



US009514385B2

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

(10) **Patent No.:** **US 9,514,385 B2**
(45) **Date of Patent:** **Dec. 6, 2016**

(54) **KEY BLANK IDENTIFICATION SYSTEM
WITH GROOVE SCANNING**

2235/41;B23C 2235/44; B23Q
33/00; G06K 2209/401

See application file for complete search history.

(71) Applicant: **HY-KO PRODUCTS COMPANY,**
Northfield, OH (US)

(56) **References Cited**

(72) Inventors: **Chester O. D. Thompson,** Painesville,
OH (US); **William R. Mutch,** North
Ridgeville, OH (US)

U.S. PATENT DOCUMENTS

40,480 A 3/1863 Hill
288,300 A 11/1883 Borowsky
(Continued)

(73) Assignee: **HY-KO PRODUCTS COMPANY,**
Northfield, OH (US)

FOREIGN PATENT DOCUMENTS

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

CH 673612 3/1990
DE 2951065 7/1981
(Continued)

(21) Appl. No.: **14/162,157**

OTHER PUBLICATIONS

(22) Filed: **Jan. 23, 2014**

Chinese Office Action, Application No. 200780009675.0, Hy-Ko
Products Company, Dec. 4 2009.

(65) **Prior Publication Data**

(Continued)

US 2014/0139683 A1 May 22, 2014

Primary Examiner — Michelle Entezari

(74) *Attorney, Agent, or Firm* — McDonald Hopkins LLC

Related U.S. Application Data

(57)

ABSTRACT

(63) Continuation of application No. 12/772,709, filed on
May 3, 2010, now Pat. No. 8,644,619.
(Continued)

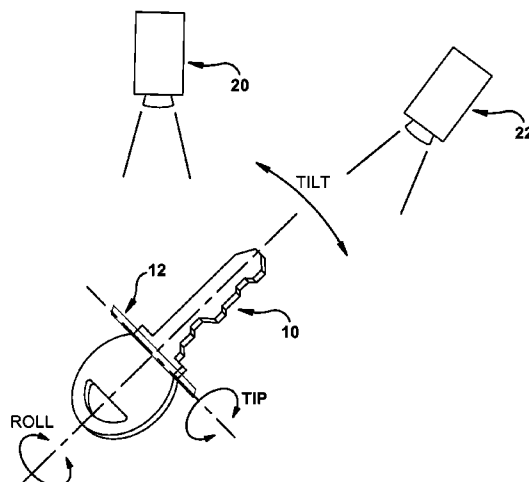
A key identification system is provided. The key identifica-
tion system comprises an imaging system to capture an
image of a master key, and a logic to analyze the captured
image. The imaging system may be capture an image of a
groove in the master key from an angle between perpen-
dicular and parallel to the blade of said master key. The logic
analyzes the captured image to compare characteristics of
the groove with groove characteristics of known key blanks
to determine the likelihood of a match between the master
key and a known key blank. The key identification system
may further compensate for displacement or orientation of
the master key with respect to the imaging system when
analyzing characteristics of the groove.

(51) **Int. Cl.**
G06K 9/62 (2006.01)
G06K 9/00 (2006.01)
(Continued)

(52) **U.S. Cl.**
CPC **G06K 9/6202** (2013.01); **G06K 9/00208**
(2013.01); **G06K 9/209** (2013.01);
(Continued)

(58) **Field of Classification Search**
CPC B23C 2235/24; B23C 2235/28; B23C

26 Claims, 12 Drawing Sheets



Related U.S. Application Data

- (60) Provisional application No. 61/215,152, filed on May 1, 2009, provisional application No. 61/275,654, filed on Sep. 1, 2009.

(51) Int. Cl.

G06K 9/20 (2006.01)

G06K 9/48 (2006.01)

G06T 7/60 (2006.01)

(52) U.S. Cl.

CPC **G06K 9/48** (2013.01); **G06T 7/602** (2013.01); **B23C 2235/41** (2013.01); **Y10T 409/300952** (2015.01); **Y10T 409/301008** (2015.01); **Y10T 409/301064** (2015.01)

(56)

References Cited

U.S. PATENT DOCUMENTS

466,044 A	12/1891	Jacobs	3,286,597 A	11/1966	Schwartz
943,806 A	12/1909	Billings	3,305,100 A	2/1967	Barbee
1,059,545 A	4/1913	Kunze	3,323,420 A	6/1967	Roxburgh
1,081,472 A	12/1913	Tucker	3,388,619 A	6/1968	Schreiber et al.
1,135,676 A	4/1915	Engelbert	3,418,882 A	12/1968	Brand
1,218,653 A	3/1917	Heidrich	3,424,056 A	1/1969	Stolove et al.
1,367,280 A	2/1921	Reiges	3,429,207 A	2/1969	John
1,390,958 A	9/1921	Hulbert	3,430,535 A	3/1969	Haggstrom
1,440,459 A	1/1923	Greff	3,440,906 A	4/1969	Allen
1,628,637 A	5/1927	Shaw	3,442,174 A	5/1969	Weiner et al.
1,656,295 A	1/1928	Schechter	3,457,831 A	7/1969	Adler et al.
1,674,291 A	6/1928	Malone	3,466,747 A	9/1969	Patriquin et al.
1,702,488 A	2/1929	Baird	3,496,636 A	2/1970	Lieptz
1,750,218 A	3/1930	Falk	3,499,366 A	3/1970	Spain
1,752,668 A	4/1930	Johnson	RE26,848 E	4/1970	Simon
1,775,921 A	9/1930	Williams	3,599,147 A	8/1971	Rogers et al.
1,848,046 A	3/1932	Caron	3,602,092 A	8/1971	Richens
1,889,461 A	11/1932	Hansen	3,625,111 A	12/1971	Carlo et al.
1,923,164 A	8/1933	Roos	3,633,451 A	1/1972	Lieptz
1,948,260 A	2/1934	Fowler	3,651,573 A	3/1972	Kaplan
1,961,516 A	6/1934	Hansen	3,656,402 A	4/1972	French
1,978,628 A	10/1934	Hansen	3,675,536 A	7/1972	Hungerford, Jr. et al.
1,991,151 A	2/1935	Hansen	3,682,041 A	8/1972	Essig
2,032,820 A	3/1936	Turrell	3,707,999 A	1/1973	Coats
2,038,949 A	4/1936	Mintz	3,722,341 A	3/1973	Hungerford, Jr. et al.
2,098,728 A	11/1937	McPhee	RE27,665 E	6/1973	Spain
2,105,099 A	1/1938	Schuyler	3,769,865 A	11/1973	Kleist
2,114,597 A	4/1938	Goddard	3,773,360 A	11/1973	Timbers
2,148,668 A	2/1939	Yoskowitz et al.	3,792,639 A	2/1974	Richens et al.
2,176,106 A	10/1939	Segal	3,795,174 A	3/1974	Oliver et al.
2,274,012 A	2/1942	Swayze et al.	3,796,130 A	3/1974	Gartner
2,325,541 A	7/1943	Poole	3,807,276 A	4/1974	Oliver
2,329,269 A	9/1943	Jacobi	3,810,416 A	5/1974	Nelms, Jr.
2,386,816 A	10/1945	Scholz	3,826,555 A	7/1974	Matsumoto
2,430,924 A	11/1947	Fowle et al.	3,848,235 A	11/1974	Lewis et al.
2,445,041 A	7/1948	Scholz	3,865,011 A	2/1975	Patriquin
2,499,124 A	2/1950	Zipp et al.	3,870,895 A	3/1975	Lax et al.
2,556,577 A	6/1951	Drake	3,880,047 A	4/1975	Dosier
2,582,012 A	1/1952	Currier	3,884,121 A	5/1975	Agius
2,605,294 A	7/1952	Barnhart	3,902,382 A	9/1975	Lieptz
2,622,485 A	12/1952	Martellotti	3,919,589 A	11/1975	Hanak
2,645,978 A	7/1953	Sejarto et al.	3,919,920 A	11/1975	Schlage
2,707,335 A	5/1955	Falk	3,945,298 A	3/1976	Cockcroft
2,728,251 A	12/1955	Turner	3,955,179 A	5/1976	Planke
2,860,884 A	11/1958	Sloan et al.	3,956,968 A	5/1976	Crasnianski
2,929,177 A	3/1960	Sheps	3,978,764 A	9/1976	Patriquin
2,940,183 A	6/1960	Fromberg	3,981,214 A	9/1976	Wich
3,053,149 A	9/1962	Rossetti	4,012,991 A	3/1977	Uyeda
3,094,039 A	6/1963	Spain	4,019,415 A	4/1977	Wich
3,138,999 A	6/1964	Haggstrom	4,023,464 A	5/1977	Zion
3,172,969 A	3/1965	Haggstrom	4,051,748 A	10/1977	Sherman
3,245,149 A	4/1966	Haggstrom	4,062,261 A	12/1977	Stahl
3,257,908 A	6/1966	Haggstrom	4,088,060 A	5/1978	Johns
3,259,022 A	7/1966	Vietorisz	4,090,303 A	5/1978	Uyeda
3,276,328 A	10/1966	Schreiber et al.	4,092,806 A	6/1978	Wich
3,286,596 A	11/1966	Lieptz	4,105,340 A	8/1978	Kempf
			4,117,763 A	10/1978	Uyeda
			4,121,292 A	10/1978	Galanis et al.
			4,132,151 A	1/1979	Weber
			D251,365 S	3/1979	Lipinski
			4,143,582 A	3/1979	Heimann
			4,166,949 A	9/1979	Pold et al.
			4,171,161 A	10/1979	Jung
			4,172,632 A	10/1979	Holmes, Jr.
			4,188,163 A	2/1980	Juskevic
			4,223,791 A	9/1980	Taggart
			4,233,746 A	11/1980	Troillet
			D257,758 S	1/1981	Limacher
			4,251,173 A	2/1981	Saucedo
			4,256,423 A	3/1981	Juskevic
			4,281,379 A	7/1981	Austin
			4,283,859 A	8/1981	Roland
			4,294,096 A	10/1981	Heimann
			4,300,042 A	11/1981	Oldenkamp et al.
			4,300,170 A	11/1981	Sakamoto
			4,300,836 A	11/1981	Holmes, Jones F. et al.
			4,301,373 A	11/1981	Sjodin
			4,354,780 A	10/1982	Bougiouris
			4,359,299 A	11/1982	Sagarian

(56)

References Cited

U.S. PATENT DOCUMENTS

4,373,414 A	2/1983	Agius	5,127,532 A	7/1992	Cimino et al.
4,426,179 A	1/1984	Jefferson	5,128,531 A	7/1992	Fadel
4,432,142 A	2/1984	Korsak	5,130,064 A	7/1992	Smalley et al.
4,433,487 A	2/1984	Roland	5,139,246 A	8/1992	Yakou
4,437,150 A	3/1984	Dahlgren, Jr. et al.	5,144,561 A	9/1992	Soper
4,453,432 A	6/1984	Widen	5,146,689 A	9/1992	Roland
4,468,994 A	9/1984	Lieptz	5,165,315 A	11/1992	Terada
4,472,056 A	9/1984	Nakagawa et al.	5,167,171 A	12/1992	Heredia
4,479,673 A	10/1984	Inaba et al.	5,171,112 A	12/1992	Roland
4,521,142 A	6/1985	Juskevici	5,192,469 A	3/1993	Smalley et al.
4,525,908 A	7/1985	Bernstein	5,201,203 A	4/1993	Almblad
4,526,498 A	7/1985	Fieldhouse	5,229,619 A	7/1993	Van Amstel
4,541,760 A	9/1985	Zoueki	5,244,321 A	9/1993	Sopko
4,545,569 A	10/1985	Schroder et al.	5,255,199 A	10/1993	Barkman et al.
4,551,046 A	11/1985	Kinas	5,259,708 A	11/1993	Brice
4,553,844 A	11/1985	Nakagawa et al.	5,271,698 A	12/1993	Heredia et al.
4,557,488 A	12/1985	Litherland	5,293,687 A	3/1994	Willoughby, Jr. et al.
4,558,215 A	12/1985	Kaneko et al.	5,307,151 A	4/1994	Hof et al.
4,562,759 A	1/1986	Schmitt	5,308,360 A	5/1994	Neitzke et al.
4,592,683 A	6/1986	Wu	5,311,286 A	5/1994	Pike
4,601,185 A	7/1986	Sheldon	5,311,756 A	5/1994	Villani
4,614,465 A	9/1986	Wu	5,311,758 A	5/1994	Neitzke et al.
4,625,107 A	11/1986	Planke	5,314,274 A	5/1994	Heredia et al.
4,638,567 A	1/1987	Leversee	D348,393 S	7/1994	Neitzke et al.
4,647,028 A	3/1987	Yang	5,330,168 A	7/1994	Enomoto et al.
4,648,585 A	3/1987	Yang	5,351,409 A	10/1994	Heredia
4,651,604 A	3/1987	Almblad et al.	5,360,299 A	11/1994	Oliana
4,652,738 A	3/1987	Nishihara et al.	5,363,463 A	11/1994	Kleinerman
4,652,765 A	3/1987	Nishihara	5,365,812 A	11/1994	Harnden
4,653,104 A	3/1987	Tamura	5,382,784 A	1/1995	Eberhardt
4,656,590 A	4/1987	Ace	5,393,967 A	2/1995	Rice et al.
4,657,448 A	4/1987	Alexander	5,416,591 A	5/1995	Yoshimura et al.
4,666,351 A	5/1987	Marchal	5,429,202 A	7/1995	Millard et al.
4,671,711 A	6/1987	Steinbach et al.	5,441,369 A	8/1995	Foscan et al.
4,677,835 A	7/1987	Almblad	5,443,339 A	8/1995	Heredia et al.
4,679,331 A	7/1987	Koontz	5,485,399 A	1/1996	Saigo et al.
4,687,389 A	8/1987	Santii et al.	5,496,138 A	3/1996	Drori
4,697,300 A	10/1987	Warlop	5,497,888 A	3/1996	Michaels et al.
4,710,808 A	12/1987	Hoogenboom et al.	5,503,785 A	4/1996	Crump et al.
4,717,294 A	1/1988	Grasser	5,515,903 A	5/1996	Hronas et al.
4,741,652 A	5/1988	Marchal	5,538,374 A	7/1996	Cole et al.
4,767,110 A	8/1988	Yang	5,543,103 A	8/1996	Hogan et al.
4,780,032 A	10/1988	Uyeda et al.	5,545,367 A	8/1996	Bae et al.
4,783,829 A	11/1988	Miyakawa et al.	5,552,992 A	9/1996	Hunter
4,803,371 A	2/1989	Durland	5,555,176 A	9/1996	Menhennett et al.
4,805,224 A	2/1989	Koezuka et al.	5,556,240 A	9/1996	Almblad
4,809,341 A	2/1989	Matsui et al.	5,583,443 A	12/1996	McMurtry et al.
4,821,200 A	4/1989	Oberg	5,592,728 A	1/1997	Susnjara
4,821,393 A	4/1989	Spigarelli	5,594,652 A	1/1997	Penn et al.
4,839,913 A	6/1989	Annis et al.	5,607,267 A	3/1997	Heredia et al.
4,845,764 A	7/1989	Ueda et al.	5,617,323 A	4/1997	Stansberry et al.
4,848,116 A	7/1989	Lizotte	RE35,518 E	5/1997	Sussina
4,853,866 A	8/1989	Andrada Galan et al.	5,630,332 A	5/1997	Aldieri et al.
4,868,559 A	9/1989	Pinnow	5,660,509 A	8/1997	Cole et al.
4,898,504 A	2/1990	Agius et al.	5,671,523 A	9/1997	Juchinewicz
4,899,391 A	2/1990	Cimino et al.	5,676,504 A	10/1997	Mueller et al.
4,909,892 A	3/1990	Quinn et al.	5,677,522 A	10/1997	Rice et al.
4,929,129 A	5/1990	Dickson	5,711,643 A	1/1998	Parr et al.
4,929,843 A	5/1990	Chmielewski, Jr. et al.	5,739,766 A	4/1998	Chaloux
4,941,335 A	7/1990	Allen	5,764,156 A	6/1998	Chaloux
4,969,782 A	11/1990	Castain	5,771,176 A	6/1998	Froehlich et al.
4,971,489 A	11/1990	Womack	5,807,042 A	9/1998	Almblad et al.
4,993,291 A	2/1991	Sopko	5,855,836 A	1/1999	Leyden et al.
4,998,349 A	3/1991	Killeen	5,886,775 A	3/1999	Houser et al.
5,029,459 A	7/1991	Almblad	5,906,365 A	5/1999	Wu
5,043,144 A	8/1991	Gordon et al.	5,908,273 A	6/1999	Titus et al.
5,056,204 A	10/1991	Bartschi	5,926,388 A	7/1999	Kimbrough et al.
5,058,940 A	10/1991	Hart	5,940,229 A	8/1999	Baumgarten
5,083,759 A	1/1992	Pollak et al.	5,964,554 A	10/1999	Drori
5,088,864 A	2/1992	Yanagida	5,966,457 A	10/1999	Lemelson
5,094,538 A	3/1992	Reedman et al.	5,982,491 A	11/1999	Breyer et al.
5,096,346 A	3/1992	Ueda	5,984,597 A	11/1999	Chen
5,111,056 A	5/1992	Yoshimura et al.	5,997,224 A	12/1999	Beauregard et al.
5,119,190 A	6/1992	Lemelson	5,997,795 A	12/1999	Danforth et al.
5,122,018 A	6/1992	Zion	6,053,677 A	4/2000	Juchinewicz
			6,059,495 A	5/2000	Mueller et al.
			6,064,747 A	5/2000	Wills et al.
			6,065,911 A *	5/2000	Almblad et al. 409/83
			6,082,580 A	7/2000	Mueller et al.

(56)

References Cited

FOREIGN PATENT DOCUMENTS

U.S. PATENT DOCUMENTS

6,094,953	A	8/2000	Evans	
6,152,662	A	11/2000	Titus et al.	
6,175,638	B1	1/2001	Yanovsky	
6,179,531	B1	1/2001	Jaw	
6,185,311	B1	2/2001	Yanovsky et al.	
6,186,711	B1	2/2001	Mueller	
6,243,960	B1	6/2001	Andrews et al.	
6,321,430	B1	11/2001	Goldman et al.	
D455,104	S	4/2002	Hillman et al.	
6,406,227	B1	6/2002	Titus et al.	
6,415,931	B1	7/2002	Mueller	
6,449,381	B1	9/2002	Yanovsky et al.	
6,478,515	B1	11/2002	Mueller	
6,543,972	B1	4/2003	Cimino	
6,588,995	B2	7/2003	Wills et al.	
6,602,030	B1	8/2003	Markbreit	
6,612,142	B1	9/2003	Capwell	
6,641,339	B2	11/2003	Chies et al.	
6,647,308	B1 *	11/2003	Prejean	700/117
6,687,565	B2	2/2004	Wetterlin et al.	
6,711,557	B1	3/2004	Palaniappan	
6,801,829	B2	10/2004	Kawai	
6,817,814	B2	11/2004	Mueller	
6,836,553	B2	12/2004	Campbell et al.	
6,839,449	B1	1/2005	Campbell et al.	
6,839,451	B2	1/2005	Campbell et al.	
6,895,100	B1	5/2005	Pacenzia et al.	
6,959,862	B2	11/2005	Neumark	
6,965,911	B1	11/2005	Coffman et al.	
7,010,498	B1	3/2006	Berstis	
7,111,894	B2	9/2006	Kora et al.	
7,114,436	B1	10/2006	Mueller	
7,114,894	B2	10/2006	Mueller et al.	
7,163,364	B2	1/2007	Foscan et al.	
7,214,011	B2	5/2007	Ryai, Sr. et al.	
7,484,446	B1	2/2009	Gula	
7,643,685	B2 *	1/2010	Miller	382/209
7,890,878	B2	2/2011	Bass et al.	
7,891,919	B2	2/2011	Bass et al.	
7,918,629	B2	4/2011	Belflower et al.	
8,128,322	B2	3/2012	Bass et al.	
8,532,809	B2	9/2013	Freeman	
8,585,029	B2	11/2013	Ryai, Sr.	
8,634,655	B2 *	1/2014	Thompson	G06K 9/48 382/141
8,644,619	B2 *	2/2014	Thompson	G06T 7/602 382/141
2001/0033781	A1	10/2001	Wills et al.	
2001/0056385	A1	12/2001	Timms et al.	
2002/0031251	A1	3/2002	Campbell et al.	
2002/0168241	A1	11/2002	David et al.	
2002/0191849	A1 *	12/2002	Campbell et al.	382/181
2003/0145499	A1	8/2003	Tarter et al.	
2003/0154135	A1	8/2003	Covington et al.	
2003/0205070	A1	11/2003	Chaum	
2004/0024486	A1	2/2004	Almblad et al.	
2004/0036595	A1	2/2004	Kenny et al.	
2004/0095380	A1	5/2004	Bass et al.	
2004/0253067	A1	12/2004	Bosch	
2005/0000052	A1	1/2005	Byles	
2005/0216120	A1	9/2005	Rosenberg et al.	
2006/0003676	A1	1/2006	Bernard et al.	
2006/0147289	A1 *	7/2006	Gimelfarb et al.	409/277
2007/0224008	A1	9/2007	Bass et al.	
2007/0234614	A1	10/2007	Tarter et al.	
2008/0145163	A1	6/2008	Freeman et al.	
2008/0252551	A1	10/2008	Kubo et al.	
2009/0074528	A1	3/2009	Hadad	
2009/0180664	A1	7/2009	Efstathiades et al.	
2010/0059484	A1 *	3/2010	Inoue et al.	219/61.5
2010/0110380	A1 *	5/2010	Allred et al.	351/214
2011/0262240	A1	10/2011	Mutch et al.	
2014/0260809	A1 *	9/2014	Miller	H04N 5/2254 76/110

EP	0053730	10/1981
EP	0133091	2/1985
EP	0835720	4/1998
EP	1976656	10/2014
ES	2017240	1/1991
FR	2499435	8/1982
GB	2276106	9/1994
JP	S59201708	11/1984
JP	S63-311108	12/1988
JP	S63-311109	12/1988
JP	H04-250911	9/1992
MX	291113	1/2007
WO	WO90/03867	4/1990
WO	WO91/13535	9/1991
WO	WO96/19309	6/1996
WO	WO01/57472	8/2001
WO	WO0201480	1/2002
WO	WO2005042196	5/2005
WO	WO2007087389	8/2007
WO	WO2012096685	7/2012

OTHER PUBLICATIONS

Chinese Office Action, Application No. 201080024166.7, Hy-Ko Products Company, Dec. 6, 2013.

Chinese Office Action, Application No. 201080024166.7, Hy-Ko Products Company, Sep. 30, 2014.

Chinese Office Action, Application No. 201080024163.3, Hy-Ko Products Company, Aug. 1, 2013.

Supplementary European Search Report, Application No. 07709849.9-1702/ 1976656, Hy-Ko Products Company, May 15, 2013.

Extended European Search Report, Application No. 07709849.9-1702/ 1976656, Hy-Ko Products Company, Apr. 26, 2013.

European Communication pursuant to Article 94(3) EPC, Application No. 10 770 4891-1901, Hy-Ko Products, Jun. 27, 2014.

Supplementary European Search Report, Application No. 10770489.2-1901/ 2424690, Hy-Ko Products, Nov. 12, 2013.

Extended European Search Report, 10770489.2-901 /2424690, Hy-Ko Products, Oct. 25, 2013.

European Communication pursuant to Article 94(3) EPC, Application No. 12 003 030.9-1702, Hy-Ko Products Company, Mar. 20, 2014.

European Communication pursuant to Article 94(3) EPC, Application No. 12 003 030.9-1702, Hy-Ko Products Company, Jul. 30, 2013.

Extended European Search Report, Application No. 12003030.9-2302, Hy-Ko Products Company, Sep. 4, 2012.

European Communication pursuant to Article 94(3) EPC, Application No. 03 767 220.1-2201, Hy-Ko Products, Aug. 18, 2010.

European Supplementary Search Report, Application No. 03767220.1-2201, Hy-Ko Products, Jul. 18, 2007.

Mexican Office Action, Application No. MX/A/2011/011630, Hy-Ko Products, Nov. 18, 2014.

Mexican Office Action, Application No. MX/A/2011/011630, Hy-Ko Products, Apr. 28, 2014.

International Preliminary Report on Patentability, PCT/US2011/034564, Mutch, William R. et al., Jul. 16, 2013.

International Search Report and the Written Opinion of the International Searching Authority, PCT/US2011/034564, Hy-Ko Products Company, Jul. 15, 2011.

International Preliminary Report on Patentability, PCT/US2010/033414, Hy-Ko Products et al., Nov. 1, 2011.

International Search Report and the Written Opinion of the International Searching Authority, PCT/US2010/033414, Hy-Ko Products, Aug. 18, 2010.

International Preliminary Report on Patentability, PCT/US2007/002015, Hy-Ko Products Company, Jul. 29, 2008.

International Search Report and the Written Opinion of the International Searching Authority, PCT/US2007/02015, Hy-Ko Products Company, Sep. 28, 2007.

(56)

References Cited

OTHER PUBLICATIONS

International Preliminary Report on Patentability, PCT/US2010/033421, Hy-Ko Products et al., Nov. 1, 2011.
 International Search Report and the Written Opinion of the International Searching Authority, PCT/US2010/033421, Hy-Ko Products, Sep. 17, 2010.
 Giuliani Productivity Through Flexibility, Multicode CCE-1, 2 pages.
 Giuliani Productivity Through Flexibility, Multicode CCE-2, 3 pages.
 Farzin Mokhtarian and Hiroshi Murase, Silhouette-Based Object Recognition through Curvature Scale Space, IEEE, Proceedings from Fourth International Conference on Computer Vision, 1993, pp. 269-274.
 Ihtisham Kabir, A Computer Vision System Using Fast, One Pass Algorithms, (Thesis), Graduate Division of the University of California, Davis, 1986 pp. 1-164.

Roger D. Quinn et al., Design of an Agile Manufacturing Workcell for Light Mechanical Applications, Apr. 1996, pp. 858-863, Proceedings from the 1996 IEEE International Conference on Robotics and Automation, Minneapolis, Minnesota.
 Anil K. Jain, Fundamentals of Digital Image Processing, Ch. 9, Image Analysis and Computer Vision, University of California, Davis, 1989, pp. 342-430, Prentice Hall, Inc., Englewood Cliffs, NJ.
 Amir Novini, Fundamentals of Machine Vision Lighting, IEEE, Proceedings of Northcon 93 Electrical and Electronics Convention, 1993, pp. 38-46.
 Wesley E. Snyder, Industrial Robots Computer Interfacing and Control, Ch. 13 Computer Vision, North Carolina State University, 1985, pp. 248-283, Prentice-Hall, Inc., Englewood, NJ.
 European Search Report for European Patent Application No. 12 00 3030, dated Aug. 27, 2012.
 International Preliminary Report on Patentability for International Patent Application No. PCT/US2011/034564, dated Jul. 25, 2013.

* cited by examiner

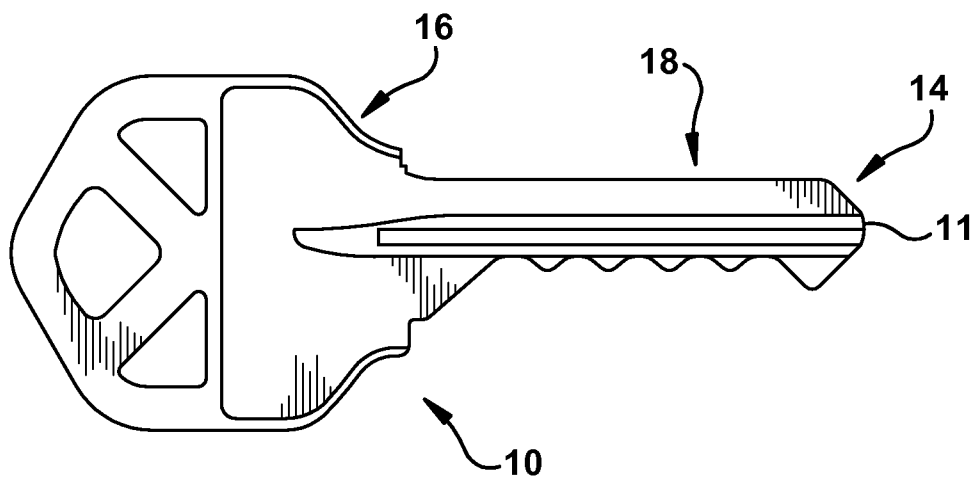


FIG. 1

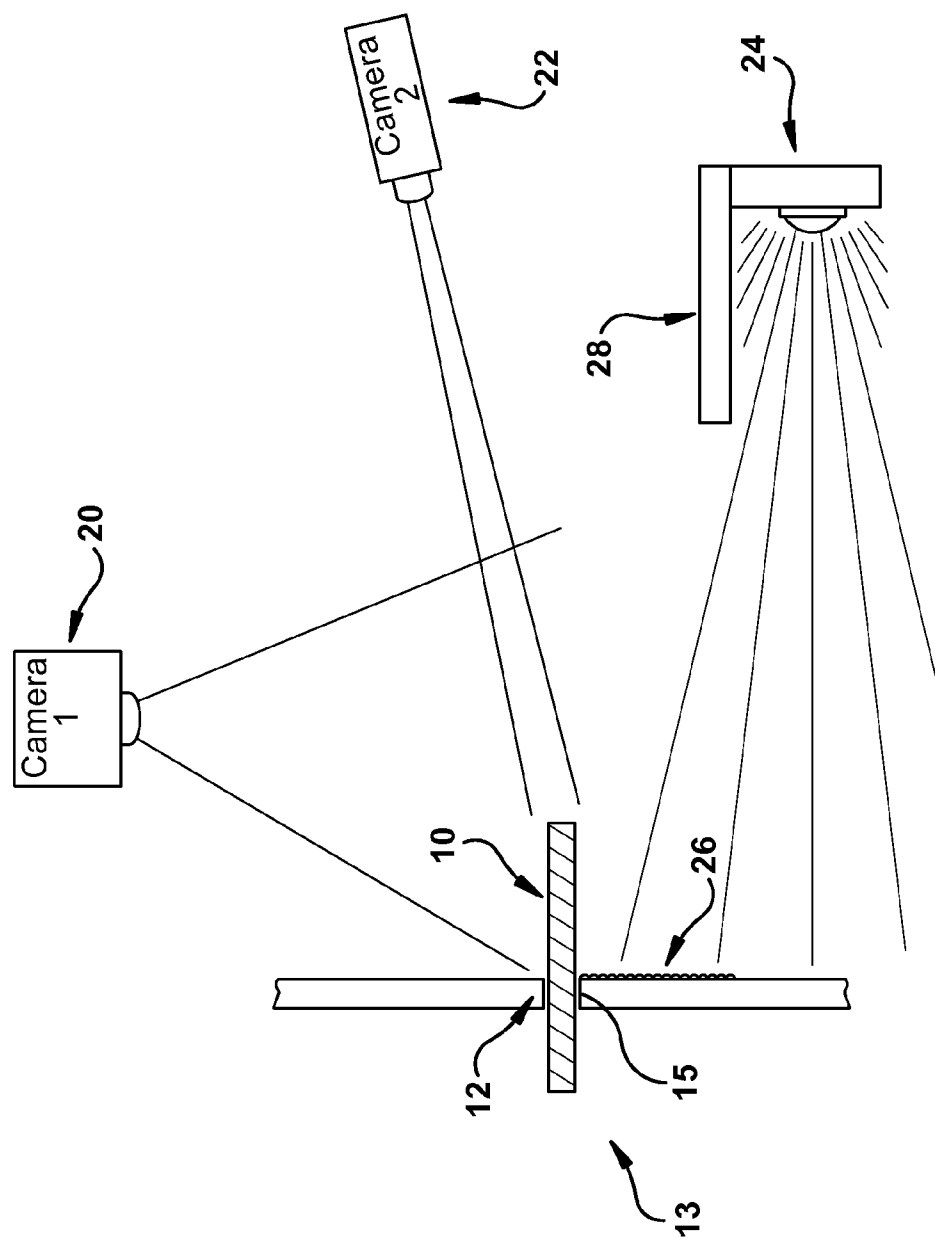
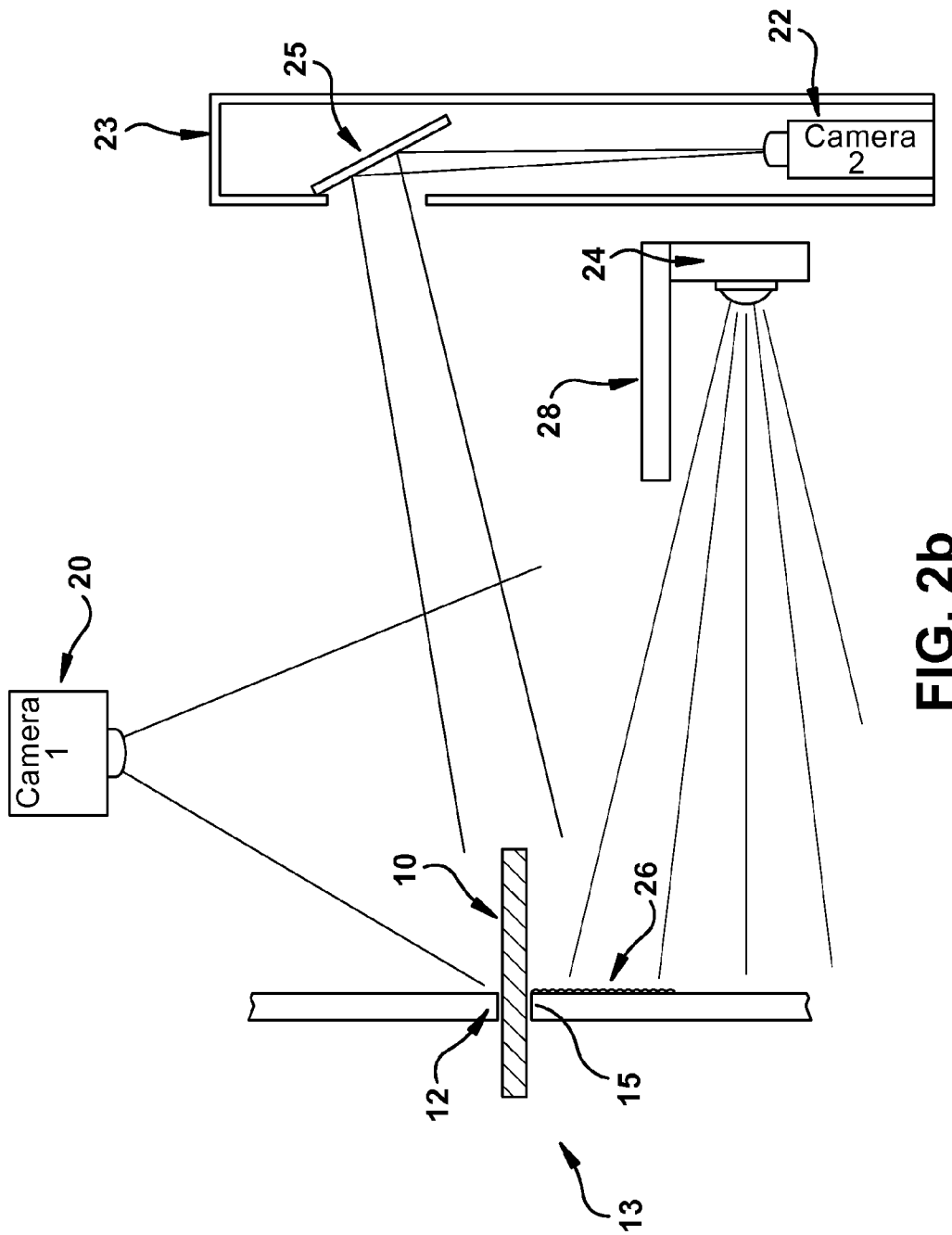


FIG. 2a



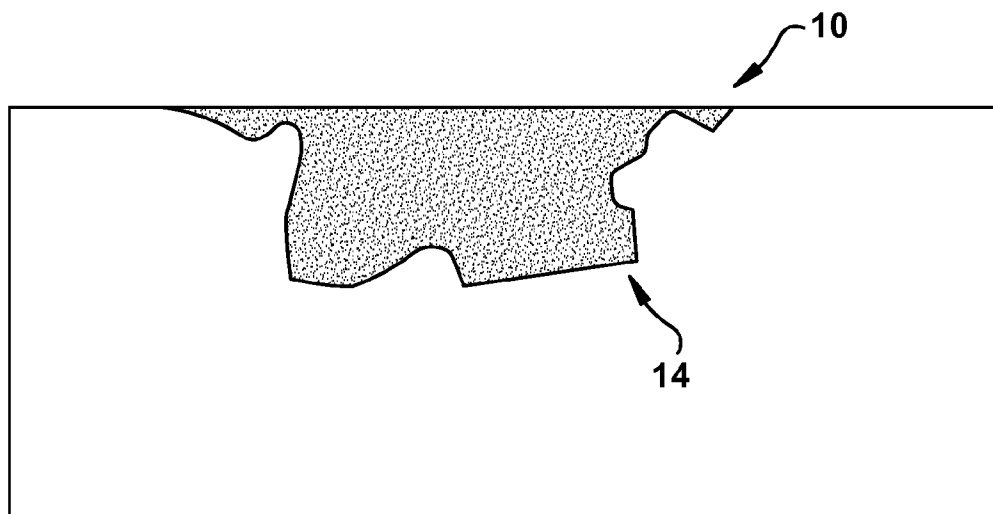
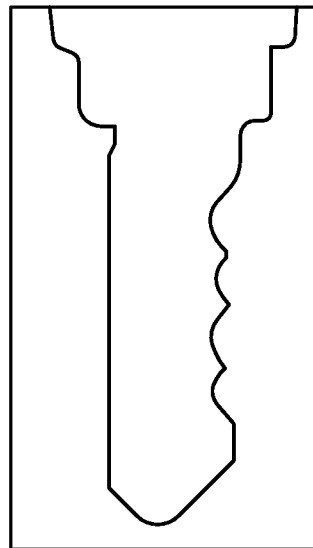
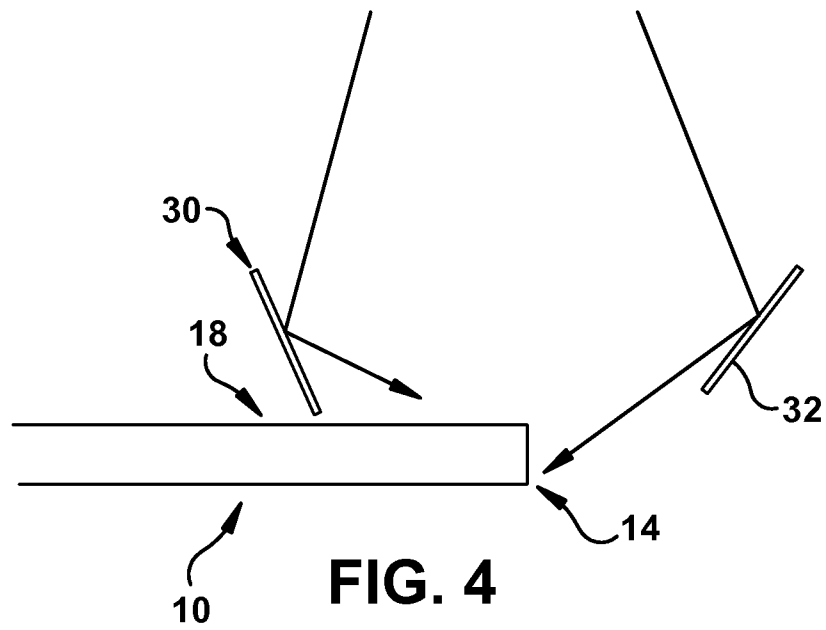


FIG. 3



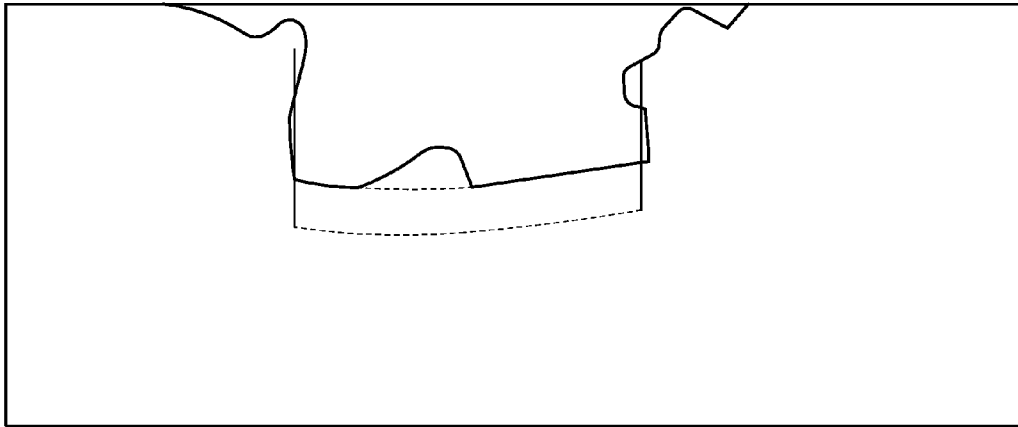


FIG. 6



FIG. 7

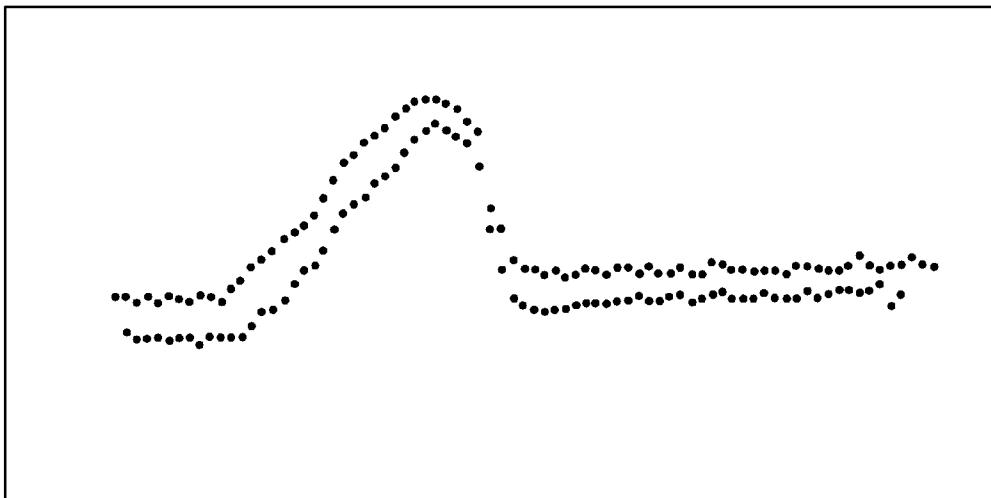


FIG. 8

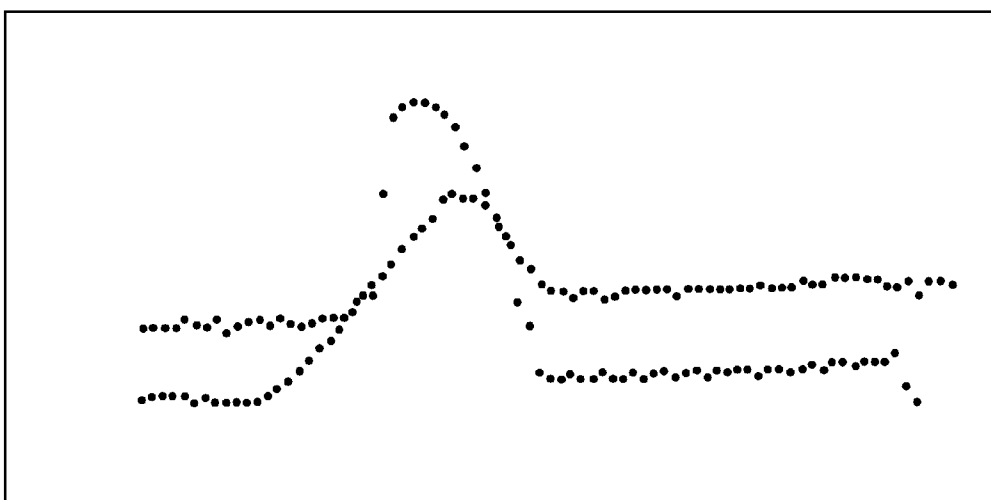
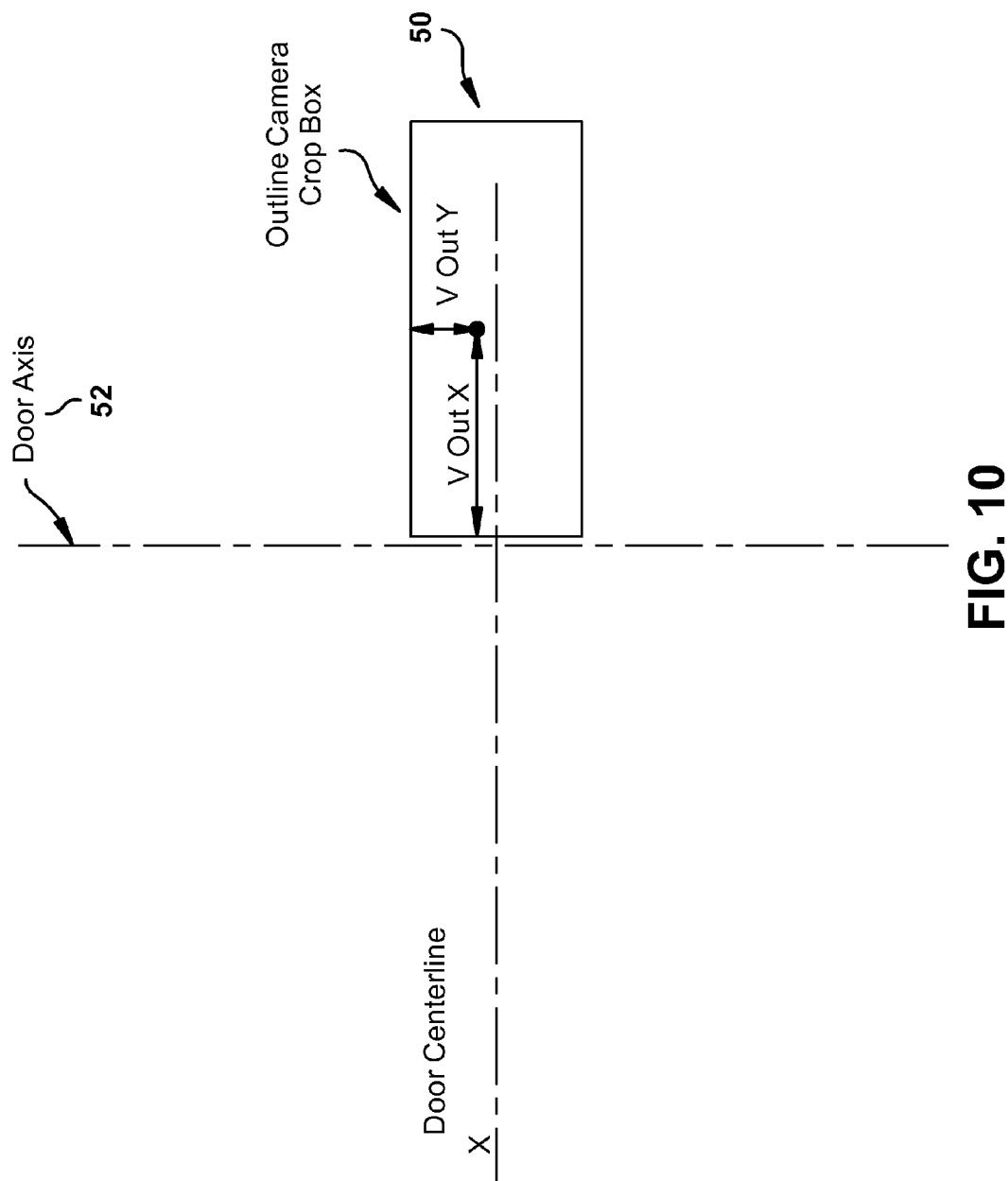


FIG. 9



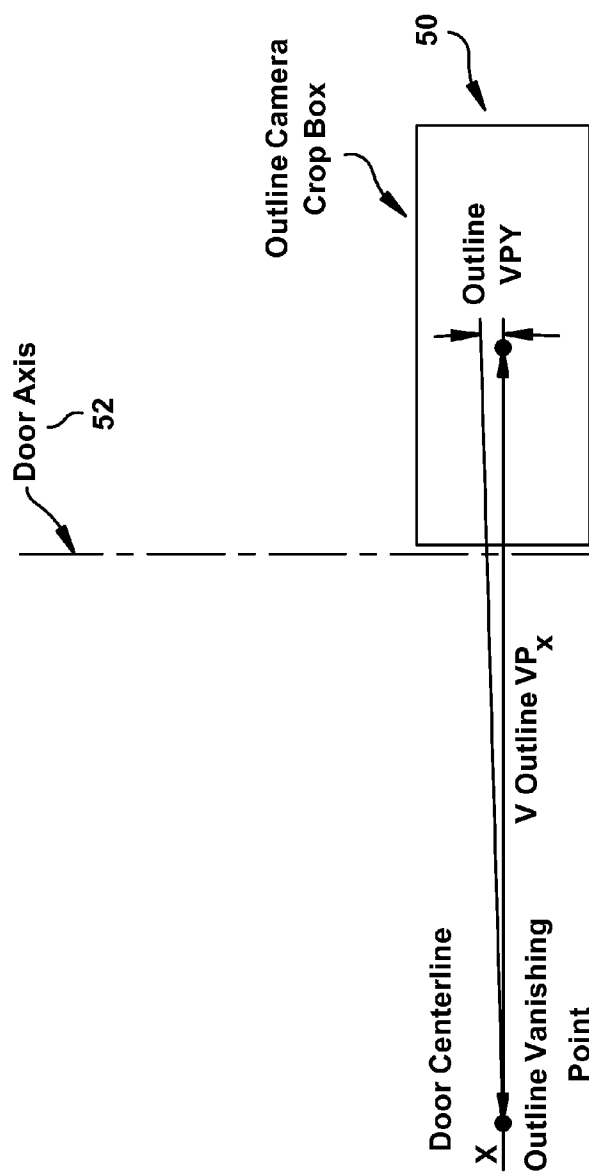
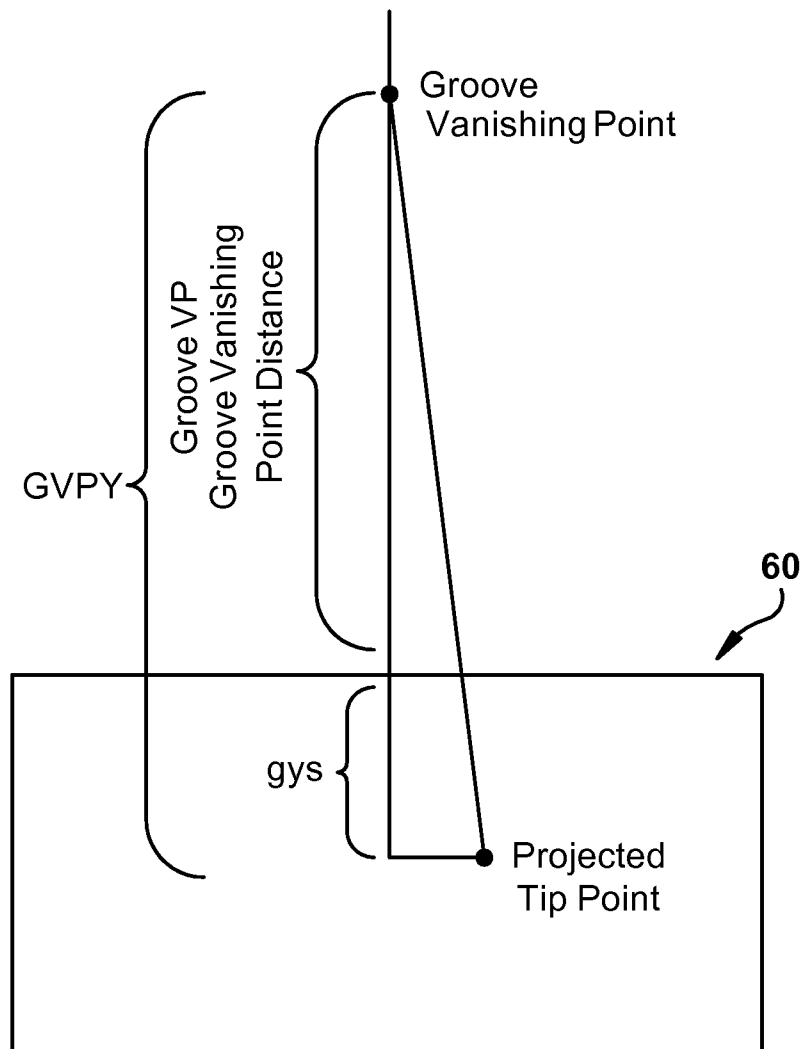
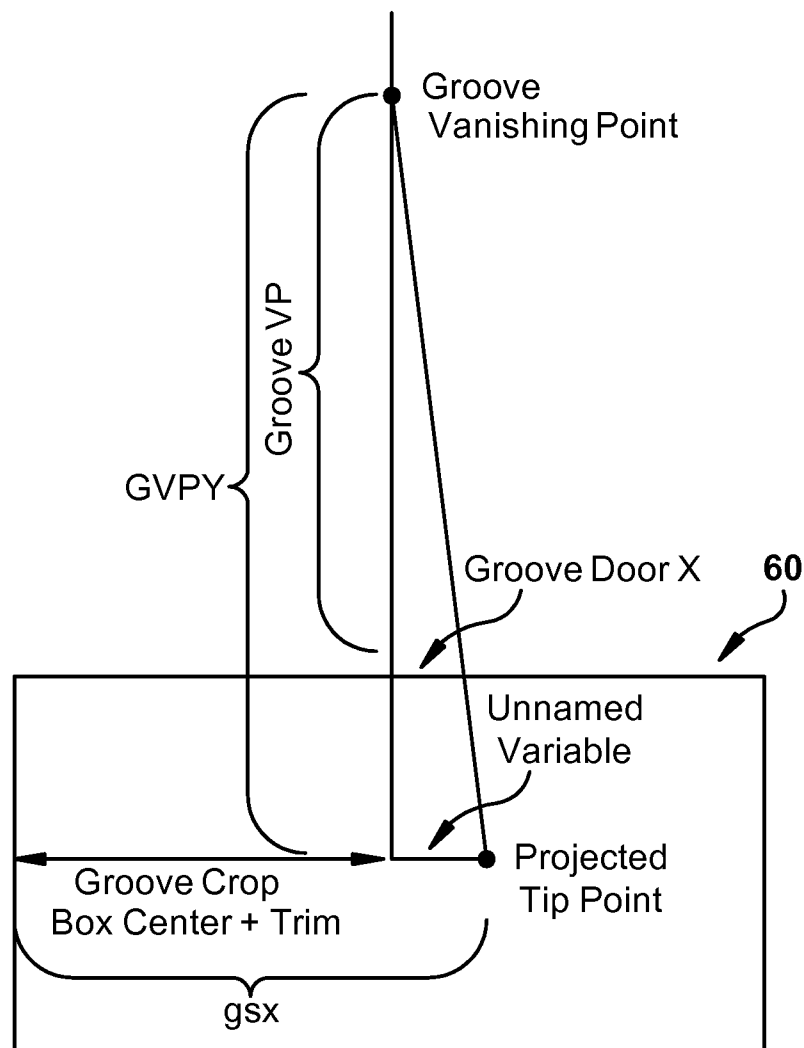


FIG. 11

**FIG. 12**

**FIG. 13**

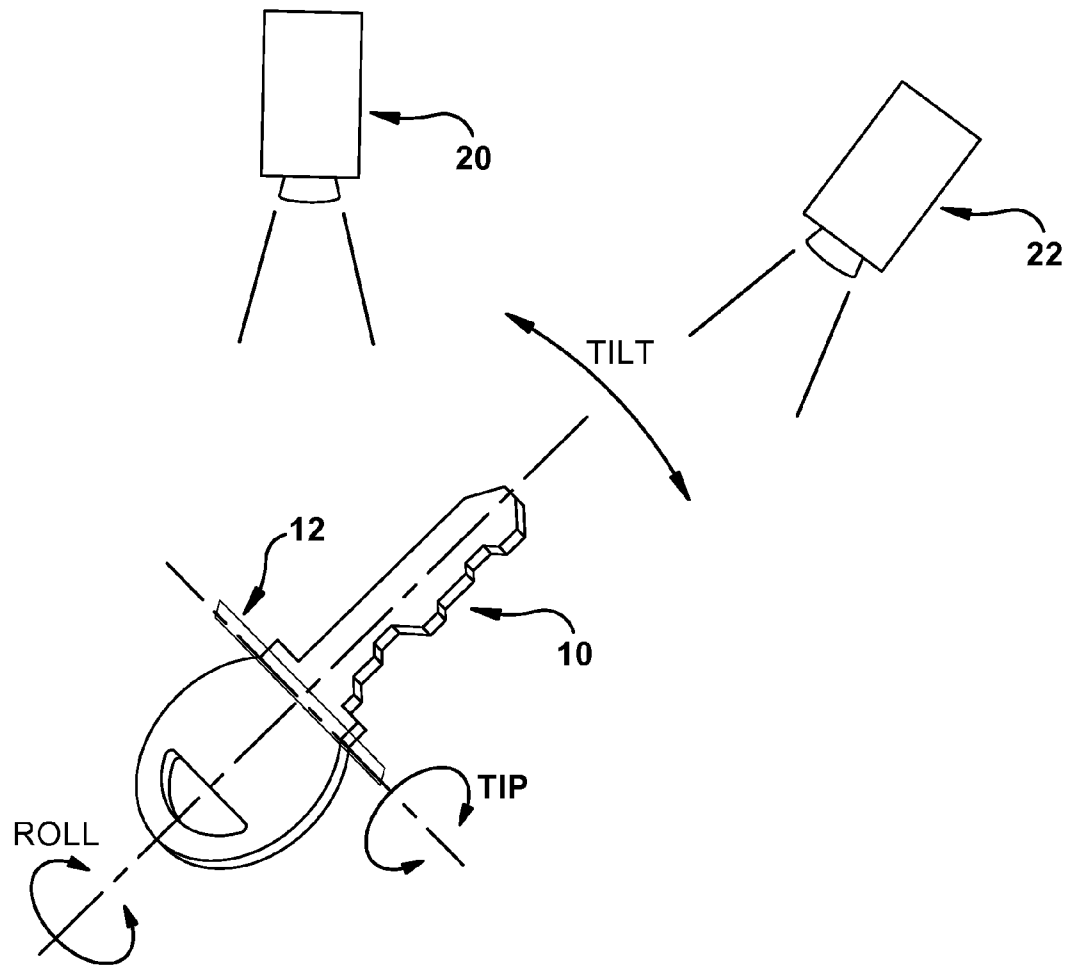


FIG. 14

1

KEY BLANK IDENTIFICATION SYSTEM WITH GROOVE SCANNING

CROSS-REFERENCE TO RELATED APPLICATIONS

This application is a continuation of U.S. application Ser. No. 12/772,709 filed on May 3, 2010 entitled "KEY BLANK IDENTIFICATION SYSTEM WITH GROOVE SCANNING," which claims the benefit of priority of U.S. Provisional Patent Application Ser. No. 61/215,152 filed on May 1, 2009, and U.S. Provisional Patent Application Ser. No. 61/275,654 filed on Sep. 1, 2009, each of which are hereby incorporated by reference in their entirety.

FIELD OF ART

This invention relates generally to the field of systems for identifying objects and, more particularly to systems for utilizing electronic means for identifying key blanks that are compatible with an unknown key.

BACKGROUND OF THE INVENTION

The art of key replication is well known. Commonly, a key intended for duplication (the master key) is copied on to an appropriately identified key blank utilizing any number of different systems known in the art. The process of identifying an appropriate key blank to use when making copies of a key can be a difficult, tedious and time consuming affair. It is important that each master key be copied onto the proper key blank so as to prevent numerous adverse consequences caused by reproducing a master key onto an inappropriate key blank. However, choosing the correct key blank can be difficult even for experts in the field.

There are hundreds, if not thousands, of key blanks, and many blanks are not readily distinguished from others. Identifying the correct key blank for use in duplication involves selecting a blank from hundreds or even thousands of possibilities, where differences between key blanks may be very subtle. These hard-to-notice subtleties significantly increase the level of difficulty for all operators of such key replication systems, both inexperienced trainees and experts alike.

Once a key blank is chosen, it goes through a cutting process. The typical cutting process simply traces the profile of the master key onto the key blank, such that the key blank will exactly match (within the error limits and accuracy of the tracing machine) the original master key. Normally, a mechanically linked cutting wheel actually cuts into the key blank while it mimics the movement of the tracer as the tracer moves longitudinally along the profile of the master key. If the incorrect key blank is provided during this process, the key blank being formed into the duplicate key may not possess the correct longitudinal length, thereby causing a failure. When this type of failure occurs, the entire process of selecting a key blank for replication and then mechanically cutting the key must begin again. Worse still, if the blank has the proper length but does not possess the appropriate thickness, contour, groove or other traits, the failure may not be discovered until the key is actually inserted into the lock.

Businesses that offer key cutting services are often times not staffed by experienced locksmiths. Instead, employees are usually trained to "eyeball" what is thought to be the correct blank and then cut a duplicate key. Such informal and imprecise key blank identification invariably increases

2

the rate of failures for the duplication process. These failures often occur at the expense of the industry and to the extreme dismay of the key holder. Therefore, the industry would welcome an easy-to-use key blank identification system that increases the accuracy and efficiency of key replication.

Not surprisingly, numerous attempts have been made to improve identification systems and/or key replication systems. Many of these improvements include imaging systems designed to determine the proper key blank based on physical parameters of the key to be copied, such as length, shape, and groove characteristics.

While many of these systems provide useful improvements for determining a proper key blank, they still suffer from various deficiencies. Specifically, many of these systems compare scanned data from a master key to be copied with data from known key blanks in order to determine if the master key matches the key blank. However, in some instances the scanned key parameters and the key blank data are insufficient to determine a matching key blank. In such cases, additional information about the master key and the key blank would be useful in narrowing the field of prospective key blanks. Accordingly, an improved system and method for determining a key blank is needed.

SUMMARY

A key identification system is provided. The key identification system comprises an imaging system to capture an image of a master key, and a logic to analyze the image. The imaging system may be configured to capture an image of a groove in the key from an angle between perpendicular and parallel to the blade of said master key. The logic analyzes the captured image to compare characteristics of the groove with groove characteristics of known key blanks.

The key identification system may account for the orientation or positioning of the master key with respect to the imaging system or key holder to determine groove characteristics of the master key. For example, the logic may analyze a contour of the groove and determine groove characteristics of the master key based on the contour and the orientation and positioning of the master key.

DESCRIPTION OF THE DRAWINGS

Objects and advantages together with the operation of the invention may be better understood by reference to the following detailed description taken in connection with the following illustrations, wherein:

FIG. 1 illustrates a master key;

FIG. 2a illustrates a first example configuration of a key ID system;

FIG. 2b illustrates a second example configuration of a key ID system;

FIG. 3 illustrates an example silhouette of a key tip;

FIG. 4 illustrates an example configuration of a key ID system with reflectors;

FIG. 5 illustrates an example scanned image of a master key blade silhouette;

FIG. 6 illustrates an example projection of a tip outline onto the image of a tip;

FIG. 7 illustrates an example calculated data set of tip groove contours;

FIG. 8 illustrates an example matching comparison between master key tip contour data and stored key blank data; and

3

FIG. 9 illustrates an example unmatched comparison between master key tip contour data and stored key blank data.

FIG. 10 illustrates the coordinate references for the outline camera image.

FIG. 11 illustrates the coordinate references for the outline camera image including the outline vanishing point.

FIG. 12 illustrates the coordinate references for the groove camera image including the groove vanishing point relating to the y-axis projection.

FIG. 13 illustrates the coordinate references for the groove camera image including the groove vanishing point relating to the x-axis projection.

FIG. 14 illustrates an angular coordinate system for a master key.

DETAILED DESCRIPTION OF THE INVENTION

Reference will now be made in detail to exemplary embodiments of the present invention, examples of which are illustrated in the accompanying drawings. It is to be understood that other embodiments may be utilized and structural and functional changes may be made without departing from the respective scope of the present invention.

A system and method for identifying a key blank are provided. The system ("key ID system") analyzes a master key to be duplicated, such as a house key, car key or other key, and determines the appropriate key blank to be used in duplicating the master key. The system and method described herein may be used independently to determine a proper key blank, or may be used in conjunction with other systems to narrow the field of prospective key blanks. Moreover, it will be understood that existing key identification systems may be modified or retrofitted to implement some or all features described herein.

The key ID system may scan a master key to determine traits and characteristics of the master key. Based on these characteristics, the key ID system may then determine the proper key blank to be used to duplicate the master key. The key ID system may include any means known in the art for determining the traits and characteristics of the master key geometry. For example, the key ID system may include an imaging system, such as a camera, laser, or any other imaging system known in the art. The imaging system may scan the master key to determine characteristics of the master key, specifically characteristics that may be unique to a specific key blank. While the key ID system is described herein as including an imaging system, it will be appreciated that other known methods or devices, such as electrical or mechanical sensors, may be used in place of or in conjunction with the imaging system to determine the traits and characteristics of the master key geometry.

With reference to FIG. 1, a master key 10 is depicted. The master key 10 may include standard key features such as a head 16 connected to a blade 18 and a groove 11. The groove 11 may comprise a channel, opening, geometric shape, or other indentation formed in the blade 18. A master key 10 may include a single groove 11 on one side of the blade 18, a single groove 11 on each side of the blade 18, multiple grooves 11 on either side of the blade 18, or any other configuration of grooves 11 with respect to the blade 18. Further, it will be appreciated, that the master key 10 may be any key and is not limited to keys having a head 16, blade 18 or groove 11.

The key ID system may include a key holder to hold the master key. The key holder may be any device capable of

4

holding or supporting a master key. For example, as shown in FIGS. 2a and 2b, the key holder 13 may comprise a lower support 15 and an upper door 12 to close onto the key. The key holder may alternatively comprise a clamp, gripper, platform, suspension, or any other device configured to hold the master key 10.

In an embodiment, the key ID system includes a camera system. The camera system includes one or more cameras configured to record images, such as digital images, of the master key. The camera system may further include other components to assist in recording images of the master key, such as lights and mirrors. The lights may be positioned to enhance the clarity and quality of the image recorded by the camera. The mirrors may be positioned to allow a camera in a first position to record an image of the key from a second position. The mirrors may further allow a single camera to record multiple images of the master key from different angles, thereby increasing the amount of information related to the master key recorded by a single camera.

The key ID system may include a logic to analyze images captured by the imaging system. As used herein, the term "logic" includes but is not limited to a software, a firmware, an executable program, a hardware or hard-wired circuit, or combinations thereof. For example, based on a desired application or needs, a logic may include a software controlled microprocessor, discrete logic like an application specific integrated circuit (ASIC), an analog circuit, a digital circuit, a programmed logic device, a memory device containing instructions, or the like. Logic may include one or more gates, combinations of gates, or other circuit components. Logic may also be fully embodied as software. Where multiple logical logics are described, it may be possible to incorporate the multiple logical logics into one physical logic. Similarly, where a single logical logic is described, it may be possible to distribute that single logical logic between multiple physical logics.

The logic may be configured to determine a correlation or likelihood of a match between a known key blank and the master key. For example, the logic may include a database to store key related information ("key data"). The key data may include characteristics of known key blanks, such as length, shape, biting information, size, shape and location of key grooves, and other geometric and physical characteristics of known key blanks. The database may be integral with the logic, in communication with the logic, or remotely accessible to the logic. The database may associate key data with specific key blanks or with types or groups of key blanks. For example, the database may associate key data with specific key manufacturers or different types of keys such as house keys or car keys. The key ID system may access the database to compare scanned characteristics of the master key with the stored key data in the database. Key blanks that do not have characteristics consistent with those of the master key may be then ruled out as possible matches for the key blank. The key ID system may scan the master key 10 one or more angles and compare the scanned data with stored key data.

The key ID system may scan a master key 10 to determine information related to the groove 11. Keys and key blanks commonly include a groove 11 or grooves 11 in the blade 18 of the key. Characteristics of the grooves 11 may be unique to a given key blank or group of key blanks. For example, the size, location, angle, and other geometric parameters of a given groove may be unique to a key blank or blanks. Further, the location of a groove 11 on a first side of the key

5

blade ("top groove") may be unique with respect to the location of a groove 11 on the second side of a key blade ("bottom groove").

The key ID system may analyze various aspects of the groove 11 of a master key 10. For example, the imaging system may capture an image of the groove 11 from a position perpendicular to the key blade 18, as illustrated by the overhead camera 20 in FIG. 2a. This camera angle provides a top view of the blade 18 and allows the overhead camera to scan the length of the groove 11. The imaging system may also capture an image of the groove 11 from the end of the tip 14 at an angle parallel to the blade 18. This angle provides a view of the groove 11 cross-section. However, neither overhead scanning of the groove 11 nor parallel scanning of the groove 11 provide sufficient contrast between the groove 11 and the rest of the key 10 to effectively determine certain parameters of the groove 11.

In many keys, a groove 11 extends from the shoulder 16 through the tip 14 of the key 10. Therefore, the shape and contours of the tip geometry reflect characteristics of the groove 11. Accordingly, unique characteristics of a master key may be determined by scanning the tip 14 from an angle designed to capture the top groove or bottom groove characteristics. This may be best accomplished by scanning the tip 14 at an angle other than perpendicular or parallel to the blade 18. For example, as shown in FIG. 2a, the key ID system may include a camera 22 facing the tip 14, and positioned at an angle slightly above parallel to the blade. In an embodiment, the camera is positioned facing the tip of the key 10, between 5 and 15 degrees from parallel to the blade of the key 10. This positioning allows the camera 22 to capture the contours of the tip 14 formed by the bottom groove 11. Alternatively, it will be appreciated that the camera may be positioned similarly underneath the key to capture the contours of the tip 14 formed by the top groove 11. As illustrated in FIG. 3, the camera 22 may capture a silhouette of the bottom groove. This silhouette may be unique to a key blank or group of key blanks, thereby narrowing the field of prospective key blanks.

It will be appreciated that configurations other than the camera configuration shown in FIG. 2a may be used to capture the tip-groove geometry. For example, the key ID system may include only a groove camera 22 without any overhead camera 20. Further, the key ID system may include a plurality of mirrors to allow a single camera at a remote position to capture multiple angles of the master key, including angles of the tip 14. In an embodiment, as shown in FIG. 4, a first mirror 30 may be positioned to provide a top view of the tip 14 from behind the key 10. A mirror may be similarly positioned below and behind the key 10 to capture an image of the bottom groove 11. This view allows the camera to capture the contours of the tip 14 formed by the top groove 11. A second mirror 32 may also be positioned to provide a top view of the tip 14 from in front of the key 10. This view allows the camera to capture the contours of the tip 14 formed by the bottom groove 11. It will be appreciated that the key ID system may include any number of cameras, mirrors, and other imaging devices to capture the desired views of the contours of the tip 14.

In an embodiment, the key ID system scans the master key 10 to capture the silhouette of the blade 18, as shown in FIG. 5. This silhouette is used to determine the outline shape of the tip 14 in order to isolate groove geometry from the tip geometry. The key ID system may also scan the tip 14 from an angled position to capture the contours of the tip 14 formed by the groove 11.

6

As shown in FIG. 6, a trigonometric projection of the tip 14 may be used to identify the portion of the tip contour that is due to the groove shape. Specifically, contour data related to contours of the groove 11 may be determined by calculating a set of scalar variables based on image information and machine constants. As described herein, points in the image taken by the overhead camera 20 are mapped to their corresponding points from the image taken from the groove camera 22.

The contour image may be compiled from data obtained by the overhead or outline camera 20. Once the outline or contour data has been generated, the outline image is resampled to generate a set of data points, as shown in FIGS. 7-9. For example, data points may be generated every 0.005 inches along the tip of the key. The data point interval of the resampled or resampled image may be adjusted based on the required accuracy for groove identification and the optical characteristics of the outline and groove cameras. For example, the data point interval may be 0.002 in order to obtain a better defined sample.

The groove contour may be compared to contours of known key blanks stored in the database to determine a matching key blank. Tolerance and/or correlation values may be set to determine if the comparison yields a match. FIG. 8 illustrates a comparison between a scanned key tip contour and stored key data of a known key blank. The statistical correlation value between the data sets is approximately 0.985, indicating a match between the master key and compared key blank. FIG. 9 illustrates another comparison between a scanned key tip contour and stored key data of a known key blank. The statistical correlation value between the data sets here is approximately 0.879, indicating that the master key and compared key blank do not match.

Referring to FIG. 2a, the plane of the overhead camera 20 image intersects the groove camera 22 image at the lower edge of the door opening 12. The overhead camera 20 observes the profile of the key 10 while the groove camera 22 is focused on the tip of the key 10. With reference to FIGS. 10-13, the line at which these two images intersect, referred to as the door axis 52, is a primary axis for purposes of determining contour data. The primary reference or origin point of the door axis is located at the center of the door 12. The plane of the door also passes through this intersection and is by definition perpendicular to the overhead camera 20 image plane.

A silhouette image of the key 10 may be captured by the groove camera 22. To capture the silhouette image, the key ID system may utilize elements such as a light source 24 and a diffuse reflector element 26, as shown in FIGS. 2a and 2b. The light source 24 may be shielded with a light shield 28 to illuminate the reflector element 26 while avoiding the tip of the key 10. In an embodiment, the directional light from the light source 24 is angled to direct the light substantially on the diffuse reflector element 26, but not on the tip of the key 10.

The light source 24 may be any light source known in the art. For example, the light source 24 may be a series of discrete LED lights substantially oriented in a row. It will be appreciated, however, that the light source 24 may be any lights arranged in any configuration. The diffuse reflector element 26 may be affixed to the interior surface of the door, such that when the light from the light source 24 strikes the diffuse reflector element 26, the diffuse reflector element 26 provides a backlit area. In other words, this arrangement provides a backlit area behind the key 10 with respect to the groove camera 22 while minimizing the amount of light that is directed toward the key 10. Thus, the groove camera 22

7

may view the key **10** tip as a substantially dark or black feature, similar to that shown in FIG. **3**. It will be appreciated, however, that the key ID system may include any additional lights, such as backlights, positioned throughout the system.

With reference to FIG. **2b**, an alternative configuration for the key ID system is shown. The groove camera **22** may be mounted in a vertical camera box **23**. The vertical camera box **23** mounts the groove camera **22** at the bottom directed upward toward a mirror **25** mounted at the other end of the vertical camera box **23**. The mirror **25** is directed toward the key **10** tip, such that the angle of incidence is nominally about 15 degrees. However, it will be appreciated that the angle of incidence upon the key **10** of the image may be any angle, preferably between approximately 5 degrees and approximately 45 degrees.

The key **10** is not constrained to a particular orientation or position when held within the key holder **13**. With reference to FIG. **14**, the key may be tilted or yawed in a plane perpendicular to the orientation of the outline camera **20**; tipped up or down relative to the plane defined perpendicular to the door opening **12**; and rotated around the axis of the key blank it self (rolled) or combinations of any of the preceding as well as variations caused by the overall length of the key blade **10** that would position the tip of the key at various focus positions relative to the groove camera **22**. Thus it is necessary to correct for the optical distortions and transform the images obtained from the two different cameras to obtain an effective image of the tip **14**.

The concept of a vanishing point is used to handle the foreshortening of the key **10** when viewed by the groove camera **22**. The effects of this foreshortening vary greatly as the end of the key **10** is tipped up or down slightly by the clamping action of the door **12**. The distance from the door to the vanishing point may be substantially affected by this tipping action.

To compensate for the angle between the groove camera **22** and the key **10**, the distance from the tip of the key to the door axis is readily determined for both the overhead camera **20** image and groove camera **22** image. The ratio of these distances (hereinafter "GrooveLR") is dependent both on the angle between the groove camera **22** angle and the key tipping angle. The actual values of these angles may be ignored because only the ratio is required for the calculations to compensate for the key location.

In an embodiment, a groove image vanishing point may be determined by multiplying the distance to the outline image vanishing point by the ratio GrooveLR. The outline image vanishing point may first be empirically determined. For example, previous test indicate a sample outline image vanishing point to be 20 inches from the origin of the door axis. The outline image vanishing point depends on the configuration of the key ID system and the characteristics of the cameras. Vanishing points may be assumed to be on the door centerline axis. However, in other embodiments vanishing points may be offset from the door centerline axis with additional compensation.

FIGS. **10-13** illustrate a crop box **50** used for limiting the image of the key **10**. An example of an outline crop box **50** is shown in FIG. **5**, where the outline crop box **50** defines the outer periphery of the image. The outline crop box functions to limit the image that is actually processed by the system, even though the actual image captured by the camera is larger than the outline crop box **50**. The outline vanishing point is far to the left of the outline crop box **50** along its X axis shown as point **52**. The groove vanishing point is above the groove crop box **60**, shown in FIG. **6**, along its Y axis at

8

point **62**. The groove crop box **60**, serves a similar function to the outline crop box **50**, namely it reduces the overall image processed by the system to a subset of the actual image captured, in this case by the groove camera **22**. This outline image vanishing point distance is combined with vOutX to calculate the x axis distance from the vanishing point to the starting point. While a specific method determining the vanishing points and associated distances is described, it will be appreciated that other methods may be used.

FIG. **10** shows the position of the starting location relative to the door axis and the Outline Camera image. vOutX and vOutY are the x and y coordinates of a point at the tip of a key image that is to be mapped to the groove image. These points correspond to the set of data points that define the tip of the key. The units of the outline camera **20** are in pixels. Thus a series of vOutX and vOutY points are created to define the tip of the key.

FIG. **11** shows the starting point translation to distances from the outline view vanishing point. This distance is multiplied by GrooveLR to yield the outline VPy shown on FIG. **11** and referred to as GVPY (groove image vanishing point distance).

FIG. **12** shows the construction of the projected tip point y axis coordinate. This projection is made on the Groove Camera image plane. The y axis projection is simply the difference between GVPY and GrooveVP.

The x axis projection calculation uses the GVPY to GrooveVP ratio as shown in FIG. **13**. The Groove Door X distance may be determined from the outline image. The Groove Door X distance may be scaled by the GVPY to GrooveVP ratio and added to the Groove Crop Box Center distance to find gsx which is the x axis coordinate. A trim value may be added to enable small physical offsets to be adjusted during machine calibration.

Once each point on the outline camera **20** image has been mapped to the groove camera **22** image, the groove contour data may be determined. FIG. **6** shows a typical groove image with two rows on points drawn at its tip. The row that is touching the tip may be calculated using the method described here. The lower row may be extrapolated from the same data points.

The groove contour is found by measuring the distance from a point that is eight pixels below the mapped point to the actual white to black edge in the groove image. Giving the edge detection software the extra pixels allows it to readily find a transition and allows for small errors if the mapped points are slightly above the actual transition. The set of these distances forms the groove contour.

Various tip shapes and bittings near the tip of the key may affect the image of the grooves as seen by the groove camera **22**. Therefore, it may be helpful to manipulate the groove data in an attempt to compute how the grooves would appear if the key blade was cut off square. To accommodate this manipulation, a scan of the outline data (from the outline camera **20** image) along the tip of the key may be performed with respect to a series lines that are parallel with the axis of the key. This yields a series of measurements that determine the distance from the edges of the tip of the key to some arbitrary squarely cut edge. These measurements may then be translated to the groove camera **22** image using a process described below. These translated key tip points **62** in the groove image **60** represent the tip of the key as if there were no grooves in the key. Differences between these points and the observed edge of the tip of the key in the groove image **60** represent the actual shape of the grooves as if the key blade was cut off square.

The final task of blank identification is to match the measured contour with the stored characteristics. The type of key 10 may be used to help match the contour with the appropriate data set. For symmetrical double sided keys the direction of the key insertion into the key identification system is irrelevant because the grooves and other features are symmetrical so a single characteristic reference image is stored for those symmetric keys. For most single sided keys, both sides of the key (referred to as left and right) are distinctive. In those cases, the characteristic reference images for each key includes a left and right view. When performing comparisons, right cuts are only matched to data for single cut blanks and only right cut data for those blanks. The data is also aligned so the key reference sides (e.g. in the case of a single sided key, the flat of the blank) are near each other. Often cut key data has many fewer data points so it is assumed data points opposite the reference side is where the metal (and data) have been removed. Double cut keys are matched based on the centerlines.

A series of comparisons may performed between the characteristic reference image that is stored in the database and the actual captured image to compensate for small registration errors. The comparison may be performed via a 2-D correlation analysis described in greater detail below. Specifically, the data may be moved a few data points in each direction. These points may then be compared and analyzed with the best result being chosen as the correct data point.

Small errors in image registration and performing the transpositions between the images can cause the contour data to be sloped up or down. This is called "roll" and is similar to an airplane roll where the wings are not level. Some level of roll is presumed to be dependent on unique machine set up details. To compensate for this roll, each key ID system may have a roll constant that is used to adjust its measured values. This insures that biases are not a factor when compared to stored data sets that were generated on other machines.

There also may be roll based on individual key scans. A second roll test may be used to insure the best possible match after the machine roll has been accounted for, and the best horizontal sliding position has been determined. Each comparison is done for as many as 40 different roll values to determine the best match. These calculations assure the comparison is done as accurately as possible. In other embodiments, larger numbers of roll values may be used to handle greater variation in the image captured by the groove camera 22.

Mathematical correlation may also be as the basis of contour comparison. The correlation may be done based on a standard formula. However, if a data point in the newly collected data or stored data is potentially in error it may be excluded from the correlation calculation. The actual data may have values larger than one as we begin the scan for groove edge data 8 pixels below the first expected transition point. Alternatively, different pixel offsets may be used based on the likelihood of erroneous data. If this data is set to -1 that point is excluded from the calculation. Some stored data is manually set to -1 to compensate for scan errors and to de-emphasize some features of the contours. Errors in edge detection can cause -1 values in the newly scanned data.

Other methods may be employed to compare the tip image to the reference contours. One method is to fit the contour inside an envelope based on the stored contours. Other techniques taking advantage of various basis functions are also suitable for performing the comparisons between

the characteristic reference images and the captured image in order to obtain a match as well.

A secondary test may be added to the standard correlation calculation. Some key blanks have the same overall pattern of grooves, but the groove depths are exaggerated on some blanks more than others. Since correlation may be insensitive to scale, these blanks may be found to match even where there are large differences in actual groove depths. A second factor based on the standard deviation of the two contour data sets is used to aid in this differentiation. The factor is calculated by taking the difference between the two standard deviations and dividing it by the sum of the two values. This value is then subtracted from the correlation coefficient and a secondary test is performed. The resulting correlation results are used to provide an estimate as to which type of key is inserted into the key ID system. In an embodiment, the correlation results are used in conjunction with the key outline characterization to further narrow and reduce the type of key identified.

Both the standard correlation value and the adjusted correlation value are unitless and non-scaled numbers between 0 and 1. In order to provide more meaning to the values, each is resealed to a scoring system of 0 to 100% where 0 is considered to be an impossible match and 100 is a perfect match. In an embodiment, standard correlations of 0.60 to 1.0 are resealed to a score of 0 to 100% and adjusted correlations of 0.50 to 1.0 are resealed to a score of 0 to 100%. Any correlations of less than the 0.60 and/or 0.50, respectively, are considered to be impossible matches. The total groove scanning score or correlation score may be a weighted average of these two individual scores.

The key ID system as described may be used in conjunction with other known key identification systems. For example, the key ID system may be used in conjunction with user interface identification systems, such as the object identification system disclosed in U.S. Publication No. 2004/0095380 and the key duplication system disclosed in U.S. Publication No. 2007/0224008, each of which are hereby incorporated by reference in their entirety.

The invention has been described above and, obviously, modifications and alternations will occur to others upon a reading and understanding of this specification. The claims as follows are intended to include all modifications and alterations insofar as they come within the scope of the claims or the equivalent thereof.

What is claimed is:

1. A key identification system comprising:

an imaging system including a camera configured to capture an image of the tip of a master key, wherein said image includes a contour;

a logic configured to analyze said captured image to determine characteristics of said contour and compare said characteristics with characteristics of known key blanks to determine the likelihood of a match between said master key and a known key blank; and

one or more mirrors positioned to allow said camera to capture two or more views of the master key wherein said characteristics of said contour are determined based on image data from at least said two or more views of said master key wherein at least one said view is substantially a tip end view, and wherein said logic calculates the geometry of the contour based on data from at least said two or more views of said master key.

2. The key identification system of claim 1, wherein said logic includes a database containing data related to characteristics of grooves of known key blanks.

11

3. The key identification system of claim 1, wherein said imaging system includes a reflecting device.

4. The key identification system of claim 3, wherein said imaging system includes a light.

5. The key identification system of claim 4, wherein said light is directed toward said reflecting device.

6. The key identification system of claim 5, wherein said light includes a shield to direct light away from said master key.

7. The key identification system of claim 1, wherein said captured image is a digital image.

8. The key identification system of claim 1, wherein said captured image comprises a silhouette of said tip of said master key.

9. The key identification system of claim 1, wherein said logic accounts for rolling of said master key with respect to said imaging system to determine characteristics of said contour.

10. The key identification system of claim 1, wherein said logic accounts for tilting of said master key with respect to said imaging system to determine characteristics of said contour.

11. The key identification system of claim 1, wherein said logic accounts for tipping of said master key with respect to said imaging system to determine characteristics of said contour.

12. The key identification system of claim 1, wherein said captured image comprises a silhouette of the blade of said master key.

13. The key identification system of claim 1, wherein said logic calculates the geometry of the contour as seen from a view of the tip parallel to the blade based on data from at least said two or more views of said master key.

14. The key identification system of claim 1, wherein said logic calculates the geometry of the contour as though the tip were squarely cut based on data from at least said two or more views of said master key.

15. The key identification system of claim 1 further comprising a key holder configured to hold said master key.

16. The key identification system of claim 15, wherein said key holder includes a lower support.

17. The key identification system of claim 15, wherein said key holder includes an upper door.

18. The key identification system of claim 15, wherein said key holder includes a clamp.

19. The key identification system of claim 1, wherein one of said views of said master key includes a view from above the master key blade of a groove in the bottom of said blade.

20. The key identification system of claim 1, wherein one of said views of said master key includes a view from an

12

angle between perpendicular and parallel to the blade of said master key and not including perpendicular or parallel to the blade of said master key.

21. The key identification system of claim 1, wherein the captured image of said tip includes a contour of a groove in said master key.

22. The key identification system of claim 1, wherein the logic is configured to shift data related to said characteristics of said contour to compare with said known key blank characteristics.

23. The key identification system of claim 1, wherein said logic includes a tolerance range for each characteristic of said master key to determine whether a master key passes or fails to match a known key blank.

24. A key identification system comprising:
an imaging system including a camera in a first position configured to directly capture at least one image of one side of a master key, wherein said image includes a contour;

at least one mirror positioned to allow said camera to capture at least one image of a second side of a master key from a second position wherein the second position is from a different angle than the first position, wherein the image from the second angle is substantially a tip end view; and

a logic configured to analyze said captured images to determine characteristics of said contour and compare said characteristics with characteristics of known key blanks to determine the likelihood of a match between said master key and a known key blank.

25. The key identification system of claim 24, wherein the at least one mirror is configured to allow the camera to capture one image with multiple views of the master key from different angles.

26. A key identification system comprising:
an imaging system including a camera configured to capture an image of a master key, the image includes a first view and a second view;

a first mirror positioned at a first position to allow said camera to capture the first view of the master key wherein the first view is a substantial tip end view, at least one second mirror positioned at a second position to allow said camera to capture a second view of the master key, wherein the first view is from a different angle than the second view; and

a logic configured to analyze said captured image to determine characteristics of said contour and compare said characteristics with characteristics of known key blanks to determine the likelihood of a match between said master key and a known key blank.

* * * * *