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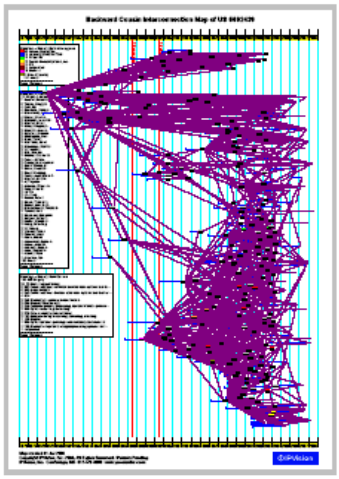
Lemelson-MIT Prize

U.S. Patent Portfolio of Luis von Ahn - 2018 Winner

Report for: Lemelson-MIT Program



IPVision
Patent Interconnection Map

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Report Date: September 6, 2018

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Report Prepared For: Lemelson-MIT Program

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Important Note About Data. The analyses presented in this Report were based on data as of September 6, 2018 – i.e., the patents listed for a given company represent patents owned of record as shown at the U.S. Patent and Trademark Office databases as of that date. Patents issued to, acquired by or disposed of by such a company after September 6, 2018 will not appear in the list of patents shown in this Report. However, patents that issue after September 6, 2018 that cite a patent shown in an analysis in this Report will appear in any citation analysis run after September 6, 2018 on the information stored on See-The-Forest.com™. In such as case there will be an inconsistency between the results presented in this Report (which is a snapshot in time) and the results shown on See-The-Forest.com™.

1. LUIS VON AHN

Luis von Ahn is Associate Professor in the Computer Science Department at Carnegie Mellon University; CEO/co-Founder of Duolingo and CEO/Founder of reCAPTCHA.

Professor von Ahn received his B.S. in Mathematics from Duke University (2000) and his Ph.D in Computer Science from Carnegie Mellon University (2005).

1.1 TECHNICAL INNOVATION HIGHLIGHTS

Professor Von Ahn's research interests include novel techniques for utilizing the computational abilities of humans, such as games in which people collectively solve large-scale problems that computers cannot yet solve. He has also researched human-computer interaction, artificial intelligence, theoretical cryptography and security, and computer science theory in general.

- Cryptography. Together with Nicholas Hopper and John Langford, Professor von Ahn was the first to provide rigorous definitions of steganography and to prove that private-key steganography is possible.
- CAPTCHA. Computer-generated tests that humans are routinely able to pass but that computers have not mastered. Websites use CAPTCHAs to prevent automated programs from perpetrating large-scale abuse, such as automatically registering for large numbers of accounts or buying huge amounts of tickets for resale by scalpers.
- Games With A Purpose / The ESP Game. Offered an innovative solution to the otherwise tedious task of image recognition; it is difficult for computers to perform independently, and while humans are perfectly capable of it, they are not necessarily willing. By making the recognition task a "game," Professor von Ahn found that people were more likely to participate. Google bought the ESP Game in 2006 in the form of the Google Image Labeler, which was critical in improving the accuracy of the Google Image Search.
- ReCAPTCHA. ReCAPTCHA technology was developed not just to enhance cybersecurity, but also as a way to harness and reuse all of the human time and energy spent solving and typing CAPTCHAs. By constructing CAPTCHAs using words tagged as unreadable in the digitization of books and other printed material, millions of web users play a part every day in the preservation of human knowledge by transcribing words. ReCAPTCHA was acquired by Google in 2009.
- Duolingo. Co-founded by Professor von Ahn, Duolingo has grown to be the largest online language-learning platform in the world, offering nearly 100 courses to over 150 million users globally.

1.2 VON AHN U.S PATENT PORTFOLIO

Professor von Ahn is a named inventor on 6 issued U.S. patents (the "von Ahn Patents") and 3 published pending U.S. patent applications (together with the von Ahn Patents, the "von Ahn Patent Properties"). The following table shows these, the number of Backward Citations (BCs) (i.e., prior patents cited by von Ahn) and the number of Forward Citations (FCs) (i.e., patents issued after the von Ahn Patents that cite the von Ahn Patents as prior patent art):

U.S. Patent Properties of Luis von Ahn				
Patent #	Title	Inventors	# of Patent Citations By (BCs)	# of Patent Citations To (FCs)
7478110	Game-powered search engine	von Ahn Arellano, Luis A.; Brill, Eric D.; Platt, John C.; Benaloh, Josh	16	1
7603343	Quality of web search results using a game	von Ahn Arellano, Luis; Benaloh, Josh D.	11	4
7785180	Method, apparatus, and system for object recognition, object segmentation and knowledge acquisition	von Ahn, Luis; Liu, Ruoran; Blum, Manuel; Efros, Alexei A.; Veloso, Maria Manuela	10	16
7980953	Method for labeling images through a computer game	von Ahn Arellano, Luis	0	5
8555353	Methods and apparatuses for controlling access to computer systems and for annotating media files	Von Ahn, Luis; Blum, Manuel; Maurer, Benjamin D.	47	4
9600648	Methods and apparatuses for controlling access to computer systems and for annotating media files	Von Ahn, Luis; Blum, Manuel; Maurer, Benjamin D.	73	0
20120141959	CROWD-SOURCING THE PERFORMANCE OF TASKS THROUGH ONLINE EDUCATION	von Ahn Arellano Luis Alfonso (Pittsburgh, PA); Hacker Severin Benedict Hans (Pittsburgh, PA)	0	16
20150128236	Systems and Methods for Verifying a User Based on Reputational Information	Moscicki, Angelique; Tan, Edison; Arnoud, Sacha Christophe; Abraham, David John; Crawford, Michael; McMillen, Colin; McClain, Joseph Andrew; Pendleton, Bryan Arthur; Russell, Mark R.; Von Ahn, Luis	0	6

U.S. Patent Properties of Luis von Ahn				
Patent #	Title	Inventors	# of Patent Citations By (BCs)	# of Patent Citations To (FCs)
20170068986	INTERACTIVE SPONSORED EXERCISES	Chan, Brooke Elizabeth; Gotthilf, Regina; Hartman, Gregory David; Murphy, Tyler; Verma, Awaneesh; von Ahn Arellano, Luis Alfonso; Alvarez Mury, Rogelio	0	0
7478110	Game-powered search engine	von Ahn Arellano, Luis A.; Brill, Eric D.; Platt, John C.; Benaloh, Josh	16	1

View von Ahn Patents on IPVision *See-The-Forest.com*™ ► Link to List

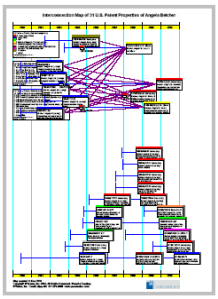
1.2.1 VON AHN PATENT PORTFOLIO INTERCONNECTION MAP

An IPVision Patent Portfolio Interconnection Map shows all of the U.S. patents and published U.S. patent applications that comprise the patent portfolio of the Inventor. These are displayed as "patent boxes" arrayed in time from left (earliest) to right (more recent). A line connecting a later patent box to an earlier patent box shows that the later patent cited the earlier patent as "prior patent art". See, Appendix A – Reading IPVision Maps.

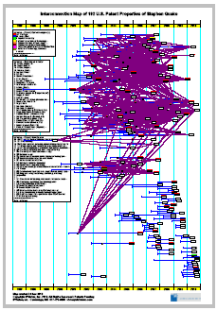
Note: A portfolio with a high degree of self citation is likely to have more commercial potential than a portfolio of individual inventions "scattered about".

Two examples of patent portfolios are shown to the right. The top portfolio is of Angela Belcher (44 patent properties), the 2013 Lemelson-MIT Prize Winner. The bottom portfolio is that of Stephen Quake (192 patent properties), the 2012 Lemelson-MIT Prize Winner. Not only does Dr. Quake have more patents, they are also more "clustered" than those of Dr. Belcher. Note: in both cases we have included published U.S. patents applications that have issued as U.S. patents.

Dr. Quake's portfolio is more clustered primarily because of the patents issued to Fluidigm, a leading microfluidics company founded by Dr. Quake.



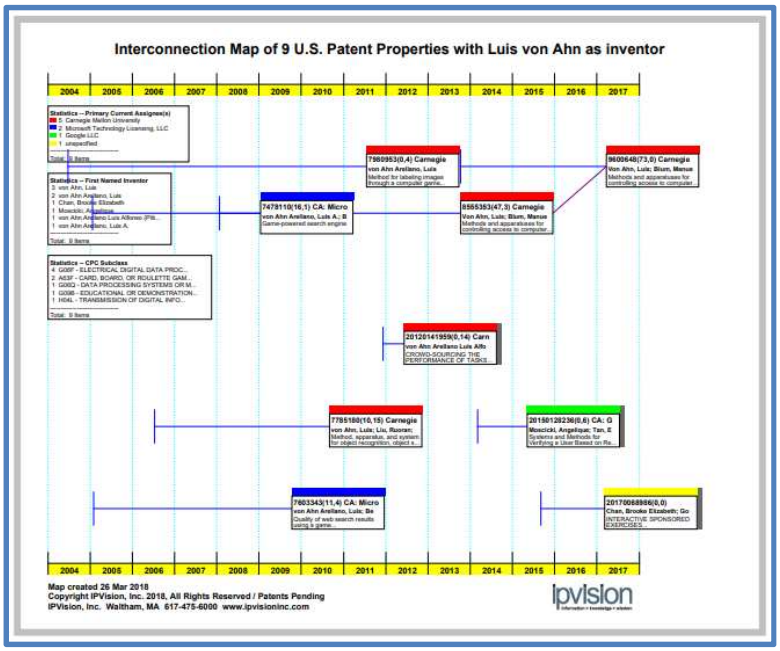
Angela Belcher – 2013 Winner



Stephen Quake – 2012 Winner

The following is an IPVision Patent Portfolio Interconnection Map™ showing the patent citation relationships among the von Ahn Patent Properties:

Patent Portfolio Interconnection Map™ of Luis von Ahn



Statistics -- Primary Current Assignee(s)
5 Carnegie Mellon University
2 Microsoft Technology Licensing, LLC
1 Google LLC
1 unspecified
Total: 9 Items

Patent Citation Interconnection Map™: This IPVision Patent Citation Interconnection Map™ shows the 9 U.S. patent properties of Luis von Ahn on a timeline from left to right. Each box is a patent or pending application with the left edge of the box aligned in time based on issue date (for patents) or publication date (for applications).

On a interconnection map the lines connecting the boxes are the patents citation references. In the case of von Ahn there is only one cross-citation, suggesting that his patents are discrete, separate inventions.

Click on the Map Image to view an interactive map online. When viewing the interactive map you can "right click" to view the underlying patent and related information.

Note: For information about Reading IPVision Maps, see Appendix A

View Live IPVision Map™ ► Link to Map

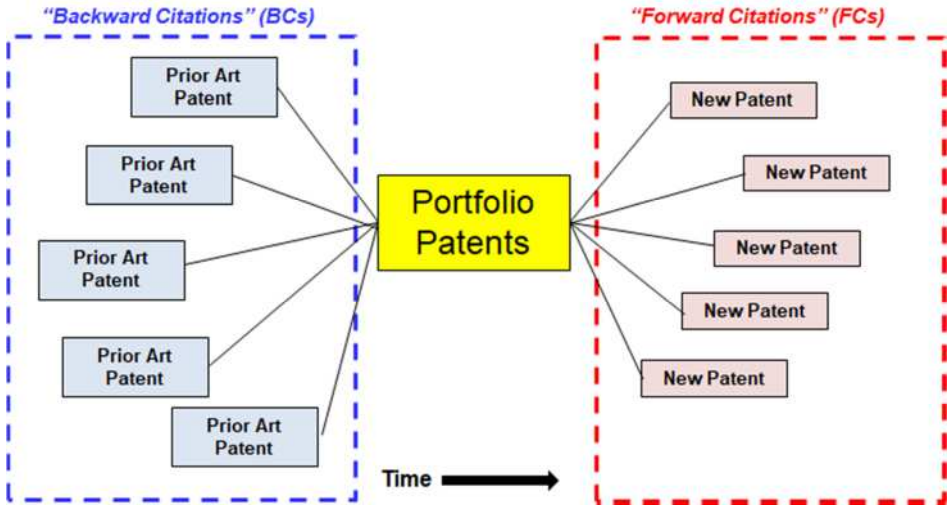
1.3 DIRECT PATENT CITATION LANDSCAPE

In order to obtain a patent an inventor must show that his or her invention is "novel", i.e. new. During the patent prosecution process the inventor must disclose to the U.S. Patent and Trademark Office all "prior art" of which the inventor is aware that is relevant to the determination of whether the invention is novel. Prior art consists of papers, articles and patents. In addition the Patent Office Examiner conducts searches of literature and patents as part of the novelty determination.

The citations by patents of prior art are often more relevant than citations in academic papers because the prior art citations have legal significance, i.e., a patent can be invalidated if an inventor fails to cite prior art of which he or she is aware, so called Fraud on the Patent Office.

Patent citations also provide insights into how the invention(s) described in the patent lead to later inventions, i.e., how those inventions "spawned" later inventions.

To get a sense of how "crowded" the technology area is around Professor von Ahn's patent portfolio we looked at the direct patent citation landscape, i.e., the patents that the patents in the portfolio cite as prior art (Backward Citations) and the patents that cite patents in the portfolio (Forward Citations):

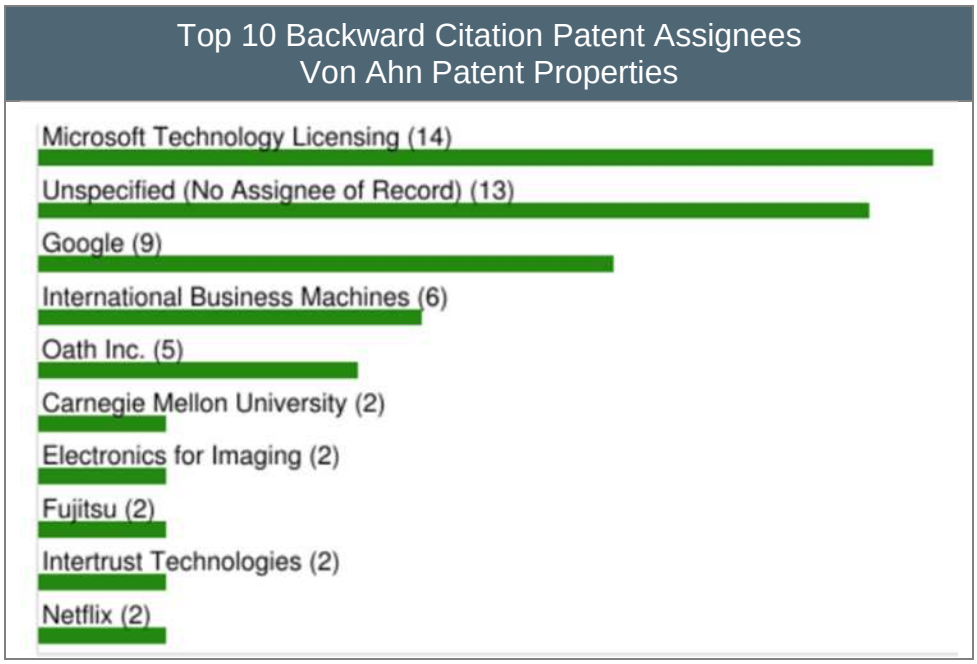


Backward Citations: Patents Cited by von Ahn Patents. There are 109 other U.S. patent properties ("Backward Citation Patents" or "BCs") that are cited by the 6 patents[1] in the von Ahn Portfolio. These patents are cited 157 times by patents in the Portfolio. These Backward Citation patents are owned of record by 60+ organizations or persons:

View "List of Backward Citation Patents" ► Link to List

According to the U.S. Patent and Trademark Office records, the Top 10 Current Assignee/Owners of the Backward Citation Patent Properties are:

[1] Patents cite other patents and published patent applications. A published patent application does not contain prior art citations – those are added if and when the application becomes an issued patent.

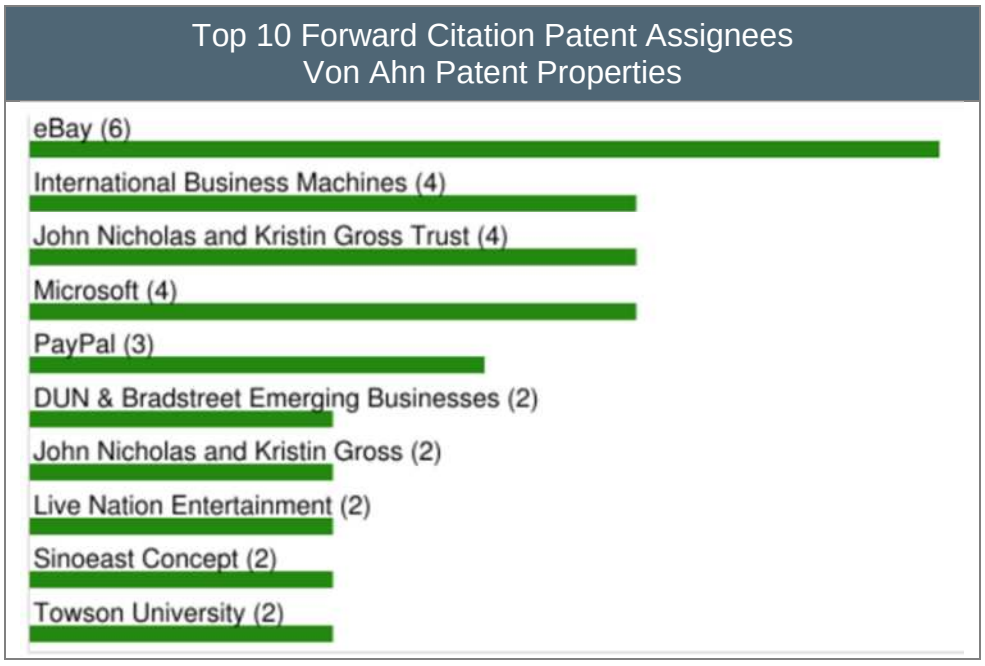


View "Backward Citation Assignee Analysis" ► Link to Analysis

Forward Citations: Patents Citing von Ahn Patents. There are 49 other U.S. patent properties ("Forward Citation Patents" or "FCs") that cite the U.S. patent properties in the von Ahn Portfolio. These FC patents cite the von Ahn Portfolio 51 times. These Forward Citation patents are owned of record by 24 organizations:

View "List of Forward Citation Patents" ► Link to List

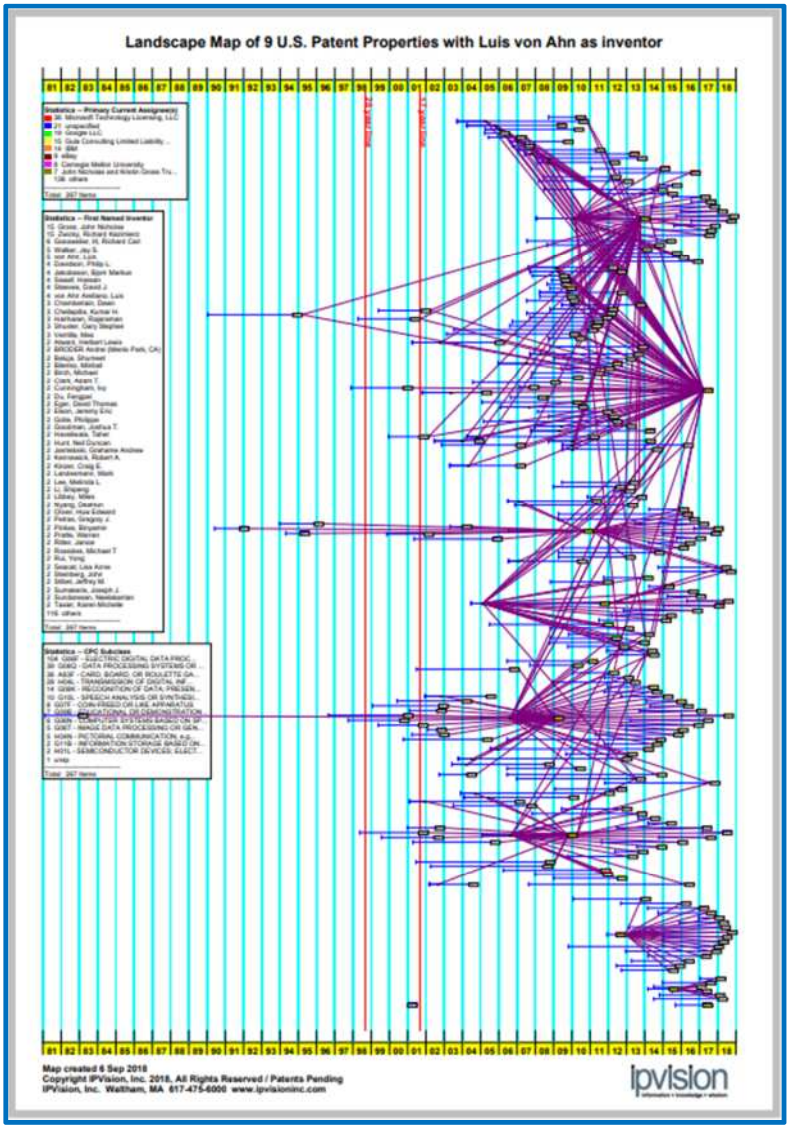
According to the U.S. Patent and Trademark Office records, the Top 10 Current Assignee/Owners of the Forward Citation Patent Properties are:



View "Forward Citation Assignee Analysis" ► Link to Analysis

Full Landscape Map of von Ahn Portfolio. The following Full Landscape Map shows the von Ahn Patents, the Backward Citation Patents they cite and the Forward Citation Patents that cite the von Ahn Portfolio:

Full Patent Citation Landscape Map™
Von Ahn Portfolio



Statistics -- Primary Current Assignee(s)
38 Microsoft Technology Licensing, LLC
21 unspecified
19 Google LLC
15 Gula Consulting Limited Liability ...
14 IBM
9 eBay
8 Carnegie Mellon University
7 John Nicholas and Kristin Gross Tru...
136 others

Total: 267 Items

Patent Citation Landscape Map™: This IPVision Full Patent Citation Landscape Map™ shows the von Ahn Patents (yellow colored) on a timeline from left to right. To the right of each von Ahn patent are the Forward Citation Patents, – i.e., patents that cite the von Ahn Patents as prior patent art.

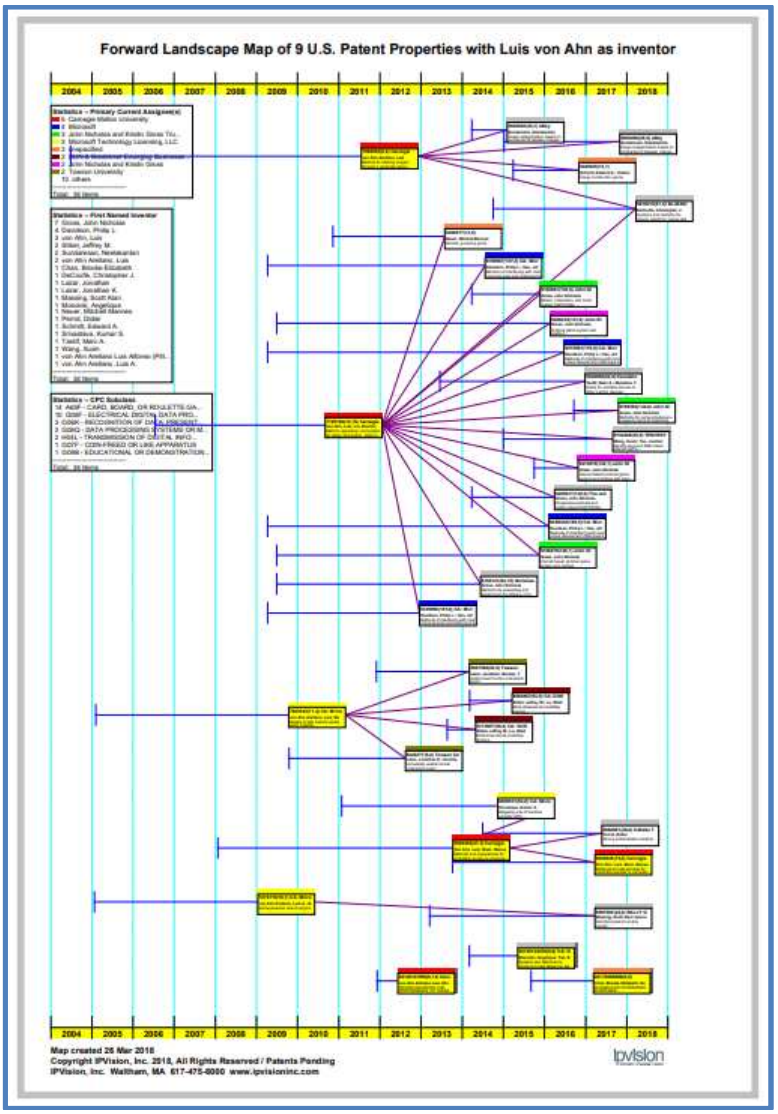
To the left of the von Ahn Patents are the Backward Citation Patents – i.e., patents that are cited by von Ahn as prior art.

Note: For information about Reading IPVision Maps, see Appendix A

View Live IPVision Map™ ►	Link to Map

Forward Landscape Map of von Ahn Portfolio. To illustrate better the patents that have recognized von Ahn's work we pulled out the Forward Citation Patents and mapped them separately with the von Ahn Portfolio, creating a "Forward Landscape Patent Map":

Forward Patent Citation Landscape Map™
Von Ahn Portfolio



Statistics -- Primary Current Assignee(s)
5 Carnegie Mellon University
4 Microsoft
3 John Nicholas and Kristin Gross Tru...
3 Microsoft Technology Licensing, LLC
3 unspecified
2 DUN & Bradstreet Emerging Businesse...
2 John Nicholas and Kristin Gross
2 Towson University
10 others
Total: 34 Items

Patent Citation Landscape Map™: This IPVision Forward Patent Citation Landscape Map™ shows the von Ahn Patents (yellow colored) on a timeline from left to right. To the right of each von Ahn patent are the Forward Citation Patents, – i.e., patents that cite the von Ahn Patents as prior patent art.

As can be seen from the list of Current Assignees, there is a mixture of academic institutions and commercial companies, perhaps indicating that this technology, although "new", is starting to see commercialization.

Note: For information about Reading IPVision Maps, see Appendix A

View Live IPVision Map™ ► Link to Map

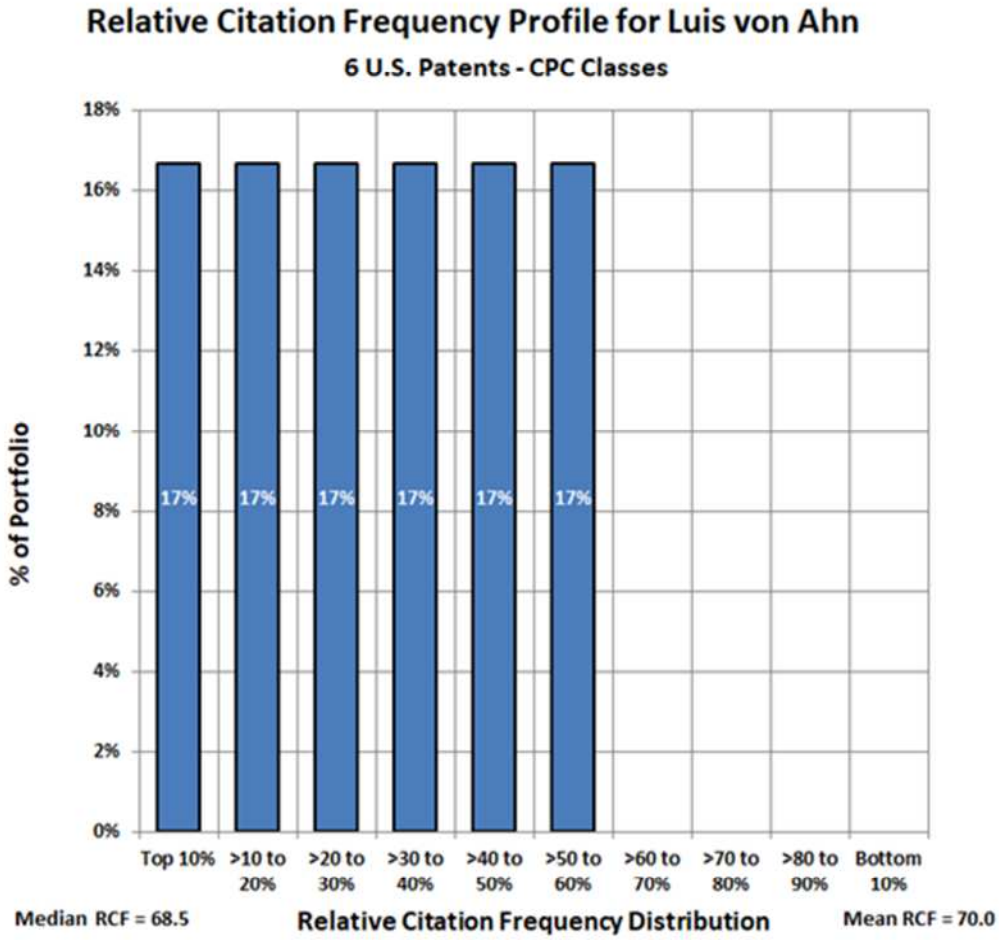
1.4 RELATIVE CITATION FREQUENCY

The number of citations of an inventor's patents by other inventors is a measure of the importance of an invention.[2] The Relative Citation Frequency for a patent is an IPVision developed normalized metric that measures how highly cited the patent is relative to Peer Patents (patents in the same technology area of the same age) where 100 equals the most cited.[3]

[2] See, Jaffe, Adam B. and Trajtenberg, Manuel, *Patents, Citations & Innovations: a Window on the Knowledge Economy* (Cambridge, The MIT Press, 2002)

[3] See "Appendix B - Relative Citation Frequency" for a fuller description of Relative Citation Frequency.

The Relative Citation Frequency scores distribution for the von Ahn Optogenetics Portfolio are:

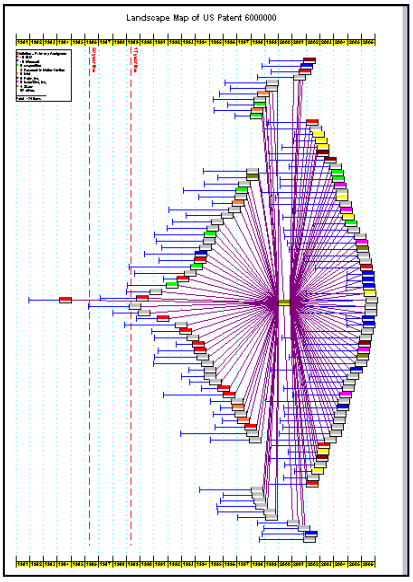


This profile shows that the von Ahn patents are **Somewhat Highly Cited** relative to their Peer Patents, with 34% of the patents in the portfolio being in the top 20% most highly cited range and 17% in the top 10%. Mean RCF Score = 70.0; Median = 68.5. It will be interesting to see how this develops as the technology area matures. See Appendix B - Relative Citation Frequency.

2. APPENDICES AND EXHIBITS

APPENDIX A – HOW TO READ AN IPVISION MAP

An IPVision Map is a visual representation of the relationships between objects. The following is an example of a Landscape Map for a single U.S. Patent:

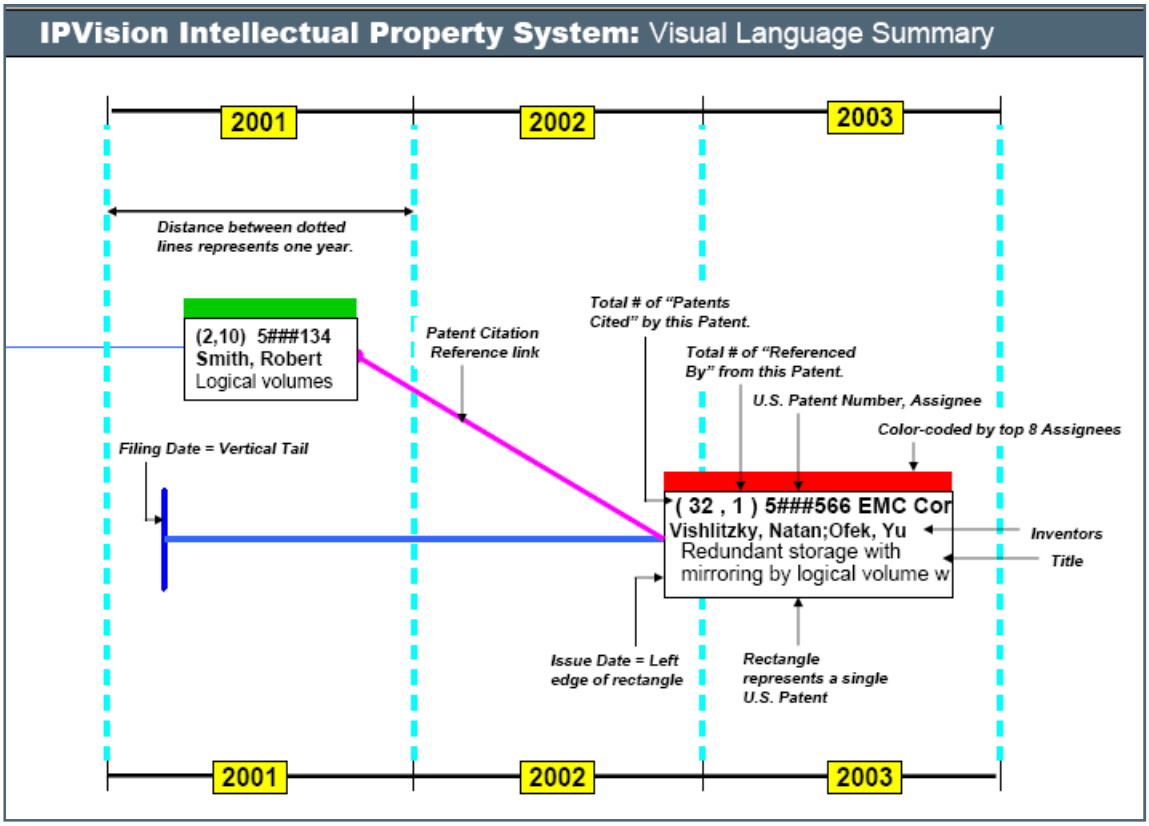


This Landscape Map is of U.S. Patent 6,000,000 entitled "Extendible method and apparatus for synchronizing multiple files on two different computer systems". It is the basic patent for the Palm Pilot software.

The horizontal X axis is "time"

Patent 6000000 is in the middle of the "fan". The lines going backward (to the left) are the patents cited by Patent 6000000 and the lines going forward (to the right) show the patents which cite Patent 6000000.

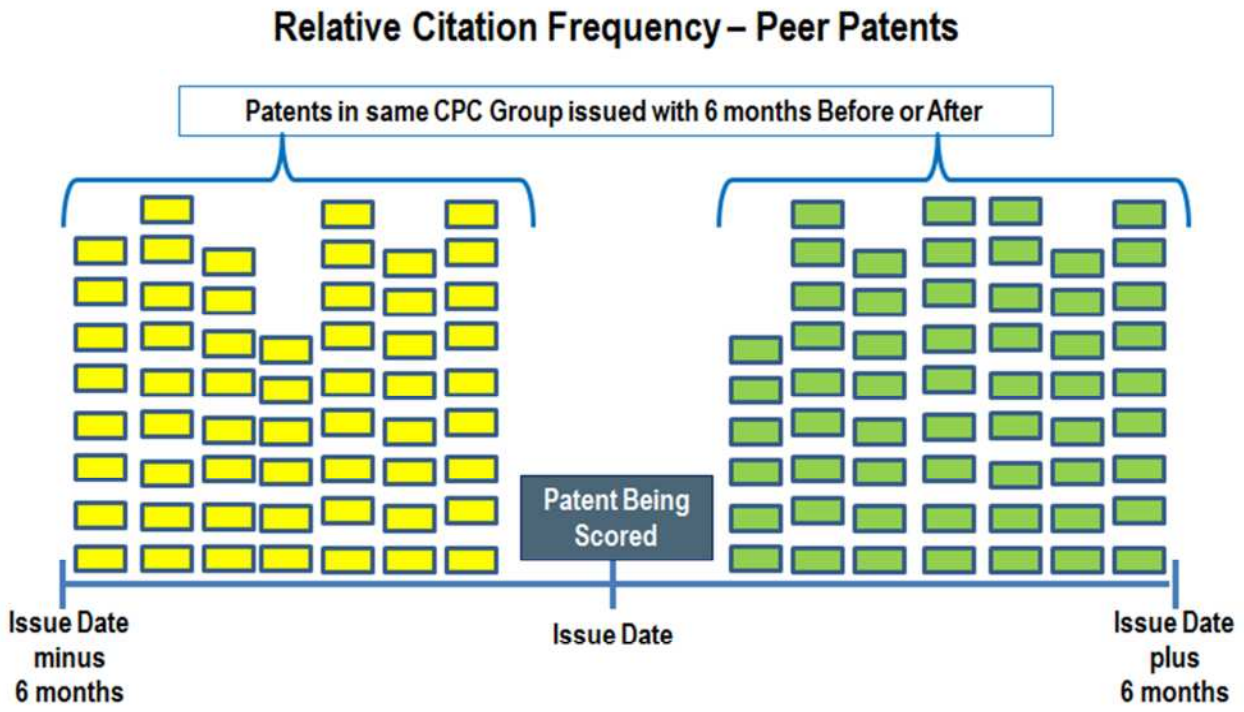
The details of an IPVision Map are explained in more detail below. See also a Guide To Reading IPVision Patent Maps.



APPENDIX B - RELATIVE CITATION FREQUENCY

The number of citations of an inventor's patents by other inventors is a measure of the importance of an invention.[4] However, the number of patent citations to a patent is a function of the importance of the patent, the speed of patenting in the technology area and the age of the patent (the older the patent the more time it has to be cited). Accordingly, it can not be determined whether a patent that is cited 50 times is "highly cited" or whether 50 citations is "average" unless you look at the number of citations relative to the patent's "peers".

IPVision has developed a Relative Citation Frequency (RCF) Score for a patent. For a given patent the RCF Score algorithm finds that patent's "Peer Patents", i.e., all patents in the same Cooperative Patent Classification System[5] "group" that were issued within 6 months before or after the patent being scored. RCF then determines the relative citation frequency of the patent versus its Peer Patents.



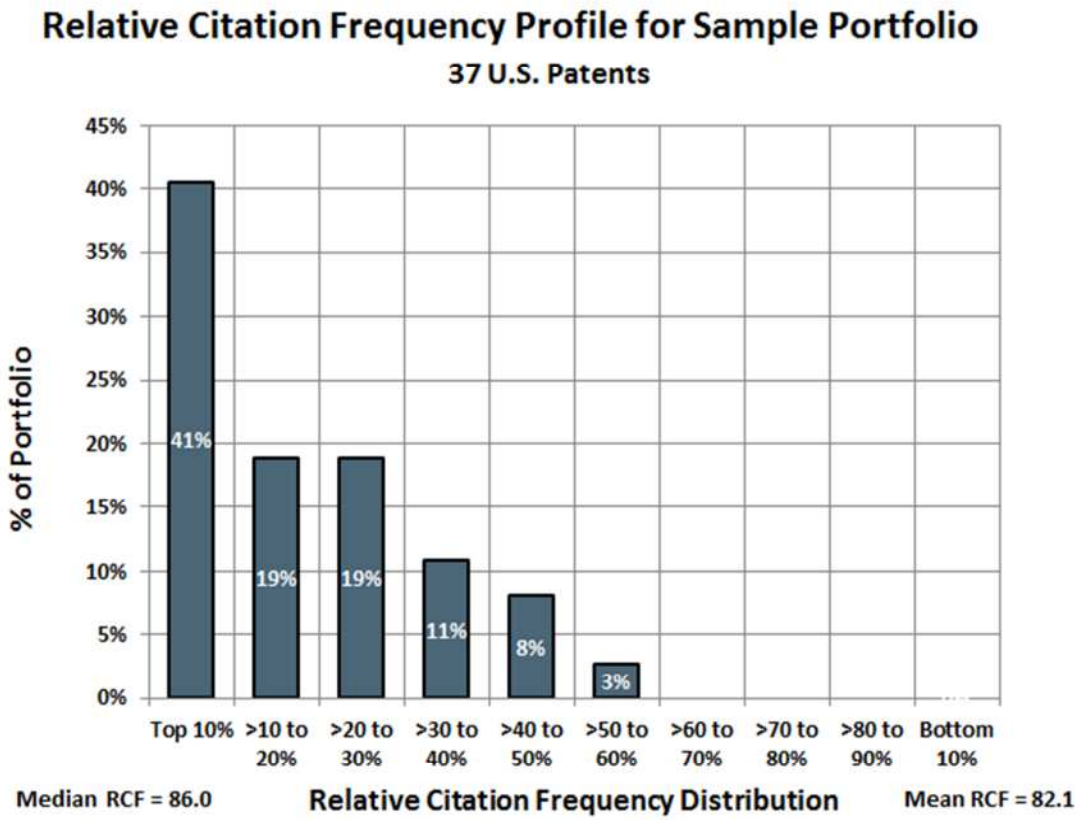
RCF Score for a Patent

Once the Peer Patents are assembled for the patent being scored we look at the minimum and maximum number of citations to the Peer Patents and we normalize these on a scale from 0 to 100 where 100 is the most highly cited of the Peer Patent group. We then place the patent being scored in context in the Peer Patent group. The resulting score represents the percentage of the Peer Patents that is cited LESS than the patent being scored, -e.g., a score of 92 means the patent is cited more often than 91.9% of the Peer Patents.

[4] See, Jaffe, Adam B. and Trajtenberg, Manuel, *Patents, Citations & Innovations: a Window on the Knowledge Economy* (Cambridge, The MIT Press, 2002)
[5] See the description of the Patent Classification System at the end of this Appendix.

RCF Score for a Portfolio

To analyze a group or portfolio of patents we run RCF Scores on each patent and then calculate the Mean or Average RCF Score for the group. We then group the individual scores into deciles and present this information in a visual form such as:



This profile shows that the patents in this Sample Portfolio are highly cited relative to their Peer Patents, with 60% of the patents in the portfolio being in the top 20% most highly cited range and 41% in the top 10%. Mean RCF Score = 82.1; Median = 86.0 Explanation: a RCF Score of 92 on an individual patent means that it is more highly cited than 91.9% of its Peer Patents (all patents in its technology area that were issued in the same time period) – i.e. it is in the "Top 10%" category in the above chart. For this Sample Portfolio 41% of the patents are in the Top 10% most highly cited category and the Mean RCF Score of 86.0 means that overall the patents in the Sample Portfolio are more cited than 85.9% of Peer Patents.

What is a Patent Classification? This is how the U.S. Patent and Trademark Office describes a Patent Classification:

> "*A Patent Classification is a code which provides a method for categorizing the invention. Classifications are typically expressed as "482/1". The first number, 482, represents the class of invention. The number following the slash is the subclass of invention within the class. There are about 450 Classes of invention and about 150,000 subclasses of invention in the USPC.*

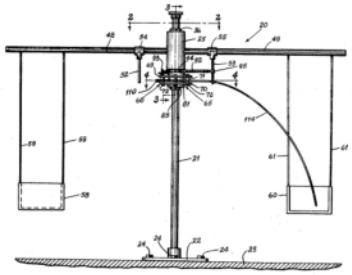
Classes and subclasses have titles which provide a short description of the class or subclass. Classes and subclasses also have definitions which provide a more detailed explanation. Many Classes and subclasses have explicitly defined relationships to one another….

A patent classification also represents a searchable collection of patents grouped together according to similarly claimed subject matter.

A classification is used both as a tool for finding patents (patentability searches), and for assisting in the assignment of patent applications to examiners for examination purposes….. Classifications have hierarchical relationships to one another."

What is a Class Hierarchy? The USPTO Classification System sets up a hierarchy of classes to describe areas of technology and invention. The following Class Hierarchy for "playground equipment" illustrates how a hierarchy is set up:

Example: Class Hierarchy for "Playground Equipment"



This is the drawing of the invention described in a patent entitled "Occupant-Propelled Roundabout Swing Set". A rider sitting in one of the swings can pull on a cable which causes the swings to rotate around the poll.

The USPTO placed this invention in Class 472/122: Amusement Devices/Swing/Having a hand operator/Cable grasp. This Hierarchy is illustrated as follows:

US Patent Class 472 - Amusement Devices		
106	SEESAW	
	107	Motor Operated
	108	Foot, hand or seat operated
	109	Having a safety feature
	etc	
116	BODY SLIDE	
	117	Water Slide
118	SWING	
	119	Motor operated
	120	Having hand and foot operator
	121	Having hand operator
	122	Cable grasp
	124	Having foot operator with separate suspender

What is the CPC? The Cooperative Patent Classification (CPC) is a joint partnership between the USPTO and the European Patent Office (EPO) where the Offices agreed to harmonize their existing classification systems (ECLA and USPC, respectively) and migrate towards a common classification scheme. As of June 1, 2015 US utility patents and applications are no longer published with USPCs. Plant patents and design patents are the exception, and they will continue to carry a USPC designation.

The CPC has the following "top level" Sections:

A: Human Necessities
B: Operations and Transport
C: Chemistry and Metallurgy
D: Textiles
E: Fixed Constructions
F: Mechanical Engineering
G: Physics
H: Electricity
Y: Emerging Cross-Sectional Technologies

From the "top level" Section the classification hierarchy goes as follows:

Hierarchy

- Section (one letter A to H and also Y)
  - Class (two digits)
    - Subclass (one letter)
      - Group (one to three digits)
        - Main group and subgroups (at least two digits)

In the above example "A01B 35/16"

Section: A *(Human Necessities)*
Class: 01 *(A01: Agriculture; Forestry; Animal Husbandry; Hunting; Trapping; Fishing)*
Subclass B *(A01B: Soil Working In Agriculture Or Forestry; Parts, Details, Or Accessories Of Agricultural Machines Or Implements, In General)*
Group 35 (*A01B 35: Other machines for working soil)*
Main group 16 (A01B 35/16: with rotating or circulating non-propelled tools)

An example of a patent classified in A01B 35/16 is US 8393407 "Crop residue clearing device"

Abstract: Apparatus for clearing crop residue from a field is adapted for attachment to a tool bar of an agricultural implement or to a planter unit such that the apparatus is pulled through a field by the implement. The apparatus includes a support structure extending forward of the tool bar and at least one and preferably a pair of floating arms pivotally attached to a forward portion of the support structure and extending rearwardly, with a toothed wheel rotationally attached to an aft end of the arm(s). A coulter attached to the support structure is disposed between and extends forward of the soil-engaging toothed wheel(s) and in combination with the wheel(s) severs and removes residue in the seeding pathway. An adjustable biasing arrangement urges the toothed wheels, either in unison or independently, downwardly into engagement with the soil. Upper and lower stop limits are provided to limit vertical positioning of the toothed wheel(s).