US006906700B1

(12) **United States Patent**
Armstrong

(10) **Patent No.: US 6,906,700 B1**
(45) **Date of Patent: Jun. 14, 2005**

(54) **3D CONTROLLER WITH VIBRATION**

(75) Inventor: **Brad A. Armstrong**, Carson City, NV (US)

(73) Assignee: **Anascape**, Carson City, NV (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 481 days.

(21) Appl. No.: **09/715,532**

(22) Filed: **Nov. 16, 2000**

Related U.S. Application Data

(63) Continuation of application No. 08/677,378, filed on Jul. 5, 1996, now Pat. No. 6,222,525, which is a continuation-in-part of application No. 08/393,459, filed on Feb. 23, 1995, now Pat. No. 5,565,891, which is a continuation-in-part of application No. 07/847,619, filed on Mar. 5, 1992, now Pat. No. 5,589,828.

(51) **Int. Cl.**[7] **G09G 5/08**
(52) **U.S. Cl.** **345/161**; 345/156
(58) **Field of Search** .... 345/156–172; 74/471 XY; 200/5 R, 6 A, 6 R, 9, 40, 41, 50.32–50.37, 61, 45 R, 61.46, 61.53, 512, 518–521, 530, 564; 341/20–35

(56) **References Cited**

U.S. PATENT DOCUMENTS

2,430,284 A 11/1947 Evers 341/187
3,296,882 A 1/1967 Durand 74/471
3,611,068 A 10/1971 Fujita 338/2
3,693,425 A 9/1972 Starita et al. 73/862.044
3,710,050 A 1/1973 Richards 200/61.43
3,771,037 A 11/1973 Bailey 318/580
3,806,471 A 4/1974 Mitchell 252/519
3,921,445 A 11/1975 Hill et al. 73/862
3,952,173 A 4/1976 Tsuji et al. 200/511
3,988,556 A 10/1976 Hyodo 200/511
3,993,884 A 11/1976 Kondur et al. 200/295
4,045,650 A 8/1977 Nestor 200/556
4,099,409 A 7/1978 Edmond 73/862
4,133,012 A 1/1979 Takamiya et al. 360/90
4,158,759 A 6/1979 Mason 219/720
4,164,634 A 8/1979 Gilano .... 200/5 A
4,216,467 A 8/1980 Colston 341/20
4,224,602 A 9/1980 Anderson et al. 340/321
4,246,452 A * 1/1981 Chandler .... 200/5 A

(Continued)

FOREIGN PATENT DOCUMENTS

AU 2379484 8/1984
AU 544234 5/1985
AU 557120 12/1986

(Continued)

OTHER PUBLICATIONS

IBM Technical Disclosure Bulletin, vol. 21, No. 9, Feb. 1, 1979, pp. 3845–3846, Anonymous author, Title: "Keyboard Device For Upper And Lower Case Keying Without Shifting". The Present Applicant could not locate a copy of this IBM disclosure but lists the data because it was cited as an "X" reference in a European Patent Office Search report on a related invention filed for by another Applicant.

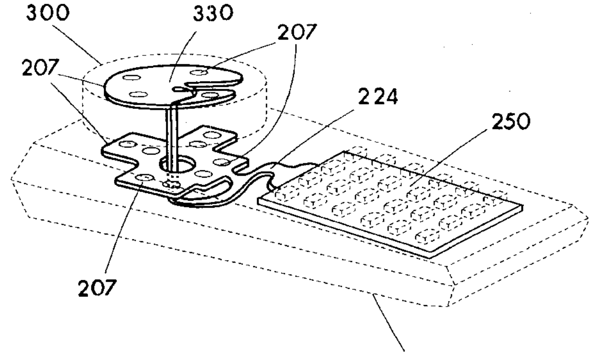
(Continued)

Primary Examiner—Chanh Nguyen

(57) **ABSTRACT**

A hand operated controller or converter structured for allowing hand inputs to be converted or translated into electrical outputs, the controller structured with a plate or platform moveable relative to a base or housing about two mutually perpendicular axes generally parallel to the platform to effect a plurality of sensors for defining output signal(s) based on movement of the platform. The sensors each have an electrically active activator spatially separated from an electric contact surface. A tactile feedback motor with shaft and offset weight is mounted as a component of the controller for providing vibration to be felt by a hand operating the controller. In some embodiments the sensors are pressure sensitive variable output sensors.

33 Claims, 40 Drawing Sheets



U.S. PATENT DOCUMENTS

4,268,815	A		5/1981	Eventoff et al.	338/69
4,276,538	A		6/1981	Eventoff et al.	338/69
4,297,542	A		10/1981	Shumway	200/6 A
4,301,337	A		11/1981	Eventoff	200/5 A
4,313,113	A		1/1982	Thornburg	345/159
4,314,227	A		2/1982	Eventoff	
4,314,228	A		2/1982	Eventoff	338/114
4,315,238	A		2/1982	Eventoff	
4,323,888	A		4/1982	Cole	341/34
4,348,142	A		9/1982	Figour	414/2
4,349,708	A		9/1982	Asher	200/6 A
4,369,663	A		1/1983	Venturello et al.	73/862.043
4,369,971	A		1/1983	Chang et al.	463/2
4,385,841	A		5/1983	Kramer	368/29
4,406,217	A		9/1983	Oota	99/280
4,408,103	A		10/1983	Smith	200/6 A
4,414,537	A		11/1983	Grimes	341/20
4,419,653	A		12/1983	Waigand	338/114
4,420,808	A		12/1983	Diamond et al.	701/4
4,469,330	A	*	9/1984	Asher	463/38
4,469,930	A		9/1984	Takahashi	219/121.72
4,489,302	A		12/1984	Eventoff	338/99
4,490,587	A		12/1984	Miller et al.	200/5
4,491,325	A		1/1985	Bersheim	463/38
4,504,059	A		3/1985	Weinrieb	273/148
4,514,600	A		4/1985	Lentz	200/5 R
4,536,746	A		8/1985	Gobeli	341/20
4,546,347	A		10/1985	Kirsch	345/166
4,552,360	A		11/1985	Bromley et al.	463/38
4,555,960	A		12/1985	King	74/471 XY
4,573,682	A		3/1986	Mayon	273/148
4,604,502	A		8/1986	Thomas	200/6 A
4,604,509	A		8/1986	Clancy et al.	200/513
4,615,252	A		10/1986	Yamauchi et al.	84/687
4,630,823	A		12/1986	Grant	273/148
4,647,916	A		3/1987	Boughton	345/156
4,667,271	A		5/1987	Wilson	361/725
4,670,743	A		6/1987	Zemke	345/157
4,673,919	A		6/1987	Kataoka	341/11
4,680,577	A		7/1987	Straayer et al.	345/160
4,684,089	A		8/1987	Lely	248/124.1
4,687,200	A		8/1987	Shirai	463/37
4,694,231	A		9/1987	Alvite	318/568.11
4,713,007	A		12/1987	Alban	463/37
4,724,292	A		2/1988	Ichikawa	219/708
4,733,214	A		3/1988	Andresen	219/708
4,745,301	A		5/1988	Michalchik	307/119
4,766,271	A		8/1988	Mitsuhashi et al.	200/512
4,786,764	A		11/1988	Padula et al.	178/18
4,786,895	A		11/1988	Castaneda	345/160
4,811,608	A		3/1989	Hilton	73/862.043
4,850,591	A		7/1989	Takezawa et al.	273/85
4,855,704	A		8/1989	Betz	336/132
4,858,930	A		8/1989	Sato	463/23
4,866,542	A		9/1989	Shimada et al.	386/69
4,866,544	A		9/1989	Hashimoto	360/40
4,879,556	A		11/1989	Duimel	341/20
4,909,514	A		3/1990	Tano	273/148
4,910,503	A		3/1990	Brodsky	345/161
4,924,216	A		5/1990	Leung	463/38
4,933,670	A	*	6/1990	Wislocki	345/167
4,935,728	A		6/1990	Kley	345/161
4,962,448	A	*	10/1990	DeMaio et al.	700/17
4,975,676	A		12/1990	Greenhalgh	338/114
5,038,144	A		8/1991	Kaye	341/176
5,049,079	A		9/1991	Furtado et al.	434/253
5,059,958	A		10/1991	Jacobs et al.	345/158
5,065,146	A		11/1991	Garrett	345/161
5,068,498	A		11/1991	Engel	200/6 A
5,103,404	A		4/1992	McIntosh	318/568
5,116,051	A		5/1992	Moncrief et al.	463/36
5,128,671	A	*	7/1992	Thomas, Jr.	341/20
5,132,658	A		7/1992	Dauenhauer et al.	338/92
5,139,439	A		8/1992	Shie	439/359
5,142,931	A	*	9/1992	Menahem	74/471 XY
5,164,697	A		11/1992	Kramer	338/69
5,168,221	A	*	12/1992	Houston	324/207.13
5,182,796	A		1/1993	Shibayama et al.	345/841
5,183,998	A		2/1993	Hoffman et al.	219/492
5,184,120	A		2/1993	Schultz	340/870
5,184,830	A		2/1993	Okada et al.	463/29
5,189,355	A		2/1993	Larkins et al.	318/685
5,196,782	A		3/1993	D'Aleo et al.	323/320
5,200,597	A		4/1993	Eastman et al.	235/455
5,203,563	A		4/1993	Loper	273/148 B
5,207,426	A		5/1993	Inoue et al.	463/36
5,222,400	A		6/1993	Hilton	73/862
5,231,386	A		7/1993	Brandenburg et al.	345/174
5,237,311	A		8/1993	Mailey et al.	345/167
5,250,930	A		10/1993	Yoshida et al.	345/168
5,252,952	A		10/1993	Frank et al.	345/157
5,258,748	A		11/1993	Jones	345/172
5,259,626	A		11/1993	Ho	463/37
5,264,768	A		11/1993	Gregory et al.	318/561
D342,740	S		12/1993	Parker	D14/218
5,271,290	A	*	12/1993	Fischer	74/471 XY
5,278,557	A		1/1994	Stokes et al.	341/34
5,280,926	A		1/1994	Sogge et al.	277/641
5,286,024	A		2/1994	Winblad	273/148 B
5,287,089	A		2/1994	Parsons	345/156
5,293,158	A		3/1994	Soma	345/161
5,294,121	A		3/1994	Chiang	273/148 B
5,298,919	A		3/1994	Chang	345/163
5,311,779	A		5/1994	Teruo	73/726
5,313,229	A		5/1994	Gilligan et al.	345/157
5,315,204	A		5/1994	Park	310/339
5,327,201	A		7/1994	Coleman et al.	399/342
5,329,276	A	*	7/1994	Hirabayashi	340/870.31
5,333,057	A		7/1994	Morikawa et al.	358/296
5,345,807	A		9/1994	Butts et al.	73/1.15
5,349,370	A		9/1994	Katayama et al.	345/159
5,349,371	A		9/1994	Fong	345/166
5,355,352	A		10/1994	Kobayashi et al.	368/281
5,358,259	A		10/1994	Best	273/434
5,364,108	A		11/1994	Esnouf	368/281
5,365,494	A		11/1994	Lynch	368/10
5,367,631	A		11/1994	Levy	395/162
5,374,787	A		12/1994	Miller et al.	
5,376,913	A		12/1994	Pine et al.	338/114
5,386,084	A		1/1995	Risko	174/52.3
D355,901	S		2/1995	Bradley	D14/410
5,389,757	A		2/1995	Souliere	200/345
5,391,083	A		2/1995	Roebuck et al.	174/52.3
5,392,337	A		2/1995	Baals	379/457
5,394,168	A		2/1995	Smith, III et al.	345/156
5,396,225	A		3/1995	Okada et al.	463/40
5,396,235	A		3/1995	Maeshima et al.	341/34
5,399,823	A		3/1995	McCusker	200/521
5,419,613	A		5/1995	Wedeking	297/217
5,440,237	A		8/1995	Brown et al.	324/601
5,452,615	A		9/1995	Hilton	73/862
5,457,478	A		10/1995	Frank	345/158
5,459,487	A		10/1995	Bouton	463/37
5,467,108	A		11/1995	Mimlitch	345/161
5,485,171	A		1/1996	Copper et al.	345/160
5,487,053	A		1/1996	Beiswenger et al.	368/69
5,488,204	A		1/1996	Mead et al.	
5,495,077	A		2/1996	Miller et al.	
5,499,041	A		3/1996	Brandenburg et al.	345/174
5,508,719	A		4/1996	Gervais	345/157
5,510,812	A		4/1996	O'Mara et al.	345/161

5,512,892	A		4/1996	Corballis et al.	341/22
5,517,211	A		5/1996	Kwang-Chien	345/166
5,528,265	A		6/1996	Harrison	345/158
5,530,455	A		6/1996	Gillick et al.	345/163
5,541,622	A		7/1996	Engle et al.	345/161
5,542,039	A		7/1996	Brinson et al.	345/800
5,543,588	A		8/1996	Bisset et al.	
5,543,590	A		8/1996	Gillespie et al.	
5,543,591	A		8/1996	Gillespie et al.	
5,543,781	A		8/1996	Ganucheau, Jr. et al.	340/7.52
5,550,339	A		8/1996	Haugh	200/5 A
5,551,693	A		9/1996	Goto et al.	463/37
5,552,799	A		9/1996	Hashiguchi	345/3.2
5,555,004	A		9/1996	Ono et al.	345/161
5,555,894	A		9/1996	Doyama et al.	600/595
5,559,432	A		9/1996	Logue	324/207.17
5,564,560	A		10/1996	Minelli et al.	200/516
5,565,891	A		10/1996	Armstrong	345/167
5,589,828	A		12/1996	Armstrong	341/20
5,591,924	A		1/1997	Hilton	73/862
5,602,569	A		2/1997	Kato	345/158
5,606,594	A		2/1997	Register et al.	455/556.2
5,607,158	A		3/1997	Chan	273/148 B
5,615,083	A		3/1997	Burnett	361/686
5,619,180	A		4/1997	Massimino et al.	
5,640,152	A		6/1997	Copper	340/825
5,640,566	A		6/1997	Victor et al.	717/113
5,644,113	A		7/1997	Date et al.	200/5 R
5,648,642	A		7/1997	Miller et al.	
D381,982	S		8/1997	Zeitman	D14/162
5,657,051	A		8/1997	Liao	345/163
5,659,334	A		8/1997	Yaniger et al.	345/156
5,669,818	A		9/1997	Thorner et al.	463/30
5,670,955	A		9/1997	Thorn et al.	341/34
5,670,988	A		9/1997	Tickle	345/157
5,673,066	A		9/1997	Toda et al.	345/157
5,673,237	A		9/1997	Blank	368/10
5,675,309	A		10/1997	DeVolpi	338/68
5,675,329	A		10/1997	Barker et al.	341/22
5,675,359	A		10/1997	Anderson	345/161
5,684,759	A		11/1997	Huang et al.	368/10
5,687,080	A		11/1997	Hoyt et al.	700/85
5,687,331	A		11/1997	Volk et al.	395/327
5,689,285	A		11/1997	Asher	345/161
5,704,612	A		1/1998	Kelly et al.	273/402
5,706,027	A		1/1998	Hilton et al.	345/156
5,714,983	A		2/1998	Sacks	345/168
5,716,274	A		2/1998	Goto et al.	463/37
5,738,352	A		4/1998	Ohkubo et al.	273/148 B
5,749,577	A	*	5/1998	Couch et al.	273/148 B
5,764,219	A		6/1998	Rutledge et al.	345/159
5,767,839	A	*	6/1998	Rosenberg	345/161
5,767,840	A		6/1998	Selker	345/161
5,774,109	A		6/1998	Winksy et al.	345/685
5,778,404	A		7/1998	Capps et al.	715/531
5,781,807	A		7/1998	Glassgold et al.	396/71
5,790,102	A		8/1998	Nassimi	345/163
5,805,138	A		9/1998	Brawne et al.	345/156
5,808,540	A		9/1998	Wheeler et al.	
5,812,114	A		9/1998	Loop	345/157
5,815,139	A		9/1998	Yoshikawa et al.	345/157
5,828,363	A		10/1998	Yaniger et al.	345/156
5,831,596	A		11/1998	Marshall et al.	345/161
5,835,977	A		11/1998	Kamentser et al.	73/862.05
5,841,078	A		11/1998	Miller et al.	
5,847,305	A		12/1998	Yoshikawa et al.	84/634
5,847,639	A		12/1998	Yaniger	338/99
5,847,694	A		12/1998	Redford et al.	345/158
5,847,698	A		12/1998	Reavey et al.	345/173
5,853,324	A		12/1998	Kami et al.	462/2
5,853,326	A		12/1998	Goto et al.	463/37
5,854,622	A		12/1998	Brannon	345/161
5,854,624	A		12/1998	Grant	345/169
5,861,583	A		1/1999	Schediwy et al.	
5,867,808	A		2/1999	Selker et al.	702/41
5,872,521	A		2/1999	Lopatukin et al.	340/7.52
5,880,411	A		3/1999	Gillespie et al.	
5,883,619	A		3/1999	Ho et al.	345/163
5,889,236	A		3/1999	Gillespie et al.	178/18.01
5,889,507	A		3/1999	Engle et al.	345/161
5,895,471	A		4/1999	King et al.	707/104.1
5,898,359	A		4/1999	Ellis	338/47
5,898,425	A		4/1999	Sekine	345/168
5,909,207	A		6/1999	Ho	345/156
5,910,798	A		6/1999	Kim	345/163
5,910,882	A		6/1999	Burrell	361/681
5,914,465	A		6/1999	Allen et al.	
5,917,779	A		6/1999	Ralson et al.	368/83
5,923,267	A		7/1999	Beuk et al.	340/825
5,923,317	A		7/1999	Sayler et al.	345/156
5,942,733	A		8/1999	Allen et al.	
5,943,044	A		8/1999	Martinelli et al.	345/174
5,948,066	A		9/1999	Whalen et al.	709/229
5,952,631	A		9/1999	Miyaki	200/6 A
5,963,196	A		10/1999	Nishiumi et al.	345/161
5,966,117	A		10/1999	Seffernick et al.	345/161
5,973,668	A		10/1999	Watanabe	345/157
5,974,238	A		10/1999	Chase	709/248
5,983,004	A		11/1999	Shaw et al.	709/227
5,984,785	A		11/1999	Takeda et al.	463/38
5,991,594	A		11/1999	Froeber et al.	434/317
5,995,026	A		11/1999	Sellers	341/34
5,995,319	A		11/1999	Tanigawa et al.	360/90
5,999,084	A		12/1999	Armstrong	338/114
5,999,168	A		12/1999	Rosenberg et al.	
5,999,808	A		12/1999	LaDue	455/412.2
6,001,014	A		12/1999	Ogata et al.	463/37
6,004,210	A		12/1999	Shinohara	463/36
6,007,423	A		12/1999	Nakamura	463/6
6,020,884	A		2/2000	MacNaughton et al.	345/747
6,027,828	A		2/2000	Hahn	429/100
6,028,271	A		2/2000	Gillespie et al.	
6,028,531	A		2/2000	Wanderlich	
6,031,516	A		2/2000	Leiper	345/629
6,037,954	A		3/2000	McMahon	345/169
6,040,821	A		3/2000	Franz et al.	345/159
6,041,068	A		3/2000	Rosengren et al.	370/538
6,049,323	A		4/2000	Rockwell et al.	345/784
6,049,812	A		4/2000	Bertram et al.	715/516
6,059,660	A		5/2000	Takada et al.	463/38
6,060,701	A		5/2000	McKee et al.	219/681
6,064,766	A		5/2000	Sklarew	382/189
6,067,005	A		5/2000	DeVolpi	338/47
6,067,863	A		5/2000	Favre et al.	73/862.68
6,072,469	A		6/2000	Chen et al.	345/157
6,073,034	A		6/2000	Jacobsen et al.	455/566
6,102,802	A		8/2000	Armstrong	463/37
6,112,014	A		8/2000	Kane	358/1.16
6,118,979	A		9/2000	Powell	340/7.6
6,124,845	A		9/2000	Toda et al.	345/157
6,135,886	A		10/2000	Armstrong	463/37
6,146,278	A		11/2000	Kobayashi	463/53
6,147,674	A		11/2000	Rosenberg et al.	345/157
6,153,843	A		11/2000	Date et al.	200/339
6,155,926	A		12/2000	Miyamoto et al.	463/32
6,157,381	A		12/2000	Bates et al.	345/786
6,157,935	A		12/2000	Tran et al.	715/503
6,177,926	B1		1/2001	Kunert	345/173
6,178,338	B1		1/2001	Yamagishi et al.	455/566
6,185,158	B1		2/2001	Ito et al.	368/37
6,198,472	B1		3/2001	Lection et al.	345/161
6,198,473	B1		3/2001	Armstrong	345/163

6,198,948	B1	3/2001	Sudo et al.	455/566
6,208,271	B1	3/2001	Armstrong	341/34
6,217,444	B1	4/2001	Kataoka et al.	463/3
6,222,525	B1	4/2001	Armstrong	345/161
6,225,976	B1	5/2001	Yates et al.	345/156
6,231,444	B1	5/2001	Goto et al.	463/37
6,239,389	B1	5/2001	Allen et al.	
6,239,786	B1	5/2001	Burry et al.	345/161
6,239,790	B1	5/2001	Martinelli et al.	345/174
6,256,011	B1	7/2001	Culver	345/157
6,262,406	B1	7/2001	McKee et al.	219/681
6,275,138	B1	8/2001	Maeda	338/47
6,275,213	B1	8/2001	Tremblay et al.	345/156
6,285,356	B1	9/2001	Armstrong	345/167
6,310,606	B1	10/2001	Armstrong	345/161
6,321,158	B1	11/2001	DeLorme et al.	701/201
6,322,448	B1	11/2001	Kaku et al.	463/32
6,326,948	B1	12/2001	Kobachi et al.	345/157
6,343,991	B1	2/2002	Armstrong	463/37
6,344,791	B1	2/2002	Armstrong	338/114
6,347,997	B1	2/2002	Armstrong	463/37
6,351,205	B1	2/2002	Armstrong	338/114
6,352,477	B1	3/2002	Soma et al.	463/36
6,400,303	B2	6/2002	Armstrong	341/176
6,400,353	B1	6/2002	Ikehara et al.	345/157
6,404,584	B2	6/2002	Armstrong	360/88
6,414,996	B1	7/2002	Owen et al.	375/240
6,415,707	B1	7/2002	Armstrong	99/280
6,422,941	B1	7/2002	Thorner et al.	463/30
6,424,333	B1	7/2002	Tremblay et al.	345/156
6,424,336	B1	7/2002	Armstrong	345/159
6,456,778	B2	9/2002	Armstrong	386/46
6,469,691	B1	10/2002	Armstrong	345/159
6,470,078	B1	10/2002	Armstrong	379/93.19
6,496,449	B1	12/2002	Armstrong	345/159
6,504,527	B1	1/2003	Armstrong	345/159
6,518,953	B1	2/2003	Armstrong	345/159
6,524,187	B2	2/2003	Komata	463/37
6,529,185	B1	3/2003	Armstrong	345/159
6,532,000	B2	3/2003	Armstrong	345/159
6,538,638	B1	3/2003	Armstrong	345/159
6,559,831	B1	5/2003	Armstrong	345/159
6,563,415	B2	5/2003	Armstrong	338/47
2001/0009037	A1	7/2001	Komata	
2001/0040585	A1	11/2001	Hartford et al.	
2002/0036660	A1	3/2002	Adan et al.	
2002/0122027	A1	9/2002	Kim	

FOREIGN PATENT DOCUMENTS

AU	8142991		2/1992
AU	2780892		5/1993
AU	645462		1/1994
AU	3544395		3/1996
AU	3544495		3/1996
AU	667688		4/1996
CA	1143030		3/1983
CA	1153577		9/1983
CA	1153801		9/1983
CA	1153802		9/1983
CA	1153803		9/1983
CA	1161921		2/1984
CA	1203738		4/1986
CA	2048167		2/1992
CA	120502		4/1993
CA	2038894		5/1994
CN	1058728		2/1992
CN	1166214		11/1997
CN	1202254		12/1998
DE	3044384		8/1981
DE	3031484		11/1982
DE	3543890		6/1987
DE	3634912		4/1988
DE	4019211		1/1991
DE	4013227		5/1991
DE	4004760		8/1991
DE	4011636		10/1991
DE	3687571		3/1993
DE	69114400		12/1995
DE	69306678		1/1997
DE	19519941		3/1997
DE	19606408		8/1997
DE	69324067D		4/1999
DE	69324067	T	7/1999
DE	198803627		8/1999
DE	69521617D		8/2001
EP	0050231		12/1983
EP	0169624		1/1986
EP	0205726		12/1986
EP	0227432		7/1987
EP	0295368		12/1988
EP	0337458		10/1989
EP	0403054		12/1990
EP	0438919		7/1991
EP	0451676		10/1991
EP	0 470 615	A1	2/1992
EP	0470615		2/1992
EP	0574213		12/1993
EP	0579448		1/1994
EP	0606388		7/1994
EP	0616298		9/1994
EP	0626634		11/1994
EP	663648		7/1995
EP	0777875		6/1997
EP	0777888		6/1997
EP	0302158		11/1997
EP	0835676		4/1998
EP	0852961		7/1998
EP	0830881		8/1998
EP	0861462		9/1998
EP	0905725		3/1999
EP	1080753		3/2001
EP	1080753		6/2001
ES	2079529		1/1996
FR	2470435		5/1981
GB	2058462		4/1981
GB	2064873		6/1981
GB	2113920		8/1983
GB	2133957		8/1984
GB	2134320		8/1984
GB	2134321		8/1984
GB	2155953		10/1985
GB	2159953		12/1985
GB	2205941		12/1988
GB	2233499		1/1991
GB	2240614		8/1991
GB	2247107		2/1992
GB	2267392		12/1993
GB	213422		8/1994
GB	2308448		6/1997
HK	30195		3/1995
IT	1143185		10/1986
JP	56108279		8/1981
JP	60175401		9/1985
JP	61292734		12/1986
JP	62160623		7/1987
JP	62177426		8/1987
JP	1125871		5/1989
JP	63-029113		8/1989
JP	2158105		6/1990
JP	02158105		6/1990
JP	2049029		10/1990
JP	03108701		5/1991

JP	3108701		5/1991
JP	63318623		12/1991
JP	4155707		5/1992
JP	04155707		5/1992
JP	4230918		8/1992
JP	1710832		11/1992
JP	4077335		12/1992
JP	5022398		3/1993
JP	05151828		6/1993
JP	5151828		6/1993
JP	5196524		8/1993
JP	5197381		8/1993
JP	5326217		10/1993
JP	5-87760		11/1993
JP	5-87760		12/1993
JP	6058419		3/1994
JP	6154422		6/1994
JP	6058276		8/1994
JP	1875027		9/1994
JP	6101567		12/1994
JP	6511340	T	12/1994
JP	07-051467		2/1995
JP	1976280		10/1995
JP	7281824		10/1995
JP	1993198		11/1995
JP	7-302159		11/1995
JP	7302159		11/1995
JP	2108444		11/1996
JP	09213168		8/1997
JP	9218737		8/1997
JP	9223607		8/1997
JP	092236607		8/1997
JP	10505182	T	5/1998
JP	10505183	T	5/1998
JP	B-H1-40545		1/1999
JP	11031606		2/1999
JP	11009837		4/1999
JP	10-258181		9/1999
JP	0952555		10/1999
JP	11511580		10/1999
JP	11511580	T	10/1999
KR	9705724		6/1997
KR	264640		10/2000
MX	9100564		4/1992
NL	8006409		6/1981
RU	2010369		3/1994
SE	8008205		5/1981
SE	452925		12/1987
SG	8095		6/1995
SU	739505		12/1977
SU	739505		6/1980
TW	288636		10/1996
TW	369431		9/1999
WO	WO9304348		3/1993
WO	WO9307606		4/1993
WO	WO9428387		8/1995
WO	WO9522828		8/1995
WO	WO9532776		12/1995
WO	WO9607966		3/1996
WO	WO9607981		3/1996
WO	WO9318475		12/1996
WO	WO9718508		5/1997
WO	WO9806079		2/1998
WO	WO9957630		11/1999
WO	WO0152042		7/2001
ZA	8400356		8/1984

OTHER PUBLICATIONS

Jim Boyce et al, Inside Window 3.11, New Riders Publishing, Platinum Edition, p. 87–89.

Mouse Ball–Actuating Device with Force and Tactile Feedback, IBM DisclosureBulletin, vl 32, No. 9B, Feb. 1990, pp. 230–235, Footnote 2—Special Interest.

Research Disclosures, vol. 283, Nov. 1987 (USA) "Joystick with Tactile Feedback".

Development of a General Purpose Hand Controller for Advanced Teleoperation KV Siva Harwell Laboratory, UK. Jul. 1988, Footnote 12—Special Interest.

The "CyberMan" 3D Controller by Logitech Inc. of Fremont California US in 1993, a two page advertisement flyer is provided herewith, as are detailed drawings, Footnote 9—Special Interest.

Kambic "Keyboard Switch with Stroke and Feedback Enhancement Using Vertically Conducting Elastomer In a Laterally Conducting Mode", IBM Technical Disclosure Bulletin, vol. 20, No. 5, Oct. 1977, pp. 1833–1834, Footnote 22—Special Interest.

USB Device Class Definition for Human Devices, Oct. 14, 1998.

Search results titled Questel–Orbit QWEB dated Dec. 1999, pp. 1–24 having short descriptions/abstracts thereon are submitted herewith by Applicant for study.

Namco, 1994, a hand held controller for video games having a button to drive a gear and rotate a rotary potentiometer which creates an analog signal change based on positional change; to be considered prior art to some of Applicant's claims.

Flightstck Pro by CH Products, San Marcos, Califonia USA, a joystick which uses a gimbal and rotary potentiometers, the joystick is prior art sold in stores.

Known prior art are rotary operated potentiometers which have an Off position usually in the far counterclockwise direction of rotation and an audible "click" is provided when rotated in or out of the Off position. Such potentiometers are variable output electrical devices controlled by rotation .

IBM Technical Disclosure Bulletin pp230–235 Feb. 1990 Mouse Ball–Actuating Device With Force And Tactile Feedback.

Research Disclosure Nov. 1987 28373 Joystick with Tactile Feedback.

S.F. Kambic, IBM Technical Disclosure Bulletin, vol. 20 No. 5 Oct. 1977 Questel–Orbit QWEB pp. 1–24 (submitted herewith).

* cited by examiner

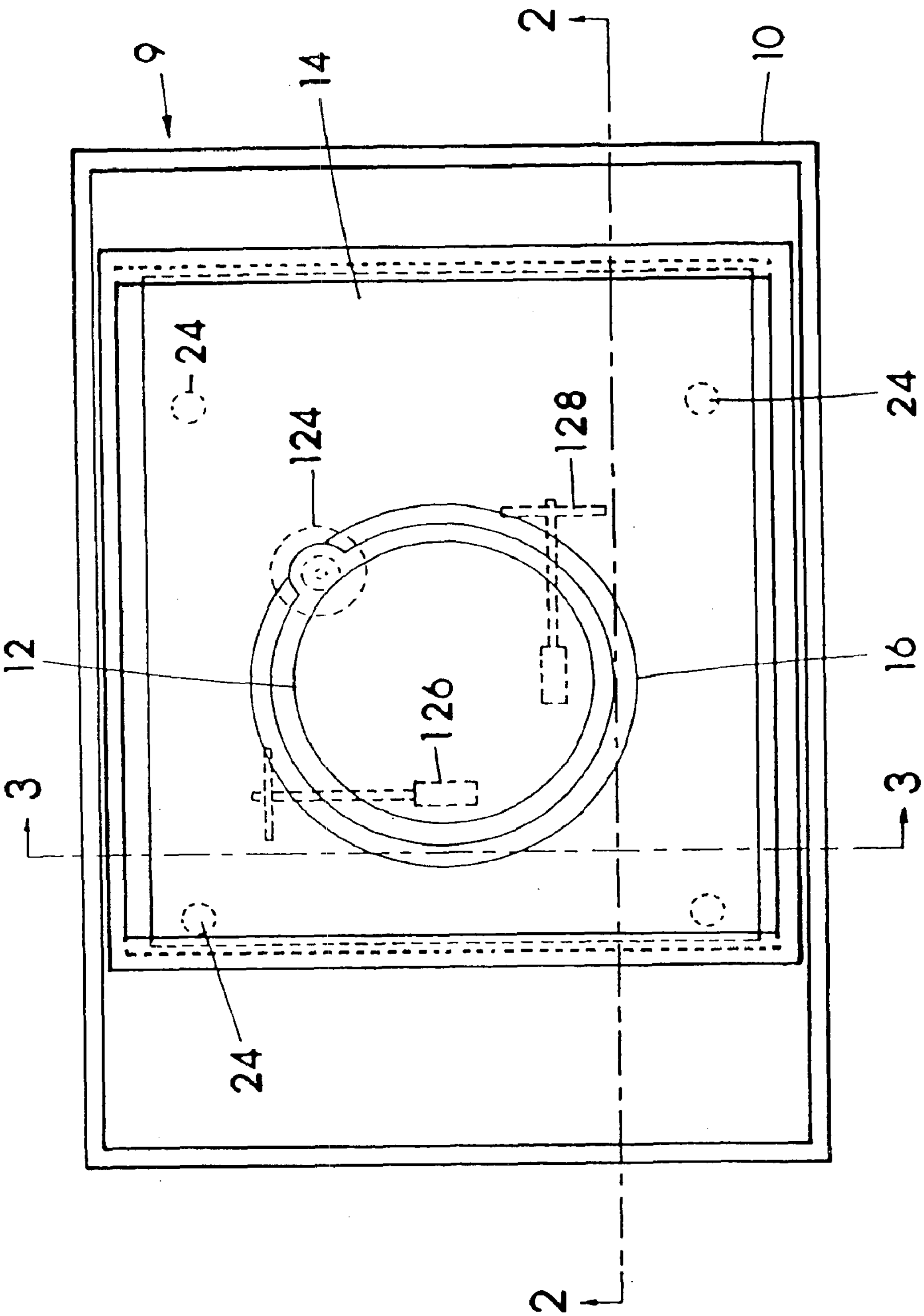


FIG. 1

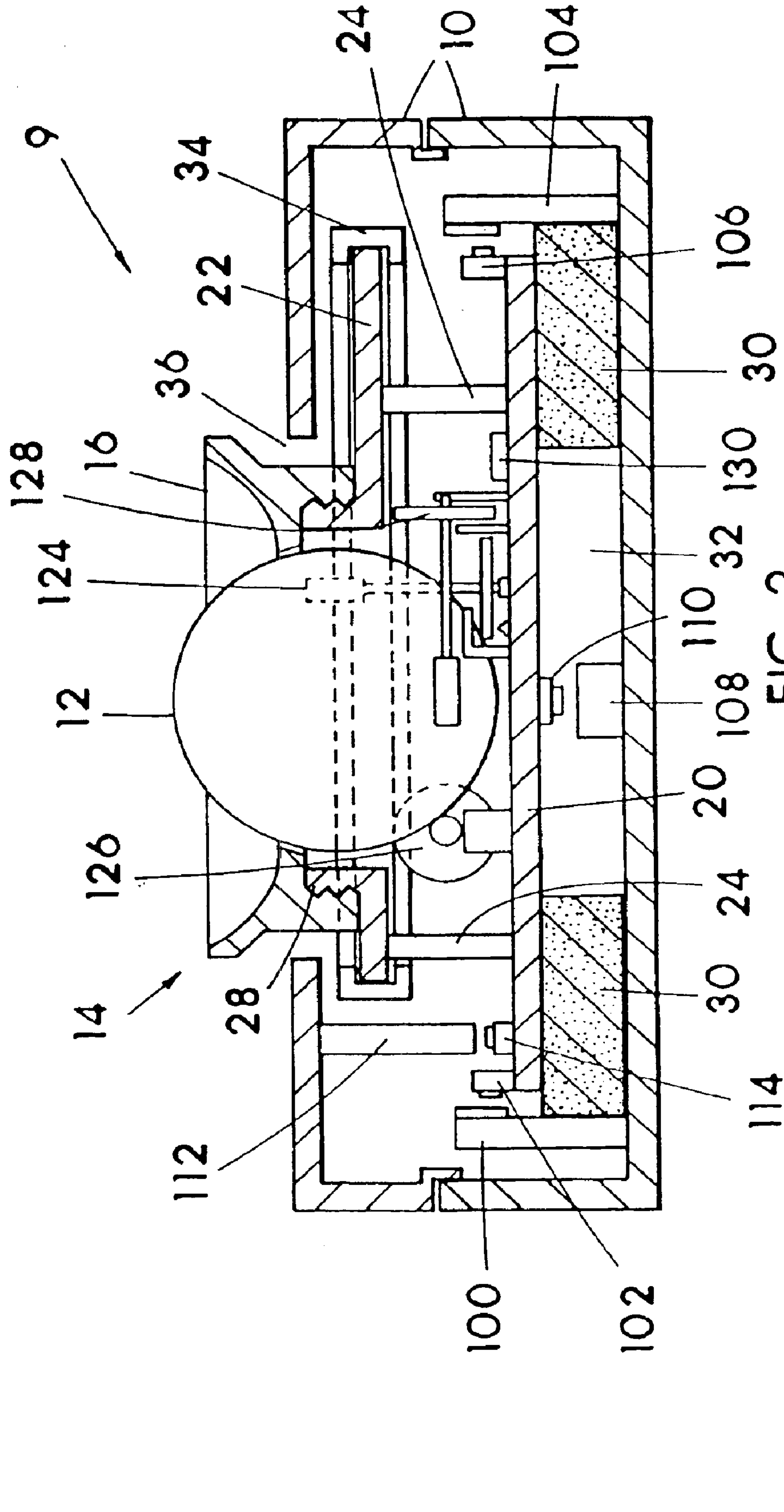

9
10
24
104
34
22
106
36
30
16
128
130
32
124
110
12
108
20
126
24
14
28
30
112
114
100
102

FIG. 2

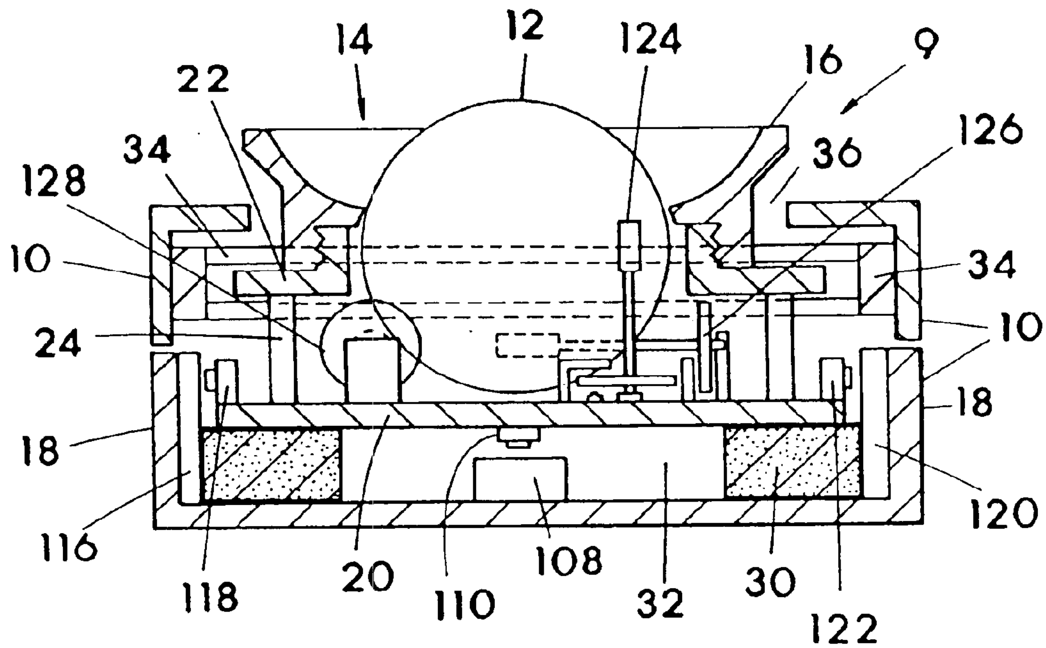

14
12
124
16
9
22
34
36
126
128
10
34
24
10
18
18
116
120
118
20
110
108
32
30
122

FIG. 3

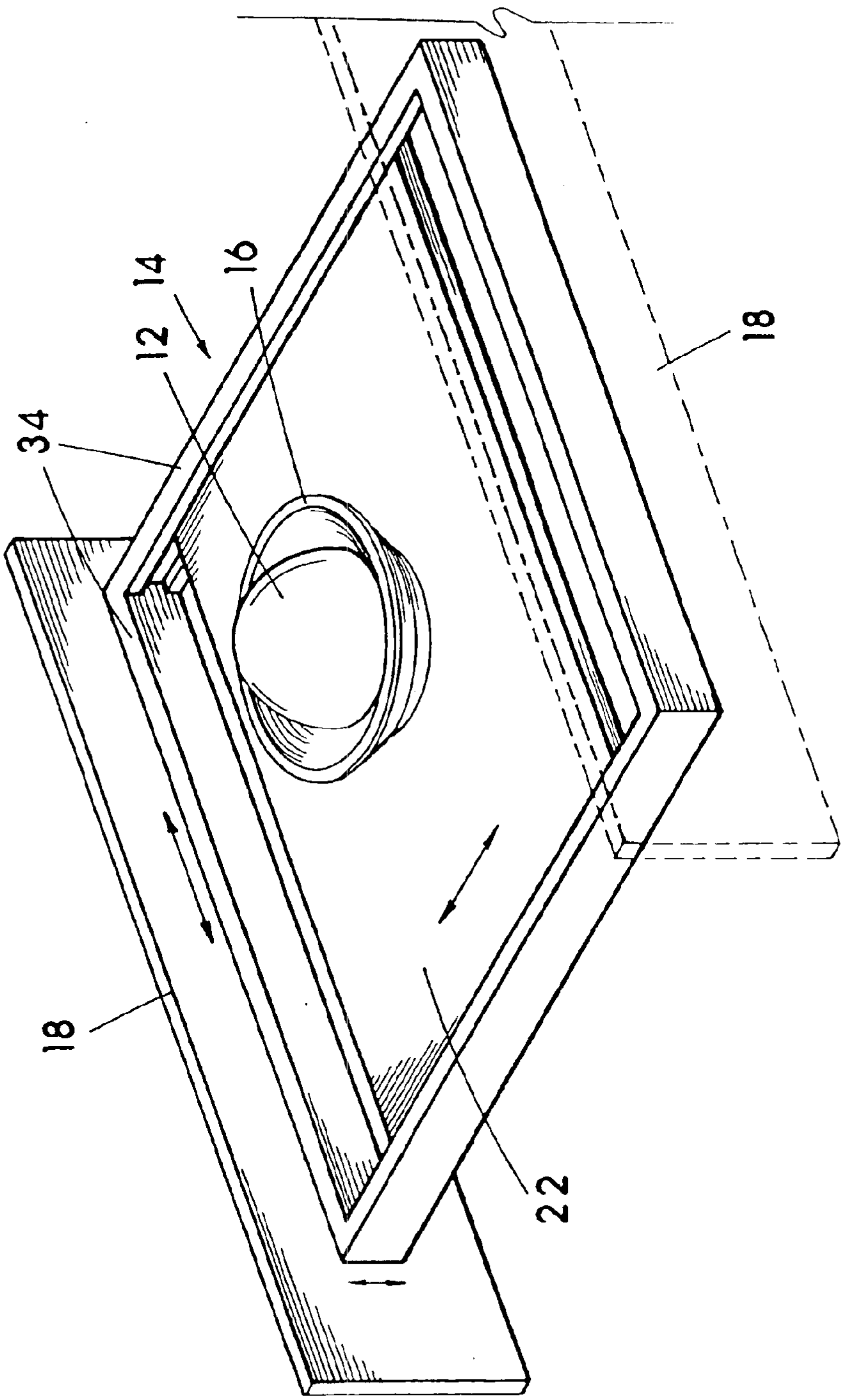


FIG. 4

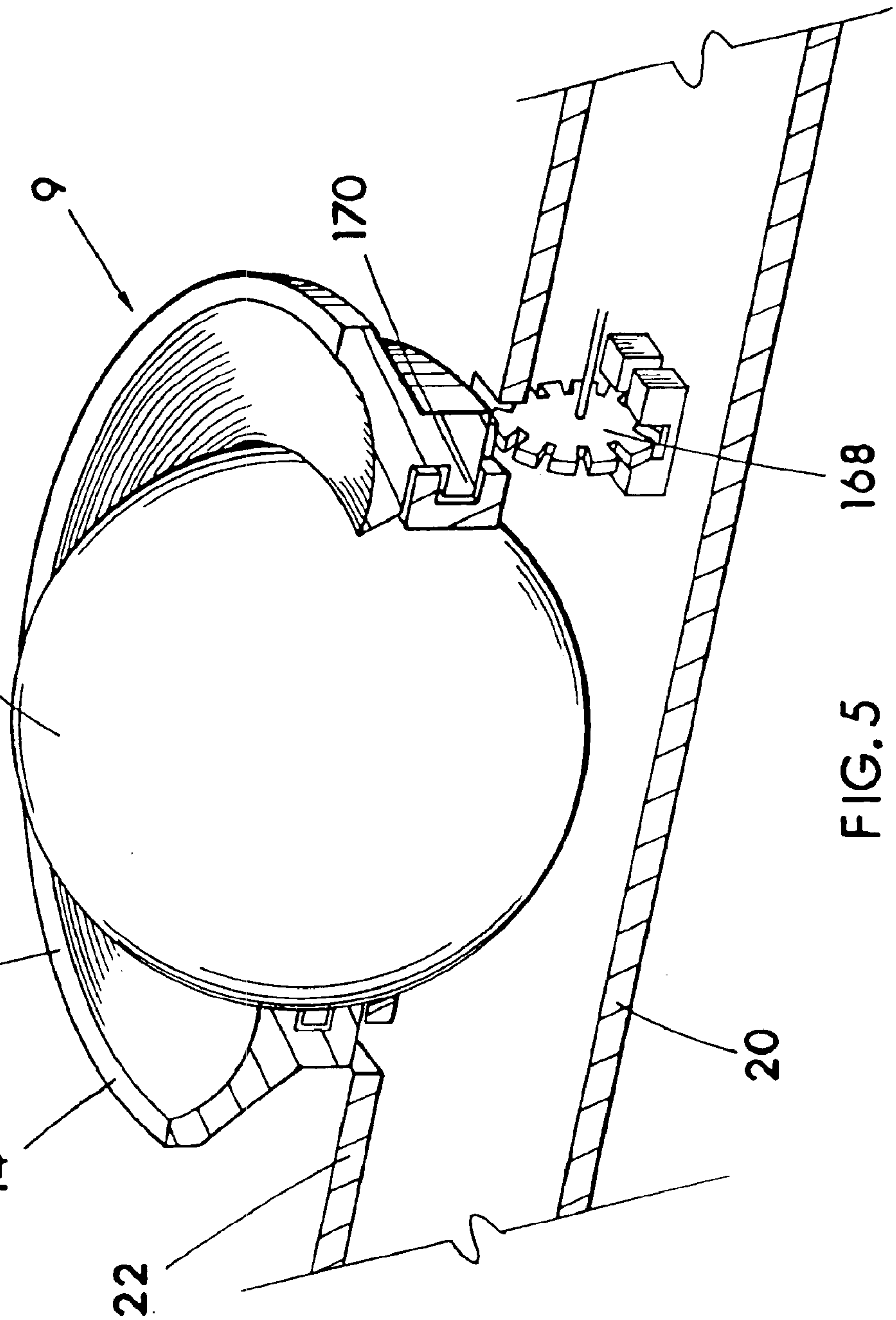


FIG. 5

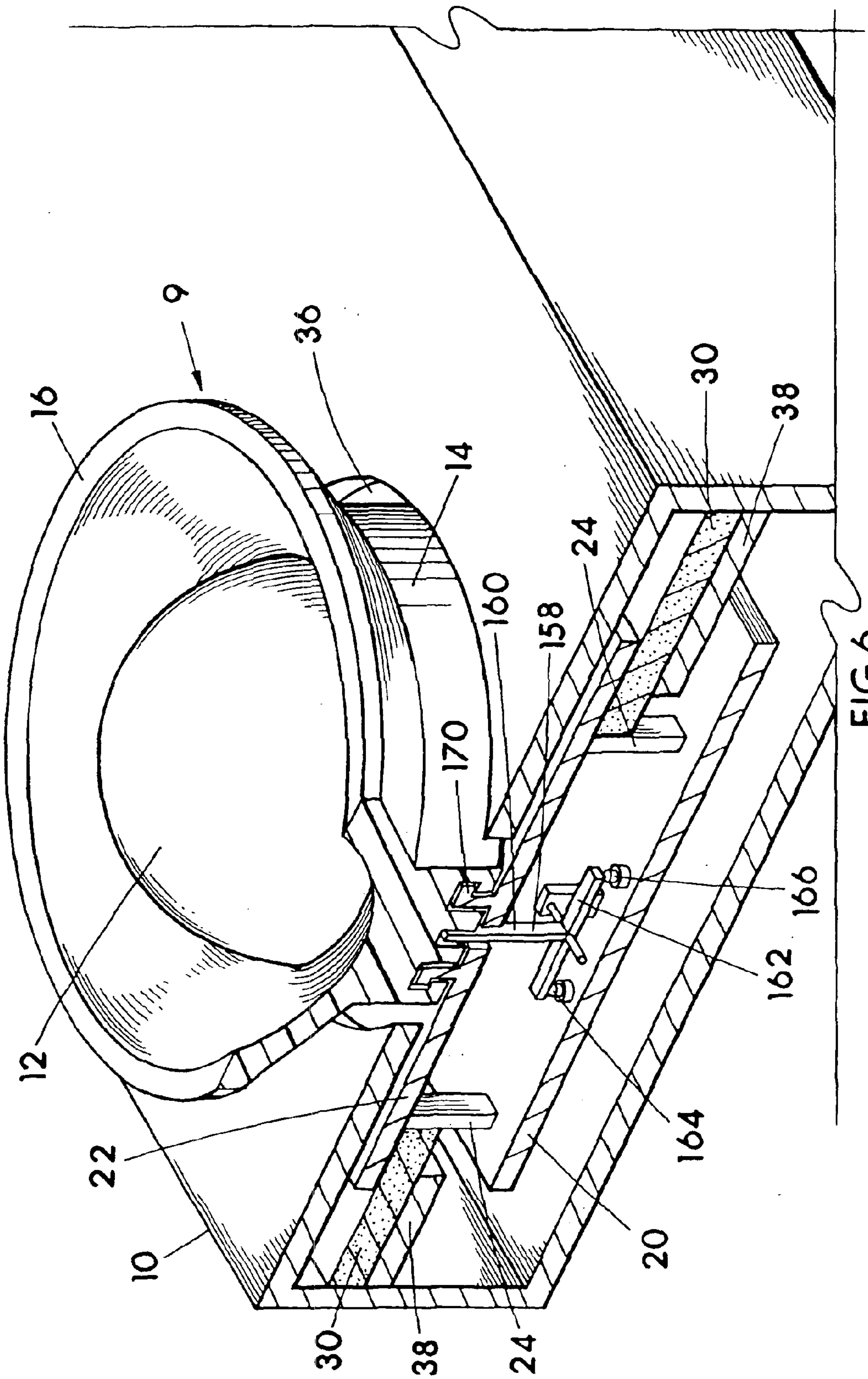


FIG. 6

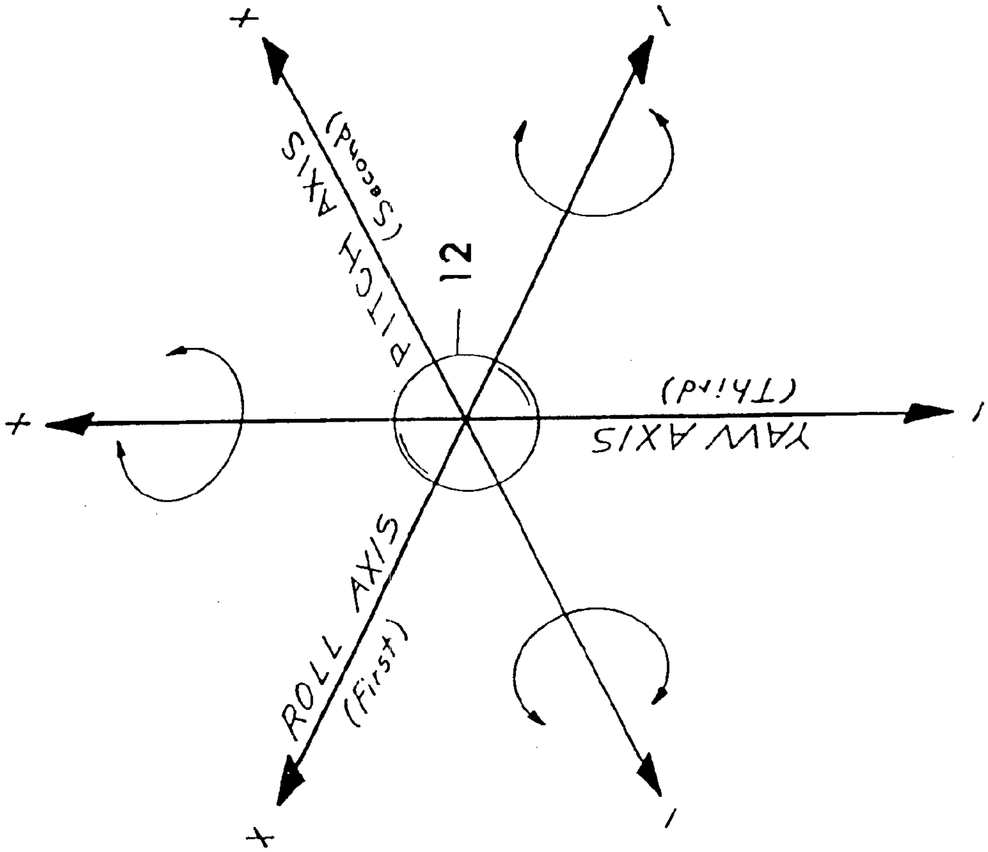


FIG. 7

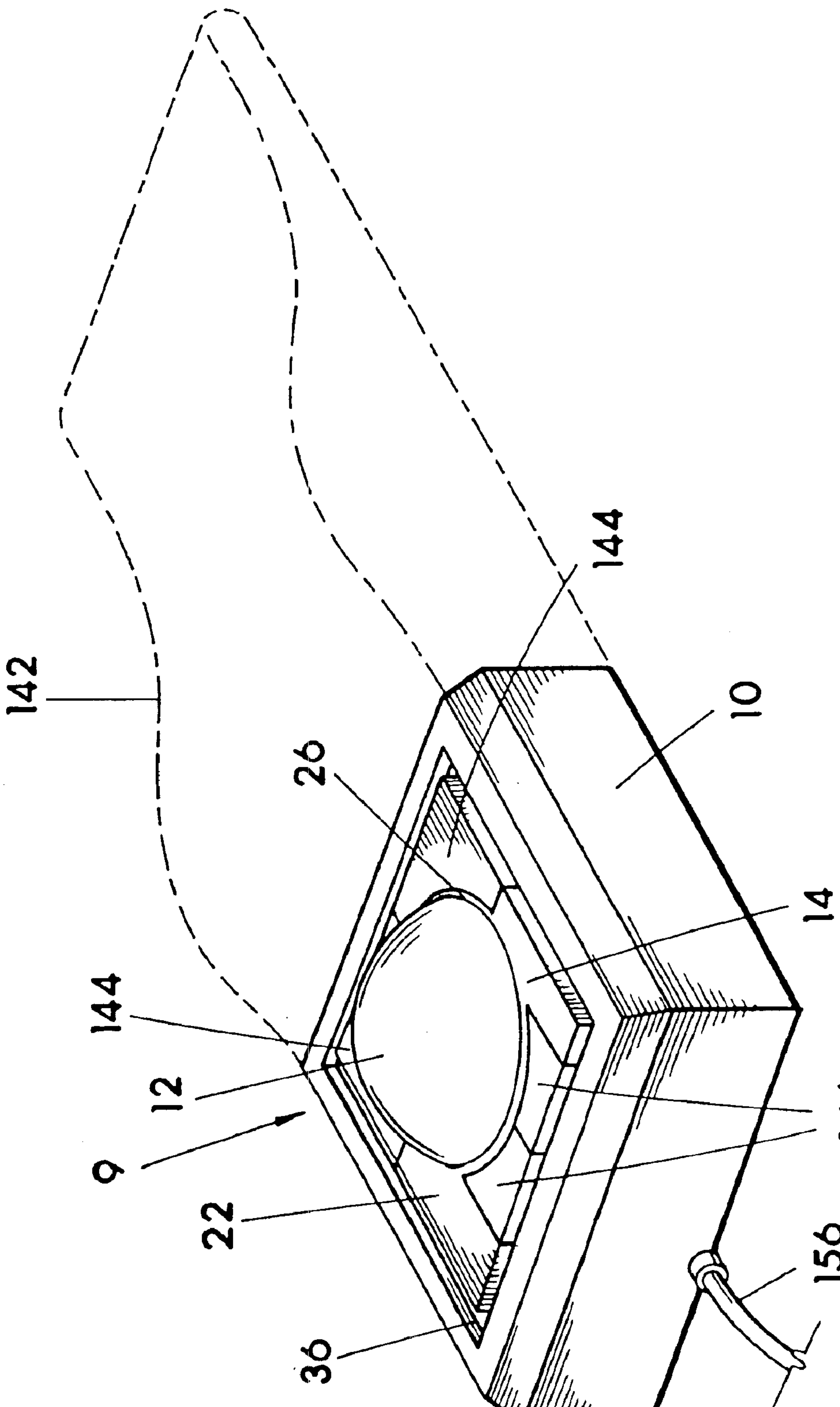


FIG. 8

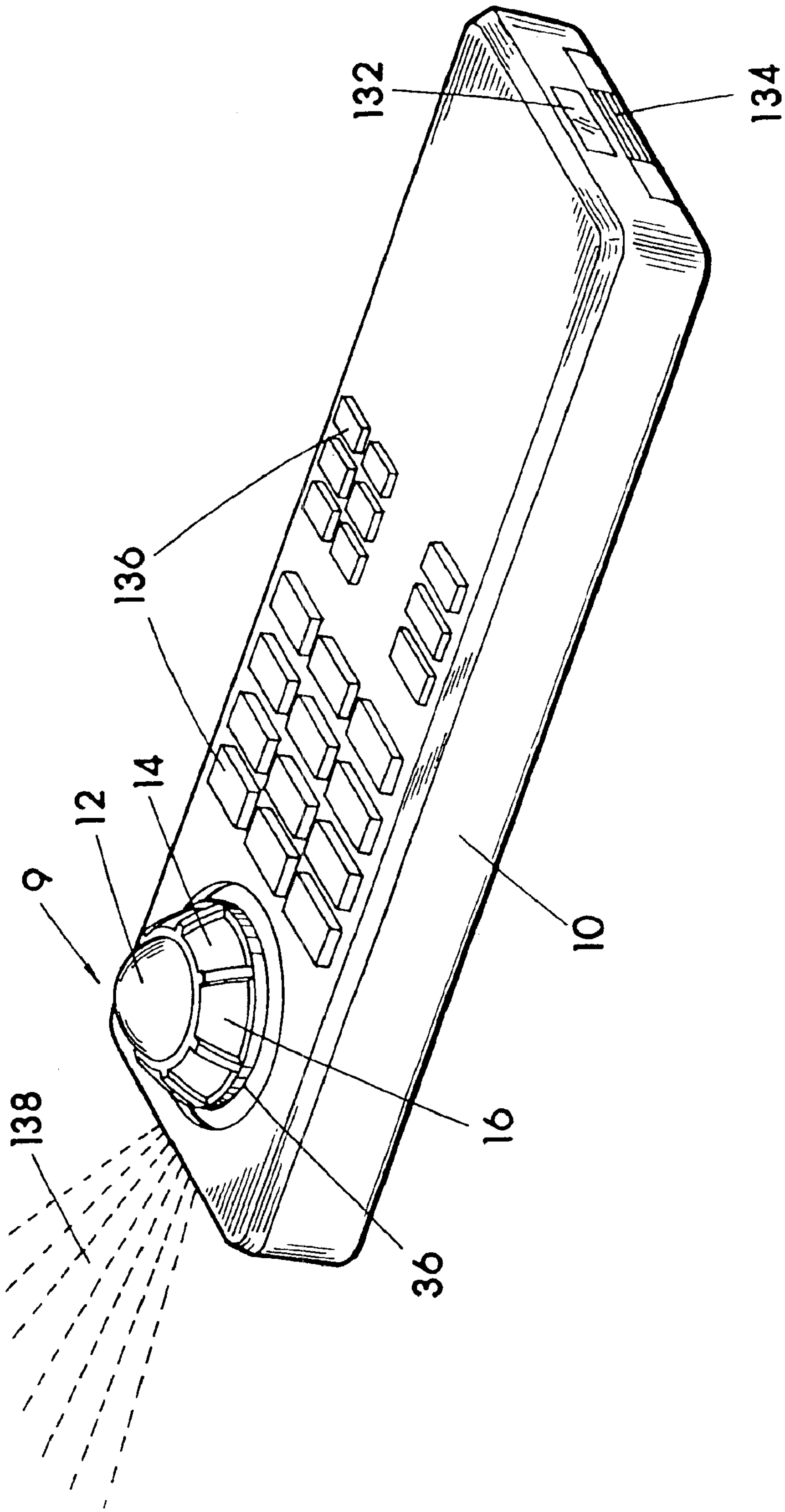


FIG. 9

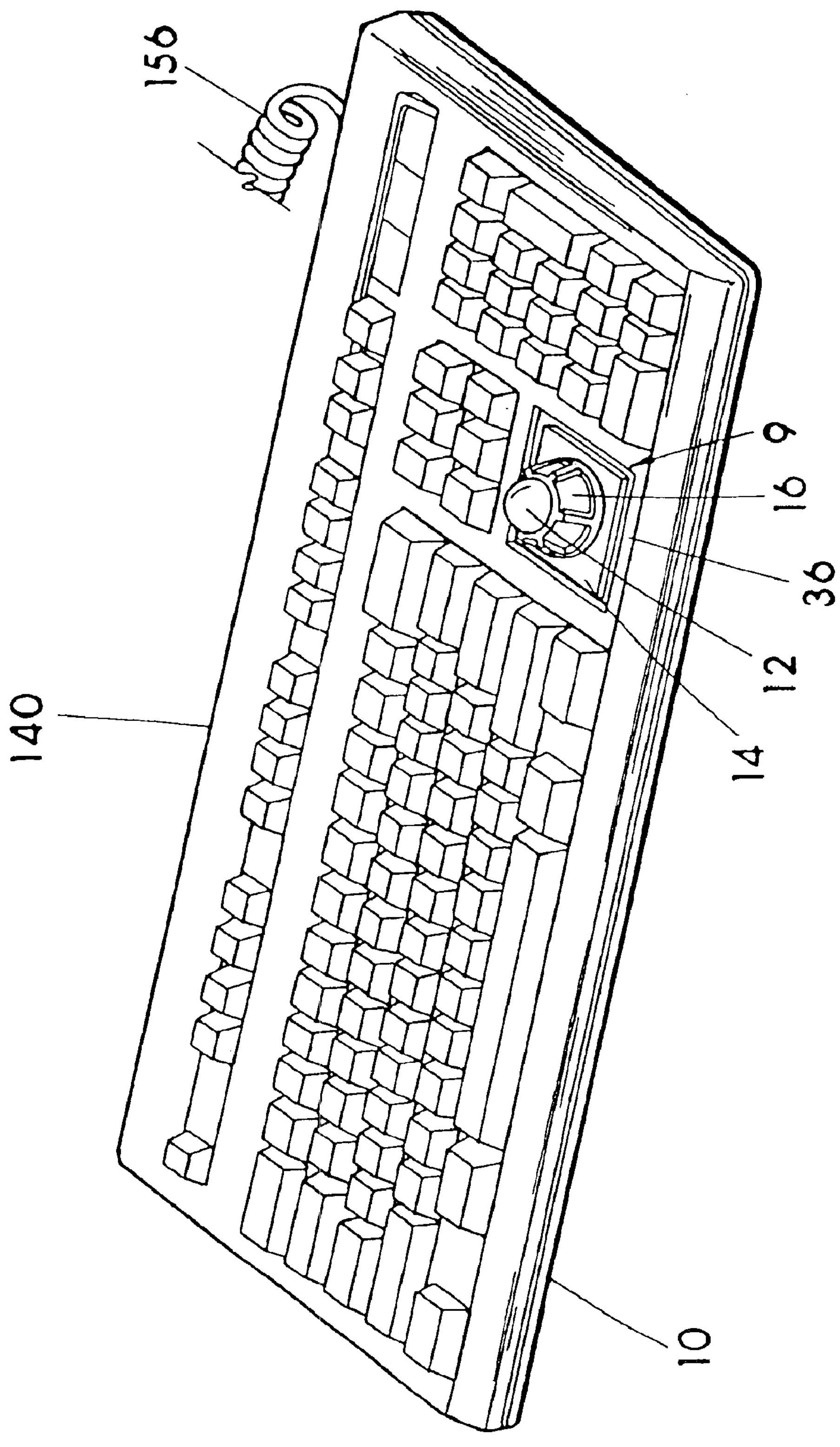


FIG. 10

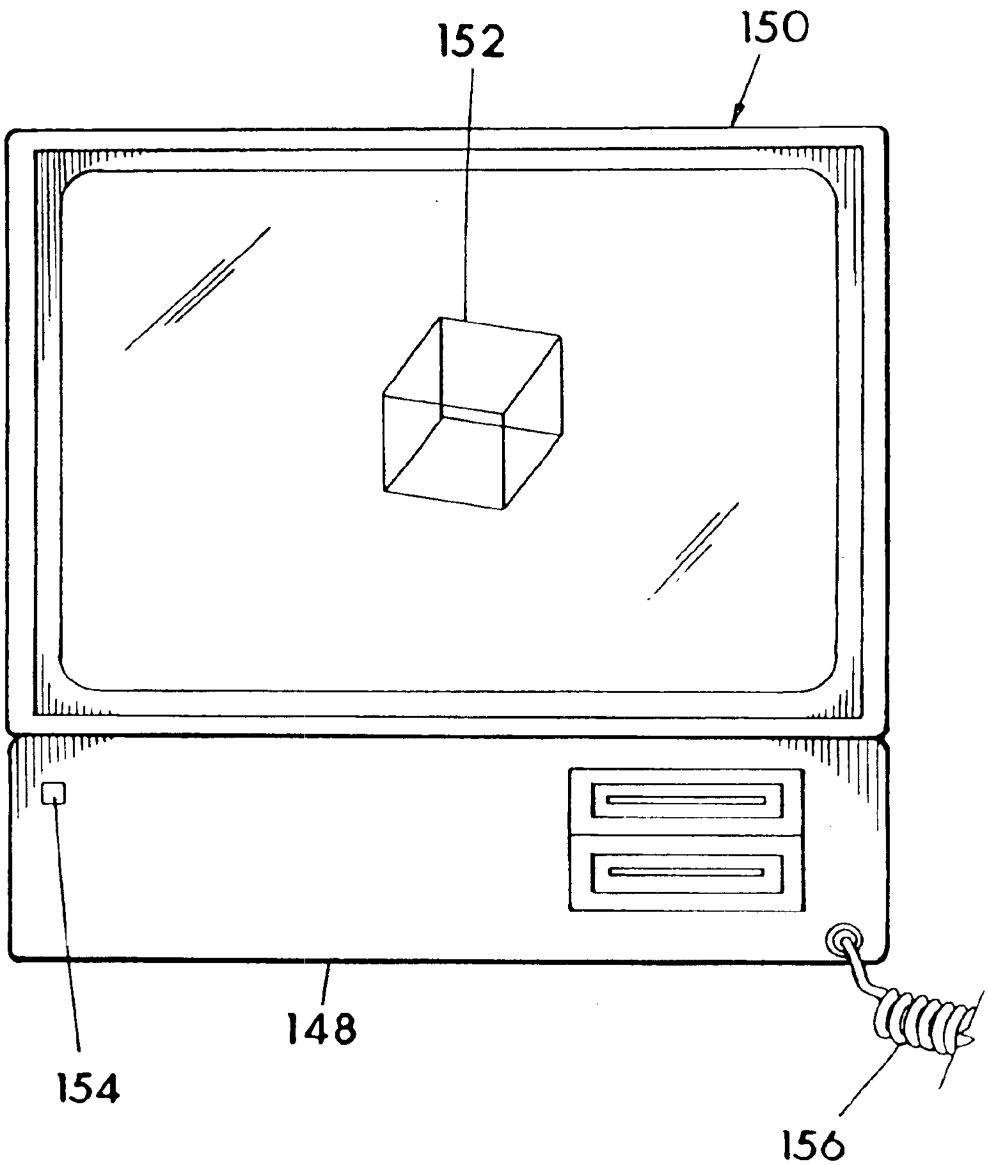


FIG. 11

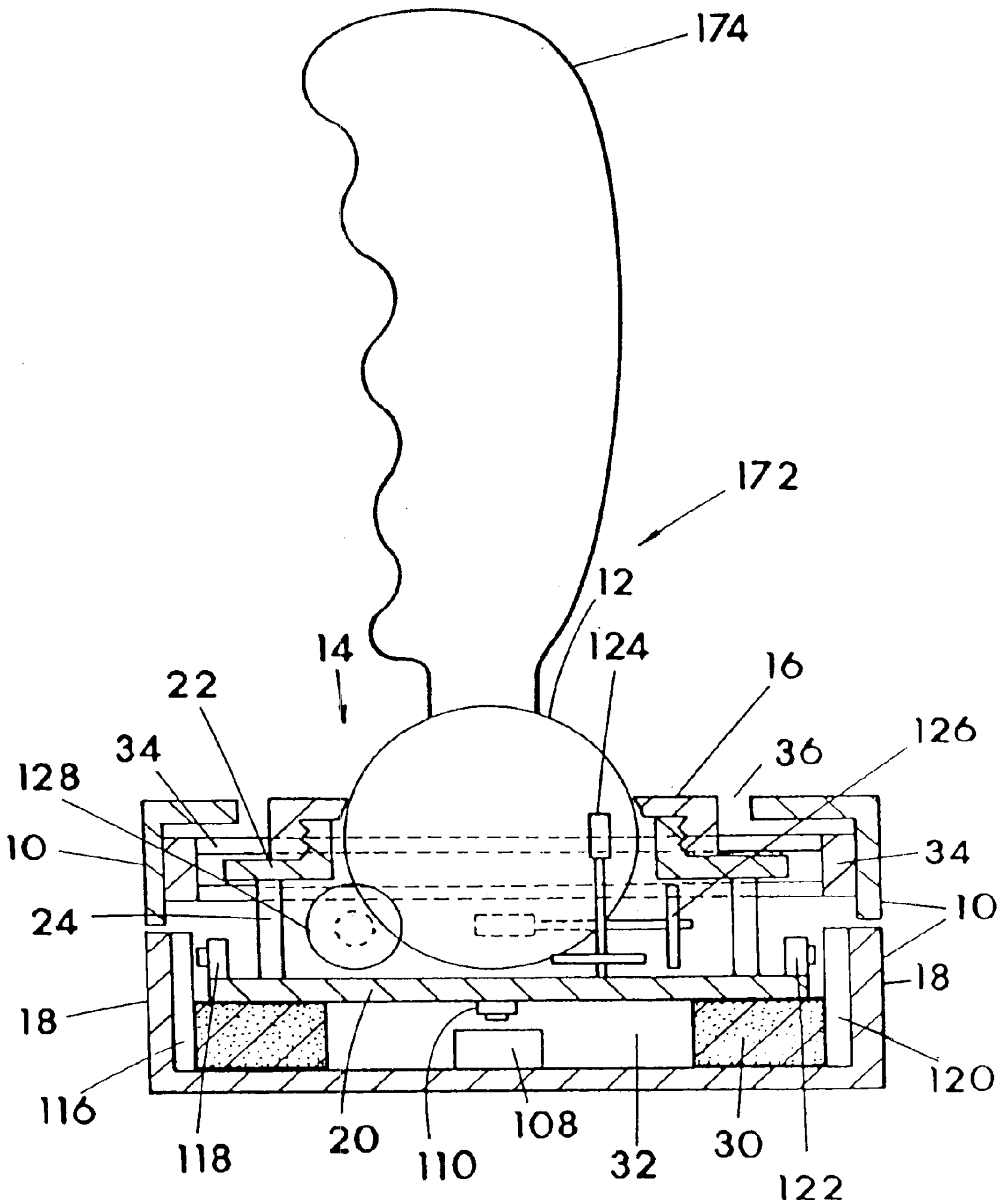

174
172
12
124
14
16
22
126
36
34
128
10
34
24
10
18
18
116
120
118
20
110
108
32
30
122

FIG. 12

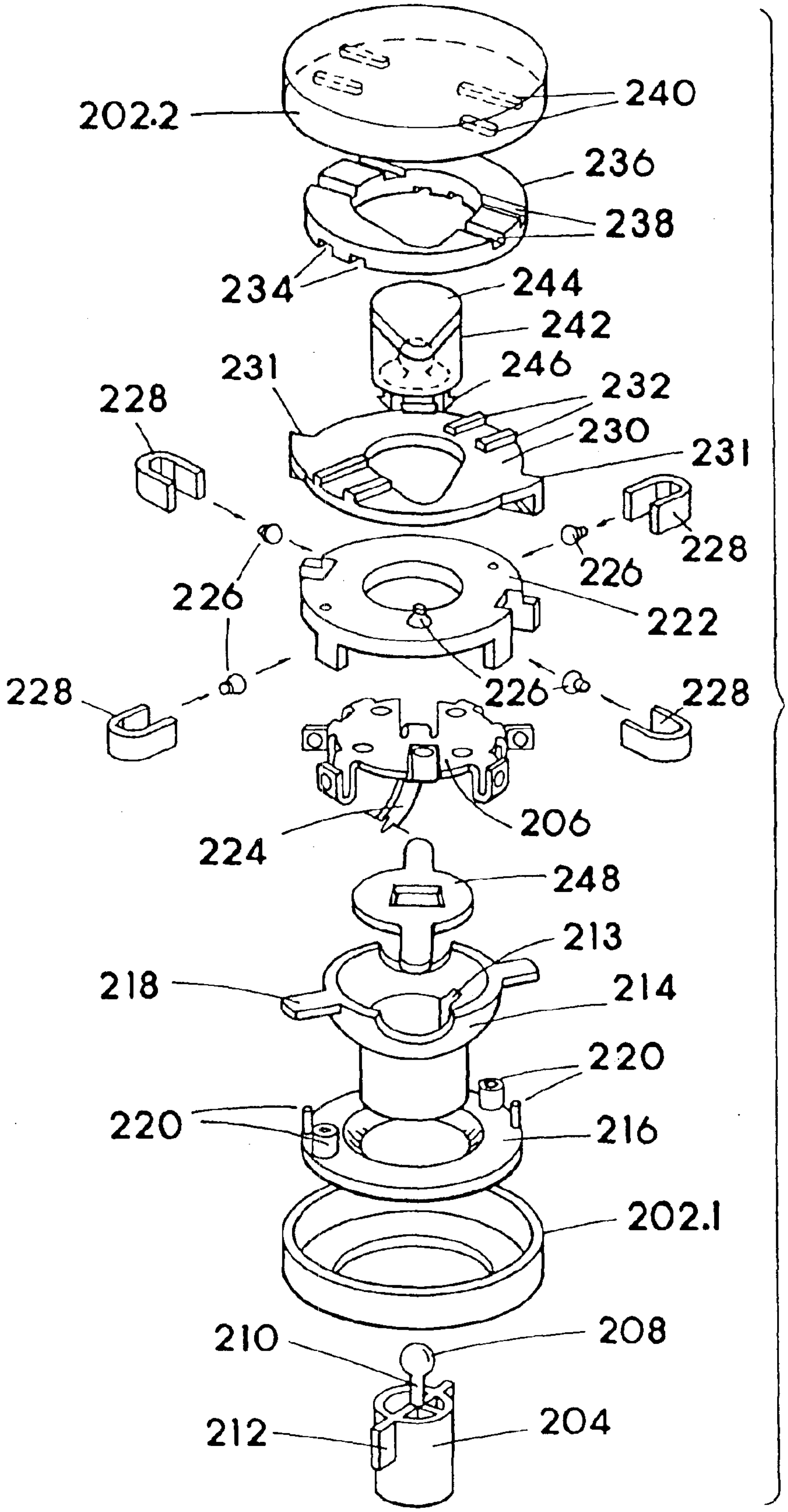

202.2
240
236
238
234
244
242
246
231
232
230
231
228
228
226
226
222
226
228
228
224
206
248
213
218
214
220
220
216
202.1
210
208
212
204

FIG. 13

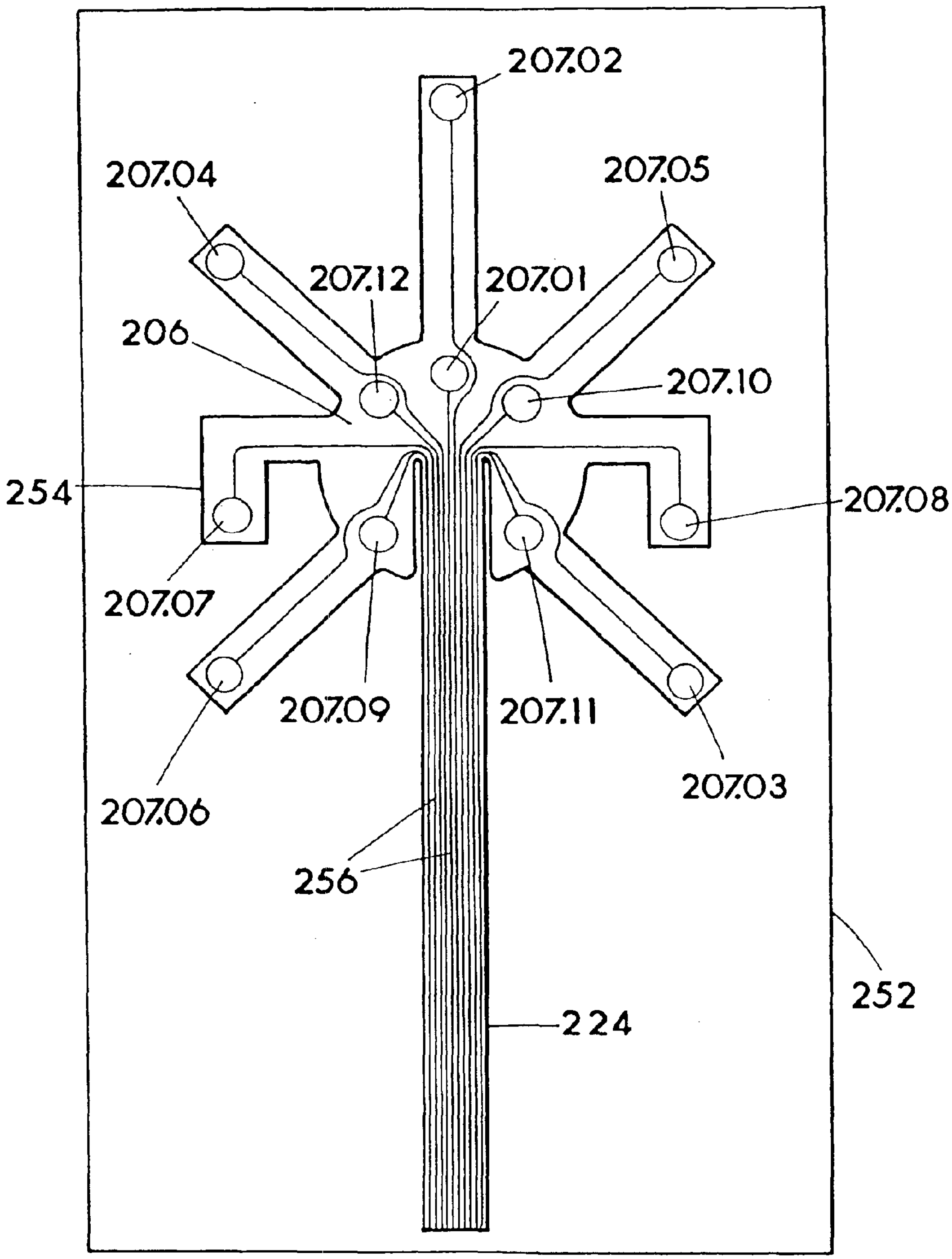

207.02
207.04
207.05
207.12
207.01
206
207.10
254
207.08
207.07
207.09
207.11
207.06
207.03
256
252
224

FIG. 14

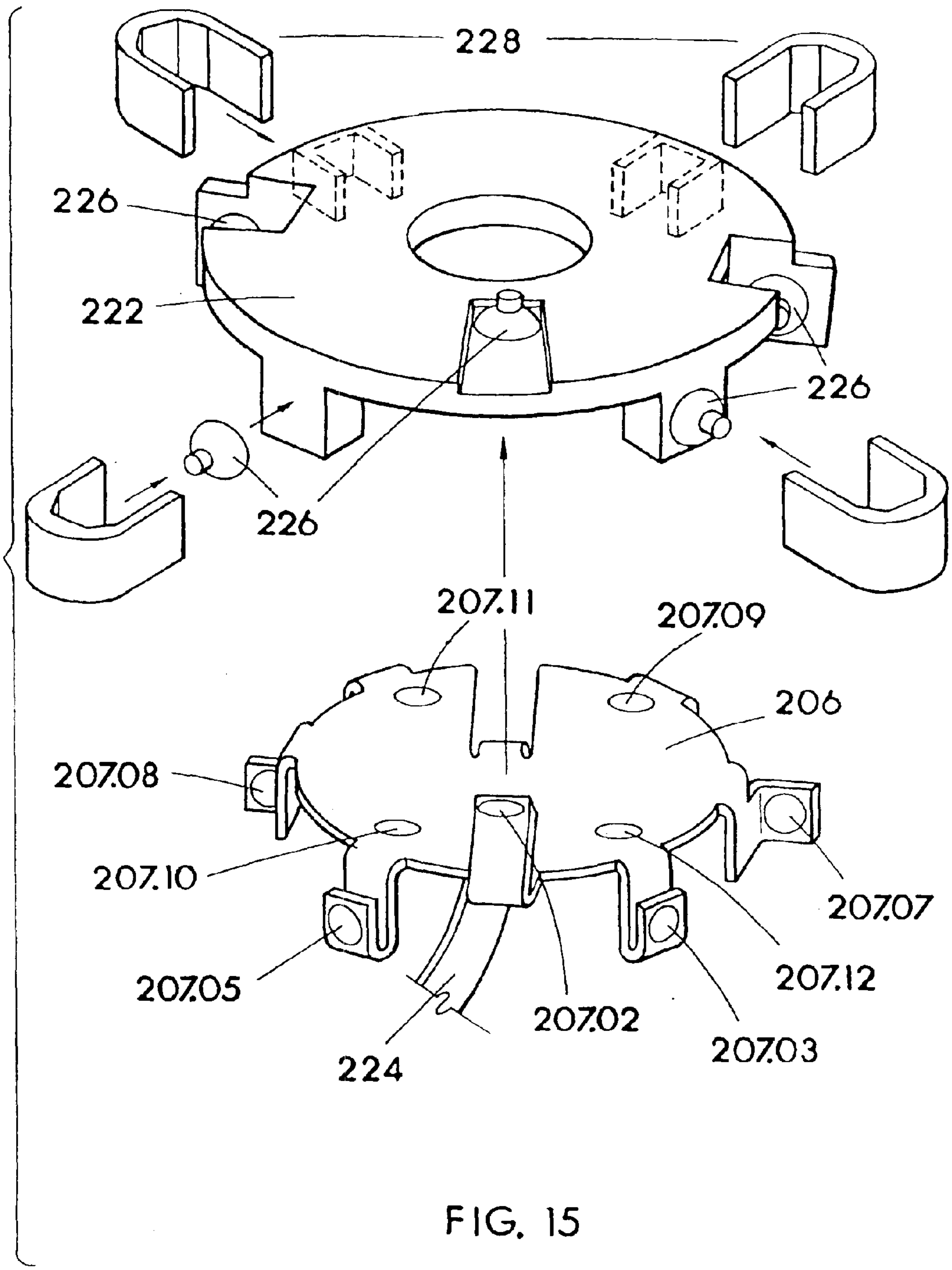

228
226
222
226
226
226
207.11
207.09
206
207.08
207.10
207.07
207.05
207.12
207.02
207.03
224

FIG. 15

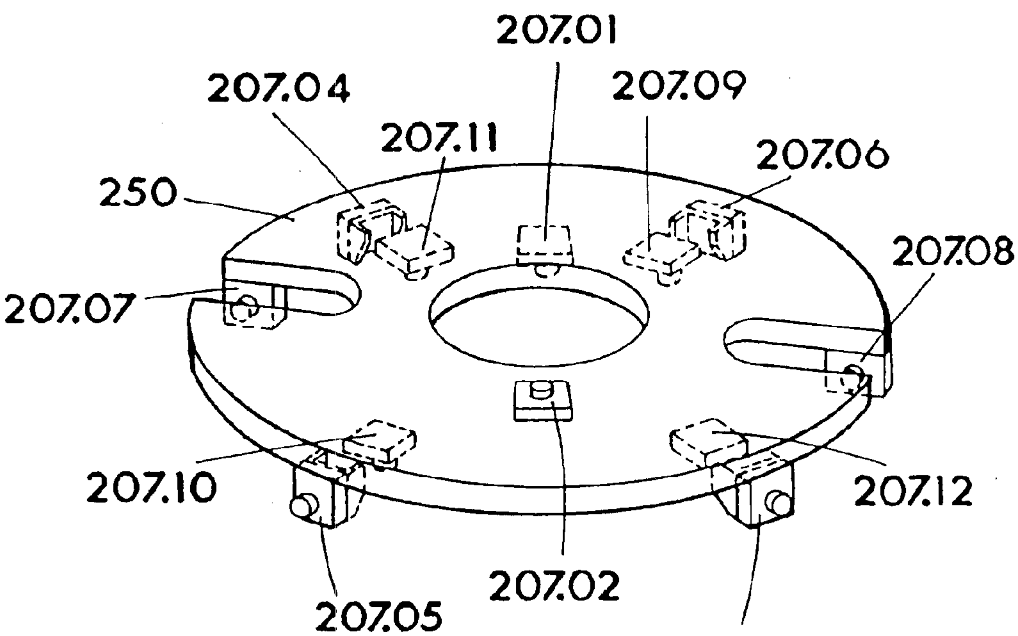

207.01
207.04
207.09
207.11
207.06
250
207.08
207.07
207.10
207.12
207.02
207.05
207.03

FIG. 16

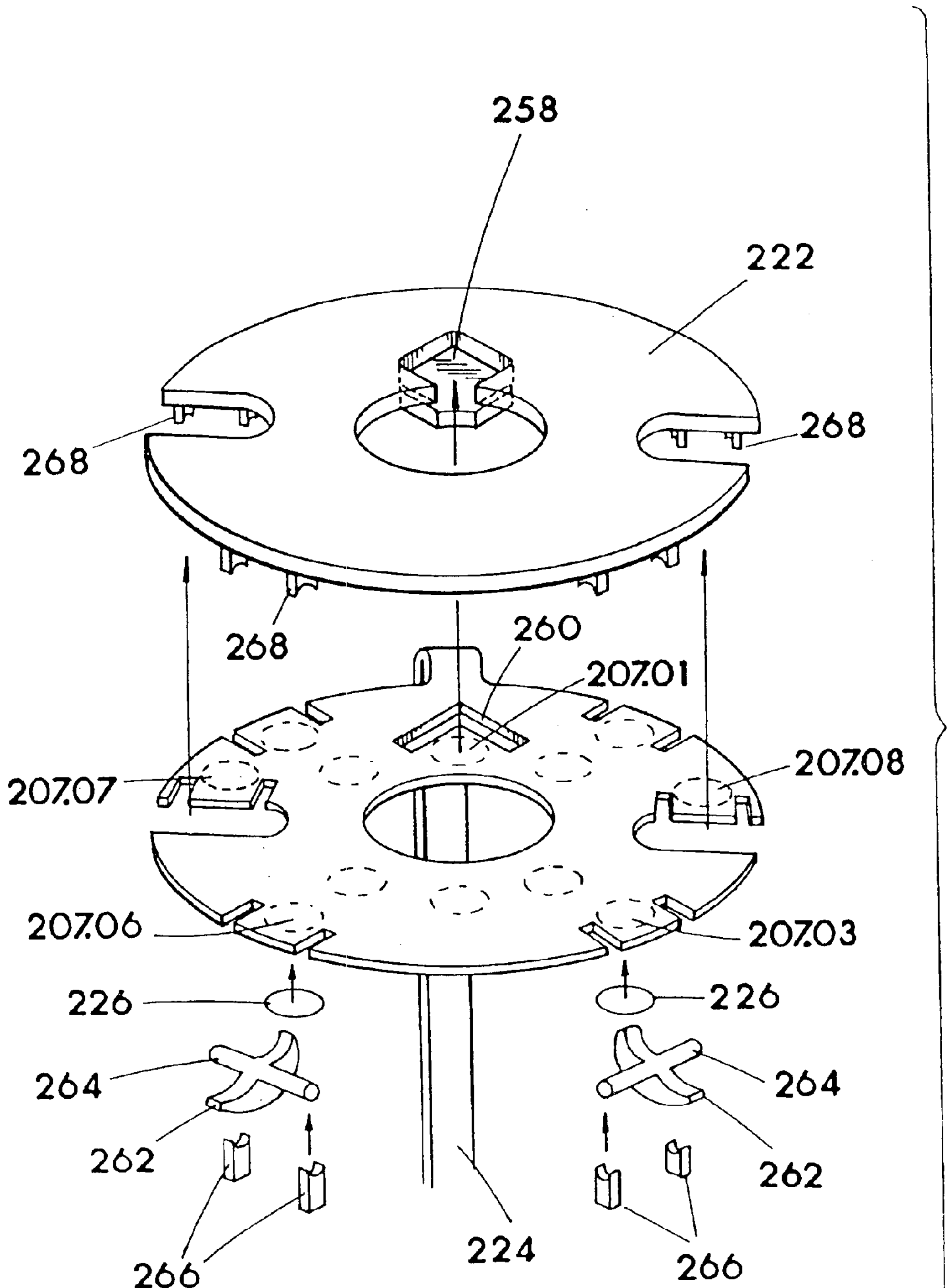

258
222
268
268
268
260
207.01
207.07
207.08
207.06
207.03
226
226
264
264
262
262
266
224
266

FIG. 17

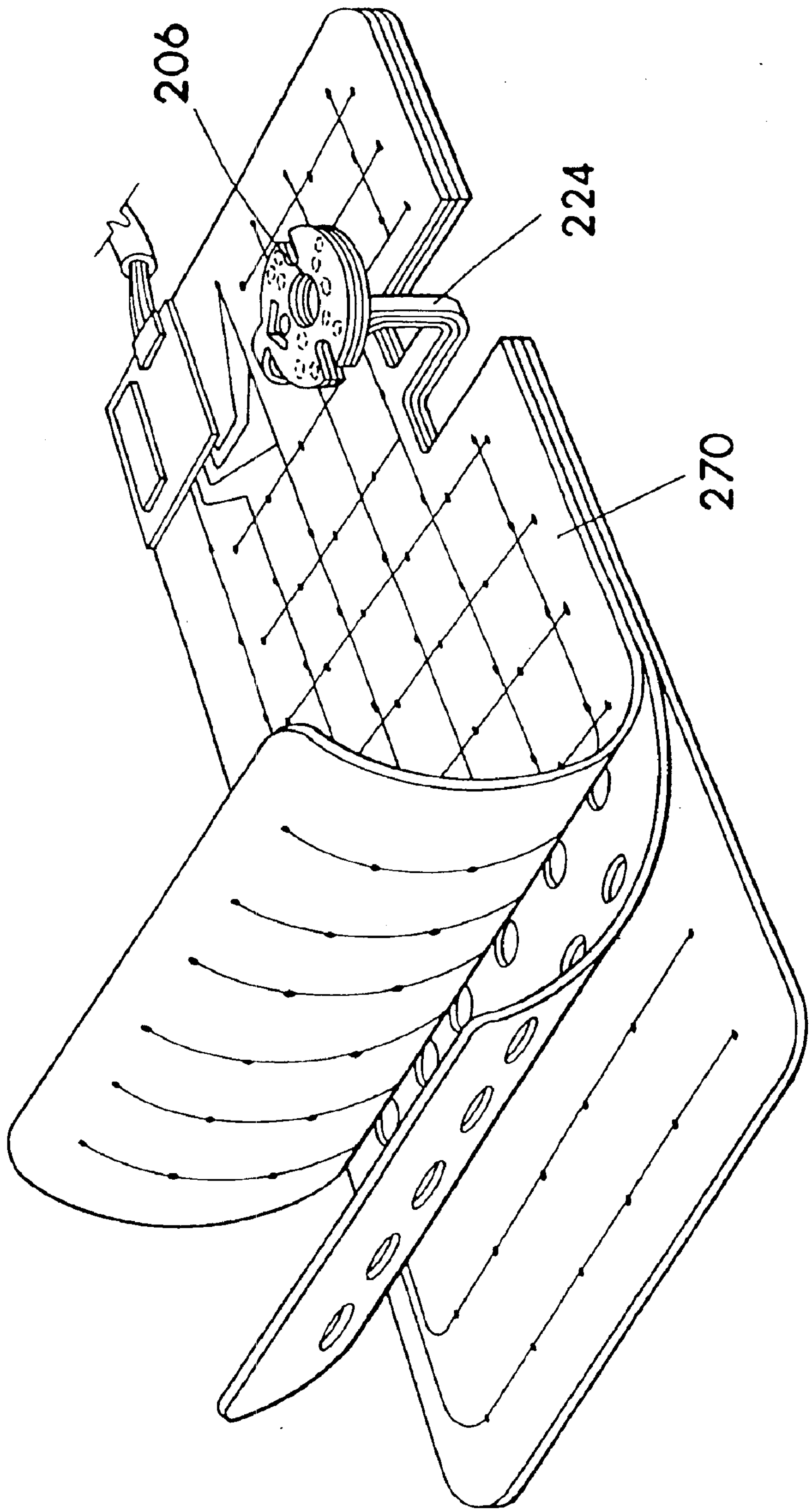


FIG. 18

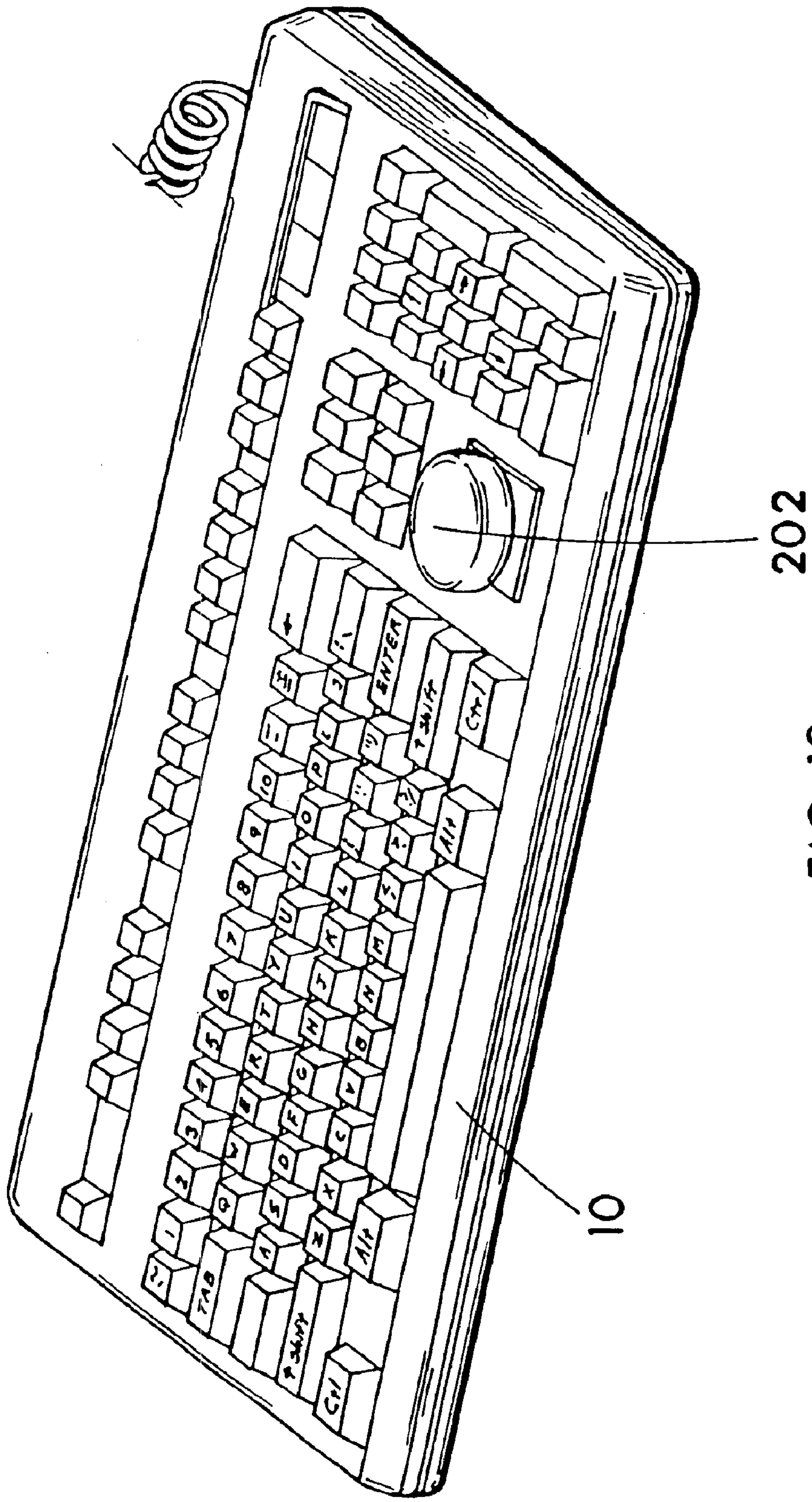


FIG. 19

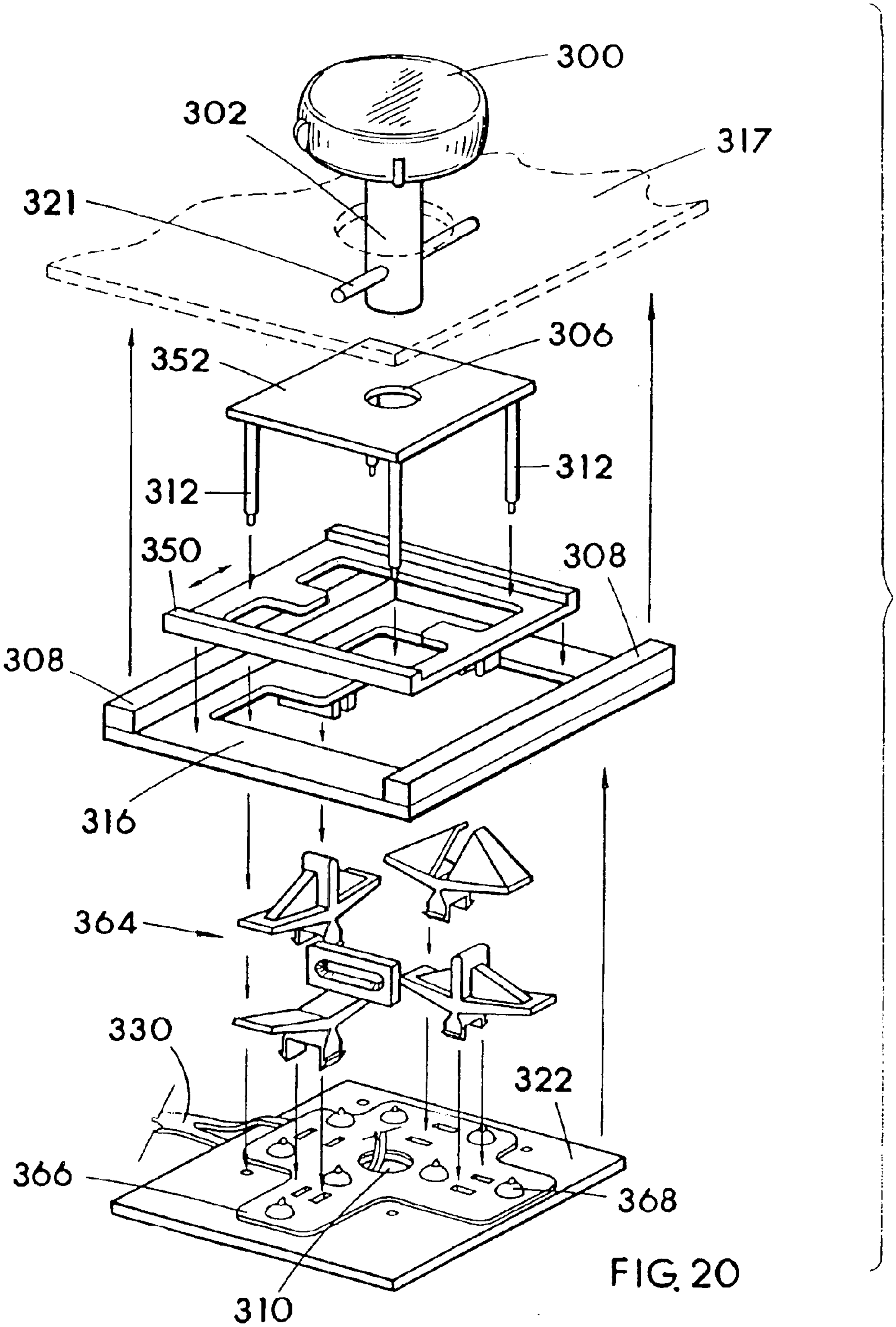

300
302
317
321
306
352
312
312
350
308
308
316
364
330
322
366
368
310

FIG. 20

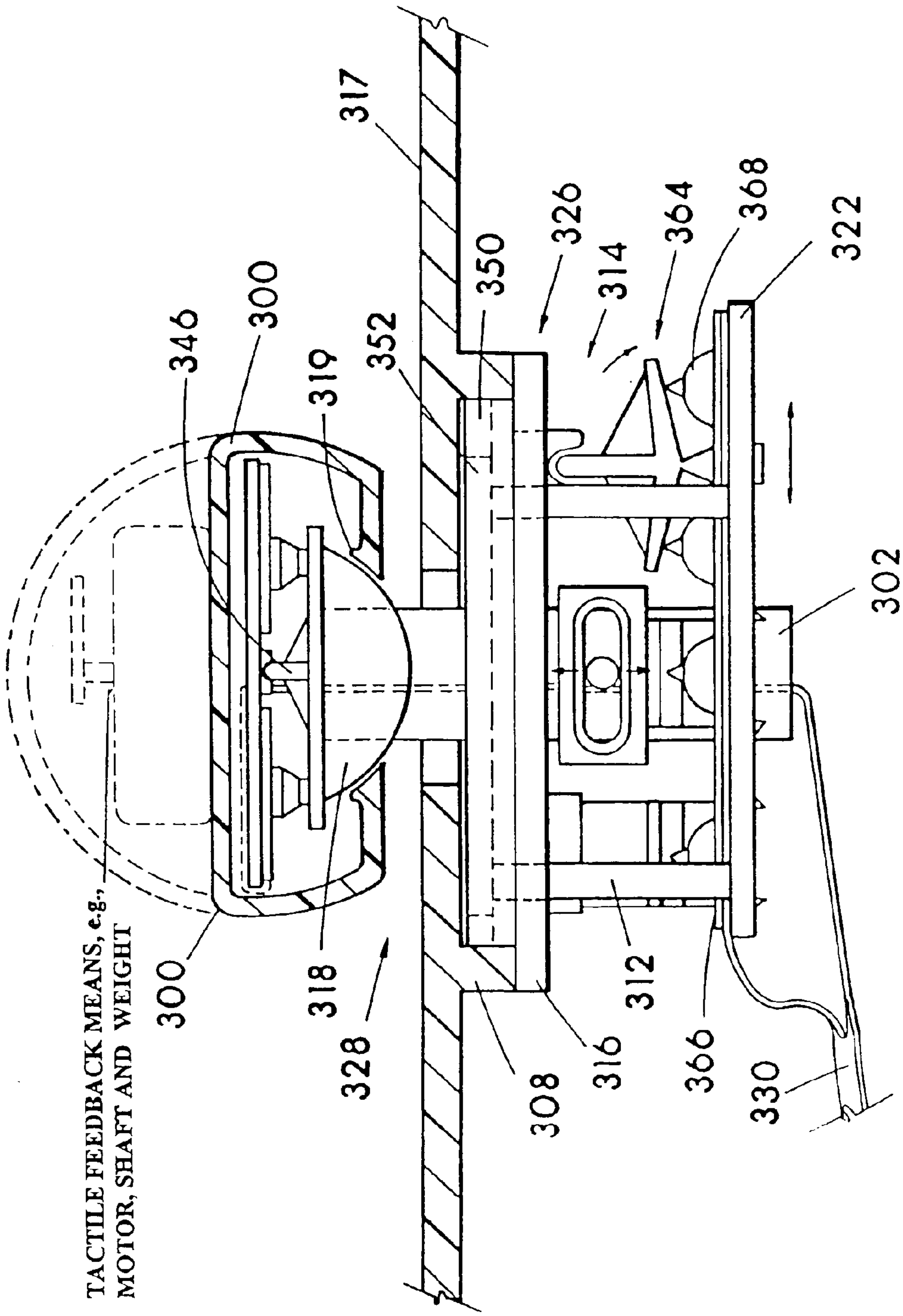

TACTILE FEEDBACK MEANS, e.g.,
MOTOR, SHAFT AND WEIGHT
300
346
300
319
352
350
317
326
314
364
368
322
302
318
328
308
316
312
366
330

FIG. 21

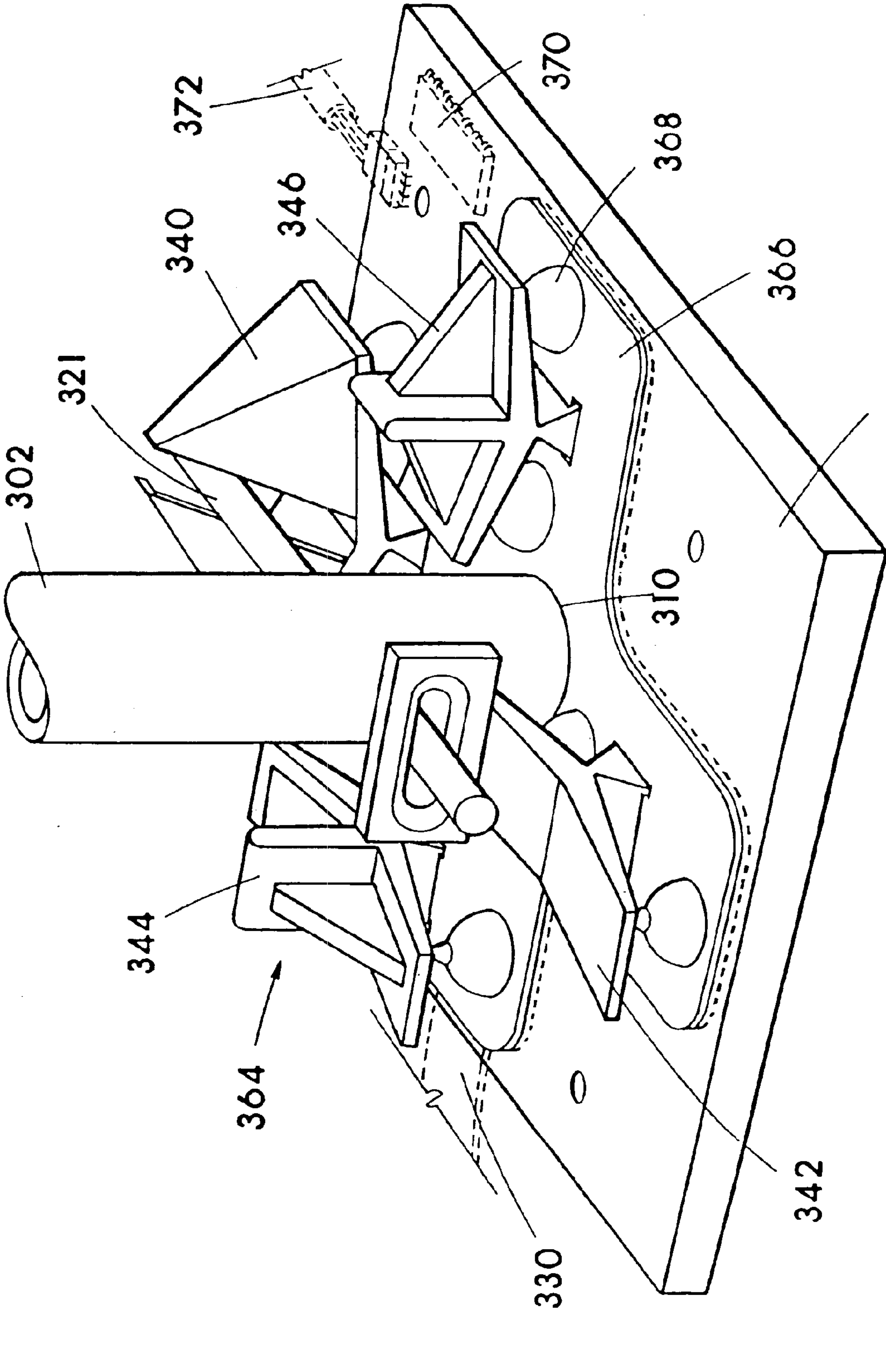


FIG. 22

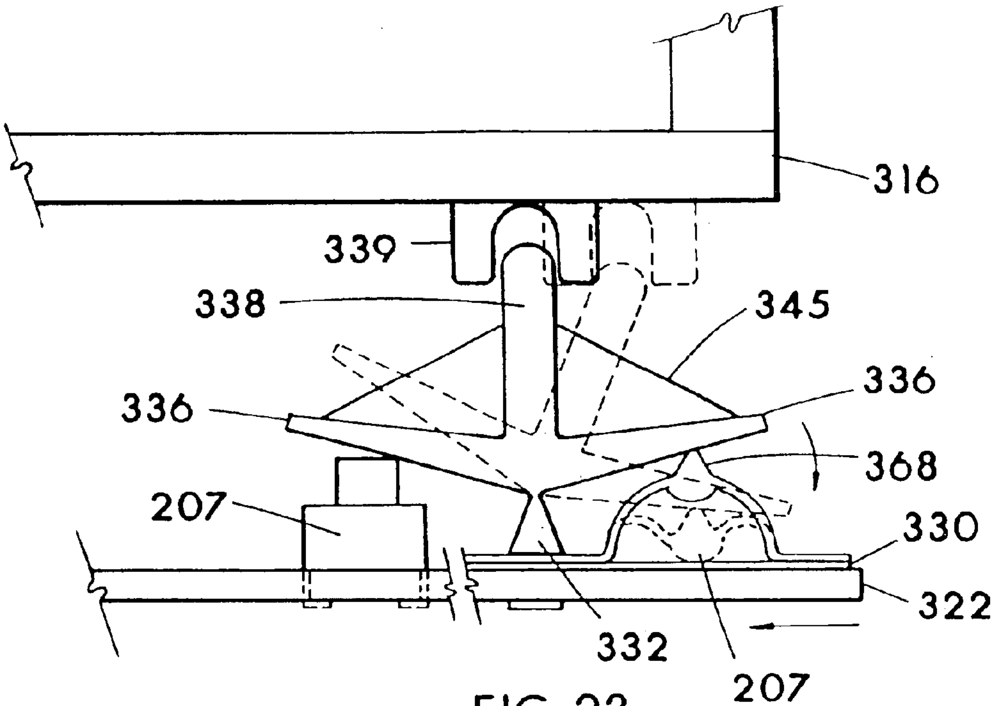

316
339
338
345
336
336
368
207
330
322
332
207

FIG. 23

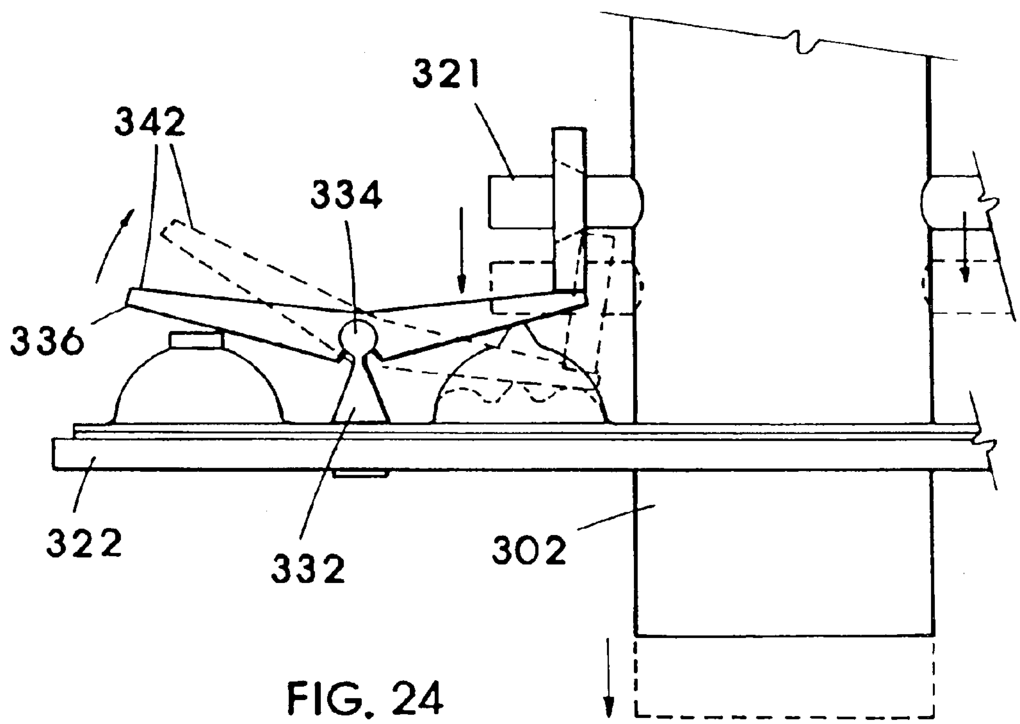

321
342
334
336
322
332
302

FIG. 24

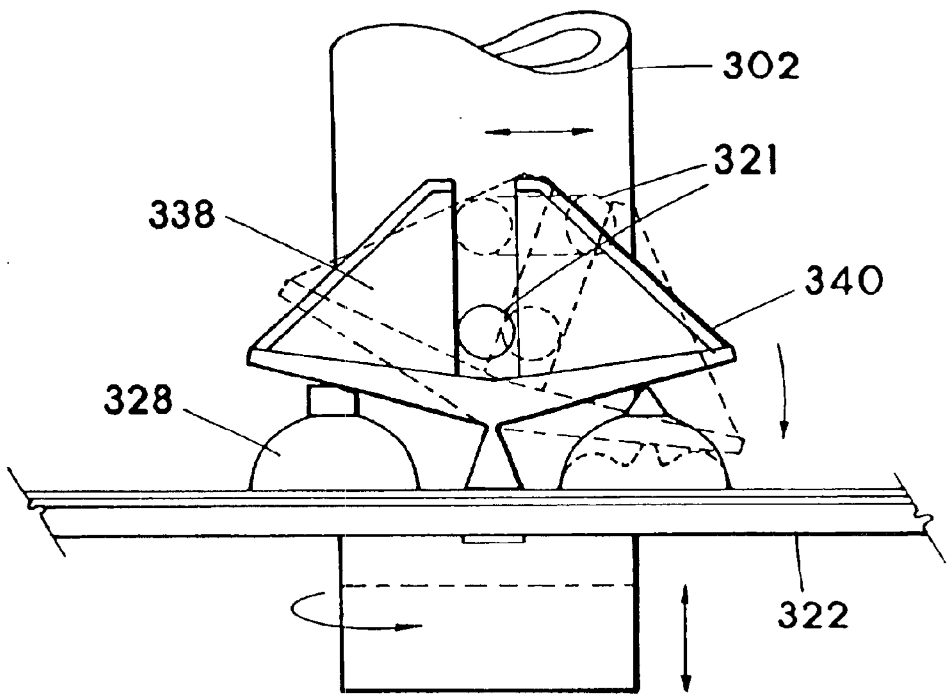


FIG. 25

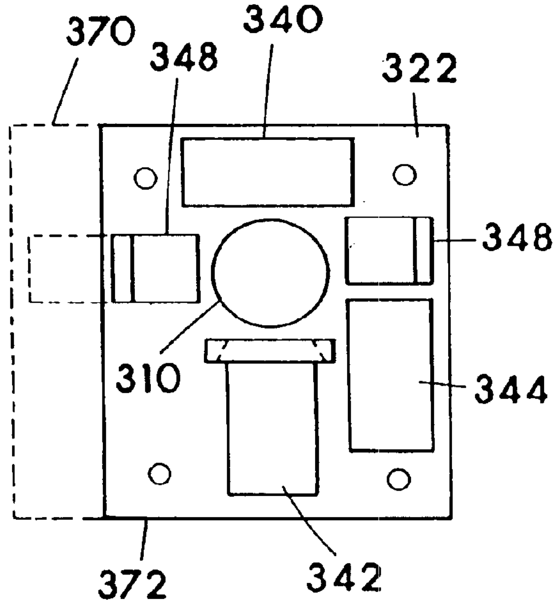


FIG. 26

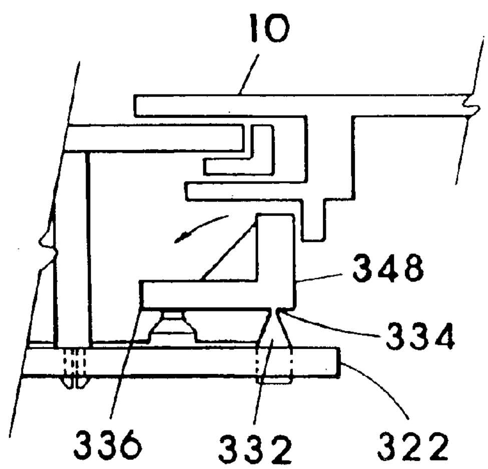


FIG. 27

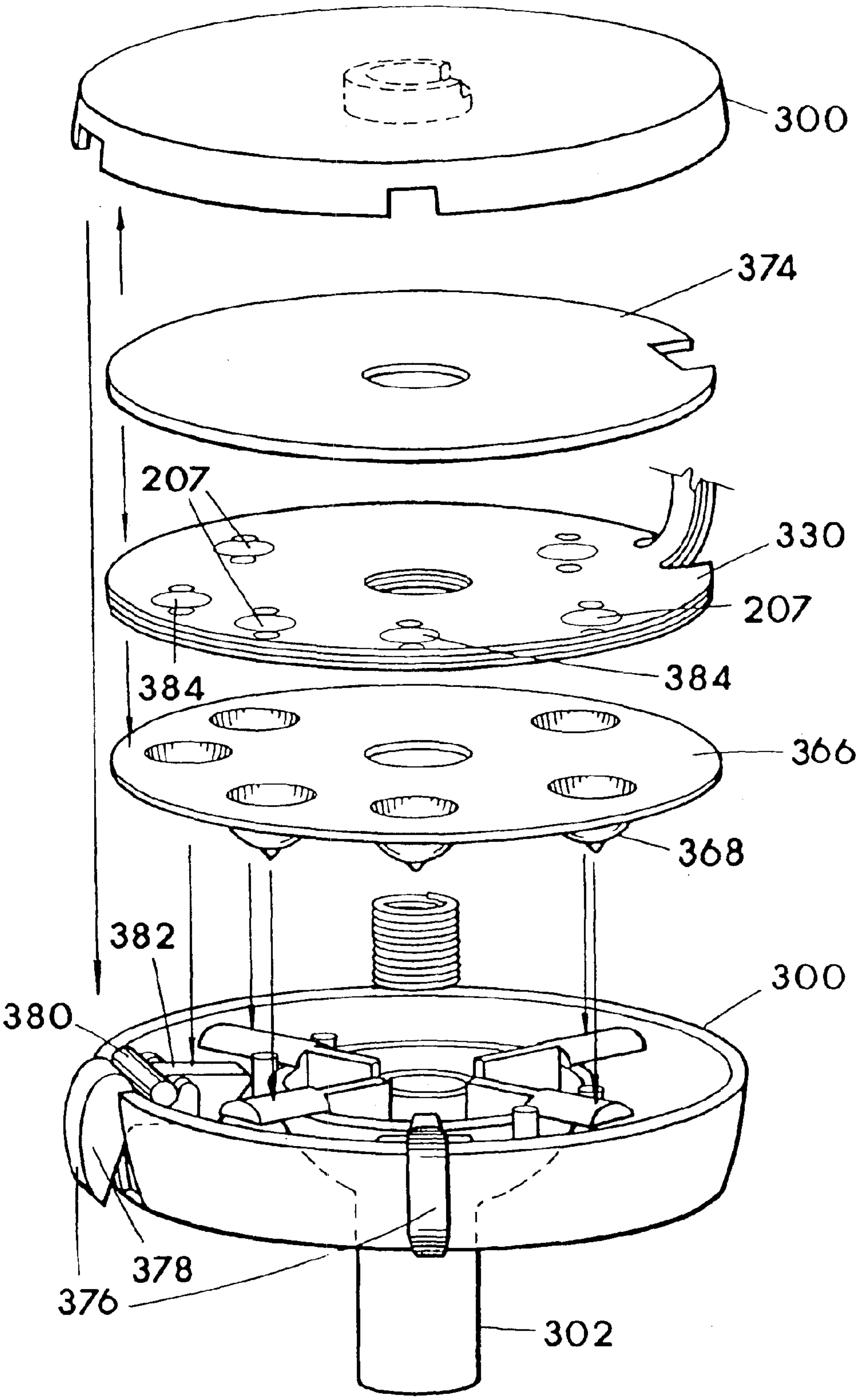


FIG. 28

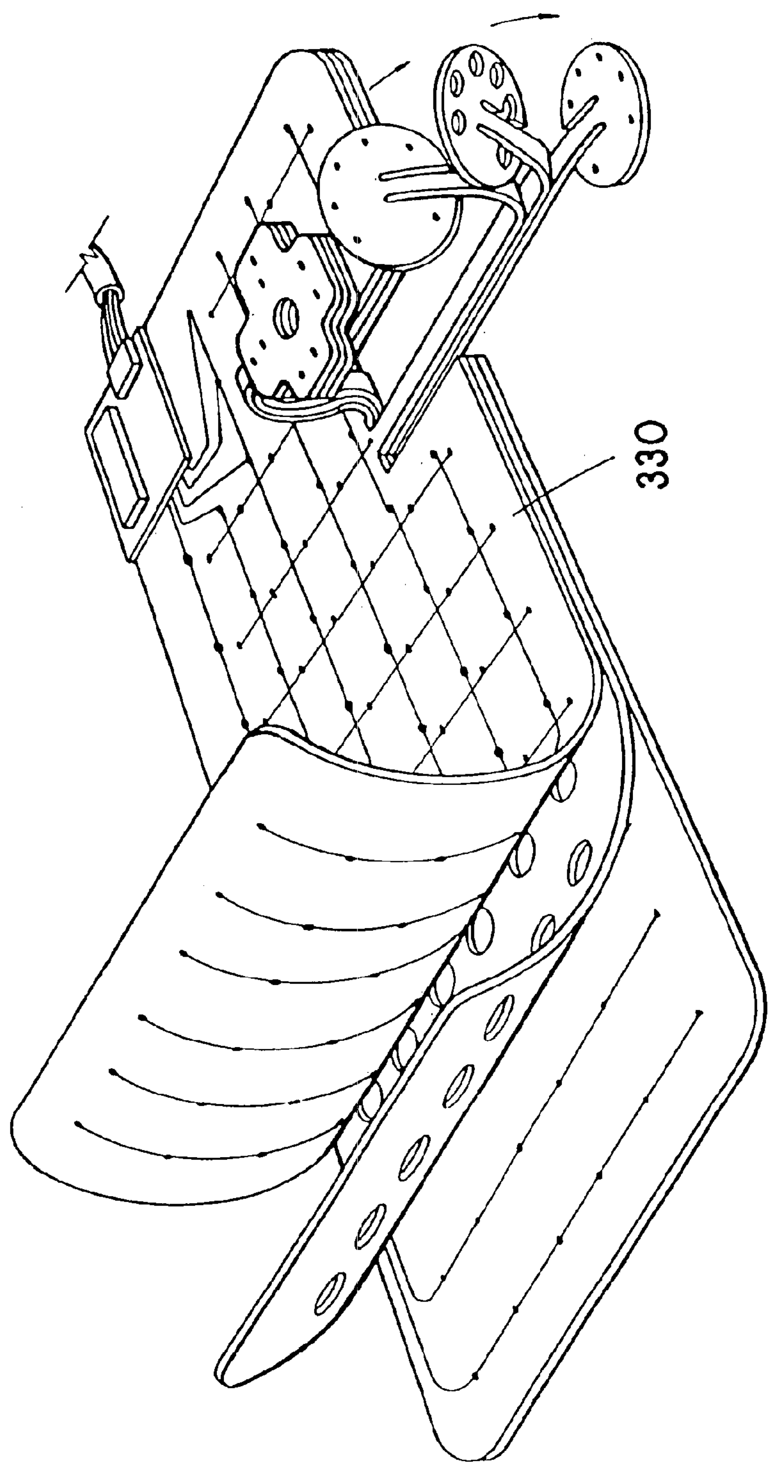


FIG. 29

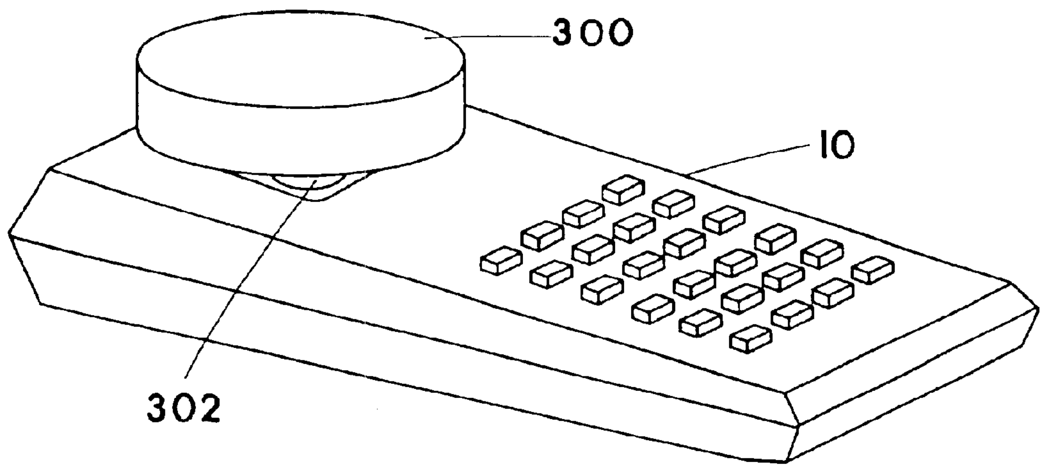


FIG. 30

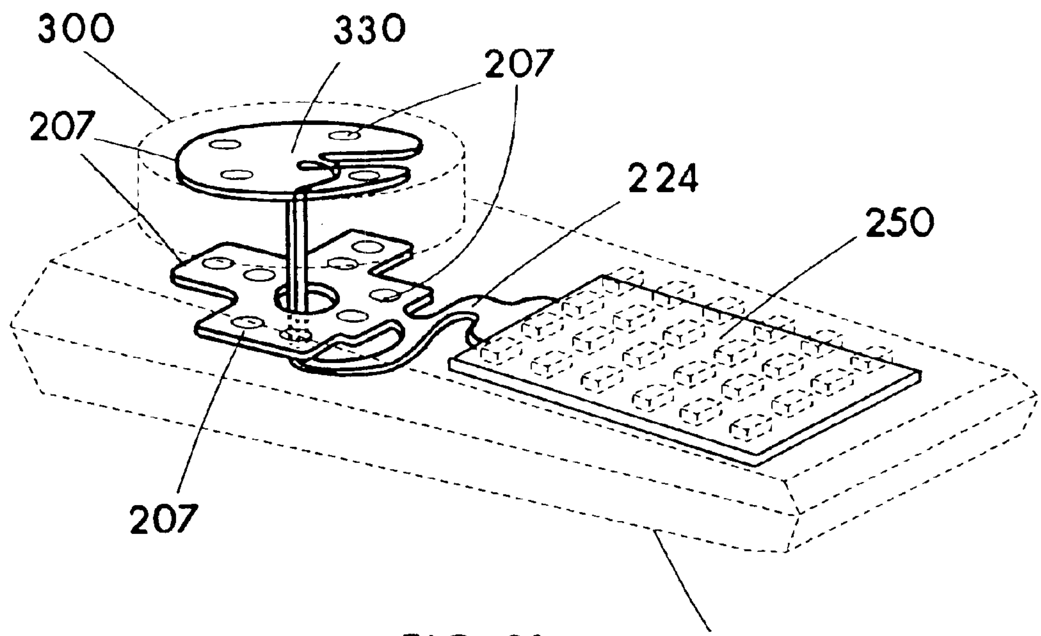


FIG. 31

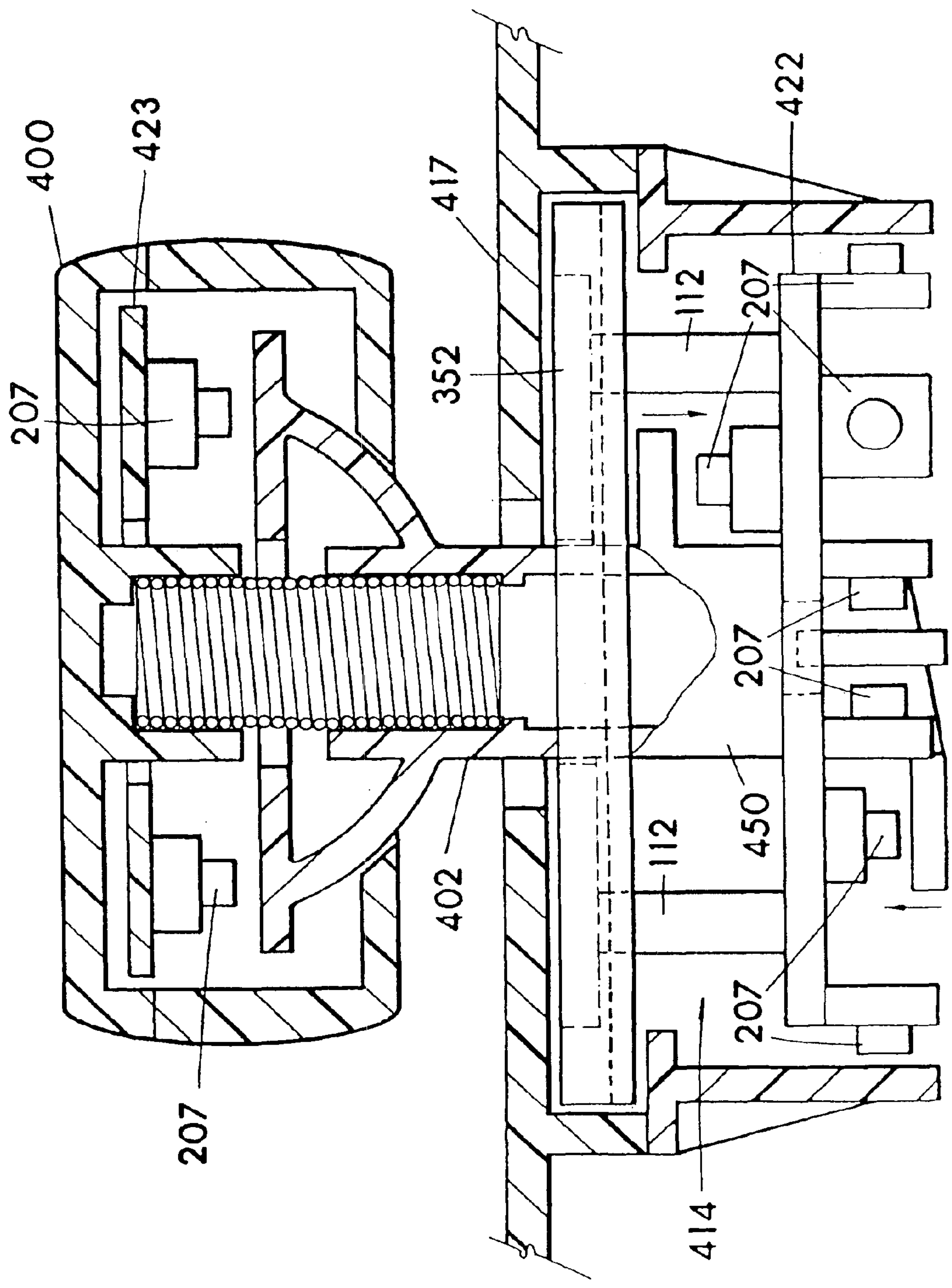

400
423
207
417
352
112
207
422
207
207
450
402
112
207
207
207
414

FIG. 32

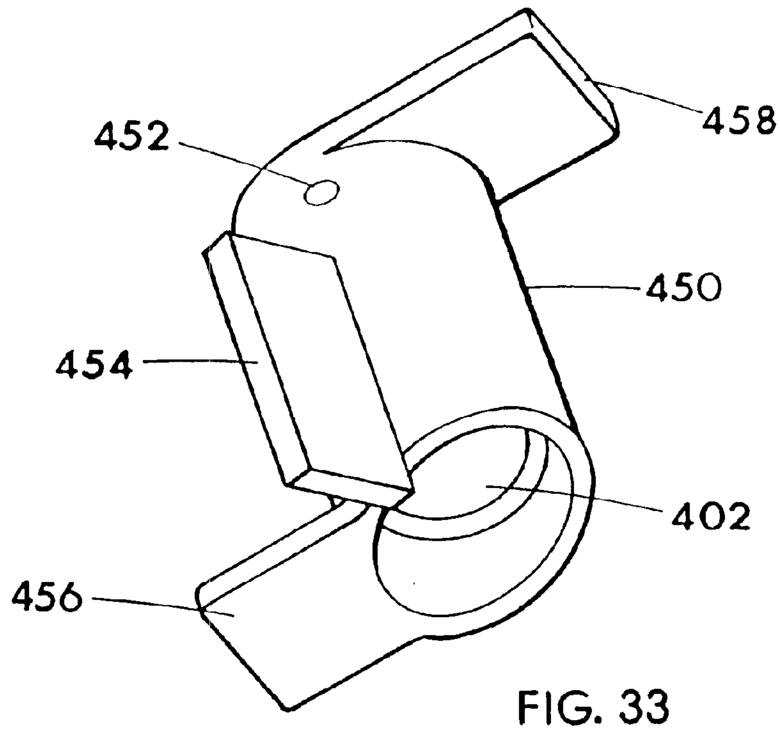


FIG. 33

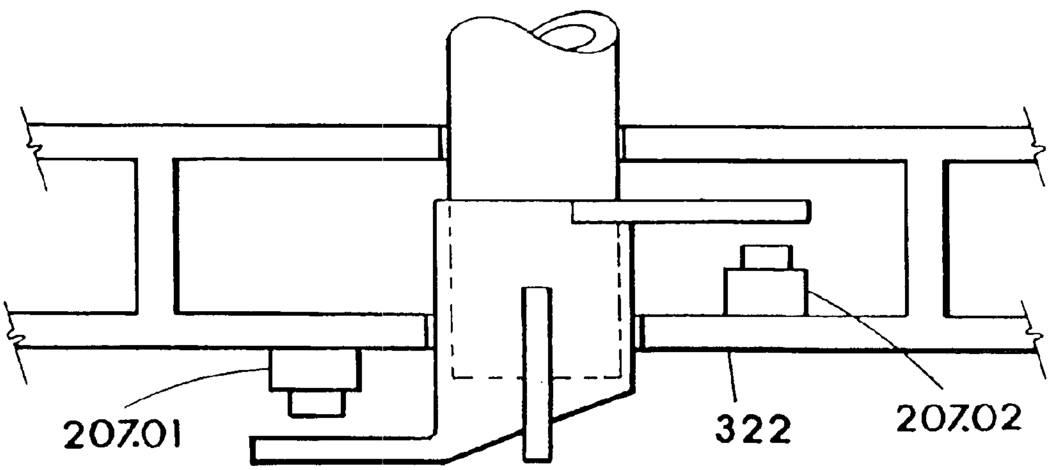


FIG. 34

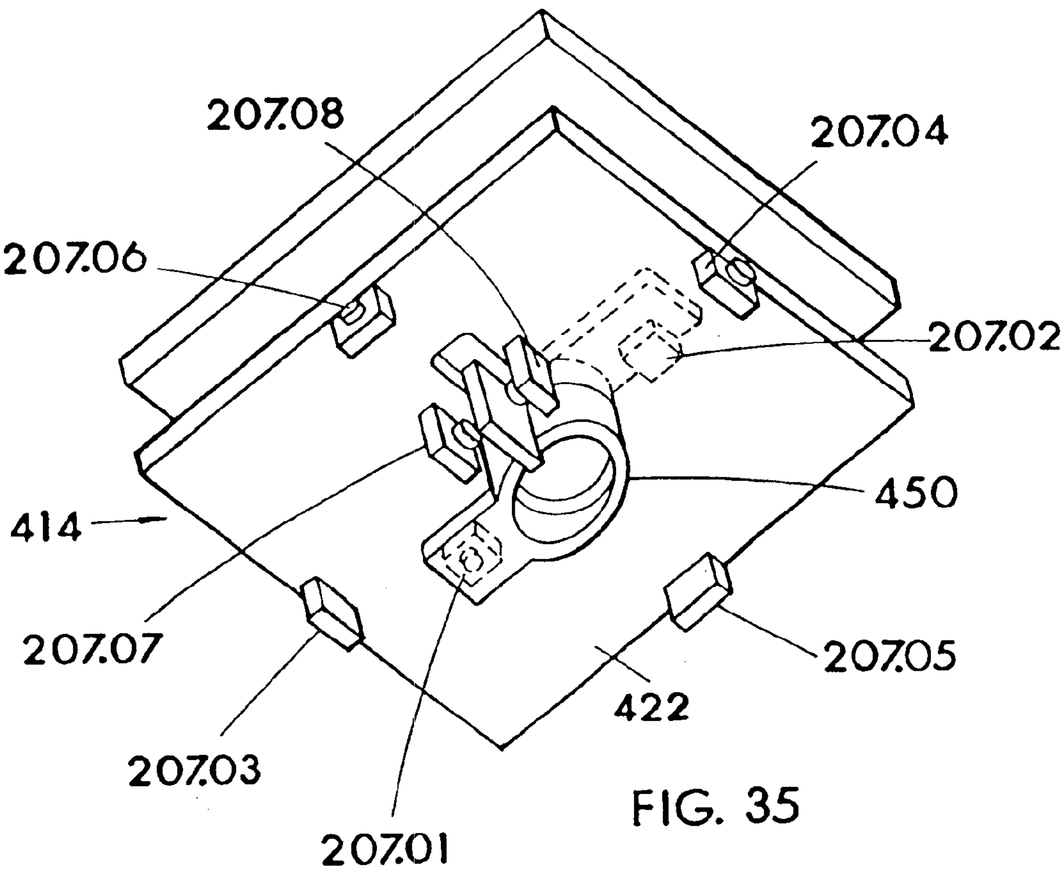


FIG. 35

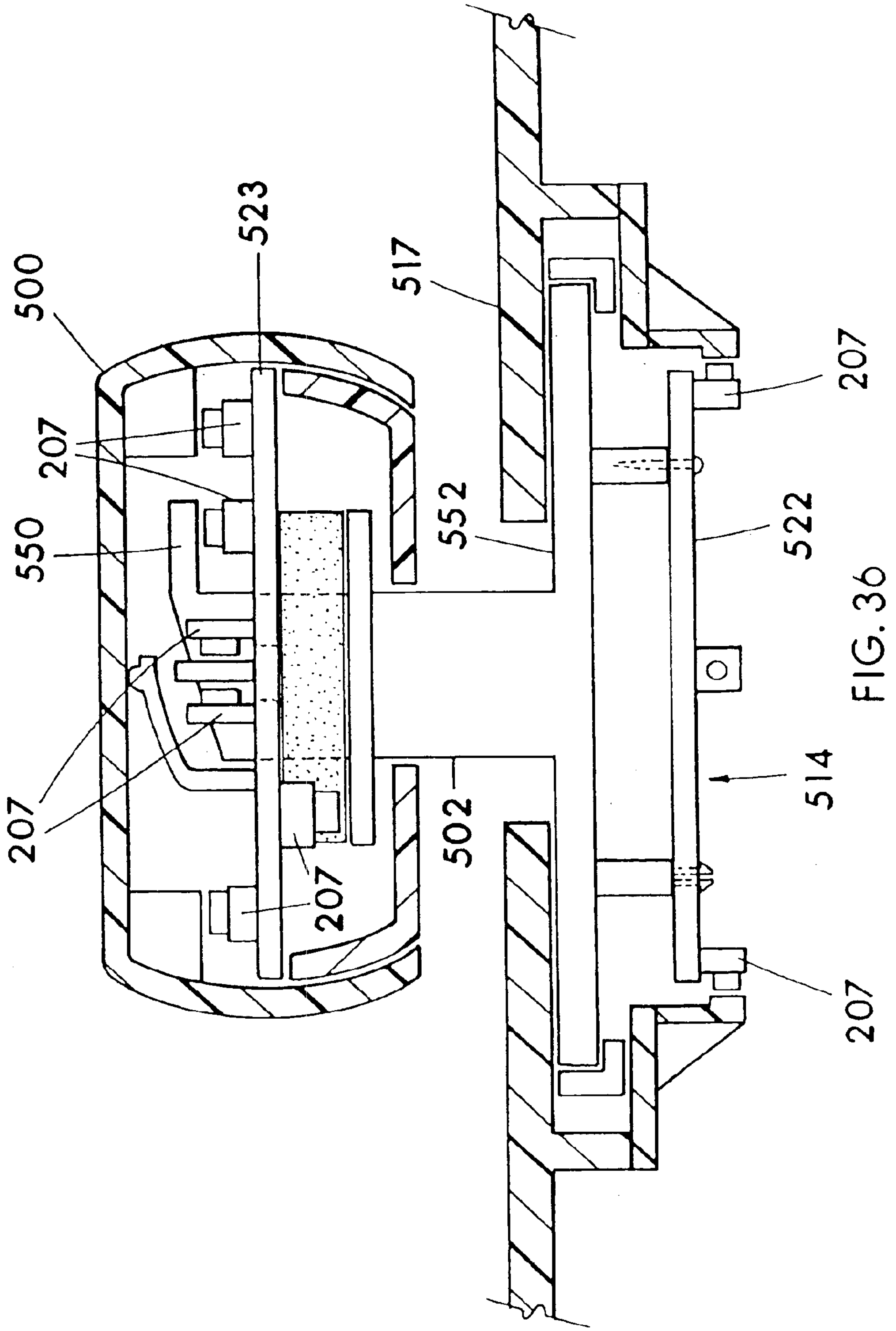


FIG. 36

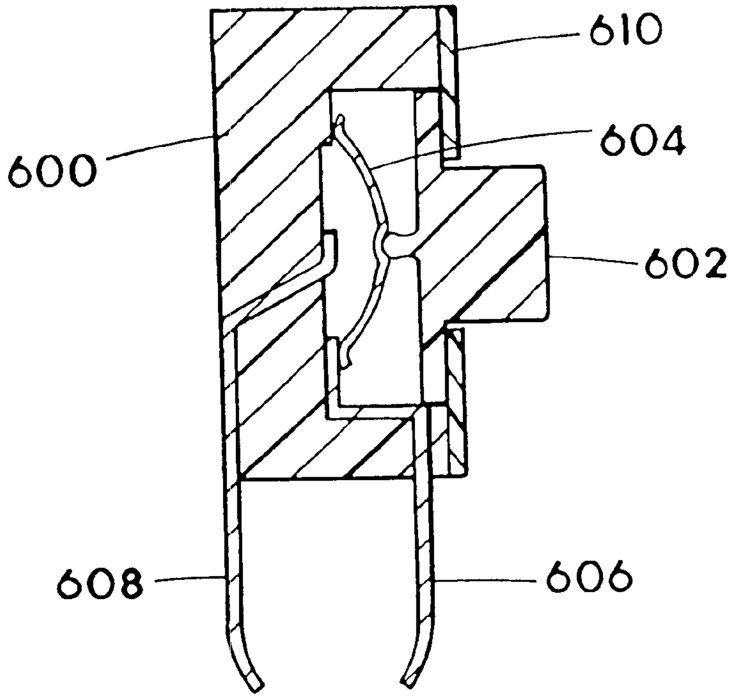


FIG. 37

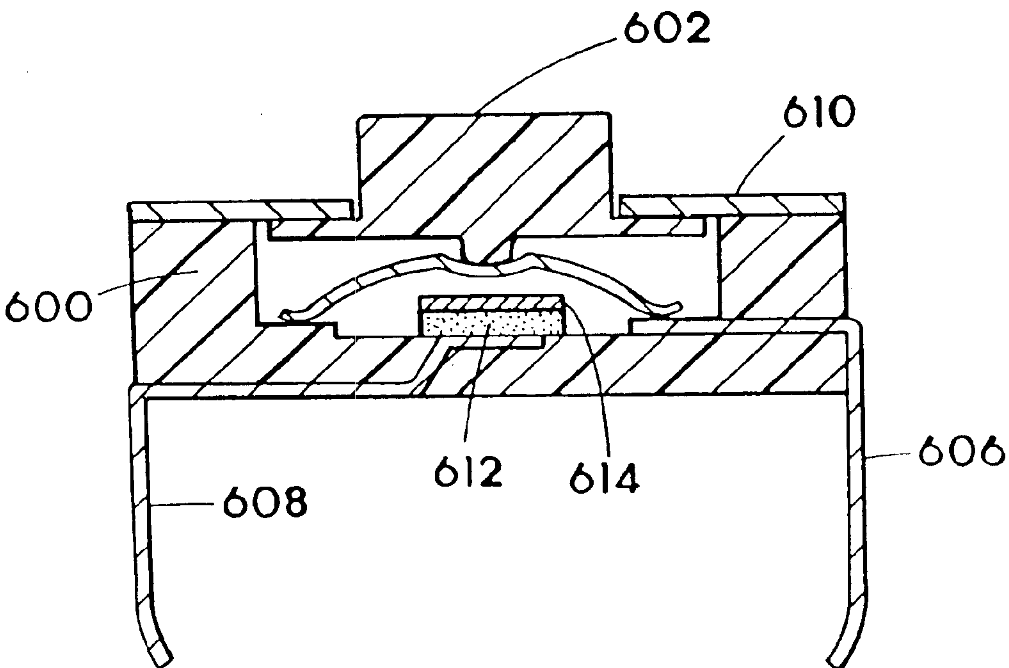


FIG. 38

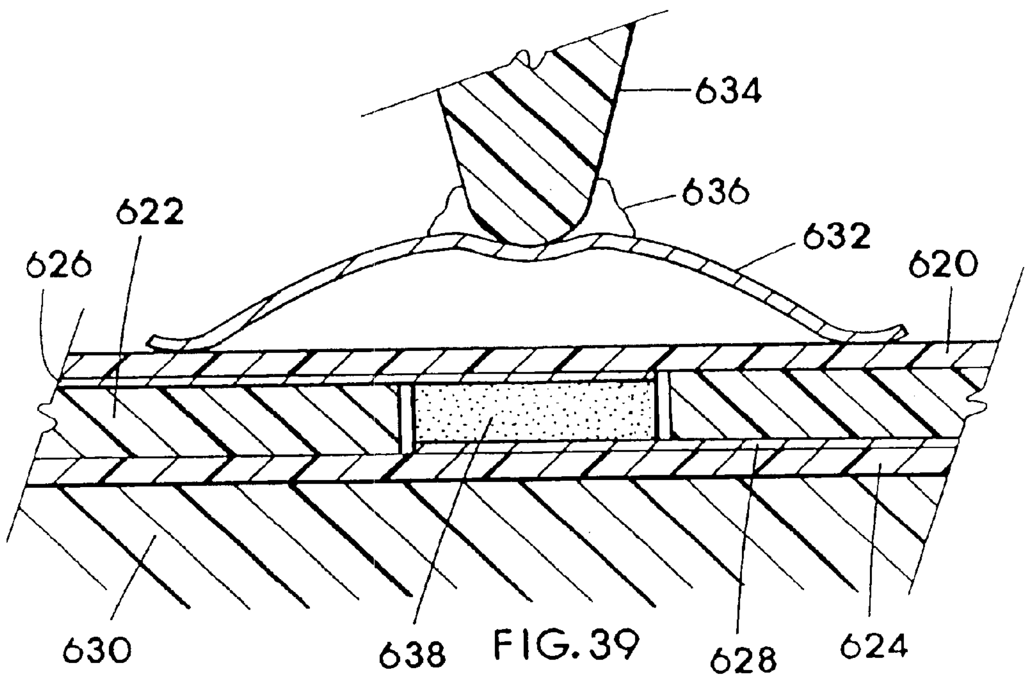

634
636
622
632
626
620
630
638
628
624

FIG. 39

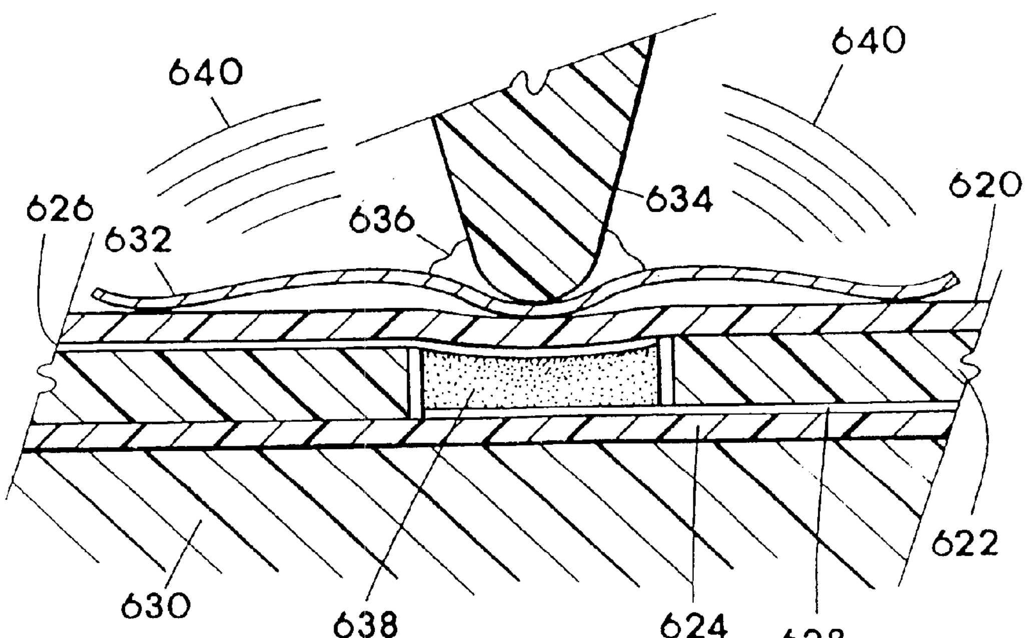

640
640
620
634
626
636
632
622
630
638
624
628

FIG. 40

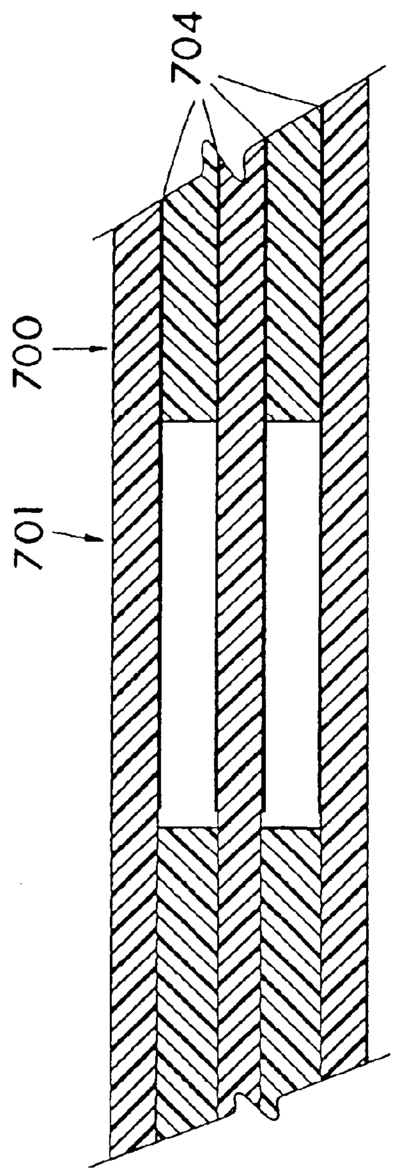


FIG. 41

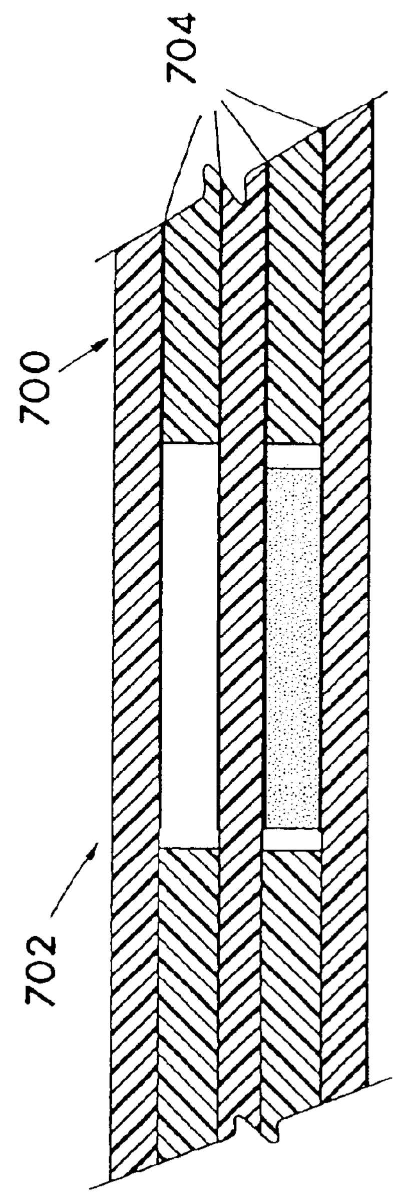


FIG. 42

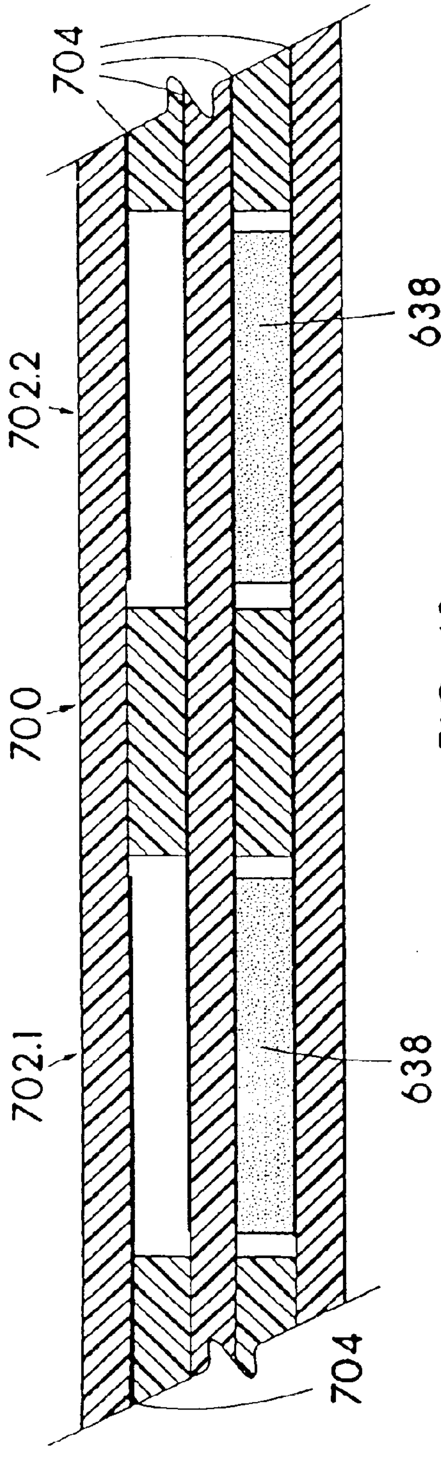


FIG. 43

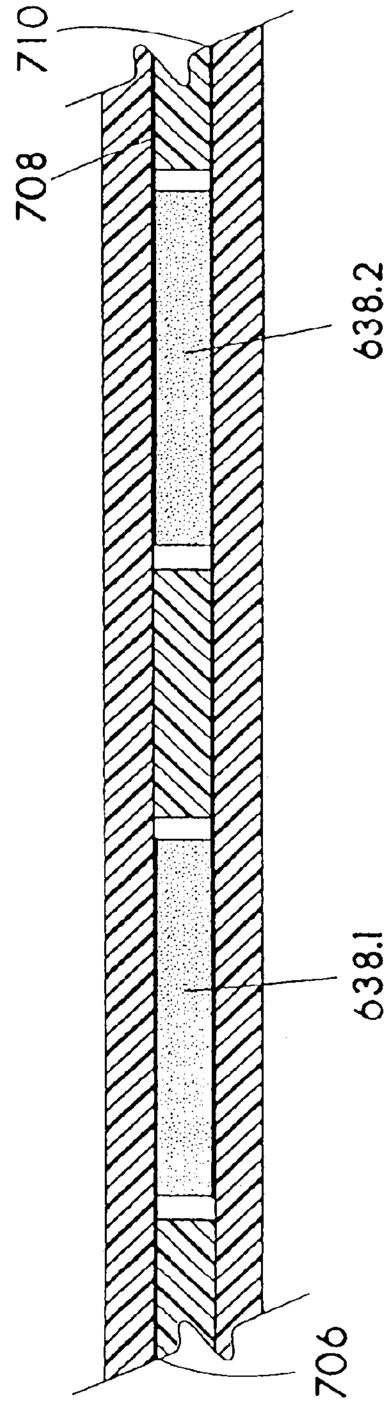


FIG. 44

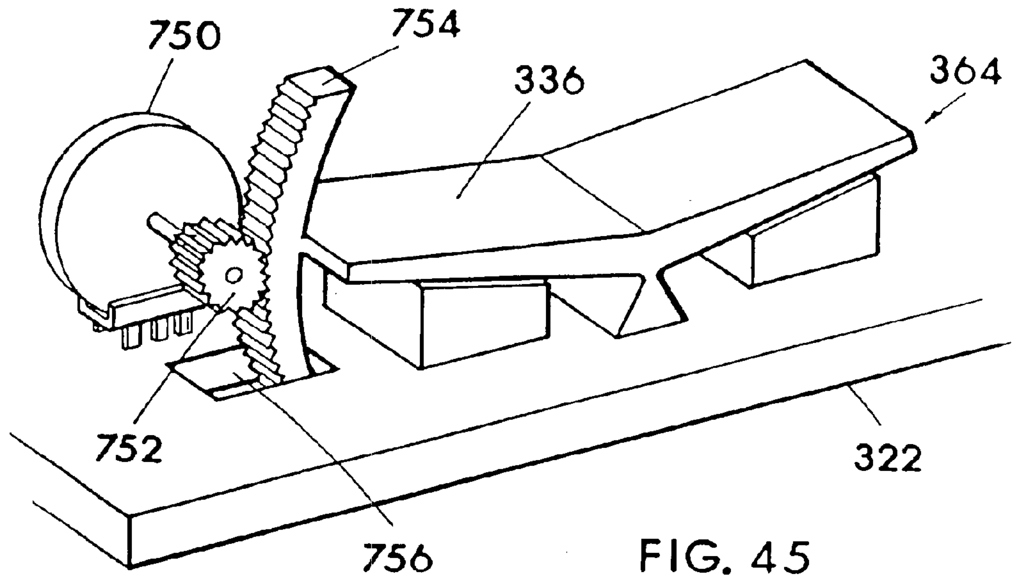


FIG. 45

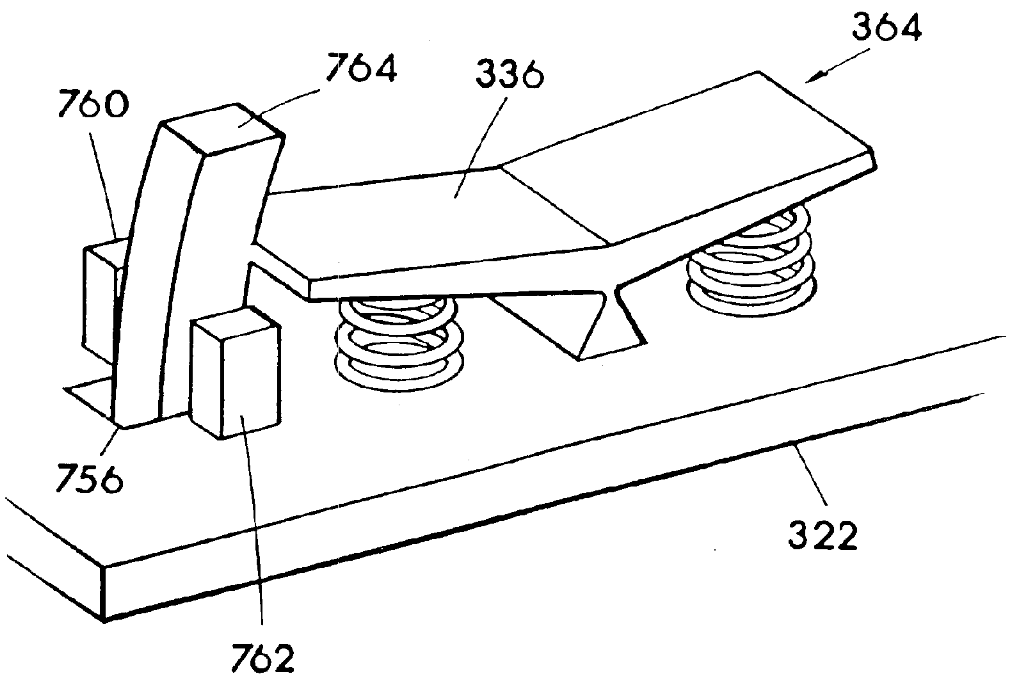


FIG. 46

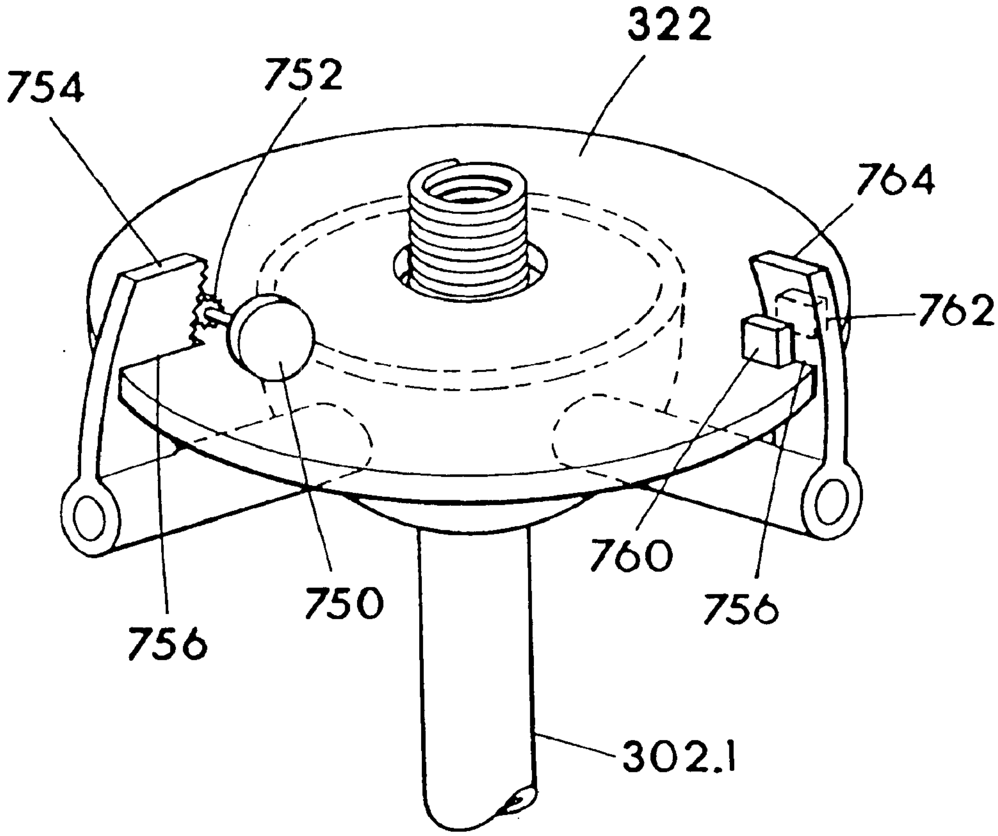


FIG. 47

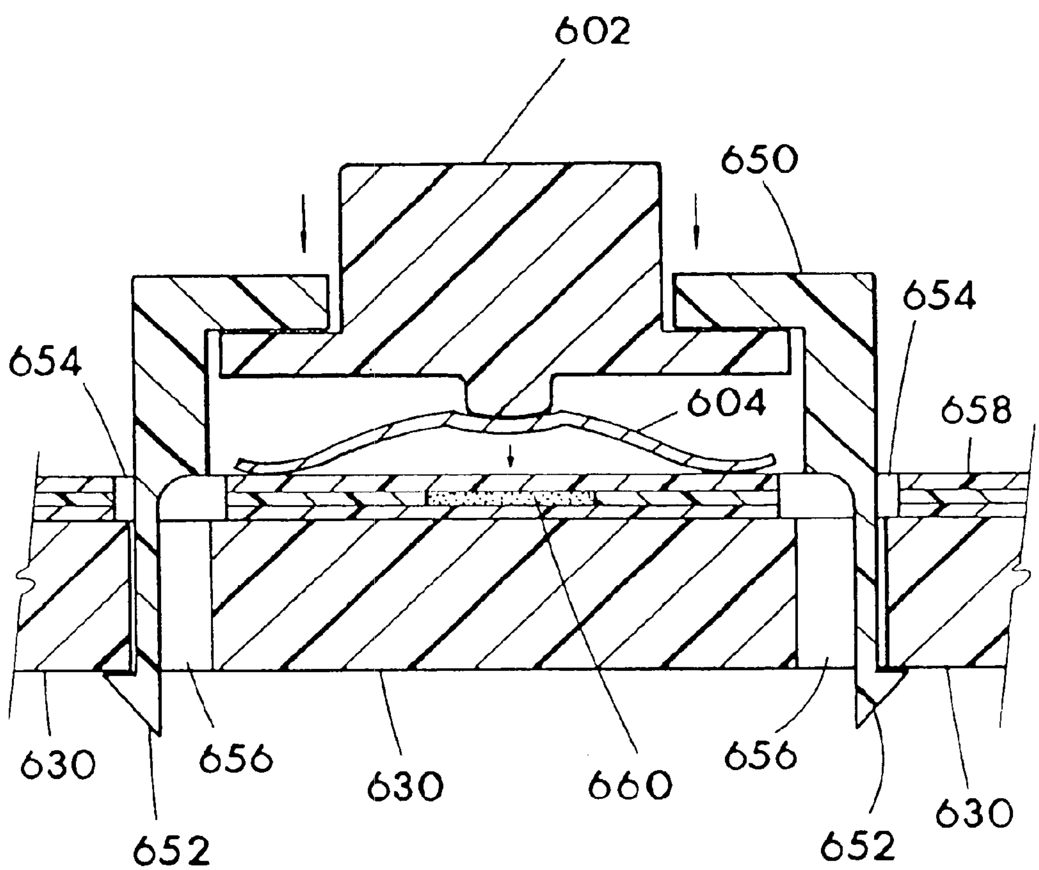


FIG. 48

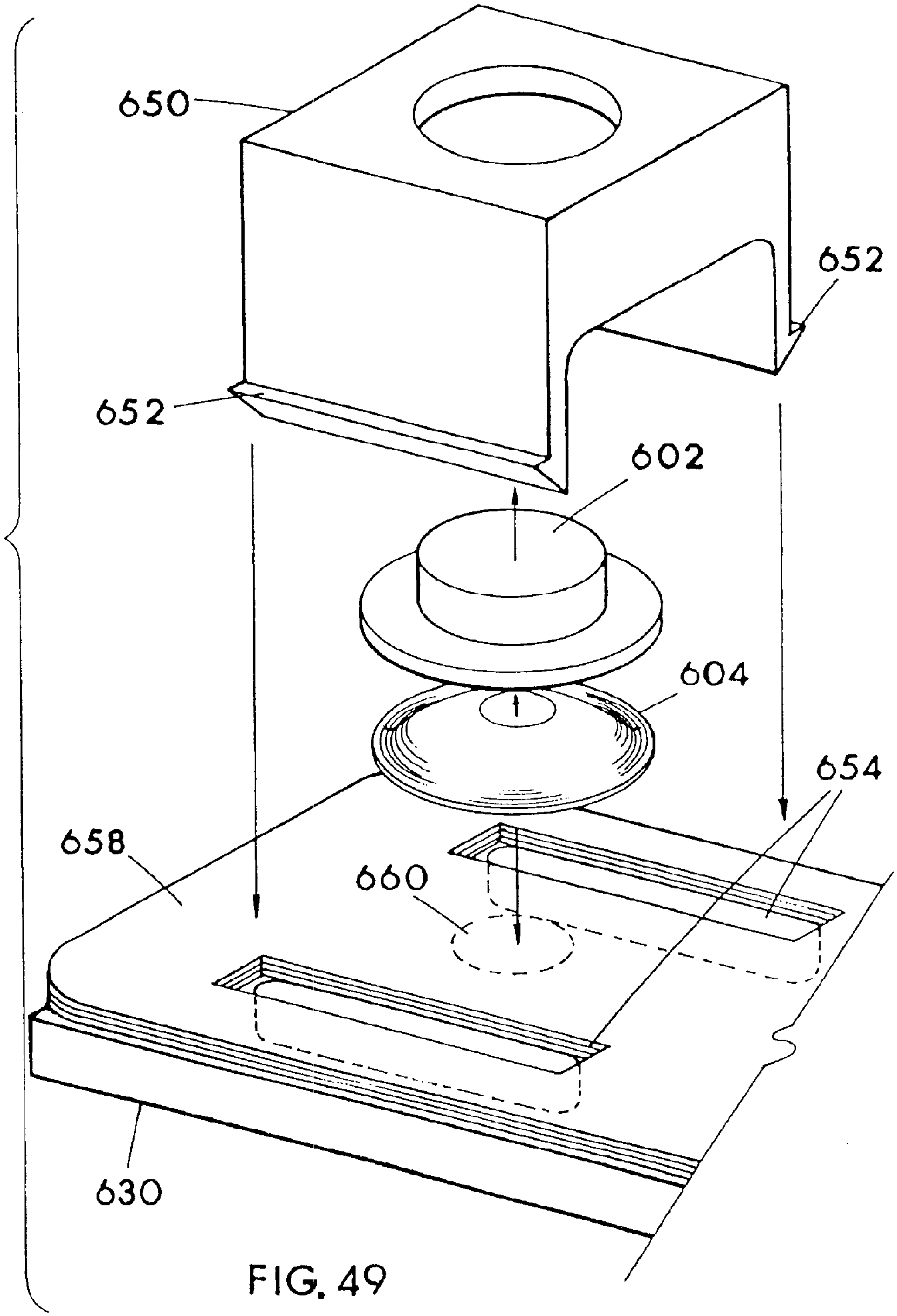


FIG. 49

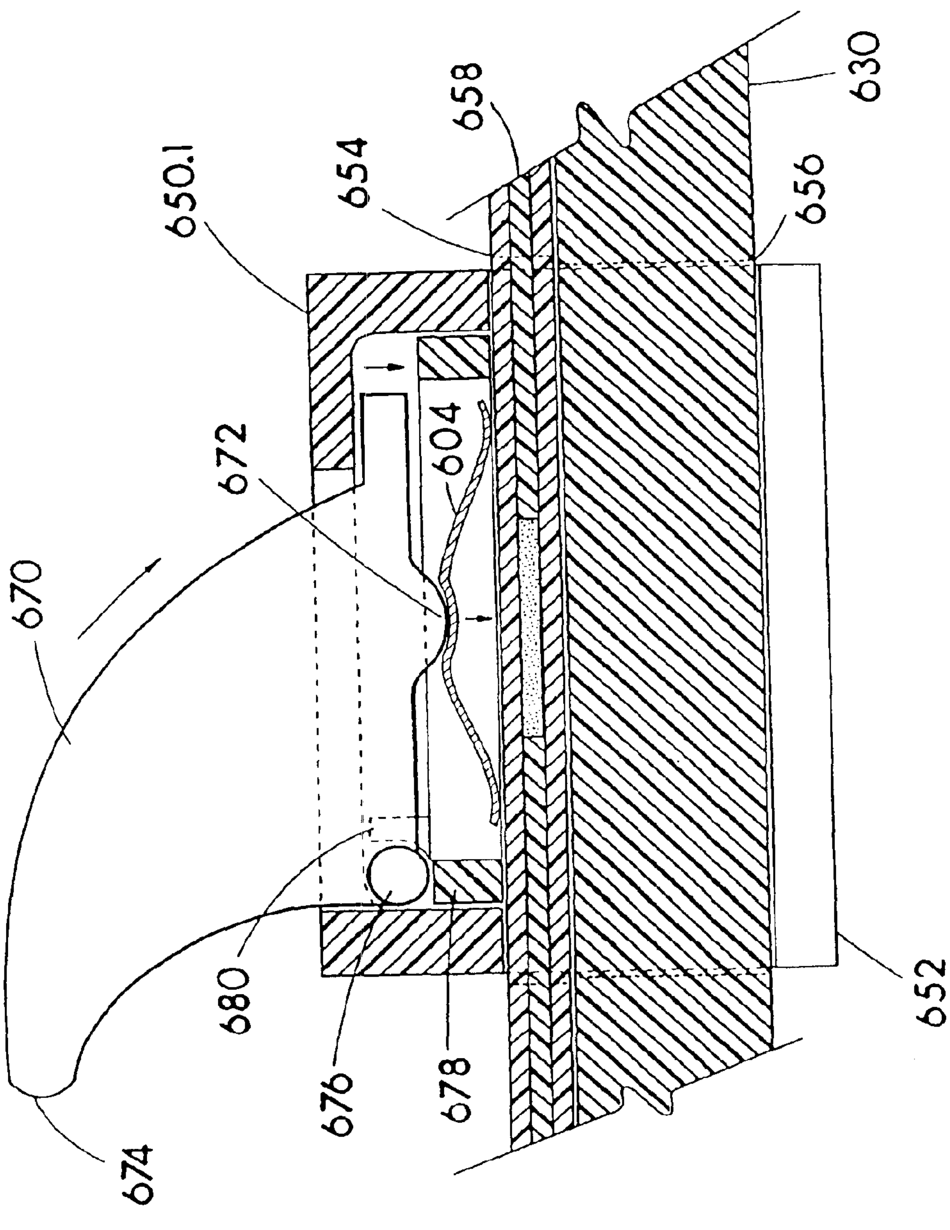


FIG. 50

3D CONTROLLER WITH VIBRATION

CROSS REFERENCE TO RELATED APPLICATIONS AND PATENTS

This application is a continuation of U.S. patent application Ser. No. 08/677,378 filed on Jul. 5, 1996, now U.S. Pat. No. 6,222,525.

U.S. patent application Ser. No. 08/677,378 is a continuation-in-part of U.S. patent application Ser. No. 08/393,459 filed on Feb. 23, 1995, now U.S. Pat. No. 5,565,891.

U.S. patent application Ser. No. 08/677,378 is also a continuation-in-part of U.S. patent application Ser. No. 07/847,619 filed on Mar. 5, 1992, now U.S. Pat. No. 5,589,828.

The instant application claims the benefits under 35 U.S.C120 of the filing dates of the above listed Patents and or Applications.

BACKGROUND OF THE INVENTION

1. Field of the Invention

This invention relates to hand input controllers which serve as interface input devices between the human hand(s) and image displays and electronics such as a computer or television display, a head mount display or any display capable of being viewed or perceived as being viewed by a human.

2. Description of the Prior Art

All of the references cited in the applications and patents which are above mentioned may be of interest, copies of which are of record in the specific application file wrappers, and the reader is requested/invited to review such references. All of the references cited in the above patents and applications listed in the "CROSS REFERENCE TO RELATED APPLICATIONS AND PATENTS" are not prior art, although some are, to the present invention as claimed, because through a chain of pendency, the present invention finds support in my U.S. Pat. No. 5,589,828 filed as an application on Mar. 5, 1992. Although there are related physical-to-electrical hand-controlled interfacing devices interfacing with computers, game consoles and the like image generation machines connected to image displays and the like shown and described in disclosures/documents (references) currently in the file wrappers of the above specified patents and applications, no disclosures or documents which are/is "prior art" teach or suggest singularly or in reasonable combination the present claimed invention.

SUMMARY OF THE INVENTION

The positive teachings and disclosure of U.S. Pat. No. 6,222,525 is herein incorporated by reference.

The invention is new and or improved apparatus associated with human control or manipulation of objects, views or the like imagery shown on a display and associated or driven with or by a computer or the like electronics. The present invention as claimed finds substantial support in the description and drawings in the incorporated U.S. Pat. No. 5,589,828. From one viewpoint for example only, the invention is a hand operated controller structured for allowing hand inputs rotating a platform on two mutually perpendicular axes to be translated into electrical outputs, the controller structured with sensors to allow controlling objects and navigating a viewpoint, such as within a display for example, the sensors including spaced components generally preventing false activation thereof through vibration, and the controller including an electro-mechanical tactile feedback means mounted thereto, i.e. motor with shaft and offset weight mounted to shaft to rotate and provide vibration detectable by the user through the hand operating the input member of the controller.

Increased appreciation of the numerous structural arrangements in accordance with the invention can be gained with continued reading and with a reading of the incorporated disclosures.

In order that hand input to electrical output controllers be more affordable, and for a user to be easily able to control objects and/or navigate a viewpoint within a three-dimensional graphics display, I have developed improved, low-cost hand operated controllers, providing up to 6 degrees of freedom in preferred embodiments, for use with a computer or computerized television or the like host device. The controllers in preferred embodiments, while not restricted or required to be full six degrees of freedom (6DOF), provide structuring for converting full six degrees of freedom physical input provided by a human hand on a hand operable input member(s) into representative outputs or signals useful either directly or indirectly for controlling or assisting in controlling graphic image displays. The present controllers sense hand inputs on the input member via movement or force influenced sensors, and send information describing rotation or rotational force of the hand operable input member in either direction about three mutually perpendicular bi-directional axes herein referred to as yaw, pitch and roll, (or first, second and third); and information describing linear moment of the hand operable input member along the axes to a host computer or like graphics generation device for control of graphics of a display, thus 3D or six degrees of freedom of movement or force against the input member are converted to input-representative signals for control of graphics images.

The present controllers include at least one hand operable input member (platform) defined in relationship to a reference member, e.g., base, housing or handle of the controller. The input member can be a trackball operable relative to a housing (reference member), or the input member can be any handle fit to be manipulated by a human hand, such as a joystick type handle, but in any case, the input member(s) accept 3D of hand input relative to the reference member, and the converter acts or operates from the hand inputs to cause influencing of the sensors which inform or shape electricity to be used as, or to produce such as by way of processing, an output signal suitable for a host device to at least in part control or assist in controlling the image on the display of the host device.

The present 3D controller provides structuring for sensors to be located, in some embodiments, in a generally single plane, such as on a substantially flat flexible membrane sensor sheet, or a circuit board sheet. The use of flat sheet mounted or positioned sensors preferably electrically connected with fixed-place trace circuitry provides the advantages of very low cost sensor and associated sensor circuit manufacturing; ease in replacing a malfunctioning sensor or conductor by entire sheet replacement, and increased reliability due to the elimination of individually insulated wires to the sensors.

The use of sheet supported sensors and associated circuits enable the use of highly automated circuit and sensor defining and locating, resulting in lower manufacturing costs and higher product reliability. The utilization of flat sheet substratum supporting the sensors, and preferably sensor circuitry in conductive fixed-place trace form, provides many advantages, with one being the allowance of a short or low profile 3D controller, and another, as previously mentioned, lower cost in manufacturing. In at least one preferred embodiment, all sensors for 3D are positioned on one substantially flat sheet member, such as a circuit board sheet or membrane sensor sheet, and electrically conductive traces are applied to the sheet members and engaging the sensors. The conductive traces can be used to bring electricity to the sensors, depending on the sensor type selected to be utilized, and to conduct electricity controlled, shaped or informed by the sensor to an electronic processor or cable-out lead or the like.

As will be detailed in reference to a present embodiment of 3D controller, the sensors and conductive traces can be manufactured on a generally flat flexible membrane sensor sheet material such as a non-conductive plastic sheet, which then may or may not be bent into a three dimensional configuration, even a widely-spread 3-D sensor constellation, thus sheet supported sensor structuring provides the advantages of very low cost sensor and associated sensor circuit manufacturing; ease in replacing a malfunctioning sensor or conductor by entire sheet replacement, and increased reliability due to the elimination of individually insulated wires to the sensors.

The present invention solves the aforementioned prior art problems associated with 3D controllers having one 3D input member, with multiple, individually hand mounted and positioned sensors or sensor units in widely-spread three dimensional constellations, and the problems of hand applied wiring of individually insulated wire to the individual sensors or sensor units. The present 3D controller solves these problems primarily with sheet supported sensor structuring and most associated circuitry on the sheet which is at least initially flat when the sensors and conductive circuit traces are applied; the sheet circuitry and sensors being an arrangement particularly well suited for automated manufacturing, and well suited for fast and simple test-point trouble shooting and single board or "sheet" unit replacement if malfunction occurs. Hand applying of the sensors and associated electrical conductors onto the flat sheet is not outside the scope of the invention, but is not as great of an advancement, for reasons of cost and reliability, compared to utilizing automated manufacturing processes that are currently in wide use.

Automated manufacturing of circuit boards with fixed-place trace conductors, sensors, discrete electronic components and integrated chips is in wide use today for television, computer, video and stereo manufacturing for example, and can employ the plugging-in of sensor and electrical components with computer controlled machinery, and the application of conductive trace conductors onto the otherwise non-conductive circuit board sheets is usually performed using automatic machinery, wherein the solder or conductive material adheres to printed fluxed or non-etched areas where electrical connections and conductive traces are desired, although other processes are used. Automated manufacturing of flat, flexible membrane sensor sheets is in wide use today for computer keyboards, programmable computer keypads, and consumer electronics control pads, to name just a few for example. Flexible membrane sensor sheets are currently being manufactured by way of utilizing non-conductive flexible plastics sheets, and printing thereon with electrically conductive ink when the sheets are laying flat, to define circuit conductors and contact switches (sensors). Usually, and this is believed well known, printed contact switches on flexible membranes utilizes three layers of plastic sheets for normal contact pair separation, with a first contact on one outer sheet, and a second contact of the pair on the opposite outer sheet, and a third inner sheet separating the aligned contact pair, but with a small hole in the inner sheet allowing one contact to be pressed inward through the hole to contact the other aligned contact of the pair, thus closing the circuit. A conductor trace of printed conductive ink is printed on each of the outer sheets and connects to the contact of that sheet. The contacts are also normally defined with conductive ink. Although this flexible membrane sensor structure in formed of multiple sheets stacked upon one another, it will herein generally be referred to as a membrane sensor sheet since it functions as a single unit. The printed conductive inks remain, or can be formulated to remain flexible after curing, and this allows the flexible membrane sensor sheet to be bent without the printed circuits breaking. Flexible membrane sensor sheets can be cut into many shapes before or after the application of the sensors and associated circuits.

For the purposes of this teaching, specification and claims, the term "sensor" or "sensors" is considered to include not only simple on/off, off/on contact switches, but also proportional sensors such as, proximity sensors, variable resistive and/or capacitive sensors, piezo sensors, variable voltage/amperage limiting or amplifying sensors, potentiometers, resistive and optical sensors or encoders and the like, and also other electricity-controlling, shaping or informing devices influenced by movement or force. Pressure sensitive variable resistance materials incorporated into sensors applied directly on flexible membranes, circuit boards and sensor packages mounted on sheet structures are anticipated as being highly useful as proportional sensors and desirable in 3D controllers of the types herein disclosed.

A primary object of the invention is to provide a 3D image controller (physical-to-electrical converter), which includes at least one input member being hand operable relative to a reference member of the controller, and the controller providing structure with the advantage of mounting the sensors in a generally single area or on at least one planar area, such as on a generally flat flexible membrane sensor sheet or circuit board sheet, so that the controller can be highly reliable and relatively inexpensive to manufacture.

Another object of the invention is to provide an easy to use 3D controller (physical-to-electrical converter) which includes at least one input member being hand operable relative to a reference member of the controller, and which provides the advantage of structure for cooperative interaction with the sensors positioned in a three dimensional constellation, with the sensors and associated circuit conductors initially applied to flexible substantially flat sheet material, which is then bent or otherwise formed into a suitable three dimensional constellation appropriate for circuit trace routing and sensor location mounting.

Another object of the invention is to provide an easy to use 3D controller, which includes at least one input member hand operable relative to a reference member of the controller, and which has the advantage that it can be manufactured relatively inexpensively using sensors and associated circuits of types and positional layout capable of being assembled and/or defined with automated manufacturing processes on flat sheet material.

Another object of the invention is to provide an easy to use 3D controller, which includes at least one input member hand operable relative to a reference member, e.g., base, housing or handle of the controller, and which has the advantage that it can be manufactured using highly reliable automated manufacturing processes on flat sheet material, thus essentially eliminating errors of assembly such as erroneously routed wiring connections, cold or poor solder connections, etc.

Another object of the invention is to provide an easy to use 3D controller, which includes at least one input member hand operable relative to a reference member of the controller, and which has the advantage that it can be manufactured using sensors and associated circuits on flat sheet material so that serviceability and repair are easily and inexpensively achieved by a simple sheet replacement.

Another object of the invention is to provide a 3D controller which is structured in such a manner as to allow the controller to be made with a relatively low profile input member, which offers many advantages in packaging for sale, operation in various embodiments and environments (such as a low profile 3D handle integrated into a keyboard so that other surrounding keys can still be easily accessed) and functions of the device such as still allowing room for active tactile feedback means (electric motor, shaft and weight) within a still small low handle shape as indicated in the attached FIG. **21** in broken lines. "tactile feedback means" in reference to the active type as herein used can be an equivalent to or that which is detailed in the incorporated U.S. Pat. No. 5,589,828 which is shown and described therein basically as a motor with shaft and weight on the shaft, the shaft being offset so that when rotated, vibration occurs which can be felt by the hand(s) operating the controller.

Another object of the invention is to provide and meet the aforementioned objects in a 3D controller which allows for the application and advantage of sensor choice. The invention can be constructed with sensors as simple as electrical contacts or more sophisticated proportional and pressure-sensitive variable output sensors, or the like. The printed circuit board provides great ease in using a wide variety of sensor types which can be plugged into or formed onto the board with automated component installing machinery, and the flexible membrane sensor sheet can also utilize a variety of sensors such as contact pairs and pressure-sensitive variable output sensors (pressure-sensitive variable resistors) printed or otherwise placed onto flexible membrane sensor sheets.

Another object of the invention is to provide and meet the aforementioned objects in a 3D or six degree of freedom controller providing the advantage of versatility of complex movements wherein all three perpendicular Cartesian coordinates (three mutually perpendicular axes herein referred to as yaw, pitch and roll) are interpreted bi-directionally, both in a linear fashion as in movement along or force down any axis, and a rotational fashion as in rotation or force about any axis. These linear and rotational interpretations can be combined in every possible way to describe every possible interpretation of three dimensions.

These, as well as further objects and advantages of the present invention will become better understood upon consideration of the remaining specification and drawings, as well as the incorporated disclosures.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a top view of a trackball type embodiment of the invention within a housing specific for a carriage and the trackball.

FIG. **2** is a cross-sectional side view of the FIG. **1** embodiment taken at line **2**.

FIG. **3** is a cross-sectional end view taken at line **3** of FIG. **1**.

FIG. **4** is a partial illustration of the carriage, the trackball and a track frame between two walls.

FIG. **5** is an illustration showing a portion of a slightly varied carriage, the trackball, and a collet which is rotatable about the trackball which can be used within the scope of the present invention. A rotary encoder is shown as an example of a sensor in contact with the bottom of the collet.

FIG. **6** is an illustration basically showing another form of the rotatable collet.

FIG. **7** shows three mutually perpendicular axes herein referred to as first, second and third, or respectively roll, pitch and yaw axes, which are shown having a mutual point of intersection at the center of the input member which is shown as a trackball but may be any hand manipulated input member.

FIG. **8** is an illustration of a housing structured specific for the carriage and trackball, and one which is generally flat-bottomed and thus structured suitably to rest upon a support surface such as a table or desk when utilized. A broken outline indicates the possibility of an additional extension which is ergonomically designed as a wrist and forearm rest.

FIG. **9** is the carriage and trackball in a hand held housing sized and shaped to be grasped in a hand of a user while the user controls graphic images with the controller.

FIG. **10** is the carriage and trackball housed in an otherwise relatively conventional computer keyboard having well over 40 keys for the alphabet, numbers 1–9, a spacebar and other function keys.

FIG. **11** represents a display such as a computer or television with display showing a cube displayed three dimensionally.

FIG. **12** is a partial cross-sectional end view of a joystick type embodiment of the invention. This embodiment is or can be structured identically to the FIG. **1** trackball embodiment, with the exception of an elongated graspable handle engaged on an exposed portion of the ball.

FIG. **13** shows an exploded view of another joystick embodiment of the current invention exhibiting structuring enabling use of a membrane sensor sheet.

FIG. **14** shows a membrane sensor sheet in flat form.

FIG. **15** shows a membrane sensor sheet in the folded 3-D configuration.

FIG. **16** shows all sensors in mechanical flat mount and right angle mount packages as they may be positioned on a rigid flat sheet, such as a circuit board sheet.

FIG. **17** shows a membrane sensor sheet in a variation where all 3D sensors are positioned on a flat plane.

FIG. **18** shows structuring of the membrane sensor sheet as described in FIG. **17** as a novel appendage on an otherwise conventional membrane sensor sheet such as is found in a typical modern computer keyboard.

FIG. **19** shows an external view of a 3D controller in accordance with the present invention positioned where the arrow key pad would be on an otherwise common computer keyboard housing.

FIG. **20** shows an exploded view of a two-planar embodiment having rocker-arm actuators.

FIG. **21** shows a side view of the embodiment of FIG. **20**.

FIG. **22** shows a perspective view of the rocker-arm actuators of the embodiment of FIGS. **20–21**.

FIGS. **23–25** show various side views of two-armed rocker arm actuators in operation.

FIG. **26** shows a top view of a rocker arm layout and its reduced area by using two one-armed actuators.

FIG. **27** shows a side view of a one-armed rocker actuator.

FIG. **28** shows an exploded view of the handle of the embodiment of FIGS. **20** and **21**.

FIG. **29** shows an otherwise typical computer keyboard membrane with custom appendages to fit into and be actuated by the structures of the embodiment shown in FIGS. **20–28** located in the arrow pad region of an otherwise typical computer keyboard.

FIG. **30** shows a perspective view of a 3D handle integrated into an otherwise typical remote control device such as are used to control TVs, VCRs, Cable Boxes, and some computers, etc.

FIG. **31** shows a perspective view of the device of FIG. **30** in dashed lines and an internal view of a membrane shaped to fit the embodiment shown in FIGS. **20–29**.

FIG. **32** shows a side view of a 3D two planar device using one circuit board per plane for support of sensors and electronics with eight sensors located on a plane in the base and four sensors located on a plane in the handle.

FIG. **33** shows a perspective view of a third axis translation component for the embodiment shown in FIG. **32**.

FIG. **34** shows a side view of the component of FIG. **34** in a carriage.

FIG. **35** shows a perspective view of the components shown in FIGS. **32–34**.

FIG. **36** shows a side view of a two planar embodiment using circuit boards but having substantially different sensor placements and structuring, with eight sensors located on a plane in the handle and four sensors on a plane in the base.

FIG. **37** shows a side cross-section view of a typical right angle solder mount sensor package for a momentary-On switch sensor.

FIG. **38** shows a side cross-section view of a horizontal or flat solder mount sensor package containing a proportional pressure sensitive element internally.

FIG. **39** shows a side cross-section view of a proportional membrane sensor having a metallic dome cap actuator in the non-activated position.

FIG. **40** shows a side cross-section view of a proportional membrane sensor having a metallic dome cap actuator in the activated position.

FIG. **41** shows a side cross-section view of a compound membrane sensor having multiple simple On/Off switched elements piggy backed one on top of another.

FIG. **42** shows a side cross-section view of a compound membrane sensor having both a simple on/off switched element and a proportional element which are simultaneously activated.

FIG. **43** shows a side cross-section view of two compound sensors of the type shown in FIG. **42** arranged to create a single bi-directional proportional sensor.

FIG. **44** shows a side cross-section view of two uni-directional proportional sensors electrically connected to form a single bi-directional sensor with a central null area.

FIG. **45** shows a perspective view of a generic rocker arm actuator operating a bi-directional rotary sensor.

FIG. **46** shows a perspective view of a generic rocker arm actuator operating a bi-directional optical sensor.

FIG. **47** shows a perspective view of the sensors of FIGS. **45** and **46** as they can be embodied within a handle.

FIG. **48** shows a side cross-section view of a novel structure for anchoring a membrane sensor in position and also for holding sensor actuating structures in position.

FIG. **49** shows an exploded view of the embodiment of FIG. **41**.

FIG. **50** shows a median cross-section view of the embodiment of FIGS. **48** and **49** but in a right angle variation.

BEST MODES FOR CARRYING OUT THE INVENTION

Referring now to the drawings in general, and particularly to drawing FIGS. **1** through **11** for a description a trackball-type embodiment **9** exemplifying principles of the invention. Joystick-type embodiments further exemplifying the principles of the invention are then described as additional preferred embodiments of the invention.

With reference to FIGS. **1–4** in particular wherein trackball-type embodiment **9**, being a hand operable 3D controller for outputting control information is illustrated showing a rectangular housing **10** which is considered a reference member relative to which is operated trackball **12** which in this example is the hand operable single input member operable in full six degrees of freedom. FIGS. **2–3** being cross-sectional views of the FIG. **1** embodiment showing housing **10** which can at least in part support, retain and protect moveable carriage **14**.

As may be appreciated already from the above writing and drawings, carriage **14** is supported at least in part within housing **10** and with structuring for allowing carriage **14** to be moveable or moved in all linear directions relative to housing **10**, for example, left, right, forward, rearward, up and down, and in the possible combinations thereof. Furthermore, housing **10** may be specific for the present 3D or six degree of freedom controller as exemplified in FIGS. **1–3** and **8**, or the housing **10** of another functional device such as an otherwise typical hand held remote control housing or computer keyboard housing as shown in FIGS. **9** and **10** respectively, and offering or including functions such as keyboarding, cursor control, on/off, volume control, channel control and the like in addition to that offered by the present 3D or six degree of freedom controller. Housing **10** may be in effect the panel or panels of a control console of a vehicle or machine. Housing **10** may be any size within reason, although trackball **12**, any exposed part of carriage **14** or housing **10** intended to be manually controlled or hand held should of course be correctly sized to interface with the human hand or hands. When housing **10** is too large to allow easy use of the housing walls upon which to place carriage movement stops (stationary walls or posts to limit movement of the carriage) or sensor actuators or sensor supports such as would be likely with the keyboard housing of FIG. **10** wherein the housing side walls are a substantial distance apart, then walls, partitions or posts specific for these purposes may be placed in any desired and advantageous location within housing **10** as shown for example in FIG. **2** wherein actuators **100** and **104** are shown extending vertically upward from the interior bottom of housing **10**, inward of the interior side walls of the housing, and supporting or serving as a switch/sensor actuator, or a second component of the sensor, such as a second component of a two piece proximity sensor for example. Actuator **100** functions in conjunction with forward sensor **102**, and actuator **104** functions in conjunction with rearward sensor **106** in this example. FIG. **3** illustrates for example the use of side walls **18** of housing **10** as the sensor actuators **116** and **120** or press plates for right sensor **118** and left sensor **122**. Housing **10** in most all applications will be made of rigid or semi-rigid plastics for cost, weight and strength considerations, although other materials might be functionally suitable.

Although it must be noted that within the scope of the invention carriage **14** functions may conceivably be provided with numerous structures, carriage **14** is shown in the drawings as including a lower member **20** and an upper member **22** positioned above lower member **20**. In this example, lower member **20** is shown as a rigid sheet member such as a circuit board, but could be structured as a rigid sheet supporting a flexible membrane sensor sheet having at least circuitry in the form of electrically conductive circuit traces which are stationary on the sheet member. Lower and upper members **20**, **22** in this example are each plate-like and rectangular, are in spaced parallel relationship to one another, are horizontally disposed, and are rigidly connected to one another via vertically oriented rigid connecting posts **24**. Upper member **22** and lower member **20** are preferably of rigid materials such as rigid plastics, as are connecting posts **24** which may be integrally molded as one part with upper member **22** and connected to lower member **20** utilizing a mushroom-head shaped snap connector end on each posts **24** snapped through holes in member **20**, or with screws passed upward through holes in member **20** and threadably engaged in holes in the bottom terminal ends of posts **24**. Glue or adhesives could be used to connect posts **24** to lower member **20**. Typically four connecting posts **24** would be used as indicated in dotted outline in FIG. **1** although the posts could easily be substituted with equivalent structures such as two walls, etc. The separate lower member **20** which is then attached to upper member **22**, allows member **20** to be flat on each side and more suitably shaped and structured to allow circuit traces and sensors to be applied utilizing automated machinery, without upper member **22** being in the way. Upper member **22** includes an opening **26** in which trackball **12** resides and extends partly therethrough, and opening **26** may include an annular raised lip or ring such as a threaded ring **28** or the like for engaging a cooperatively structured collet **16** such as one having threading at the bottom edge thereof, or it may be an opening absent any raised lip or extending collet as illustrated in FIG. **8** wherein trackball **12** is shown extending upward through opening **26** in upper member **22**. Trackball **12** also might be exposed in great part (more than 50 percent) without using collet **16** by utilizing an arm extending upward from carriage **14** and partially over trackball **12** is such a manner as to retain trackball **12** in unison with carriage **14** for all linear movements. Collet **16**, if utilized, serves as an easily gripped member allowing the human hand to move carriage **14** and thus trackball **12** in any linear direction desired, although when collet **16** is not utilized, trackball **12** can be grasped by the fingers of the hand to also move carriage **14** in any linear direction. If a graspable collet is not used, then the exposed portion of trackball **12** is available for grasping with the fingers to apply force in any linear direction, much like a basketball player grasps a basketball in one hand or in the fingers.

Lower member **20** of carriage **14** preferably physically supports wheels, rollers, bearing or slide members or smooth surfaces which otherwise aid in supporting trackball **12** in a freely spherically rotatable manner, and in the example illustrated, three mutually perpendicular encoders (sensors) **124**, **126**, **128** mounted on the upper surface of lower member **20** for sensing rotation, direction and amount of rotation of trackball **12** about the yaw, pitch and roll axes include rotatable wheels upon and against which trackball **12** rests, and is thereby rotatably supported. In most applications, the weight of trackball **12** and its most common positioning within the supporting rotatable wheels of the encoders causes sufficient frictional engagement between the encoder wheels and trackball **12** so that rotation of the trackball causes rotation of one or more of the encoders, depending upon the axis about which trackball **12** is rotated. The structure of carriage **14** and collet **16** if the extending collet is used, is sufficiently close in fit to trackball **12** to render a substantial link in linear movement between carriage **14**, collet **16** and trackball **12**. In other words, linear movements in trackball **12** are substantially equal to linear movement of carriage **14** and collet **16**. It should be noted that I consider collet **16** as shown in FIG. **2** and some other drawings, whether it is a fixed or rotatable collet (to be detailed) to be part of carriage **14** since it is supported or fastened to carriage **14** and moves therewith. As previously stated, carriage **14** is supported with structuring for allowing movement in all linear directions relative to housing **10**, for example, left and right which is linear movement along the pitch axis in this example; forward and rearward which is linear movement along the roll axis in this example; up and down which is linear movement along the yaw axis in this example; and in the possible combinations thereof, and sensors are positioned to detect and provide (output) information related to such linear movements of carriage **14** relative to housing **10**. Clearly since trackball **12** and collet **16** are linked to move linearly with carriage **14**, trackball **12** can be moved linearly in all directions relative to housing **10**, wherein housing **10** is considered the reference member. I prefer carriage **14** to be not rotatable relative to housing **10** since rotation interpretations about the three mutually perpendicular axes (see FIG. **7**) are provided via trackball **12** and encoders **124**, **126**, **128** for sensing spherical rotation of trackball **12** about yaw, pitch and roll. Therefore, I prefer carriage **14** to be supported or retained in such a manner and by appropriate structure to allow carriage **14** to be moved linearly in all possible directions, but prevented from being axially rotated relative to housing **10** so that trackball **12** can be rotated when desired without carriage **14** unintentionally being rotated, and this so the encoders (or whatever rotational sensors which may be utilized) will be rotated. I would consider it to be within the scope of the invention if carriage **14** was to be supported in a manner which would allow limited axial rotation thereof, although I believe this to be an undesirable aspect.

Although the structuring to physically support carriage **14** so it can be moved in any linear direction can conceivably be accomplished through numerous structural arrangements, two are illustrated for example, with a first shown in FIGS. **1–4**, and a second shown in FIG. **6**. I prefer there be a return-to-center aspect regarding carriage **14**, and preferably a center null associated with this return-to-center wherein no significant linear sensor activation occurs. This carriage return-to-center and to center null can conceivably be accomplished with numerous structures, but one structure which should be readily understandable and therefore makes a good example is to simply utilize on/off switches as the carriage position linear sensors for moment related information output, with the switches including activation buttons which are outwardly spring biased, wherein carriage **14** can be pushed against one of the switches to the point of activating the switch closing or opening a set of electrical contacts), which of course sends or outputs information relating to this event via allowing or interrupting current flow, and the button spring being depressed by carriage **14** would then push carriage **14** back toward the center and the null position upon the user releasing pressure toward that particular switch. Furthermore, as mentioned above, if such an on/off switch using spring biasing were to be of a type which made a detectable click or snap upon being activated by pressure from carriage **14**, and this is a commonly available snap switch, then this click or snap could be felt or heard by the user, and thus the user would be provided information alerting him of the activation or possibly deactivation of the switch. Snapping or clicking mechanisms which are not sensors can of course be installed when sensors of a type which are silent are used, and tactile or audible signals indicating sensor activation or deactivation is desired.

With reference to FIGS. **2–3**, expanded foam rubber **30** is shown placed against the bottom interior of housing **10** and underneath lower member **20** of carriage **14**. Snap or spring biased switches as described above may be used in conjunction with foam rubber **30**. Foam rubber **30** is a resiliently compressible and thus spring material. Foam rubber **30**, and other spring materials such as coiled compression springs, leaf springs and the like could conceivably be used instead of foam rubber, however foam rubber functions well, is inexpensive, readily available and easily shaped or cut. I have even considered suspending carriage **14** on tension springs hung from the underside interior of housing **10**, but this seems to be an excessively complicated structure compared to using foam rubber as shown and described. Foam rubber **30** in the example of FIGS. **2–3** is a rectangular piece having a center cut-out or opening at **32** to allow for the interaction of down sensor **110** shown mounted on the underside of lower member **20** with actuator **108** specific for interaction with down sensor **110** located beneath the sensor **110**. The actuator **108** for down sensor **110** is sized to allow the abutment or actuation of the down sensor **110** no matter where carriage **14** has been moved laterally when the user wishes to push down on carriage **14** to activate the sensor **110**. Foam rubber **30** being compressible will allow the user to push down on trackball **12** or collet **16**, or possibly the exposed top of carriage **14** (upper member **22**) to push carriage **14** downward to activate the down sensor **110**. This pushing downward compresses the foam rubber **30**, and when the user releases the downward pressure, the foam rubber **30** being resilient pushes carriage **14** upward again to deactivate the down sensor **110** and to move carriage **14** into the center null position. Foam rubber **30** in the example shown in FIGS. **2–3** is rectangular and slightly larger in all dimensions than the size of lower member **20**, and the foam rubber **30** is affixed to the underside of lower member **20** such as by glue or mechanical fasteners so that the foam is securely affixed to the lower member (carriage). Since the foam rubber **30** is slightly larger than the lower member **20**, the foam rubber **30** extends outward laterally beyond all peripheral sides of the lower member **20**. This extending portion of the foam rubber **30** serves as a spring bumper which as shown in FIG. **2** is compressed against actuators **100**, **104** (or housing side walls **18** under some circumstances) prior to the sensors **102**, **106** shown on the left and right being activated, and in the case of the FIG. **3** drawing is compressed against the side walls **18** of housing **10** prior to the sensors **118**, **122** shown on the left and right being activated. When the user releases the pushing pressure, the compressed foam rubber **30** will push carriage **14** back toward the center null position, as the foam rubber **30** is normally in a partially extended state, being able to be compressed and to then spring back. The up sensor **114** shown in FIG. **2** is shown mounted on the top of the lower member **20**, and the weight of carriage **14** is normally sufficient to pull carriage **14** and sensor **114** downward away from its actuator **112** upon release of upward pulling pressure by the user, although a spring such as a foam rubber pad or the like could conceivably be placed between the underside of the housing top panel and the upper member **22** to push carriage **14** downward to deactivate the up sensor **114** if weight and gravity were insufficient or unavailable such as in outer space. The actuator **112** for the up sensor **114** is shown suspended from the interior underside of the housing top portion, and is a member which may be formed as an integral component of housing **10** if desired. The actuator **112** for the up sensor **114** may be simply a plate or panel against which a snap switch mounted on carriage **14** strikes or is pressed against, or it may be a second component of the sensor, or may be supporting a second component of the sensor such as the second component of a two piece proximity sensor, and this is generally true of all of the actuators shown and described. Also generally true of all of the actuators shown and described is that they must be sufficiently large and or properly positioned be useful even when carriage **14** is moved to any allowed extreme position.

In FIGS. **2–4** is track frame **34** located under the top of housing **10**. Track frame **34** is free to be moved vertically within housing **10**, which will allow carriage **14** to be moved vertically to activate the up or down sensors **114**, **110**. Additionally from FIGS. **2–3** it can be seen that carriage **14** is sized and shaped relative to housing **10** and components within housing **10** such as the actuators to allow carriage **14** to be moved in all linear directions, although only in small amounts in the example shown. I prefer the linear movement requirements from the center null to activating a sensor or sensors to be small, although the distances could be made substantial if desired. The track frame **34** is a structure which can be utilized to positively prevent axial rotation of carriage **14**. The foam rubber **30** of FIGS. **2–3** being positioned tightly between either walls or actuators or both on the four peripheral sides of the foam normally serves to a satisfactory degree as an anti-axial rotation structure for carriage **14**, however, for more positive prevention of axial rotation of carriage **14**, track frame **34** or like structure may be applied. As shown in FIG. **4**, track frame **34** is a rectangular frame opened centrally in which upper member **22** is slidably retained. Two oppositely disposed sides of frame **34** are abutted, but slidably so, against and between two stationary parallel walls which may be side walls **18** of housing **10** or partitions installed specific for this purpose. The lower member **20** in this arrangement would be supported by resting on foam rubber **30**, and if upper member **22** were pushed forward or rearward for example, frame **34** would slide between the walls **18**. Frame **34** can also move up and down sliding between the walls **18**, but due to the close fit, the frame **34** will not axially rotate between the walls **18**. The upper member **22** fits lengthwise snugly yet slidably between two oppositely disposed U-shaped track sides of frame **34** as can be seen in FIGS. **2** and **4**, but is narrower than the width of the frame **34** as can be seen in FIGS. **3–4**, and thus when upper member **22** is pushed forward and rearward (for example) it pushes frame **34** with it due to the close fit in this direction between the frame **34** and upper member **22**, and when upper member **22** is pushed left and right (for example) it slides in the U-shaped track portion of frame **34**, as the frame **34** cannot move in these directions due to its close abutment against the parallel walls **18**. When upper member **22** is moved up and down, track frame **34** moves up and down also, as does the balance of carriage **14** and trackball **12**. It should be remembered that in this example, upper member **22** and lower member **20** are rigidly tied together with connecting posts **24**, and that the members **20** and **22** constitute components of carriage **14**, and that the carriage is to be manually controlled linearly via a hand applying force to collet **16** or the trackball or both, or possibly an exposed portion of the upper member **22** as mentioned previously. It should be noted that a space **36** or clearance is provided between the upper portion of the housing surrounding trackball **12**, carriage **14** or collet **16** to allow movement of carriage **14** laterally, since carriage **14** and trackball **12** move independent of housing **10**. The space **36** or crack may be covered with flexible or rubbery sheet material or any suitable boot or seal arrangement to exclude debris, or the space **36** (crack) may be kept (manufactured) narrow or small to be less likely to collect debris.

Another example of using foam rubber **30** is shown in FIG. **6** wherein the foam **30** is located atop a stationary shelf **38** within housing **10**, and directly under upper member **22** which rests atop of the foam rubber **30**. Foam rubber **30** extends beyond shelf **38** inward as may be seen in the drawing. The inward most edges of the foam rubber **30** are abutted against the vertical connecting posts **24** of carriage **14**. Carriage **14** being supported by foam rubber **30** being between the underside of upper member **22** and the top of the shelf **38** is allowed to be moved in all linear directions, and the foam rubber **30** abutting connecting posts **24** and abutting the interior of the housing walls as shown functions as a return-to-center and return to null arrangement much like that described for the FIGS. **2–3** structural arrangement. The shelf **38** in this example should be on all interior sidewalls of housing **10**, or at least under some resilient foam placed about the periphery of carriage **14**. It should be noted clearance above upper member **22** and the top interior surface of housing **10** must be provided to allow upward movement of carriage **14** with pulling action to activate the up sensor **114**, and the support for carriage **14** such as the foam rubber must allow carriage **14** to move away and to clear the activation of the up sensor **114** upon the termination of the upward pulling pressure on carriage **14**, and this principle applies in most if not all embodiments of the invention.

With reference to FIGS. **5–6** for a brief description of an optional arrangement wherein collet **16** can be rotatably attached to upper member **22** allowing collet **16** to be manually rotated about trackball **12**, as opposed to being non-rotatably affixed to upper member **22** as in the FIGS. **1–3** embodiment. The rotatable collet of FIGS. **5–6** may at least for some users be an easier process to achieve rotation about the yaw axis as compared to rotating trackball **12** at least in terms of rotation about yaw. The rotating collet may be able to rotate 360 degrees as in FIG. **5**, or only in part rotatable as in FIG. **6** wherein collet **16** can only move through a short arc back and forth, being limited such as by a multiple-position rocker style sensor **158**. Both of the collets **16** shown in FIGS. **5–6** are connected to the upper member **22** via a loose fit tongue and groove connection shown for example at **170**, the tongue being an upward extension of upper member **22** and the groove being a component of collet **16** and engaged over the tongue. In FIG. **5** an optical encoder **168** is shown as an example of a sensor in contact with the bottom of collet **16** so that rotation of collet **16** in either direction rotates the optical wheel of the encoder **168**, this could be achieved by gear teeth around the outer periphery of a drive wheel of encoder **168** mated to gear teeth around the bottom of collet **16**, and the encoder outputs information indicative of the direction and amount of rotation of collet **16** about the yaw axis. In FIG. **6** a rocker style sensor assembly **158** includes a T-shaped member and having a vertical center arm **160** engaged within a groove in the underside of collet **16**, and the T-shaped member being pivotally supported at a lower center so that the two oppositely disposed lateral arms **162** may be pivotally moved up and down dependent upon the direction of rotation of the collet to interact with a direction indicating negative sensor **164** and a direction indicating positive sensor **166** shown mounted on lower member **20**. The negative and positive sensors **164, 166** may be simple on/off switches, or may be more sophisticated sensors which indicate degree or pressure in addition to the direction collet **16** has been rotated, such as by varying voltage via resistance changes, or by varying electrical output such as with piezo electric material and the like. When a rotatable collet is used, a sensor is used to detect rotation of collet **16** as described above, but this does not bar still having a sensor (encoder) in communication with trackball **12** for detecting rotation of the trackball about the yaw axis, and this would give the user the option of rotating about yaw via the trackball or the rotatable collet. Further, the trackball **12** input member may be interpretable on all six axes as previously described, and the rotatable collet can serve as an additional secondary input member for whatever use may be desired by a software designer or end-user.

I prefer most all of the circuits, switches and sensors be mounted on carriage **14**, and more particularly the lower member **20**, which is a sheet member, and this being an advantage for maintaining low cost in manufacturing. Dependent upon the type and sophistication of the sensors utilized in the present controller, and the electronics and/or software and electronics of the host graphics image generation device which the present invention is intended to interface, and at least in part control, there may be little more than flexible electrical conductors connected to on/off switches mounted on the lower member **20**, with the flexible conductors leaving the lower member to exit housing **10** via a cord **156** connectable to the host image generation device, or leaving circuitry on lower member **20** to connect to an emitter of electromagnetic radiation (not shown) mounted on housing **10** for communicating the linear moment and rotational information with the host device via wireless communication such as via infra red light or radio signals. Lower member **20** may be a printed circuit board having sensors, integrated and or discrete electronic components thereon, and in FIG. **2** an application specific integrated circuit chip is illustrated at **130** which could be utilized for computations, encoding, memory, signal translations such as analog to digital conversions, data formatting for communication to the host device, serial and/or parallel communications interfacing, and the like steps or processes. The specific circuitry and electronics built onto or into the present invention will in all likelihood be different when the invention is built primarily for use with a personal desk top computer than when it is built primarily for use with an interactive television or television based electronic game for example. Any required electrical power for electronics or sensors or output signals may be provided by batteries within housing **10**, or via a connected cord or any other suitable power source. A combination of electrical power inputs may be used, and this would depend on the particular application for which the controller was designed.

As previously mentioned, housing **10** may be in numerous forms, for example, FIG. **8** is an illustration of housing **10** structured specifically for carriage **14** and trackball **12**, and one which is structured to rest upon a support surface such as a table or desk when utilized, and this unit may be used to replace a typical mouse used with a computer. An optional extending portion **142** is shown indicated in dotted outline, and which is ergonomically designed as a wrist and forearm rest. The embodiment shown in FIG. **8** is also shown with two thumb select switches **144** and two finger select switches **146** (secondary input members) which may be included to be used as function select switches as is common on a trackball, mouse or joy stick. A further example of a useful housing **10** is shown in FIG. **9** wherein a hand held housing **10** sized and shaped to be grasped in a hand of a user while the user controls graphic images with the controller in accordance with the present invention is shown. This "remote control" style version of the invention may be direct wired with long flexible conductors to the host graphic image generation device (computer or television for example), but is preferably a wireless remote controller which sends information to the graphics generation device via wireless electromagnetic radiation indicated at **138**. The FIG. **9** remote control is battery powered with a battery in compartment **134**, and may include a scan or program window shown at **132** for allowing programming of internal electronics. This version may prove to be particularly useful with interactive television and interactive three-dimensional displays such as are commonly referred to as virtual reality displays, and most likely will include additional function keys **136** for on/off, volume, channel selection, special functions and the like.

FIG. **10** shows carriage **14** and trackball **12** (embodiment **9**) housed in an otherwise relatively conventional computer keyboard **140**. Embodiment **9** is shown replacing the arrow-keypad, although is can be incorporated into other areas of the keyboard **140**. Embodiments **172** and **200**, to be disclosed, can also be incorporated into a computer or like keyboard, and as will become appreciated.

FIG. **11** represents a desk top computer **148** as an example of a graphic image generation device, and shown on the display **150** (computer monitor) is a cube **152** displayed three dimensionally. An electromagnetic signal receiver window is shown at **154** for receiving signals such as are sent via a wireless communicating version of the present invention such as that shown in FIG. **9**. Alternatively the keyboard **140** of FIG. **10** could be connected to the host image generation device via flexible conductor set **156** to allow typical keyboarding when desired, and control of graphic images with the use of the present 3D six degree of freedom controller when desired.

With reference now to FIG. **12**, wherein a partial cross-sectional end view of a joystick type embodiment **172** of the invention is shown. Embodiment **172** is or can be structured identically to the FIGS. **1–3** trackball embodiment, with the exception of an elongated graspable handle **174** engaged, by any suitable connecting arrangement on an exposed portion of the ball **12**, such as by integral molding or casting, or connecting with adhesives or screws, etc. Full 3D is provided with embodiment **172**, as the user grasps handle **174** and can control carriage **14** and ball **12** with linear and rotational forces applied to handle **174**. The input member in embodiment **172** is considered handle **174**, and the reference member is considered housing **10**. Embodiment **172** can include housings in numerous shapes and sizes such as the housing **10** shown in FIGS. **8**, **9** and **10** for example.

At this point in the description, it is believed those skilled in the art can build and use at least one embodiment of the invention, and further can build and use a trackball type and a joystick type embodiment in accordance with the present invention without having to resort to undue experimentation, however further joystick type embodiments in accordance with the present invention will be described to further exemplify the broad scope of the invention.

FIGS. **13–21** show variations on a joystick-type embodiment **200** which is a hand operated 3D physical/mechanical to electrical converter for image control which has all 6 axes bi-directionally mechanically resolved in a pure fashion to the respective individual sensors representing each axis. Further embodiment **200** teaches all necessary sensors located within a handle **202**. Embodiment **200** further teaches structuring enabling the possible location upon a single sheet of all necessary sensors for a 3D controller device.

FIG. **13** shows an exploded view of joystick embodiment **200** of the current invention exhibiting structuring enabling use of a membrane sensor sheet **206**. All 3D operations of the input member shown as joystick-type handle **202** (comprised of upper handle part **202.2** and lower handle part **202.1**) relative to the reference member shown as shaft **204** are translated to specific locations on membrane sensor sheet **206**.

Shown at the bottom of the drawing is shaft **204** which may or may not be mounted to many different base-type or other structures. Shaft **204** is shown as generally cylindrical and substantially aligned, for purposes of description, along the yaw axis. Shaft **204** is substantially hollow to allow passage of the membrane tail, wiring or electrically connecting material, and is made of a generally rigid and strong material such as injection molded acetal plastics or steel etc. Shaft **204** has fixed to one end a short extending pedestal **210** and fixed to pedestal **210** is pivot ball **208**. Shaft **204** also has a yaw slide-rail **212**. Slide-rail **212** is a component that serves to keep translator **214** from rotating relative to shaft **204** about the yaw axis while still allowing translator **214** to move vertically along the yaw axis. One skilled in the art will readily recognize variants in the specifically drawn and described structure after reading this disclosure. For example, slide rail **212** would not be necessary if shaft **204** were square shaped rather than cylindrically shaped.

Substantially surrounding but not directly connected to shaft **204** is a lower handle part **202.1** which is made of a substantially rigid material and is shown having a round short vertical outer wall and essentially flat bottom with a central large round cut out area to allow for movement of handle **202** relative to shaft **204**. Lower handle part **202.1** is fixed, preferably by screws, to upper handle part **202.2** thus the two parts in unity form handle **202** which encompasses all the remaining parts of this embodiment. The flat bottom of lower handle part **202.1** is slidable horizontally along the pitch and roll axes relative to the essentially flat underside area of a first carriage member **216**. First carriage member **216** has centrally disposed an aperture which is shown with edges forming a planar cut of a female spherical section which is rotatably slidably mated to a male spherical section of translator **214**. Translator **214** has a vertical female cylindrical aperture and yaw slide rail slot **213** to mate with shaft **204** as previously described. Translator **214** additionally has at its upper edge two oppositely disposed anti-yaw tabs **218** which lay essentially in a horizontal plane described by the pitch and roll axes. Anti-yaw tabs **218** fit within substantially vertical slots formed by rising posts **220** which are fixed to and preferably mold integrally with carriage member **216**. The functional result of anti-yaw tabs **218** working within the slots and the mating of the male spherical section of translator **214** with the female spherical section of carriage member **216** creates the mechanical result that while translator **218** is held substantially non rotatable relative to shaft **204**, carriage member **216** is rotatable about the pitch and roll axes but not the yaw axis relative to both translator **214** and the general reference member shaft **204**. Rising posts **220** fixedly connect first carriage member by screws, snap fit connectors, or other connecting means to a second carriage member **222** which may in some variations of this embodiment be a circuit board sheet supporting all necessary sensors, but as shown in the embodiment of FIG. **13** support sheet allows a formative and supportive backing for membrane sensor sheet **206**. Second carriage member **222** is made of a rigid material such as, for example, injection molded acetal plastic and is shown in FIG. **13** as being essentially a flat circular plate with a circular cut out at its center and with six downwardly extending plate like structures (as shown) which serve as back supports for sensors located on flexible sensor membrane **206** which is bent or flexed (as shown) at appropriate locations to allow sensors to be positioned correctly between the second carriage member and the activating part for each individual sensor.

In association with the sensors, in a preferred embodiment, are resilient "tactile" return-to-center parts **226** (herein after "tactile RTCs **226**") which are shown in FIG. **13** as rubber dome cap type activators. These tactile RTCs **226** are positioned between sensors and activating mechanical hardware so that when the input member is operated a specific piece of activating mechanical hardware, member, or part (which specific activating part depends on which specific sensor is being described) moves to impinge on the local tactile RTC **226** and compresses it. As the impinging/compressing force grows a force "break-over" threshold, inherent in the tactile RTC **226**, is overcome and the force rapidly but temporarily decreases and the sensor is impinged and activated. This break-over tactile threshold can be achieved with numerous simple tactile structures, such as the rubber dome cap structures illustrated as RTCs **226** in FIG. **13**, or metallic dome cap structures (which give an exceptionally strong clear feedback sensation) and other more complex spring based break over structures. These resilient break-over structures are typically used in the industry for simple on-off switches, such as the audible and tactile break-over switches commonly used to turn on and off lights in the home, and in the operation of typical computer keyboard keys.

I believe that my structuring enabling the use of this common break-over technology in a 3D controller is a highly novel and useful improvement in the field of 3D graphic image controllers. Further, it can clearly be seen here, after study of this disclosure, that tactile break-over devices can also be used to great advantage in novel combination with proportional or variable sensors within my mechanically resolved 3D controller structurings, and that this is a novel and very useful structure.

The resilient components RTCs **226**, when compressed, are energized within their internal molecular structure, to return to the uncompressed state, thus when the user takes his hand off of the input member, or relaxes the force input to the input member then the resilient RTCs **226** push the mechanical parts of the controller back off of the sensor and toward a central null position of the input member. RTCs **226** serve to great advantage on all six axes in most joystick type controllers and on the three linear axes in the trackball type controller.

Positioned to activate sensors **207.03** through **207.06**, as shown in FIGS. **14** and **15**, are sliding actuators which are impinged upon by the inside surface of the outer wall of handle **202**.

Above member **222** is a yaw translator plate **230** with an oblong central cut out (as shown) and distending plate-like members are two oppositely disposed yaw activators **231** which extend, when assembled, down through the illustrated slots of member **222** to activate sensors **207.07** and **207.08** when handle **202** is rotated back and forth about the yaw axis.

On the upper surface of plate **230** are fixed or integrally molded pitch slide rails **232** which are oriented substantially parallel to the linear component of the pitch axis, and fit into and slide within female complementary pitch slide slots **234** which are molded into the underside of anti-rotating plate **236** which is located above plate **230** and sandwiched between plate **230** and upper handle part **202.2**. Anti-rotating plate **236** is a plate like structure with an oblong-shaped central cutout and on the upper surface are molded roll slide slots **238** which are substantially aligned with the linear component of the roll axis and through which slide roll slide rails **240** which are integrally molded on the inside surface of upper handle part **202.2**.

Within the assembled embodiment **200** located at the approximate center of handle **202** is pivot ball **208** which is fixed to shaft **204**. Pivot ball **208** is immediately surrounded on top and sides by the recess within a linear yaw axis translator **242** which is a substantially rigid structure having an oblong-shaped horizontally protruding upper activating arm **244** (as shown) and on its lower portion are snap-fit feet **246** or other attaching means or structures for fixing a lower activating arm **248** to the bottom of translator **242**, thus pivot ball **208** becomes trapped within the recess within translator **242** by the attachment of lower activating arm **248** forming a classic ball in socket joint, wherein translator **242** is free to rotate about ball **208** on all rotational axes but not free to move along any linear axis relative to ball **208** and shaft **204**.

FIG. **14** shows membrane sensor sheet **206** in flat form as it would appear after being printed with conductive pads for sensors **207** and conductive circuit traces **256** but prior to being cut from sheet stock along cut line **254**.

FIG. **15** shows a larger clearer view of membrane **206** and second carriage member **222**, with membrane **206** in the folded configuration as it would fit on the membrane support sheet **222** and the rubber dome cap tactile resilient activators **226** where they would rest upon membrane **206** each one above a sensor **207**.

FIG. **16** shows all sensors **207** in mechanical packages having solder tangs that are solder mounted to the second carriage member, which in this case, specifically, is a rigid circuit board sheet **250**. Sensors **207.01** through **207.12** are positioned essentially in the same locations as indicated in FIGS. **13** and **14**. The different sensor sheet technologies are shown to be interchangeable within the novel structuring of the invention. Substituting circuit board **250** into the embodiment shown in FIG. **13** replaces the parts shown in FIG. **15**, specifically, membrane **206**, second carriage member **222**, sliding actuators **228** and rubber dome caps **226** can all be replaced by the structure of FIG. **16**.

Whether on membrane sheet **206** or circuit board **250** specific sensors **207** are activated by the following movements and rotations with the respective structures described here:

linear input along the yaw axis in the positive direction (move up) causes sensor **207.01** to be activated by upper activating arm **244**,

linear input along the yaw axis in the negative direction (move down) causes sensor **207.02** to be activated by lower activating arm **248**,

linear input along the roll axis in the positive direction (move forward) causes sensor **207.03** to be activated by the inner surface of the outer wall of handle **202**, (with rubber dome cap **226** and slide **228** on membrane variation), linear input along the roll axis in the negative direction (move back) causes sensor **207.04** to be activated by the inner surface of the outer wall of handle **202**, (with rubber dome cap **226** and slide **228** on membrane variation),

linear input along the pitch axis in the positive direction (move right) causes sensor **207.05**, to be activated by the inner surface of the outer wall of handle **202**, (with rubber dome cap **226** and slide **228** on membrane variation),

linear input along the pitch axis in the negative direction (move left) causes sensor **207.06**, to be activated by the inner surface of the outer wall of handle **202**, (with rubber dome cap **226** and slide **228** on membrane variation), rotational input about the yaw axis in the positive direction (turn right) causes sensor **207.07** to be activated by yaw activator **231**,

rotational input about the yaw axis in the negative direction (turn left) causes sensor **207.08**, to be activated by yaw activator **231**,

rotational input about the roll axis in the positive direction (roll right) causes sensor **207.09** to be activated by the top edge of translator **214**,

rotational input about the roll axis in the negative direction (roll left) causes sensor **207.10** to be activated by the top edge of translator **214**,

rotational input about the pitch axis in the positive direction (look down) causes sensor **207.11** to be activated by the top edge of translator **214**,

rotational input about the pitch axis in the negative direction (look down) causes sensor **208.12** to be activated by the top edge of translator **214**.

FIG. **17** shows membrane **206** in a variation where all 3D sensors **207** are positioned on a flexible membrane sensor sheet and positioned on a single flat plane. All sensors are activated by structuring acting on membrane **206** from the lower side as membrane **206** is pressed up against the second carriage member **222**, except for sensor **207.01** which is activated by structure from above pressing sensor **207.01** down against a recessed support shelf **258** which is integrally molded as part of plate member **222**. Shelf **258** is molded in such a way as to leave at least one side, and as drawn two sides, open so that sensor **207.01** can be slid through the open side during assembly to rest on recessed support shelf **258**. Sensor **207.01** having a cut-out **260** near at least two edges of sensor **207.01** thus allowing positioning of membrane **206** with all sensors **207** on an essentially single plane. Sensors **207.03** through **207.08** which were flexed into right angle positioning in the variation of FIGS. **13–15** are now all on the same plane and each is impinged upon and activated by right angle translation structuring shown as a rocker-arm activator **262** which pivots on an integrally molded cylindrically shaped fulcrum **264** which is held in position by saddle shaped upward protrusions **266** fixed to first carriage member **216** and saddle shaped downward protrusions **268** fixed to second carriage member **222**. This right angle translation structuring works as follows: For example, if input member handle **202** is pressed to move along the roll axis in a positive manner then a flattened area along the inside surface of the outer wall of handle **202** impinges upon the lower portion of rocker-arm activator **262** causing activator **262** to pivot about fulcrum **264** and the upper part of activator **262** impinges upon tactile resilient activator **226** (shown here as a metallic dome cap) until sufficient force has built to allow tactile actuator **226** to "snap through" and come to bear upon and activate sensor **207.03**. These structures do not have to have "snap through" or tactile turn-on resilient structuring to be fully functional, but this tactile turn-on resilient structuring is believed to be novel in 3D controllers and highly advantageous in the feedback it offers to the user.

FIG. **18** shows structuring of membrane **206**, as described in FIG. **17**, integrated into an otherwise typical computer keyboard membrane **270** by connection of membrane tail **224** to keyboard membrane **270** which may be structured of the common three layer membrane structuring, or single layer membrane structuring, or any other type). In this embodiment shaft **204** is fixed to keyboard housing **10** (shown in FIG. **19**) and for assembly membrane **206** is rolled up and inserted through shaft **204** and then unrolled where it is positioned against member **222**.

FIG. **19** shows an external view of a 3D handle **202** positioned where the arrow key pad would be on an otherwise common computer keyboard housing **10**. With the current structuring many different positionings of a 3D handle on a keyboard are possible, such as positioning handle **202** in the area normally occupied by the numeric keypad, or on an ergonomically designed keyboard having the large key bank of primarily alphabetic keys divided into two banks angled apart positioning of handle **202** between the two alphabetic key banks is a distinct possibility, etc. Further, in the common keyboard the 3D operations can or cannot emulate keys such as the arrow keys when handle **202** is operated appropriately. An optimum keyboard may have proportional sensors built into the membrane and output both proportional and simple switched data. For example, an optimum keyboard may sense a certain handle **202** movement and send out both a scan code value representing an appropriate key stroke (such as an arrow key value) and the keyboard may also output a proportional value representing how intense the input operation is being made.

FIGS. **20–31** show another preferred embodiment exhibiting two planar structuring. Two planar design offers some advantages. Such a device still has all the benefits of a pure mechanically resolved device and with two planar execution additional benefits are realized, such as: the capability of exceptionally low profile design for integration into computer keyboards and hand held remote controllers, ready integration of finger operated buttons on the handle for operating sensors incorporated into the sensor sheet, space to place active tactile feedback means in a still small handle, etc.

Referring to FIGS. **20–21**, an input member which is shown as a hand manipulatable handle **300** is shown supported on a shaft **302**. Shaft **302** extends into a base or reference member housing **317**. Shaft **302** passes through a shaft guide first main hole **306** within a sliding plate or platform called a first platform **352**. Shaft **302** further passes through a shaft guide second main hole **310** located in a second platform **322**. FIG. **21** shows Platform **322** fixedly attached to connecting structure shown as legs **312** which are fixed to first platform **352**, thus platform **322**, connecting structure **312** and platform **352** cooperate together forming the structure of a carriage **314**.

First platform **352** is slidably retained along a first axis by a sliding plate called an anti-rotating plate **350** which is slidably retained along a second axis by at least one housing guide **308** which is fixed to housing **317**. First platform **352** and plate **350** are further constrained by retaining shelf **316** and housing **317** from linear movement along the yaw or third axis. Thus plate **350**, guide **308**, housing **317**, and shelf **316** cooperate to form a carriage support structure **316** in which platform **352** (and thus also carriage **314**) is prohibited from significantly rotating on any axis, and also is allowed to linearly move significantly along the first and second axes (pitch and roll axes) but is prohibited from significant movement along the third axis, relative to housing **317**.

Within carriage **314**, and platforms **352, 322**, holes **306** and **310** cooperate to offer sufficient fit in the passage of shaft **302** to provide advantageous structural cooperation in two substantial ways. The first is the provision of an anti-tilting structure **324** which prevents shaft **302** from significant tilting (rotating about the first or second axes) relative to carriage **314**. The second is provision of two-axes structure where any and all linear movement along parallel to the first and second axes (linear along length of pitch and roll axes) by shaft **302** is coupled to equivalent movement along parallel to the first and second axes of carriage **314**.

A second endward region of shaft **302** as shown in FIG. **21** is shaped with a male partial spherical shape **318** which slideably contacts a complimentary female partial spherical shape **319** which is part of handle **300**, and shaft **302** also comprises a male pivot protrusion having a pivot or rotational point located approximately central to handle **300** and approximately at the center of the spherical partial section shapes. Protrusion **346** provides a pivot point for handle **300** and may mate to a female pivot receptacle. Thus handle **300** can be rotational relative to shaft **302** yet coupled for all linear movement along parallel to the first and second axes with equivalent linear movement of shaft **302** and also two-axes structure **326**, therefore the above mentioned members connecting handle **300** to shaft **302**, and shaft **302** to carriage **314** serve as a handle support structure **328** in which handle **300** is coupled for equivalent movement with carriage **314** along parallel to the first and second axes.

On carriage **314** are rocker-arm structures **364** shown mounted on second platform **322**. Rocker-arm structures **364** convert movement of carriage **314** relative to housing **317** to a resilient thermoplastic rubber (TPR) sheet **366** formed with a plurality of "tactile" resilient dome cap structures **368**. Resilient sheet **366** and second platform **322** sandwich sensors supported on a membrane sensor sheet **330**. Again, shown in broken lines is the motor with shaft and weight mounted offset to the shaft as an example of an active tactile feedback means (vibrator).

FIG. **22** shows the positioning of four rocker-arm structures **364** as they are mounted on second carriage part **322** which is shown as a substantially flat plate that might be manufactured as a traditional printed circuit board sheet bearing on-board sensors and containing on-board active electronic circuitry **370** and a cable **372** for routing data to a graphics display device, or as a flat rigid plate-like structure supporting a flexible membrane sensor sheet **330**. Shown on top of and essentially parallel to plate **322** is rubber sheet **366** having a multiplicity of tactile resilient rubber dome cap type actuators **368**.

Rocker-arm structures **364** have at least the following structure: a mounting structure **332**, which is structure essentially fixed to carriage **314** and is illustrated as a snap-fit design having two legs which snap into slots within plate **322**; a fulcrum **334**, illustrated in all figures as a living hinge located at the top of mounting structure **332** except in FIG. **24** where fulcrum **334** is illustrated as a more traditional cylindrical bore-and-core type hinge; at least one sensor actuating arm **336**, and in all drawings rocker-arm structures **364** are illustrated as commonly having two arms for actuating two sensors one on each side of mount **332**, except in drawings **26** and **27** where are illustrated one-armed variants; and finally rocker-arm structures **364** have a super-structure **338** by which the rocker-arm is activated or caused to move against and actuate the associated sensor(s). Super-structure **338** is the distinctive part of the different two armed rocker-arm types shown in FIGS. **20–22**, of which are a V-slot type **340**, an H-slot type **342**, and a T-bone type **345** of which there are two rocker-arms being approximately identical but oriented perpendicular to one another and being called a first t-bone **344** and a second t-bone **364** rocker-arm actuators.

FIG. **23** shows T-bone actuator **345** mounted to plate **322** by mounting structure **352** and pivoting (shown actuating sensor in dashed lines) about fulcrum **334** shown as a living hinge which is connected to the bottom of two oppositely disposed actuating arms **336** above which is fixed super-structure **338** which is activated into motion by a activating receptacle **339** that is fixed to the reference member base or housing **10** by way of retaining shelf **316**. Under the opposite side of actuator **345** from dome cap **368** (which is shown in dashed lines as being depressed and thus actuating sensor **207** located on flexible membrane sensor sheet **330)** is illustrated a packaged mechanical sensor **207** soldered to a flat circuit board sheet. Thus, FIGS. **22** and **23** clearly show how the same inventive structurings can translate mechanical or physical inputs to either a flexible membrane sensor sheet or to a rigid circuit board sensor sheet.

FIG. **24** shows H-slot actuator **342** as it is activated by shaft pin **321** which is fixed within shaft **302**. As shaft **302** moves vertically or along the yaw or third axis then so in unison moves shaft pin **321** and actuator **342**.

A first end of shaft pin **321** passes through a beveled slot within super structure **338** of rocker-arm H-slot type **342** in which the slot is approximately perpendicular to the third axis and the length of shaft **302,** so that when shaft **302** and shaft pin **321** move along the third axis rocker-arm **342** in moved in kind with one arm descending to compress its respective resilient dome cap **328** and upon collapse of dome cap **328** the respective underlying sensor is actuated, as shown in FIG. **24**. Of course movement of shaft **302** in the opposite direction along the third axis likewise actuates the opposite complimentary sensor of the sensor pair. Rotation within operational limits of shaft **302** about its cylindrical center or approximately about the third axis simply causes shaft pin **321** to move within the slot and does not activate the H-type rocker-arm **342**.

FIG. **25** shows activation of V-slot actuator **340**. A second end of shaft pin **321** passes through a slot of V-slot rocker-arm **340** which is activated in the converse of the above H-slot rocker arm **342**. Movement of shaft **302** along the third or yaw axis simply causes shaft pin **321** to move within the slot and not actuate V-type rocker-arm **340**, but rotation about the third axis causes shaft pin **321** to activate rocker-arm **340** in the following manner. Rotational motion of shaft **302** conveyed to shaft pin **321** activates rocker-arm **340** causing compression of dome cap **328** and stimulation of the sensor located on the membrane. Super structure **338** of rocker-arm **340** has a slot in structure slanting away from shaft **302**. This is to accommodate the increasing movement of pin **321** as it may change in distance from fulcrum **334** when shaft **302** is moved along the third axis. Thus the slope of the slot compensates for varying effectiveness of shaft pin **321** so that rotation of shaft about the third axis causes rotationally equivalent activation of rocker-arm **340** regardless of the distance shaft pin **321** is from fulcrum **334** of rocker-arm **340**.

FIGS. **26** and **27** show space savings structuring for the area of second platform **322**. This space savings may be valuable in tightly constricted areas such as integration of the invention into computer keyboards and hand held remote control devices. The layout of second platform **322** as illustrated in FIGS. **20–22** is shown by a dashed line indicating the original larger perimeter **370** the area of the newer smaller platform **322** shown by solid line **372** and first t-bone rocker-arm **364** has been divided into two separate one-armed type **348** actuators each with its own mount **332**, fulcrum **334**, sensor actuating arm **336**, and super structure **338**.

FIG. **28** shows structuring within handle **300** for support and activation of sensors **207** supported on sensor membrane sheet **330** which may be supported within the inside upper portion of handle **300** or as shown here supported by a rigid support sheet **374** the appendage of membrane **330** passes through shaft **302**. Also shown here are two buttons **378** for operation by the user's fingers. Buttons **378** have an exterior activating surface area **378** which can be depressed by the user's finger(s) causing button structure **376** to rotate about an integrated cylindrical fulcrum **380** which rests within saddle supports fixed to handle **300**. The pivoting motion of button **376** causes the internal sensor actuating part **382** to rise against resilient dome cap **368** and activate sensor(s) **384**. This button structuring is similar to that shown in FIG. **17** with the exception that the structuring of FIG. **17** is completely internal while this design has the button externally operated for additional input (other than 3D input) by the user's finger(s).

FIG. **29** shows a sensor membrane **330** of a three layer traditional computer keyboard type, but with the inventive exception of having two additional appendages designed for fitting into the two planar structure design shown in FIGS. **20–28** for incorporation in a keyboard as shown in FIG. **19**. The appendage having the longer attachment and a rounded head passes from inside the keyboard housing **10** up through the shaft and into the handle and the other appendage resides on carriage part **322** within housing **10**.

FIG. **30** shows 3D input member handle **300** integrated with shaft **302** fixed to housing **10** of an otherwise normal wireless remote control device, such as for operating a television, or other device, etc.

FIG. **31** shows the device of FIG. **30** in dashed lines showing an internal view of a likely form for membrane sensor sheet **330**. Membrane sheet **330** is shown connected to a circuit board sensor sheet **250** that commonly is positioned under the normal input keys and also contains electronic circuitry. Membrane tail **224** connects from sheet **250** to the greater body of membrane **330** which in this case is shown as a two planar type as shown in FIGS. **20–28**. This arrangement of sensors on two planes is quite ideal for many uses. It allows the origin of all axes to remain within handle **300** and yet much of the mechanical resolving structure is moved down into housing **10** where space is more plentiful, thus handle **300** can be made even smaller and even lower in profile, if desired. Additionally, auxiliary secondary input buttons (select, fire buttons, special function keys, etc.) are readily integrated in an economical and rugged fashion for operation by the user's finger(s).

FIGS. **33–35** show a preferred embodiment of the two planar design without using rocker arms and having packaged sensors **207** shown here as simple mechanical flat-mount and right-angle-mount switch packages, mounted on second carriage part **322** which, in this embodiment, is a circuit board to which the sensor packages are soldered, and also the sensor packages are solder mounted on a second circuit board **423** within handle **400**. This embodiment has some parts and structures that are similar to equivalent parts in earlier embodiments such as a hand operable input member shown as a handle **400** supported on a shaft **402** which extends into a housing which serves as a reference member or base **417** where it interfaces with carriage **414**. Carriage **414** is supported by a similar carriage support structuring and carriage **414** has platform **352** with distending legs **112** which connect to second carriage part **422** which, in this embodiment, is specifically a circuit board carrying eight sensors for interpretation of four axes.

Specifically shown in FIG. **33** is a 3rd axis actuator part **450** which has a specific structuring that allows all sensor mountings on the circuit board to be fully functional with flat and right-angle-mount mechanical sensor packages. Actuator part **450** is integrated to the end of shaft **402** that is in communication with carriage **414**. Actuator **450** may be integrated with shaft **402** as a single, injection-molded part or actuator part **400** may be a separate molded part fit over the end of shaft **402** and secured to shaft **402** by a pin **452** passing through both shaft **402** and actuator part **450**. Actuator part **450** has at least a 3rd axis rotational actuator **454** which is a plate-like member fixed to actuator part **450** and extending outward in a plane having substantially the 3rd (yaw) axis as a member of that plane so that when shaft **402** rotates in either direction about the 3rd axis, actuator part **454** moves through space, actuating the appropriate right-angle-mount sensors indicating a 3rd axis rotational movement in either the positive or negative direction. Actuator part **450** has a 3rd axis negative (yaw—move down) linear actuator **458** and a 3rd axis positive (yaw—move up) linear actuator **456** which also are fixed to actuator part **450** and extend outward from part **450** perpendicular to the 3rd axis and substantially aligned with a plane parallel to the 1st and 2nd axes, so that when shaft **402** moves along the 3rd axis in a positive direction, actuator **456** activates the appropriate flat mount sensor indicating linear movement along the 3rd axis in a positive direction, and when shaft **402** moves along the 3rd axis in a negative direction, actuator **458** activates the appropriate flat mount sensor indicating linear movement along the 3rd axis in a negative direction.

FIG. **36** shows a final preferred embodiment having some similar structures to earlier embodiments, especially those shown in FIGS. **32–35**, with the primary exception that in this embodiment eight sensors are located within the hand operable input member handle **500** and only four sensors are located within the reference member housing **517**. In this embodiment a similar carriage **514** is located within housing **517** but shaft **502** is fixed to plate **552** of carriage **514** so that shaft **502** is free to move only linearly within a plane perpendicular to the 3rd (yaw) axis. A part shaped almost identically to part **450** is fixed at the top of shaft **502**. Sensors **207** within handle **500** are mounted to circuit board **523**.

In the interest of brevity, it is appreciated that after study of the earlier embodiments one skilled in the art will be able to easily construct the full structuring of the embodiment of FIG. **36** from this full illustration without an overly extensive written description.

FIG. **37** shows a right angle simple switched sensor package as is commonly available in the industry. It is comprised of a non-conductive rigid plastic body **600** supported by electrically conductive solder mounting tangs **606** and **608** which are typically made of metal. Electrically conductive tang **606** passes from the exterior of body **600** to the interior where it resides in a generally peripheral position of an internal cavity of body **600**, and electrically conductive tang **608** passes from the exterior of body **600** to the interior where it resides in a generally central position of the internal cavity. Positioned over the internal portions of tangs **606** and

608 is a metallic dome cap 604 having resilient momentary “snap-through” characteristics. Metallic dome cap 604 typically resides in electrical contact with tang 606 on the periphery and typically not in contact with centrally positioned tang 608. Positioned to depress dome cap 604 is a plunger 602 which is generally made on non-conductive rigid plastic material. Dome cap 604 and plunger 602 are typically held in place by a thin metallic plate 610 which is fixed to body 600 by plastic melt riveting or other means. Plate 610 has an aperture large enough for a portion of plunger 602 to protrude to pressed upon by an outside force and thus to depress conductive dome cap past a tactile snap-through threshold and down onto centrally disposed conductive tang 608, thus completing an electrically closed circuit between tangs 606 and 608.

FIG. 38 shows an even more typical sensor package body 600 in that it is horizontally mounted, which is the most common style. But the sensor of FIG. 38 has an additional very important element. In the inner cavity of body 600 and fixed above, and electrically in connection with, centrally positioned conductive tang 608 is a pressure sensitive electrical element 612, which may have a conductive metallic plate 614 fixed to the upper surface of element 612 for optimal operation. Of course, this same design can be integrated into the sensor of FIG. 37. Pressure element 612 is constructed of a pressure sensitive material, such as for example, molybdenum disulfide granules of approximately 600 grit size mixed with a base material such as silicon rubber in, respectively, an 80-20 as taught in U.S. Pat. No. 3,806,471 issued to inventor Robert J. Mitchell on Apr. 23, 1974, ratio, or other pressure sensitive electrically regulating materials. I believe that integration of pressure sensitive technology into a tactile-snap through sensor package is novel and of great advantage in 3D controllers as shown herein and described in my earlier 3D controller patent applications.

FIGS. 39 and 40 show cross-section views, respectively, of a non-actuated and an actuated flexible planar three layer membrane comprised of an upper electrically non-conductive membrane layer 620, a mid electrically non-conductive membrane layer 622 and a lower electrically non-conductive membrane layer 624 all positioned essentially parallel to each other with upper layer 620 having an electrically conductive trace 626 on its lower side and lower layer 624 having an electrically conductive trace 628 on its upper side with mid layer 622 normally isolating the traces except in the central switching or sensing region where mid layer 622 has an aperture. In a traditional three layer flexible membrane sensor the aperture in mid layer 622 is empty allowing upper layer 620 to be depressed flexing down until electrically conductive trace 626 comes into contact with electrically conductive trace 628 of lower layer 624 and completes an electrical connection, as is commonly known in the prior art. The membrane layers are supported upon a generally rigid membrane support structure 630 such as a rigid plastic backing plate.

The membrane sensor shown is novel with the inclusion of a pressure-sensitive electrically regulating element 638 disposed in the sensing region, filling the traditionally empty aperture of mid layer 622. Pressure element 638 remains in electrical contact with broad conductive areas of conductive traces 626 and 628 at all times. Pressure element 638 may be of a type having ohmic or rectifying granular materials (such as 600 grit molybdenum disulfide granules 80–98%) in a buffering base matter (such as silicon rubber 2–20%) as described in U.S. Pat. No. 3,806,471 issued to inventor Robert J. Mitchell on Apr. 23, 1974, or other pressure sensitive electrically regulating technology as may exist and is capable of being integrated with membrane sheet technology.

Also I believe it is novel to use a metallic “snap-through” resilient dome cap 632 with for its excellent tactile turn-on feel properties in combination with membrane sensors and especially with membrane pressure sensors as shown, where metallic dome cap 632 resides on top of upper membrane layer 620 and is shown held in place by silicon adhesive 636 adhering dome cap 632 to any generic actuator 634. Generic actuator 634 may be the actuating surface area of any part which brings pressure to bear for activation of a sensor, for example, actuator 634 might be a nipple shaped protrusion on the underside of rocker arm actuator arms 336 on the embodiment of FIGS. 20–31, etc. Vibration lines 640 indicate an energetic vibration emanating outward either through support 630 or actuator 634 as a mechanical vibration transmitted through the connected parts to the user's hand, or as air vibrations perceived by the user's ear, and indicating the “snap-through” turn-on/off sensation of resilient dome cap 632 as it impinges upon and activates the sensor. With twelve possible singular input operations, and a very large number of combined input operations the user perceivable tactile sensation indicating sensor activation is of high value to the operator of the device.

FIG. 41 shows a compound membrane sensor sheet 700 containing a multiple-layer staged sensor 701. Staged sensor 701 is comprised by layering, one on top of the other, more than one traditional simple membrane switch and sharing layering which can be used in common. For example, the top layer of the lower sensor and the bottom layer of the top sensor can be combined using both sides of the common layer to full avail, thus two three layer sensors are combined into one five layer sensor, etc. Staged sensor 701 can be useful in measuring increased activating force of the impinging activator coming down on sensor 701 from above with sufficient force first activates the upper sensor and with sufficient additional force then activates the second sensor, and so on. Many layered sensors are possible.

FIG. 42 shows a compound membrane sensor sheet 700 containing a compound sensor 702 which in essence is a commonly known simple switched membrane sensor on top of my novel proportional membrane sensor as described in the embodiment of FIGS. 39 and 40, with the two respective sensors sharing the middle sheet so that two three sheet sensors are combined into one five sheet sensor. In combination with earlier drawings and descriptions herein, and the commonly known prior art the compound sensor shown here becomes self descriptive to one skilled in the art.

Some commonly known simple switched sensors use only a single sheet rather than three sheets, with the single sheet having both conductive traces sharing one surface area and the resilient dome cap having a conductive element which when depressed connects the conductive traces. One skilled in the art will also appreciate that the novel compound sensor 702 may be made with less than five sheets using such technology and judicious routing of conductive traces.

Both the simple switched portion and the proportional portion of sensor 702 are activated approximately simultaneously when an activator impinges upon sensor 702 with the simple switched sensor indicating an on state and the proportional sensor indicating how much force is being brought to bear on sensor 702.

A novel sensor of this type, having both a simple switched and a proportional component in combination with my novel keyboard integrated devices, such as those shown in FIGS. 18, 19 and 29 demonstrate the design of having a 3D controller which outputs both a scan code (keyboard type information) and a proportional signal. This could be very useful in any multiple-axes controller even strictly hand-held devices such as those taught in my co-pending provisional application filed Sep. 5, 1995. Outputting both scan codes and proportional signals (possibly to separate keyboard and serial ports) could be of substantial value because for all pre Windows95 machines virtually all 3-D graphics programs already have software drivers to be driven by scan codes (with programmable key maps) so that the 3-D software can controlled by common keyboards. Outputting this data type allows my 3D controllers to interface with existing software that is controllable by scan codes. Outputting both of these data types is not dependent on this compound sensor rather it is simply demonstrated here. Information gathered from any proportional sensor can be massaged into these two different data output types which are believed to be novel in regard to output of multiple-axes controller devices and specifically for 3D devices.

FIG. **43** shows a pair of compound sensors **702** integrated into compound sensor sheet **700**, the compound sensor on the left side is identified as sensor **702**.**1** and the compound sensor on the right side is identified as sensor **702**.**2**. Sensor pairs are valuable because a 3D device has 6 axes which are interpreted bi-directionally (move along the axis to the left or right, but not both simultaneously). Simple switches and the pressure sensors so far shown are uni-directional sensors so ideally a pair of unidirectional sensors are used to describe each axis, thus six pair of unidirectional sensors (twelve individual sensors) can describe six degrees of freedom. Unidirectional sensors are highly desirable both from and cost stand point and from a superior functional stand point, because they allow a natural null or play space for accommodating inaccuracies of the human hand and for optimally accommodating the passive turn-on tactile feedback where the user can feel the different axes turn on and off with manipulation of the input member as described earlier herein.

The pair of sensors **702**.**1** and **702**.**2** offer advantage, for example, in a computer keyboard embodiment where the simple switched portions may emulate key inputs and the proportional portions may serve to create sophisticated 3D outputs. Further, for some applications an incremental output (simple switched) is more desirable than a proportional output. Sensor **702** provides both types of output in hardware. Finally, the compound sensor pair offers structure to lessen the necessary electronics requirement for reading the unidirectional proportional sensors. As shown if FIG. **43** the simple switched portions have electrical connections **704** which make the switches electrically distinct from each other, but the proportional sensor portions have electrical connections **704** which are in parallel, thus the proportional sensor portions are not electrically distinct one from the other. The simple switched portion yields information about which direction along or about an axis and the proportional sensors yield information representing intensity. Thus allowing only one analog channel to read two unidirectional proportional sensors, and correspondingly, only six analog channels to read twelve unidirectional sensors. A savings in electronic circuit complexity.

FIG. **44** shows proportional sensors **638**.**1** and **638**.**2** in a paired relationship within a membrane structure. Sensors **638**.**1** and **638**.**2** have in common a center electrical connection **710** which connects to one side of both sensors **638**.**1** and **638**.**2** of the pair. Each individual sensor has a second and distinct electrical connection, being for sensor **638**.**1** electrical connection **706** and for sensor **638**.**2** electrical connection **708**. The sensors are essentially in a center taped arrangement, so that the center connection **710** can be read with one analog to digital converter yielding bi-directional information, if, for example, connection **706** carries a substantial voltage and connection **708** is grounded. Thus the mechanical and cost advantages of unidirectional proportional sensors is utilized with economical electrical circuitry.

FIGS. **45**–**47** show bi-directional sensors mounted on circuit board sheet means for creating 3D functional structures with previously described structures of the embodiment of FIGS. **20**–**28**, thus for full 3D operability six bi-directional sensors would be used. The embodiment shown in FIGS. **1**–**3** specifically shows a nine sensor 3D embodiment with three bi-directional rotational sensors and six uni-directional linear sensors. The embodiments shown in FIGS. **13**–**36** show twelve sensor 3D embodiments with all sensors being unidirectional sensors.

FIGS. **45** and **46** show generic rocker-arm type actuators **364** mounted on circuit board **322**. Actuators **364** are shown without a differentiating super-structure **338** because the illustrated novel bi-directional sensor application could serve on any or all of the actuators **364** in the embodiment shown in FIGS. **20**–**27**.

FIG. **45** shows rocker-arm actuator **364** mounted on circuit board sheet **322** and a bi-directional sensor **750** such as a rotary encoder or potentiometer solder mounted to sheet **322** and operationally connected to rocker arm **336** by a rack and pinion type gear assembly with the rotary shaft to rotary sensor **750** bearing a small gear or pinion gear **752** which is activated by riding on an arced gear rack **754** fixed to one end of rocker-arm actuator **336** and passing freely through an aperture **756** in sheet **322**.

FIG. **46** is similar to FIG. **45** except that the bi-directional sensor shown is an optical sensor having a light transmitting unit **760** and a light sensing unit **762** which are both solder mounted to circuit board sheet **322** and are separated by an arc shaped light regulating unit **764** such as a graduated optical filter or a shuttering device which is fixed to one end of a actuator arm **336**.

FIG. **47** shows sensors of the same type as described in FIGS. **45** and **46** but with the exception that they are shown with structuring to operate within the handle such as in the embodiment shown in FIG. **28**.

FIGS. **48** and **49** respectfully show a cross-section view and an exploded view of novel structuring for anchoring in a desired position a flexible membrane sensor sheet **658** or at least a portion of membrane sheet **658** carrying at least one sensor **660** and for retaining in operational positions structure appropriate for actuating mechanisms. Sensor **660** may be of either the common simple switched type or my novel pressure sensitive proportional membrane type. This embodiment is also for aligning and retaining sensor actuating structures, of which I believe, especially valuable are actuating structures of the resilient tactile type. A package member **650** is a housing like structure shown here with four side walls. Aligned along two of the opposing walls are downwardly distending snap-fit legs **652** having a hook-like snap-fit shape at the bottom most extremity. Package **652** might be made of an injection molded plastic such as a resin from the acetal family having excellent dimensional stability, rigidity and also resiliency for the bending of snap fit legs **652** during mounting of package **650** to a rigid support structure **630**. The internal portion of package **650** is a cavity within which is retained at least an actuator shown here as a plunger **602** which is retained at least in part within housing package **650** by an upper or top portion of package

650 partially enclosing the package cavity but having an aperture through which extends a portion of plunger **602** for being depressed or activated by external forces. Resilient metallic dome cap **604** is also shown within the cavity and located between plunger **602** and membrane sensor **660** which is supported on rigid support structure **630**. Rigid support structure **630** has two elongated apertures **656** sized to allow the passage during mounting and retention thereafter of snap-fit legs **652**. Membrane **658**, which may be any sensor bearing membrane, also has elongated apertures **654** positioned around a membrane sensor shown here as sensor **660**. Apertures **654** being of size allowing the passage of snap fit legs **652**.

The entire embodiment is assembled by positioning membrane sensor sheet **658** or at least the portion of membrane sensor sheet **658** bearing a sensor and apertures **654** along side of support structure **630** and aligning membrane apertures **654** with support structure apertures **656**, then, with housing package **650** containing both plunger **602** and dome cap **604**, pressing legs **652** through the aligned apertures thus fixing the membrane sensor and actuating plunger **602** in accurate and secure position for activation.

This novel membrane sensor anchoring and activating structure may be useful for fixing into position a flexible membrane and associated sensor(s) in a wide variety of applications, not just for fixing a membrane having multiple relatively long arms to fit a widely-spread set of sensors within a 3D device such as for my co-pending application (Ser. No. 07/847,619, filed Mar. 5, 1992) and for finger activated buttons which may be located elsewhere within the device, such as on either the handle housing or the base housing, etc. This structuring also offers tremendous advantage in many non 3D applications where hand wiring is now common. For example, typical assembly of two axis joysticks involves hand wiring of numerous different finger and thumb operated switches at various different positions located within a handle and often includes additional switches located with the base of the joystick also. The hand wiring to these widely spread switch locations is error prone and expensive in labor, thus this process could be greatly advantaged by employment of flexible membrane based sensors, which is made possible by this novel structuring.

FIG. **50** shows a right angle mount embodiment in common with the device of FIGS. **48** and **49**. The right angle mount embodiment has a housing **650.1** formed much like housing **650** with the exception that the aperture in the upper surface is not necessarily round to accommodate passage of plunger **602** but rather the aperture may be slot-shaped to accommodate passage of a right angle actuator **670** which upon external activation pivots about a fulcrum **676**. Right angle actuator **670** is structurally similar to the right angle translator parts shown in FIG. **17** as part **262**, in FIG. **27** as part **348** and in FIG. **28** as part **376**. Specifically actuator **670** has an externally exposed actuating nub **674** which is impinged upon by an actuating part in a manner essentially parallel to mounting **630** thus pivoting about fulcrum **676** and causing an internal actuating nub **672** to impinge downward upon dome cap **604**. Fulcrum **676** is held in place within housing **650.1** by a retainer **678** which may be essentially ring like and with protrusions **680** which provide a saddle for pivotal retainment of fulcrum **676**.

The anchoring and retaining embodiments shown in FIGS. **48–50** provide an optimal low-cost of manufacture embodiment where ever membrane sheet based sensors are shown in the current teaching and can also operate to equal advantage providing structuring and translating for sensors based on circuit board sheets.

Although I have very specifically described best modes and preferred structures and use of the invention, it should be understood that many changes in the specific structures and modes described and shown in my drawings may clearly be made without departing from the true scope of the invention.

I claim:

1. A 3-D graphics controller used with a television based game, comprising:

a game, said game at least in part controlled by

circuitry, said circuitry located on

at least one sheet, said at least one sheet comprising:

a circuit board sheet connected to

a flexible membrane sheet;

a first element structured to activate

four unidirectional sensors, said four unidirectional sensors at least in part connected to said at least one sheet, said four unidirectional sensors useful to control said game;

a second element with structure to activate

a first two rotary potentiometers, said first two rotary potentiometers at least in part connected to said at least one sheet, said first two rotary potentiometers useful to control said game;

a third element with structure to activate

a second two rotary potentiometers, said second two rotary potentiometers at least in part connected to said at least one sheet, said second two rotary potentiometers useful to control said game;

an independent first button structured to activate

a first button sensor, said first button depressible by a single finger of a user, said first button sensor at least in part connected to said at least one sheet, said first button sensor creates simple switched On/Off data useful to control said game;

an independent pivotal second button structured to activate

a second button sensor, said second button pivots upon depression by a single finger of the user, said second button sensor at least in part connected to said at least one sheet, said second button sensor capable of outputing a proportional signal useful to control said game;

an independent pivotal third button structured to activate

a third button sensor, said third button pivotal upon depression by a single finger of the user, said third button sensor at least in part connected to said at least one sheet, said third button sensor capable of outputing a proportional signal useful to control said game;

active tactile feedback vibration detectable by the user of said game.

2. A 3-D graphics controller used with a television based game according to claim **1** wherein said active tactile feedback vibration is provided by a motor and offset weight.

3. A 3-D graphics controller for controlling a television based game, comprising:

circuitry located at least in part on

at least one sheet, said at least one sheet comprising:

a circuit board sheet; said circuit board sheet connected with

a flexible membrane sheet;

a first element structured to activate

four unidirectional sensors, said four unidirectional sensors at least in part connected to said at least one sheet, said four unidirectional sensors useful to control the game;

a second element with structure to activate

a first two rotary potentiometers, said first two rotary potentiometers at least in part connected to said at least one sheet, said first two rotary potentiometers useful to control the game;

a third element with structure to activate

a second two rotary potentiometers, said second two rotary potentiometers at least in part connected to said at least one sheet, said second two rotary potentiometers useful to control the game;

an independent first button structured to activate

a first button sensor, said first button depressible by a single finger of a user, said first button sensor at least in part connected to said at least one sheet, said first button sensor creates simple switched On/Off data useful to control the game;

an independent pivotal second button structured to activate

a second button sensor, said second button pivots upon depression by a single finger of the user, said second button sensor at least in part connected to said at least one sheet, said second button sensor capable of outputing a proportional signal useful to control the game;

an independent pivotal third button structured to activate

a third button sensor, said third button pivotal upon depression by a single finger of the user, said third button sensor at least in part connected to said at least one sheet, said third button sensor capable of outputing a proportional signal useful to control the game;

tactile feedback means for providing vibration detectable by the user of the game, said tactile feedback means connected to said circuitry.

4. A 3-D graphics controller according to claim **3** wherein said tactile feedback means comprises a motor and offset weight.

5. A 3-D graphics controller for controlling a television based game, comprising:

circuitry located at least in part on

at least one sheet, said at least one sheet comprising:

a circuit board sheet; said circuit board sheet connected with

a flexible membrane sheet;

a first element structured to activate

four unidirectional sensors, said four unidirectional sensors at least in part connected to said at least one sheet, said four unidirectional sensors useful to control the game;

a second element with structure to activate

a first two rotary potentiometers, said first two rotary potentiometers at least in part connected to said at least one sheet, said first two rotary potentiometers useful to control the game;

a third element with structure to activate

a second two rotary potentiometers, said second two rotary potentiometers at least in part connected to said at least one sheet, said second two rotary potentiometers useful to control the game;

an independent first button structured to activate

a first button sensor, said first button depressible by a single finger of a user, said first button sensor at least in part connected to said at least one sheet, said first button sensor creates simple switched On/Off data useful to control the game;

an independent pivotal second button structured to activate

a second button sensor, said second button pivots upon depression by a single finger of the user, said second button sensor at least in part connected to said at least one sheet, said second button sensor capable of outputing a proportional signal useful to control the game;

an independent pivotal third button structured to activate

a third button sensor, said third button pivotal upon depression by a single finger of the user, said third button sensor at least in part connected to said at least one sheet, said third button sensor capable of outputing a proportional signal useful to control the game.

6. A 3-D graphics controller for controlling a television based game, comprising:

circuitry located at least in part on

at least one sheet, said at least one sheet comprising:

a circuit board sheet connected to

a flexible membrane sheet;

a first element structured to activate

four unidirectional sensors, said four unidirectional sensors at least in part connected to said at least one sheet, said four unidirectional sensors useful to control the game;

a second element with structure to activate

a first two rotary potentiometers, said first two rotary potentiometers at least in part connected to said at least one sheet, said first two rotary potentiometers useful to control the game;

a third element with structure to activate

a second two rotary potentiometers, said second two rotary potentiometers at least in part connected to said at least one sheet, said second two rotary potentiometers useful to control the game;

an independent first button structured to activate

a pressure-sensitive first button sensor useful to control the game, said first button depressible by a single finger of a user, said first button sensor at least in part connected to said at least one sheet, said first button sensor capable of outputing a proportional signal representing amount of pressure applied to said first button;

an independent second button structured to activate

a pressure-sensitive second button sensor useful to control the game, said second button depressible by a single finger of the user, said second button sensor at least in part connected to said at least one sheet, said second button sensor capable of outputing a proportional signal representing amount of pressure applied to said second button;

tactile feedback vibration in the controller detectable by the user of the game.

7. A 3-D graphics controller according to claim **6** wherein said tactile feedback vibration is supplied by a motor and offset weight.

8. A 3-D graphics controller according to claim **6** wherein said controller further includes an independent third button structured to activate

a third button sensor, said third button depressible by a single finger of the user, said third button sensor at least in part connected to said at least one sheet, said third button sensor creates simple switched On/Off data useful to control the game.

9. A 3-D graphics controller for controlling a television based game, comprising:

circuitry located at least in part on

at least one sheet, said at least one sheet comprising:

a circuit board sheet connected to

a flexible membrane sheet;

a first element structured to activate

four unidirectional sensors, said four unidirectional sensors at least in part connected to said at least one sheet, said four unidirectional sensors useful to control the game;

a first rotary potentiometer at least in part connected to said at least one sheet, said first rotary potentiometer useful to control the game;

a second rotary potentiometer at least in part connected to said at least one sheet, said second rotary potentiometer useful to control the game;

a third rotary potentiometer at least in part connected to said at least one sheet, said third rotary potentiometer useful to control the game;

a fourth rotary potentiometer at least in part connected to said at least one sheet, said fourth rotary potentiometer useful to control the game;

an independent first button structured to activate

a pressure-sensitive first button sensor useful to control the game, said first button depressible by a single finger of a user, said first button sensor at least in part connected to said at least one sheet, said first button sensor capable of outputing a proportional signal representing amount of pressure applied to said first button;

an independent second button structured to activate

a pressure-sensitive second button sensor useful to control the game, said second button depressible by a single finger of the user, said second button sensor at least in part connected to said at least one sheet, said second button sensor capable of outputing a proportional signal representing amount of pressure applied to said second button;

tactile feedback vibration in the controller detectable by the user of the game.

10. A 3-D graphics controller according to claim 9 wherein said controller further includes an independent third button structured to activate

a third button sensor, said third button depressible by a single finger of the user, said third button sensor at least in part connected to said at least one sheet, said third button sensor creates simple switched On/Off data useful to control the game.

11. A 3-D graphics controller according to claim 9 wherein said tactile feedback vibration is provided by a motor and offset weight.

12. A 3-D graphics controller used with a television based game, comprising:

a first element structured to activate

four unidirectional sensors, said four unidirectional sensors useful to control said game; said four unidirectional sensors at least in part connected to circuitry;

a second element with structure to activate

a first two rotary potentiometers, said first two rotary potentiometers at least in part connected to said circuitry, said first two rotary potentiometers useful to control said game;

a third element with structure to activate

a second two rotary potentiometers, said second two rotary potentiometers at least in part connected to said circuitry, said second two rotary potentiometers useful to control said game;

an independent first button structured to activate

a first button sensor, said first button depressible by a single finger of a user, said first button sensor at least in part connected to said circuitry, said first button sensor creates simple switched On/Off data useful to control said game;

an independent pivotal second button structured to activate

a second button sensor, said second button pivots upon depression by a single finger of the user, said second button sensor at least in part connected to said circuitry, said second button sensor capable of outputing a proportional signal useful to control said game;

an independent pivotal third button structured to activate

a third button sensor, said third button pivotal upon depression by a single finger of the user, said third button sensor at least in part connected to said circuitry, said third button sensor capable of outputing a proportional signal useful to control said game;

active tactile feedback vibration detectable by the user of said game, said active tactile feedback vibration provided by

an offset weight connected to

a motor, said motor at least in part connected to said circuitry.

13. A 3-D graphics controller used with a television based game, comprising:

a first element structured to activate

four unidirectional sensors, said four unidirectional sensors used to control said game;

a second element with structure to activate

a first two rotary potentiometers, said first two rotary potentiometers used to control said game;

a third element with structure to activate

a second two rotary potentiometers, said second two rotary potentiometers used to control said game;

an independent first button structured to activate

a first button sensor, said first button depressible by a single finger of a user, said first button sensor creates simple switched On/Off data used to control said game;

an independent pivotal second button structured to activate

a second button sensor, said second button pivots upon depression by a single finger of the user, said second button sensor capable of outputing a proportional signal used to control said game;

an independent pivotal third button structured to activate

a third button sensor, said third button pivotal upon depression by a single finger of the user, said third button sensor capable of outputing a proportional signal used to control said game;

an offset weight is connected to

a motor to provide active tactile feedback used to provide vibration to the user of said game.

14. A 3-D graphics controller used with a television based game, comprising:

a first element movable on two axes, said first element structured to activate four unidirectional sensors, said four unidirectional sensors used to input a first axis and a second axis of control for the game;

a first bi-directional proportional sensor, said first bi-directional proportional sensor used to input a third axis of control for the game;

a second bi-directional proportional sensor, said second bi-directional proportional sensor used to input a fourth axis of control for the game;

a third bi-directional proportional sensor, said third bi-directional proportional sensor used to input a fifth axis of control for the game;

a fourth bi-directional proportional sensor, said fourth bi-directional proportional sensor used to input a sixth axis of control for the game;

an independent first button structured to activate

a first button sensor, said first button depressible by a single finger of the user, said first button sensor capable of outputing a proportional signal used to control the game;

an independent second button structured to activate

a second button sensor, said second button depressible by a single finger of the user, said second button sensor capable of outputing a proportional signal used to control the game;

a sheet connecting to at least eight of the sensors.

15. A 3-D graphics controller used with a television based game, comprising:

a housing;

a first element structured to activate four unidirectional sensors used to control a television based game, said first element supported at least in part by said housing and sufficiently exposed to allow two axes of input;

a second element structured to activate a first two bi-directional proportional sensors used to control the game, said second element supported at least in part by said housing;

a third element structured to activate a second two bi-directional proportional sensors used to control the game, said third element supported at least in part by said housing;

an independent first button sensor, said first button sensor depressible by a single finger of a user, said first button sensor creates simple switched On/Off data used to control the game, said independent first button sensor at least in part connected to

a sheet;

an independent pivotal second button structured to activate

a second button sensor, said second button pivots upon depression by a single finger of the user, said second button sensor at least in part connected to said sheet, said second button sensor capable of outputing a proportional signal used to control the game;

an independent pivotal third button structured to activate

a third button sensor, said third button pivotal upon depression by a single finger of the user, said third button sensor at least in part connected to said sheet, said third button sensor capable of outputing a proportional signal used to control the game;

active tactile feedback vibration detectable by the user of the game, said active tactile feedback vibration provided by

an offset weight connected to

a motor, said motor supported within said housing.

16. A 3-D graphics controller for controlling a television based game, comprising:

a first element structured to activate four unidirectional sensors, said four unidirectional sensors useful to control the television based game; said four unidirectional sensors at least in part connected to

a first sheet;

a second element structured to activate a first two bi-directional proportional sensors, said first two bi-directional proportional sensors at least in part connected to said first sheet, said first two bi-directional sensors useful to control the television based game;

a third element structured to activate a second two bi-directional proportional sensors, said second two bi-directional proportional sensors useful to control the television based game; said second two bi-directional proportional sensors at least in part connected to

a second sheet, said first sheet located on a first plane, and said second sheet located on a second plane;

an independent first button sensor, said first button sensor depressible by a single finger of the user, said first button sensor at least in part connected to said first sheet, said first button sensor capable of transforming depression into a proportional signal useful to control the television based game;

an independent second button sensor, said second button sensor depressible by a single finger of the user, said second button sensor at least in part connected to said first sheet, said second button sensor capable of transforming depression into a proportional signal useful to control the television based game;

tactile feedback means for providing vibration detectable by the user of said electronic game, said tactile feedback means supported within said controller.

17. A 3-D graphics controller for controlling a game, comprising:

a first element structured to activate four unidirectional sensors, said four unidirectional sensors useful to control a game; said four unidirectional sensors at least in part connected to

a first sheet;

a second element structured to activate a first two bi-directional proportional sensors, said first two bi-directional proportional sensors at least in part connected to said first sheet, said first two bi-directional sensors useful to control the game;

a third element structured to activate a second two bi-directional proportional sensors, said second two bi-directional sensors useful to control the game; said second two bi-directional proportional sensors at least in part connected to a second sheet, said first sheet located on a first plane, and said second sheet located on a second plane within said controller;

an independent first button, said first button depressible by a single finger of the user, said first button positioned to activate a first proportional sensor and said first button positioned to activate a simple switched On/Off sensor useful to control the game; said first proportional sensor connected to said first sheet, said first proportional sensor capable of transforming depression of said first button into a proportional signal useful to control said electronic game;

an independent second button, said second button depressible by a single finger of the user, said second button positioned to activate a second proportional sensor and said second button positioned to activate a simple switched On/Off sensor useful to control said electronic game; said second proportional sensor connected to said first sheet, said second proportional sensor capable of transforming depression of said second button into a proportional signal useful to control said electronic game;

tactile feedback means for providing vibration detectable by the user of said electronic game, said tactile feedback means supported within said controller.

18. A 3-D graphics controller according to claim **17** wherein the first and the second proportional sensors are each unidirectional sensors.

19. A hand operated controller comprising structure allowing hand inputs rotating a platform on two mutually perpendicular axes to be translated into electrical outputs by four unidirectional sensors to allow controlling objects and navigating a viewpoint, the controller including a tactile feedback means for providing vibration detectable by the user through the hand operating the controller;

a second element movable on two mutually perpendicular axes, said second element structured to activate two bi-directional proportional sensors providing outputs at least in part controlling objects and navigating a viewpoint;

a third element movable on two mutually perpendicular axes, said third element structured to activate two bi-directional proportional sensors providing outputs at least in part controlling objects and navigating a viewpoint;

a plurality of independent finger depressible buttons, each button associated with

a button sensor, said button sensor outputs at least On/Off data to allow controlling of the objects.

20. A hand operated controller according to claim **19** wherein the sensors are connected by at least one sheet.

21. A hand operated controller according to claim **20** wherein said at least one sheet comprises a flexible membrane sheet connected to a substantially rigid circuit board sheet.

22. A hand operated controller according to claim **19** wherein said button sensor outputs data proportionate to depression of one of said buttons.

23. A hand operated controller according to claim **22** wherein the bi-directional proportional sensors are rotary potentiometers.

24. A hand operated controller according to claim **22** wherein the bi-directional proportional sensors are optical encoders.

25. A hand operated controller according to claim **24** wherein said tactile feedback means comprises a motor and offset weight.

26. A hand operated controller comprising structure allowing hand inputs rotating a platform on two mutually perpendicular axes to be translated into electrical outputs, the controller structured with four unidirectional sensors to allow controlling objects and navigating a viewpoint, the controller including an electromechanical tactile feedback structure providing vibration detectable by the user through the hand operating the controller;

a second element movable on two mutually perpendicular axes, said second element structured to activate two bi-directional proportional sensors;

a third element movable on two mutually perpendicular axes, said third element structured to activate two bi-directional proportional sensors;

a plurality of independent finger depressible buttons, each button associated with

a button sensor, said button sensor outputs at least On/Off data;

the sensors are connected by at least one sheet, said at least one sheet comprises

a flexible membrane sheet connected to

a circuit board sheet.

27. A hand operated controller according to claim **26** wherein said button sensor outputs data proportionate to depression of one of said buttons.

28. A hand operated controller according to claim **27** wherein at least two of said buttons pivot upon depression to activate their respective proportional sensors.

29. A hand operated controller according to claim **28** wherein the bi-directional proportional sensors are rotary potentiometers.

30. A hand operated controller according to claim **28** wherein the bi-directional proportional sensors are optical encoders.

31. A hand operated controller according to claim **27** wherein said tactile feedback means comprises a motor and offset weight.

32. A 3-D graphics controller having an economical combination of elements and buttons allowing a user to control a television based game, the controller comprising:

a housing;

a first element structured to activate four unidirectional sensors used to control a television based game, said first element supported at least in part by said housing and sufficiently exposed to allow two axes of input;

a second element structured to activate a first two rotary potentiometers used to control the game;

a third element structured to activate a second two rotary potentiometers used to control the game;

a circuit board supporting circuitry, said circuit board located in said housing, the rotary potentiometers mounted to said circuit board;

an independent first button structured to activate

a first button sensor, said first button depressible by a single finger of the user, said first button sensor at least in part supported by said housing, said first button sensor capable of outputting a proportional signal used to control the game;

an independent second button structured to activate

a second button sensor, said second button depressible by a single finger of the user, said second button sensor at least in part supported by said housing, said second button sensor capable of outputting a proportional signal used to control the game;

active tactile feedback structure located in said housing.

33. A 3-D graphics controller according to claim **32** wherein said active tactile feedback structure includes

an offset weight connected to

a motor.

* * * * *