United States Patent [19]

Burt et al.

[54] **SYSTEM FOR AUTOMATICALLY ALIGNING IMAGES TO FORM A MOSAIC IMAGE**

[75] Inventors: **Peter J. Burt**, Princeton; **Michal Irani**, Princeton Junction; **Stephen Charles Hsu**, East Windsor; **Padmanabhan Anandan**, Lawrenceville, all of N.J.; **Michael W. Hansen**, New Hope, Pa.

[73] Assignee: **David Sarnoff Research Center, Inc.**, Princeton, N.J.

[21] Appl. No.: **339,491**

[22] Filed: **Nov. 14, 1994**

[51] Int. Cl.^{6} **G06K 9/36**

[52] U.S. Cl. **382/284**; 348/588; 382/294

[58] Field of Search 382/100, 284, 382/294; 358/450; 348/564, 588; 345/115; 395/111, 135, 153

[56] **References Cited**

U.S. PATENT DOCUMENTS

4,928,252	5/1990	Gabbe et al.	364/519
5,034,986	7/1991	Karmann et al.	382/1
5,040,067	8/1991	Yamazaki	358/183
5,187,754	2/1993	Currin et al.	382/54
5,258,837	11/1993	Gormley	358/140
5,325,449	6/1994	Burt et al.	382/56
5,339,104	8/1994	Hong	348/155
5,416,606	5/1995	Katayama et al.	358/467

OTHER PUBLICATIONS

Michal Irani, "Isolating Multiple 2D Image Motions for Image Enhancement and for 3D Motion Analysis", Hebrew University of Jerusalem, 1993.

Burt et al., "Enhanced Image Capture Through Fusion", International Conference on Computer Vision Proceedings, 1993.

Burt et al., "Merging Images Through Pattern Decomposition", Applications of Digital Processing VIII, SPIE, vol. 575, pp. 173–181, 1985.

Burt et al., "A Multiresolution Spline With Application to Image Mosaics", ACM Transactions on Graphics, vol. 2, No. 4, pp. 217–236, Oct. 1983.

Bove et al., "Real–Time Decoding and Display of Structured Video", IEEE ICMCS, May 1994.

Lundmark et al., "Image Sequence Coding at Very Low Bitrates: A Review", IEEE Transactions on Image Processing, vol. 3, No. 5, pp. 589–609, Sep. 1994.

McLean, "Structured Video Coding", Massachusetts Institute of Technology, 1991.

Bergen et al., "Hierarchical Model–Based Motion Estimation", Proceedings of European Conference on Computer Vision, Mar. 23, 1992.
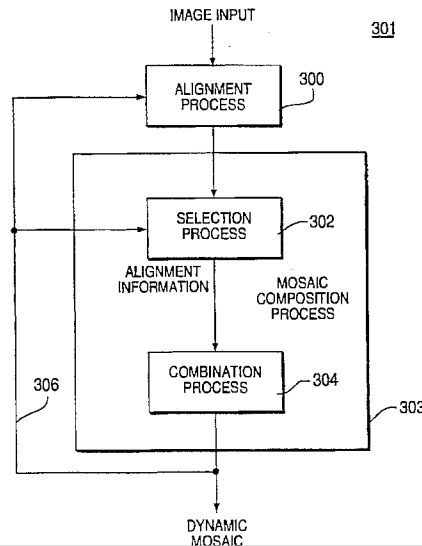
Primary Examiner—Andrew Johns
Attorney, Agent, or Firm—William J. Burke

[57] **ABSTRACT**

A system for automatically generating a mosaic from a plurality of input images. The system sequentially executes an image alignment process, an editing process, and a combining process such that, from a sequence of images, the system automatically produces a seamless mosaic for various applications. Illustrative applications for the mosaic include: (1) a mosaic based display system including an image printing system, (2) a surveillance system and (3) a mosaic based compression system. The mosaic based display system permits a system user to display, manipulate and alter a mosaic. The mosaic based compression system exploits the temporal and spatial redundancy in image sequences and efficiently compresses the image information. The compression system can be used for compressing image information for storage in a storage device or can be used for compressing image information for transmission through a band-limited transmission channel. The surveillance system combines the mosaic construction system, the compression system and the display system into a comprehensive system for remote motion detection.
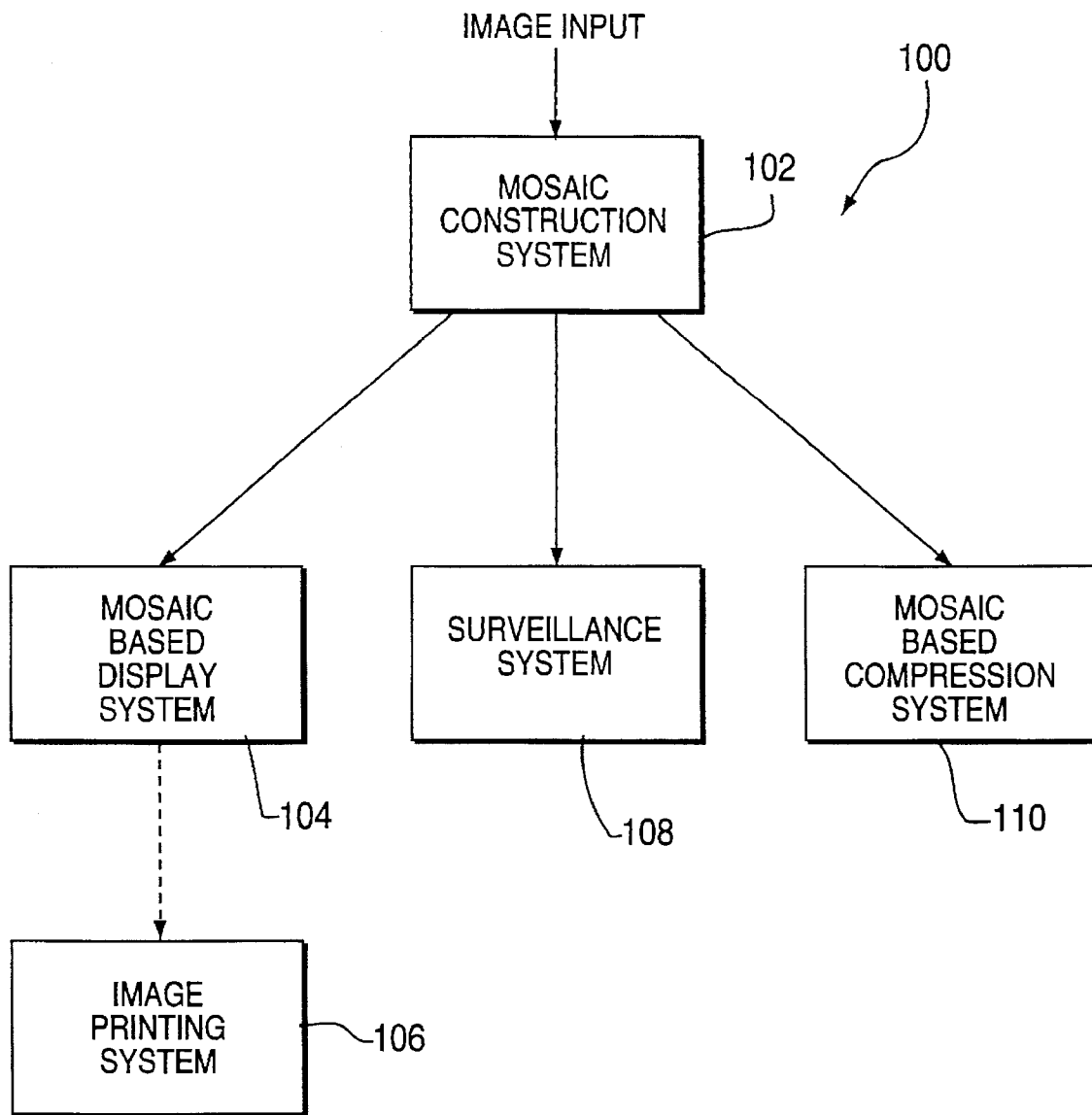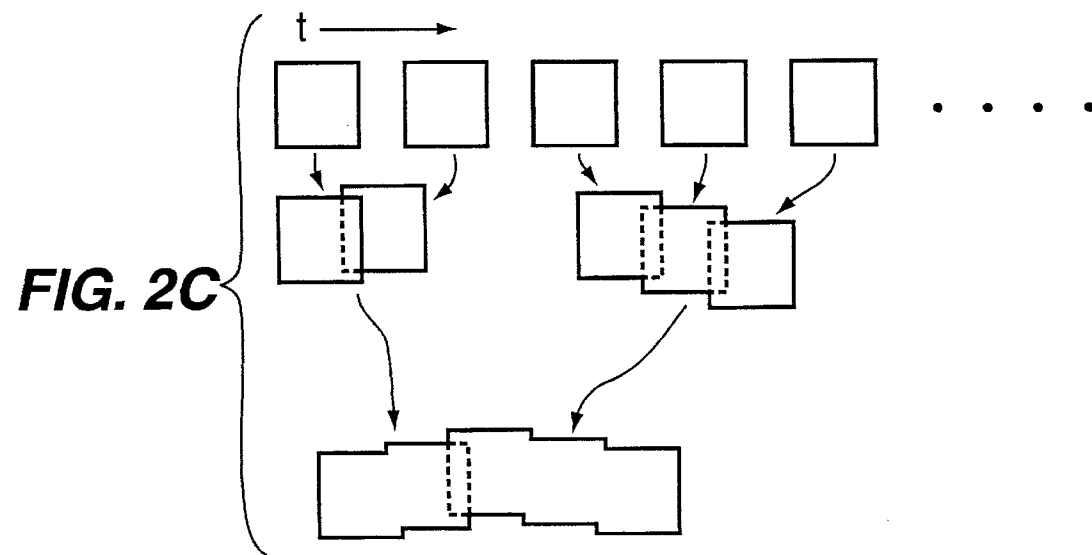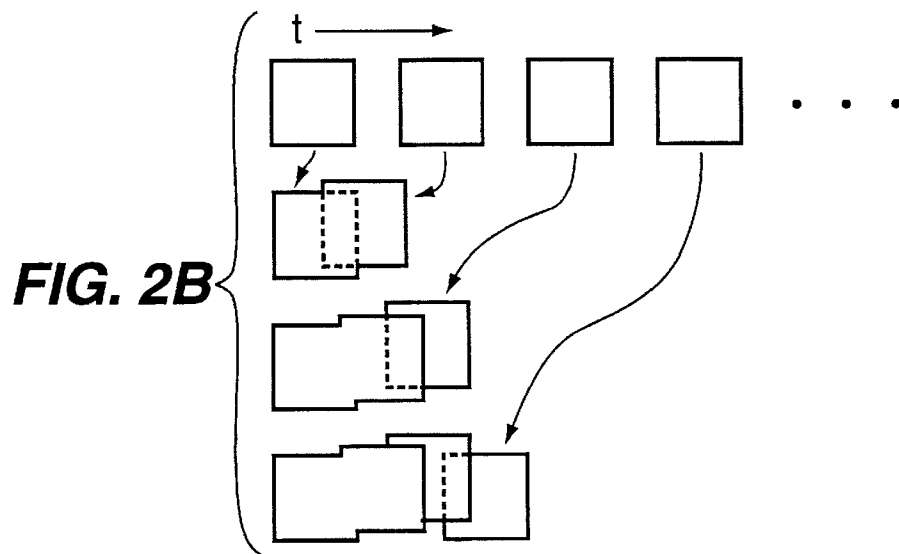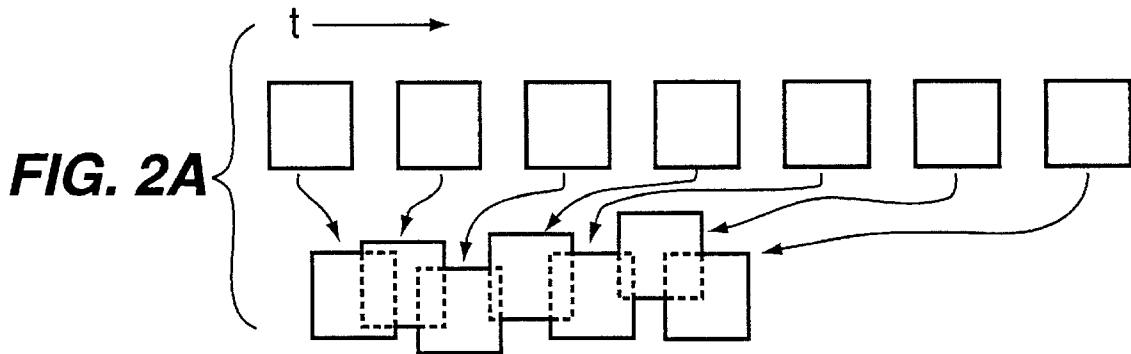
30 Claims, 14 Drawing Sheets

IMAGE INPUT

100

MOSAIC
CONSTRUCTION
SYSTEM

102

MOSAIC
BASED
DISPLAY
SYSTEM

104

SURVEILLANCE
SYSTEM

108

MOSAIC
BASED
COMPRESSION
SYSTEM

110

IMAGE
PRINTING
SYSTEM

106

FIG. 1

FIG. 2A

FIG. 2B

FIG. 2C

IMAGE INPUT

301

ALIGNMENT
PROCESS

300

SELECTION
PROCESS

302

ALIGNMENT
INFORMATION

MOSAIC
COMPOSITION
PROCESS

COMBINATION
PROCESS
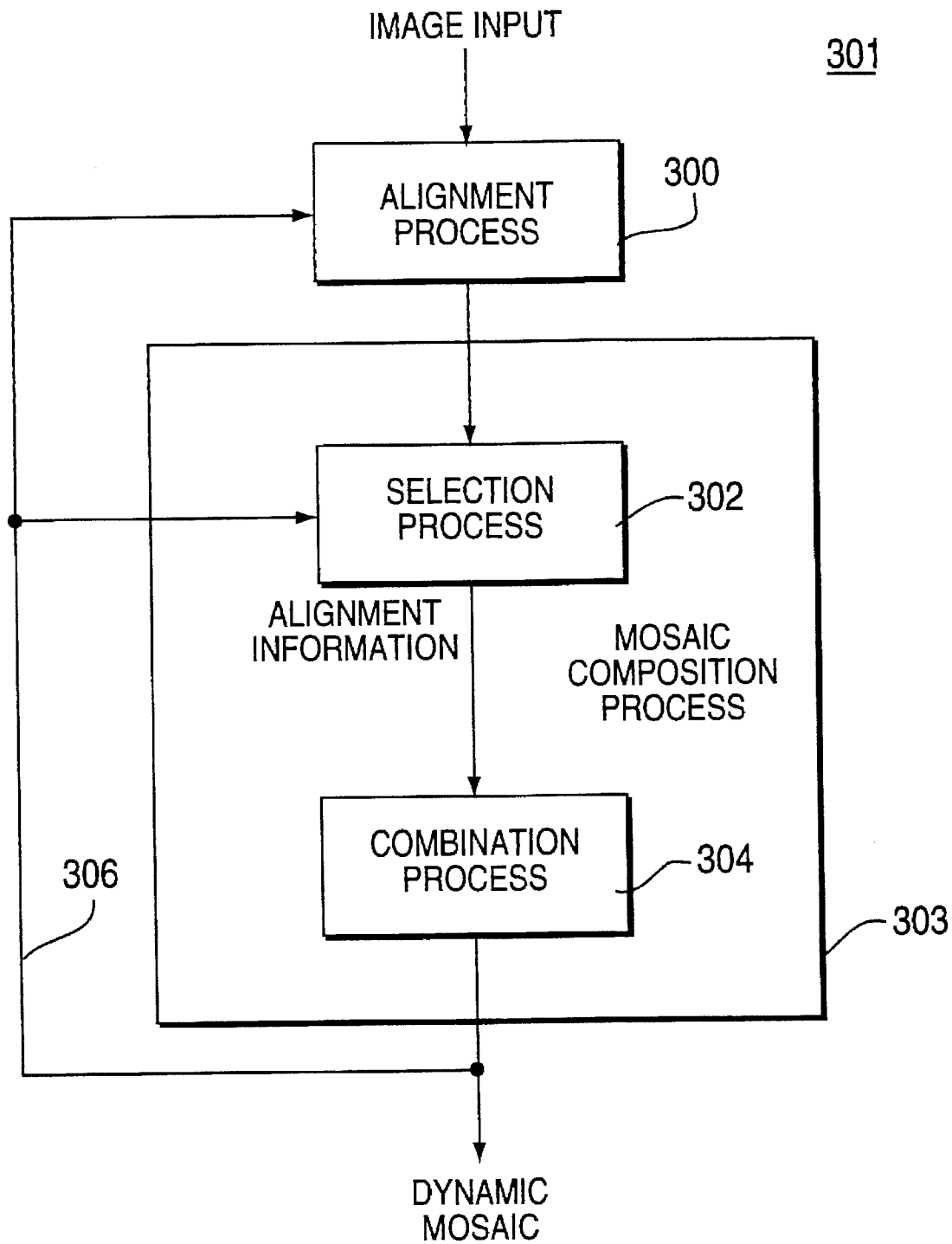
304

306

303

DYNAMIC
MOSAIC

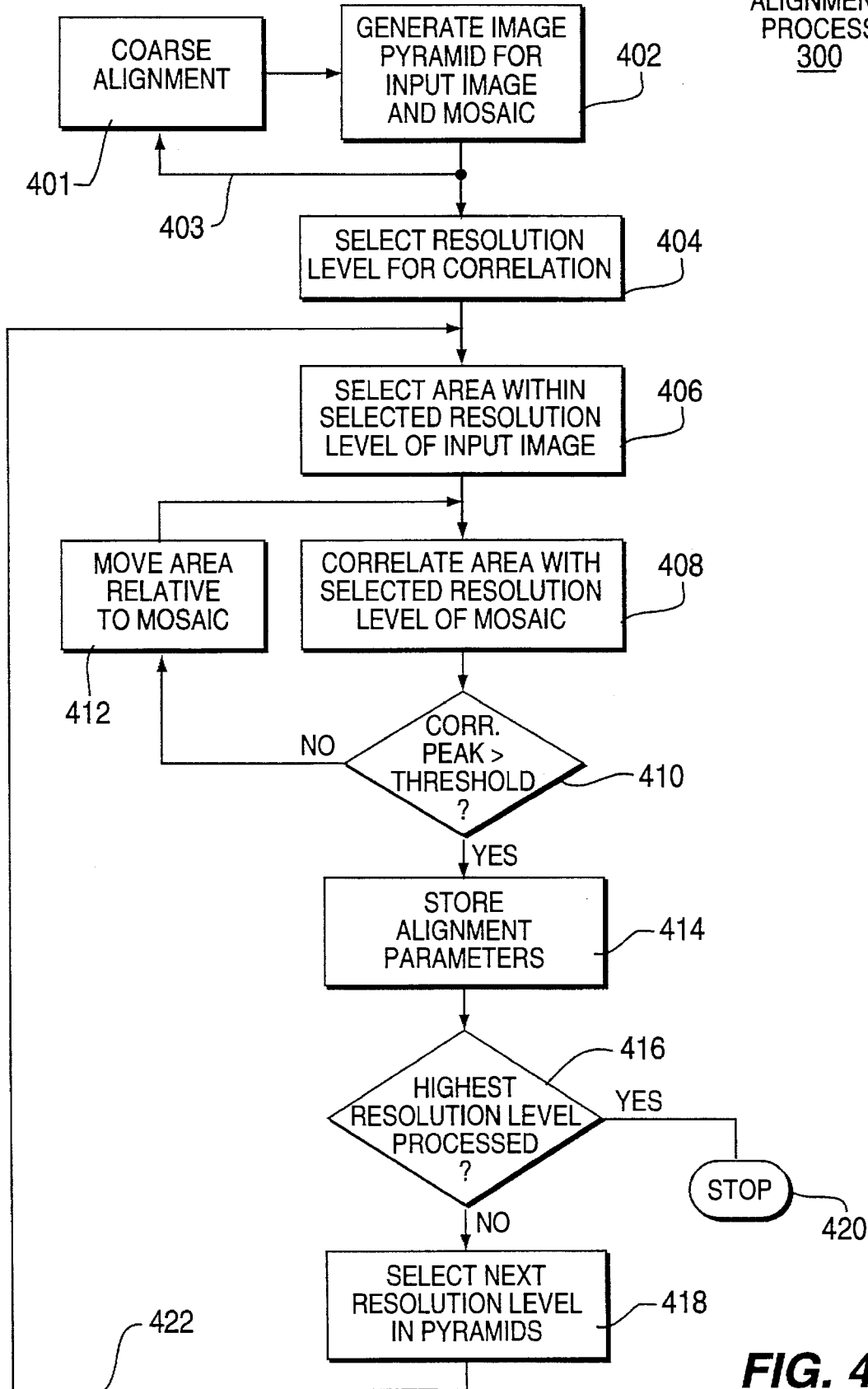*FIG. 3*

IMAGE
ALIGNMENT
PROCESS
300

FIG. 4

DOCKET ALARM

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.

fastcase®
Smarter legal research.