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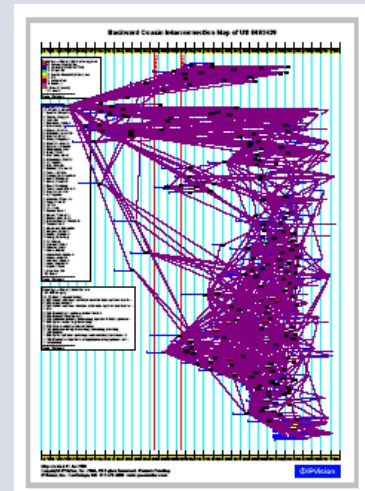
2019 Lemelson-MIT Prize
U.S. Patent Portfolio of Cody Friesen - 2019 Winner
For: Lemelson-MIT Program

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IPVision
Patent Interconnection Map

U.S. Patent Portfolio of Cody Friesen - 2019 Winner
For: Lemelson-MIT Program

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Important Note About Data.   The analyses presented in this Report were based on data as of June 1, 2019 – 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 a company after June 1, 2019 will not appear in the list of patents shown in this Report or on IPVision See-The-Forest.com™.   However, patents that issue after June 1, 2019 that cite a patent shown in an analysis in this Report will appear in any citation analysis run after June 1, 2019 on the information stored on IPVision 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 IPVision See-The-Forest.com ™.

1. CODY A. FRIESEN

Cody A. Friesen is the Fulton Engineering Professor of Innovation and Associate Professor of Materials Science and Engineering, School for Engineering of Matter, Transport and Energy, Arizona State University.

Dr. Friesen's major technologically inventive accomplishments range from electrochemical cells to clean water generation. Dr. Friesen received a B.S.E. in Materials Science & Engineering from Arizona State University (2000) and a Ph.D in Material Science & Engineering from M.I.T. (2004).

1.1 Technical Innovation Highlights

Dr. Friesen focuses on new paradigms in thermodynamics & surface/interface physics, potable water science, electrochemical energy devices, physical electrochemistry, metal-air batteries, ionic liquid physical electrochemistry, and thin film sciences.

Fluidic Energy. Dr. Friesen's first major start-up, focuses on manufacturing rechargeable metal-air batteries. Fluidic Energy is the first new battery technology to scale significantly since Li-ion batteries came on the scene 25 years ago. Fluidic batteries and systems are now providing storage on five continents, across some of the toughest environments in the world. Fluidic Energy is undertaking projects such as the Indonesian "500 Island project" which is to build out 500 islanded microgrids across the archipelago as well as 100 village microgrids in Madagascar, currently benefiting over 3.36M people and covering almost 1M long-duration grid outages. Dr. Friesen helped to raise over $150MM in equity financing to build the company. Fluidic Energy is now known as NantEnergy. Click on diagram to see Dr. Friesen describe this technology.
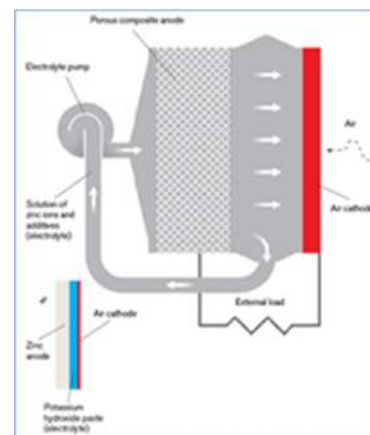
Zero Mass Water. Dr. Friesen is also the founder and CEO of Zero Mass Water, which focuses on perfecting water for every person in every place by deploying unique solar panels called Hydropanels. These Hydropanels make drinking water from sunlight and air alone and require neither electricity nor piped water. The technology has been deployed in thirty-three countries across six continents with installations ranging from individual use up to commercial or community scale. The technology is enabling every person- from developing countries and rural areas to urban centers- to own the production and supply of their quality drinking water. . Click on image to see a YouTube by Dr. Friesen.

1.2 Friesen Patent Portfolio

As of the date of this report Professor Friesen is a named inventor on 51 issued U.S. patents (the "Friesen Patents") and 26 published pending U.S. patent applications (together with the Friesen Patents, the "Friesen Patent Properties"). The following table shows the top 10 most cited issued Friesen Patents, the number of Backward Citations (BCs) by each (i.e., prior patents cited by Friesen) and the number of Forward Citations (FCs) to each (i.e., patents issued after the publication of the Friesen Patents that cite these Friesen Patents as prior patent art):

Top Ten Most Cited U.S. Patents of Cody A. Friesen				
Patent #	Title	Inventor	Citations By (BCs)	Citations To (FCs)
8309259	Electrochemical cell, and particularly a cell with electrodeposited fuel	Friesen, Cody A.; Hayes, Joel R.	252	20
8168337	Electrochemical cell, and particularly a metal fueled cell with non-parallel flow	Friesen, Cody A.; Hayes, Joel R.	62	17
8491763	Oxygen recovery system and method for recovering oxygen in an electrochemical cell	Friesen, Cody A.	34	7
8492052	Electrochemical cell with spacers for flow management system	Friesen, Cody A; Krishnan, Ramkumar; Friesen, Grant	230	6
8659268	Electrochemical cell with stepped scaffold fuel anode	Krishnan, Ramkumar; Friesen, Grant; Friesen, Cody A.	256	6
8481207	Metal-air room-temperature ionic liquid electrochemical cell with liquid fuel	Friesen, Cody A.; Martinez, Jose Antonio Bautista; Zeller, Robert	5	5
8546028	Electrochemical cell, and particularly a cell with electrodeposited fuel	Friesen, Cody A.; Hayes, Joel	256	4
8741491	Ionic liquid containing sulfonate ions	Wolfe, Derek; Friesen, Cody A.; Johnson, Paul Bryan	18	4
8877391	Electrochemical cell, and particularly a cell with electrodeposited fuel	Friesen, Cody A.; Trimble, Todd	11	4
9147919	Methods of producing sulfate salts of cations from heteroatomic compounds and dialkyl sulfates and uses thereof	Friesen, Cody A.; Wolfe, Derek; Johnson, Paul Bryan	11	4

View the Friesen U.S. Patents on IPVision *See-The-Forest.com*™ ► [Link to List](#)

View Full List of U.S. Patent Properties on IPVision *See-The-Forest.com*™ ► [Link to List](#)
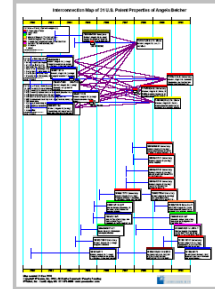
1.2.1 Friesen Patent Portfolio Map

What Is a 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 an 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 – How to Read an IPVision Map.
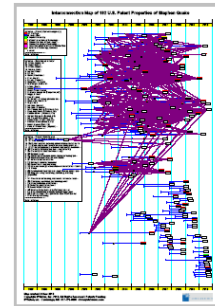
Note: A portfolio with a high degree of self citation is likely to have more commercial potential than a portfolio of individual inventions that are "scattered about".

Angela Belcher – 2013 Winner

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.

Stephen Quake – 2012 Winner

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

U.S. Patent Portfolio Interconnection Map™ of Cody A. Friesen

Interconnection Map of 77 U.S. Patent Items of Cody Friesen

Statistics -- Primary Current Assignee(s)
- 44 Nantenergy, Inc.
- 9 Arizona Board of Regents for and on...
- 8 Arizona Board of Regents On Behalf ...
- 4 Fluidic, Inc.
- 3 Arizona Board of Regents Acting for...
- 2 Zero Mass Water, Inc.
- 1 Arizon Board of Regents On Behalf o...
- 1 Arizon Board of Regents for and on ...
- 5 others

Total: 77 Items

Patent Portfolio Interconnection Map™: This IPVision Patent Portfolio Interconnection Map™ shows the U.S. patent properties of Cody A. Friesen on a timeline from left to right. Each box is a patent or published patent application with the left edge of the box aligned in time based on issue date (for patents) or publication date (for applications).

The lines connecting the boxes are citation references.

A "cluster" of cross-citations usually indicates a building out of a technology, with the inventor citing his or her prior patents as prior art.

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.

See, Appendix A – How to Read an IPVision Map

**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 Dr. Friesen'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):
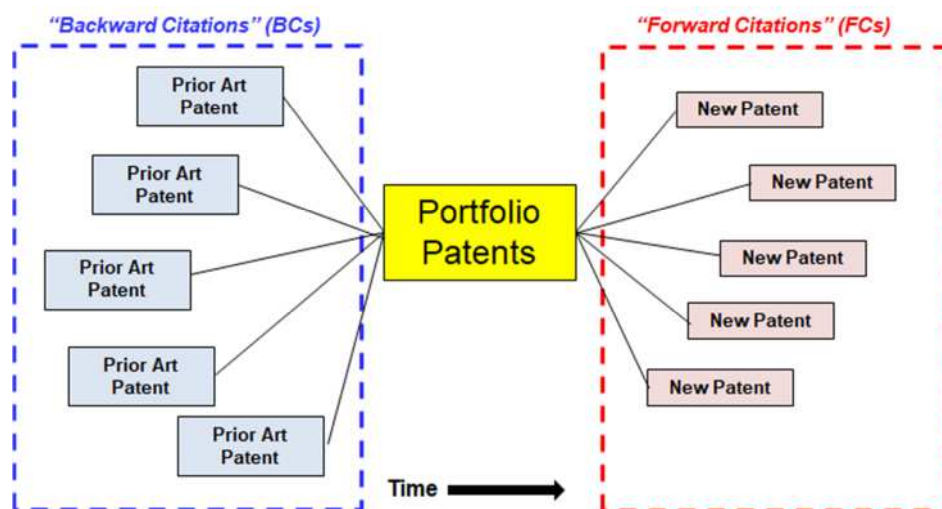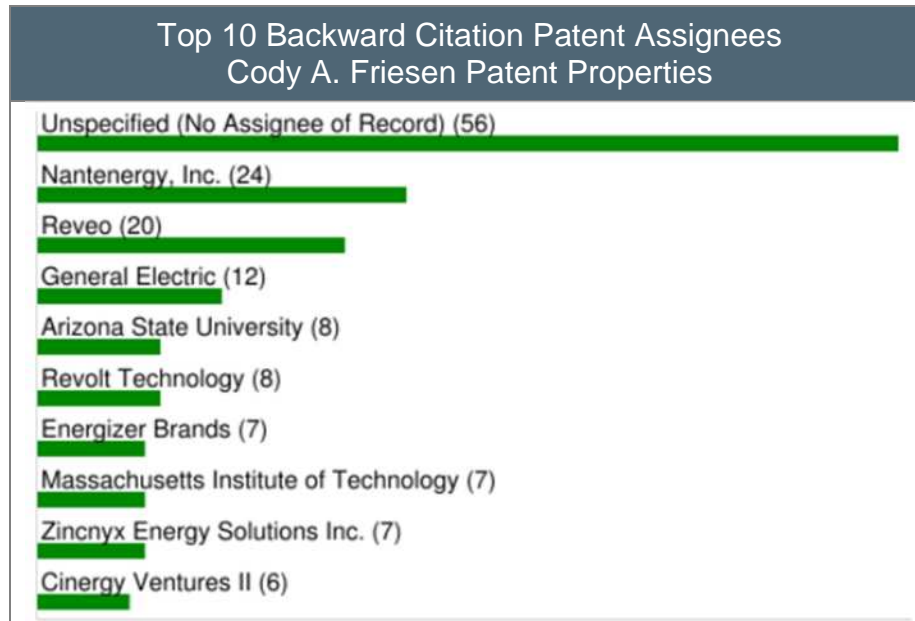

Backward Citations: Patents Cited by Friesen Patents. There are 608 other U.S. patent properties ("Backward Citation Patents" or "BCs") that are cited by the 77 patents[1] in the Friesen Portfolio. These patents are cited 2,937 times by patents in the Portfolio. These Backward Citation patents are owned of record by 300+ 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:

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[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.

Top 10 Backward Citation Patent Assignees
Cody A. Friesen Patent Properties

Unspecified (No Assignee of Record) (56)

Nantenergy, Inc. (24)

Reveo (20)

General Electric (12)

Arizona State University (8)

Revolt Technology (8)

Energizer Brands (7)

Massachusetts Institute of Technology (7)

Zincnyx Energy Solutions Inc. (7)

Cinergy Ventures II (6)

View "Backward Citation Assignee Analysis" ► [Link to Analysis](#)

Forward Citations: Patents Citing Friesen Patents. There are 35 other U.S. patent properties[2] ("Forward Citation Patents" or "FCs") that cite the U.S. patent properties in the Friesen Portfolio. These FC patents cite the Friesen Portfolio 76 times. These Forward Citation patents are owned of record by 20 organizations:
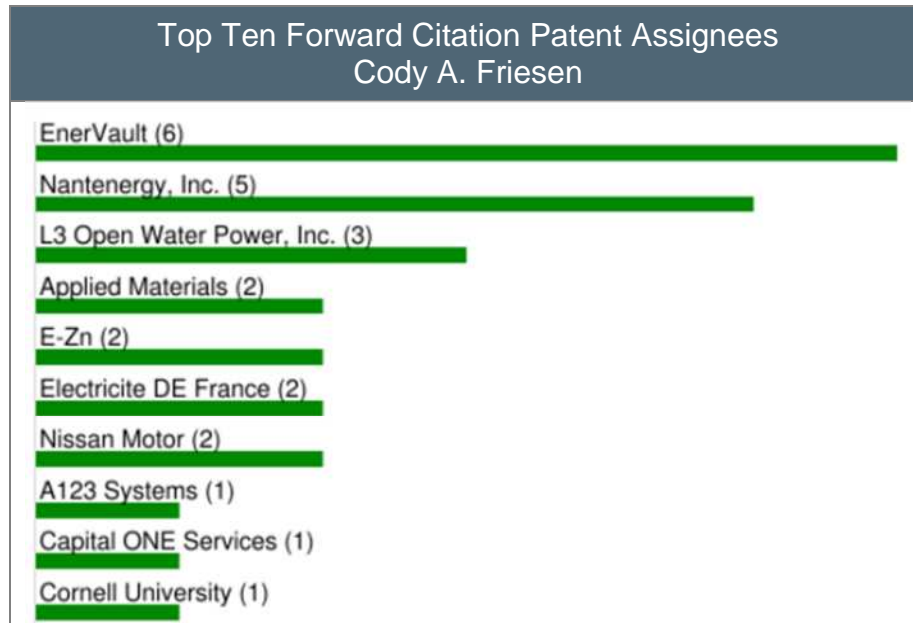
View "List of Forward Citation Patents" ► [Link to List](#)

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

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[2] We have only included patents on which Dr. Friesen is NOT an inventor – i.e., we have removed "self cites"

Top Ten Forward Citation Patent Assignees
Cody A. Friesen

EnerVault (6)

Nantenergy, Inc. (5)

L3 Open Water Power, Inc. (3)

Applied Materials (2)

E-Zn (2)

Electricite DE France (2)

Nissan Motor (2)

A123 Systems (1)
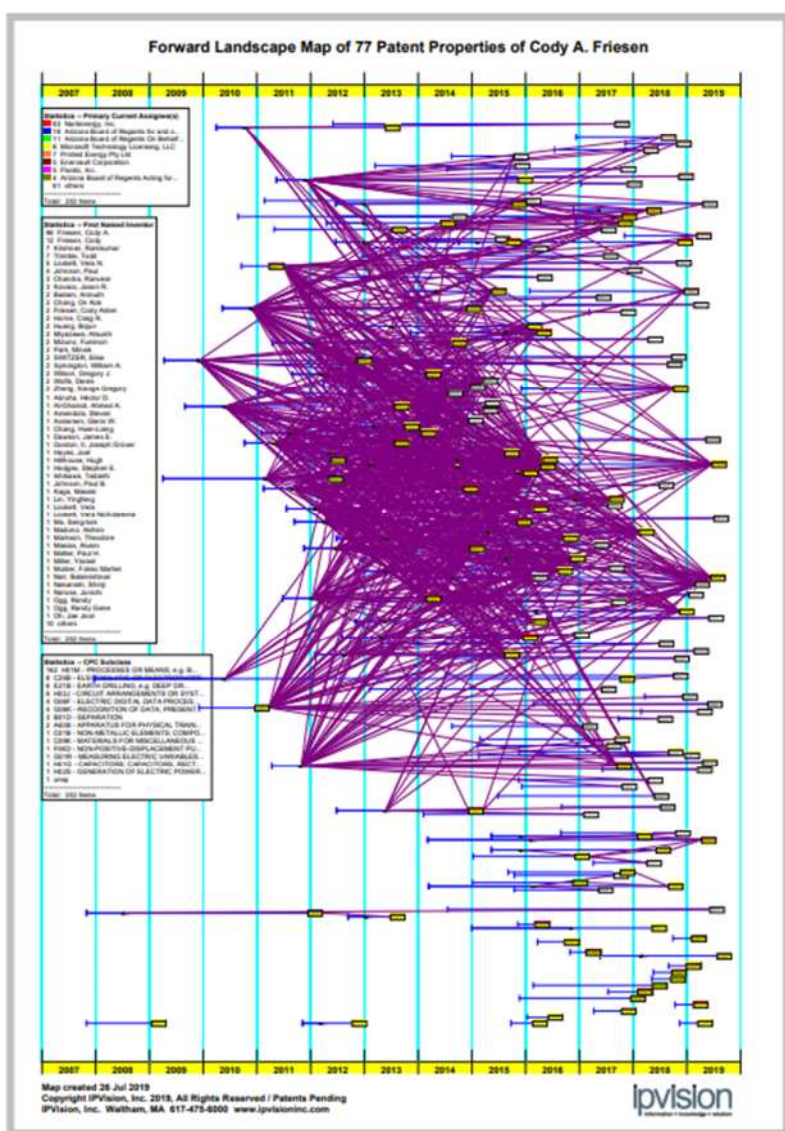
Capital ONE Services (1)

Cornell University (1)

View "Forward Citation Assignee Analysis" ►   Link to Analysis

1.3.1 Friesen Forward Citation Patent Landscape Map

Because of the large number of patents cited by the Friesen Portfolio it is not practical to make a full citation landscape map.   Instead we produced a "Forward Citation Landscape Map" showing the Friesen Patent Properties and the U.S. patents that cite them:

Forward Patent Citation Landscape Map™ of Cody A. Friesen U.S. Patents

Forward Landscape Map of 77 Patent Properties of Cody A. Friesen

Statistics -- Primary Current Assignee(s)
- 83 Nantenergy, Inc.
- 18 Arizona Board of Regents for and o...
- 11 Arizona Board of Regents On Behalf...
- 8 Microsoft Technology Licensing, LLC
- 7 Printed Energy Pty Ltd
- 5 Enervault Corporation
- 5 Fluidic, Inc.
- 4 Arizona Board of Regents Acting for...
- 61 others

Total: 202 Items

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

Map created 26 Jul 2019
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See, Appendix A – How to Read an IPVision Map

View Live IPVision Map™ ► | Link to Map
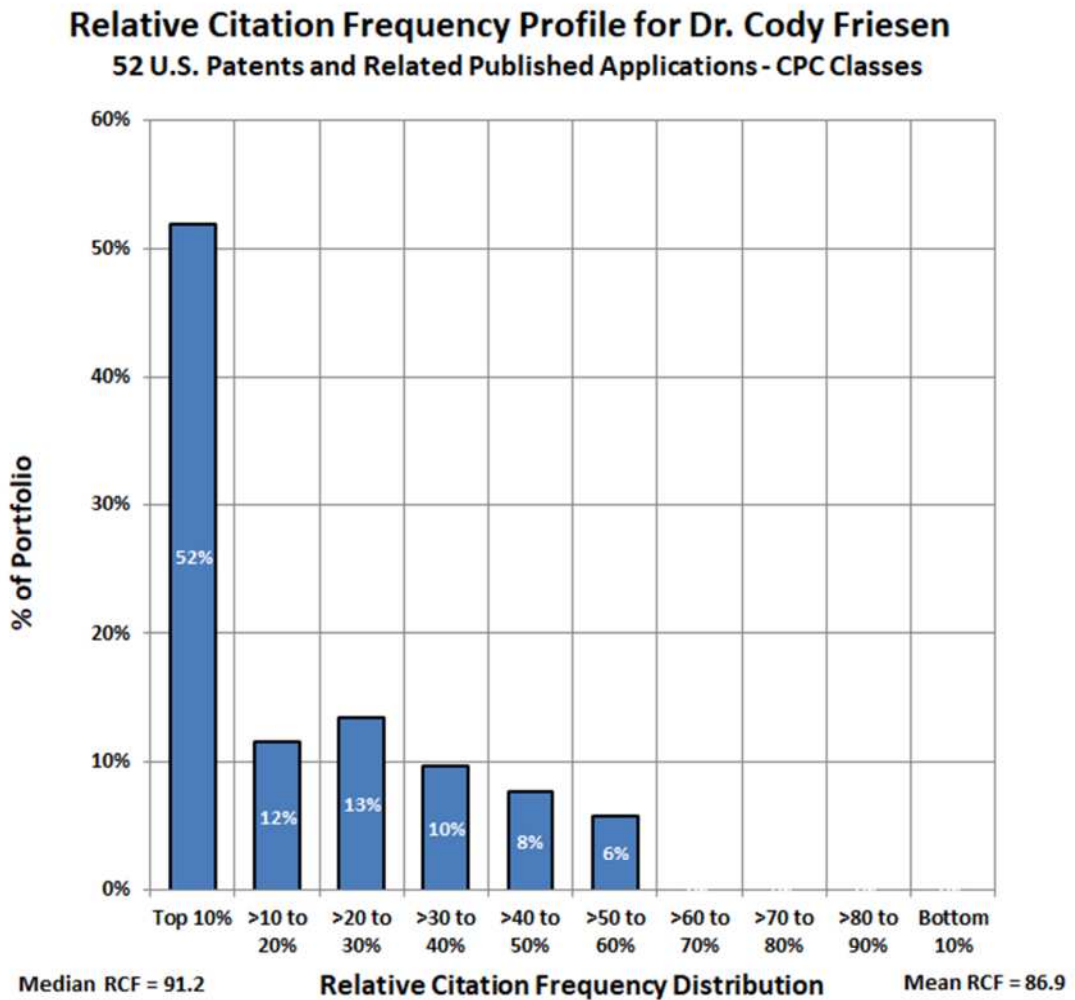
1.4 Relative Citation Frequency

The number of citations of an inventor's patents by other inventors is a measure of the importance of an invention.[3] The Relative Citation Frequency for a patent is an IPVision developed normalized metric that measures how highly cited the patent (and its related published application) is relative to Peer Patents (patents and their related published applications in the same technology area of the same age) where 100 equals the most cited.[4]

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[3] See, Jaffe, Adam B. and Trajtenberg, Manuel, *Patents, Citations & Innovations: a Window on the Knowledge Economy* (Cambridge, The MIT Press, 2002)
[4] See "Appendix B - Relative Citation Frequency" for a fuller description of Relative Citation Frequency.

The Relative Citation Frequency scores distribution for the Friesen Portfolio are:

Relative Citation Frequency Profile for Dr. Cody Friesen
52 U.S. Patents and Related Published Applications - CPC Classes

Median RCF = 91.2   **Relative Citation Frequency Distribution**   Mean RCF = 86.9

This profile shows that the Friesen patents are highly cited relative to their Peer Patents, ***with 64% of the patents in the portfolio being in the top 20% most highly cited range***.   Mean RCF Score = 86.9; Median = 91.2.   Explanation: a RCF Score of 92 on an individual patent means that it is more highly cited than 91.99% 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 Dr. Friesen, 52% of the Frisen patents are in the Top 10% most highly cited category and the Mean RCF Score of 86.9 means that overall the Friesen patents are more cited than 86.89% of Peer Patents. See Appendix B - Relative Citation Frequency.

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:


Landscape Map of US Patent 6000000
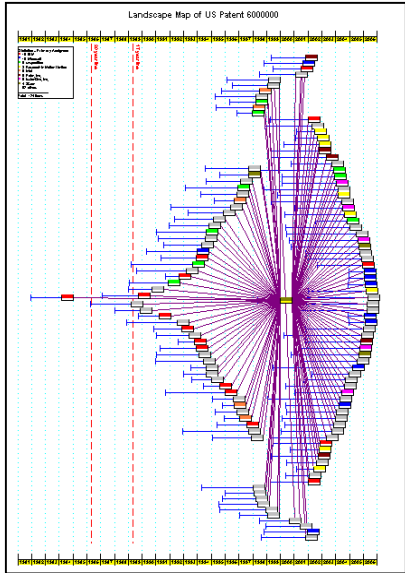
This Landscape Map is of U.S. Patent 6,000,000 entitled "Extendible method and apparatus for synchronizing multiple files on two different computer systems". It is the basic patent for the Palm Pilot software.

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.

"Right click" on any of the patent boxes to access information about that patent.

The details of an IPVision Map are explained in more detail below. See also a Guide To Reading IPVision Patent Maps.
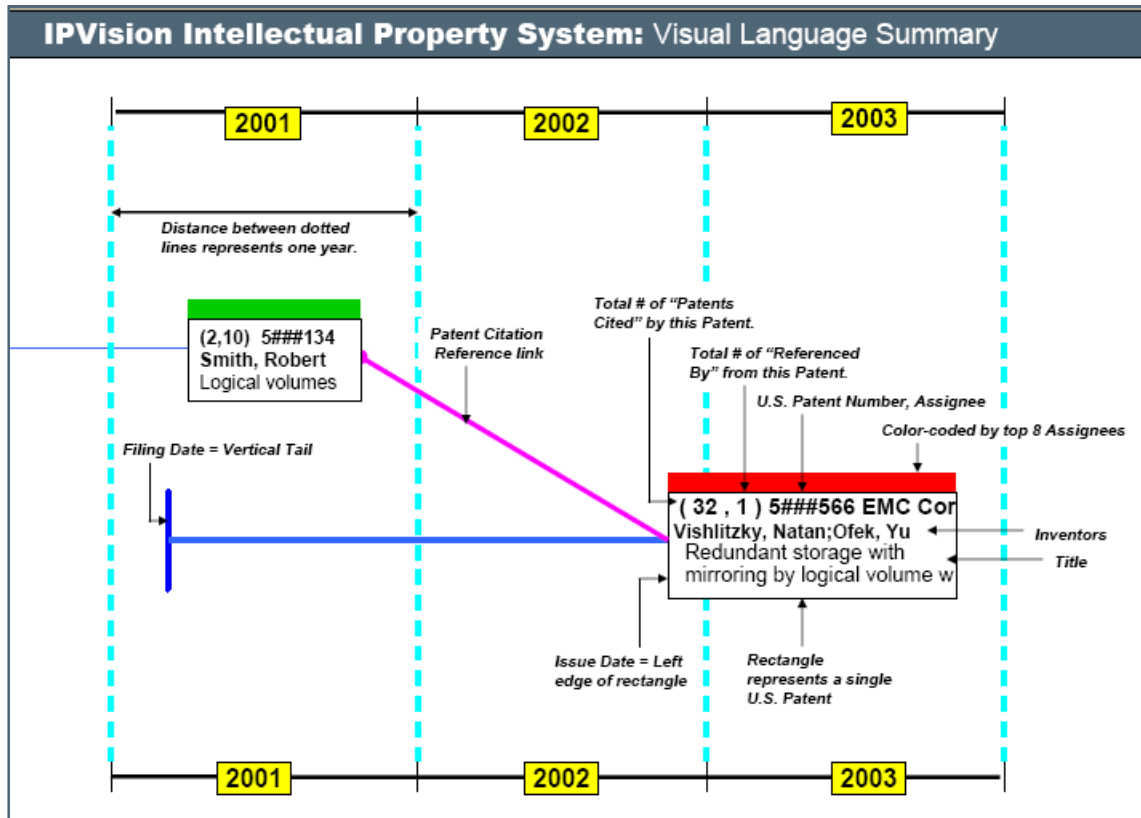
APPENDIX B - RELATIVE CITATION FREQUENCY

The number of citations of an inventor's patents by other inventors is a measure of the importance of an invention.[5]   However, the number of citations 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 more time it has to be cited). Accordingly, one can not tell 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[6] "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.

Relative Citation Frequency – Peer Patents
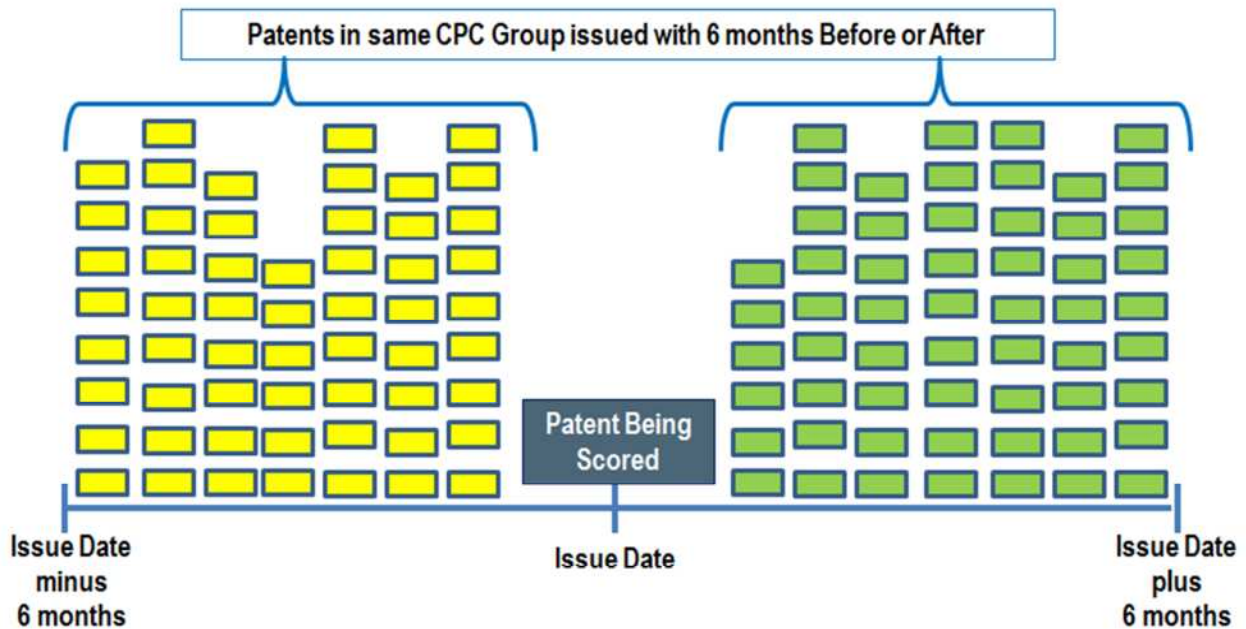
RCF Score for a Patent

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[7] 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 are 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.

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[5] See, Jaffe, Adam B. and Trajtenberg, Manuel, *Patents, Citations & Innovations: a Window on the Knowledge Economy* (Cambridge, The MIT Press, 2002)
[6] See the description of the Patent Classification System at the end of this Appendix.
[7] The patent applications for most patents are published and are available to be cited before the patent is issued.   For each Peer Patent we add together (a) the number of citations to its published application and (b) the number of citations to the Peer Patent itself.   We remove any duplicate citations. We do the same for each patent being scored.

How We Count Citations

With a few exceptions, patent applications filed in the United States on or after November 29, 2000 are published by the United States Patent and Trademark Office after expiration of an 18-month period following the earliest effective filing date of the application.   As a result, these applications are "available to be cited" by later issued patents[8]. Consider the following example:
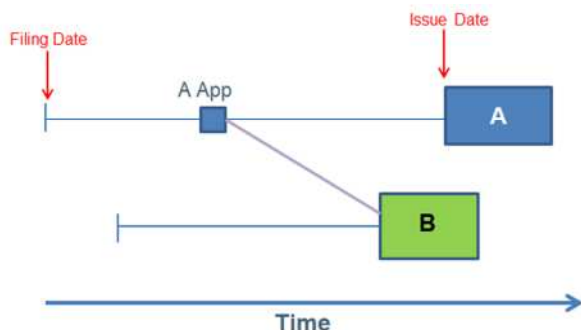
Here Patent B cites the Published Application of Patent A because at the time Patent B issued the application for Patent A was still pending but Patent A had not issued and therefore could not be cited.

To capture the total number of citations to Patent A we add together (a) the number of citations to Patent A and (b) the number of citations to its published application. To avoid double counting we remove any duplicate citations to both the patent and its related published application.

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:

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[8] NOTE: published patent applications do NOT contain any citations – only issued patents contain citations to prior art.

Relative Citation Frequency Profile for Sample Portfolio
37 U.S. Patents

Median RCF = 86.0   **Relative Citation Frequency Distribution**   Mean RCF = 82.1
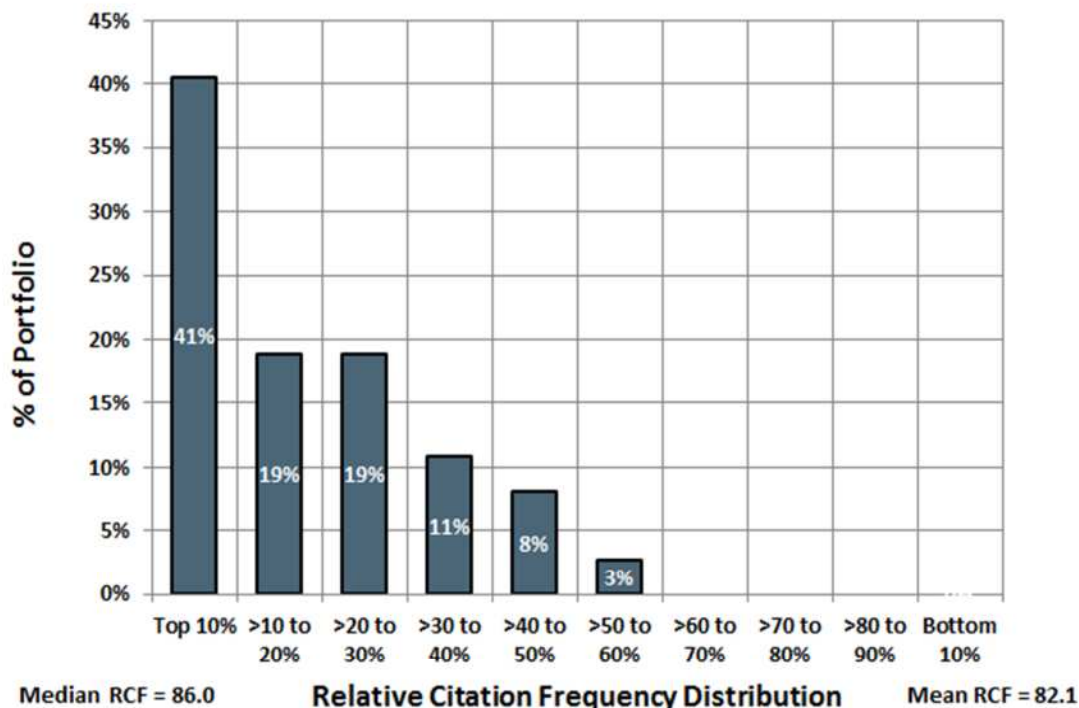
This profile shows that the patents in this Sample Portfolio are highly cited relative to their Peer Patents, with 60% of the patents in the portfolio being in the top 20% most highly cited range and 41% in the top 10% of most highly cited. Mean RCF Score = 82.1; Median = 86.0 Explanation: a RCF Score of 92 on an individual patent means that it is more highly cited than 91.99% 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 85.99% 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….*
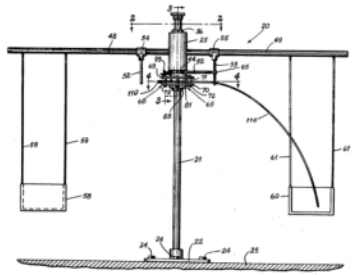>
> *A patent classification also represents a searchable collection of patents grouped together according to underlined_similarly claimed subject matter.*
>
> *A classification is used both as a tool for finding patents (patentability searches), and for assisting in the assignment of patent applications to examiners for examination purposes.…. Classifications have hierarchical relationships to one another.*"

What is a Class Hierarchy? The United States Patent Classification (USPC) 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).