2001, Ser. No. 60/270,942, filed Feb. 22, 2001, Ser. No. 60/273,177, filed Mar. 2, 2001, Ser. No. 60/273,178, filed Mar. 2, 2001, and Ser. No. 60/273,902, filed Mar. 6, 2001; and Ser. No. 10/932,339 is also a continuation of Ser. No. 10/050,085, filed Jan. 14, 2002, now abandoned;

Ser. No. 10/100,211, filed Mar. 13, 2002, which claims the benefit of and priority from U.S. Provisional Patent Application Ser. No. 60/275,583, filed Mar. 13, 2001;

Ser. No. 11/256,757, filed Oct. 24, 2005, which is a continuation of Ser. No. 09/955,418, filed Sep. 17, 2001, issuing as U.S. Pat. No. 6,957,601 on Oct. 25, 2005, which in turn claimed the benefit of and priority to a number of U.S. Provisional Patent Applications, including: Ser. No. 60/233,459, filed Sep. 18, 2000, Ser. No. 60/270,011, filed Feb. 20, 2001, Ser. No. 60/270,941, filed Feb. 22, 2001, Ser. No. 60/270,942, filed Feb. 22, 2001, Ser. No. 60/273,177, filed Mar. 2, 2001, Ser. No. 60/273,178, filed Mar. 2, 2001, Ser. No. 60/273,902, filed Mar. 6, 2001, Ser. No. 60/275,594, filed Mar. 13, 2001, Ser. No. 60/275,595, filed Mar. 13, 2001, Ser. No. 60/279,313, filed Mar. 27, 2001, Ser. No. 60/292,081, filed May 17, 2001, Ser. No. 60/292,100, filed May 17, 2001, Ser. No. 60/298,207, filed Jun. 13, 2001, Ser. No. 60/302,937, filed Jul. 2, 2001, Ser. No. 60/302,916, filed Jul. 3, 2001, Ser. No. 60/306,202, filed Jul. 18, 2001, Ser. No. 60/307,756, filed Jul. 25, 2001, Ser. No. 60/308,492, filed Jul. 27, 2001, and Ser. No. 60/312,141, filed Aug. 13, 2001;

Ser. No. 10/146,527, filed May 15, 2002, which claims the benefit of and priority from U.S. Provisional Patent Application Ser. No. 60/292,100, filed May 17, 2001;

Ser. No. 12/586,469, filed Sep. 21, 2009, which is a continuation of Ser. No. 11/702,330, filed Feb. 5, 2007, issuing as U.S. Pat. No. 7,591,210 on Sep. 22, 2009, which is a continuation of Ser. No. 10/189,031, filed Jul. 2, 2002, issuing as U.S. Pat. No. 7,171,879 on Feb. 6, 2007, which claims the benefit of and priority from U.S. Provisional Patent Application Ser. No. 60/302,937, filed Jul. 2, 2001;

Ser. No. 11/208,214, filed Aug. 19, 2005, issuing as U.S. Pat. No. 7,784,507 on Aug. 31, 2010, which is a continuation of Ser. No. 10/251,576, filed Sep. 20, 2002, now abandoned, which is a continuation of Ser. No. 10/197,975, filed Jul. 18, 2002, now abandoned, and which claimed the benefit of and priority to U.S. Provisional Patent Application Ser. No. 60/323,975, filed Sep. 21, 2001, and Ser. No. 11/208,214 is also a continuation of Ser. No. 09/676,190, filed Sep. 29, 2000, issuing as U.S. Pat. No. 7,055,417 on Jun. 6, 2006, which in turn claimed the benefit of and priority from U.S. Provisional Patent Application Ser. No. 60/157,340, filed Oct. 1, 1999 and Ser. No. 60/182,866, filed Feb. 16, 2000;

Ser. No. 12/231,080, filed Aug. 29, 2008, issuing as U.S. Pat. No. 7,900,541 on Mar. 8, 2011, which is a continuation of Ser. No. 11/487,717, filed Jul. 17, 2006, issuing as U.S. Pat. No. 7,421,315, on Sep. 2, 2008, which is a continuation of U.S. patent application Ser. No. 10/292,607, filed Nov. 12, 2002, issued as U.S. Pat. No. 7,077,039 on Jul. 18, 2006, which claims the benefit of and priority from U.S. Provisional Patent Application Ser. No. 60/335,970, filed Nov. 13, 2001;

Ser. No. 12/655,962, filed Jan. 11, 2010, now abandoned, which is a continuation of Ser. No. 12/313,277, filed Nov. 17, 2008, issuing as U.S. Pat. No. 7,644,645 on Jan. 12, 2010, which is a continuation of Ser. No. 10/345,630, filed Jan. 15,

2003, which claims the benefit of and priority from U.S. Provisional Patent Application Ser. No. 60/349,989, filed Jan. 16, 2002;

Ser. No. 12/658,759, filed Feb. 12, 2010, now abandoned, which is a continuation of Ser. No. 11/787,471, filed Apr. 17, 2007, issuing as U.S. Pat. No. 7,661,343 on Feb. 16, 2010, which is a continuation of Ser. No. 10/341,260, filed Jan. 13, 2003, now abandoned, which claims the benefit of and priority from U.S. Provisional Patent Application Ser. No. 60/351,797, filed Jan. 25, 2002;

Ser. No. 11/647,676, filed Dec. 29, 2006, issuing as U.S. Pat. No. 7,836,804 on Nov. 23, 2010, which is a continuation of Ser. No. 10/923,290, filed Aug. 20, 2004, issuing as U.S. Pat. No. 7,472,634 on Jan. 6, 2009, which claims the benefit of and priority from U.S. Provisional Patent Application Ser. No. 60/496,550, filed Aug. 20, 2003;

Ser. No. 12/079,820, filed Mar. 27, 2008, issuing as U.S. Pat. No. 7,845,258 on Dec. 7, 2010, which is a continuation of Ser. No. 10/923,273, filed Aug. 20, 2004, issuing as U.S. Pat. No. 7,350,445 on Apr. 1, 2008, which claims the benefit of and priority from U.S. Provisional Patent Application Ser. No. 60/496,574, filed Aug. 20, 2003;

Ser. No. 12/454,569, filed May 18, 2009, which is a continuation of Ser. No. 11/027,600, filed Dec. 31, 2004, issuing as U.S. Pat. No. 7,536,238 on May 19, 2009, which claims the benefit of and priority from U.S. Provisional Patent Application Ser. No. 60/533,791, filed Dec. 31, 2003;

Ser. No. 12/799,915, filed May 3, 2010, which is a continuation of Ser. No. 12/322,069, filed Jan. 26, 2009, issuing as U.S. Pat. No. 7,707,918 on May 4, 2010, which is a continuation of U.S. patent application Ser. No. 11/107,499, filed Apr. 15, 2005, issuing as U.S. Pat. No. 7,481,140 on Jan. 27, 2009;

Ser. No. 12/077,576, filed Mar. 19, 2008, now abandoned, which is a continuation of Ser. No. 11/027,254, filed Dec. 31, 2004, now abandoned, which claims the benefit of and priority from U.S. Provisional Patent Application Ser. No. 60/533,852, filed Dec. 31, 2003;

Ser. No. 12/799,920, filed May 3, 2010, which is a continuation of Ser. No. 11/026,114, filed Dec. 31, 2004, issuing as U.S. Pat. No. 7,707,920 on May 4, 2010, which claims the benefit of and priority from U.S. Provisional Patent Application Ser. No. 60/533,811, filed Dec. 31, 2003;

Ser. No. 11/026,006, filed Dec. 31, 2004, which claims the benefit of and priority from U.S. Provisional Patent Application Ser. No. 60/533,575, filed Dec. 31, 2003;

Ser. No. 11/045,972, filed Jan. 28, 2005, issuing as U.S. Pat. No. 7,827,890 on Nov. 9, 2010, which claims the benefit of and priority from U.S. Provisional Patent Application Ser. No. 60/540,377, filed Jan. 29, 2004; and

Ser. No. 12/454,730, filed May 20, 2009, which is a continuation of Ser. No. 11/395,502, filed Mar. 31, 2006, which claims the benefit of and priority from U.S. Provisional Patent Application Ser. No. 60/667,485, filed Mar. 31, 2005.

FIELD

The present disclosure relates to safety systems and more particularly to methods for enhancing the safety of power equipment.

BACKGROUND

Power equipment such as table saws, miter saws and other woodworking machinery include cutting tools like circular saw blades and knife blades that present a risk of injury to a user of the equipment. Accordingly, safety features or systems are incorporated with power equipment to minimize the risk of injury. Probably the most common safety feature is a guard that physically blocks an operator from making contact with dangerous components of machinery, such as belts, shafts or blades. In many cases, guards effectively reduce the risk of injury, however, there are many instances where the nature of the operations to be performed precludes using a guard that completely blocks access to hazardous machine parts.

Other safety systems try to prevent or minimize injury by detecting and reacting to an event. For instance, U.S. Pat. Nos. 3,953,770, 4,075,961, 4,470,046, 4,532,501 and 5,212,621, the disclosures of which are incorporated herein by reference, disclose radio-frequency safety systems which utilize radio-frequency signals to detect the presence of a user's hand in a dangerous area of the machine and thereupon prevent or interrupt operation of the machine. U.S. Pat. Nos. 3,785,230 and 4,026,177, the disclosures of which are herein incorporated by reference, disclose a safety system for use on circular saws to stop the blade when a user's hand approaches the blade. The system uses the blade as an antenna in an electromagnetic proximity detector to detect the approach of a user's hand prior to actual contact with the blade. Upon detection of a user's hand, the system engages a brake using a standard solenoid.

U.S. Pat. No. 4,117,752, which is herein incorporated by reference, discloses a braking system for use with a band saw, where the brake is triggered by actual contact between the user's hand and the blade. However, the system described for detecting blade contact does not appear to be functional to accurately and reliably detect contact. Furthermore, the system relies on standard electromagnetic brakes operating off of line voltage to stop the blade and pulleys of the band saw. It is believed that such brakes would take 50 ms-1 s to stop the blade. Therefore, the system is too slow to stop the blade quickly enough to avoid serious injury.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a schematic block diagram of a machine with a fast-acting safety system.

FIG. **2** is a schematic diagram of an exemplary safety system in the context of a machine having a circular blade.

FIG. **3** is a schematic side view of a table saw with a retraction system.

FIG. **4** is a schematic side view of a second side of a table saw with a retraction system.

FIG. **5** is a schematic, side view of a saw with another embodiment of a retraction system.

FIG. **6** is a section view of a retraction system using a deformable bushing.

FIG. **7** is a schematic side view of a miter saw with a retraction system.

FIG. **8** is a section view of the miter saw shown in FIG. **7**.

FIG. **9** shows another embodiment of a miter saw with a retraction system.

FIG. **10** shows a schematic drawing of a retraction system using a spring to retract a cutting tool.

FIG. **11** is a sectional view of the retraction system shown in FIG. **10**.

FIG. **12** also is a sectional view of the retraction system shown in FIG. **10**.

FIG. **13** is a schematic view of a band saw with a retraction system.

FIG. **14** is a top view of a roller used in the system shown in FIG. **13**.

FIG. **15** shows an explosive charge that can be triggered by a firing subsystem.

FIG. **16** is a schematic side elevation view of a miter saw having an alternative exemplary safety system configured to stop the miter saw pivot arm as well as the blade.

FIG. **17** is a magnified side view of an exemplary retraction assembly according to the present invention.

FIG. **18** is a magnified cross-sectional view of the retraction assembly of FIG. **17**.

FIG. **19** is a magnified, fragmentary view of the retraction assembly of FIG. **17**, showing the restraining mechanism in detail.

FIG. **20** is similar to FIG. **18** except that the clamping device is shown pivoted to the locked position.

FIG. **21** is similar to FIG. **20** except that the housing is shown pushed upward relative to the brace member. For clarity, the components of the restraining member are not shown.

DETAILED DESCRIPTION

A machine that may incorporate a retraction system according to the present disclosure is shown schematically in FIG. **1** and indicated generally at **10**. Machine **10** may be any of a variety of different machines adapted for cutting workpieces, such as wood, including a table saw, miter saw (chop saw), radial arm saw, circular saw, band saw, jointer, planer, etc. Machine **10** includes an operative structure **12** having a cutting tool **14** and a motor assembly **16** adapted to drive the cutting tool. Machine **10** also includes a safety system **18** configured to minimize the potential of a serious injury to a person using machine **10**. Safety system **18** is adapted to detect the occurrence of one or more dangerous conditions during use of machine **10**. If such a dangerous condition is detected, safety system **18** is adapted to engage operative structure **12** to limit any injury to the user caused by the dangerous condition.

Machine **10** also includes a suitable power source **20** to provide power to operative structure **12** and safety system **18**. Power source **20** may be an external power source such as line current, or an internal power source such as a battery. Alternatively, power source **20** may include a combination of both external and internal power sources. Furthermore, power source **20** may include two or more separate power sources, each adapted to power different portions of machine **10**.

It will be appreciated that operative structure **12** may take any one of many different forms, depending on the type of machine **10**. For example, operative structure **12** may include a stationary housing configured to support motor assembly **16** in driving engagement with cutting tool **14**. Alternatively, operative structure **12** may include a movable structure configured to carry cutting tool **14** between multiple operating positions. As a further alternative, operative structure **12** may include one or more transport mechanisms adapted to convey a workpiece toward and/or away from cutting tool **14**.

Motor assembly **16** includes one or more motors adapted to drive cutting tool **14**. The motors may be either directly or indirectly coupled to the cutting tool, and may also be adapted to drive workpiece transport mechanisms. Cutting tool **14** typically includes one or more blades or other suitable cutting implements that are adapted to cut or remove portions from the workpieces. The particular form of cutting tool **14** will vary depending upon the various embodiments of machine **10**. For example, in table saws, miter saws, circular saws and radial arm saws, cutting tool **14** will typically include one or more circular rotating blades having a plurality of teeth disposed along the perimetrical edge of the blade. For a jointer or planer, the cutting tool typically includes a plurality of radially spaced-apart blades. For a band saw, the cutting tool includes an elongate, circuitous tooth-edged band.

Safety system **18** includes a detection subsystem **22**, a reaction subsystem **24** and a control subsystem **26**. Control subsystem **26** may be adapted to receive inputs from a variety of sources including detection subsystem **22**, reaction subsystem **24**, operative structure **12** and motor assembly **16**. The control subsystem may also include one or more sensors adapted to monitor selected parameters of machine **10**. In addition, control subsystem **26** typically includes one or more instruments operable by a user to control the machine. The control subsystem is configured to control machine **10** in response to the inputs it receives.

Detection subsystem **22** is configured to detect one or more dangerous, or triggering, conditions during use of machine **10**. For example, the detection subsystem may be configured to detect that a portion of the user's body is dangerously close to, or in contact with, a portion of cutting tool **14**. As another example, the detection subsystem may be configured to detect the rapid movement of a workpiece due to kickback by the cutting tool, as is described in U.S. Provisional Patent Application Ser. No. 60/182,866, the disclosure of which is herein incorporated by reference. In some embodiments, detection subsystem **22** may inform control subsystem **26** of the dangerous condition, which then activates reaction subsystem **24**. In other embodiments, the detection subsystem may be adapted to activate the reaction subsystem directly.

Once activated in response to a dangerous condition, reaction subsystem **24** is configured to engage operative structure **12** quickly to prevent serious injury to the user. It will be appreciated that the particular action to be taken by reaction subsystem **24** will vary depending on the type of machine **10** and/or the dangerous condition that is detected. For example, reaction subsystem **24** may be configured to do one or more of the following: stop the movement of cutting tool **14**, disconnect motor assembly **16** from power source **20**, place a barrier between the cutting tool and the user, or retract the cutting tool from its operating position, etc. The reaction subsystem may be configured to take a combination of steps to protect the user from serious injury. Placement of a barrier between the cutting tool and teeth is described in more detail in U.S. Provisional Patent Application Ser. No. 60/225,206, entitled "Cutting Tool Safety System," filed Aug. 14, 2000 by SD3, LLC, the disclosure of which is herein incorporated by reference.

The configuration of reaction subsystem **24** typically will vary depending on which action(s) are taken. In the exemplary embodiment depicted in FIG. **1**, reaction subsystem **24** is configured to stop the movement of cutting tool **14** and includes a brake mechanism **28**, a biasing mechanism **30**, a restraining mechanism **32**, and a release mechanism **34**. Brake mechanism **28** is adapted to engage operative structure **12** under the urging of biasing mechanism **30**. During normal operation of machine **10**, restraining mechanism **32** holds the brake mechanism out of engagement with the operative structure. However, upon receipt of an activation signal by reaction subsystem **24**, the brake mechanism is released from the restraining mechanism by release mechanism **34**, whereupon, the brake mechanism quickly engages at least a portion of the operative structure to bring the cutting tool to a stop.

It will be appreciated by those of skill in the art that the exemplary embodiment depicted in FIG. **1** and described above may be implemented in a variety of ways depending on the type and configuration of operative structure **12**. Turning attention to FIG. **2**, one example of the many possible implementations of safety system **18** is shown. System **18** is configured to engage an operative structure having a cutting tool

in the form of a circular blade **40** mounted on a rotating shaft or arbor **42**. Blade **40** includes a plurality of cutting teeth (not shown) disposed around the outer edge of the blade. As described in more detail below, braking mechanism **28** is adapted to engage the teeth of blade **40** and stop the rotation of the blade. U.S. Provisional Patent Application Ser. No. 60/225,210, entitled "Translation Stop For Use In Power Equipment," filed Aug. 14, 2000 by SD3, LLC, the disclosure of which is herein incorporated by reference, describes other systems for stopping the movement of the cutting tool. U.S. Provisional Patent Application Ser. No. 60/225,058, entitled "Table Saw With Improved Safety System," filed Aug. 14, 2000 by SD3, LLC, and U.S. Provisional Patent Application Ser. No. 60/225,057, entitled "Miter Saw With Improved Safety System," filed Aug. 14, 2000 by SD3, LLC, the disclosures of which are herein incorporated by reference, describe safety system **18** in the context of particular types of machines **10**.

In the exemplary implementation, detection subsystem **22** is adapted to detect the dangerous condition of the user coming into contact with blade **40**. The detection subsystem includes a sensor assembly, such as contact detection plates **44** and **46**, capacitively coupled to blade **40** to detect any contact between the user's body and the blade. Typically, the blade, or some larger portion of cutting tool **14** is electrically isolated from the remainder of machine **10**. Alternatively, detection subsystem **22** may include a different sensor assembly configured to detect contact in other ways, such as optically, resistively, etc. In any event, the detection subsystem is adapted to transmit a signal to control subsystem **26** when contact between the user and the blade is detected. Various exemplary embodiments and implementations of detection subsystem **22** are described in more detail in U.S. Provisional Patent Application Ser. No. 60/225,200, entitled "Contact Detection System For Power Equipment," filed Aug. 14, 2000 by SD3, LLC, and U.S. Provisional Patent Application Ser. No. 60/225,211, entitled "Apparatus And Method For Detecting Dangerous Conditions In Power Equipment," filed Aug. 14, 2000 by SD3, LLC, the disclosures of which are herein incorporated by reference.

Control subsystem **26** includes one or more instruments **48** that are operable by a user to control the motion of blade **40**. Instruments **48** may include start/stop switches, speed controls, direction controls, etc. Control subsystem **26** also includes a logic controller **50** connected to receive the user's inputs via instruments **48**. Logic controller **50** is also connected to receive a contact detection signal from detection subsystem **22**. Further, the logic controller may be configured to receive inputs from other sources (not shown) such as blade motion sensors, workpiece sensors, etc. In any event, the logic controller is configured to control operative structure **12** in response to the user's inputs through instruments **48**. However, upon receipt of a contact detection signal from detection subsystem **22**, the logic controller overrides the control inputs from the user and activates reaction subsystem **24** to stop the motion of the blade. Various exemplary embodiments and implementations of control subsystem **26** are described in more detail in U.S. Provisional Patent Application Ser. No. 60/225,059, entitled "Logic Control For Fast Acting Safety System," filed Aug. 14, 2000 by SD3, LLC, and U.S. Provisional Patent Application Ser. No. 60/225,094, entitled "Motion Detecting System For Use In Safety System For Power Equipment," filed Aug. 14, 2000 by SD3, LLC, the disclosures of which are herein incorporated by reference.

In the exemplary implementation, brake mechanism **28** includes a pawl **60** mounted adjacent the edge of blade **40** and selectively moveable to engage and grip the teeth of the blade. Pawl **60** may be constructed of any suitable material adapted to engage and stop the blade. As one example, the pawl may be constructed of a relatively high strength thermoplastic material such as polycarbonate, ultrahigh molecular weight polyethylene (UHMW) or Acrylonitrile Butadiene Styrene (ABS), etc., or a metal such as aluminum, etc. It will be appreciated that the construction of pawl **60** will vary depending on the configuration of blade **40**. In any event, the pawl is urged into the blade by a biasing mechanism in the form of a spring **66**. In the illustrative embodiment shown in FIG. **2**, pawl **60** is pivoted into the teeth of blade **40**. It should be understood that sliding or rotary movement of pawl **60** might also be used. The spring is adapted to urge pawl **60** into the teeth of the blade with sufficient force to grip the blade and quickly bring it to a stop.

The pawl is held away from the edge of the blade by a restraining mechanism in the form of a fusible member **70**. The fusible member is constructed of a suitable material adapted to restrain the pawl against the bias of spring **66**, and also adapted to melt under a determined electrical current density. Examples of suitable materials for fusible member **70** include NiChrome wire, stainless steel wire, etc. The fusible member is connected between the pawl and a contact mount **72**. Preferably, fusible member **70** holds the pawl relatively close to the edge of the blade to reduce the distance the pawl must travel to engage the blade. Positioning the pawl relatively close to the edge of the blade reduces the time required for the pawl to engage and stop the blade. Typically, the pawl is held approximately 1/32-inch to 1/4-inch from the edge of the blade by fusible member **70**, however other pawl-to-blade spacings may also be used within the scope of the invention.

Pawl **60** is released from its unactuated, or cocked, position to engage blade **40** by a release mechanism in the form of a firing subsystem **76**. The firing subsystem is coupled to contact mount **72**, and is configured to melt fusible member **70** by passing a surge of electrical current through the fusible member. Firing subsystem **76** is coupled to logic controller **50** and activated by a signal from the logic controller. When the logic controller receives a contact detection signal from detection subsystem **22**, the logic controller sends an activation signal to firing subsystem **76**, which melts fusible member **70**, thereby releasing the pawl to stop the blade. Various exemplary embodiments and implementations of reaction subsystem **24** are described in more detail in U.S. Provisional Patent Application Ser. No. 60/225,056, entitled "Firing Subsystem For Use In Fast Acting Safety System," filed Aug. 14, 2000 by SD3, LLC, U.S. Provisional Patent Application Ser. No. 60/225,170, entitled "Spring-Biased Brake Mechanism for Power Equipment," filed Aug. 14, 2000 by SD3, LLC, and U.S. Provisional Patent Application Ser. No. 60/225,169, entitled "Brake Mechanism For Power Equipment," filed Aug. 14, 2000 by SD3, LLC, the disclosures of which are herein incorporated by reference.

Other systems can also be used to shift the pawl or pawls into contact with the blade, and firing system **76** may also be used to trigger some action other than burning a fusible member. For example, firing system **76** can fire a small explosive charge to move a pawl. FIG. **15** shows a relatively small, self-contained explosive charge **660** in the form of a squib or detonator that can be used to drive pawl **60** against a blade. An example of a suitable explosive charge is an M-100 detonator available, for example, from Stresau Laboratory, Inc., of Spooner, Wis. Although any suitable explosive charge system may be used, the exemplary embodiment preferably uses a self-contained charge or squib to increase safety and focus the force of the explosion along the direction of movement of the

pawl. A trigger line **662** extends from the charge, and it may be connected to firing system **76** to trigger detonation.

Explosive charge **660** can be used to move pawl **60** by inserting the charge between the pawl and a stationary block **664** adjacent the charge. When the charge detonates, the pawl is pushed away from the block. A compression spring **66** is placed between the block and pawl to ensure the pawl does not bounce back from the blade when the charge is detonated. Prior to detonation, the pawl is held away from the blade by the friction-fit of the charge in both the block and pawl. However, the force created upon detonation of the charge is more than sufficient to overcome the friction fit. Alternatively, the pawl may be held away from the blade by other mechanisms such as a frangible member, gravity, a spring between the pawl and block, etc.

Firing system **76** may also trigger a DC solenoid, which can be over-driven with a current surge to create a rapid displacement, a pressurized air or gas cylinder to supply the pressure in place of the spring or charge, or an electromagnet to either repel the pawl against the blade or to release a spring-loaded pawl toward the blade.

It will be appreciated that activation of the brake mechanism will require the replacement of one or more portions of safety system **18**. For example, pawl **60** and fusible member **70** typically must be replaced before the safety system is ready to be used again. Thus, it may be desirable to construct one or more portions of safety system **18** in a cartridge that can be easily replaced. For example, in the exemplary implementation depicted in FIG. **2**, safety system **18** includes a replaceable cartridge **80** having a housing **82**. Pawl **60**, spring **66**, fusible member **70** and contact mount **72** are all mounted within housing **82**. Alternatively, other portions of safety system **18** may be mounted within the housing. In any event, after the reaction system has been activated, the safety system can be reset by replacing cartridge **80**. The portions of safety system **18** not mounted within the cartridge may be replaced separately or reused as appropriate. Various exemplary embodiments and implementations of a safety system using a replaceable cartridge are described in more detail in U.S. Provisional Patent Application Ser. No. 60/225,201, entitled "Replaceable Brake Mechanism For Power Equipment," filed Aug. 14, 2000 by SD3, LLC, and U.S. Provisional Patent Application Ser. No. 60/225,212, entitled "Brake Positioning System," filed Aug. 14, 2000 by SD3, LLC, the disclosures of which are herein incorporated by reference.

While one particular implementation of safety system **18** has been described, it will be appreciated that many variations and modifications are possible within the scope of the invention. Many such variations and modifications are described in U.S. Provisional Patent Application Ser. Nos. 60/182,866 and 60/157,340, the disclosures of which are herein incorporated by reference.

As briefly mentioned above, reaction subsystem **24** can be configured with a retraction system to retract or move a cutting tool away from the point of accidental contact with a user. Moving away from the point of accidental contact reduces the time the cutting tool is in contact with the user, thereby minimizing any injury to the user. Moving the cutting tool away from the point of accidental contact also prevents the cutting tool from moving toward the user, which could increase any injury to the user. For example, a spinning blade in a miter saw has substantial angular momentum, and that angular momentum could cause the blade to move downward toward a user when a brake pawl hits the blade. The spinning blade in a table saw also has substantial angular momentum that could cause the blade to move upward toward a user when a brake pawl hits the blade, depending on the position of the brake, the weight of the blade and the amount of play in the structure supporting the blade. Preventing any such movement lessens the potential injury to the user. A retraction system may be used in addition to or instead of other safety mechanisms.

FIGS. **3** and **4** show side views of a table saw configured with both a retraction system and a braking mechanism. A blade **300** is mounted on an arbor **301** to spin in the direction of arrow **302**. A table **303** (not shown in FIG. **4**), which defines the work surface or cutting region for the table saw, is adjacent the blade and the blade extends above the table. A support structure **304** may support blade **300** and arbor **301** in any known way, or as described in more detail in U.S. Provisional Patent Application Ser. No. 60/225,058, titled "Table Saw with Improved Safety System," filed Aug. 14, 2000.

Blade **300** is configured to pivot up and down so that a user can position the blade to extend above the table as needed. The blade pivots around a pin **305**. A user may pivot the blade to adjust its position by turning a shaft **306** on which a worm gear **307** is mounted. The worm gear is mounted on the shaft so that it turns with the shaft, but so that it may slide on the shaft when necessary, as explained below. Worm gear **307** is mounted on shaft **306** like a collar, with the shaft extending through a longitudinal hole in the worm gear. The worm gear is held in place during normal operation of the saw by a spring clip **308**, which is positioned in a groove or channel **309** on the worm gear and which also engages a detent or shoulder on shaft **306** to hold the worm gear in place. The worm gear engages an arcuate rack **310** that supports an arbor block **311**, which in turn supports arbor **301** and blade **300**. Thus, when a user turns shaft **306**, such as by turning a knob attached to the shaft (not shown), worm gear **307** moves arbor block **311** and the blade up or down, depending on the direction that the worm gear is turned.

A brake cartridge **312** is mounted in the saw adjacent blade **300**. The brake cartridge includes a pawl **314** biased toward blade **300** by a spring **316**. The pawl is held away from blade **300** by a release mechanism **318**, as described generally above and as described in more detail in U.S. Provisional Patent Application Ser. No. 60/225,170, entitled "Spring-Biased Brake Mechanism for Power Equipment," U.S. Provisional Patent Application Ser. No. 60/225,169, entitled "Brake Mechanism for Power Equipment," U.S. Provisional Patent Application Ser. No. 60/225,201, entitled "Replaceable Brake Mechanism for Power Equipment," and U.S. Provisional Patent Application Ser. No. 60/225,212, entitled "Brake Positioning System," all filed Aug. 14, 2000. The cartridge is configured so that the release mechanism releases the pawl into the blade upon the receipt of a detection signal, as explained generally above and as explained in more detail in U.S. Provisional Patent Application Ser. No. 60/225,056, titled "Firing Subsystem for use in a Fast-Acting Safety System," filed Aug. 14, 2000.

Brake cartridge **312** is positioned on the blade's pivot axis so that pawl **314** can move around pin **305**. Thus, when pawl **314** hits the blade, the angular momentum of the blade is transferred to the arbor block, and the blade, arbor block, rack and cartridge try to retract or move down in the direction of arrow **320**. Alternatively, the cartridge may be positioned on a pin different from pin **305**, but that still pivots with the blade.

The blade will move down to the extent permitted by the contact between rack **310** and worm gear **307**. If the worm gear is fixed in place, the downward movement of the blade may strip teeth on the rack and/or worm gear, and may prevent the blade from moving down as far as desired. In the embodiment shown in FIGS. **3** and **4**, the worm gear is adapted to snap free and move on shaft **306** when the pawl hits the blade.

When the pawl hits the blade, the resultant angular momentum impulse causes spring clip **308** to snap loose, allowing the worm gear to slide down the shaft toward an end **322** of the shaft. The spring clip snaps loose because the rack moves down when the blade is stopped, and the rack contacts the worm gear and forces the worm gear to move. The force of the rack against the worm gear causes the spring clip to snap loose. The worm gear is put back in place by moving it back along shaft **306** until the spring clip snaps into place on the shaft.

The table saw shown in FIGS. **3** and **4** also includes a support **326** configured with a seat or region **328** in which is placed an impact-absorbing material **330**. The support is positioned under the arbor and arbor block so that when the blade retracts, the arbor block strikes impact-absorbing material **330**. Support **326** and impact absorbing material **330** act as a barrier to stop the downward movement of the blade. The support is positioned so that blade **300** may retract a sufficient distance. The impact-absorbing material can be any one of a number of cushioning materials, such as rubber, dense foam, plastic, etc. One material found to be suitable is available under the part number C-1002-06 from AearoEAR, of Indianapolis, Ind. Alternatively, impact-absorbing material **330** may be attached to the undersurface of the arbor block instead of on support **326**. Additionally, support **326** may take many forms. In fact, shaft **306** may be configured and positioned so that it provides a surface to stop the downward movement of the blade.

FIG. **4** also shows a splitter **335** that extends above table **303** behind blade **300** to prevent kickback. A blade guard may also substantially enclose blade **300**. FIG. **4** further shows a housing **337** for electronic components relating to the safety system, and a motor mount **339**, which are not shown in FIG. **3**.

In the construction described above, the angular momentum of the blade causes the blade, arbor block and cartridge to all pivot down away from the cutting region when the pawl strikes the blade. Thus, the angular momentum of the blade causes the retraction. Blade **300** is permitted to move downward a sufficient distance so that the blade is completely retracted. In independent experiments, the safety system depicted in FIGS. **3** and **4** and described above has been shown to retract the blade completely below table **303** within approximately 14 milliseconds after contact is detected. Indeed the downward motion of the blade during retraction is too fast to detect with the human eye, i.e., the blade disappears below table **303** with no discernable transition or downward motion. The ability of the blade to retract minimizes any injury from accidental contact with the blade.

FIG. **5** shows another embodiment of a retraction system used with a brake pawl. A saw **331** includes a blade **300** and a brake cartridge **312** housing a brake pawl **314**. The cartridge and pawl are mounted to the frame of the saw by a pin **332**. The pin is mounted to the saw in such a way that it may not pivot up and down with the blade. When the blade hits the pawl, the blade climbs down the pawl, or in other words, moves generally around the point of contact with the pawl. The pawl and blade do not pivot downward together, as in the embodiment shown in FIGS. **3** and **4**, because the pawl is fixed to the frame of the saw. In this embodiment, the blade retracts by "climbing" down the pawl.

Another embodiment of a retraction system comprises a compressible bushing. Typically, a blade **300** in a table saw, miter saw or other machine is mounted to an arbor over a bushing **333**, as shown in FIG. **6**. A locking nut, washers and an arbor flange are used to secure the blade to the arbor. Bushing **333** may be constructed from a material that is soft enough to deform when the blade is stopped suddenly. For example, depending on the type of braking system used, a substantial radial impact load may be transmitted to the arbor when the brake is actuated. A deformable bushing can be used to absorb some of this impact and reduce the chance of damage to the arbor. In addition, proper positioning of the brake in combination with a deformable bushing may be employed to cause the blade to move away from the user upon activation of the brake. Where a plastic bushing is placed between the blade and the arbor, the substantial force created by stopping the blade almost instantly may cause the bushing to deform. Typically, the edge of the mounting hole of the blade will bite into the bushing as the blade attempts to rotate about the pawl. Therefore, if the pawl is mounted at the back of the blade, then the blade will tend to move downward into the bushing and away from the user when the pawl engages the blade.

FIGS. **7** and **8** show a miter saw equipped with both a brake and a retraction system. The miter saw is configured with a pivotal motor assembly to allow the blade to move upward into the housing upon engagement with a brake pawl **348**. Motor assembly **350** is connected to housing **352** via pivot bolt **354**, allowing the motor assembly to pivot about bolt **354** in the direction of blade rotation. A spring **356** is compressed between the motor assembly and an anchor **358** to bias the motor assembly against the direction of blade rotation. The motor assembly may include a lip **360**, which slides against a flange **362** on the housing to hold the end of the motor assembly opposite the pivot bolt against the housing.

When the saw is in use, spring **356** holds the motor assembly in a normal position rotated fully counter to the direction of blade rotation. However, once the pawl is released to engage the blade, the motor assembly and blade pivot upward against the bias of the spring. In this embodiment, the pawl is positioned at the front of the blade so that the pivot bolt **354** is between the pawl and the arbor. This arrangement encourages the blade to move upward into the housing when stopped. The spring is selected to be sufficiently strong to hold the motor assembly down when cutting through a workpiece, but sufficiently compressible to allow the blade and motor assembly to move upward when the blade is stopped. Of course, the blade and motor assembly may be configured in any of a variety of ways to at least partially absorb the angular momentum of the blade.

FIG. **9** shows an alternative configuration of a miter saw adapted to move away from an accidental contact with a user by absorbing the angular momentum of the blade. In this configuration, the miter saw includes two swing arms **370** and **372**. One end **374** of each swing arm **370**, **372** is connected to base **376**, and the opposite end **378** of each swing arm is connected to housing **380**, the blade, and/or the motor assembly (not shown). The position of the swing arms relative to each other may vary depending on the swing arm motion desired. In FIG. **9**, swing arm **370** is connected to base **376** somewhat below and forward of swing arm **372**. Typically, the motor assembly is rigidly attached to end **378** of swing arm **370**, while housing **380** is connected to rotate about end **378** of swing arm **370**. End **378** of swing arm **372** is connected only to the housing. Alternatively, the motor assembly may be connected to rotate about end **378** of swing arm **370** along with the housing.

The geometry of the configuration shown in FIG. **9** causes the housing and/or motor assembly to rotate as the swing arms pivot. Significantly, when the swing arms move upward, the housing and/or motor assembly rotate in the same direction in which the blade rotates during cutting. As a result, when a brake pawl engages the blade and transfers the angular momentum of the blade to the housing and/or motor assem-

bly, the housing and/or motor assembly tend to rotate in the same direction as the blade. This causes the swing arms to pivot upward, drawing the blade away from the workpiece and the user's body. Thus, the miter saw configuration illustrated in FIG. **9** is adapted to absorb the angular momentum of the blade and translate that angular momentum into an upward force on the swing arms.

In any of the systems described above, a spring or other force can be used to push the blade away from the point of contact with the user. The spring could be released by a mechanism similar to the mechanism that releases the pawl to strike the blade. FIGS. **10-12** show how a spring may be used to retract a blade in a table saw. FIG. **10** is a top view and FIGS. **11** and **12** are side views of an arbor block **381** holding an arbor **382** used to drive a blade (not shown). Arbor block **381** is pivotally mounted to pin **383** so that the arbor block and blade may pivot up and down to adjust the position of the blade in the saw.

A segment gear **384**, like rack **310** described above in connection with FIGS. **3** and **4**, is also mounted on pin **383**, and is connected to arbor block **381** in the manner described below, to raise and lower the arbor. Segment gear **384** includes a side portion **385** positioned substantially perpendicularly to the plane of arbor block **381**, and a top portion **386** positioned over arbor block **381**. The side portion **385** includes gear teeth **387** to engage a worm gear to raise and lower the arbor block. Side portion **385** and top portion **386** are connected to each other and move together. Top portion **386** extends over the top of the entire arbor block, as shown. The arbor block is constructed with a region to accommodate top portion **386** so that top portion **386** does not extend substantially above the arbor block, which could limit the ability of the arbor block and blade to pivot upward when desired, such as by contacting the underside of a table in a table saw.

A pocket **388** is formed in arbor block **381** to house a spring **389**. In the position shown in FIG. **11**, spring **389** is compressed between top portion **386** of segment gear **384** and arbor block **381** because the segment gear and arbor block are coupled together.

The segment gear and arbor block are coupled by a compound linkage having, as shown in FIG. **12**, a first arm **390** attached at one end to the arbor block and at its other end to a second arm **391**. The second arm, in turn, is attached to top portion **386** of segment gear **384**, as shown. First and second arms **390** and **391** are hingedly connected to each other, and to the arbor block and segment gear. The arms are configured so that the force of the spring pushing apart the arbor block and the top portion of the segment gear biases the first and second arms in such a way that the arms want to move. A fusible member **392**, which may take the form of a wire as described above, restrains the arms from movement. Of course, numerous different linkages may be used, and numerous types and configurations of fusible members or other release mechanisms may be used. The linkage may be selected to provide a sufficient mechanical advantage so that the arbor block and top portion of the segment gear may be held together with as thin a fusible member as possible, so that the fusible member may be burned as easily as possible. Various analogous compound linkages are described in U.S. Provisional Patent Application Ser. No. 60/225,170, entitled "Spring-Biased Brake Mechanism for Power Equipment," filed Aug. 14, 2000. The fusible member may be burned by a system as described above, or as described in more detail in U.S. Provisional Patent Application Ser. No. 60/225,056, entitled "Firing Subsystem for Use in Fast-Acting Safety System," filed Aug. 14, 2000, the disclosure of which is hereby incorporated by reference. The compound linkage and the fusible member are preferably configured so that they accommodate spring forces of 100 to 500 pounds or more. In other embodiments, the restraining member may include various mechanical linkages, or may be part of various actuators, and those linkages and/or actuators may be released or fired by solenoids, gas cylinders, electromagnets, and/or explosives, as explained in U.S. Provisional Patent Application Ser. No. 60/302,916, entitled "Actuators for Use in Fast-Acting Safety Systems," filed Jul. 3, 2001, the disclosure of which is hereby incorporated by reference.

When the fusible member is burned, the compound linkage is free to move, and the spring pushes arbor block **381** down, away from top portion **386** of the segment gear, as shown by the dashed lines in FIG. **11**, thereby retracting the blade. The stronger the spring, the faster the blade will be retracted. The segment gear does not move because it is coupled through teeth **387** to a worm gear or some other structure.

Retracting a blade by a spring or some other force may be thought of as direct retraction. A spring or other force may be used with some other retraction system to increase the speed that a cutting tool retracts, or a spring or other force may be used as the sole means of retraction. The systems for direct retraction described above may be used on various pieces of equipment, including table saws, miter saws and band saws.

FIG. **13** is a schematic diagram of a system to retract the blade of a band saw. Typically, a band saw includes a main housing enclosing a pair of vertically spaced-apart wheels. The perimeter of each wheel is coated or covered in a high-friction material such as rubber, etc. A relatively thin, continuous loop blade tightly encircles both wheels. A workpiece is cut by passing it toward the blade in a cutting zone between the wheels. The workpiece is passed toward the blade on a table, which forms the bottom of the cutting zone.

The band saw shown in FIG. **13** includes roller **393** positioned adjacent the blade. The roller is configured to contact the blade and push the blade away from the point of accidental contact with a user. In addition, the roller may be configured to push the blade off the wheels, thereby stopping the motion of the blade. A top view of the roller is shown in FIG. **14** pushing against a blade in the direction of the arrow. The roller may be part of a cartridge, and may be released into the blade just as the pawls described above are released. The roller should have a diameter large enough so that the roller can roll over the teeth of the blade.

The systems for direct retraction of a cutting tool may also be implemented on hand-held circular saws. Such saws typically include a base plate that contacts a workpiece during sawing. The base plate supports the saw on the workpiece. The base plate may be configured so that it is pushed down when the blade contacts a user. The result of that action is to effectively retract the blade because the base plate would push the user away from the blade.

FIG. **16** illustrates an exemplary miter saw **89** having an alternative embodiment of safety system **18** configured to at least partially retract the pivot arm in the event of contact between the blade and the user's body.

Exemplary miter saw **89** includes a base assembly **90** adapted to support a workpiece (not shown) during cutting. Typically, one or more fences **92** are mounted on base assembly **90** and adapted to prevent the workpiece from shifting across the base assembly during cutting. Operative structure **12** is coupled to base assembly **90** and includes a platen **94**, a tilt mechanism **96**, and a pivot arm **98**. Platen **94** is coupled to base assembly **90** and rotatable, relative to the base assembly, about the axis indicated at A. Tilt mechanism **96** is coupled to platen **94**. At least a portion of the tilt mechanism is rotatable, relative to base assembly **90**, about the axis indicated at B.

Pivot arm **98** is coupled to tilt mechanism **96** and selectively pivotal toward and away from base assembly **90**, as illustrated in FIG. **16**. Typically, the pivot arm is biased upward away from base assembly **90** by a spring or other suitable mechanism.

Motor assembly **16** is mounted on pivot arm **98** and includes at least one motor **100** and a control handle **102**. Blade **40** is coupled to an arbor shaft (not shown) that is rotatably driven by motor **100**. Control handle **102** includes one or more controls (not shown) that are operable by a user to control motor **100**. A user brings blade **40** into contact with a workpiece by grasping control handle **102** and pulling pivot arm **98** downward against the upward bias from a nominal position (indicated generally by dash lines in FIG. **16**), toward base assembly **90**. Once the cutting operation is completed, the user allows the pivot arm to pivot upward toward the nominal position.

It will be appreciated by those of skill in the art that the miter saw configuration depicted in FIG. **16** and described above is one commonly referred to as a "compound miter saw," which allows a user to make a compound (i.e., both mitered and beveled) cut in a workpiece by adjusting the position of platen **94** and/or tilt mechanism **96**. However, there are many other miter saw configurations known to those of skill in the art which are also suitable for use with the present invention. Thus, it will be understood that the particular miter saw configurations depicted and described herein are provided to illustrate exemplary embodiments of the invention, and should not be interpreted to limit the scope or application of the present invention.

Although not shown in FIG. **16**, detection subsystem **22** and control subsystem **26** may be mounted at any desired location on miter saw **89** and configured to detect contact between blade **40** and a user's body as described above and in the references incorporated herein. Alternatively, the detection and control subsystems may be configured to detect contact between the user's body and some other portion of the miter saw such as a guard, etc. Upon receiving an activation signal, a first portion **104** of reaction subsystem **24** is configured to stop the rotation of blade **40**, while a second portion **106** of the reaction subsystem is configured to move pivot arm **98** upward away from the base assembly. In the exemplary embodiment, first portion **104** includes a brake pawl **60** mounted in a cartridge **80**, such as described above and in the incorporated references. Brake pawl **60** is selectively pivotal into blade **40** to stop the rotation of the blade. Alternatively, the first portion may employ other brake mechanisms such as described in the incorporated references. As a further alternative, first portion **104** may be omitted so that the rotation of blade **40** is not stopped in response to the occurrence of a dangerous condition.

In any event, second portion **106** retracts the pivot arm upward far enough to remove the blade from contact with the user's body. Preferably, the second portion is configured to move the pivot arm upward at least ⅛-inch, more preferably at least ¼-inch, and most preferably at least ½-inch or more. In embodiments where the reaction subsystem is configured to stop the rotation of blade **40**, the second portion preferably retracts the pivot arm before or at the same time the blade is stopped. This prevents the pivot arm from moving downward as a result of angular momentum transferred to the pivot arm from the blade. The second portion of the reaction subsystem may be triggered prior to the first portion, or the second portion may be configured to engage the pivot arm more quickly than the brake pawl engages the blade.

Second portion **106** of exemplary reaction subsystem **24** includes a brace member **108** and a retraction assembly **110**. Brace member **108** is pivotally coupled to tilt mechanism **96** at **105**. Retraction assembly **110** is pivotally coupled to pivot arm **98** at **107** and configured to slidably receive at least a portion of brace member **108**. The retraction assembly is configured to quickly grip or lock onto the brace member and urge the pivot arm upward upon receipt of an actuation signal from control subsystem **26**. Once the retraction assembly has been triggered, pivot arm **98** is prevented from further downward movement toward base assembly **90**. While second portion **106** is illustrated as having a single brace member and a single retraction assembly on one side of miter saw **89**, it will be appreciated that the reaction subsystem may alternatively include a plurality of brace members and/or retraction assemblies positioned at selected locations on miter saw **89**.

Brace member **108** may take any of a variety of different forms. In the exemplary embodiment, the brace member is an elongate bar or shaft pivotally coupled to tilt mechanism **96**. Brace member **108** may be constructed of any suitably rigid material such as steel, aluminum, plastic, ceramic, etc. The pivotal coupling between the brace member and the tilt mechanism allows the brace member to pivot as necessary to follow the retraction assembly as the pivot arm moves toward and away from the base assembly. In the exemplary embodiment, the brace member is coupled to the tilt mechanism by a ball-joint-rod-end-bearing coupling **105**, such as are available from a variety of sources including MSC Industrial Supply Company of Melville, N.Y. Alternatively, other types of couplings may be used, such as universal couplings, etc.

In the exemplary embodiment, brace member **108** is coupled to an arm portion **112** of tilt mechanism **96** that extends outward from the tilt mechanism toward the base assembly. While arm **112** is depicted as an integral, unitary portion of the tilt mechanism, the arm portion may alternatively take the form of a separate bracket attached to the tilt mechanism. Alternatively, the arm may be omitted and brace member **108** may be coupled to another portion of the tilt mechanism. As further alternatives, the brace member may be coupled to a different portion of miter saw **10** such as platen **94**, fence **92**, or base assembly **90**, etc. In any event, the brace member should be relatively rigidly supported to ensure that pivot arm **98** is moved upward when retraction assembly **110** is triggered.

Retraction assembly **110** may be coupled to pivot arm **98** in any of a variety of different places. Typically, the retraction assembly and pivot point **107** are disposed to position brace member **108** spaced apart from pivot point **114** of arm **98** to increase the moment of the upward force applied by reaction subsystem **24** to pivot arm **98**. It will be appreciated that the further brace member **108** is positioned from pivot point **114**, the greater the moment of force provided by the retraction assembly. Thus, it is generally desirable, though not necessary, to position the brace member as close to the front of miter saw **89** (i.e., the left side as shown in FIG. **16**) as possible without interfering with the use of the miter saw. Similarly, the pivot point **105** of the brace member is disposed, relative to the retraction assembly, to orient the brace member generally perpendicular to the direction in which the pivot arm moves. This arrangement ensures that the downward force on the brace member is substantially a compression force rather than torque. Alternatively, retraction assembly **110** and pivot point **105** may be disposed at any selected positions suitable for stopping downward movement of pivot arm **98**.

Since brace member **108** is coupled to tilt mechanism **96**, the brace member will rotate along with pivot arm **98** about axis A when the miter saw is adjusted for mitered cuts. Similarly, the brace member will tilt about axis B when the miter

saw is adjusted for beveled cuts. Thus, the exemplary configuration of reaction subsystem **24** depicted in FIG. **16** allows a user to adjust miter saw **89** throughout its full range of movement.

Optionally, reaction subsystem **24** may include one or more positioning mechanisms configured to remove any play or looseness in the couplings between brace member **108** and tilt mechanism **96**, and/or the couplings between retraction assembly **110** and pivot arm **98**. In situations where play or looseness may be present, the positioning mechanism ensures that the brace member and retraction assembly do not shift when the reaction subsystem is triggered.

Turning attention now to FIGS. **17-21**, one exemplary embodiment of retraction assembly **110** is illustrated. Exemplary retraction assembly **110** is configured to grip and push downward on brace member **108** to move pivot arm **98** upward in response to an activation signal from control subsystem **26**. Retraction assembly **110** includes a housing **118** configured to slidably receive brace member **108**. Housing **118** includes a lower wall **120**, and an upper wall **122** spaced apart from the lower wall. Housing **118** also includes a first end wall **124** and a second end wall **126** extending between opposite ends of lower wall **120** and upper wall **122**. The lower, upper and end walls are connected together by any suitable mechanism such as bolts **127**. A pair of side walls **128** (shown in FIG. **16**) cover the sides of the lower, upper and end walls to enclose the housing.

Housing **118** is connected to the side of pivot arm **98** by a pivotal coupling **107** that allows the housing to move relative to the pivot arm as needed. Any of a variety of different couplings may be used which are known to those of skill in the art, such as a shoulder screw, etc. The pivotal coupling allows housing **118** to move as necessary to maintain a constant orientation or alignment with the brace member. In embodiments where the brace member is connected to a different structure on miter saw **89** such as platen **94** or fence **92**, coupling **107** may be configured to allow the housing to both pivot parallel to the side of the pivot arm and tilt away from the pivot arm as needed.

As mentioned above, housing **118** is configured to slide along brace member **108**. Lower wall portion **120** includes an orifice **130** configured to slide over the brace member. Similarly, upper wall portion **122** includes an orifice **132** configured to slide over the brace member. Orifices **130** and **132** are generally axially aligned and sized to closely fit around the brace member, thereby maintaining the housing in a uniform orientation relative to the brace member as pivot arm **98** is moved toward and away from the workpiece.

Retraction assembly **110** also includes an actuator **134** configured to selectively grip brace member **108** and push the housing upward. Actuator **134** may be any one or a combination of elements, devices or mechanisms configured to quickly and securely grip the brace member. In the exemplary embodiment, actuator **134** includes a clamping device **136** adapted to selectively grip the brace member, and a drive mechanism **138** adapted to urge the housing upward relative to the clamping device. Clamping device **136** is formed to define an orifice **140** adapted to closely fit and slide along the brace member. The clamping device is pivotal between a nominal or unactuated position (as shown in FIGS. **17** and **18**), and an actuated or locked position (as shown in FIG. **20**). When the clamping device is in the nominal position, the sides of orifice **140** are substantially aligned with the sides of brace member **108** so that the clamping device slides relatively freely along the brace member. Conversely, when the clamping device is pivoted into the locked or actuated position, the sides of orifice **140** press into and bind against the brace member to releasably lock the clamping device onto the brace member. Drive mechanism **138** is disposed between the clamping device and upper wall **122** and configured to push the upper wall away from the clamping device when the clamping device is in the locked position. As a result, housing **118** and pivot arm **98** are pushed upward relative to the brace member and base assembly **90**.

Clamping device **136** may be constructed of any suitable material adapted to grip the brace member and support the force exerted by drive mechanism **138**. Typically, the clamping device is constructed of a material which does not cause damage to brace member **108** when the retraction assembly is triggered. For example, the clamping device and brace member may each be formed from a relatively rigid material such as hardened steel. Alternatively, the clamping device and/or brace member may be formed of any of a variety of other suitable materials known to those of skill in the art.

When in the nominal position, clamping device **136** is disposed adjacent the lower surface of upper wall **122** between end walls **124** and **126**. The end walls are spaced to align the clamping device and orifice **140** end-to-end with the upper wall and orifice **132**. Each end wall is inwardly tapered adjacent the upper wall so as not to obstruct the movement of the clamping device. Upper wall **122** includes a pair of alignment structures **142** adapted to align the clamping device and orifice **140** side-to-side with the upper wall and orifice **132**. When clamping device **136** is in the nominal position, orifice **140** is generally axially aligned with orifice **132** and orifice **130** to slidably receive the brace member.

Clamping device **136** is held in the nominal position by a yieldable support element such as spring **144** that engages the clamping device adjacent a first end **146**, as well as a releasable restraining mechanism **148** that engages the clamping device adjacent a second end **150**. First end wall **124** includes a recessed region adapted to hold a portion of spring **144** and align the spring with the clamping device. Although spring **144** is depicted as a compression spring, it will be appreciated that spring **144** may be any type of spring or other mechanism adapted to yieldably hold first end **146** adjacent the lower surface of upper wall **122**.

Restraining mechanism **148** may take any of a variety of different configurations adapted to releasably support second end **150** of the clamping device. In the exemplary embodiment, drive mechanism **138** (which will be discussed in more detail below) exerts a constant downward force on the clamping device adjacent second end **150**. Restraining mechanism **148** is configured to support the clamping device against the force exerted by the drive mechanism. Typically, though not necessarily, the restraining mechanism is generally aligned with the drive mechanism to reduce any bending stress to the clamping device.

Exemplary restraining mechanism **148** is selectively collapsible to release the second end of the clamping device. The restraining mechanism includes an elongate collapsible base **154** adapted to support an elongate brace **156**. In its uncollapsed state illustrated in FIGS. **17-19**, a lower end **158** of base **154** rests on the upper surface of lower wall **120**. The base extends upward from the lower wall toward the clamping device. A lower end **160** of brace **156** rests on an upper end **162** of base **154**. The brace extends upward from the base to support the clamping device. When the base collapses, the brace is dislodged, thereby releasing the clamping device as shown in FIGS. **20-21**.

When in the uncollapsed, upright position, one side of base **154** is disposed against a buttress structure **164**. One side of lower end **160** of the brace is also disposed against the buttress structure, while an upper end **166** of the brace is disposed

against a shoulder structure **168** on the clamping device. Shoulder structure **168** is configured to position the brace in upright alignment on top of the base. Base **154** and brace **156** are clamped against the buttress structure by a stabilizer member **170**. The stabilizer member is held in clamping engagement with the base and the brace by a fusible member **70** such as described above and in the incorporated references. Fusible member **70** extends from the stabilizer member, over a contact mount **72** to an anchor point **172**. Contact mount **72** is coupled to a firing subsystem (not shown) adapted to supply sufficient electrical current to melt the fusible member. In the exemplary embodiment, contact mount **72** is anchored to buttress structure **164**, which is constructed of an electrically non-conducting material such as plastic, etc.

Lower end **158** of the base includes a beveled region **174** opposite the buttress structure. As shown in FIG. **19**, beveled region **174** extends through more than half the thickness of the base. Lower end **160** of the brace includes a beveled region **176** adjacent the buttress structure. As a result, a portion of the downward pressure exerted on the clamping device by the drive mechanism is translated onto upper end **162** as a pivoting force away from the buttress structure. The remainder of the downward force is translated into a downward force on lower wall **128**. The upper end of the base is prevented from pivoting outward so long as stabilizer structure **170** remains in place.

Those of skill in the art will appreciate that the particular configuration of restraining mechanism **148** described above provides a mechanical advantage for supporting second end **150** of the clamping device under the downward force of the drive mechanism. The proportion of downward force translated into pivoting force on the base will vary with the depth of beveled regions **174** and **176**. Beveled regions **174** and **176** typically are configured so that much of the downward force applied by the drive mechanism is translated into downward force on base **154** rather than pivoting force. As a result, fusible member **70** is only required to support a portion of the force exerted by the drive mechanism. Indeed, several hundred pounds of downward force may be translated into only 10-20 pounds of outward pivoting force on stabilizer structure **170**. This allows the fusible member to have a smaller diameter, thereby requiring less energy to melt. Nevertheless, the outward pivoting force should be sufficient to ensure the base collapses within 5-10 milliseconds, and preferably within 1-5 milliseconds.

In any event, when stabilizer member **170** is released, the upper end of base **154** quickly pivots outward from the buttress structure and collapses beneath the brace, as illustrated in FIGS. **19** and **20**. Upper end **166** of the brace includes a beveled region **178** opposite shoulder structure **168** to allow the lower end of the brace to freely pivot outward from the buttress structure along with the base. Second end **150** of the clamping device is thereby released to move downward under the urging of the drive mechanism.

While second end **150** of the clamping device is pushed downward by the drive mechanism, first end **146** is pushed upward by spring **144**. As a result, clamping device **136** pivots about brace member **108** into the locked position where the edges of orifice **140** bind against the sides of the brace member as shown in FIG. **20**. The angle through which the clamping device must pivot before binding against the brace member will vary based at least partially on the size differential between orifice **140** and brace member **108**. It is believed that the binding force generated by the clamping device against the brace member is increased where the pivot angle between the nominal position and the locked position is relatively small. Therefore, orifice **140** typically is sized to fit relatively closely around the brace member. For example, in an embodiment where brace member **108** takes the form of a rod having a circular cross-section with a diameter of approximately 0.375-inch, one suitable diameter for orifice **140** would be approximately 0.376-inch. Alternatively, other diameters may also be used within the scope of the invention. For clarity, the size difference between orifice **140** and brace member **108** is shown substantially exaggerated in FIGS. **18**, **20** and **21**.

As mentioned above, drive mechanism **138** is disposed between upper wall **122** and second end **150** of the clamping device. The drive mechanism is configured to urge the second end and upper wall apart when the clamping device is released from restraining mechanism **148**. Once clamping device **136** pivots to the locked position, further downward movement of second end **150** is prevented because the clamping device is locked against the brace member. As a result, the additional drive force exerted by the drive mechanism forces upper wall **122** and housing **118** upward relative to the clamping device and brace member, as illustrated in FIG. **21**. Since the housing is coupled to pivot arm **98**, the pivot arm is forced upward as well.

Drive mechanism **138** should be configured to overcome the downward momentum of the pivot arm as well as any transferred angular momentum caused by stopping blade **40**. In addition, the upward force exerted by the drive mechanism on the housing should be substantially larger than any downward force exerted by spring **144**. Typically, the drive mechanism is configured to provide 100-500 pounds of upward force on the pivot arm. The length of upward travel of the pivot arm will depend on the length of translation, or 'throw,' of the drive mechanism as well as the distance second end **150** pivots downward before locking against the brace member.

In the exemplary embodiment, drive mechanism **138** includes a plurality of Belleville springs **180** stacked in series. The number of springs in the series is selected to provide a desired throw. Optionally, each spring in the series may alternatively be plural springs stacked in parallel to provide a desired amount of driving force. Springs **180** are disposed in a recessed region **182** of upper wall **122**. The recessed region is sized to maintain the springs in general axial alignment. Additionally, clamping device **136** includes a spindle structure **183**, adapted to fit within the central bores of at least a portion of the springs to maintain alignment between the springs. The spindle structure also serves to maintain alignment between the springs and the clamping device. It will be appreciated by those of skill in the art that drive mechanism **138** may alternatively take any of a variety of other configurations adapted to lock the clamping device against the brace member and force the pivot arm upward. For example, the drive mechanism may include a coil compression spring, explosive device, etc.

In any event, once the retraction assembly has been triggered, it may be uncoupled from the pivot arm and slid off the brace member. A new, untriggered retraction assembly may then be installed to place miter saw **89** and safety system **18** back in operation. Alternatively, the triggered retraction assembly may be reset using a new fusible member.

While one particular implementation of retraction assembly **110** has been described, it will be appreciated that numerous alterations and modifications are possible within the scope of the invention. Additionally, while the retraction assembly has been described in the context of retracting the pivot arm of a miter saw, it will be appreciated that the retraction assembly may also be adapted for use in other ways and on other machines.

Machines that include various components and features discussed above may be described as follows:

A cutting machine comprising a cutter; a brake adapted to stop the cutter, where the brake has an idle position and a braking position; and an actuation system adapted to selectively move the brake from the idle position to the braking position, where at least a portion of the actuation system must be replaced after moving the brake from the idle position to the braking position; wherein the actuation system includes an explosive device.

A cutting machine comprising a support structure; a cutting tool adapted to cut a workpiece, where the cutting tool is supported by the support structure; a detection system adapted to detect a dangerous condition between the cutting tool and a person; a reaction system adapted to perform a specified action upon detection of the dangerous condition; an explosive to trigger the reaction system to perform the specified action upon firing of the explosive; and a firing subsystem to fire the explosive upon detection of the dangerous condition.

INDUSTRIAL APPLICABILITY

The present invention is applicable to power equipment, and specifically to woodworking equipment such as table saws, miter saws, band saws, circular saws, jointers, etc. The present invention provides a safety system or reaction system wherein a cutting tool or other dangerous item is retracted upon the occurrence of a specified event, such as when accidental contact between a user and a blade is detected. Retraction of a cutting tool, for example, can minimize any injury from accidental contact with the cutting tool by reducing the amount of time the cutting tool is in contact with a user or by moving the cutting tool to a position where the user cannot contact it. A retraction system may be used in combination with other safety features to maximize the performance of an overall safety system. For example, a retraction system may be used with a system that quickly stops a cutting tool so that the cutting tool simultaneously stops and moves away from a user. A fusible member or explosive may be used to trigger the reaction system to perform the specified action. A firing subsystem may be used to fuse the fusible member or fire the explosive upon detection of the dangerous condition.

It is believed that the disclosure set forth above encompasses multiple distinct inventions with independent utility. While each of these inventions has been disclosed in its preferred form, the specific embodiments thereof as disclosed and illustrated herein are not to be considered in a limiting sense as numerous variations are possible. The subject matter of the inventions includes all novel and non-obvious combinations and subcombinations of the various elements, features, functions and/or properties disclosed herein. No single feature, function, element or property of the disclosed embodiments is essential to all of the disclosed inventions. Similarly, where the claims recite "a" or "a first" element or the equivalent thereof, such claims should be understood to include incorporation of one or more such elements, neither requiring nor excluding two or more such elements.

It is believed that the following claims particularly point out certain combinations and subcombinations that are directed to one of the disclosed inventions and are novel and non-obvious. Inventions embodied in other combinations and subcombinations of features, functions, elements and/or properties may be claimed through amendment of the present claims or presentation of new claims in this or a related application. Such amended or new claims, whether they are directed to a different invention or directed to the same invention, whether different, broader, narrower or equal in scope to the original claims, are also regarded as included within the subject matter of the inventions of the present disclosure.

The invention claimed is:

1. A woodworking machine having a cutting region for cutting workpieces, comprising:

a movable cutting tool for cutting workpieces in the cutting region;

a detection system adapted to detect a dangerous condition between a person and the cutting tool; and

a reaction system associated with the detection system and the cutting tool, where the reaction system is configured to pivot the cutting tool at least partially away from the cutting region upon detection of the dangerous condition by the detection system.

2. The woodworking machine of claim **1** where the dangerous condition is contact between a person and the cutting tool.

3. The woodworking machine of claim **1** where the dangerous condition is proximity of a person to the cutting tool.

4. The woodworking machine of claim **1** further comprising a rotatable arbor on which the cutting tool is mounted, an arbor block adapted to support the arbor, and a support structure to which the arbor block is pivotally mounted; and where the reaction system is configured to pivot the arbor block and the arbor with the cutting tool at least partially away from the cutting region upon detection of the dangerous condition by the detection system.

5. The woodworking machine of claim **4** where the cutting tool is a circular blade, where the machine is configured to cut a workpiece by moving the workpiece in a feed direction past the blade, and where the arbor block is pivotally mounted to the support structure downstream from the blade relative to the feed direction.

6. The woodworking machine of claim **4** where the support structure includes a trunnion to which the arbor block is pivotally mounted.

7. The woodworking machine of claim **4** where the cutting tool is a circular blade, where the machine is configured to cut a workpiece by moving the workpiece in a feed direction past the blade, and where the arbor block is mounted to the support structure at a pivot point behind the blade relative to the feed direction.

8. The woodworking machine of claim **4** where the cutting tool is a circular blade, where the machine is configured to cut a workpiece by moving the workpiece in a feed direction past the blade, where the support structure includes a trunnion to which the arbor block is pivotally mounted, and where the trunnion is positioned behind the blade relative to the feed direction.

9. The woodworking machine of claim **1** further comprising a stop to limit the pivoting of the cutting tool.

10. The woodworking machine of claim **9** where the stop includes an impact-absorbing material.

11. The woodworking machine of claim **1**, where the reaction system includes an explosive.

* * * * *

JS 44 (Rev. 12/12)

CIVIL COVER SHEET

The JS 44 civil cover sheet and the information contained herein neither replace nor supplement the filing and service of pleadings or other papers as required by law, except as provided by local rules of court. This form, approved by the Judicial Conference of the United States in September 1974, is required for the use of the Clerk of Court for the purpose of initiating the civil docket sheet. *(SEE INSTRUCTIONS ON NEXT PAGE OF THIS FORM.)*

I. (a) PLAINTIFFS
SawStop, LLC & SD3, LLC

(b) County of Residence of First Listed Plaintiff Clackamas
(EXCEPT IN U.S. PLAINTIFF CASES)

(c) Attorneys *(Firm Name, Address, and Telephone Number)*
Bruce L. Campell, OSB 925377
Miller Nash Graham & Dunn LLP
111 SW Fifth Ave., Suite 3400, Portland, OR 97204

DEFENDANTS
Robert Bosch Tool Corporation & Robert Bosch GMBH

County of Residence of First Listed Defendant _____
(IN U.S. PLAINTIFF CASES ONLY)

NOTE: IN LAND CONDEMNATION CASES, USE THE LOCATION OF THE TRACT OF LAND INVOLVED.

Attorneys *(If Known)*

II. BASIS OF JURISDICTION *(Place an "X" in One Box Only)*

- ❒ 1 U.S. Government Plaintiff
- ☒ 3 Federal Question *(U.S. Government Not a Party)*
- ❒ 2 U.S. Government Defendant
- ❒ 4 Diversity *(Indicate Citizenship of Parties in Item III)*

III. CITIZENSHIP OF PRINCIPAL PARTIES *(Place an "X" in One Box for Plaintiff and One Box for Defendant)*
(For Diversity Cases Only)

	PTF	DEF		PTF	DEF
Citizen of This State	❒ 1	❒ 1	Incorporated *or* Principal Place of Business In This State	❒ 4	❒ 4
Citizen of Another State	❒ 2	❒ 2	Incorporated *and* Principal Place of Business In Another State	❒ 5	❒ 5
Citizen or Subject of a Foreign Country	❒ 3	❒ 3	Foreign Nation	❒ 6	❒ 6

IV. NATURE OF SUIT *(Place an "X" in One Box Only)*

CONTRACT
- ❒ 110 Insurance
- ❒ 120 Marine
- ❒ 130 Miller Act
- ❒ 140 Negotiable Instrument
- ❒ 150 Recovery of Overpayment & Enforcement of Judgment
- ❒ 151 Medicare Act
- ❒ 152 Recovery of Defaulted Student Loans (Excludes Veterans)
- ❒ 153 Recovery of Overpayment of Veteran's Benefits
- ❒ 160 Stockholders' Suits
- ❒ 190 Other Contract
- ❒ 195 Contract Product Liability
- ❒ 196 Franchise

REAL PROPERTY
- ❒ 210 Land Condemnation
- ❒ 220 Foreclosure
- ❒ 230 Rent Lease & Ejectment
- ❒ 240 Torts to Land
- ❒ 245 Tort Product Liability
- ❒ 290 All Other Real Property

TORTS

PERSONAL INJURY
- ❒ 310 Airplane
- ❒ 315 Airplane Product Liability
- ❒ 320 Assault, Libel & Slander
- ❒ 330 Federal Employers' Liability
- ❒ 340 Marine
- ❒ 345 Marine Product Liability
- ❒ 350 Motor Vehicle
- ❒ 355 Motor Vehicle Product Liability
- ❒ 360 Other Personal Injury
- ❒ 362 Personal Injury - Medical Malpractice

PERSONAL INJURY
- ❒ 365 Personal Injury - Product Liability
- ❒ 367 Health Care/ Pharmaceutical Personal Injury Product Liability
- ❒ 368 Asbestos Personal Injury Product Liability

PERSONAL PROPERTY
- ❒ 370 Other Fraud
- ❒ 371 Truth in Lending
- ❒ 380 Other Personal Property Damage
- ❒ 385 Property Damage Product Liability

CIVIL RIGHTS
- ❒ 440 Other Civil Rights
- ❒ 441 Voting
- ❒ 442 Employment
- ❒ 443 Housing/ Accommodations
- ❒ 445 Amer. w/Disabilities - Employment
- ❒ 446 Amer. w/Disabilities - Other
- ❒ 448 Education

PRISONER PETITIONS

Habeas Corpus:
- ❒ 463 Alien Detainee
- ❒ 510 Motions to Vacate Sentence
- ❒ 530 General
- ❒ 535 Death Penalty

Other:
- ❒ 540 Mandamus & Other
- ❒ 550 Civil Rights
- ❒ 555 Prison Condition
- ❒ 560 Civil Detainee - Conditions of Confinement

FORFEITURE/PENALTY
- ❒ 625 Drug Related Seizure of Property 21 USC 881
- ❒ 690 Other

LABOR
- ❒ 710 Fair Labor Standards Act
- ❒ 720 Labor/Management Relations
- ❒ 740 Railway Labor Act
- ❒ 751 Family and Medical Leave Act
- ❒ 790 Other Labor Litigation
- ❒ 791 Employee Retirement Income Security Act

IMMIGRATION
- ❒ 462 Naturalization Application
- ❒ 465 Other Immigration Actions

BANKRUPTCY
- ❒ 422 Appeal 28 USC 158
- ❒ 423 Withdrawal 28 USC 157

PROPERTY RIGHTS
- ❒ 820 Copyrights
- ☒ 830 Patent
- ❒ 840 Trademark

SOCIAL SECURITY
- ❒ 861 HIA (1395ff)
- ❒ 862 Black Lung (923)
- ❒ 863 DIWC/DIWW (405(g))
- ❒ 864 SSID Title XVI
- ❒ 865 RSI (405(g))

FEDERAL TAX SUITS
- ❒ 870 Taxes (U.S. Plaintiff or Defendant)
- ❒ 871 IRS—Third Party 26 USC 7609

OTHER STATUTES
- ❒ 375 False Claims Act
- ❒ 400 State Reapportionment
- ❒ 410 Antitrust
- ❒ 430 Banks and Banking
- ❒ 450 Commerce
- ❒ 460 Deportation
- ❒ 470 Racketeer Influenced and Corrupt Organizations
- ❒ 480 Consumer Credit
- ❒ 490 Cable/Sat TV
- ❒ 850 Securities/Commodities/ Exchange
- ❒ 890 Other Statutory Actions
- ❒ 891 Agricultural Acts
- ❒ 893 Environmental Matters
- ❒ 895 Freedom of Information Act
- ❒ 896 Arbitration
- ❒ 899 Administrative Procedure Act/Review or Appeal of Agency Decision
- ❒ 950 Constitutionality of State Statutes

V. ORIGIN *(Place an "X" in One Box Only)*

☒ 1 Original Proceeding ❒ 2 Removed from State Court ❒ 3 Remanded from Appellate Court ❒ 4 Reinstated or Reopened ❒ 5 Transferred from Another District *(specify)* ❒ 6 Multidistrict Litigation

VI. CAUSE OF ACTION

Cite the U.S. Civil Statute under which you are filing ***(Do not cite jurisdictional statutes unless diversity)***:
35 USC 271, 281

Brief description of cause:
Infringement of Patent '712, '455, '836, '927, '279 '450

VII. REQUESTED IN COMPLAINT:

❒ CHECK IF THIS IS A **CLASS ACTION** UNDER RULE 23, F.R.Cv.P.

DEMAND $

CHECK YES only if demanded in complaint:
JURY DEMAND: ☒ Yes ❒ No

VIII. RELATED CASE(S) IF ANY
(See instructions):

JUDGE _____ DOCKET NUMBER _____

DATE
07/16/2015

SIGNATURE OF ATTORNEY OF RECORD

FOR OFFICE USE ONLY

RECEIPT # _____ AMOUNT _____ APPLYING IFP _____ JUDGE _____ MAG. JUDGE _____

INSTRUCTIONS FOR ATTORNEYS COMPLETING CIVIL COVER SHEET FORM JS 44

Authority For Civil Cover Sheet

The JS 44 civil cover sheet and the information contained herein neither replaces nor supplements the filings and service of pleading or other papers as required by law, except as provided by local rules of court. This form, approved by the Judicial Conference of the United States in September 1974, is required for the use of the Clerk of Court for the purpose of initiating the civil docket sheet. Consequently, a civil cover sheet is submitted to the Clerk of Court for each civil complaint filed. The attorney filing a case should complete the form as follows:

I.(a) **Plaintiffs-Defendants.** Enter names (last, first, middle initial) of plaintiff and defendant. If the plaintiff or defendant is a government agency, use only the full name or standard abbreviations. If the plaintiff or defendant is an official within a government agency, identify first the agency and then the official, giving both name and title.

(b) **County of Residence.** For each civil case filed, except U.S. plaintiff cases, enter the name of the county where the first listed plaintiff resides at the time of filing. In U.S. plaintiff cases, enter the name of the county in which the first listed defendant resides at the time of filing. (NOTE: In land condemnation cases, the county of residence of the "defendant" is the location of the tract of land involved.)

(c) **Attorneys.** Enter the firm name, address, telephone number, and attorney of record. If there are several attorneys, list them on an attachment, noting in this section "(see attachment)".

II. **Jurisdiction.** The basis of jurisdiction is set forth under Rule 8(a), F.R.Cv.P., which requires that jurisdictions be shown in pleadings. Place an "X" in one of the boxes. If there is more than one basis of jurisdiction, precedence is given in the order shown below.
United States plaintiff. (1) Jurisdiction based on 28 U.S.C. 1345 and 1348. Suits by agencies and officers of the United States are included here.
United States defendant. (2) When the plaintiff is suing the United States, its officers or agencies, place an "X" in this box.
Federal question. (3) This refers to suits under 28 U.S.C. 1331, where jurisdiction arises under the Constitution of the United States, an amendment to the Constitution, an act of Congress or a treaty of the United States. In cases where the U.S. is a party, the U.S. plaintiff or defendant code takes precedence, and box 1 or 2 should be marked.
Diversity of citizenship. (4) This refers to suits under 28 U.S.C. 1332, where parties are citizens of different states. When Box 4 is checked, the citizenship of the different parties must be checked. (See Section III below; **NOTE: federal question actions take precedence over diversity cases.)**

III. **Residence (citizenship) of Principal Parties.** This section of the JS 44 is to be completed if diversity of citizenship was indicated above. Mark this section for each principal party.

IV. **Nature of Suit.** Place an "X" in the appropriate box. If the nature of suit cannot be determined, be sure the cause of action, in Section VI below, is sufficient to enable the deputy clerk or the statistical clerk(s) in the Administrative Office to determine the nature of suit. If the cause fits more than one nature of suit, select the most definitive.

V. **Origin.** Place an "X" in one of the six boxes.
Original Proceedings. (1) Cases which originate in the United States district courts.
Removed from State Court. (2) Proceedings initiated in state courts may be removed to the district courts under Title 28 U.S.C., Section 1441. When the petition for removal is granted, check this box.
Remanded from Appellate Court. (3) Check this box for cases remanded to the district court for further action. Use the date of remand as the filing date.
Reinstated or Reopened. (4) Check this box for cases reinstated or reopened in the district court. Use the reopening date as the filing date.
Transferred from Another District. (5) For cases transferred under Title 28 U.S.C. Section 1404(a). Do not use this for within district transfers or multidistrict litigation transfers.
Multidistrict Litigation. (6) Check this box when a multidistrict case is transferred into the district under authority of Title 28 U.S.C. Section 1407. When this box is checked, do not check (5) above.

VI. **Cause of Action.** Report the civil statute directly related to the cause of action and give a brief description of the cause. **Do not cite jurisdictional statutes unless diversity.** Example: U.S. Civil Statute: 47 USC 553 Brief Description: Unauthorized reception of cable service

VII. **Requested in Complaint.** Class Action. Place an "X" in this box if you are filing a class action under Rule 23, F.R.Cv.P.
Demand. In this space enter the actual dollar amount being demanded or indicate other demand, such as a preliminary injunction.
Jury Demand. Check the appropriate box to indicate whether or not a jury is being demanded.

VIII. **Related Cases.** This section of the JS 44 is used to reference related pending cases, if any. If there are related pending cases, insert the docket numbers and the corresponding judge names for such cases.

Date and Attorney Signature. Date and sign the civil cover sheet.