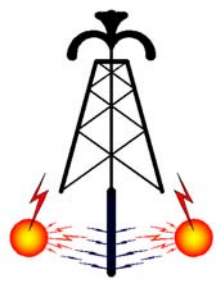
Past, Present, and Pending Intellectual Property for Electromagnetic Heating of Oil Shale

28th Annual Oil Shale Symposium

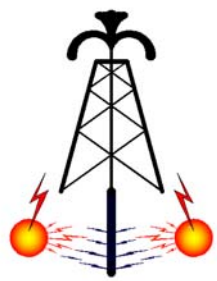
Colorado School of Mines

October 13 – 15, 2008



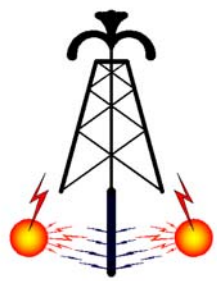
Objectives

- To provide relevant prior art research
- To show breadth of prior art
- To depict the intensity of electromagnetic heating research prior to the 1980s bust in oil prices
- To illustrate that most R&D was conducted prior to the modern microprocessor, PC software, and sensory input technology
- An overview of Quasar Energy LLC intellectual property



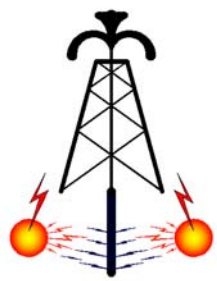
Definition of a Patent

A patent is a set of exclusive rights granted by a state to an inventor, or his/her assignee, for a fixed period of time, in exchange for a disclosure of an invention.



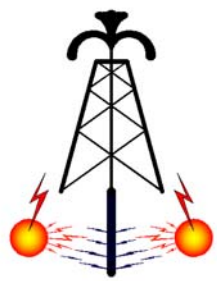
Scope of Prior Art for this Presentation

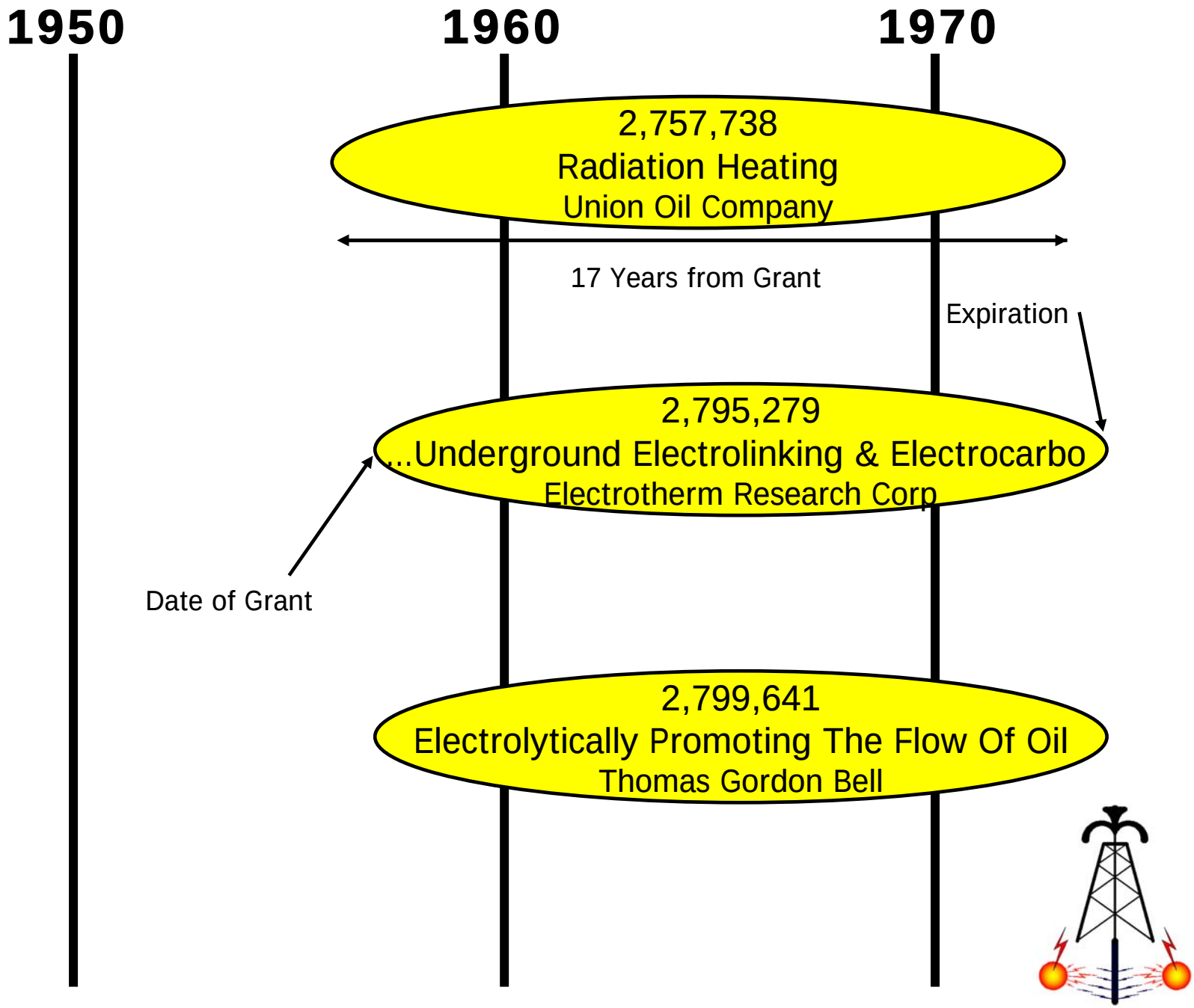
In-Situ passage of an electrical current through an oil shale formation, or an apparatus and/or method that is integral or supportive.

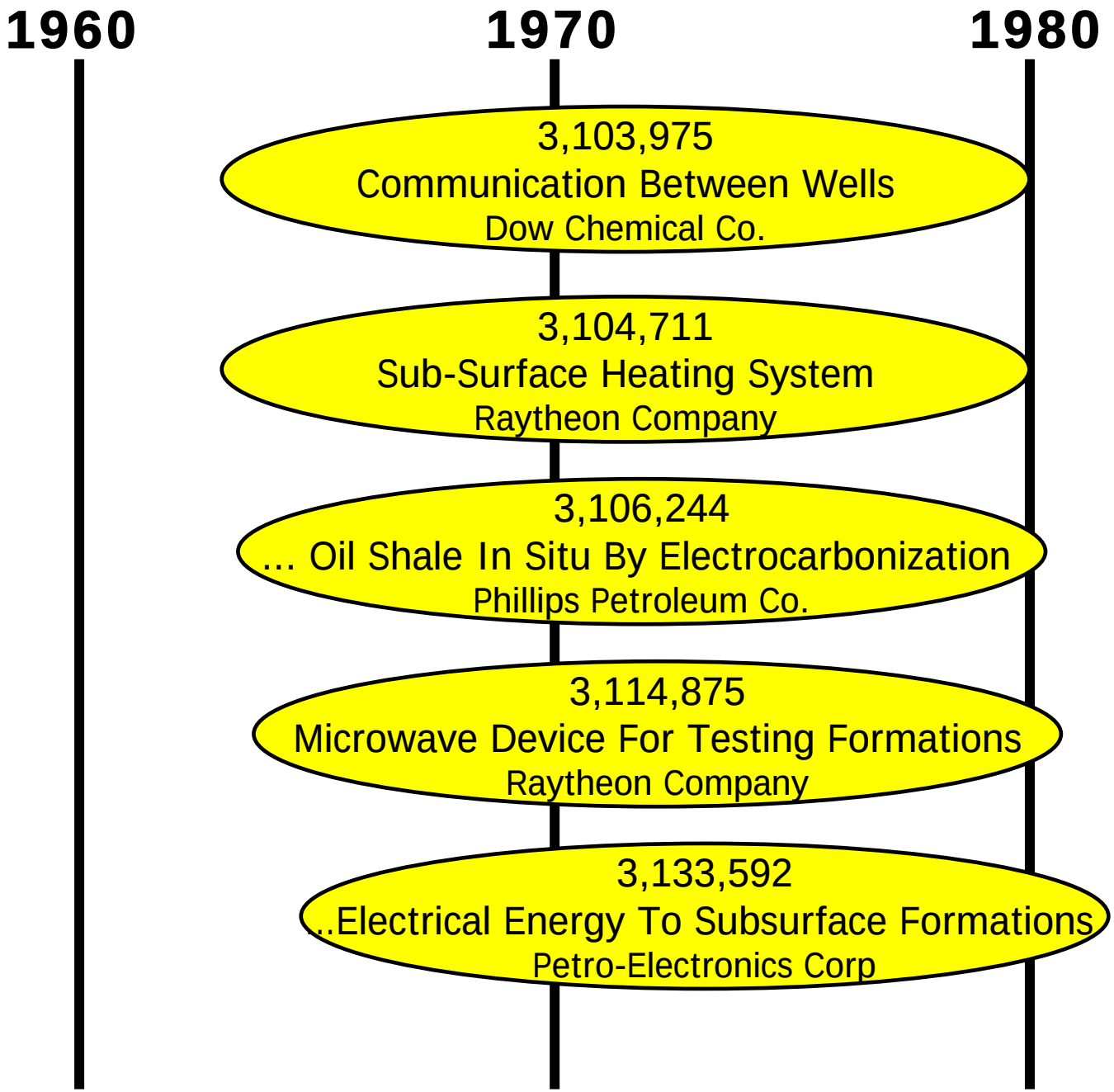


Categories of the Prior Art Search

- Resistive Heating
  - 1 Hz to 300 KHz
  - also known as Joule or Ohmic heating
- Radio Frequency Heating
  - 300 KHz to 300 MHz (Medium, High, Very High Bands)
- Microwave Heating
  - 300 MHz to 300 GHz
- Downhole Tool
- Supportive Apparatus and/or Method




1950
1960
1970
2,757,738
Radiation Heating
Union Oil Company
17 Years from Grant
Expiration
2,795,279
...Underground Electrolinking & Electrocarbo
Electrotherm Research Corp
Date of Grant
2,799,641
Electrolytically Promoting The Flow Of Oil
Thomas Gordon Bell


1960
1970
1980
3,103,975
Communication Between Wells
Dow Chemical Co.
3,104,711
Sub-Surface Heating System
Raytheon Company
3,106,244
... Oil Shale In Situ By Electrocarbonization
Phillips Petroleum Co.
3,114,875
Microwave Device For Testing Formations
Raytheon Company
3,133,592
..Electrical Energy To Subsurface Formations
Petro-Electronics Corp

1960 1970 1980

3,137,347
In Situ Electrolinking Of Oil Shale
Phillips Petroleum Co.

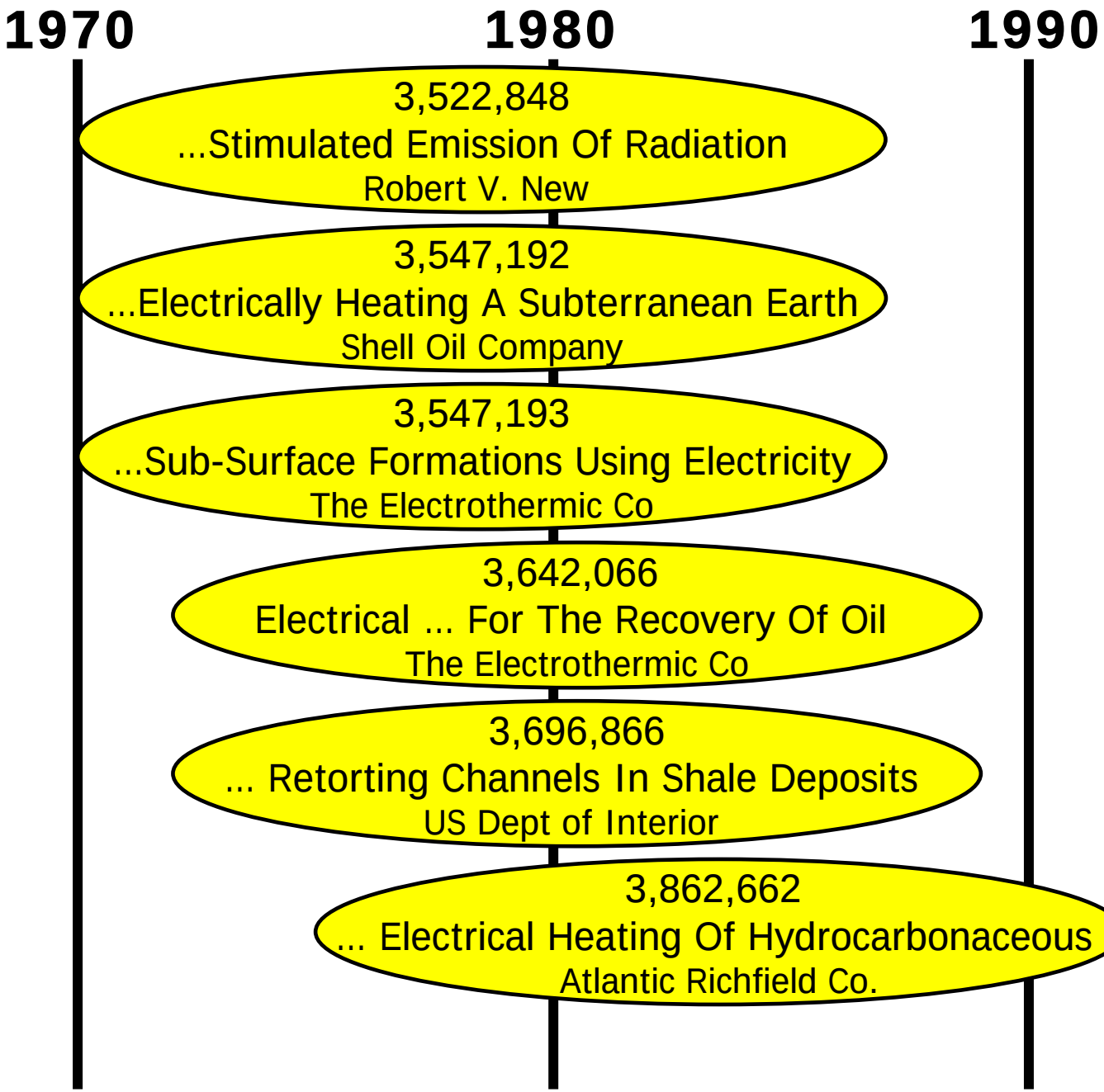
3,149,672
..Electrical Heating Of Oil-Bearing Formations
Jersey Prod. Research Co

3,169,577
Electrolinking By Impulse Voltages
Electrofrac Corporation

3,170,519
Oil Well Microwave Tools
Duane B. Haagensen

3,211,220
Single Well Subsurface Electrification Process
Electrofrac Corporation

3,428,125
Hydro-Electropyrolysis Of Oil Shale In Situ
Phillips Petroleum Co


1970
1980
1990
3,522,848
...Stimulated Emission Of Radiation
Robert V. New
3,547,192
...Electrically Heating A Subterranean Earth
Shell Oil Company
3,547,193
...Sub-Surface Formations Using Electricity
The Electrothermic Co
3,642,066
Electrical ... For The Recovery Of Oil
The Electrothermic Co
3,696,866
... Retorting Channels In Shale Deposits
US Dept of Interior
3,862,662
... Electrical Heating Of Hydrocarbonaceous
Atlantic Richfield Co.

1970 1980 1990

3,874,450
...Electrically Heating A Subsurface Formation
Atlantic Richfield Co.

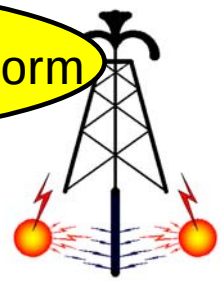
3,931,856
Method Of Heating A Subterranean Formati
Atlantic Richfield Co.

3,946,809
... Steam Stimulation & Electrical Heating
Exxon Production Research

3,948,319
...Varying Current Flow ... Source Formation
Atlantic Richfield Co.

4,008,762
... In Situ From Underground Deposits
Sidney T. Fisher

4,010,799
.. Electrical Heating Of A Subterranean Form
Petro-Canada Exploration Inc.



1970 1980 1990

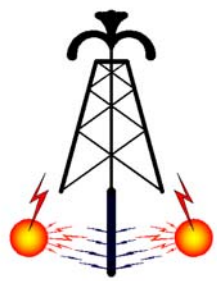
4,084,637
... Materials From Subterranean Formations
Petro-Canada Exploration Inc.

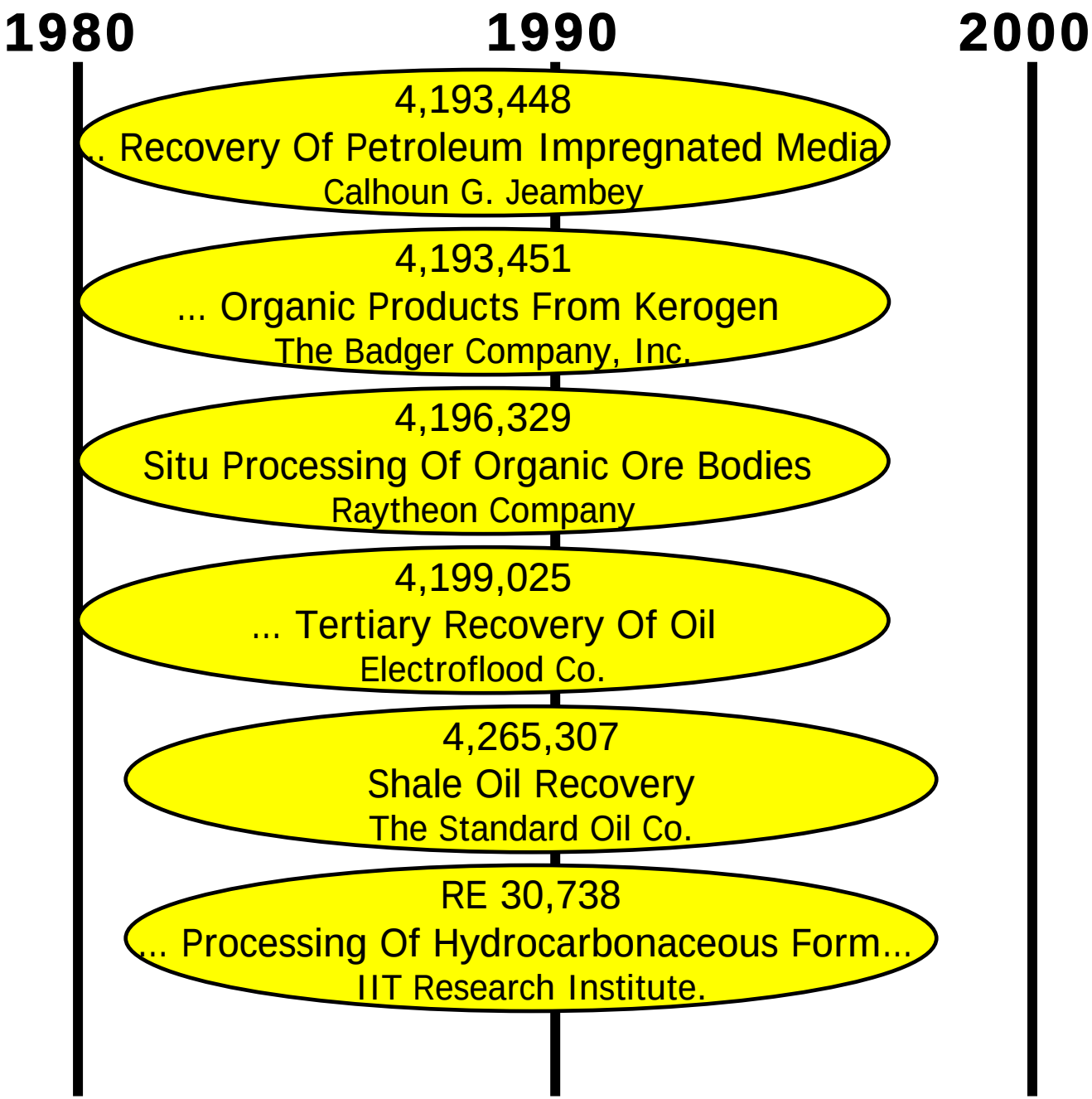
4,135,579
In Situ Processing Of Organic Ore Bodies
Raytheon Company

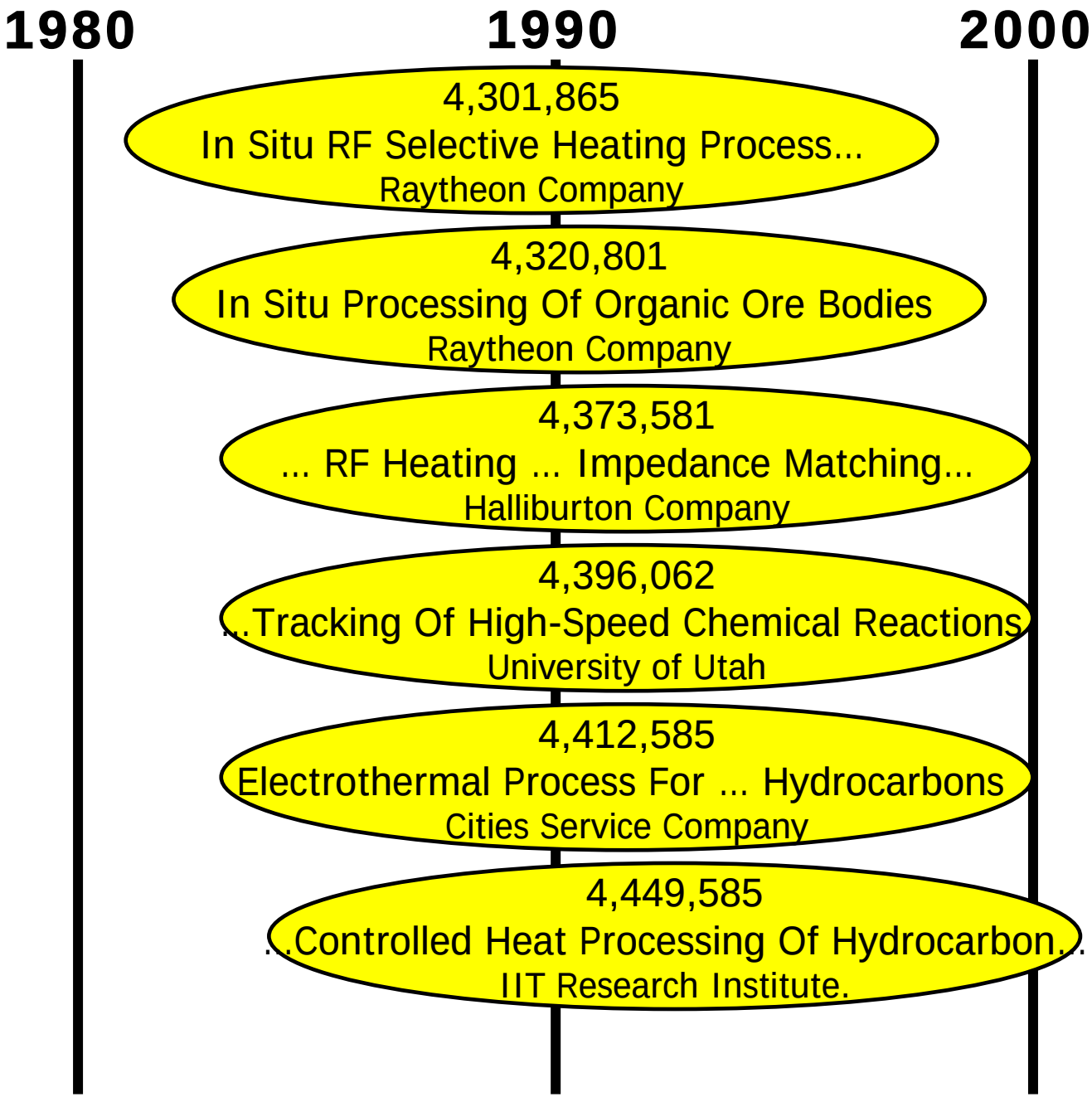
4,140,179
In Situ Radio Frequency Selective Heating...
Raytheon Company

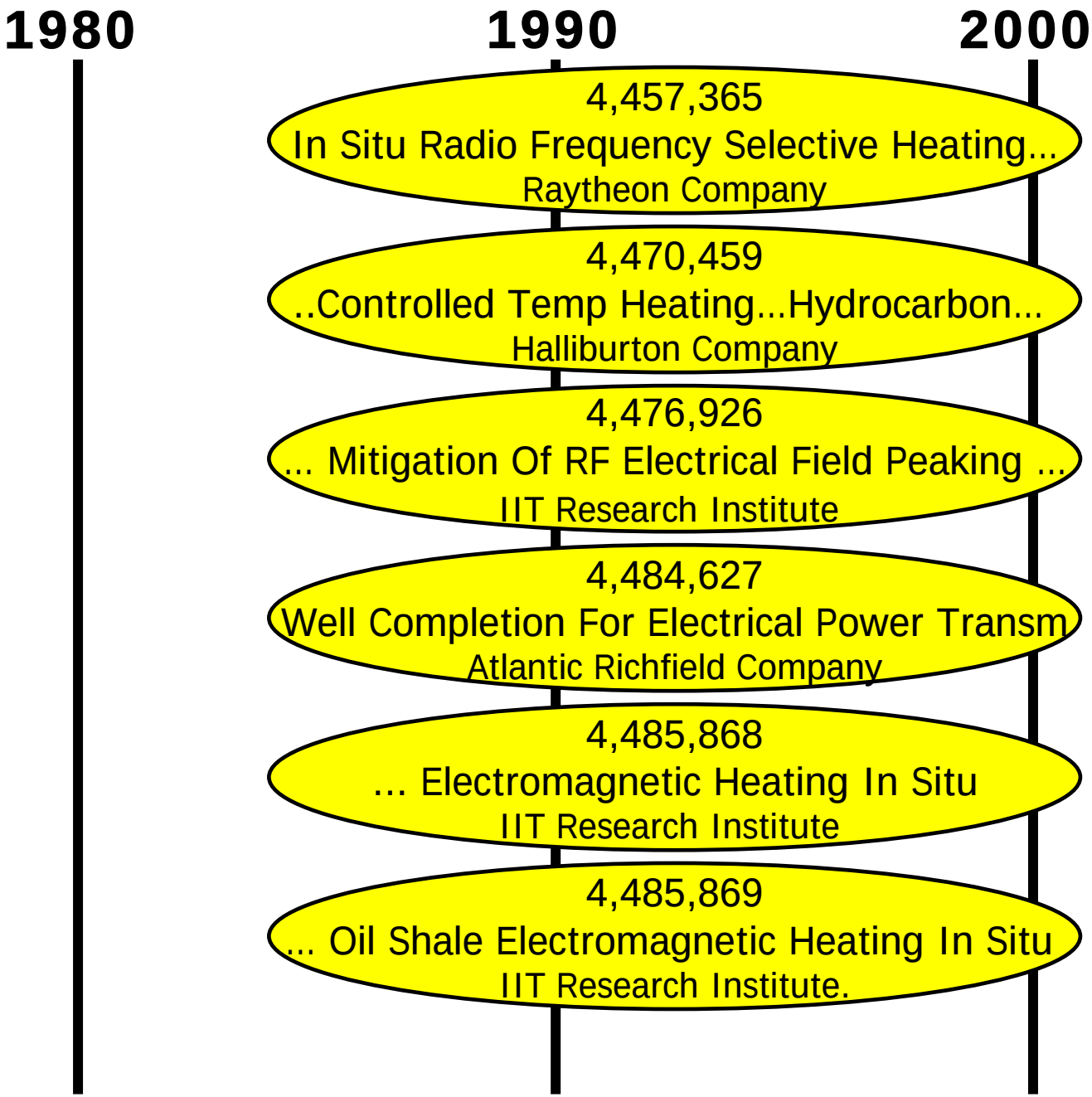
4,140,180
... Heat Processing Of Hydrocarbonaceous ...
IIT Research Institute

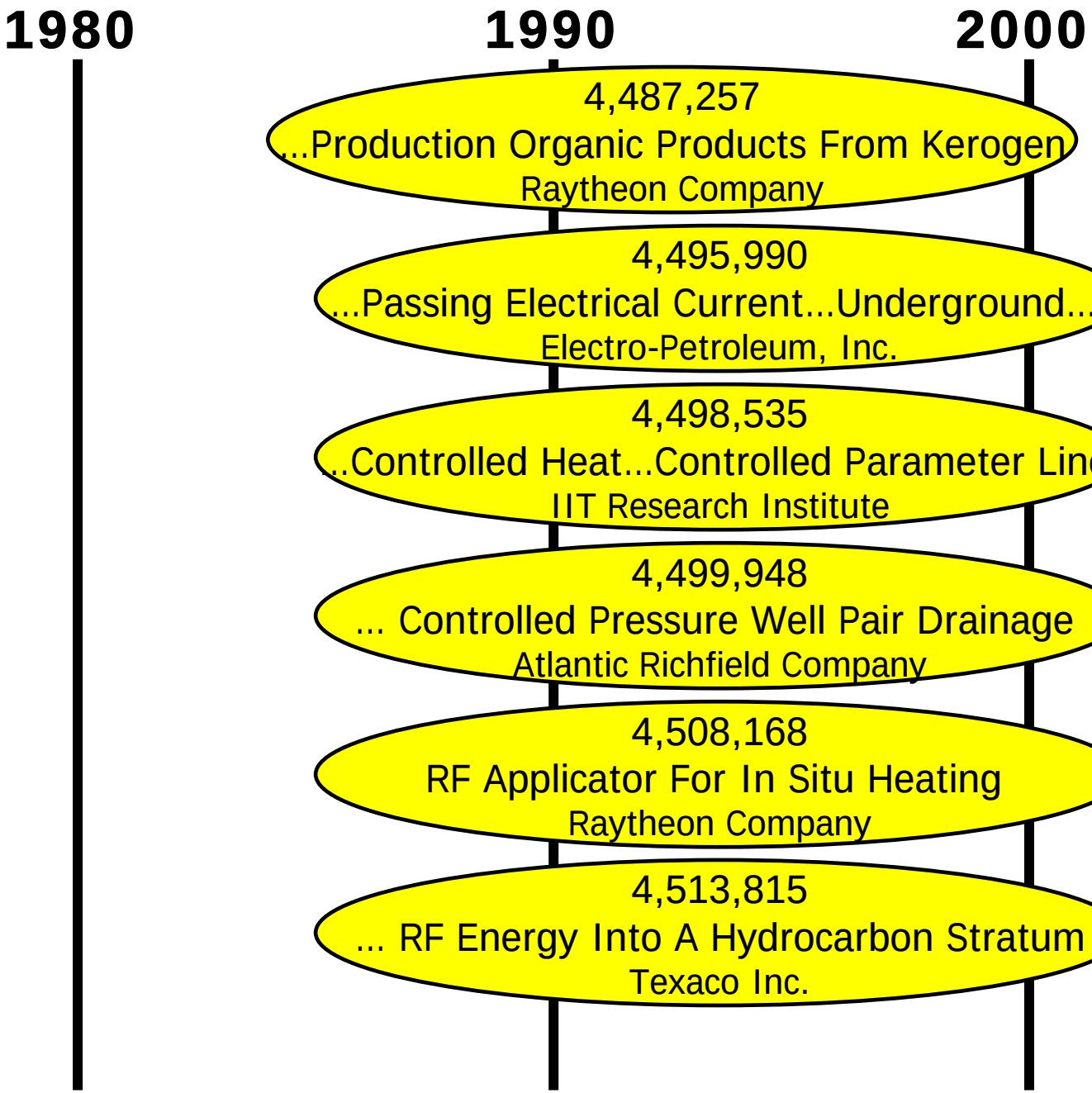
4,144,935
... Heat Processing Of Hydrocarbonaceous ...
IIT Research Institute




1980
1990
2000
4,193,448
... Recovery Of Petroleum Impregnated Media
Calhoun G. Jeambey
4,193,451
... Organic Products From Kerogen
The Badger Company, Inc.
4,196,329
Situ Processing Of Organic Ore Bodies
Raytheon Company
4,199,025
... Tertiary Recovery Of Oil
Electroflood Co.
4,265,307
Shale Oil Recovery
The Standard Oil Co.
RE 30,738
... Processing Of Hydrocarbonaceous Form...
IIT Research Institute.


1980
1990
2000
4,301,865
In Situ RF Selective Heating Process...
Raytheon Company
4,320,801
In Situ Processing Of Organic Ore Bodies
Raytheon Company
4,373,581
... RF Heating ... Impedance Matching...
Halliburton Company
4,396,062
...Tracking Of High-Speed Chemical Reactions
University of Utah
4,412,585
Electrothermal Process For ... Hydrocarbons
Cities Service Company
4,449,585
...Controlled Heat Processing Of Hydrocarbon...
IIT Research Institute.


1980
1990
2000
4,457,365
In Situ Radio Frequency Selective Heating...
Raytheon Company
4,470,459
..Controlled Temp Heating...Hydrocarbon...
Halliburton Company
4,476,926
... Mitigation Of RF Electrical Field Peaking ...
IIT Research Institute
4,484,627
Well Completion For Electrical Power Transm
Atlantic Richfield Company
4,485,868
... Electromagnetic Heating In Situ
IIT Research Institute
4,485,869
... Oil Shale Electromagnetic Heating In Situ
IIT Research Institute.


1980
1990
2000
4,487,257
...Production Organic Products From Kerogen
Raytheon Company
4,495,990
...Passing Electrical Current...Underground...
Electro-Petroleum, Inc.
4,498,535
...Controlled Heat...Controlled Parameter Line
IIT Research Institute
4,499,948
... Controlled Pressure Well Pair Drainage
Atlantic Richfield Company
4,508,168
RF Applicator For In Situ Heating
Raytheon Company
4,513,815
... RF Energy Into A Hydrocarbon Stratum
Texaco Inc.

1980 1990 2000

4,524,826
Method Of Heating An Oil Shale Formation
Texaco Inc.

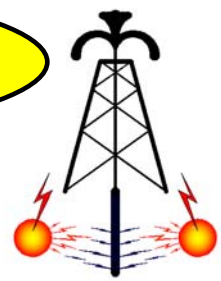
4,524,827
...Well Stimulation...From Subsurface Format
IIT Research Company

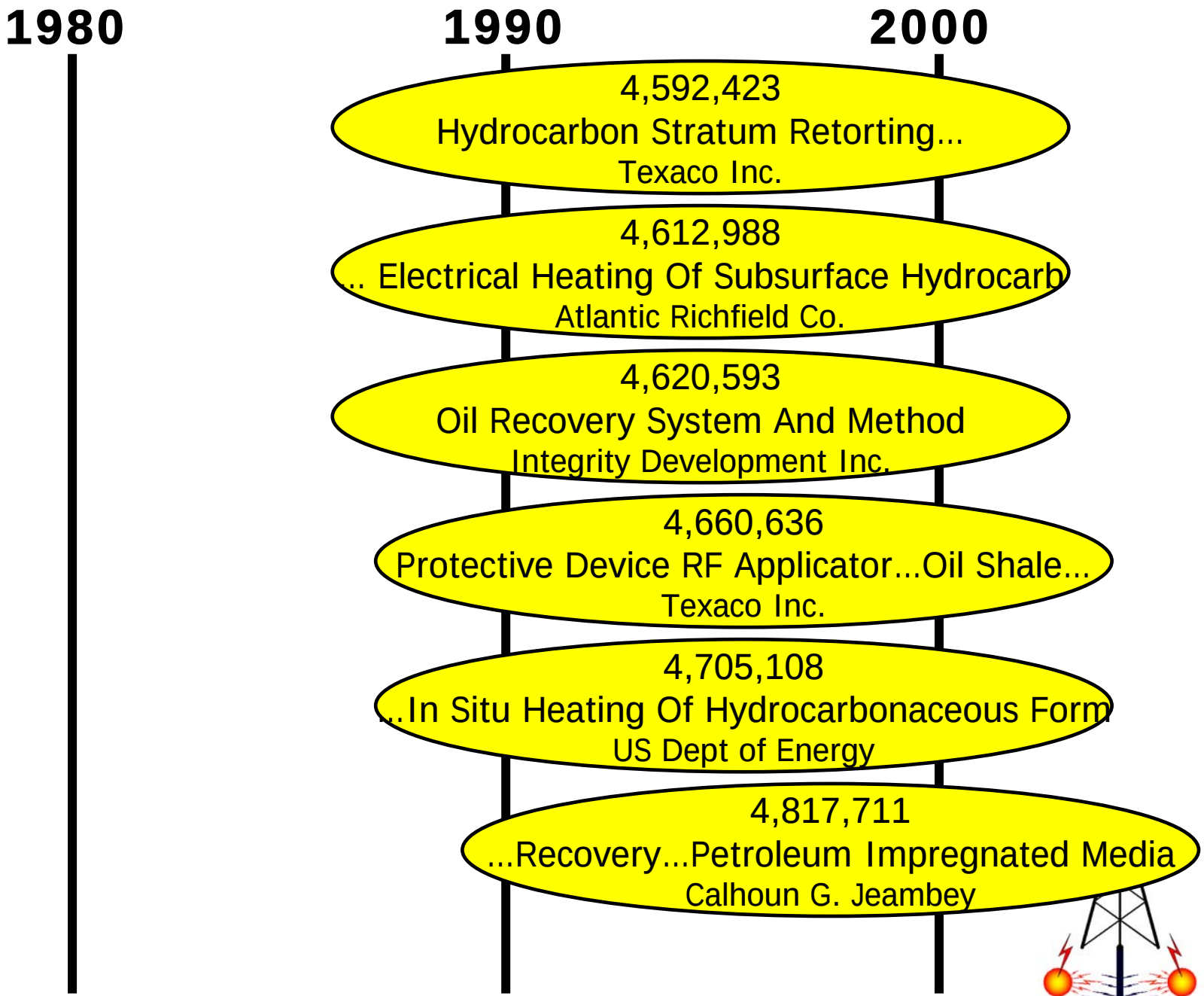
4,545,435
Conduction Heating Of Hydrocarbon Form
IIT Research Institute

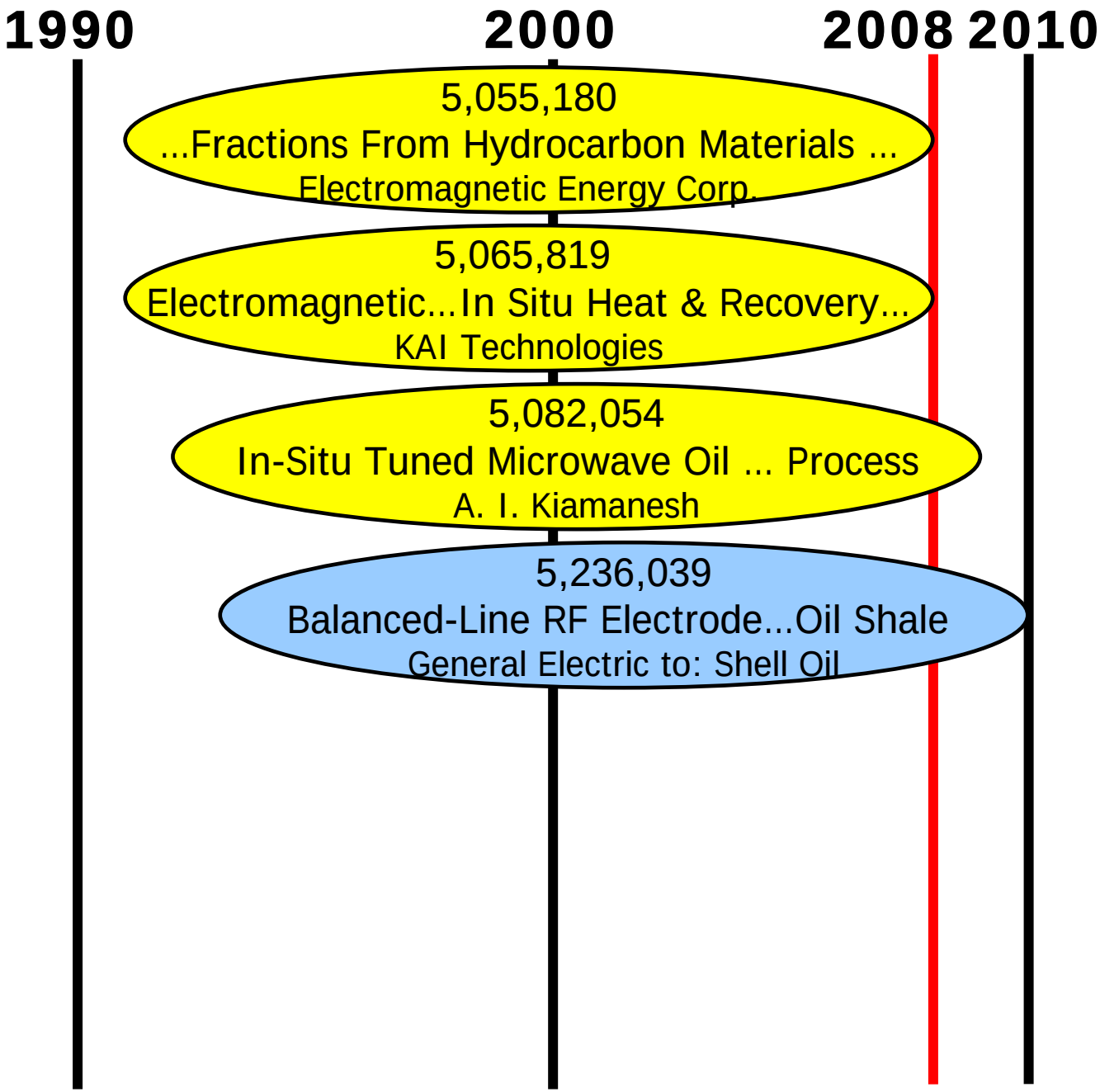
4,553,592
Method Of Protecting An RF Applicator
Texaco Inc.

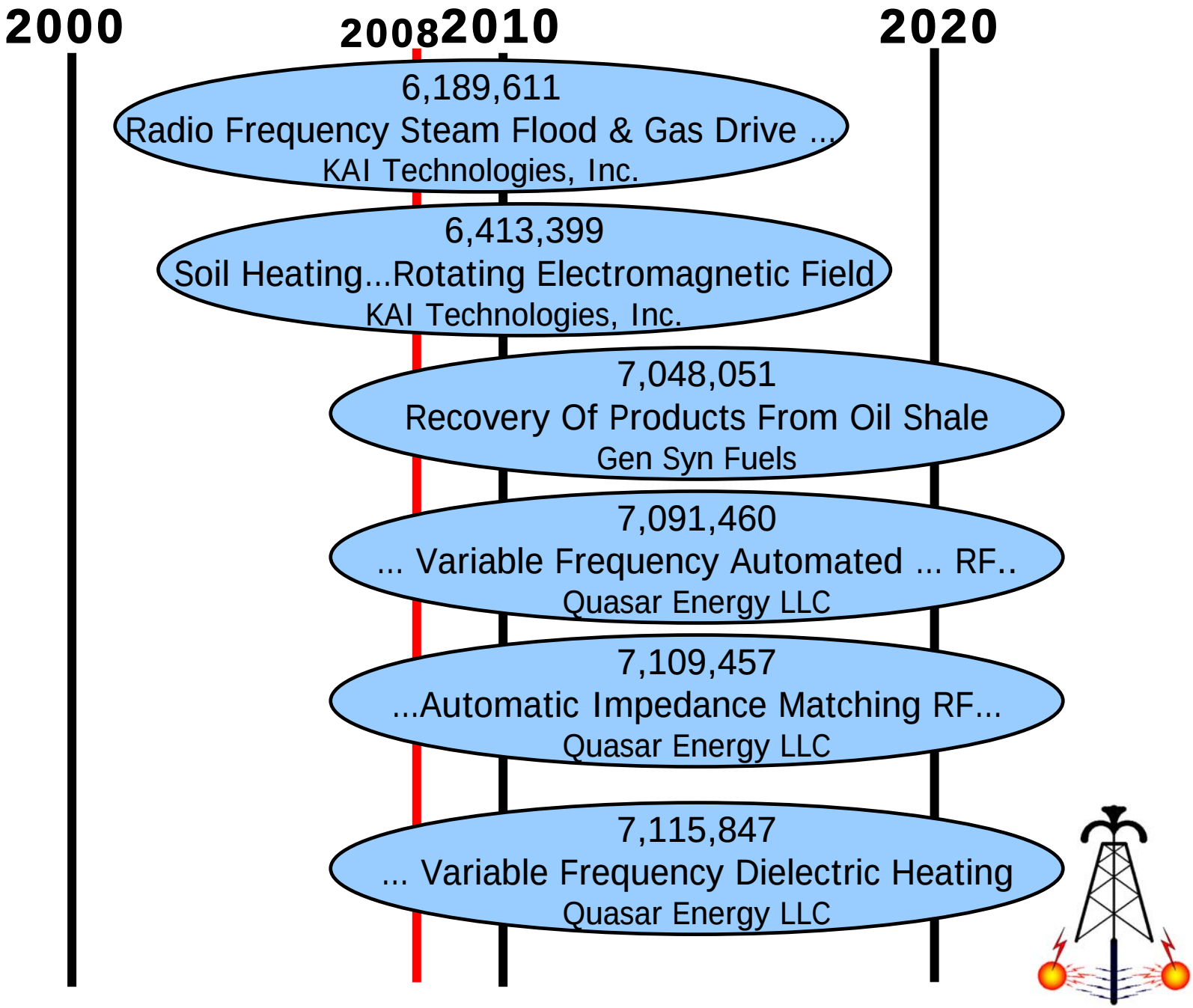
4,576,231
... Encroachment By In Situ Treated Format
Texaco Inc.

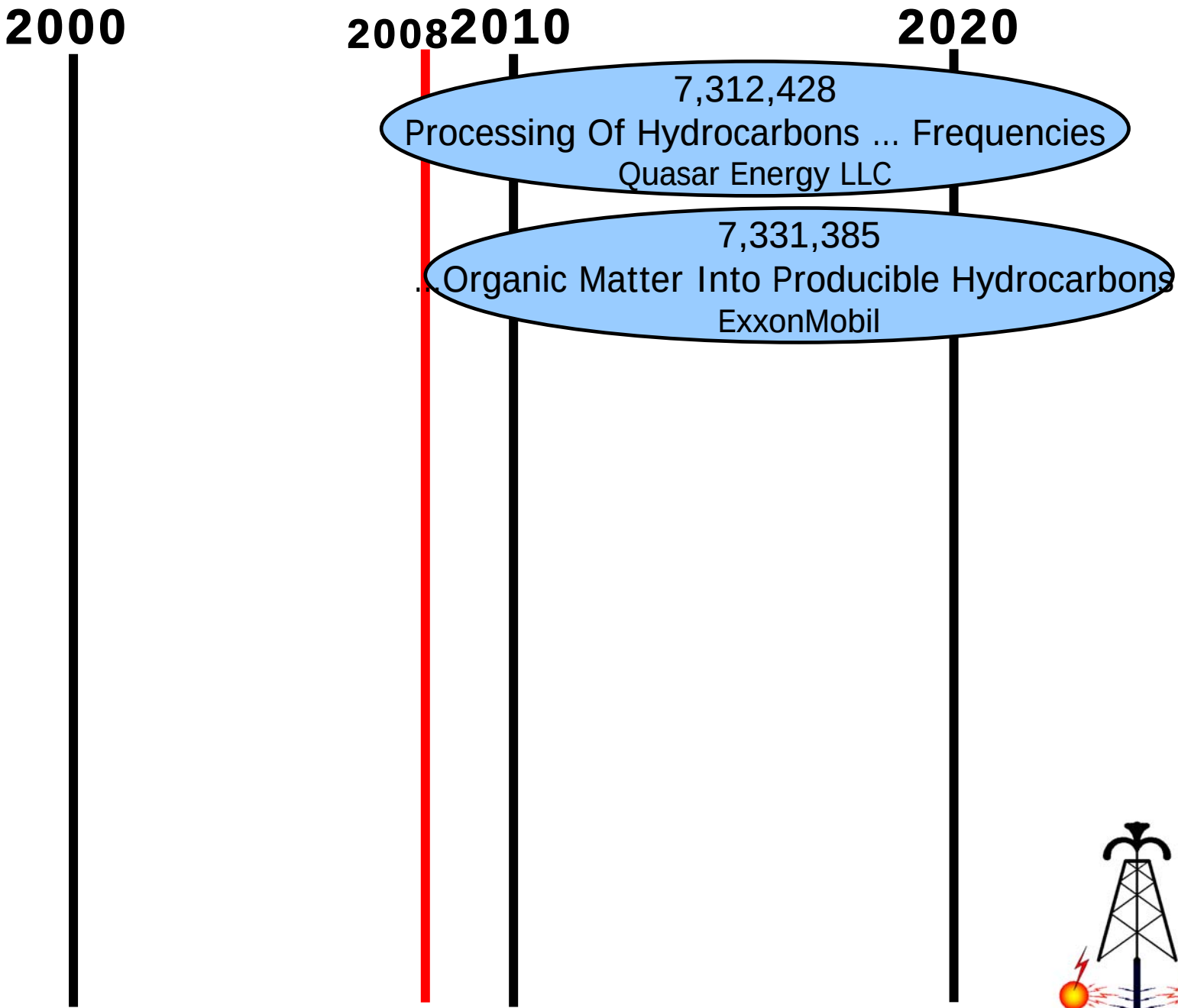
4,583,589
Subsurface Radiating Dipole
Raytheon Company




1980
1990
2000
4,592,423
Hydrocarbon Stratum Retorting...
Texaco Inc.
4,612,988
.. Electrical Heating Of Subsurface Hydrocarb
Atlantic Richfield Co.
4,620,593
Oil Recovery System And Method
Integrity Development Inc.
4,660,636
Protective Device RF Applicator...Oil Shale...
Texaco Inc.
4,705,108
..In Situ Heating Of Hydrocarbonaceous Form
US Dept of Energy
4,817,711
...Recovery...Petroleum Impregnated Media
Calhoun G. Jeambey


1990
2000
2008
2010
5,055,180
...Fractions From Hydrocarbon Materials ...
Electromagnetic Energy Corp.
5,065,819
Electromagnetic...In Situ Heat & Recovery...
KAI Technologies
5,082,054
In-Situ Tuned Microwave Oil ... Process
A. I. Kiamanesh
5,236,039
Balanced-Line RF Electrode...Oil Shale
General Electric to: Shell Oil


2000
2008
2010
2020
6,189,611
Radio Frequency Steam Flood & Gas Drive ...
KAI Technologies, Inc.
6,413,399
Soil Heating...Rotating Electromagnetic Field
KAI Technologies, Inc.
7,048,051
Recovery Of Products From Oil Shale
Gen Syn Fuels
7,091,460
... Variable Frequency Automated ... RF..
Quasar Energy LLC
7,109,457
...Automatic Impedance Matching RF...
Quasar Energy LLC
7,115,847
... Variable Frequency Dielectric Heating
Quasar Energy LLC


2000
2008
2010
2020
7,312,428
Processing Of Hydrocarbons ... Frequencies
Quasar Energy LLC
7,331,385
...Organic Matter Into Producible Hydrocarbons
ExxonMobil

D. Kinzer, 20

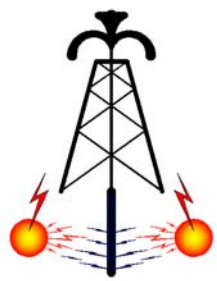
US Patents Pending

11/314,857
Method...Using Electrical Energy And Critical Fluids
Raytheon Company – Assigned to: Schlumberger
August 07, 2008: Notice of Allowance Mailed

11/314,880
Apparatus...Using Electrical Energy And Critical Fluids
Raytheon Company – Assigned to: Schlumberger
July 16, 2008: Non-Final Rejection mailed

11/600,992
Method And System For Extraction Of Hydrocarbons From Oil Shale
SASOR – Assigned to: Shale And Sands Oil Recovery LLC
September 29, 2008: Publications -- Issue Fee Payment Received

11/610,823
Microwave-Based Recovery Of Hydrocarbons And Fossil Fuels
Mobilestream Oil, Inc. (Global Resources Inc.)
April 11, 2007: Docketed New Case - Ready for Examination



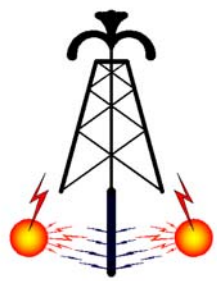
US Patents Pending

11/655,533
Radio Frequency Technology Heater For Unconventional Resources
Pyrophase, Inc.
August 14, 2008: Response to Non-Final Office Action Entered

11/708,912
Electro Thermal In-Situ Energy Storage ...
Pyrophase, Inc.
September 19, 2008: Response to Non-Final Office Action Entered

11/678,614
In-Situ Extraction Of Hydrocarbons From Oil Sands
HCE, LLC
September 11, 2008: Response to Non-Final Office Action Entered

11/682,171
Stimulation And Recovery Of Heavy Hydrocarbon Fluids
HW Advanced Technologies, Inc.
May 29, 2007: Docketed New Case - Ready for Examination



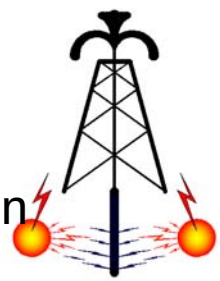
US Patents Pending

11/786,474
Method And Apparatus ... Using Energy And Critical Fluids
Raytheon Company
August 06, 2008: Non-final office action mailed

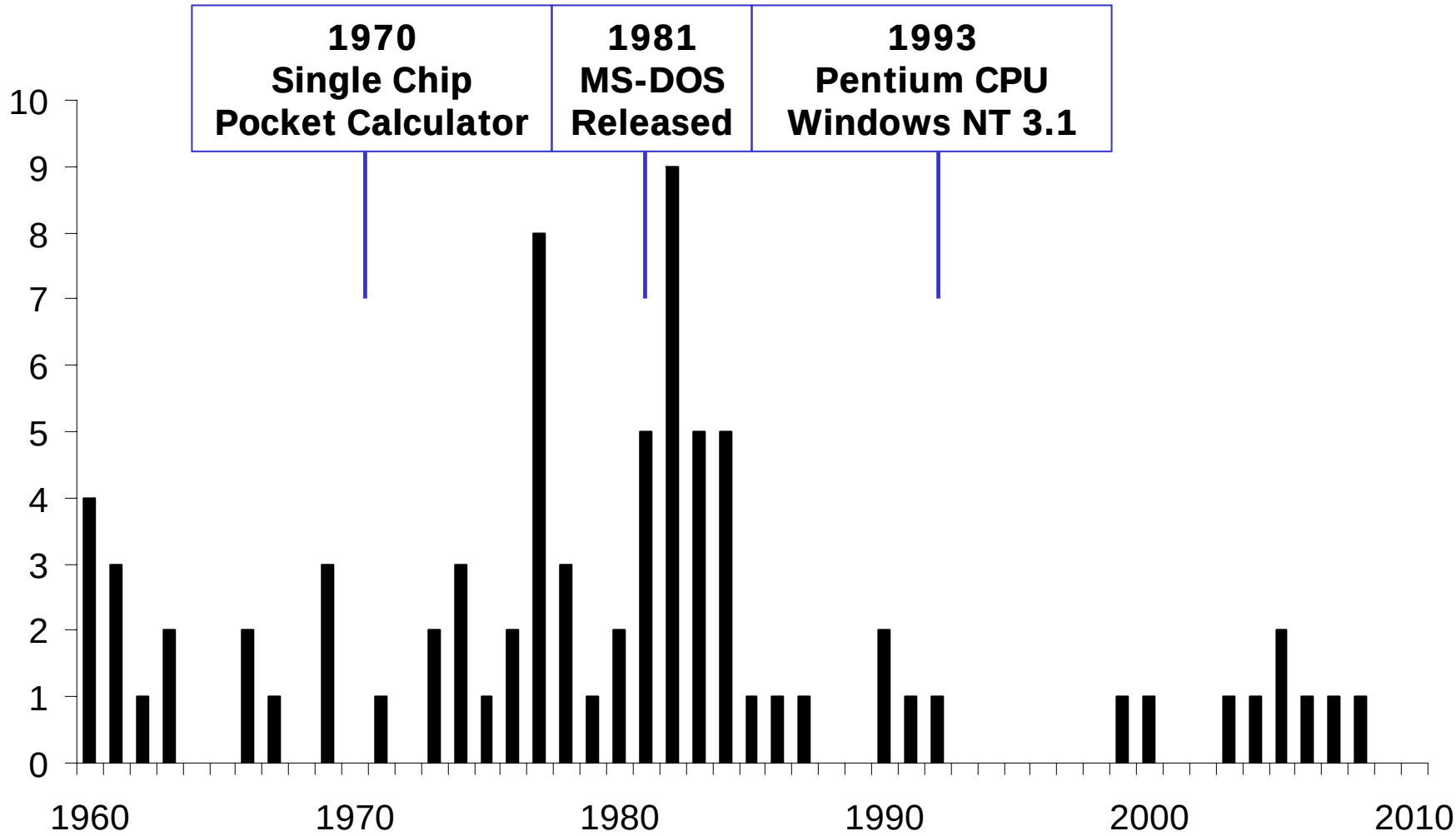
11/805,906
Microwave Process For Intrinsic Permeability Enhancement ...
Peter M. Kearl – Assigned to Geoscience Services
March 16, 2008: Docketed New Case - Ready for Examination

12/011,456
Methods Of Treating A Subterranean Formation To Convert Organic ...
ExxonMobil Upstream Research Company
May 12, 2008: Docketed New Case - Ready for Examination

10/591,566
Extracting And Processing Hydrocarbon-Bearing Formations
Quasar Energy LLC
October 17, 2007: Docketed New Case - Ready for Examination



Number of US Patents Issued By Year



Patents by Company

Raytheon Company - 11

IIT Research Institute - 10

Atlantic Richfield Company - 7

Texaco, Inc. - 6

Quasar Energy LLC - 4

KAI Technologies - 3

Phillips Petroleum Company - 3

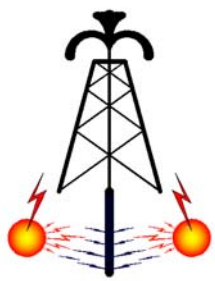
Electrofrac Corporation - 2

The Electrothermic Company - 2

Gulf Research & Development Company - 2

Halliburton Company - 2

Petro-Canada Exploration Inc - 2



Patents by Inventor

10 - Bridges, Jack E.

7 - Kasevich, Raymond S.

7 - Taflove, Allen

5 - Savage, Kerry D.

4 - Haagensen, Duane B.

4 - Kinzer, Dwight Eric

3 - DeBettencourt, Joseph T.

3 - Dwyer, Arthur S.

3 - Kern, Loyd R.

3 - Kolker, Myer

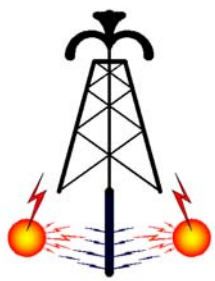
3 - Parker, Harry W.

3 - Perkins, Thomas K.

3 - Rowland, Howard J.

3 - Sarapuu, Erich

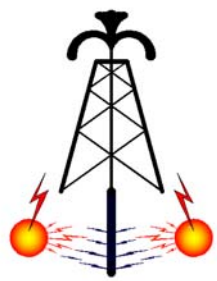
3 - Sresty, Guggilam C.



Quasar Energy LLC

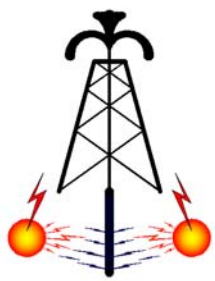
Optimized radio frequency heating typically combines:

- Automatic impedance matching based upon multiple process parameters – Patent 7,091,460
- Automatic impedance matching with variable frequency – Patent 7,109,457
- Automatic impedance matching based on temperature – Patent 7,115,847
- Computer controlled variable frequency based on Temperature – Patent 7,312,428



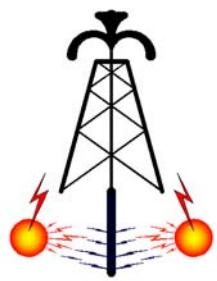
Advantages of Quasar Energy IP

- Optimized Energy Transfer
  - Real time optimization of energy transfer by monitoring variations in load properties during heating and selecting optimal frequency(s) and controlling impedance match
- Automatic Impedance Matching
  - By matching the impedance, maximum power is supplied to the load, and the maximum heating rate is achieved.
    - Electrical “impedance”: a measure of the total opposition that a circuit or a part of a circuit presents to electric current for a given applied electrical voltage, and includes both resistance and reactance
    - Matches effective adjusted load impedance to the output impedance of the signal generating unit



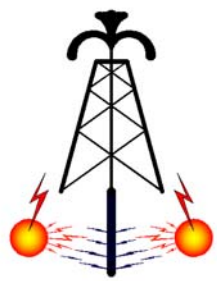
Advantages of Quasar Energy IP

- Characterization of dielectric properties vs. frequency, temperature, and control parameters assists in the design of an optimized Radio Frequency dielectric heating system
- Specific dielectric properties are determined and/or used, either
  - directly as process control parameters, or
  - indirectly as by reference to a model used in the process that includes relationships based on the properties



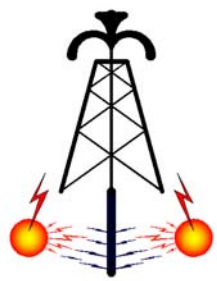
Advantages of Quasar Energy IP

- Process Control Parameters
  - Resistance
  - Voltage
  - Electric field
  - Current
  - Measuring voltage and current and determining a phase angle
  - A reverse power level of RF reflected from an effective load
  - Calculating a voltage standing wave ratio (SWR) from a reverse power level
  - Automatically adjusting an effective load impedance until SWR is about 2:1, and preferably 1:1
  - Adjusting selected frequency (Variable Frequency)
  - Tuning a tunable impedance matching network
  - Measuring temperature then automatically adjust effecti load impedance to match output impedance



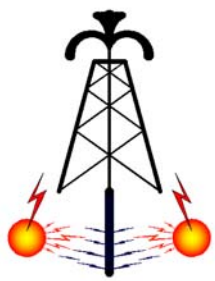
Advantages of Quasar Energy IP

- Resonance Frequency
- Debye resonance frequency:
  - frequency at which lattice limitations occur;
  - frequency at which maximum heating can be imparted for a given electric field



What's Next?

- Spectral analysis simulating reservoir conditions has never been conducted!
  - Spectral analysis of each constituent residing in an oil shale formation under reservoir conditions
  - Spectral analysis of each constituent at various temperatures as they increase in temperature
  - Determining Debye resonance frequency for each constituent at various temperatures and pressures
  - Measuring and characterizing dielectric properties as functions of frequency, temperature, and pressure



Thank You

For a CD of the patents (in pdf format) presented, which pertain to in-situ electromagnetic heating of oil shale and hydrocarbon-bearing formations, contact:

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Quasar Energy LLC

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Fargo, ND 58102

701.388.3645

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