



US006849837B2

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

(10) **Patent No.:** US 6,849,837 B2  
(45) **Date of Patent:** \*Feb. 1, 2005

(54) **METHOD OF ADHESIVE BONDING BY INDUCTION HEATING**  
  
(75) Inventors: **Edward A. Riess**, Cincinnati, OH (US); **Adam G. Malofsky**, Symmes Township, OH (US); **John P. Barber**, Kettering, OH (US); **David P. Bauer**, Xenia, OH (US)

(73) Assignee: **Nexicor LLC**, Loveland, OH (US)  
  
(\* ) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

This patent is subject to a terminal disclaimer.

(21) Appl. No.: **10/661,655**

(22) Filed: **Sep. 12, 2003**

(65) **Prior Publication Data**

US 2004/0050839 A1 Mar. 18, 2004

**Related U.S. Application Data**

(60) Continuation of application No. 10/302,158, filed on Nov. 22, 2002, now Pat. No. 6,639,197, and a continuation of application No. 10/302,692, filed on Nov. 22, 2002, now Pat. No. 6,710,314, which is a division of application No. 09/705,282, filed on Nov. 2, 2000, now Pat. No. 6,509,555.

(60) Provisional application No. 60/163,301, filed on Nov. 3, 1999.

(51) **Int. Cl.**<sup>7</sup> ..... **H05B 6/10**

(52) **U.S. Cl.** ..... **219/634**; 219/633; 219/645

(58) **Field of Search** ..... 219/600-603, 219/618, 633-635, 645; 156/272.2, 272.4, 275.1, 275.3; 428/516-519, 521, 523

(56) **References Cited**

**U.S. PATENT DOCUMENTS**

1,566,500 A 12/1925 Northrup  
2,378,801 A 6/1945 Sidell et al.  
2,429,819 A 10/1947 Jordan

(List continued on next page.)

**FOREIGN PATENT DOCUMENTS**

AT 321432 3/1975  
CA 1110961 10/1981

(List continued on next page.)

**OTHER PUBLICATIONS**

"Rapid Adhesive Bonding of Composites," NASA Tech Brief, 2 pages (Jan./Feb. 1986).

(List continued on next page.)

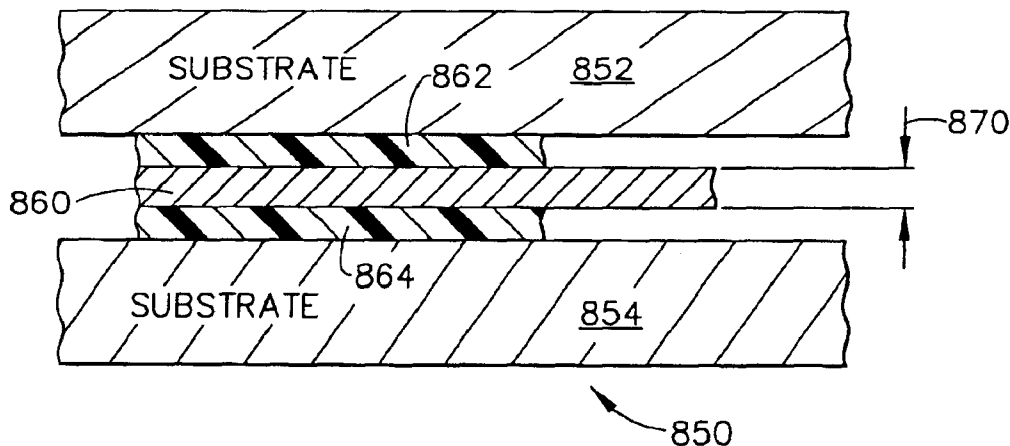
*Primary Examiner*—Tu Hoang

(74) *Attorney, Agent, or Firm*—Frederick H. Gribbell, LLC

(57) **ABSTRACT**

A method for using magnetic fields to heat magnetically susceptible materials within and/or adjacent to adhesives, so as to bond, bind, or fasten solid materials to one another. The system uses alternating magnetic fields that induce eddy currents and generate heat within susceptors. An induction heating tool is used to emit the magnetic field at its work coil, and an electronic controller measures the energy being used by a power converter that generates the alternating current driving the work coil which creates the magnetic field. The heating tool is used in a method of adhesive bonding in which the thickness of the conductive layer of the susceptor is in the range of 0.01-3.0 mils, or the heating event time interval is in the range of 0.05-10.0 seconds, or the average power density of the magnetic field at the susceptor is in the range of 10-5000 Watts per square inch.

**20 Claims, 26 Drawing Sheets**



U.S. PATENT DOCUMENTS					
			4,845,332 A	7/1989	Jancosek et al.
2,549,930 A	4/1951	Riegel et al.	4,847,746 A	7/1989	Rilly et al.
3,238,346 A	3/1966	Savko	4,853,832 A	8/1989	Stuart
3,272,954 A	9/1966	Seulen et al.	4,897,518 A	1/1990	Mucha et al.
3,466,528 A	9/1969	Adams	4,941,936 A	7/1990	Wilkinson et al.
3,562,054 A	2/1971	Wolf	4,950,348 A	8/1990	Larsen
3,574,031 A	4/1971	Heller, Jr. et al.	4,969,968 A	11/1990	Leatherman
3,609,104 A	9/1971	Ehrreich et al.	RE33,467 E	12/1990	Steck et al.
3,612,803 A	10/1971	Klass	4,978,825 A	12/1990	Schmidt et al.
3,657,038 A	4/1972	Lightfoot	4,983,804 A	1/1991	Chan et al.
3,671,371 A	6/1972	Wolf	5,025,123 A	6/1991	Pfaffmann et al.
3,710,062 A	1/1973	Peters, Jr.	5,030,816 A	7/1991	Strecker
3,733,231 A	5/1973	Rutkowski et al.	5,031,088 A	7/1991	Tanaka
3,737,611 A	6/1973	Killian	5,057,370 A	10/1991	Krieg et al.
3,743,808 A	7/1973	Kasper	5,075,034 A	12/1991	Wanthal
3,746,825 A	7/1973	Pfaffmann	5,093,545 A	3/1992	McGaffigan
3,816,690 A	6/1974	Mittelmann	5,113,049 A	5/1992	Border et al.
3,823,362 A	7/1974	Bailey	5,123,989 A	6/1992	Horiishi et al.
3,833,439 A	9/1974	Smith	5,124,203 A	6/1992	Leatherman
3,845,268 A	10/1974	Sindt	5,128,504 A	7/1992	McGaffigan et al.
3,846,204 A	11/1974	Eisler	5,134,000 A	7/1992	Smythe et al.
3,902,940 A	9/1975	Heller, Jr. et al.	5,134,261 A	7/1992	Larkin et al.
3,953,700 A	4/1976	Sindt	5,170,025 A	12/1992	Perry
3,953,783 A	4/1976	Peters, Jr.	5,198,053 A	3/1993	Duncan
3,996,402 A	12/1976	Sindt	5,222,185 A	6/1993	McCord, Jr.
4,017,701 A	4/1977	Mittelmann	5,225,287 A	7/1993	Perry et al.
4,018,642 A	4/1977	Pike et al.	5,266,764 A	11/1993	Fox et al.
4,029,837 A	6/1977	Leatherman	5,272,216 A	12/1993	Clark, Jr. et al.
4,038,120 A	7/1977	Russell	5,286,941 A	2/1994	Bel
4,112,286 A	9/1978	Alderman et al.	5,286,952 A	2/1994	McMills et al.
4,120,712 A	10/1978	Sindt	5,298,194 A	3/1994	Carter et al.
4,123,305 A	10/1978	Krzyszowski	5,313,034 A	5/1994	Grimm et al.
4,177,494 A	12/1979	Tellert	5,313,037 A	5/1994	Hansen et al.
4,234,824 A	11/1980	den Hollander	5,317,045 A	5/1994	Clark, Jr. et al.
4,268,737 A	5/1981	Paschakarnis et al.	5,328,539 A	7/1994	Sato
4,277,667 A	7/1981	Kiuchi	5,340,428 A	8/1994	Kodokian
4,280,038 A	7/1981	Havas et al.	5,343,023 A	8/1994	Geissler
4,293,363 A	10/1981	Wakabayashi et al.	5,350,902 A	9/1994	Fox et al.
4,327,268 A	4/1982	Frank	5,352,871 A	10/1994	Ross et al.
4,355,222 A	10/1982	Geithman et al.	5,374,808 A	12/1994	Coultrip et al.
4,382,275 A	5/1983	Glennon	5,374,809 A	12/1994	Fox et al.
4,388,510 A	6/1983	Hughes	5,376,403 A	12/1994	Capote et al.
4,410,457 A	10/1983	Fujimura et al.	5,378,879 A	1/1995	Monovoukas
4,420,876 A	12/1983	McDermott	5,391,595 A	2/1995	Clark, Jr. et al.
4,467,165 A	8/1984	Kiuchi et al.	5,438,181 A	8/1995	Volkman et al.
4,481,709 A	11/1984	McDermott	5,483,043 A	1/1996	Sturman, Jr. et al.
4,483,896 A	11/1984	Gray et al.	5,490,759 A	2/1996	Hoffman
4,506,131 A	3/1985	Boehm et al.	5,500,511 A	3/1996	Hansen et al.
4,511,956 A	4/1985	Dewan et al.	5,504,309 A	4/1996	Geissler
4,516,104 A	5/1985	McDermott	5,508,496 A	4/1996	Hansen et al.
4,521,659 A	6/1985	Buckley et al.	5,534,097 A	7/1996	Fasano et al.
4,528,057 A	7/1985	Challenger et al.	5,543,604 A	8/1996	Taylor
4,543,555 A	9/1985	McDermott	5,573,613 A	11/1996	Lunden
4,567,094 A	1/1986	Levin	5,630,958 A	5/1997	Stewart, Jr. et al.
4,578,553 A	3/1986	Yamashita et al.	5,639,847 A	6/1997	Chiang et al.
4,581,158 A	4/1986	Lin	5,705,796 A	1/1998	Hansen et al.
4,602,139 A	7/1986	Hutton et al.	5,710,413 A	1/1998	King et al.
4,637,199 A	1/1987	Steck et al.	5,714,739 A	2/1998	Irrera et al.
4,650,947 A	3/1987	Hutton et al.	5,717,191 A	2/1998	Christensen et al.
4,654,495 A	3/1987	Hutton et al.	5,723,849 A	3/1998	Matsen et al.
4,668,851 A	5/1987	Kupper	5,773,799 A	6/1998	Maxfield et al.
4,677,535 A	6/1987	Kawabata et al.	5,799,653 A	9/1998	Carlson
4,695,712 A	9/1987	Busch	5,830,389 A	11/1998	Capote et al.
4,707,402 A	11/1987	Thorsrud	5,837,088 A	11/1998	Palmgren et al.
4,749,833 A	6/1988	Novorsky et al.	5,874,713 A	2/1999	Cydzik et al.
4,762,864 A	8/1988	Goel et al.	5,877,552 A	3/1999	Chiang
4,763,093 A	8/1988	Cirkel et al.	5,916,469 A	6/1999	Scoles et al.
4,769,519 A	9/1988	Hall	5,919,387 A	7/1999	Buckley et al.
4,776,980 A	10/1988	Ruffini	5,925,455 A	7/1999	Bruzzo et al.

5,935,475	A	8/1999	Scoles et al.
6,043,471	A	3/2000	Wiseman et al.
6,056,844	A	5/2000	Guiles et al.
RE36,787	E	7/2000	Hansen et al.
6,083,558	A	7/2000	Bremont
6,100,696	A	8/2000	Sinclair
6,110,565	A	8/2000	Matthews
6,137,093	A	10/2000	Johnson, Jr.
6,229,127	B1	5/2001	Link
6,302,178	B1	10/2001	Givens
6,316,754	B1	11/2001	Schatz et al.
6,639,197	B2	* 10/2003	Riess et al. .... 219/633

NL	6811765	2/1970
WO	WO 93/10962	6/1993
WO	WO 93/18247	9/1993
WO	WO 97/34247	9/1997
WO	WO 98/18877	5/1998
WO	WO 99/60824	11/1999
WO	WO 00/27941	5/2000
WO	WO 01/29142	4/2001
WO	WO 01/33909 A3	5/2001
WO	WO 01/33909 A2	5/2001

OTHER PUBLICATIONS

FOREIGN PATENT DOCUMENTS

CA	1301396	5/1992
DE	1761776	4/1971
DE	3040820 A1	5/1982
DE	3710085 A1	10/1988
DE	3831787	4/1989
DE	4101215 A1	7/1992
DE	197 02 348	7/1998
EP	128837	12/1984
EP	0 237 657	9/1987
EP	0 289 632	11/1988
EP	0 461 979 A1	12/1991
EP	0 504 957	9/1992
EP	0 461 979 B1	4/1994
EP	1 136 878	9/2001
FR	842259	6/1939
FR	1558393	2/1969
FR	2 660 559	10/1991
FR	2 663 491	12/1991
GB	979283	1/1965
GB	2325982 A	12/1998
JP	57073064	5/1982
JP	57082151	5/1982
JP	59176014	10/1984
JP	62126582	6/1987
JP	62155451	7/1987
JP	63120786	5/1988
JP	63273682	11/1988
JP	63308080	12/1988
JP	1200937	8/1989
JP	1203825	8/1989
JP	2124108	5/1990
JP	2167726	6/1990
JP	04223137	8/1992
JP	4261691	9/1992
JP	4261692	9/1992
JP	5315064	11/1993
JP	6111924	4/1994
JP	7137140	5/1995
JP	7179828	7/1995
JP	09309980	12/1997
JP	10083884	3/1998
JP	11278134	10/1999
KR	92-6673	8/1992

Stein, Bland A., et al., "Rapid Adhesive Bonding of Advanced Composites and Titanium," AIAA Paper No. 85-0750-CP, AIAA, ASME, ASCE and AHS, 26th Structures, Structural Dynamics, and Materials Conference, Orlando, Florida, pp. 1-9 (Apr. 15-17, 1985).

Stein, Bland A., "Rapid Adhesive Bonding and Field Repair of Aerospace Materials," Welding, Bonding and Fastening, NASA Langley Research Center, pp. 419-438 (Oct. 1984).

Buckley, John D., et al., "Equipment and Techniques for Rapid Bonding of Composites," Advanced Composites, NASA Langley Research Center, pp. 155-162 (Dec. 1985).

Stein, Bland A., et al., "Rapid Adhesive Bonding Concepts for Specimen and Panel Fabrication and Field Repair," 16th National SAMPE Technical Conference, Albuquerque, New Mexico, pp. 103-118 (Oct. 1984).

Buckley, John D., et al., "Toroid Joining Gun," International Congress & Exposition, Detroit, Michigan, SAE Paper 850408, pp. 1-11 (Feb. 25-Mar. 1, 1985).

Stein, B. A., et al., "Rapid Adhesive Bonding Concepts," NASA Technical Memorandum 86256, pp. 1-72 (Jun. 1984).

"Owner's Manual," Miller Electric Manufacturing Company, pp. 1-29 (Apr. 1994).

Sales pamphlet, Fluxtrol Manufacturing, Inc., 2 pages.

"The Miller IHC Controller," Miller Electric Manufacturing Company, sales pamphlet, 3 pages.

"Induction Sealing Compak, Jr.," Enercon Industries Corporation, sales pamphlet, 2 pages (Feb. 20, 2001).

"Rhinobond," Olympic Fasteners, sales pamphlet, 2 pages.

"International Search Report," PCT/US01/13393, Nov. 21, 2001 (7 pages).

"International Preliminary Examination Report," PCT/US00/30517, Feb. 11, 2002 (18 pages).

"PCT International Search Report," European Patent Office, Application No. PCT/US00/30517, 11 pages (Jul. 27, 2001).

"Invitation to Pay Additional Fees with Annex," European Patent Office, Application No. PCT/US00/30517, 5 pages (Mar. 12, 2001).

\* cited by examiner

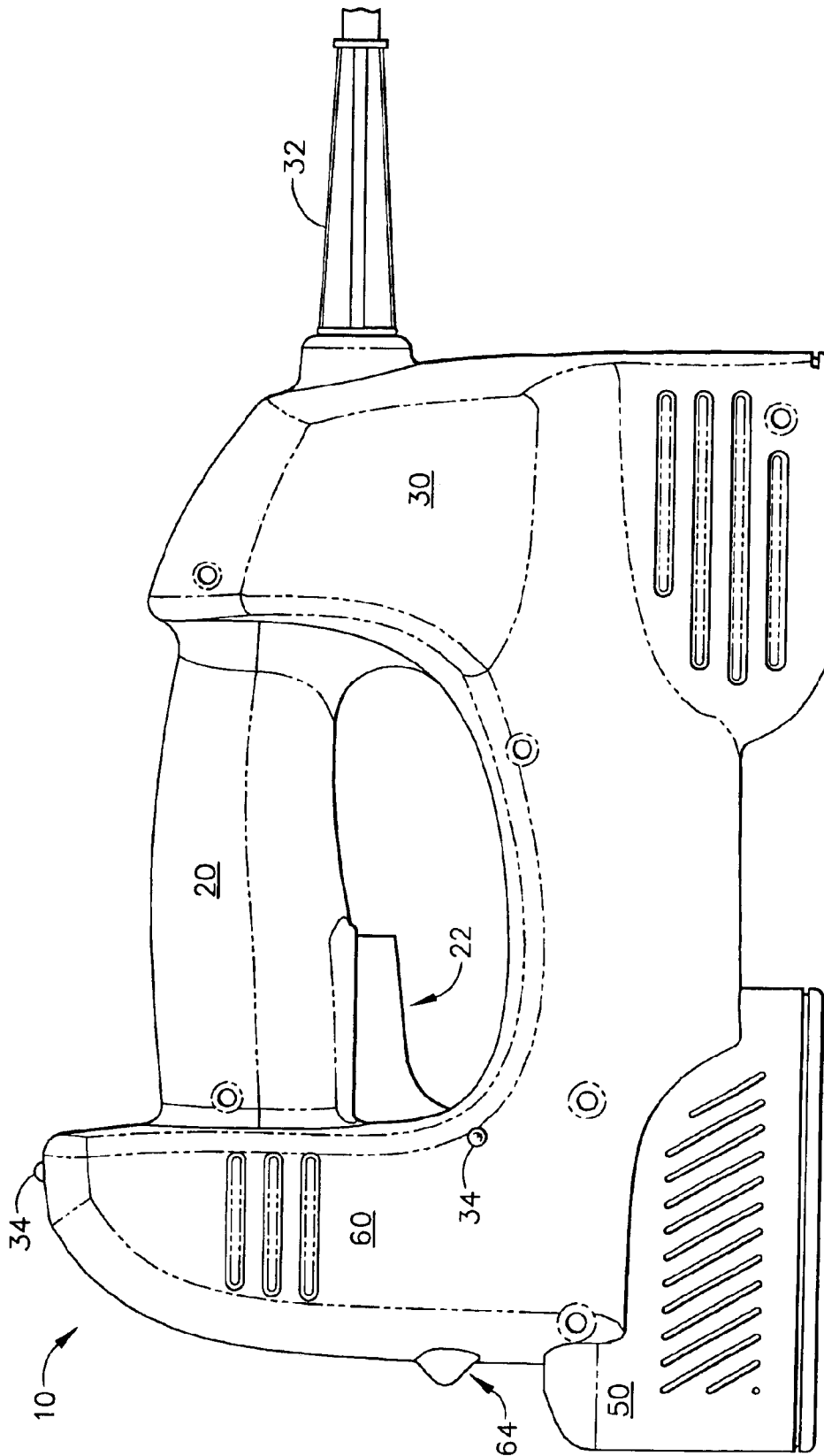


FIG. 1

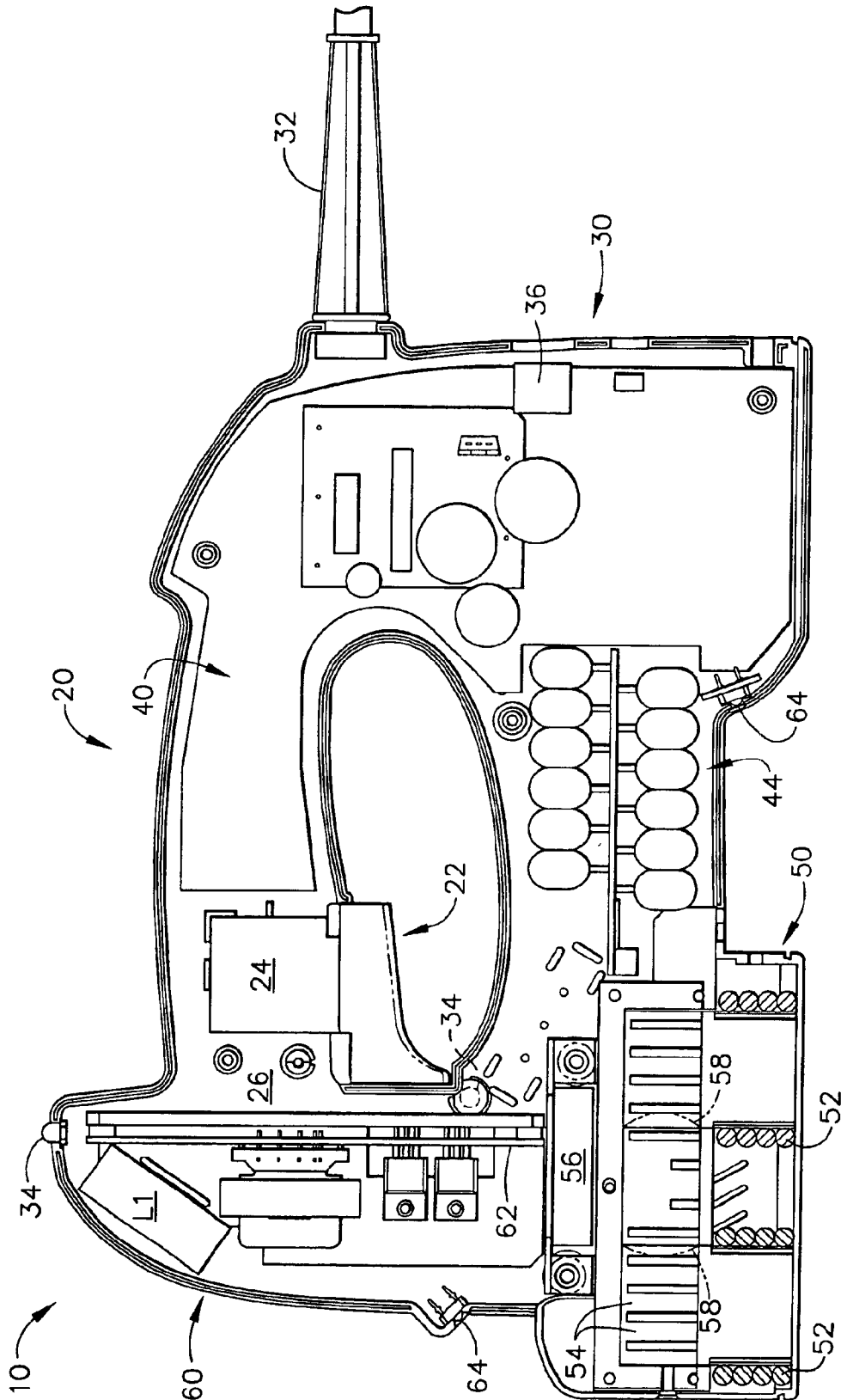


FIG. 2

# Explore Litigation Insights

Docket Alarm provides insights to develop a more informed litigation strategy and the peace of mind of knowing you're on top of things.

## Real-Time Litigation Alerts



Keep your litigation team up-to-date with **real-time alerts** and advanced team management tools built for the enterprise, all while greatly reducing PACER spend.

Our comprehensive service means we can handle Federal, State, and Administrative courts across the country.

## Advanced Docket Research



With over 230 million records, Docket Alarm's cloud-native docket research platform finds what other services can't. Coverage includes Federal, State, plus PTAB, TTAB, ITC and NLRB decisions, all in one place.

Identify arguments that have been successful in the past with full text, pinpoint searching. Link to case law cited within any court document via Fastcase.

## Analytics At Your Fingertips



Learn what happened the last time a particular judge, opposing counsel or company faced cases similar to yours.

Advanced out-of-the-box PTAB and TTAB analytics are always at your fingertips.

## API

Docket Alarm offers a powerful API (application programming interface) to developers that want to integrate case filings into their apps.

## LAW FIRMS

Build custom dashboards for your attorneys and clients with live data direct from the court.

Automate many repetitive legal tasks like conflict checks, document management, and marketing.

## FINANCIAL INSTITUTIONS

Litigation and bankruptcy checks for companies and debtors.

## E-DISCOVERY AND LEGAL VENDORS

Sync your system to PACER to automate legal marketing.