A Preliminary Analysis of Patent Trends for Magnetic Fusion Technology

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A PRELIMINARY ANALYSIS OF
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EXECUTIVE SUMMARY

This study presents a preliminary analysis of development trends in magnetic fusion technology based on data from U.S. patents. The research is limited to identification and description of general patent activity and ownership characteristics for 373 patents. The results suggest that more detailed studies of fusion patents could provide useful R&D planning information.

BACKGROUND

Although magnetic fusion is a young technology, decades away from commercial applications, patent research of its component technologies is a useful program planning activity. Past experience indicates that basic research developments for many nascent technologies are patented at a very early stage of research. Moreover, these patents can provide useful R&D planning information on issues such as patterns of component development or identification of spinoff research activity.

Pacific Northwest Laboratory (PNL) has developed a family of statistical and computer graphics techniques to describe technology development trends using patent indicators. The objective of this research is to provide a preliminary analysis of the nature of magnetic fusion patent activity and ownership characteristics using these PNL methods. Only a limited number of the PNL patent activity indicators are used in this research. Thus, an important focus of the work is to provide recommendations as to the value of further analysis using the more advanced PNL patent citation indicators.

RESEARCH APPROACH AND FINDINGS

After definition of the problem domain and the associated research objectives, a systematic patent search was undertaken. This search was based on a classification of fusion technology components to permit comparisons of research progress. Computer analysis of the resulting patent data was then completed and the graphical results were interpreted in light of the research objectives.

The key findings from the patent indicator output are:

- o No dramatic change in the aggregate level of 10-15 magnetic fusion patents per year has occurred since 1965.
- o Patents assigned to the U.S. government constitute a majority of the the patents studied. However, a surprisingly high percentage (12%) of the patents are held by independent inventors.
- o U.S.-held patents comprise 80.7% of all patents with the balance owned by foreign assignees. France (6.4%) and West Germany (3.8%) are second and third in activity, respectively. No foreign patent activity shows any recent burst of activity; however, most of the Japanese patent activity (2.1%) has occurred since 1977.
- o Three technical areas -- heating, ion/plasma generation, and magnetic field geometry -- dominate the 14 categories analyzed with 67.3% of all patents. Of these areas, ion/plasma generation patent activity has decreased slightly in recent years while the other areas have remained stable.
- o Most U.S. government, foreign, and U.S. private patents occur in the same three technical areas identified above. However, corporate assignees have a greater patent emphasis than others in tritium breeding, process utilization, and electric power equipment.

RECOMMENDATIONS FOR FURTHER RESEARCH

Given these results, the study recommendations for further work emphasize selective analyses to aid in fusion program planning, justification and evaluation. Several types of follow-on patent analysis studies are possible, but research into technical progress should be limited to the three major technical areas identified. Patent citation analysis could be useful in these studies for more in-depth research of linkages between technical areas, inventors, and assignees. For all technical areas, highly cited patents could be identified as a partial measure of the technical significance of research work. In broader program evaluation studies, patent references outside the study set

could be reviewed to characterize "spinoff developments" from fusion research. Analysis of the research productivity by various organizations could also be conducted with patent data to identify the payoffs from publicly-funded work.

This study also suggests that, since R&D program planning and evaluation involve multidimensional measures of performance, patent data could be combined with bibliometric analysis of scientific literature to add additional observations on research outcomes. Technical leaders, cross-fertilization of developments, and areas of high or low progress could be identified in these studies to support program evaluation requirements.

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A PRELIMINARY ANALYSIS OF PATENT TRENDS FOR MAGNETIC FUSION TECHNOLOGY

1.0 INTRODUCTION

This document presents a preliminary analysis of development trends in magnetic fusion technology based upon data from the U.S. patent system. The study scope is limited to identification and description of broad patterns of technology change from 373 patents. However, the results suggest that additional, more detailed studies of fusion patents could provide useful research planning information.

1.1 BACKGROUND

The current state of development in magnetic fusion technology suggests that commercial applications are decades away. Substantial engineering and system development problems must still be overcome (Conn, 1983). However, progress in fusion research is a matter of great current national interest because of the important need for reliable and low pollution energy sources. Thus, even for a very young technology like magnetic fusion, using all sources of planning information -- including patents -- is an important strategy for effective research and development (R&D) program management.

There are a number of ways of detecting and documenting technological progress. Pacific Northwest Laboratory (PNL) has developed several well-known analytic tools for tracking and predicting technological change using data from patents (Campbell and Nieves, 1979). These tools, called the Battelle Patent Indicators, have proven valuable for a variety of research and development planning studies in previous applications. The PNL methods are able to evaluate several key parameters of progress and change in areas of technical R&D which result in patents. For example, questions such as the following have been addressed in previous patent analysis studies:

- o Are technological developments occurring primarily in narrow areas of a field or is progress occurring in several areas?

- o Are shifts occurring in the focus or pace of technological development?
- o Are the developments being carried out by many organizations or by only a few?
- o Have developments been primarily due to private initiative, or have they been heavily influenced by federal support?
- o Is there a cohesive body of patents in the field, or are significant patents scattered among many different topics?
- o What can be inferred about the level of foreign interest in the field from the number of foreign-held patents?

Patent data provide a unique and valuable source of information with which issues such as these can be investigated.

1.2 RESEARCH OBJECTIVES AND SCOPE

The purpose of this study is to provide a preliminary analysis of the nature of developments in magnetic fusion technology using U.S. patent data. The research will be limited to a description of the general characteristics of patent activity and assignees for major fusion technology components. The trends in some key activity variables over time are also examined where information on patent filing or issue dates provide useful insights.

This research is not intended as a comprehensive analysis of fusion patent data. The study is preliminary in nature; its focus is to evaluate recent magnetic fusion patent data and to develop recommendations concerning the advisability of more detailed research of patent information. More advanced methods to evaluate patent trends, such as analysis of patent citations or combining patent data with expert judgement, are not undertaken in this study. Also, information on cross-referencing to foreign patents or to other R&D program indicators is not considered.

1.3 THE VALUE OF PATENT ANALYSIS FOR NASCENT TECHNOLOGIES

An important question can be raised concerning the significance of patent analysis when applied to a technology such as magnetic fusion which has a long

development period and which is far from commercialization. However, on the basis of past experience, it appears that patent analysis does have utility in some of these cases as an aid for planning or evaluating development program activities. First, historical evidence indicates that for many youthful and basic technologies, significant patenting of new developments has occurred (Carpenter, 1980). Economic motivations are not the only reasons to patent. There are non-economic uses of patents -- from the standpoint of the inventor and the assignee (patent owner) -- to be considered earlier in the development cycle than is generally practiced. Furthermore, the technical content of these patents, taken together, may hold useful information for R&D program or investment planning. Finally, patent data is valuable for evaluation of research program technical progress, even in nascent technical areas.

Within some parts of the scientific community there is little regard for patenting the kinds of basic inventions which emerge from fundamental research, rather than applied research. The historical association of patenting with the creation of a product monopoly no doubt contributes to this situation. The fact is that a substantial percentage of truly basic discoveries in the last fifty years have been patented. Fermi, for example, patented the nuclear pile -- clearly a basic invention (his family received \$50,000).

Many scientists use the patent system not for profit but to establish "priority" or order-of-discovery. Given the number of multiple, independent discoveries within the U.S. patent system, this is not a trivial issue. A U.S. patent in this situation provides a government certificate of originality and priority, produced by a disinterested third party. Further, by virtue of the special characteristics of patent referencing, the position of a patented discovery relative to the state of the art is often spelled out in detail (particularly if one reads the correspondence generated during the rejection/amendment process).

A scientist's professional stature is strongly determined by receiving proper scientific credit for his or her inventions and discoveries. This can be problematic in turbulent, emerging areas where the research front may be changing rapidly. The professional stakes involved are obviously very high for individual or group that leaps some of the present technical hurdles in an area such as fusion. Thus, patents will be sought even by those with no profit motive.

Beyond establishing scientific credit for professional reasons, from the standpoint of governments and firms there is often a need or a reasonable rationale for defensive patenting to protect multi-billion dollar R&D investments from opportunistic, nuisance, or offensive patents. The objective of such patenting is often not to exclude others, but for an assignee or inventor to protect themselves from being excluded from an area of interest by patent actions of others.

These characteristics of patenting behavior suggest two broad aspects of program management for youthful technologies that can benefit from patent studies. First, from the standpoint of program evaluation, patent data can provide important information either on the research productivity or the significance of research activity from participating individuals or groups. Second, as a program planning and justification tool, patent data allow insights into the performance of competitors -- in particular to monitor foreign competition. In addition, patents permit identification of indirect research benefits such as "spinoff developments" in related technical areas. Patents are of course also an extensive and well-documented source of innovative ideas.

For these reasons, the patent system can be productively used to monitor and evaluate technical developments in areas that are far from commercialization. While not the only source of technical information, patents can provide valuable insights into the current state of the art of an emerging technology.

(1) We have defined defensive patents as those patents assigned to an organization or individual covering a parallel invention or variant. These could be potential competitive inventions to those which are generally not intended to be "worked," i.e., produced; but used to limit a competitor's more basic patents or to establish a negotiating position for cross-licensing agreements. Thus, offensive patents as defined here are not generally alternatives to the basic patent, but improvements or applications (i.e., minor spinoff inventions).

1.4 OUTLINE OF THE STUDY

Section 2 of this study presents the general approach to performing a patent trend analysis and describes the specific steps used in this preliminary study of magnetic fusion. The details of the approach to fusion technology classification and the patent search are given in Section 3. Analysis results are then presented in Section 4, where both the aggregate trend data and the findings from the technology classification comparison are given. Section 5 contains recommendations for further work.

2.0 STUDY METHODOLOGY

The general research approach for this study is summarized in this section. The methods presented here are based on more detailed discussions of patent analysis in previous Battelle research studies (Campbell and Nieves, 1979).

2.1 INTRODUCTION

The major objectives of this research are to better understand the nature of technological patent activity and the composition of patent ownership for magnetic fusion technologies. The analysis undertaken to accomplish this task used information from U.S. patents of both U.S. and foreign origin. Abstracted data from these patents was analyzed by statistical techniques to identify trends or patterns in the technology.

2.2 ANALYSIS STEPS AND PROCEDURES

A summary of the analysis process is contained in Figure 1. Each of the major steps is summarized below along with comments regarding the analysis procedures used to complete the research task.

Step 1 concerns formulation of the research problem. In general, this process includes identification of the technology area to be studied as well as definition of the particular problem domain of the technology area which is the specific focus of the work. A problem domain is considered to be some aspect of a system or product's functional performance which is addressed by technological developments or solutions. One or more technical approaches to a set of related product or system development requirements may be the focus of patent activity in a problem domain. As an illustration, fuel injection, stratified charge formation, and electronic ignition are all technical approaches related to the problem domain of automotive fuel economy.

Figure 1. Battelle Patent Analysis Process

Definition of the problem domain is an important step for identifying the set of patents relevant to a study and for interpreting their characteristics. The choice of an appropriate problem domain should be guided by both the area of technical interest and the specific questions and issues the analysis is designed to address. For this study the problem domain was defined to be general regarding technical area (magnetic fusion technology) and unfocused as to functional performance or problem (all aspects are relevant). Thus, all patents which are directly related to magnetic fusion research are of interest in this problem domain.

This step also includes a categorization of the technology in question into technical areas, subgroups, or components relevant to the overall problem domain. The resulting classification helps in identifying relevant patents and allows comparative analyses of the relative development activity, technical linkages, and assignees for the corresponding patent subgroups. The classification of magnetic fusion developed for this research is described in Section 3.

Step 2 concerns formulation of the research questions to be addressed by the analysis. For this study the following concerns define the scope of the research:

- o What are the significant areas and timing for technological developments and is progress apparent primarily in narrow areas of the magnetic fusion field?
- o Is there a cohesive body of patents in the field, or are significant patents scattered among many different topics and many different organizations?
- o Have developments been due to private initiative, or have they been heavily influenced by federal support?
- o What can be inferred about the level of foreign interest in the field from the number of foreign-held patents?

These questions are addressed with the purpose of formulating recommendations on the value of more detailed follow-on, patent-based studies of fusion

research. This study will only address patent activity and ownership. Advanced techniques, such as patent citation analysis, will not be covered in this research.

The patent search activity is covered in Step 3. The purpose of this step is to identify patents relevant to the analysis and to construct the patent study data set. The patent search may be conducted with two basic approaches -- first, using the U.S. Patent Office numerical classification system, and second, using selected patent title or abstract keywords. Often both methods are used, as was the case for this study.

Information on each analyzed patent was then entered into a computerized data base management system for subsequent analysis. For this preliminary patent evaluation, the information included:

o Patent Number	o Assignee Sector
o Issue Date (DDMMYY)	o Assignee Country
o Filing Date (DDMMYY)	o Technology Type
o Title (up to 68 characters)	o Inventor Name (up to 5 names)
o Assignee Name	

After the data base is established, the specific analysis procedures and patent indicators are selected and organized in Step 4. For this study the Battelle Activity Indicators were the principle analysis tools used (Campbell, 1983). Computer analysis of the patent data set, including computer graphics, is conducted in Step 5.

The tabular and graphic output from the computer processing are interpreted in Step 6. In some cases, other data sources are used to facilitate this process. For example, in this research PNL technical staff members familiar with fusion research provided expert knowledge to aid in understanding the patent analysis results.

Finally, the research process, analysis results, and study recommendations are documented in Step 7.

3.0 FUSION PATENT DATA BASE AND TECHNOLOGY CLASSIFICATION

This section describes the technology breakdown used to classify the fusion patents into technological groups for further analysis and presents the results of the patent search process.

3.1 FUSION PATENT TECHNOLOGY CLASSIFICATION

In order to aid the patent search process and to permit a comparative analysis of fusion technology components, fourteen different magnetic fusion technical categories were established. A detailed explanation of these technology types, as well as other fields of the patent data base is included in Appendix A.

The technology categories are summarized below:

1. Magnetic Field Geometry and Confinement Schemes
2. Ion, Plasma Generation
3. Plasma Control/Field Shaping
4. Plasma Boundary/Impurity Control
5. Heating
6. Coil/Magnet Technology
7. Instrumentation/Diagnostics
8. Vacuum Technology
9. Tritium Breeding/Extraction/Recovery/Processing
10. Process Utilization of Fusion/Plasma Energy
11. Heat Generation/Blanket and Shield Designs
12. Power Conversion, Thermodynamic Cycles
13. Electrical Power Supplies/Power Storage/Switching/Transmission
14. Materials

These categories are similar to those used in DOE's computerized Energy Data Base (U.S. Department of Energy, 1983). The categories were developed in consultation with PNL staff experienced in magnetic fusion technology. During the patent search process, the patent office classification structure and the patents themselves served as additional inputs to define the scope of each category.

3.2 PATENT SEARCH RESULTS

One of the most important elements of any patent trend analysis is the selection of the relevant patents. PNL conducted an extensive patent search for magnetic fusion-related patents. The patent set was initially limited to those patents issued after 1965. Three data bases were used in this search:

- o Pergamon
- o Claims/U.S. Patent Abstracts
- o U.S. Patent Office (OTAF)

Table 1 contains the results of the Pergamon search for patents related to magnetic fusion using the keywords shown. Patents filed from January 1971 through March 1983 were included. An asterisk indicates a search for patents with any version of that keyword.

These patents were reviewed for class and subclass based on the patent Manual of Classification (U.S. Patent Office, 1981). Patents classified in areas thought to be irrelevant to the study scope were eliminated. The remaining patents were sorted by patent number. Patents duplicating those found in the Claims/U.S. Patent Abstracts data-base search were eliminated. This left a unique set of 260 potentially relevant patents not classified under Class 376, the nuclear patent class (this patent class was revised in October 1981).

The Claims/U.S. Patent Abstracts search was limited to the years 1965-1982. It was restricted to patents referenced or cross-referenced to Class 376, Subclass 121-150; 331 patents were found. Table 2 lists these subclasses.

The U.S. Patent Office search of the same subclasses yielded 451 for the period 1963-1982. Limiting the years to 1965-1982 reduced the total to 329. A comparison of the patent numbers listed against the Pergamon and Claims/U.S.

TABLE 1. Keyword Search Results

<u>Keyword</u>	<u>Number of Patents</u>
Magnetic (or thermonuclear or nuclear) and Fusion	95
Plasma and Fusion	30
Tritium and Fusion	8
Magnet* and Plasma	223
Tokomak	12
Fusion and Reactor Wall	2
Neutral and Beam*	101
Plasma and Confine*	29
Toroid* and Magnet	<u>171</u>
TOTAL	671

TABLE 2. Class 376: Induced Nuclear Reactions, Systems and Elements
(From Manual of Classification Order 811 - October 15, 1981)

- 100 NUCLEAR FUSION
- 121 ..Magnetic confinement of plasma
- 122 ..Plasma formed in situ by laser
- 123 ..Principal heating by wave energy
- 124 ...Heating by time varying magnetic field (e.g., by compression)
- 125 ..Imploding liners
- 126..With enveloping charged particle confinement (e.g., E or P layer)
- 127 ..With injection of electrically charged or accelerated particles
- 128 ...Plasma injection
- 129 ...Negatively charged particle injection
- 130 ...Neutral particle injection
- 131 ..Auxiliary heating
- 132 ...Electromagnetic wave energy
- 133 ..Toroidal confinement of plasma
- 134 ...Divertors
- 135Effuser
- 136 ...Limiters or liners
- 137 ...With solid internal conductor
- 138 ...Bumpy torus
- 139 ..Linear confinement
- 140 ...Mirror devices
- 141Plasma formed or contained between spaced electrodes
- 142 ..Magnetic structure
- 143 ..With circuitry
- 144 ..Plasma formed between spaced electrodes
- 145 ..Plasma focus
- 146 ..Including removal or use of impurities or reaction products (e.g., energy)
- 147 ..Direct conversion of energy
- 148 ..Including use of heat or radiation to effect a chemical reaction
- 149 ..Shock wave heating of plasma or gas (e.g., MHD heating)
- 150 ..Chamber structure or material

Patent Abstracts searches showed five patents not previously found. This resulted in a list of 596 distinct patents:

<u>Data Base</u>	<u>Number of Magnetic Fusion Patents</u>
Pergamon	260
Claims/Abstracts	331
Patent Office	<u>5</u>
TOTAL	596

Copies of these 596 patents were then acquired and individually reviewed for their relevance to the magnetic fusion problem domain in this study. This resulted in a final list of 373 patents for inclusion in the data base. In short, the search identified 37 patents beyond those classified in Class 376, Subclass 121-150.

A listing of the 373 patents (in patent number order) is included in Appendix B.

4.0 ANALYSIS AND FINDINGS

The magnetic fusion patent data base was individually sorted on specific fields to permit a more detailed analysis of both static characteristics as well as trends in the data over time. Aggregate patent activity (total number of patents per year) was analyzed initially to identify general trends. Significant corporate assignees were identified. Yearly patent activity for assignee sector, country, and technology type were also reviewed. In addition, breakdowns of patent activity by technology type were analyzed separately.

4.1 AGGREGATE ACTIVITY AND OWNERSHIP TRENDS

The solid line in Figure 2 plots the total number of magnetic fusion patents issued from 1965 through 1982. The dashed line represents the filing date of these issued patents. This means that not all patents filed before 1965 are plotted; only those which were filed in 1965 and issued in 1965 or later are included. In addition, the sharp decline in filings in 1981 and 1982 is a result of the average 2-3 year time lag between the filing and issuance of a patent. Only patents issued before January 1, 1983 were included for analysis. These patents were filed before 1981.

Figure 2 reveals a span of sustained patent activity at a relatively modest level. A majority of the period shows a rate of activity of 10-15 patents filed per year. Only in 1973 did the number of filings exceed 25. By way of comparison, the number of patents filed in photovoltaic cells, which is a new energy technology very close to rapid commercial development, exceeded 45 each year during the period 1975-80. The figure suggests continued interest in magnetic fusion without any dramatic shift in the level of patent activity.

4.1.1 Activity Disaggregated by Assignee Sector

Table 3 lists the number and percentage of patents issued to different types of assignees. Not surprisingly, the largest share of the patents issued

FIGURE 2. Magnetic Fusion Aggregate Patent Activity

in this area were assigned to a government agency or laboratory, although private firms hold nearly the same numbers. The low number of patents assigned to universities is probably due to the fact that most fusion research performed at universities is under contract to government agencies. Patents developed during the course of such research would normally be assigned to the funding agency. It is somewhat surprising to see that nearly 12% of the patents were individually owned; i.e., issued to independent inventors. Apparently there is room for innovation in magnetic fusion from inventors without large organizational resources. The relatively low level of private firm/corporate sector patents is indicative of a technology far from commercialization.

TABLE 3. Breakdown by Sector

<u>Sector</u>	<u>No. of Patents</u>	<u>% of Patents</u>
1 Private Firm or Corporation	154	41.3
2 University, College	5	1.3
3 Non-Profit Research Foundation	3	0.8
4 Government Agency or Laboratory	163	43.7
6 University Patent Broker	4	1.1
7 Individually-Owned Patent	<u>44</u>	<u>11.8</u>
TOTAL	373	100.0

Figure 3 plots the yearly activity disaggregated by assignee sector. University, research foundation, and patent broker assigned patents were combined as "other" for easier graphical interpretation. Except for the fact that 10 of the 12 patents in the "other" category were issued in the last 8 years, there are no apparent major trends (up or down) in the level of activity of the various sectors. Increased federal funding for fusion research from 1977-1982 has not as yet produced an appreciably higher rate of government assigned patents (Norman, 1983).

4.1.2 Corporate Assignees

A total of 58 private firms or corporations were assigned 154 patents, 41.3% of the total number of patents issued (see Table 3). Among these

FIGURE 3. Patent Activity by Scope

assignees, the top six most active corporations received 40% of this sector's patents. These six assignees are listed in Table 4. The top corporation -- General Atomic -- has also worked as a contractor for the Federal government (inferred from the common inventor names). Therefore, truly independent work by corporates was probably responsible for 25-30% of the total patents.

TABLE 4. Patent Activity for the Top Six Assignees

<u>Top Corporate Assignees</u>	<u># of Patents</u>	<u>% of All Corporate</u>
General Atomic Company	15	9.7
Texas Gas Transmission/KMS Fusion	14	9.1
TRW	9	5.8
International Telephone & Telegraph	8	5.2
Siemens	8	5.2
Xerox	8	5.2

4.1.3 Activity Disaggregated by Country

Table 5 lists the number and percentage of patents by assignee country (the inventor country is used when the patent is unassigned). The U.S. received 80.7% of the patents in magnetic fusion, considerably higher than the proportion of U.S. assigned patents across all technologies in recent years (OTAF, 1981). The remaining 19.3% of the patents are distributed among 14 other countries, with France being the most active.

Figure 4 disaggregates the yearly activity by country. The figure shows that the number of foreign assigned patents per year has remained relatively constant, averaging close to four per year over an 18-year period. The level of U.S. activity has shown more yearly variation, although some activity occurred in each of the years studied. By contrast, West German activity declines after 1975. No foreign country shows any recent burst of major activity; however, the Japanese have received most of their patents in the last seven years.

TABLE 5. Breakdown by Country

	<u>Country</u>	<u># of Patents</u>	<u>% of Patents</u>
01	U.S.A.	301	80.7
54	West Germany	14	3.8
55	Japan	8	2.1
56	France	24	6.4
57	Belgium	1	.3
59	Canada	2	.5
60	Austria	2	.5
61	Italy	2	.5
65	Liechtenstein	4	1.1
67	Switzerland	1	.3
68	USSR	2	.5
71	Australia	1	.3
80	The Netherlands	2	.5
85	United Kingdom	8	2.1
90	Luxembourg	<u>1</u>	<u>.3</u>
	TOTAL	373	100.0

FIGURE 4. Patent Activity by Country

4.2 FUSION TECHNOLOGY TYPE COMPARISON

Table 6 lists the number and percentage of patents by technology type. These categories are defined in Appendix A. Each patent was reviewed in depth before classification into one of the 14 types.

The three largest categories were heating, ion/plasma generation, and magnetic-field geometry. Together they include 251 patents, 67.3% of the total. This probably is an accurate reflection of the emphasis in fusion research. The fact that instrumentation/diagnostics, power conversion, and electrical equipment have relatively few patents provides additional evidence of a technology far from commercialization. While much of the relevant technology probably exists "off the shelf," more patents in these areas would be expected as the technology evolves to focus on engineering concerns.

4.2.1 Technology Type Activity Trend Results

Figures 5 and 6 show the yearly activity disaggregated by technology type. Note that Figure 6 is at twice the scale as Figure 5 to aid visual interpretation. Figure 5 reveals that the number of patents concerning ion/plasma generation is declining over time, particularly after 1974. By contrast, heating and field geometry show no decline. The other categories have appreciably fewer patents, making trend interpretation difficult.

4.2.2 Technology Type Activity by Country and Sector

Table 7 is a cross-tabulation of technology type by country. Generally, most foreign assigned patents are in heating (Type 05), confinement (Type 01), and plasma generation (Type 02), like the U.S.-held patents. However, in contrast to the U.S., which has patents in each category, foreign patents have noteworthy gaps. No foreign patents occur in plasma control (Type 03), boundary control (Type 04), process utilization (Type 10), and heat generation (Type 11). Moreover, several categories have only one foreign patent.

Table 8 is a cross tabulation of technology type by sector. Again, the same three categories receive the most patents across all sectors. It is

TABLE 6. Breakdown by Technology Type

<u>Technology Type</u>	<u>No. of Patents</u>	<u>% of Patents</u>
01 MAGNETIC FIELD GEOMETRY	86	23.1
02 ION, PLASMA GENERATION	64	17.2
03 PLASMA CONTROL/FEED SHAPING	13	3.5
04 BOUNDARY/IMPURITY CONTROL	10	2.7
05 HEATING	101	27.1
06 COIL/MAGNET TECHNOLOGY	20	5.4
07 INSTRUMENTATION/DIAGNOSTICS	11	2.9
08 VACUUM TECHNOLOGY	3	.8
09 TRITIUM BREEDING/PROCESSING	22	5.9
10 PROCESS USE OF FUSION ENERGY	15	4.0
11 BLANKET AND SHIELD DESIGNS	1	.3
12 POWER CONVERSION/HEAT TRANSFER	10	2.7
13 ELECTRICAL POWER EQUIPMENT	13	3.5
14 MATERIALS	4	1.1

FIGURE 5. Patent Activity by Technology Type

FIGURE 6. Patent Activity by Technology Type

TABLE 7. Technology Type/Country Cross Tabulation

<u>Type</u>	<u>USA</u>	<u>France</u>	<u>Germany</u>	<u>Japan</u>	<u>UK</u>	<u>Other</u>
01	70	4	1	0	4	7
02	44	1	5	0	1	3
03	12	1	0	0	0	0
04	9	1	0	0	0	0
05	81	5	7	3	1	4
06	18	0	1	1	0	0
07	9	1	0	0	1	0
08	1	0	0	1	0	1
09	18	1	0	1	0	2
10	15	0	0	0	0	0
11	1	0	0	0	0	0
12	9	0	0	1	0	0
13	11	0	0	1	1	0
14	3	0	0	0	0	1
TOTAL	301	24	14	8	8	18

TABLE 8. Technology Type/Sector Cross Tabulation

<u>Type</u>	<u>Government</u>	<u>Private</u>	<u>Individual</u>	<u>Other</u>
01	33	34	13	6
02	24	30	9	1
03	8	3	2	0
04	6	4	0	0
05	55	31	13	2
06	10	7	2	1
07	6	4	0	1
08	1	2	0	0
09	6	14	2	0
10	2	13	0	0
11	1	0	0	0
12	6	2	1	1
13	3	9	1	0
14	2	1	1	0
TOTAL	163	154	44	12

interesting to note, however, that corporate assignees have a greater relative emphasis in tritium breeding (Type 09), process utilization (Type 10), and electrical power equipment (Type 13). Also, the other corporate patents cover the remaining 14 areas with nearly the same overall distribution as appears for government patents.

4.3 A SUMMARY OF RESEARCH FINDINGS

A total of 373 U.S. patents were analyzed in this study. The principle findings of the research are summarized below:

- o Fusion patent activity has been generally stable in most years since 1965 at the relatively modest level of 10-15 patents per year. No major trends in patent volume, either up or down, were apparent in the data.
- o The largest share of U.S. patents have been issued to either an agency (or laboratory) of the U.S. government (43.7%) or a private firm or corporation (41.3%). Also, a surprisingly high percentage (12%) of the patents are held by independent inventors.
- o U.S.-held patents comprised 80.7% of all patents compared to foreign assignees. France (6.4%) and West Germany (3.8%) are second and third in activity respectively. Furthermore, no foreign country shows any major recent burst of activity. However, most of Japan's patents (2.1%) have been issued since 1977.
- o The three largest technical areas of patent activity have been heating, ion/plasma generation, and magnetic-field geometry technologies. In fact, these areas dominate the 14 categories analyzed with 67.3% of all patents. Of these three areas, only ion/plasma generation patent activity seems to be decreasing; the other two major areas are relatively stable.
- o Most foreign patents also occur in the same three technical areas identified above.

o Also, most privately held U.S. patents are also concentrated in the three technical areas previously mentioned. However, corporate assignees have a greater relative emphasis than all other assignees in tritium breeding process utilization and electrical power equipment patents.

5.0 RECOMMENDATIONS FOR FURTHER RESEARCH

The major purpose of this research was to provide recommendations as to the need for and nature of additional fusion patent research. The key findings in this analysis of general patent characteristics confirm that fusion technology is at a very nascent stage of development, but do suggest some value for the role of patent analysis in R&D program management. The major results of this analysis are as follows:

- o No dramatic change in the aggregate level of patenting has occurred in the last five years.
- o Patents assigned to the U.S. government constitute a majority of the patents identified. However, a surprisingly high percentage of independent patents are held.
- o Foreign assigned patents represent about 20% of the patents identified. Of the foreign assignees, Japanese and French patents show the most recent sustained level of activity.
- o Confinement, plasma generation, and heating have remained the primary thrusts of patent activity research since 1965 across all the assignee sectors.

Given these results, any further patent analysis should focus on issues which would aid in the planning of future magnetic fusion research, e.g., scientific and technical productivity of funded research organizations, recent shifts in technical focus, justification of funding priorities, or identification of spinoffs from fusion research to other areas. Both the content and timing of patent data are useful contributions to understanding these issues -- particularly when combined with other types of data -- to form multiple indicators of R&D progress and its sources. For example, in program evaluation studies, patent data would be a valuable supplement to expert judgement for assessing research significance and productivity (DOE, 1982).

In planning R&D programs, patent data is a rich source of information on innovative concepts. Patents are also a good indicator by which to monitor progress of relevant organizations and it is particularly valuable to monitor foreign competition. Using patent citation analysis, spinoff developments and key work in related technical areas can be identified. To illustrate how these issues can be addressed, two general types of recommendations are given.

5.1 EXPANDED PATENT ANALYSIS

Further detailed technology analysis using patents should focus on the areas of confinement, plasma generation, and heating. The other technology categories have too few patents for meaningful trend analysis. These three areas, with approximately 250 patents, represent a relatively small but still analyzable patent set.

Patent reference and citation analysis is an important technique which was not used in this preliminary study. Citation data would be useful to permit more in-depth analysis of the linkages between technical areas, inventors, and assignees (Campbell, 1983). Highly cited patents not included in the initial list of patents should be identified for possible inclusion in a more complete patent set, particularly any patents issued before 1965. This will give a more complete picture of the evolution of this technology. Highly cited patents and inventors could be used to identify the source of significant developments.

References to fusion patents from patents outside the study set are valuable for identifying spinoffs from fusion research to other areas. This type of analysis is covered by the Battelle patent indicator Generality (Campbell and Nieves, 1979).

An analysis could also be made to identify the specific laboratory, university, or corporate contractor where work was done to produce government assigned patents. This information can be used to disaggregate the analysis at a level more useful to determining the significance of research progress and the outlook for research organizations or approaches -- which may aid technical planning decisions in budget-constrained fusion research programs.

5.2 BIBLIOMETRIC STUDIES

Clearly, magnetic fusion development is tied to advancements in both theoretical and applied science. Patents, by themselves, do not capture the full scope of these activities. Thus, to strengthen the understanding of fusion development trends, further patent analysis should be supplemented with a bibliometric analysis of articles and reports in the same three areas of magnetic fusion technology (Irvine & Martin, 1983). These articles would be identified in the U.S. DOE Technical Information Center (TIC) data base and then acquired. The bibliometric information on these articles in the A copy of the TIC data base can be augmented with the references listed in each article or report to permit a more indepth analysis.

With a bibliometric data base, highly cited articles and authors could be identified. Citations among articles could then be used to identify clusters of articles and the technical approaches they represent with the same techniques presently used for the Battelle patent analysis studies. Linkages between clusters are helpful to identify where "cross fertilization" of ideas is occurring. An attempt to correlate highly cited authors and inventors would be useful in identifying technical leaders in magnetic fusion research.

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APPENDIX A

MAGNETIC FUSION TECHNOLOGY TYPE CATEGORIES

APPENDIX A

MAGNETIC FUSION TECHNOLOGY

TYPE CATEGORIES

1. Magnetic Field Geometry and Confinement Schemes

This category would include all of the open and closed field line configurations for confining a plasma. Note that some devices such as the tokamak produce a plasma as part of the start-up operation. Others consist of the field configuration alone. Keywords: Toroidal confinement, mirror devices, linear confinement.

2. Ion, Plasma Generation

This category would include devices designed for the generation of plasmas, which are then injected into the confinement device, or used in some other fashion. (Sources used to heat other plasmas are called out separately under Heating below).

3. Plasma Control/Field Shaping

This category would include mechanisms for the control of the plasma and field configuration during operation. This includes feedback and stability control.

4. Plasma Boundary/Impurity Control

This category would include devices such as divertors and limiters which are used to control the outer boundary of the plasma and its interaction with the material walls of the vessel. These devices can consist of a localized modification to the field lines and a material object or device of some sort to subsequently trap ions directed to it, and limit back-streaming of ions or sputtered material to the plasma.

5. Heating

This category includes methods for heating plasmas which have already been created (see Categories 1 and 2). This can include particle beams, radio

or microwave frequency radiation, or lasers. Also included here are schemes for shockwave or explosive compression heating of plasmas (Imploding Liner).

6. Coil/Magnet Technology

This category includes normal and superconducting magnet technology. This includes the windings themselves, as well as radiation shields, dewars, etc.

7. Instrumentation/Diagnostics

This category includes devices, techniques, etc., for analyzing, sensing, measuring of plasma parameters or conditions in the fusion device.

8. Vacuum Technology

This includes mechanisms for vacuum vessels, pumping, valves, flanges, seals, etc.

9. Tritium Breeding/Extraction/Recovery/Processing

Fusion reactors based on the deuterium-tritium fuel cycle typically include provisions for breeding tritium in the blanket of the reactor surrounding the plasma. Lithium or lithium compounds are typically used. This category includes those areas of compound preparation and location in the device, as well as the necessary technology to recover, extract, and isotopically purify the fuel stream.

10. Process Utilization of Fusion/Plasma Energy

This category includes devices, processes, etc., which utilize the fusion energy for inducing or accelerating chemical reactions or materials production.

11. Heat Generation/Blanket and Shield Designs

In fusion reactors based on a thermal heat cycle to generate power, the plasma radiation must be converted to heat. This category includes devices, schemes, etc., to convert the kinetic energy of streaming ions and neutrons to heat. Note that this is often closely related to tritium production.

12. Power Conversion, Thermodynamic Cycles

This category includes coolants and working fluids, etc., for the transport of heat and devices for conversion of heat to other energy forms (i.e., electricity). Direct conversion of the kinetic energy of streaming ions to electricity is also possible in this category.

13. Electrical Power Supplies/Power Storage/Switching/Transmission

This category would include devices required to store, switch, and deliver high megawatt power levels to fusion devices. Storage devices include flywheels and capacitors. Special transmission lines are often needed to handle the power levels involved.

14. Materials

A category for materials or advances in material science is included. Materials in the vacuum vessel facing the plasma are of primary concern.

APPENDIX B

A LISTING OF MAGNETIC FUSION PATENTS

PAGE NO. 00001

PATENT#	ISSUED	FILED	TITLE	ASSIGNEE	SE	CO	TY
					CT	UN	FE
					OR	TR	
							Y
3166477	190165	071259	INJECTION SYSTEM FOR ELECTRIC DEVICE	COMPAGNIE GENERALE DE TEL	1	56	04
3170841	230265	140754	PYROTRON THERMONUCLEAR REACTOR AND PROCESS	U.S.A. ATOMIC ENERGY COMM	4	01	01
3171788	020365	170563	ROTATING PLASMA DEVICE	U.S.A. ATOMIC ENERGY COMM	4	01	01
3174068	160365	190460	PLASMA CONFINING DEVICE	COMPAGNIE GENERALE DE TEL	1	56	01
3177408	060465	180961	SUPERCONDUCTOR SOLENOID WITH OVERHEAT PROTECTIVE STRUCTURE AND CIRCU	U.S.A. ATOMIC ENERGY COMM	4	01	06
3189523	150665	270361	MEANS FOR PRODUCING HIGH TEMPERATURE PLASMA	AVCO MANUFACTURING CORP.	1	01	05
3191092	220665	200962	PLASMA PROPULSION DEVICE HAVING SPECIAL MAGNETIC FIELD	U.S.A. ATOMIC ENERGY COMM	4	01	02
3194739	130765	200862	FUSION RESEARCH APPARATUS	GENERAL DYNAMICS CORP.	1	01	01
3200268	100865	201161	HIGH CURRENT GENERATOR ARRANGEMENT	THE AEROSPACE CORPORATION	1	01	13
3212974	191065	310560	PARTICLE INJECTING DEVICE	COMPAGNIE GENERALE DE TEL	1	56	02
3214342	261065	220661	PROCESS FOR PRODUCING INTENSE MAGNETIC FIELDS FOR THE PURPOSE OF CON	UNASSIGNED OR INDIVIDUAL	7	61	01
3218235	161165	091263	METHOD AND APPARATUS FOR PRODUCING A MAGNETICALLY CONFINED HOT DENSE	U.S.A. ATOMIC ENERGY COMM	4	01	05
3218562	161165	200862	METHOD AND APPARATUS FOR ACCELERATION OF CHARGED PARTICLES USING A L	UNASSIGNED OR INDIVIDUAL	7	01	05
3219534	231165	261064	PLASMA CONFINEMENT APPARATUS EMPLOYING A HELICAL MAGNETIC FIELD CONF	U.S.A. ATOMIC ENERGY COMM	4	01	01
3222559	071265	111264	PRODUCTION OF COMPLETELY IONIZED PLASMA	U.S.A. ATOMIC ENERGY COMM	4	01	02
3230145	180166	041163	APPARATUS FOR MAGNETICALLY CONFINING A PLASMA	U.S.A. ATOMIC ENERGY COMM	4	01	01
3230418	180166	230661	DEVICE HAVING HIGH-GRADIENT MAGNETIC CUSP GEOMETRY	U.S.A. ATOMIC ENERGY COMM	4	01	01
3232046	010266	060662	PLASMA GENERATOR AND PROPULSION EXHAUST SYSTEM	THE AEROSPACE CORPORATION	1	01	02
3238414	010366	280765	HIGH OUTPUT DUOPLASMA-TYPE ION SOURCE	U.S.A. ATOMIC ENERGY COMM	4	01	02
3244969	050466	201263	ELECTRON ORBITING TUBES FOR ION MEASUREMENT AND GETTERING PUMPS	WISC. ALUMNI RES. FOUNDAT	6	01	07
3252047	170566	061260	CLOSED PATH PLASMA ACCELERATOR	LITTON SYSTEMS INC.	1	01	05
3256687	210666	310758	HYDROMAGNETICALLY OPERATED GAS ACCELERATOR PROPULSION DEVICE	AVCO MANUFACTURING CORP.	1	01	05
3257283	210666	210863	METHODS OF HEATING IONS IN A PLASMA	UNITED KINGDOM ATOMIC ENE	4	85	05
3257284	210666	120763	METHOD OF CONTROLLING PLASMA STABILITY	U.S.A. ATOMIC ENERGY COMM	4	01	03
3257579	210666	070460	PARTICLE-CONFINING DEVICES HAVING MAGNETIC MIRRORS	COMPAGNIE GENERALE DE TEL	1	56	01
3258401	280666	230762	FUSION-RESEARCH APPARATUS	GENERAL DYNAMICS CORP.	1	01	01
3258402	280666	110162	ELECTRIC DISCHARGE DEVICE FOR PRODUCING INTERACTIONS BETWEEN NUCLEI	INTERNATIONAL TEL. & TEL.	1	01	05
3260869	120766	210262	METHOD FOR REVERSIBLY EXTRACTING ENERGY FROM A PLASMA BY MAGNETIC PU	U.S.A. ATOMIC ENERGY COMM	4	01	12
3265583	090866	140464	APPARATUS FOR PRODUCING AND PURIFYING PLASMA	U.S.A. ATOMIC ENERGY COMM	4	01	02
3270236	300866	060364	ELECTRODELESS APPARATUS FOR PRODUCING OR ACCELERATING PLASMOIDS	SIEMENS-SCHUCKERTWERKE AK	1	54	02
3274435	200966	160260	METHOD OF INJECTING AND TRAPPING PARTICLES IN A STATIC MAGNETIC CONF	GENERAL DYNAMICS CORP.	1	01	05
3278384	111066	130465	NEGATIVE "V" STELLARATOR	U.S.A. ATOMIC ENERGY COMM	4	01	01
3279175	181066	191262	APPARATUS FOR GENERATING AND ACCELERATING CHARGED PARTICLES	RADIO CORPORATION OF AMER	1	01	02
3286162	151166	230763	METHOD OF POLARIZING IONS, AND SOURCES OF POLARIZED IONS, NOTABLY PR	COMMISSARIAT A L'ENERGIE	1	56	02
3290219	061266	190963	PLASMA CONTAINMENT METHOD AND APPARATUS	GENERAL ELECTRIC COMPANY	1	01	05
3293583	201266	170761	TOROIDAL INDUCTOR	UNASSIGNED OR INDIVIDUAL	7	01	06
3298179	070167	121163	CONFINED PARALLEL RAIL PULSED PLASMA ACCELERATOR	ROCKET RESEARCH CORP.	1	01	02
3300640	240167	130564	MEANS FOR MEASURING PLASMA DENSITY BY RESONANT CHARGE TRANSFER WITH	U.S.A. ATOMIC ENERGY COMM	4	01	07
3302026	310167	250763	ION SOURCE NEUTRON GENERATOR HAVING MAGNETICALLY STABILIZED PLASMA	ESSO PRODUCTION RESEARCH	1	01	02
3303097	070267	200865	HIGH-PRESSURE AND -TEMPERATURE GENERATOR	UNASSIGNED OR INDIVIDUAL	7	01	01
3303449	070267	280262	TOROIDAL MAGNETIC CORES HAVING VARYING CROSS-SECTIONAL AREAS	U.S.A. SEC. OF THE NAVY	4	01	06
3305448	210267	060563	INTRODUCTION OF FUEL INTO A THERMONUCLEAR REACTOR	KERNREAKTOR BAU- UND BETR	1	54	05
3305684	210267	100164	NEUTRON SOURCE HAVING MONITOR SYSTEM FOR ADJUSTING CORONA CURRENT	DRESSER INDUSTRIES INC.	1	01	02
3313707	110467	170464	APPARATUS FOR COMPRESSING AND HEATING A PLASMA CONTAINING A FUSIONAB	UNASSIGNED OR INDIVIDUAL	7	67	05
3315114	180467	050262	PLASMA CONTAINMENT APPARATUS COMPRISING ROTATING AND FIXED MAGNETIC	UNITED KINGDOM ATOMIC ENE	4	85	01
3318094	090567	040365	ALTERNATING PINCH PLASMA DEVICE	SIEMENS-SCHUCKERTWERKE AK	1	54	02
3319106	090567	181264	PLASMOID GENERATOR AND ACCELERATOR UTILIZING AN ANNUAL MAGNETIC COR	SIEMENS-SCHUCKERTWERKE AK	1	54	02
3319118	090567	160764	PROCESS AND APPARATUS FOR PRODUCING PURIFIED FAST PARTICLE BEAMS	U.S.A. ATOMIC ENERGY COMM	4	01	05

PATENT#	ISSUED	FILED	TITLE	ASSIGNEE	SE	CO	TY
					CT	UN	PE
					OR	TR	Y
3321664	230567	100864	PLASMA ACCELERATOR HAVING RAPIDLY PULSED COIL FOR EXPELLING PLASMA	U.S.A. ATOMIC ENERGY COMM	4	01	02
3321919	300567	090764	APPARATUS FOR GENERATING HIGH DENSITY PLASMA	HIGH VOLTAGE ENGINEERING	1	01	02
3324316	060667	080664	CONTROLLED FUSION DEVICES	ELECTRO-OPTICAL SYSTEMS	1	01	01
3326769	200667	200766	ENERGETIC ELECTRON PLASMA BLANKET	U.S.A. ATOMIC ENERGY COMM	4	01	01
3338788	290867	220162	APPARATUS FOR PRODUCING HIGH INTENSITY MAGNETIC FIELDS FOR USE IN CO	EUROPEAN ATOMIC ENERGY CO	4	57	05
3338789	290867	200865	FUSION GENERATOR OF HIGH INTENSITY, PULSED NEUTRONS	GENERAL DYNAMICS CORP.	1	01	01
3345524	031067	230965	METHOD AND APPARATUS FOR ENERGY CONVERSION	UNASSIGNED OR INDIVIDUAL	7	01	05
3346458	101067	070864	PROCESS AND APPARATUS FOR PLACING MATERIALS IN A STATE OF PLASMA	UNASSIGNED OR INDIVIDUAL	7	54	02
3353107	141167	061059	HIGH VOLTAGE PARTICLE ACCELERATORS USING CHARGE TRANSFER PROCESSES	HIGH VOLTAGE ENGINEERING	1	01	02
3359422	191267	281054	ARC DISCHARGE ATOMIC PARTICLE SOURCE FOR THE PRODUCTION OF NEUTRONS	GENERAL ELECTRIC COMPANY	1	01	02
3360692	261267	221264	DEVICE FOR PRODUCING HIGH-INTENSITY MAGNETIC FIELDS OF SHORT DURATIO	SIEMENS-SCHUCKERTWERKE AK	1	54	02
3361634	020168	161162	PLASMA METHOD AND APPARATUS FOR GENERATING ENERGY	LIPHA LYONNAISE INDUSTRIE	1	56	05
3363130	090168	231065	FREQUENCY TUNING OF AN ENERGETIC ARC DISCHARGE BY VARYING THE DIAMET	U.S.A. ATOMIC ENERGY COMM	4	01	02
3369140	130268	011063	ANNULAR CONFINEMENT OF HIGH TEMPERATURE PLASMAS	U.S.A. ATOMIC ENERGY COMM	4	01	01
3374629	260368	280765	HIGH EFFICIENCY PARALLEL RAIL ACCELERATOR	HUGHES AIRCRAFT COMPANY	1	01	02
3376469	020468	300965	POSITIVE ION-SOURCE HAVING ELECTRON RETAINING MEANS	COMMISSARIAT A L'ENERGIE	4	56	02
3386803	040668	130566	METHOD AND APPARATUS FOR PRODUCING NUCLEAR-FUSION REACTIONS	INTERNATIONAL TEL. & TEL.	1	01	01
3387174	040668	180767	METHOD AND APPARATUS FOR REMOVING IMPURITY GAS PARTICLES FROM A PART	U.S.A. ATOMIC ENERGY COMM	4	01	05
3408527	291068	120664	HIGH ENERGY PLASMA CONFINEMENT DEVICE UTILIZING ALTERNATE Z AND O PI	SIEMENS AKTIENGESELLSCHAFT	1	54	01
3418206	241268	080464	PARTICLE ACCELERATOR	THE BOEING COMPANY	1	01	05
3425902	040269	090367	DEVICE FOR THE PRODUCTION AND CONFINEMENT OF IONIZED GASSES	COMMISSARIAT A L'ENERGIE	4	56	05
3426233	040269	131265	PLASMA STABILIZATION BY ROTATION OF ARC DISCHARGE TUBE	VITRO CORPORATION	1	01	03
3431461	040369	180163	ELECTION CYCLOTRON RESONANCE HEATING DEVICE	KABUSHIKI KAISHA HITACHI	1	55	05
3433705	180369	280268	STELLARATOR HAVING MULTIPOLE MAGNETS	U.S.A. ATOMIC ENERGY COMM	4	01	01
3437862	080469	230555	METHOD AND APPARATUS FOR PRODUCING HIGH TEMPERATURES BY A MAGNETIC F	ZENITH RADIO CORPORATION	1	01	05
3437871	080469	270466	PLASMA CONFINEMENT APPARATUS WITH ION CYCLOTRON RESONANCE HEATING	XEROX CORPORATION	1	01	01
3441790	290469	210863	PLASMA GUN UTILIZING SUCCESSIVE ARCS FOR GENERATING AND ACCELERATING	UNASSIGNED OR INDIVIDUAL	7	56	02
3442758	060569	070863	CONFINEMENT OF A PLASMA BY A ROTATING MAGNETIC FIELD	LITTON INDUSTRIES, INC.	1	01	05
3445333	200569	011266	PROCESS FOR THE PRODUCTION OF ENERGY BY CONTROLLED FUSION	UNASSIGNED OR INDIVIDUAL	7	56	03
3445722	200569	041164	PLASMA MANIPULATION METHOD AND APPARATUS	GULF GENERAL ATOMIC INC.	1	01	02
3449628	100669	270466	PLASMA ARC ELECTRODES WITH ANODE HEAT SHIELD	XEROX CORPORATION	1	01	02
3452249	240669	210565	METHOD AND APPARATUS FOR CONTAINING A PLASMA PRODUCED BY OPPOSED ELE	ELECTRO-OPTICAL SYSTEMS	1	01	01
3453469	010769	270466	MULTI-LEVEL VACUUM PUMPING SYSTEM FOR PLASMA CONFINEMENT DEVICE	XEROX CORPORATION	1	01	02
3453474	010769	270466	PLASMA ARC ELECTRODES	XEROX CORPORATION	1	01	02
3453488	010769	200565	PLASMA ARC ELECTRODES	XEROX CORPORATION	1	01	02
3453489	010769	200565	MULTIPLE ANODE ELECTRODE ASSEMBLY	XEROX CORPORATION	1	01	02
3461033	120869	240866	ELECTRICAL APPARATUS FOR ELECTROMAGNETIC CONTROL OF PLASMOIDS	SIEMENS AKTIENGESELLSCHAFT	1	54	05
3462622	190869	270466	PLASMA ENERGY EXTRACTION	XEROX CORPORATION	1	01	12
3467885	160969	200565	METHOD AND APPARATUS FOR ELECTROMAGNETICALLY CONTAINING A PLASMA	XEROX CORPORATION	1	01	01
3485716	231269	011167	METHOD AND APPARATUS FOR INJECTING AND TRAPPING CHARGED PARTICLES IN	U.S.A. ATOMIC ENERGY COMM	4	01	05
3491318	200170	160868	BASEBALL SEAM MAGNET WITH VARIABLE MAGNETIC FIELD	U.S.A. ATOMIC ENERGY COMM	4	01	06
3500077	106370	191267	METHOD AND APPARATUS FOR ACCELERATING IONS OUT OF A HOT PLASMA REGIO	U.S.A. ATOMIC ENERGY COMM	4	01	12
3500123	100370	070667	PLASMA EJECTION SYSTEM INCLUDING BRECH AND MUZZLE, THETA-PINCH COIL	U.S.A. SEC. OF THE NAVY	4	01	02
3501376	170370	210767	METHOD AND APPARATUS FOR PRODUCING NUCLEAR FUSION	CONSUMERS POWER COMPANY	1	01	01
3508104	210470	030767	APPARATUS FOR THE STABLE CONFINEMENT OF A PLASMA	STICHTING VOORFUNDAMENTEE	3	80	01
3513351	190570	260668	DUOPLASMATRON-TYPE ION SOURCE INCLUDING A GAS RESERVOIR	U.S.A. ATOMIC ENERGY COMM	4	01	02
3523206	040870	311067	PLASMA CONFINEMENT MEANS	ENTROPY LIMITED	1	59	01
3523209	040870	290667	PLASMA DEVICE INCLUDING PLASMA INJECTION STRUCTURE AND METHOD	GULF GENERAL ATOMIC INC.	1	01	01

PATENT#	ISSUED	FILED	TITLE	ASSIGNEE	SE CT OR	CO UN TR	TY PE Y
3527977	080970	030668	MOVING ELECTRONS AS AN AID TO INITIATING REACTIONS IN THERMONUCLEAR	U.S.A. ATOMIC ENERGY COMM	4	01	01
3530036	220970	151267	APPARATUS FOR GENERATING FUSION REACTIONS	INTERNATIONAL TEL. & TEL.	1	01	01
3530497	220970	240468	APPARATUS FOR GENERATING FUSION REACTIONS	INTERNATIONAL TEL. & TEL.	1	01	01
3532915	061070	020468	HIGH FREQUENCY ION SOURCE FORMED BY A DISCHARGE BETWEEN A SECONDARY	U.S. PHILIPS CORPORATION	1	01	02
3533910	131070	180168	LITHIUM ION SOURCE IN APPARATUS FOR GENERATING FUSION REACTIONS	INTERNATIONAL TEL. & TEL.	1	01	01
3534811	201070	181268	BALL-LOADED HIGH ENERGY PARTICLE BEAM DUMP	U.S.A. ATOMIC ENERGY COMM	4	01	05
3551828	291270	010768	PLASMA CONTAINMENT APPARATUS AND METHOD	ENTROPY LIMITED	1	59	01
3571734	230371	211169	METHOD OF PRODUCTION, ACCELERATION AND INTERACTION OF CHARGED-PARTICLE	COMMISSARIAT A L'ENERGIE	4	56	05
3572948	300371	301068	APPARATUS FOR MEASURING THE ELECTRON DENSITY OF A PLASMA	COMPAGNIE GENERALE D'ELEC	1	56	07
3573691	060471	131267	PLASMA CONTAINMENT SYSTEMS	UNITED KINGDOM ATOMIC ENE	4	85	01
3575598	200471	210268	PLASMA SIMULATION AND ANALYSIS APPARATUS AND METHOD	TRW INC.	1	01	03
3577026	040571	062469	METHOD FOR PRODUCING IONS UTILIZING A CHARGE-TRANSFER COLLISION	U.S.A. ATOMIC ENERGY COMM	4	01	05
3577317	040571	010569	CONTROLLED FUSION REACTOR	U.S.A. ATOMIC ENERGY COMM	4	01	01
3579027	180571	040368	IGNITING AID FOR HIGH EFFICIENCY PLASMA PRODUCERS	GEBR. BOHLER & CO. AKTIEN	1	60	02
3579028	180571	231068	CONVERGING-BARREL PLASMA ACCELERATOR	UNASSIGNED OR INDIVIDUAL	7	01	05
3580802	250571	220469	DEVICE FOR DETERMINING THE SHAPE OF MAGNETIC SURFACES IN TOROIDAL CO	U.S.A. ATOMIC ENERGY COMM	4	01	07
3582849	010671	031269	ELECTROMAGNETIC APPARATUS FOR PRODUCING AND CONTAINING HIGH TEMPERAT	U.S.A. ATOMIC ENERGY COMM	4	01	01
3607627	210971	101068	STELLARATOR CONFIGURATION UTILIZING INTERNAL SEPARATRICES	U.S.A. ATOMIC ENERGY COMM	4	01	01
3614525	191071	140169	PLASMA COMPRESSION APPARATUS	UNASSIGNED OR INDIVIDUAL	7	01	01
3617908	021171	240269	CHARGED PARTICLE ACCELERATOR WITH SINGLE OR MULTIMODE OPERATION	UNASSIGNED OR INDIVIDUAL	7	01	05
3624240	301171	240370	FEEDBACK STABILIZATION OF A MAGNETICALLY CONFINED PLASMA	U.S.A. ATOMIC ENERGY COMM	4	01	03
3624443	301171	310870	TWO-PLASMA GUN MAGNETIC FIELD LOADING METHOD	U.S.A. ATOMIC ENERGY COMM	4	01	05
3626305	071271	270169	HIGH ENERGY ION ACCELERATOR	U.S.A. ATOMIC ENERGY COMM	4	01	05
3643123	150272	281068	PLASMA CONTAINMENT DEVICE	TRW INC.	1	01	01
3644731	220272	290869	APPARATUS FOR PRODUCING AN ION BEAM BY REMOVING ELECTRONS FROM A PLA	COMMISSARIAT A L'ENERGIE	4	56	02
3649862	140372	010569	SEPARATED ION BEAM SOURCE WITH ADJUSTABLE SEPARATION	COLLUTION CORPORATION	1	01	02
3650893	210372	021269	PORT PLUG FOR A PLASMA-CONFINING CAVITY	U.S.A. ATOMIC ENERGY COMM	4	01	08
3655508	110472	120668	ELECTROSTATIC FIELD APPARATUS FOR REDUCING LEAKAGE OF PLASMA FROM MA	INTERNATIONAL TEL. & TEL.	1	01	01
3657542	180472	040570	PRODUCTION OF BEAMS OF EXCITED ENERGETIC NEUTRAL PARTICLES	U.S.A. ATOMIC ENERGY COMM	4	01	05
3663360	160572	130870	CONVERSION OF HIGH TEMPERATURE PLASMA ENERGY INTO ELECTRICAL ENERGY	U.S.A. ATOMIC ENERGY COMM	4	01	12
3663361	160572	170270	NUCLEAR FUSION DEVICE OF THE AIR-CORE TOKAMAK TYPE	U.S.A. ATOMIC ENERGY COMM	4	01	01
3663362	160572	221270	CONTROLLED FUSION REACTOR	U.S.A. ATOMIC ENERGY COMM	4	01	01
3663858	160572	061170	RADIO-FREQUENCY PLASMA GENERATOR	UNASSIGNED OR INDIVIDUAL	7	54	05
3664920	230572	210668	ELECTROSTATIC CONTAINMENT IN FUSION REACTORS	INTERNATIONAL TEL. & TEL.	1	01	01
3664921	230572	161069	PROTON E-LAYER ANION FOR PRODUCING CONTROLLED FUSION REACTIONS	U.S.A. ATOMIC ENERGY COMM	4	01	01
3668065	060672	150970	APPARATUS FOR THE CONVERSION OF HIGH TEMPERATURE PLASMA ENERGY INTO	U.S.A. ATOMIC ENERGY COMM	4	01	12
3668066	060672	180270	DYNAMIC STABILIZER FOR PLASMA INSTABILITIES TO IMPROVE PLASMA CONFIN	U.S.A. ATOMIC ENERGY COMM	4	01	03
3668067	060672	161069	POLYGONAL ASTRON REACTOR FOR PRODUCING CONTROLLED FUSION REACTIONS	U.S.A. ATOMIC ENERGY COMM	4	01	01
3668068	060672	210169	PLASMA CONFINEMENT APPARATUS	UNITED KINGDOM ATOMIC ENE	4	85	01
3674634	040772	210169	PLASMA CONFINEMENT APPARATUS	UNITED KINGDOM ATOMIC ENE	4	85	01
3677889	180772	080770	MAGNETIC COMPRESSION CONTROLLED THERMONUCLEAR REACTOR	U.S.A. ATOMIC ENERGY COMM	4	01	05
3677890	180772	230471	PLASMA HEATING AND DENSIFICATION IN AXISYMMETRIC TOROIDAL PLASMA CON	U.S.A. ATOMIC ENERGY COMM	4	01	05
3679897	250772	051266	LASER BOMBARDMENT OF MICROPARTICLE BEAM FOR PRODUCING ATOMIC PARTICL	TRW INC.	1	01	02
3692626	190972	210369	APPARATUS FOR FORMING AND CONTAINING PLASMA	U.S.A. ATOMIC ENERGY COMM	4	01	01
3702163	071172	150470	DEVICE FOR COMPRESSION HEATING OF TOKAMAK DISCHARGES	U.S.A. ATOMIC ENERGY COMM	4	01	05
3708391	020173	200971	HIGH POWER DENSITY CONTROLLED FUSION REACTOR	U.S.A. ATOMIC ENERGY COMM	4	01	09
3710279	090173	151269	APPARATUS FOR TRAPPING AND ACCELERATING NEUTRAL PARTICLES	BELL TELEPHONE LABORATOR	1	01	09
3713967	300173	180671	ENERGETIC NEUTRAL PARTICLE INJECTION SYSTEM FOR CONTROLLED FUSION RE	U.S.A. ATOMIC ENERGY COMM	4	01	05

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3715595	060273	110570	PULSED NEUTRON SOURCE	U.S.A. SEC. OF AIR FORCE	4	01	05
3715625	060273	120171	PLASMA GENERATOR	U.S.A. ATOMIC ENERGY COMM	4	01	02
3718836	270273	181170	MULTIPACTOR ION GENERATOR	INTERNATIONAL TEL. & TEL.	1	01	02
3719554	060373	110970	HALL CURRENT ACCELERATOR ADAPTED FOR INJECTION OF IONS INTO PLASMA	UNITED KINGDOM ATOMIC EN	4	85	02
3720828	130373	180870	APPARATUS FOR AND METHOD OF CONTROLLING RELATIVISTIC CHARGED PARTICL	ENERGY SCIENCES, INC.	1	01	05
3723246	270373	270571	PLASMA PRODUCTION APPARATUS HAVING DROPLET PRODUCTION MEANS AND LASE	U.S.A. ATOMIC ENERGY COMM	4	01	02
3723703	270373	080271	LASER ENERGIZED PLASMA SOURCE	U.S.A. ATOMIC ENERGY COMM	4	01	02
3728217	170473	050672	BUMPY TORUS PLASMA CONFINEMENT DEVICE	U.S.A. ATOMIC ENERGY COMM	4	01	01
3733248	150573	180270	PLASMA CONTROL BY FEEDBACK	U.S.A. ATOMIC ENERGY COMM	4	01	03
3735591	290573	300871	MAGNETO-PLASMA-DYNAMIC ARC THRUSTER	U.S.A. NASA	4	01	05
3736539	290573	180472	MOMENT-FREE TOROIDAL MAGNET DESIGN	U.S.A. ATOMIC ENERGY COMM	4	01	06
3740554	190673	130472	MULTI-AMPERE DUPLICATION ION SOURCE	U.S.A. ATOMIC ENERGY COMM	4	01	02
3742219	260673	230671	HIGH ENERGY NEUTRAL PARTICLE BEAM SOURCE	U.S.A. ATOMIC ENERGY COMM	4	01	05
3746860	170773	170272	SOFT X-RAY GENERATOR ASSISTED BY LASER	UNASSIGNED OR INDIVIDUAL	7	01	14
3748226	240773	180572	PULSED HIGH-BETA FUSION REACTOR	U.S.A. ATOMIC ENERGY COMM	4	01	05
3748475	240773	170272	NEUTRON GENERATOR AXIALLY ASSISTED BY LASER	UNASSIGNED OR INDIVIDUAL	7	01	05
3749639	310773	110370	METHOD AND DEVICE FOR PRODUCING THERMONUCLEAR PLASMA	UNASSIGNED OR INDIVIDUAL	7	68	02
3750070	310773	301171	PRESSURE RING FOR TRANSFORMER WINDINGS	WESTINGHOUSE ELECTRIC COR	1	01	06
3755073	280873	210671	HYBRID LASER PLASMA TARGET-NEUTRAL BEAM INJECTION FUSION SYSTEM	U.S.A. ATOMIC ENERGY COMM	4	01	10
3755710	280873	240372	GAS PLASMA DEVICE	PARK-CHIO INDUSTRIES INC.	1	01	02
3757114	040973	080372	APPARATUS AND METHOD FOR MEASURING THE INTENSITY OF A BEAM OF NEUTRA	BELL TELEPHONE LABORATORY	1	01	07
3757518	110973	201071	ION ENGINE	MESSERSCHMITT-BOELKOW BLOH	1	54	05
3760225	180973	060672	HIGH CURRENT PLASMA SOURCE	U.S.A. ATOMIC ENERGY COMM	4	01	02
3761721	250973	060772	MATTER WAVE INTERFEROMETRIC APPARATUS	TRW INC.	1	01	07
3764466	091073	200170	PRODUCTION OF PLASMAS BY LONG WAVELENGTH LASERS	U.S.A. ATOMIC ENERGY COMM	4	01	05
3766004	161073	190771	LASER ASSISTED NEUTRON GENERATOR	U.S.A. SEC. OF THE NAVY	4	01	05
3767929	231073	150672	METHOD AND MEANS FOR MEASURING THE ANISOTROPY OF A PLASMA IN A MAGNE	U.S.A. ATOMIC ENERGY COMM	4	01	07
3769599	301073	220471	PARTICLE PREACCELERATOR ARRANGEMENT	THOMSON-CSF	1	56	05
3774001	201173	151172	CHAMBER FOR THE HIGH-FREQUENCY HEATING OF A CONDUCTING MEDIUM	COMMISSARIAT A L'ENERGIE	4	56	05
3778343	111273	110371	DEVICE FOR PLASMA CONFINEMENT AND HEATING BY HIGH CURRENTS AND NONCL	U.S.A. ATOMIC ENERGY COMM	4	01	01
3778612	111273	151269	NEUTRAL PARTICLE BEAM SEPARATOR AND VELOCITY ANALYZER USING RADIATIO	UNASSIGNED OR INDIVIDUAL	7	01	09
3778656	111273	260772	ION SOURCE EMPLOYING A MICROWAVE RESONANT CAVITY	COMMISSARIAT A L'ENERGIE	4	56	02
3779864	181273	291071	EXTERNAL CONTROL OF ION WAVES IN A PLASMA BY HIGH FREQUENCY FIELDS	U.S.A. ATOMIC ENERGY COMM	4	01	03
3798488	190374	280771	PLASMA SOURCE OF CHARGED PARTICLES	UNASSIGNED OR INDIVIDUAL	7	68	02
3801438	020474	030470	TOROIDAL APPARATUS FOR CONFINING PLASMA	U.S.A. ATOMIC ENERGY COMM	4	01	01
3808432	300474	151269	NEUTRAL PARTICLE ACCELERATOR UTILIZING RADIATION PRESSURE	BELL TELEPHONE LABORATORY	1	01	05
3808550	300474	151260	APPARATUSES FOR TRAPPING AND ACCELERATING NEUTRAL PARTICLES	BELL TELEPHONE LABORATORY	1	01	05
3815043	040674	110173	LASER SYSTEM EMPLOYING RAMAN ANTI-STOKES SCATTERING	U.S.A. ATOMIC ENERGY COMM	4	01	05
3816771	110674	090273	PLASMA ENERGY TO ELECTRICAL ENERGY CONVERTER	U.S.A. ATOMIC ENERGY COMM	4	01	12
3817622	180674	261272	MEASUREMENT OF PLASMA TEMPERATURE AND DENSITY USING RADIATION ABSORP	U.S.A. NASA	4	01	07
3831101	200874	050373	PARTICLE BEAM INJECTION SYSTEM	PHYSICS INTERNATIONAL CO.	1	01	05
3831121	200874	100773	FOCUSING MAGNET	MAGNA TEK SYSTEMS, INC.	1	01	06
3843889	221074	291173	HIGH INTENSITY PROTON SOURCE	U.S.A. SEC. OF AIR FORCE	4	01	02
3845300	291074	180473	APPARATUS AND METHOD FOR MAGNETOPLASMA-DYNAMIC ISOTOPE SEPARATION	U.S.A. ATOMIC ENERGY COMM	4	01	09
3846668	051174	220273	PLASMA GENERATING DEVICE	U.S.A. ATOMIC ENERGY COMM	4	01	02
3857090	241274	040673	GENERATION OF BEAMS OF CHARGED PARTICLES	NATIONAL RESEARCH DEVELOP	1	85	07
3859164	070175	200571	METHOD AND DEVICE FOR OBTAINING CONTROLLED NUCLEAR FUSION BY MEANS O	UNASSIGNED OR INDIVIDUAL	7	60	05
3859615	070175	300673	TORUS WINDINGS HAVING ASYMMETRIC MAGNET COILS	U.S.A. ATOMIC ENERGY COMM	4	01	06

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3866414	180275	180473	ION ENGINE	MESSERSCHMITT-BOLKOW-MON	1	54	05
3873930	250375	010373	MAGNETICALLY INSULATED CAPACITOR PROCESS FOR ELECTROSTATIC ENERGY ST	UNASSIGNED OR INDIVIDUAL	7	01	13
3886402	270575	070574	MAGNETIC PUMPING IN SPATIALLY INHOMOGENEOUS MAGNETIC FIELDS	U.S.A. ERDA	4	01	05
3886483	270575	311073	PLASMA PUMPED LASER	U.S.A. ERDA	4	01	12
3890535	170675	111072	ION SOURCES	AGENCE NATIONAL DE VALORI	4	56	02
3900809	190875	270674	ABSORPTION APPARATUS FOR ADJACENTLY DISPOSED MAGNET COILS	SIEMENS AKTIENGESELLSCHAFT	1	54	06
3911318	071075	290372	METHOD AND APPARATUS FOR GENERATING ELECTROMAGNETIC RADIATION	FUSION SYSTEMS CORP.	1	01	05
3914766	211075	291064	PULSATING PLASMA DEVICE	UNASSIGNED OR INDIVIDUAL	7	01	05
3919677	111175	050774	SUPPORT STRUCTURE FOR A SUPERCONDUCTING MAGNET	WISC. ALUMNI RES. FOUNDAT	6	01	06
3925990	161275	280873	SHOCK HEATED WALL CONFINED FUSION POWER SYSTEM	U.S.A. SEC. OF AIR FORCE	4	01	05
3935503	270176	261173	PARTICLE ACCELERATOR	KREIDL CHEMICO PHYSICAL	1	65	01
3935504	270176	160871	METHOD AND APPARATUS FOR INJECTION OF PLASMA	COMMISSARIAT A L'ENERGIE	4	56	02
3937917	100276	220273	METHOD FOR PRODUCING AND HEATING A PLASMA	COMMISSARIAT A L'ENERGIE	4	56	02
3946240	230376	040474	ENERGETIC ELECTRON BEAM ASSISTED FUSION NEUTRON GENERATOR	U.S.A. SEC. OF THE NAVY	4	01	05
3953731	270476	271273	ISOTOPE SEPARATION UTILIZING ZEEBMAN COMPENSATED MAGNETIC EXTRACTION	JERSEY NUCLEAR-AVCO ISOTO	1	01	09
3955153	040576	170375	RING LASER FOR PENETRATING WAVES	UNASSIGNED OR INDIVIDUAL	7	56	01
3957597	180576	280574	PROCESS FOR RECOVERING TRITIUM FROM MOLTEN LITHIUM METAL	U.S.A. ERDA	4	01	09
3959649	250576	271273	COLLECTION OF IONS IN A PLASMA BY MAGNETIC FIELD ACCELERATION WITH S	JERSEY NUCLEAR-AVCO ISOTO	1	01	09
3959659	250576	040474	INTENSE, ENERGETIC ELECTRON BEAM ASSISTED FUSION NEUTRON GENERATOR	U.S.A. SEC. OF THE ARMY	4	01	05
3959710	250576	311274	METHOD FOR EXCITING INDUCTIVE-RESISTIVE LOADS WITH HIGH AND CONTROL	U.S.A. ERDA	4	01	13
3969628	130776	040474	INTENSE, ENERGETIC ELECTRON BEAM ASSISTED X-RAY GENERATOR	U.S.A. SEC. OF THE ARMY	4	01	05
3969631	130776	200375	GAS PRODUCTION APPARATUS	U.S.A. ERDA	4	01	09
3973926	100876	230174	PROCESS AND EQUIPMENT FOR THE MAGNETIC SEPARATION OF ISOTOPES	ADVANCED TECHNOLOGY LABOR	1	01	09
3973926	100876	230174	PROCESS AND EQUIPMENT FOR THE MAGNETIC SEPARATION OF ISOTOPES	ADVANCED TECHNOLOGY LABOR	1	01	09
3979694	070976	030774	SHORT LASER PULSE GENERATION BY GAS BREAKDOWN SWITCHING AND HIGHLY	BELL TELEPHONE LABORATORI	1	01	05
3980916	140976	220775	BEAM LIMITER FOR THERMONUCLEAR FUSION DEVICE	U.S.A. ERDA	4	01	04
3983695	051076	120975	ION BEAM THRUSTER SHIELD	U.S.A. NASA	4	01	05
3992625	161176	271273	METHOD AND APPARATUS FOR EXTRACTING IONS FROM A PARTIALLY IONIZED PL	JERSEY NUCLEAR-AVCO ISOTO	1	01	09
3995136	301176	180374	ENHANCED LASER BEAM COUPLING TO A PLASMA	U.S.A. ERDA	4	01	05
3999072	211276	231075	BEAM-PLASMA TYPE ION SOURCE	SHARP KABUSHIKI KAISHA	1	55	05
4000036	281276	280870	PLASMA CONTROL AND UTILIZATION	U.S.A. ERDA	4	01	05
4007392	080277	160474	MAGNETIC WELL FOR PLASMA CONFINEMENT	IOWA ST. UNIV. RES. FOUND	6	01	01
4010396	010377	261173	DIRECT ACTING PLASMA ACCELERATOR	KREIDL CHEMICO PHYSICAL	1	65	01
4023065	100577	241073	METHOD AND APPARATUS FOR GENERATING AND UTILIZING A COMPOUND PLASMA	UNASSIGNED OR INDIVIDUAL	7	01	01
4034260	050777	190276	GRIDDED CROSSED-FIELD TUBE AND IGNITION METHOD	HUGHES AIRCRAFT COMPANY	1	01	13
4035656	120777	270575	METHOD AND APPARATUS FOR USE IN APPROACHING THERMONUCLEAR TEMPERATUR	GENERAL ATOMIC COMPANY	1	01	04
4042848	160877	170574	HYPOCYCLOIDAL PINCH DEVICE	UNASSIGNED OR INDIVIDUAL	7	01	02
4044562	300877	020574	MULTIROVARY ENERGY CONVERSION VALVE	UNASSIGNED OR INDIVIDUAL	7	01	12
4046527	060977	080274	APPARATUS FOR THE STABLE CONFINEMENT OF AN IONIZED GAS COLUMN INSIDE	ULTRACENTRIFUGE NEDERLAND	1	80	01
4047060	060977	261173	SYNCHRONOUS PLASMA PACKET ACCELERATOR	KREIDL CHEMICO PHYSICAL	1	65	05
4057462	081177	260275	RADIO FREQUENCY SUSTAINED ION ENERGY	U.S.A. ERDA	4	01	05
4059761	221177	270375	SEPARATION OF ISOTOPES BY TIME OF FLIGHT	TRW INC.	1	01	09
4064024	201277	010676	METHODS FOR RADIATION PRODUCTION OF FUELS	TEXAS GAS TRANSMISSION CO	1	01	10
4065350	271277	090774	VERTICALLY STABILIZED MAGNETED CROSS-SECTION TOKAMAK	U.S.A. DEPT. OF ENERGY	4	01	01
4065351	271277	250376	PARTICLE BEAM INJECTION SYSTEM	U.S.A. ERDA	4	01	05
4066496	030178	110974	CRYOGENIC EXPANSION JOINT FOR LARGE SUPERCONDUCTING MAGNET STRUCTURE	U.S.A. ERDA	4	01	06
4066893	030178	270375	ISOTOPE SEPARATION BY ION WAVES	TRW INC.	1	01	09
4067702	100178	121073	ISOTOPE SEPARATION BY SELECTIVE CHARGE CONVERSION AND FIELD DEFLECTI	U.S.A. DEPT. OF ENERGY	4	01	09

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4068147	100178	061175	METHOD AND APPARATUS FOR HEATING AND COMPRESSING PLASMA	UNASSIGNED OR INDIVIDUAL	7	01	05
4073680	140278	260675	TOROIDAL BAND LIMITER FOR A PLASMA CONTAINMENT DEVICE	U.S.A. DEPT. OF ENERGY	4	01	04
4081677	280378	270375	ISOTOPE SEPARATION BY MAGNETIC FIELDS	TRW INC.	1	01	09
4086506	250478	050876	CONTRA-ROTATING HOMOPOLEAR MOTOR-GENERATOR FOR ENERGY STORAGE AND RET	U.S.A. DEPT. OF ENERGY	4	01	13
4087322	020578	070976	AIR CORE POLOIDAL MAGNETIC FIELD SYSTEM FOR PRODUCING A TOROIDAL PLA	U.S.A. DEPT. OF ENERGY	4	01	06
4087720	020578	051076	MULTI-BEAM MULTI-APERTURE ION SOURCES OF THE BEAM-PLASMA TYPE	SHARP KABUSHIKI KAISHA	1	55	05
4087721	020578	120576	ION SOURCE USING A HOLLOW CATHODE DISCHARGE ARRANGEMENT AND IN PART	THOMSON-CSF	1	56	02
4091256	230578	160175	PULSED ATOMIC BEAM APPARATUS	U.S.A. SEC. OF AIR FORCE	4	01	05
4092534	300578	191176	CHARGE EXCHANGE SYSTEM	U.S.A. DEPT. OF ENERGY	4	01	05
4093856	060678	090676	METHOD AND APPARATUS FOR THE ELECTROSTATIC EXCITATION OF IONS	TRW INC.	1	01	09
4097348	270678	070674	METHOD AND APPARATUS FOR PRODUCING HYDROGEN	TEXAS GAS TRANSMISSION CO	1	01	10
4090643	040778	090774	DUAL-FUNCTION MAGNETIC STRUCTURE FOR TOROIDAL PLASMA DEVICES	U.S.A. DEPT. OF ENERGY	4	01	06
4099053	040778	020577	DEVICE FOR THE SEPARATION OF GAS MIXTURES	KREIDL CHEMICO PHYSICAL	1	65	09
4101765	180778	190776	MEANS FOR COUNTERACTING CHARGED PARTICLE BEAM DIVERGENCE	U.S.A. DEPT. OF ENERGY	4	01	05
4110595	290878	190575	HIGH-FREQUENCY PLASMA-HEATING APPARATUS	U.S.A. DEPT. OF ENERGY	4	01	05
4115190	190978	241176	HIGH PLASMA PRODUCING OPERATION IN A TOROIDAL PLASMA PRODUCING DEVIC	U.S.A. DEPT. OF ENERGY	4	01	03
4115191	190978	140677	TOKAMAK PLASMA HEATING WITH INTENSE, PULSED, ION BEAMS	U.S.A. SEC. OF THE NAVY	4	01	05
4116264	260978	051174	NUCLEAR REACTORS	EUROPEAN ATOMIC ENERGY CO	4	90	14
4121123	171078	170377	EXPLOSIVELY DRIVEN PLASMA CURRENT GENERATOR	U.S.A. SEC. OF AIR FORCE	4	01	05
4121984	241078	091173	PRODUCTION OF HYDROGEN BY RADIOLYSIS	TEXAS GAS TRANSMISSION CO	1	01	10
4123683	311078	150977	ELONGATED CROSSED-FIELD SWITCH DEVICE	HUGHES AIRCRAFT COMPANY	1	01	13
4125431	141178	160677	TANDEM MIRROR PLASMA CONFINEMENT APPARATUS	U.S.A. DEPT. OF ENERGY	4	01	01
4127442	281178	160677	CHARGE EXCHANGE COOLING IN THE TANDEM MIRROR PLASMA CONFINEMENT APPA	U.S.A. DEPT. OF ENERGY	4	01	03
4128764	051278	170877	COLLECTIVE FIELD ACCELERATOR	U.S.A. DEPT. OF ENERGY	4	01	05
4129772	121278	121076	ELECTRODE STRUCTURES FOR HIGH ENERGY HIGH TEMPERATURE PLASMAS	WISC. ALUMNI RES. FOUNDAT	6	01	02
4130781	191278	140377	HIGH VOLTAGE D-C VACUUM INTERRUPTER DEVICE WITH MAGNETIC CONTROL OF	GOULD INC.	1	01	13
4132727	020179	070674	METHOD AND APPARATUS FOR THE MANUFACTURE OF METHANOL	TEXAS GAS TRANSMISSION CO	1	01	10
4137012	300179	071077	MODULAR GETTER PUMPS	S.A.E.S. GETTERS S.P.A.	1	61	08
4140057	200279	020578	AXISYMMETRIC STABILIZED LINER IMPLSION SYSTEM	U.S.A. SEC. OF THE NAVY	4	01	05
4140576	200279	220976	APPARATUS FOR THE NEUTRALIZATION OF ACCELERATED IONS	U.S.A. DEPT. OF ENERGY	4	01	05
4140577	200279	220976	PHOTODETACHMENT PROCESS FOR BEAM NEUTRALIZATION	U.S.A. DEPT. OF ENERGY	4	01	05
4140600	200279	191173	MULTI-STEP CHEMICAL AND RADIATION PROCESS FOR THE PRODUCTION OF GAS	TEXAS GAS TRANSMISSION CO	1	01	10
4140601	200279	191173	MULTI-STEP CHEMICAL AND RADIATION PROCESS	TEXAS GAS TRANSMISSION CO	1	01	10
4140602	200279	020975	METHOD FOR OBTAINING CARBON DIOXIDE FROM THE ATMOSPHERE AND FOR PROD	TEXAS GAS TRANSMISSION CO	1	01	10
4140603	200279	191173	MULTI-STEP CHEMICAL AND RADIATION PROCESS FOR THE PRODUCTION OF GAS	TEXAS GAS TRANSMISSION CO	1	01	10
4140943	200279	010677	PLASMA GENERATING DEVICE WITH HAIRPIN-SHAPED CATHODE FILAMENTS	U.S.A. DEPT. OF ENERGY	4	01	02
4144150	130379	020975	MEANS AND METHOD FOR PROCESSING CHEMICALS WITH RADIATION	TEXAS GAS TRANSMISSION CO	1	01	10
4145250	200379	260276	INSITU REGIMINATION OF THE 1ST WALL OF A DEUTERIUM-TRITIUM FUS. DEV.	GENERAL ATOMIC COMPANY	1	01	14
4145269	200379	191173	MULTI-STEP CHEMICAL AND RADIATION PROCESS FOR THE PRODUCTION OF GAS	TEXAS GAS TRANSMISSION CO	1	01	10
4149077	100479	240877	METHOD FOR SEPARATION OF LITHIUM ISOTOPES BY LASER	M.I.T.I.	4	55	09
4149931	170479	160773	DIVERTOR FOR USE IN FUSION REACTORS	U.S.A. DEPT. OF ENERGY	4	01	04
4152625	010579	080578	PLASMA GENERATION AND CONFINEMENT WITH CONTINUOUS WAVE LASERS	U.S.A. SEC. OF THE ARMY	4	01	05
4159421	260679	040277	METHOD AND APPARATUS FOR SUPPRESSING ELECTRON GENERATION IN A VAPOR S	JERSEY NUCLEAR-AVCO ISOTO	1	01	09
4166760	040979	041077	PLASMA CONFINEMENT APPARATUS USING SOLENOIDAL AND MIRROR COILS	U.S.A. DEPT. OF ENERGY	4	01	01
4166761	040979	070278	FUSION CHAMBER	UNASSIGNED OR INDIVIDUAL	7	01	05
4167688	110979	060977	PROCESS AND APPARATUS FOR SEPARATING ISOTOPES	THOMSON-CSF	1	56	09
4172008	231079	230877	NUCLEAR FUSION REACTOR	DUBBLE WHIMMY, INC.	1	01	01
4174254	131179	120977	COMPRESSION HUB	COMBUSTION ENGINEERING IN	1	01	06

PATENT#	ISSUED	FILED	TITLE	ASSIGNEE	SE CT OR	CO UN TR	TY PE Y
4179599	181279	080578	LASER PLASMATRON	U.S.A. SEC. OF THE ARMY	4	01	05
4182561	080180	100674	PULSED DEUTERIUM LITHIUM NUCLEAR REACTOR	UNASSIGNED OR INDIVIDUAL	7	54	05
4182650	080180	170573	PULSED NUCLEAR FUSION REACTOR	UNASSIGNED OR INDIVIDUAL	7	01	05
4183671	150180	140378	INTERFEROMETER FOR THE MEASUREMENT OF PLASMA DENSITY	U.S.A. DEPT. OF ENERGY	4	01	07
4194139	180380	230878	REFLEX TETRODE FOR PRODUCING AN EFFICIENT UNIDIRECTIONAL ION BEAM	U.S.A. SEC. OF THE NAVY	4	01	05
4199402	220480	230276	PLASMA ENERGY PRODUCTION	UNASSIGNED OR INDIVIDUAL	7	01	01
4199685	220480	140477	LASER BEAM ACTIVATED ION SOURCE	UNASSIGNED OR INDIVIDUAL	7	71	09
4202725	130580	080578	CONVERGING BEAM FUSION SYSTEM	UNASSIGNED OR INDIVIDUAL	7	01	01
4209703	240680	011074	SOURCE FOR PLASMA OF LARGE TRANSVERSE SECTION AND CONSTITUTING AN ION	UNASSIGNED OR INDIVIDUAL	7	56	02
4209704	240680	140878	TANDEM ION ACCELERATION HAVING MATTER-FREE ION CHARGE REVERSAL ZONE	SIEMENS AKTIENGESELLSCHAFT	1	54	05
4213043	150780	200777	METHOD FOR FLOWING A LARGE VOLUME OF PLASMA THROUGH AN EXCITATION RE	TRW INC.	1	01	09
4217171	120880	150877	BLANKET DESIGN FOR IMPLoding LINER SYSTEMS	GENERAL ATOMIC COMPANY	1	01	05
4217172	120880	131077	COOLANT SYSTEM & COOLING METHOD UTILIZING 2-PHASE FLOW IN REACTORS	TOKYO INSTITUTE OF TECHN.	2	55	12
4228380	141080	241078	METHOD AND APPARATUS FOR HEATING AND COMPRESSING PLASMA	TRISOPS INC.	1	01	05
4229679	211080	050674	PLASMA CONTROL SYSTEM	UNASSIGNED OR INDIVIDUAL	7	01	03
4229942	281080	060678	RADIOLYTIC DISSOCIATIVE GAS POWER CONVERSION CYCLES	KMS FUSION, INC.	1	01	12
4232244	041180	251078	COMPACT, MAINTAINABLE 80-KEV NEUTRAL BEAM MODULE	U.S.A. DEPT. OF ENERGY	4	01	05
4233537	111180	180972	MULTICUSE PLASMA CONTAINMENT APPARATUS	UNASSIGNED OR INDIVIDUAL	7	01	01
4234925	181180	281075	CONTROL SYSTEMS FOR GENERATORS	TOKYO SHIBAURA DENKI KK	1	55	13
4235668	251180	251072	CONFINEMENT OF HIGH TEMPERATURE PLASMAS	BRIGHAM YOUNG UNIVERSITY	2	01	01
4236964	021280	251072	CONFINEMENT OF HIGH TEMPERATURE PLASMAS	BRIGHAM YOUNG UNIVERSITY	2	01	01
4239594	161280	290875	CONTROL OF IMPURITIES IN TOROIDAL PLASMA DEVICES	U.S.A. DEPT. OF ENERGY	4	01	04
4240873	231280	220978	SOLENOIDAL FUSION SYSTEM	UNASSIGNED OR INDIVIDUAL	7	01	01
4243916	060181	170479	MAGNETIC MIRROR FOR BEAMS OF CHARGED PARTICLES ACCELERATED IN AN ACC	C.G.R.MEV	1	56	01
4244782	130181	251077	NUCLEAR FUSION SYSTEM	ENVIRONMENTAL INST. OF MI	3	01	01
4246067	200181	300878	THERMONUCLEAR FUSION SYSTEM	UNASSIGNED OR INDIVIDUAL	7	01	01
4247804	270181	040679	COLD CATHODE DISCHARGE DEVICE WITH GRID CONTROL	HUGHES AIRCRAFT COMPANY	1	01	13
4248665	030281	050279	DEVICE AND METHOD FOR RELATIVISTIC ELECTRON BEAM HEATING OF A HIGH-D	U.S.A. DEPT. OF ENERGY	4	01	05
4252605	240281	150877	SELF-IMPLoding LINER SYSTEM FOR MAGNETIC FIELD COMPRESSION	GENERAL ATOMIC COMPANY	1	01	05
4252606	240281	060678	METHOD AND APPARATUS FOR CONFINING A PLASMA	UNASSIGNED OR INDIVIDUAL	7	01	01
4252607	240281	050279	RADIATION SOURCE	U.S.A. DEPT. OF ENERGY	4	01	05
4252608	240281	160379	GENERATING END PLUG POTENTIALS IN TANDEM MIRROR PLASMA CONFINEMENT	U.S.A. DEPT. OF ENERGY	4	01	01
4252609	240281	241178	CROSSED-FIELD DIVERTOR FOR A PLASMA DEVICE	U.S.A. DEPT. OF ENERGY	4	01	04
4263096	210481	020276	TOROIDAL MAGNET SYSTEM	U.S.A. DEPT. OF ENERGY	4	01	06
4263097	210481	230277	METHOD AND APPARATUS FOR DRIVING A CONTINUOUS CURRENT IN A TOROIDAL	GENERAL ATOMIC COMPANY	1	01	05
4264413	280481	221276	METHOD AND APPARATUS FOR HIGH BETA DOUBLETS AND MULTIPLETS	GENERAL ATOMIC COMPANY	1	01	01
4267488	120581	050179	CONFINEMENT OF PLASMAS AT THERMONUCLEAR TEMPERATURES	TRISOPS INC.	1	01	01
4268353	190581	230278	DEMOUNTABLE EXTERNALLY ANCHORED LOW-STRESS MAGNET SYSTEM AND RELATED	U.S.A. DEPT. OF ENERGY	4	01	06
4269658	260581	020773	MECHANICAL COMPRESSION PLASMA DEVICE	GENERAL ATOMIC COMPANY	1	01	01
4269658	260581	020773	MECHANICAL COMPRESSION PLASMA DEVICE	GENERAL ATOMIC COMPANY	1	01	01
4269659	260581	230370	NEUTRON GENERATOR	UNASSIGNED OR INDIVIDUAL	7	01	02
4269659	260581	230370	NEUTRON GENERATOR	UNASSIGNED OR INDIVIDUAL	7	01	02
4272319	090681	280278	DEVICE AND METHOD FOR ELECTRON BEAM HEATING OF A HIGH DENSITY PLASMA	U.S.A. DEPT. OF ENERGY	4	01	05
4274919	230681	141177	SYSTEMS FOR MERGING OF TOROIDAL PLASMAS	GENERAL ATOMIC COMPANY	1	01	01
4277306	070781	221277	COIL-LESS DIVERTORS FOR TOROIDAL PLASMA SYSTEMS	GENERAL ATOMIC COMPANY	1	01	04
4277768	070781	241178	SUPERCONDUCTING MAGNETIC COIL	GENERAL DYNAMICS CORP.	1	01	06
4282436	040881	040680	INTENSE ION BEAM GENERATION WITH AN INVERSE REFLEX TETRODE (IRT)	U.S.A. SEC. OF THE NAVY	4	01	05
4287022	010981	020179	COMPRESSION HUB FOR A FUSION REACTOR SYSTEM	COMBUSTION ENGINEERING IN	1	01	06

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